SUPPLEMENTARY LITERATURE SUMMARY AND TECHNICAL WORKING PAPER FOR THE MINNESOTA GENERIC ENVIRONMENTAL IMPACT STATEMENT ON ANIMAL AGRICULTURE

FARM ANIMAL HEALTH AND WELL-BEING

Prepared by Marlene K. Halverson
for the
Minnesota Planning Agency
Environmental Quality Board
April 23, 2001
(updated June 30, 2001)

ACKNOWLEDGEMENTS

A team of internationally recognized animal welfare scientists reviewed numerous drafts of the scientific sections of this paper and provided considerable technical input, feedback, and recommendations that contributed to the completeness and accuracy of the report. They were: Dr. Bo Algers, Dr. Ingvar Ekesbo, and Dr. Per Jensen, Swedish University of Agricultural Sciences; Dr. Donald Broom, University of Cambridge; Dr. David Fraser, University of British Columbia; Dr. Joy Mench, University of California, Davis; and Dr. Ruth Newberry, Washington State University. Dr. Ekesbo also provided valuable background information regarding the development of Swedish animal welfare laws and policies and the role and procedures of the Council of Europe's Standing Committee on Farm Animal Welfare. The generous interest and participation of these individuals are gratefully acknowledged. Their titles and contact information are given on page 3.

The help of Dr. Jeffrey Rushen, Dairy and Swine Research and Development Center, Agriculture and Agri-Food Canada, in identifying some of the pertinent issues concerning selective breeding and dairy cow welfare during a conference in Mariensee, Germany, is also acknowledged as well as communications with Dr. Theodore Kruip of the Institute for Environment and Animal Health, Lelystad, Netherlands, on the impact of artificial selection on the welfare of farmed animals, Dr. Martin Wierup of the Swedish National Health Service, regarding Sweden's antibiotics use policy and salmonella control programs, and Animal Welfare Programs Chief Gunnela Ståhle of Swedish Federation of Farmers for information regarding the Swedish farmers' response.

A number of photographic illustrations bear the credit "Ruth Harrison" or "Ruth Harrison collection." When Mrs. Harrison passed away in June 2000, she left her books and papers on the subject of farm animal welfare to my sister and me. This library has been mined in the preparation of this paper and for Mrs. Harrison's generosity in entrusting her life's work to us, my sister and I will be always grateful. Among the items in the library was a large collection of photos, slides, and snapshots covering the decades of her work. As there was no way of knowing otherwise, we have assumed Mrs. Harrison took these photos and so they bear that designation. I also wish to thank the organization Defending Farm Animals, Inc., for the use of their photos in this report. They bring home the relevance of farm animal welfare concerns to Minnesota. Farm animal advisor Diane Halverson of Animal Welfare Institute and Dr. Karen Davis of United Poultry Concerns, Inc. graciously permitted use of their photos, as well. Credits accompany the photos. Photos on the title page were taken by me.

The support of GEIS project manager George Johnson, editorial assistance by Barbara Clark, and assistance by Vivian Leven and Heather Robins with preparation of the legislative section are gratefully acknowledged.

Although every effort was made to generate an error-free report, I accept responsibility if errors remain. All conclusions and recommendations are my responsibility, as well.

Marlene Halverson
Northfield, MN
April 23, 2001

PREFACE

This Supplementary Literature Summary and Technical Working Paper on Animal Health and Well-being, prepared for the Generic Environmental Impact Statement (GEIS) on Animal Agriculture in Minnesota, covers scientific literature and public and scientific concerns relating to the *health* and *well-being* of agricultural animals, i.e., their *welfare*. *Welfare* is the commonly used, scientifically accepted term that encompasses both health and well-being, which, in turn, are conceptualized as being for the animal's sake and not for human's sake, i.e., not strictly for the purpose of meeting production goals. Often, as will be shown in the following chapters, pursuing a goal of maximizing animal productivity can result in reduced animal welfare.

In the literature summary on animal health prepared for the GEIS, Crooker, et al. (1999) covered disease and the influence of management and environmental factors on performance-related health measures. This supplement covers the influence of modern production practices on farm animal welfare in light of what is known scientifically about how farm animals experience various factors in the production environment.

A related issue, possible impacts on Minnesota's economic competitiveness as it could be affected by uneven standards and enforcement across states and nations, is left to the GEIS Technical Working Papers on economics and externalities. What this paper does is to define animal welfare, in general and with respect to specific livestock species, establish the nature of the changes that are required to produce animals according to a high welfare standard for their species, describe legislation in effect in the states, the European Union, and in selected other countries, and put forward some conclusions and recommendations for policysetting and future research. It refers to known alternative models and practices that enhance rather than compromise animal welfare.

Parts of this paper rely on the author's unpublished Ph.D. dissertation.

Marlene Halverson
Northfield, MN
April 23, 2001

Crooker, B., Halvorson, D., Moon, R., Phillips, C., Noll, S., Johnston, L., Reneau, J., Chester-Jones, H., Hathaway, M., Goyal, S., Janni, K., Pijoan, C., Shields, T., Stromberg, T., Patterson, C., Dee, S., Blaha, T., and Wells, S. (1999). A summary of the literature related to animal agriculture health. *Generic environmental impact statement on animal agriculture, State of Minnesota*. St. Paul, MN: Environmental Quality Board.

Author and contact information:

Marlene Halverson, 10346 S. Dennison Blvd., Northfield, MN 55057, USA
mkhalv@aol.com
Halverson is an agricultural consultant with a background in alternative swine production systems developed around criteria of pig welfare. She has been a visiting researcher at the Department of Animal Health and Environment, Swedish University of Agricultural Sciences, and visited farms and research universities throughout Europe. She has arranged farm visits by US farmers to Sweden. This year, she was an invited North American delegate to the Food Chain 2001 safe, sustainable, ethical conference in Uppsala, Sweden, convened as a part of the Swedish EU-Presidency. She served on the University of Minnesota Institutional Animal Care Committee subcommittee on agricultural animals used in research and teaching, and participated in the "HogsYour Way" program of the Minnesota Department of Agriculture Energy and Sustainable Agriculture Program. While employed by Iowa State University, she assisted farmers adopting a deep-bedded pig production system of Swedish farmers' design. She has coordinated foundation-sponsored projects and published papers, reports, and journal articles in animal welfare. She is a member of the Alternative Swine Production Systems Task Force, which guides the Alternative Swine Production Systems Program, Minnesota Institute of SustainableAgriculture and West Central Research and Outreach Center, University of Minnesota.

Advisory team and contact information:

Dr. Bo Algers, Professor of Veterinary Ethology and Head of Department of Animal Environment and Health, Swedish University of Agricultural Sciences, Skara
bo.algers@hmh.slu.se

Dr. Donald Broom, Professor and Macleod Chair of Animal Welfare and Head of the Centre for Animal Welfare, School of Veterinary Medicine, University of Cambridge, Cambridge
dmb16@cam.ac.uk

Dr. Ingvar Ekesbo, DVM, HonAssocRCVS, PhD, Dr.h.c. Professor emeritus, Department of Animal Environment and Health, Swedish University of Agricultural Sciences, former Chairman of the Council of Europe Standing Committee for Farm Animal Welfare, Skara
ingvar.ekesbo@hmh.slu.se

Dr. David Fraser, Professor and NSERC Industrial Research Chair in Animal Welfare, Faculty of Agricultural Sciences and Centre for Applied Ethics, University of British Columbia, Vancouver
fraserd@interchange.ubc.ca

Dr. Per Jensen, Professor of Ethology, Department of Animal Environment and Health, Swedish University of Agricultural Sciences, Skara
per.jensen@hmh.slu.se

Dr. Joy Mench, Professor of Animal Science and Director of the Center for Animal Welfare, University of California, Davis
jamench@ucdavis.edu

Dr. Ruth Newberry, Professor of Animal Welfare, Department of Animal Science, Washington State University, Pullman
rnewberry@wsu.edu

TABLE OF CONTENTS

ACKNOWLEDGEMENTS
PREFACE 1
AUTHOR AND ADVISORS 2
TABLE OF CONTENTS 3
INTRODUCTION 4

PART I. THE SCIENTIFIC CONCEPTUALIZATION OF ANIMAL WELFARE AND ITS APPLICATION TO FARM ANIMALS 9

1. Does a scientific consensus exist on the meaning of animal welfare and does animal welfare have a place in a Generic Environmental Impact Statement on Animal Agriculture in Minnesota 10
2. Overview and explanation of welfare-related terms and concepts 19
3. Some contemporary management and housing practices and their general welfare impacts 45
4. A specific management practice: Subtherapeutic antibiotic use 61

PART II. SPECIES BY SPECIES IMPACTS OF MANAGEMENT AND PRACTICES ON FARM ANIMAL WELFARE 76

5. Poultry 77
6. Cattle 107
7. Pigs 150

PART III. AVAILABLE AND POTENTIALLY AVAILABLE MITIGATION MEASURES TO ADDRESS NEGATIVE EFFECTS OF ANIMAL AGRICULTURE ON ANIMAL HEALTH AND WELL-BEING IN MINNESOTA AND OTHER PLACES, INCLUDING REGULATION 181

8. Does the market work? The political-economy of animal welfare 182
9. Animal welfare regulations in the US with special reference to farm animal protection in Minnesota 199
10. Regulations in other countries aimed at the health and well-being of farm animals 210

PART IV. REVIEW, CONCLUSIONS, AND RECOMMENDATIONS 250

11. Animal Welfare in the Context of Other GEIS Scoping Document Questions: Animal Welfare and Its Relevance to Human Health and the Environment: 251
12. Summary, Conclusions and Recommendations 264

Introduction

I. Objectives of the Supplement to the University of Minnesota Literature Summary on Animal Agriculture – Health

The Scoping Document for the Generic Environmental Impact Statement on Animal Agriculture in Minnesota contained a section entitled "Animal Health." The topic of this section of the Scoping Document was "the health and well being of animals in the livestock production system" (Minnesota Environmental Quality Board 1998).

The following questions were to have been addressed by the Literature Summary:

1. What are the current regulations and routine practices in Minnesota and other places relating to animal agriculture that are aimed at the health and well being of animals? What is known about the use of these practices, or in the case of regulation, what is known about compliance?
2. What are the effects of the animal agriculture system on animal health and well-being and how are these effects being measured and addressed, including consideration of:
    a. antibiotic use;
    b. disease and sickness;
    c. indoor confinement and animal density;
    d. air quality in confinement facilities;
    e. use of manure as feed?
3. How do the effects (in #2) vary by species, operation, system type and management practice?
4. What monitoring techniques and standards are available to determine and address the effects on animals in Minnesota and other places?
5. What are the current and potentially available prevention and mitigation measures for addressing any negative effects on animal health and well-being in Minnesota and other places and to what extent are these measures effective?

The *Literature Summary on Animal Agriculture – Health* prepared by the University of Minnesota (Crooker, et al. 1999) discussed many routine practices in Minnesota animal agriculture and their impacts on the ability of farm animals to grow and reproduce, i.e., to perform their dominant economic functions. It did not, for the most part, describe how these practices and impacts affect the welfare of farm animals or how the welfare of farm animals is related to the other Scoping Document questions. This Supplement does this and proposes that farm animal welfare – welfare defined as both the health and the well-being of the animal – is an important bridging concept between human and animal health.

Certain pressing welfare issues such as osteoporosis in crate-housed sows (contributing to the downer sow problem in the industry), laminitis and reduced fertility in dairy cattle, starvation of force-molted laying hens (a practice that extends hens' productive lives by stimulating a second laying cycle), chronic hunger in broiler-breeder hens, and transport-related suffering were not discussed in Crooker, et al. (1999).

These production environment-related and management-related problems are becoming routine in those forms of swine and poultry production that have become "industrialized" [1] over the past four to five decades, and they are becoming common in Minnesota animal agriculture. Organization of industry is influenced by (and influences) technology development and adoption. Technology choices (including biotechnology choices) have significant impacts on farm animal welfare (Kruip and van Reenen 2000). Most of the modern concerns about the welfare of farm animals stem from the impacts on animals of economic and technology choices in industrialized forms of agriculture, wherein animals are treated as if they were organic machines rather than sentient[2] beings.

The need and opportunity for people involved in agriculture in Minnesota to become informed and to seek alternatives to practices society is increasingly finding objectionable has been recognized by the GEIS Citizens Advisory Committee and is supported by these recent events and actions:

Proposals in the European Community (EC),[3] laws and ballot initiatives in New Jersey,[4] Illinois,[5] and Florida,[6] similar laws in Denmark and the United Kingdom, a longstanding Swedish ban on individual crate or stall housing of pregnant sows,[7] numerous polls showing that the public is concerned about the welfare of farm animals,[8] the year-2000 initiative with respect to egg and pork purchases by McDonald's Corporation in the United States[9] and a follow-up program by Burger King, and the growing number of animal producers joining with established animal

[1] This paper adopts Boehlje's (1995) definition of "agricultural industrialization," i.e., "the application of modern industrial manufacturing, production, procurement, distribution and coordination concepts to the food and industrial product chain" (Boehlje 1995). Strange (in Vogel 1995) expands somewhat more on this definition by including such characteristics as: "financed for growth; concentrated; specialized; management-centered; capital intensive; at an advantage in controlled markets; standardized in production practices." Boehlje (1995) further includes the elements of vertical coordination and integration. Industrial does not necessarily refer to "size," although firms that emphasize capital investment over labor and other variable inputs will need sufficient output volume to support the investment Industrial refers more to an *approach* to production that emphasizes capital investment over labor and other variable inputs.

[2] The American Heritage Dictionary defines "sentience" as the quality or state of being conscious, having sense perception, experiencing sensation or feeling (2nd ed., Houghton-Mifflin Company).

[3] EC has proposed amending EU legislation (1) on protection of pigs to improve their welfare and (2) to reform the Common Agricultural Policy to reward farmers for environmental protection and animal welfare rather than support production. (Note: Action was taken to adopt item (1) on June 19, 2001).

[4] Requiring the New Jersey Department of Agriculture to promulgate standards for the humane treatment of animals on farms.

[5] Ban forced molting of laying hens.

[6] Ban gestation crate housing of pregnant sows.

[7] Djurskyddslagen SF:534, 1988.

[8] Polls taken by Opinion Research Corporation (1995) for Animal Rights International; Lake Snell Perry and Associates (1999) for environmental and animal humane organizations; Animal Industries Foundation (1989, 1998); Zogby America (2000), National Cattlemen's Association 1989; American Farm Bureau Federation (1990); American Medical Association (1989); National Family Opinion, Inc., for the Foundation for Biomedical Research (1985) have repeatedly reaffirmed that the public cares about the well-being of farm animals and has definite opinions about how they should be treated (Swanson and Mench 2000).

[9] McDonald's requires its egg suppliers to refrain from the practice of forced molting and is also planning new standards from its pork suppliers regarding animal rearing and slaughter practices.

welfare organizations to form networks to sell products from animals raised under welfare-friendly conditions.[10]

Crooker, et al. (1999) did not cover compliance and enforcement. This likely reflects the fact that in Minnesota there is no governmental department or agency overseeing the welfare of animals on farms. The agency whose mandate is closest to animal welfare is the Minnesota Board of Animal Health. However, this Board deals with contagion and preventing the spread of animal diseases and not with the health and well-being of individual animals on farms, during transport, or at auctions, downed animal processors, stockyards, or slaughter houses (Dr. Bill Hartmann and Dr. Keith Friendshuh, Minnesota Board of Animal Health, personal communication, November 2000). Lack of disease or its symptoms are necessary for but are not the same as good health and well-being. This is an important gap related to the protection of farm animals in Minnesota.

Because it is largely the public that has raised concerns over animal welfare, and scientific study followed, the concerns presented in this paper are selected from issues raised by animal welfare organizations that are advocating reforms to contemporary animal farming practices.[11] The various concerns of these organizations are taken to be representative of the concerns of members of the broader public that are concerned with the welfare of farm animals.

Fraser, et al. (1997) note three overlapping ethical concerns expressed by the public over the quality of life of farm animals. These are:

1) Animals should lead natural lives through the development and use of their natural adaptations and capabilities;
2) animals should feel well by being free from prolonged and intense fear, pain, and other negative states and by experiencing normal pleasures; and
3) animals should function well in the sense of satisfactory health, growth and normal functioning of physiological and behavioral systems.

Most people profess concern about the well-being of farm animals. However, not all possess the scientific knowledge to act correctly on their concerns. Fraser, et al. (1997) note that the public looks to scientific research on the welfare of farm animals for guidance regarding its concerns and, for that reason, the conception of animal welfare used by scientists must relate closely to the public's ethical concerns if scientific work is to address them successfully.

[10] The Niman Ranch Pork Company, based in Iowa, sells meat from Midwestern pig farms subscribing to a humane protocol of the Animal Welfare Institute, Washington, DC.

[11] The concerns raised are not attributed to particular organizations. Overall, however, the concerns represented have been raised by organizations concerned with both animal welfare and animal rights, including: Animal Welfare Institute, Washington, DC; Animal Rights International, New York; Association of Veterinarians for Animal Rights; Compassion in World Farming, United Kingdom; Defending Farm Animals (in Minnesota); Food Animal Concerns Trust, Chicago; Farm Animal Care Trust (United Kingdom); Farm Sanctuary, New York; Humane PAC, Illinois; Humane Farming Association, California; Humane Society of the United States, Washington, DC; United Poultry Concerns, Inc., Virginia; People for the Ethical Treatment of Animals, Virginia; Swiss Society for the Protection of Animals; Dutch Society for the Protection of Animals; Universities Federation for Animal Welfare (Great Britain); Royal Society for the Prevention of Cruelty to Animals, and other member groups of the Eurogroup for Animal Welfare (Brussels) representing Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

As the basic biological and behavioral characteristics of an animal comprise the initial endowment of tools and resources the animal possesses for coping with its environment, a grounding in species-specific, natural behaviors and biology is important to understanding how farm animals experience different production systems. Much scientific research has gone into discovering farm animal needs and how they might be better met in livestock production. Adopting more natural alternatives to current practices is one way of preventing and mitigating negative effects on animal heath and well-being. These alternatives should be consistent with social goals for animal agriculture such as public health, food quality and safety, humane ethics, and environmental quality. Not all available alternatives meet all these objectives. Crooker, et al. (1999) described several known, very good alternatives to current practices in animal agriculture. This supplement will mention some additional systems and methods that could be explored further.

II. Plan of the Supplement to the University of Minnesota Literature Summary on Animal Agriculture – Health

Consideration of Questions 1, 4, and 5 is premature as long as there is an incomplete understanding of scientific aspects of animal welfare. Therefore, Part I (Chapters 1, 2, 3, and 4) provides a basic background in the scientific conceptualization of animal welfare and describes impacts of certain routine practices in animal agriculture on farm animals (questions 2 and 3).

Part II (Chapter 5, 6, and 7) deals more specifically with questions 2 and 3, relating them to farm animal species of social, economic, and environmental importance in Minnesota.

Crooker, et al. (1999) covered most issues in questions 1, 4, and 5. Part III of this report (Chapters 8, 9, and 10) will expand on existing laws and regulations in the US and abroad that affect the welfare of farm animals, discuss policy implications, and conclude with some recommendations regarding potential prevention and mitigation measures for addressing negative effects of common agricultural production practices on animal health and well-being.

Part IV concludes the report, Chapter 11 with a discussion of how animal welfare fits in with other GEIS Scoping Document topics such as environmental quality and human health and Chapter 12 with conclusions and recommendations.

This report does not cover welfare impacts of most infectious diseases or parasites, as these were well covered by Crooker, et al. (1999). It is a given that, by affecting the health of the animal, the presence of disease and parasites creates a poor welfare state in the animal and should be dealt with swiftly and humanely. Although evidence indicates that it is an urgent animal welfare concern (Eisnitz 1998, Warrick 2001), this report does not cover slaughter, as it relates specifically to farming practices.

References

Boehlje, M. (1995). Industrialization of agriculture: What are the consequences? *Industrialization of Heartland Agriculture: Challenges, opportunities, consequences, alternatives. Conference proceedings. Agricultural economics miscellaneous report No. 176.* Duncan, M. & Saxowsky,

D., eds. Fargo, ND: Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University.

Crooker, B., Halvorson, D., Moon, R., Phillips, C., Noll, S., Johnston, L., Reneau, J., Chester-Jones, H., Hathaway, M., Goyal, S., Janni, K., Pijoan, C., Shields, T., Stromberg, T., Patterson, C., Dee, S., Blaha, T., and Wells, S. (1999). A summary of the literature related to animal agriculture health. *Generic environmental impact statement on animal agriculture, State of Minnesota*. St. Paul, MN: Environmental Quality Board.

Eisnitz, G. (1998a). *Slaughterhouse*. Amherst, NY: Prometheus Books.

Fraser, D., Weary, D.M, Pajor, E.A., & Milligan, B.N. (1997). A scientific conception of animal welfare that reflects ethical concerns. *Animal Welfare, 6(3*): 187-205.

Kruip, Th.A.M. & van Reenen, C.G. (2000). Biotechnology of reproduction and farm animals welfare. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Minnesota Environmental Quality Board. (1998, December). *Scoping document: Generic Environmental Impact Statement on animal agriculture.* St. Paul, MN: State of Minnesota, Environmental Quality Board.

Swanson, J.C. & Mench, J.A. (2000). Animal welfare: Consumer viewpoints. U.C. Poultry Symposium and Egg Processing Workshops, Modesto, California (July 11, 2000) and Riverside, CA (August 11, 2000).

Vogel, S. (1995). Reaction to Michael Boehlje: "Industrialization of agriculture: What are the consequences?" *Industrialization of Heartland Agriculture: Challenges, opportunities, consequences, alternatives. Conference proceedings. Agricultural economics miscellaneous report No. 176.* Duncan, M. & Saxowsky, D., eds. Fargo, ND: Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University.

Warrick, J. (2001, April 10). 'They die piece by piece:' In overtaxed plants, humane treatment of animals is often a battle lost. *The Washington Post*, A1.

PART I

THE SCIENTIFIC CONCEPTUALIZATION OF ANIMAL WELFARE AND ITS APPLICATION TO FARM ANIMALS

The welfare of an individual is defined scientifically as its state as regards its attempts to cope with its environment (Broom 1988). Welfare is composed of the individual's health and well-being and reflects the quality of life that is lived by the individual. Animal welfare science draws on the fields of anatomy, neurophysiology, immunology, neuroendocrinology and other basic sciences. Animal welfare science, then, is on a higher, integrative level than any of these taken singly (Dr. P. Jensen, 2001, personal communication).

Part I provides the terminology and basic background to understand the issues raised in the discussions about specific livestock species in Part II. Chapters 1 and 2 discuss the scientific conceptualization of animal welfare, defining various terms and key concepts needed to follow a discussion about farm animal welfare. Chapter 3 associates these key concepts with specific practices in contemporary animal production to show general impacts of these routine practices on animal welfare. Chapter 4 discusses the animal welfare and human health implications of a specific routine practice listed in the Scoping Document (Minnesota Environmental Quality Board 1998) -- the use of antibiotics as animal feed additives.

References

Broom, D. (1988). The scientific assessment of animal welfare, in *Applied Animal Behaviour Science, 20 (1,2)*, 5-19.

Minnesota Environmental Quality Board. (1998, December). *Scoping document: Generic Environmental Impact Statement on Animal Agriculture.* St. Paul, MN: State of Minnesota, Environmental Quality Board.

CHAPTER 1

DOES A SCIENTIFIC CONSENSUS EXIST ON THE MEANING OF ANIMAL WELFARE AND DOES ANIMAL WELFARE HAVE A PLACE IN A GEIS ON ANIMAL AGRICULTURE IN MINNESOTA?

During the process of preparing this technical working paper, two issues arose and this chapter will answer them as a way of introducing the rest of the report. These issues are: I. Is there a scientific consensus as to the meaning of animal welfare? and II. Is there any place for animal welfare in a generic environmental impact statement on animal agriculture in Minnesota?

I. Does a consensus exist on animal welfare?

A. The Domain of Animal Welfare Science

Citing the 1997 Council on Agricultural Science and Technology report *The Well-Being of Agricultural Animals*" (Curtis and Baker 1997), Crooker, et al. 1999 argue that there is a "lack of consensus in the scientific community as to the meaning of animal welfare that renders attempts to improve the lives of farm animals difficult and confusing." However, among scientists who are specifically qualified in the discipline of animal welfare, there is a strong underlying commonality to their expressions concerning animal welfare.

The concept of health can serve as an analogy. "Welfare," like "health," is a complex concept involving many factors and variables. Different medical scientists may differ in which variables or factors they emphasize or consider most important, but that does not prevent them from conducting meaningful research to identify and rectify health problems (Dr. D. Fraser, 2001, personal communication). Similarly, the different emphases that animal welfare scientists place on various aspects of welfare are more complementary to and supplementary of each other than they are contradictory to each other. And if scientists may describe different aspects of animal welfare differently because of the different reference points from which they view animal welfare, it in no way implies that animal welfare itself is immaterial or that they disagree about the concept itself.

A vast scientific literature on farm animal welfare has developed since at least the 1960s, with ethology being one of the leading disciplines. Today, there are a number of scientific journals dealing specifically with animal welfare, including *Animal Welfare* (Universities Federation for Animal Welfare, publisher) and *Journal of Applied Animal Welfare Science* (Lawrence Erlbaum Associates, Inc., publisher). Other journals whose subject matter encompasses animal welfare include *Applied Animal Behaviour Science* and *Livestock Production Science* (Elsevier Science, B.V.).

Early studies in ethology concerned observations of animals in the wild. (A contemporary example is Dr. Jane Goodall's behavioral research on chimpanzees.) In 1962, Hafez published the first "compendium" of studies on the genetic origins, ontogeny, patterns and mechanisms of behavior in domestic (farm) animals (Hafez 1962).

The interest in farm animal behavior science was reinforced by the report of the Brambell Committee in 1965. The Brambell Committee was a scientific committee made up primarily of zoologists that was assigned by the British government to look into "the welfare of animals kept under intensive livestock husbandry systems" (Brambell 1965 (reprinted 1974)). The appointment of the Brambell Committee was in direct response to concerns that arose out of the public outcry caused by publication of Ruth Harrison's (1964) book *Animal Machines: An Exposé of the New Factory Farming Industry*. Following a year's study of farming systems in Europe, the Brambell Committee reported that, indeed, intensively farmed animals were living in conditions detrimental to their welfare. It recommended that production systems should allow animals at least these five basic freedoms:

1) to turn around;
2) to groom themselves;
3) to get up;
4) to lie down; and
5) to stretch their limbs.

The Committee noted the existence of a large number of intensive farms on which performance of even these basic behaviors was impossible and then it took a significant further step by stating that it "[i]n principle, disapproved of a degree of confinement which necessarily frustrates most of the major activities which make up an animal's behaviour." The Committee clearly specified that

> the evaluation of **welfare** must consider the scientific evidence available concerning the **feelings** of animals that can be derived from their **structure** and **functions** and also from their **behaviour**.

The Brambell Report was followed by the formation of the Society for Veterinary Ethology (now the International Society for Applied Ethology) in 1966. The Society provides a forum for scientific study of animal welfare. Since these events, animal welfare science has grown into a distinct discipline. Underlying this new discipline is the recognition that the observed behaviors of farm animals can tell us about their underlying physiological and mental conditions/states and about the nature of their experiences in the environment, including whether they are in harmony with their environment, are maladapted, and/or are suffering. Because behaviors are often accompanied by underlying neuroendocrine changes, neuroendocrine analysis is an important companion science to ethology in the study of animal welfare (Dantzer 1993, Dantzer, Mormède and Henry 1983a,b). Assessment of welfare includes criteria from anatomy, neurophysiology, immunology, neuroendocrinology and other basic sciences. Therefore, animal welfare science is on a higher, integrative level (Dr. P. Jensen, December 2000, personal communication).

Prior to 1965, there also was scientific work on the welfare of farm animals. The Universities Federation for Animal Welfare (UFAW) was formed in 1938 out of the University of London Animal Welfare Society, which was devoted to all animals. While an early topic of UFAW work was laboratory animal welfare, it became involved in farm animal welfare and, in 1965, submitted evidence to the Brambell committee (UFAW 1988).

Between 1977 and 1979, a committee was convened by the Reverend Edward Carpenter in the United Kingdom, to look into the ethics of concentrated animal production. The committee's membership included Mrs. Harrison, other members of the original Brambell Committee, and other British citizens. This committee's report *Animals and Ethics* was published in 1980 (Carpenter 1980). In the report, the committee elaborated on the original five freedoms of the Brambell

Committee report. "The welfare of managed animals," the committee stated, "relates to the degree to which they can adapt without suffering to the environments designated by man. So long as a species remains within the limits of the environmental range to which it can adapt, its well-being is assured."

The basic guidelines elaborated by the Carpenter committee were "that no husbandry method will deny the environmental requirements of the basic behavioural needs of the animals," including:

1) freedom to perform natural physical movement;
2) association with other animals, where appropriate of their own kind;
3) facilities for comfort activities, e.g., rest, sleep and body care;
4) provision of food and water to maintain full health;
5) ability to perform daily routines of natural activities;
6) opportunity for activities of exploration and play, especially for young animals; and
7) satisfaction of minimal spatial and territorial requirements including a visual field and 'personal' space.

Some years later, the United Kingdom's Farm Animal Welfare Council (a government body) condensed these criteria into a new statement of five freedoms that included (Webster 1995):

1) freedom from thirst, hunger, and malnutrition;
2) freedom from discomfort;
3) freedom from pain, injury, and disease;
4) freedom to express normal behavior;
5) freedom from fear and distress.

Freedom one was to be assured by providing ready access to fresh water and a diet to maintain full health and vigor. Freedom two was to be assured by providing a suitable environment including shelter and a comfortable resting area. Freedom three was to be assured by prevention or by rapid diagnosis and treatment of disease and injury. Freedom four was to be assured by providing sufficient space, proper facilities and company of the animal's own kind. Freedom five was to be assured by ensuring conditions that avoid mental suffering.

The two committees (Carpenter and FAWC) differed in their expression of the needs of farm animals only in that the Carpenter committee also emphasized "positive" welfare – that is, not simply absence of suffering or disease but opportunities for play and exploration, the possibility of experiencing pleasure, not merely some "neutral" state wherein the animal was not suffering.

Some of the first scientific studies of the impacts of the production environment on the welfare of farm animals came out of Sweden. These studies resulted directly from concerns felt by veterinarians and farmers about the welfare impacts of the industrialization of farming through the introduction of labor-saving techniques (such as slatted floors) on the incidence of trampled teats and mastitis in dairy cattle (Ekesbo 1966), on sow welfare and piglet production (Backström 1973), and on grow-to-finish hogs as indicated by daily weight gain and pathological lesions in the carcass at slaughter (Lindqvist 1974).

These studies were different from previous animal health research in that they concerned, not the incidence of epizootic diseases, but the incidence of so-called "manmade diseases" – diseases resulting directly from changes in the ways in which animals were artificially selected

and housed and in the ways their environments were managed by humans (Ekesbo 1992).[12] A field of study known as animal hygiene arose that particularly focuses on these "manmade diseases" and an International Society for Animal Hygiene was formed. Animal hygiene is "the science regarding the influence on animal health and disease by factors in the animal environment and measures taken with such factors in order to promote health and to prevent disease" (Ekesbo 1992). Hygiene is a critical factor in the prevention of disease and the maintenance of high standards of animal welfare. The two fields are highly related and complementary of each other.

As animal welfare science progresses, its practitioners continue to learn about how these objectives can be met by management and environmental design. However, much has already been learned about the biological and behavioral characteristics of farm animals and this knowledge can be used now to relieve them of the pain, distress, and boredom associated with many contemporary production practices. Swedish animal production methods, for example, stress the need to fit production systems to the animals rather than fitting animals into production systems that are designed with only human convenience in mind. There is enough solid scientific information available now regarding animal biology and behavior to design production environments that meet most of farm animals' biological and behavioral needs and also provide a higher level of functioning and welfare than is generally provided in today's livestock industry.

B. A Consensus Position on Animal Welfare

The degree to which a consensus exists among animal welfare scientists on a scientific conceptualization of animal welfare was tested recently in a study conducted at Wageningen Agricultural University and Research Center, the Netherlands (Anonymous 2001). Scientists there used a Delphi technique to "poll" animal welfare scientists in Europe and Canada on a conceptual framework for welfare assessment and its implications for priority welfare issues in cattle, pig, and poultry production.

Participation by the scientists in the Wageningen study was anonymous (they did not know who their counterparts were). Over the course of the study, these scientists demonstrated consensus on welfare from a broad spectrum of scientific specializations in applied ethology, stress-physiology, psychology and veterinary science. They identified natural selection and domestication as processes that have equipped animals with a number of behavioral and physiological control systems, including cognitive and emotional mechanisms enabling them to deal with changes in their environment. They agreed that welfare is reduced when animals cannot maintain discrepancies between actual states of their environment and the states they 'desire' within acceptable limits by making appropriate behavioral and physiological responses.

Participating scientists accepted that there are no major welfare problems when there is minimum mortality, low morbidity, little or no risk of injury, good body condition (sustaining adequate production and reproduction), the ability to perform species-specific activities (including social interactions, exploration and play), and the absence of abnormal behaviors and physiological signs of stress, including suppression of immune responses. Even though it is not yet fully understood which types of emotions animals have or how these relate to human emotions, participants agreed that animals can suffer from pain, hunger, anxiety, etc., and can also experience pleasure, e.g. when playing or when obtaining a reward.

[12] An analogy could be made to occupational safety and health concerns that burgeoned following the industrial revolution and continue to the present and the rise of occupational medicine.

The conceptual framework resulting from the consensus study was used to support the formulation of priority issues in relation to performance criteria, design criteria and housing systems. Amount and quality of space (including appropriate subdivision into functional areas), social conditions (e.g. provision of social contact and protection from aggression), and the provision of suitable substrates (enrichment) were listed as primary design criteria for animal welfare. The conceptual framework for farm animal welfare as described in Anonymous (2001) bears strong similarities to that described a decade ago in Halverson (1991). The two studies – Anonymous (2001) and Halverson (1991) -- were conducted independently of each other and by two distinct approaches – respectively, the Delphi technique of interviewing selected experts and a literature review combined with informal personal communications with experts. The similarities of the interpretations further support the position that consensus does exist, at least among animal welfare scientists, regarding the scientific definition and assessment of farm animal welfare.

II. Does Farm Animal Welfare Have a Place in a GEIS on Animal Agriculture in Minnesota?

As the questions in the Scoping Document for the GEIS illustrate, environmental impact statements cover a range of social and environmental issues associated with a particular project that affect human life. Animal welfare is one of these issues, as recognized in the Scoping Document's questions regarding animal health and well-being. As defined in the next chapter, the welfare of an individual is its "state as regards its attempts to cope with its environment" (Broom 1988). The welfare of an individual is comprised of its health and well-being, including both physical and psychological health.

Farm animals, obviously, have a prominent place in *animal agriculture*. As living organisms, their capabilities and characteristics are exploited in agriculture and their existence has impacts on humans and the natural environment. Farm animals have functions in the agro-ecosystem as producers (of products and offspring), as nutrient cyclers (taking water and food from the soil and returning fertilizers), and as final products (animals reared for meat and as replacement breeding stock) (Baker, et al. 1990, Beauchamp 1990).

Contemporary agricultural practices and veterinary health objectives focus heavily on maintaining and enhancing animal performance, placing primary importance on the function served by the animal in the agricultural system rather than on its state. The result is that most animal science research centers on modifications to the animal to enhance the animals' functions, ignoring what those modifications do to the animal as a whole (e.g., chronic hunger in broiler breeder hens resulting from genetic selection for fast growth combined with restricted feeding programs to prevent the obesity that would occur if they were allowed to eat *ad libitum* (at will), p. 95). Function and state are not equivalent. As shown in the following chapters, when function alone is emphasized, the imbalance has important effects, not only on farm animal welfare, but on the environment and human health; hence, animal welfare is not only a legitimate element of a Generic Environmental Impact Statement on Animal Agriculture, but is an integral one.

Welfare reflects the state of the animal and in subsequent chapters it is shown that productive performance alone cannot be a necessary and sufficient indicator of welfare. There are many ways to enhance productive performance at the expense of animal welfare and to sustain performance by compensating for poor welfare under bad production practices (from the

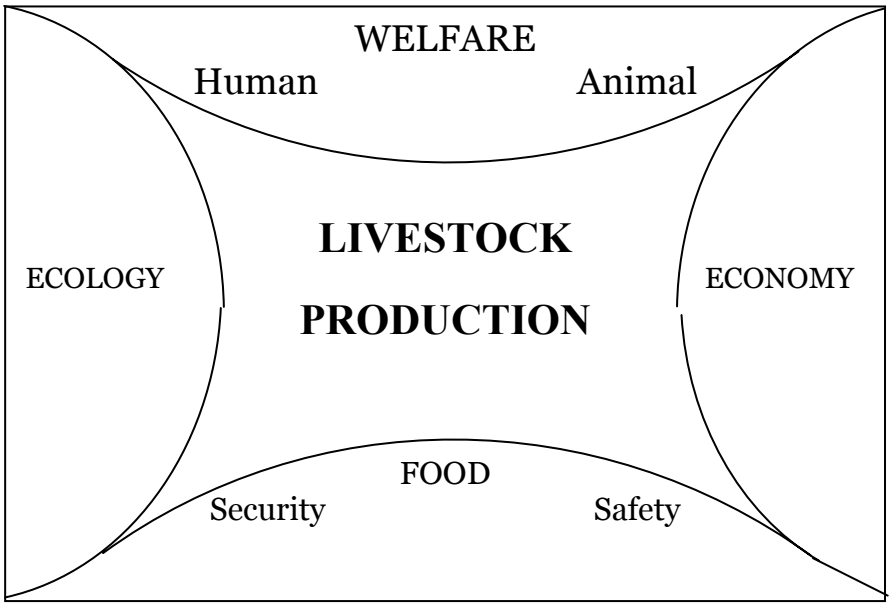
animals' standpoint) rather than supporting it by improving production systems. Many of these enhancements and compensations, such as subtherapeutic use of antibiotics in animal feed to promote growth and control disease, as well as many other routine practices in animal agriculture, have impacts on humans and the environment.

A further reason for including farm animal welfare in this GEIS on animal agriculture relates to the role of trade in Minnesota's future. This year, the EU is committed to bringing farm animal welfare to the World Trade Organization (WTO), strengthened in its commitment by the devastating social, animal welfare, and economic effects of this spring's foot and mouth disease epidemic. For cooperative work on an issue over which parties have disagreement to be fruitful, the parties must share at least a common awareness of the basic principles underlying the issue (be on the same page). The European Community, through its Scientific Veterinary and Animal Welfare Committees and the Council of Europe Standing Committee on Farm Animal Welfare, has benefited from decades of sound and apolitical scientific and technical input into policymaking on farm animal welfare. In the US, a comparable level and caliber of input have been missing and, consequently, policymakers may have had little opportunity to form an appreciation of the issue's scientific and (fully-realized) economic aspects or of the basic conceptual framework within which the Europeans are operating. A basic scientific conceptualization and economic discussion of animal welfare are presented in this report.

III. Sustainable Models of Agriculture that Include the Welfare of Farm Animals

An agricultural system is multifunctional in the sense that it provides people with nutrition and a wide range of other benefits and amenities (landscape, for example). To be sustainable, its parts must function in cooperation with each other and not at each other's expense. This integrated nature of a sustainable agricultural system is shown in the following model from the Silsoe Institute in Bedford, UK (Figure 1-1).

Figure 1-1. Elements of sustainable livestock farming. Silsoe Research Institute (presented at 8th International Congress on Animal Hygiene, International Society for Animal Hygiene, September 12-16, 1994, St. Paul, MN: University of Minnesota and Washington State University, cosponsors).

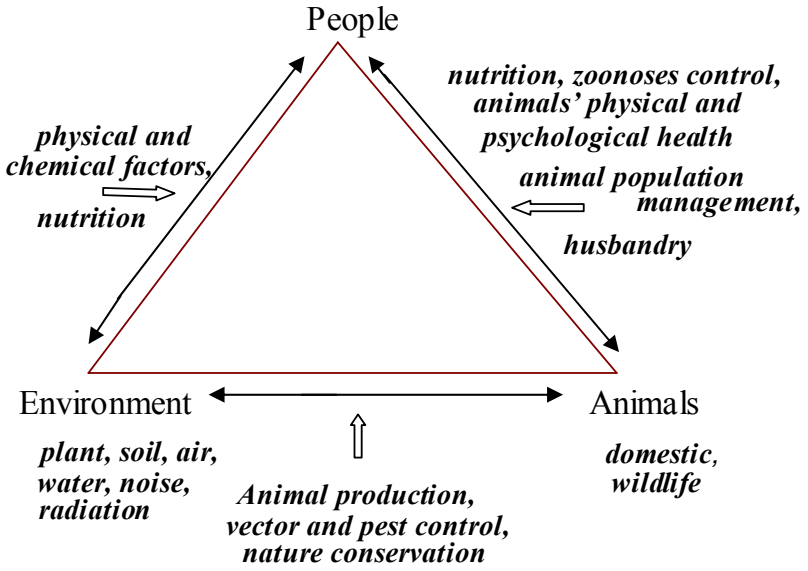


In a sustainable agricultural system, food is both secure and safe, the welfare of both humans and animals is safeguarded, and economy depends on including ecology or the requirements of natural systems in the calculus.

A similar conceptualization underlies the model in Figure 1-2, from the World Health Organization, Veterinary Public Health Division, designed to illustrate the interdependency and reciprocity between systems required to sustain the life and health of the planet.

The environment and animals (both domesticated and wild) form the base of the pyramid because healthy human life depends upon how well humans help to sustain the health of animals (including their psychological health) and to preserve the capability of the environment to support health and life (Dr. K. Bögel, ret. Chief, VPH, WHO, Geneva, 1992, personal communication; Kaplan and Bögel 1993).

Figure 1-2. The Health Triad. Structure, function, interaction: Components of sustainable systems. (Veterinary Public Health Division, World Health Organization, Geneva, Switzerland).



In the Kaplan-Bögel (WHO-VPH) model, the human and animal environment is comprised of plants, air, water, soil, noise, and radiation. Humans are affected by and have responsibilities toward the environment and animals. The responsibilities of humans to animals include population management, husbandry—maintaining both animals' psychological and physical health, and controlling spread of zoonoses (human-animal diseases). How humans manage these responsibilities determines how animals and the environment affect human welfare and whether or not the *system* is sustainable.

Under this model, farm animal welfare, as defined in subsequent chapters and encompassing not only performance criteria (which as later chapters show is not the same as welfare) but also the parameters required to ensure the physical and mental well-being of agricultural animals, can be perceived as a bridging concept between animal health and human health. Hence, animal welfare is highly relevant to a Generic Environmental Impact Statement on Animal Agriculture, along with environmental quality, social, and other GEIS concerns.

References

Anonymous. (2001). Scientists' assessment of the impact of housing and management on animal welfare. Version 8, 5/24/2000. Accepted for publication, *Journal of Applied Animal Welfare Science*.

Backström, L. (1973). Environment and animal health in piglet production: A field study of incidences and correlations. *Acta Veterinaria Scandinavica. Supplementum 41,* 1-240.

Baker, F.H., Busby, F.E., Raun, N.S., & Yazman, J.A. (1990, December). The relationships and roles of animals in sustainable agriculture and on sustainable farms. *The Professional Animal Scientist, 6 (3),* 36-49.

Beauchamp, E.G. (1990, December) Animals and soil sustainability. *Journal of Agricultural Ethics*.

Brambell, F.W.R., Chm. (1974). *Report of the technical committee to inquire into the welfare of animals kept under intensive livestock husbandry systems (December, 1965).* (Reprinted 1974). London: Her Majesty's Stationery Office.

Broom, D. (1988). The scientific assessment of animal welfare, in *Applied Animal Behaviour Science, 20 (1,2),* 5-19.

Carpenter, E. (1980). *Animals and ethics*. London: Watkins.

Crooker, B., Halvorson, D., Moon, R., Phillips, C., Noll, S., Johnston, L., Reneau, J., Chester-Jones, H., Hathaway, M., Goyal, S., Janni, K., Pijoan, C., Shields, T., Stromberg, T., Patterson, C., Dee, S., Blaha, T., and Wells, S. (1999). A summary of the literature related to animal agriculture health. *Generic environmental impact statement on animal agriculture, State of Minnesota*. St. Paul, MN: Environmental Quality Board.

Curtis, S.E. & Baker, F. (1997). *The Well-Being of Agricultural Animals.* CAST Report No. 130, Council for Agricultural Science and Technology. 1997.

Dantzer, R. (1993). Research perspectives in farm animal welfare: The concept of stress. *Journal of Agricultural & Environmental Ethics,* 6, *Supplement 2,* 86-92.

Dantzer, R., Mormède, P., & Henry, J. P. (1983a). Physiological assessment of adaptation in farm animals. *Farm animal housing and welfare*. Baxter, S.H., Baxter, M.R., & J.A.D. MacCormack, J.A.D., (Eds.). Boston: Martinus Nijhoff Publishers.

Dantzer, R., P. Mormède & Henry, J.P. (1983b). Significance of physiological criteria in assessing animal welfare, in *Indicators Relevant to Farm Animal Welfare: A Seminar in the CEC Program of Coordination of Research on Animal Welfare, November 9-10, 1982*. Smidt, D. (Ed.) Boston: Martinus Nijhoff Publishers.

Ekesbo, I. (1992). Monitoring systems using clinical, subclinical and behavioural records for improving health and welfare. In *Livestock health and welfare*, Moss, R., ed. Essex, England: Longman Scientific and Technical, Longman Group UK Limited, 20-50.

Ekesbo, I. (1966). Disease incidence in tied and loose housed dairy cattle and causes of this incidence variation with particular reference to the cowshed type. *Acta Agriculturæ Scandinavica, Supplementum 15.*

Hafez, E.S.E., ed. (1962). *The behaviour of domestic animals.* London: Baillière Tindall & Cox.

Halverson, M. (1991). *Farm animal welfare: Crisis or opportunity for agriculture?* Staff Paper P1-91. St. Paul: Department of Applied Economics, University of Minnesota. On the internet at http://agecon.lib.umn.edu/mn/p91-01.pdf

Harrison, R. (1964). *Animal machines: The new factory farming industry.* London: Vincent Stuart Ltd.

Kaplan, M. M. & Bögel, K. (1991). Systems approaches for animal and environmental health and consumer protection. (pp. 157-165) Selected Proceedings of the XXIV World Veterinary Congress.

Lindqvist, J.O. (1974). Animal health and environment in the production of fattening pigs: A study of disease incidence in relation to certain environmental factors, daily weight gain and carcass classification. *Acta Veterinaria Scandinavica, Supplementum 51*, 1-78.

UFAW. (1988). *Management and welfare of farm animals: The UFAW handbook*. 3rd edition. Universities Federation For Animal Welfare. London: Baillière Tindall.

Webster, J. (1995). *Animal welfare: A cool eye towards Eden*. Cambridge: Blackwell Science, Ltd.

CHAPTER 2

OVERVIEW AND EXPLANATION OF WELFARE-RELATED TERMS AND CONCEPTS

I. Terminology and Concepts -- What Animal Welfare Is and Is Not

An individual's **welfare** is defined to be its state as regards its attempts to cope with its **environment** (Broom 1988). An *ideal* level of animal welfare is "a state of **complete physical** and **mental health** in which the animal is in **harmony** with its **environment**" (Wood-Gush 1983, also Hughes, cited in Kilgour 1984).

Taken together, the two critical components of welfare – physical health and mental or psychological health of the animal -- define the "**quality of life**" or level of welfare the animal experiences.

The **environment** of the farm animal is defined broadly to include air quality, temperature, feeding, injections, infections, floor type, number of companions in a given area, water quality, and means of confinement (Siegel 1974). Seabrook (1980), Hemsworth, et al. (1981a&b, 1986, 1987, 1989), Hemsworth and Barnett (1987) and others include relationships with the human caretakers or handlers as important components of the animal's surroundings.

Welfare encompasses both **health** and **well-being** and these are conceptualized as being for the animal's sake, not simply for the sake of productive efficiency.

Health is not merely the absence of disease or injury but the presence of robust characteristics, that is, the animal's ability to cope with the environment. It means that skeletomuscular, cardiovascular, neuroendocrine, immune, etc. systems are operating at optimal capacity. The word 'optimal' implies balance among the animal's regulatory systems to achieve equilibrium at a high welfare level in the animal **(homeostasis)** (Broom and Johnson 1993, p. 8).

Well-being can be thought of as the individual's subjective perception of its state -- how it feels about its welfare or its state as regards its attempts to cope with the environment. How the animal feels affects its mental health and potentially its physical health as well.

Homeostasis is an "approximately constant state which varies only within tolerable limits" (Broom and Johnson 1993, p. 8). "At every instant of an animal's life, …adjustment of function is required so that the state of the body remains stable…. Most alterations in the environment and the stimuli which result from them elicit appropriate responses [from the animal], and homeostasis is maintained." Homeostasis is essential for good welfare -- physiological and mental health -- of the organism. Selye (1973a) referred to Claude Bernard's description of the internal medium of the living organism as more than a vehicle for carrying nourishment to cells: "It is the fixity of the 'milieu intérieur' which is the condition of free and independent life."

The term **coping** refers to the strategies that are used to handle **stress**, from problem-focused coping (attempts to alter the situation) to emotion-focused coping (attempts to control the emotion elicited by the situation) (Dantzer 1993).

An animal's welfare can be determined by assessing behavioural (psychological) and physiological (vigor, neuroendocrine response, etc.) indicators. In the course of its daily life, the animal responds to challenges with a range of responses, both behavioural and physiological. In some cases, adaptive physiological measures are not sufficient to achieve the animal's ends and in these cases, "new defence mechanisms are initiated, collectively referred to as stress responses" (Mormède 2000).

Selye (1936) identified a General Adaptation Syndrome (GAS), describing the reaction of laboratory animals to factors in the environment that caused **stress.** The GAS consisted of the alarm reaction, the stage of resistance, and the stage of exhaustion. He suggested that stress was the biological consequence of exposure to adverse environments, while the procedures of responding to factors in the environment that caused stress (**stressors**) were **stress responses** (Selye 1975).

In Selye's (1973a) conceptualization, when faced with stressful situations that required systemic adaptation, the organism could respond through three distinct mechanisms: nervous – by conscious planning of defense, innate or conditioned reflexes, and autonomic 'emergency reactions' partly mediated through neurohormones; immunologic and phagocytic – antibody formation, activation of the reticuloendothelial system; and hormonal – e.g., through hormones (e.g., glucocorticoids) that permit tolerance of the stressor without attacking it (Selye 1973a).

Subsequent research revealed a need to make Selye's conceptualizations more precise and useful for forming theoretical arguments (Broom and Johnson 1993). Broom and Johnson (1993) suggest differentiating between "stress," which should be avoided, and "stimulation," which is an integral part of life and cannot be avoided. For the purposes of this paper, the word stress is used with this connotation of Broom and Johnson (1993).

Broom and Johnson (1993) refer to stress as 'stimulation beyond the capacity for complete adaptation.' If adaptation to the environment is not immediately possible because the stimuli are excessive in intensity or duration, or noxious, or novel and hence no system yet exists for coping with them, inadequacy of the regulatory systems then leads to a "displacement of state outside the tolerable range." The animal's attempts to adapt to its environment are inadequate, and injury, poor health, suffering or reduced survival chances will result" (Broom and Johnson, p. 8). Consistent with this view is Moberg's (1985) suggestion that stress is a "pre-pathological state" in which the effects of the environment are to predispose the animal to development of a pathological state. The prepathological state is recognizable by abnormalities and inadequacies in behavior, physiology, immune system function, and reproduction.

Scientific understanding "that part of the stress response was the result of the emotional arousal elicited by environmental stimulations" expanded the study of stress from the physiological to psychophysiological arena (Mormède 2000). New concepts inherited from psychology were integrated into the study of stress responses, including coping that refers to the ability of the individual to control its environment and temperament that encompasses the individual variability of emotional processes. The role of the brain and central nervous system in adaptation/stress mechanisms was recognized. The central nervous system collects from the external (via sensory organs) and internal environment the information necessary for the organism (the animal) to maintain homeostasis; it gives significance to this information in terms of danger or threat, as related to personal expectations, past experience and opportunities for

control; finally, it initiates the adaptive responses, including behavioural adjustments, and neuroendocrine changes to meet the energy requirements for the behavioural response and to maintain homeostasis.

There is no single stress response but rather a wide range of physiological and other changes that usually are specific to circumstances (Broom and Johnson 1993). As well, **adrenal hormones** released in the resistive stage of adaptation also are released in response to situations that are not normally thought of as causing stress: e.g., **glucocorticoids** are released during courtship.

The most frequently used test for stress (because it is the easiest for scientists to administer) – is to take measures of circulating corticosteroid levels. Mormède (2000) cautions that this alone is not a reliable indicator. Corticosteroid levels rise even in "pleasurable" emotional stimulation, confusing the meaning of results from these tests when used alone. Corticosteroid levels also respond to non-welfare factors such as time of day. There is also experimental evidence that plasma corticosteroid levels and catecholamines secretion are strongly influenced by the feeding regimen, although this aspect has not been investigated in great detail in farm animals. It is therefore important to be able to sort out the various influences impinging upon the physiological systems under study, since physiological adjustments and psychobiological influences are usually intermingled in the global stress response measured by circulating stress hormone levels (Mormède 2000).

Species differences also exist such that stimuli that elicit an adrenal response in one species cause little or no effect in others. For these reasons, single adrenal indices are questionable indicators of stress. Mormède (2000) stressed the need to take a multifactorial approach, even within neuroendocrine analysis, to the study of welfare – e.g., measuring other hormones besides blood cortisol to get a truly reliable determination of the animal's state.

Typical physical and psychological stressors in the livestock environment are thermal (heat, cold) stress, crowding, isolation, mixing, weaning, limit-feeding, noise, restraint, frustration, fear, maintaining social hierarchies, and separation of neonatal animals from their mothers, all of which have been shown to alter the immune system in animals (Kelley 1980). To this list Wemelsfelder (1983) added boredom as a stressor. The influence of the stockperson is also significant (for a review of the literature on the human factor, see Lund 1999). In all species, a variety of biological disturbances can increase susceptibility to disease (Broom and Johnson 1993).

"When, by using behavioral or physiological adjustments or both, an animal is able to cope with environmental conditions, it is said to have **adapted**" (Broom and Johnson 1993).

The animal's basic, inherited, biological and behavioral patterns or characteristics (its genotype) comprise the initial endowment of tools and resources of the animal for coping with its environment. (Genotype refers to the actual genes the animal possesses and that it passes on to the next generation; phenotype is the appearance or traits displayed by the animal).

Ecology is the study of living things in relation to their environment. In general, ecology refers to the study of populations or species in relation to their environments rather than to the study of individuals and their environments. **Behavioral ecology** is the study of how animal behavior contributes to survival and reproduction of the individual and the species. It is about the survival value of behavior (Krebs and Davies 1981). Behavioral ecology forms one of the theoretical contexts for **ethology** (Dr. P. Jensen, 1992, personal communication). **Ethology** is the study of the behavior of individuals in relation to their natural environments, which is a discipline fundamental to

the study of welfare. Ethological studies are applied to animals and to people as well (e.g., Callan 1970).

The genetic background, the environment, and the interplay of heredity and environment result in the phenotypic expression of a behavior (Siegel 1975). The traits manifested by an individual animal, therefore, will be the product of a combination of genotype and experience or learning. The importance of studying the **species-specific** behaviors and biology of domesticated animals to understand how they respond to confinement is illustrated by the fact that different animal species respond differently to living in different population densities. What may be experienced as "crowding" by one species may be acceptable to another.

Two key words in the definition of welfare are **individual** and **state**. First, welfare is something experienced by the individual rather than by a herd or population. Thus, while measures of herd health can be excellent indicators of the overall herd condition, it is still possible for individuals in the herd to exist in a condition of poor welfare. Individual welfare is a higher standard than herd health because each and every animal in the herd must be experiencing it. Second, welfare is a **state** of the animal. The study of animal welfare recognizes that animals experience a **welfare status**, that is, a state of being (good or poor or in between) resulting from their interactions with their environments. This state of the individual is something apart from the **function** it performs (i.e., different from its role or purpose) in the agricultural system.

As noted above, contemporary agricultural practices and veterinary health objectives focus heavily on maintaining and enhancing animal performance, placing primary importance on the **function** served by the animal rather than its **state**.

As Dantzer (1992) noted, "reproduction and health have been the main disciplines of interest in the field of animal sciences. Behavioral studies were carried out only in relation to those disciplines. The aim was to optimize those behavioral patterns that contributed positively to productivity (food intake, reproductive behavior) and to get rid of those behavioral patterns that were perceived as counterproductive (exploratory behavior, social activities)."

Animal welfare science thus differs from **animal production science** in several ways. Three differences are, first, that the emphasis of animal welfare science is on health and well-being for the animal's sake, from the perspective of the animal, rather than to achieve some production (or profit) maximum or cost minimum to the industry (Dawkins 1990); second, that "unlike many other scientific specialties, the field of animal welfare science owes its existence … to ethical concerns extant in society" (Fraser, et al. 1997); and, third, that animal welfare science is distinguished by its emphasis on the "whole" of the animal rather than the functioning of its separate parts. Further, although poor production can sometimes be an indicator of poor welfare; high production levels do not necessarily imply a good welfare state. As will be discussed, high production levels may lead to poor welfare.

Fraser, et al. (1997) describe animal welfare as a "bridging concept" that links scientific research to the ethical concerns the research is intended to address. The concept of animal welfare used by animal welfare scientists needs to be amenable to scientific study while relating to (and directing scientific research toward) the relevant ethical issues. In a similar way, we can say that the concept of animal production relates to (and directs scientific research toward) the relevant output-maximizing and production cost-minimizing issues.

It is true that welfare is important for functioning, but in many cases animals can continue to produce while in a state of poor welfare. Moreover, as will be discussed later, "high-yield" or

superior production often is attained at the expense of the animal's broader welfare and in that sense can be said to be incompatible with welfare. Animals are genetically programmed to produce. Except under severest deprivation, they cannot help but do so. Animals have the ability to adapt to a significant degree to their environments, including painful or stressful ones, although the adaptation may be accompanied by severe stress (Vestergaard 1981b, Van Putten 1988, others). Growth rate may also correlate positively with stressors in the environment (Friend, et al. 1987). Grandin (Dr. T. Grandin, 1990, personal communication) has noted that rats with pinched tails grow faster than rats whose tails are not pinched.[13] Also, antibiotic and hormonal growth promoters augment performance in contemporary animal production and reproduction often is regulated or induced by administration of hormones, further confounding the usefulness of productivity as an indicator of welfare.

Quantitative production performance can ***only*** signify that quality and quantity of nutrients, the water supply, and the microclimate are adequate; that the animal did not contract any clinically-proved illnesses which influenced production yield; and that there are possible genetic differences between animals (Bogner 1981). It can be no criterion as to whether the environmental requirements of the animals concerning locomotion, resting, comfort, social behavior, predictability, and control are met or not. Each of these affects the mental or psychological health of the individual animal.

Animals' efforts to adjust to stressful conditions may result in less energy being spent in other important functions, for example, may lower resistance to disease (Curtis 1981). But with the availability of antibiotic feed additives to agriculture at relatively low cost, and if the investment in current facilities is high, so that welfare improvements would be costly, the productivity effects may not be serious enough to require a producer to invest, for economic reasons alone, in facilities improvements, even though such improvements may result in a higher welfare for the animals (Halverson 1991).

The term **animal care** has been used as a "politically-sensitive" substitute for the term animal welfare. However, welfare is not the same as care. Care is something done to or for the animal. In combination with other environmental factors, human management (care) and husbandry of animals are important determinants (for better or worse) of the welfare status of animals being used by humans. However, they are not equivalent to animal welfare. Welfare is a condition of the animal, itself. Therefore, the scientifically preferred term is animal welfare.

Animal behavior also has been used mistakenly as a synonym for animal welfare. Behavior, however, is not equivalent to welfare. Behavior is something the animal does to influence or control its environment. When natural behaviors that are important to the animal such as walking, exploration, foraging, social interactions, dustbathing (important for grooming the feathers), or nest-building are thwarted to a significant degree they can give rise to stress which can lead to abnormal behaviors. The incidence of tail-biting among pigs can be increased by various deficiencies in the environment. Horses confined to stalls may exhibit weaving and cribbing (or repetitive crib-biting). Substituting "animal behavior" for "animal welfare" is also misleading because it ignores the important role of the neuroendocrine and other systems in the maintenance of welfare. Abnormal behaviors are often accompanied by underlying neuroendocrine changes that indicate a stress response and hence are indicators of welfare (Dantzer, Mormède, and Henry 1983b, Dantzer 1993).

[13] BESCORP of Morris Plains, New Jersey, last year announced production of an Animal Behavior Modifier (ABM)® or device engineered to enhance weight gain of beef cattle and milk production of dairy cattle "based on a well-established, scientific, "tail pinch' principle that the application of mild, non-painful pressure to the tail of an animal will result in enhanced eating and other motivated behaviors leading to increased efficiencies in food animal products." (PRNewswire, May 24, 2000).

Animals have needs in common with animals of other species -- food, water, shelter, social interaction, reproduction, the possibility to perform self-maintenance behaviors (grooming and resting, for example), predictability, and control -- and they have needs that are species-specific, being dependent on the genetic history of the species, its body structure and function, changes wrought by artificial selection, and motivation.

It is not necessary from the welfare perspective to include in the production environment the possibility to perform all behaviors of which animals are capable. But many behaviors animals will try to perform even though the key stimuli are not provided in the production environment. A peri-parturient sow is strongly influenced by hormonal changes to seek out a nest site and materials with which to build a nest for farrowing (Jensen 1986, Arey 1995, 1997, Arey, et al. 1991, 1992a,b, Castrén, et al. 1993). Her welfare is reduced when she is deprived of the ability to do so (elaborated below). A sow confined to a farrowing crate will be agitated and paw and root at the bottom of her crate around farrowing even if there are no nesting materials and she is unable to leave her crate to find a nest site (and even though we thoughtfully provide her with our version of a nest).

The key to determining which behaviors it is important for the animal to be able to perform is the extent to which the animal experiences them as necessary for its current and/or future welfare. Endogenous stimuli including hormonal influences direct the animal to survival-oriented species behaviors such as nesting. Nestbuilding is an important, species-specific behavior that should be allowed for in the environments of species that depend on secure nests for survival (e.g., laying hens and pigs). Play and exploration also help animals cope with future challenges, but they are rare in unstimulating environments. Thus, in barren environments, the motivation to perform them may be redirected and appear as inappropriate or destructive behaviors against penmates (e.g., bellynosing or tail-biting in pigs). Behaviors the animal experiences as *needs* should not be confused with *capabilities* it has to perform behaviors if an extraordinary occasion presents itself. Pigs are also very good swimmers, but if there is no water, they do not try to swim anyway (Algers 1996). There is no need to provide special places for pigs to engage in swimming in the production environment.

II. What Animal Welfare Is -- More Detail

To repeat, "the **welfare** of an individual is defined to be its state as regards its attempts to cope with its environment" (Broom 1988).

Since welfare is a property of the individual, it is not a broad ecological concept such as species preservation or biodiversity. Welfare also is not an environmental concept: human and non-human animals stand in the same relation to their environment. Welfare specifically regards the relationship of **individual** animals to their environment.

Welfare concerns the quality of the life *that is lived* and is not about *whether* the animal lives or dies. If, in hunting, the animal is unaware of being hunted and is shot cleanly and death comes instantly so that the animal does not experience fear or pain, its welfare is not in question (Broom 1988). If an animal dies a long and painful death, then its welfare *is* affected negatively.

Fraser, et al. (1997) note that some ethical concerns over the **treatment** of animals include concerns that certain species should be protected because they are endangered, or pigs should be housed so as to prevent pollution, or children should not mistreat animals because they may become

cruel or destructive adults. The primary concern, in these cases, centers on genetic conservation, environmental integrity, or human virtue, rather than on the quality of life of the animals. Concerns over the **welfare** of animals arise when we consider that protecting the quality of life of animals under our control is not only of instrumental value but also is a goal of importance in itself.

An illustration of the distinction between individual welfare and broader ecological questions concerns the musk deer of Asia (Halverson 1991), which in some areas of Asia is hunted for its musk. Trade in musk is so lucrative that the deer is in danger of extinction. In other areas, the deer is "farmed." From an ecological viewpoint, if musk is to be harvested, farming a few of the animals and preserving the species clearly is preferable. From the welfare perspective, hunting may be preferable to the techniques used in farming this wild deer.

On musk farms, male deer often are kept without light in small wooden boxes that are sometimes too low for them to stand and are fed and watered sufficiently to keep them alive. Periodically, they are dragged from the boxes so the musk can be extracted and then they are returned to their boxes. There is little profit incentive to provide for the animal's broader welfare. The musk deer's physiological program is such that it produces musk.

This example also illustrates that welfare and production are not necessarily equivalent.

This does not mean that human concerns regarding welfare and ecology are always in conflict. The destruction of species habitat adversely affects the welfare of individuals belonging to the species that depends on the habitat (Halverson 1991) and farming systems that respect the biology and natural behavior of the individual animal will tend to be kinder to the natural environment.

The key words in the definition of an ideal level of welfare are **complete physical** and **mental health** and **harmony** with the environment. (See also Adler 1978).

Physical health, when defined as vigor or as absence of disease, is an important component of animal welfare, although it is not all that is needed to ensure well-being, or the individual's subjective perception of its welfare. Mental or psychological health is necessary as well.

Fitness has a specific meaning in biology and is roughly the extent to which one's genes are present in the next generation or one's reproductive rate (Dr. P. Jensen, 2000, personal communication, Dr. D. Fraser, 2001, personal communication).

In this paper, because of the popular conception of the term as denoting strength and vigor (physical fitness), the term **reproductive rate** will be used to denote the biological meaning of fitness, and the word **vigor** will be used to denote physical fitness.

Vigor, defined as "physical energy or strength, the capacity for natural growth and survival" (American Heritage Dictionary, 2nd ed.) is an important indicator and component of welfare. Contemporary breeding and housing techniques have reduced the vigor of domesticated animals vis á vis their ancestors or wild relatives, affecting their abilities to control or function in their environment and negatively affecting their welfare. Osteoporosis in intensively confined breeding sows and laying hens is an example of the adverse effects confinement housing can have on vigor (Marchant and Broom 1996b, Knowles 1990, Knowles and Broom 1990, Knowles, et al. 1993).

An example of the effects of contemporary breeding techniques on vigor is double-muscled cattle, selectively bred to satisfy consumer desires for lean meat, that are so musclebound they cannot run, and can walk only with great effort. Most of the major livestock species in many contemporary livestock operations are afflicted with lameness due to environmental factors and factors associated with selective breeding for high production, fast growth, or leanness. Presence of disease, injury, movement difficulties, and growth abnormality are all indicators of poor welfare.

Belgian Blue cows, bred to have large offspring, frequently suffer from dystocia[14] (Price 1998, Kruip and van Reenen 2000). The calf is too large for its dam to give birth naturally (she and her calf will not survive the birth process unless the calf is removed by caesarian section). Domestic turkeys have been bred to have such large breasts that Toms cannot mate without injury to the hens. Human intervention by artificial insemination is required to sustain contemporary turkey production (Siegel 1975, Price 1998, Kruip and van Reenen 2000). In the pet realm, bulldogs bred for large heads also must be delivered by caesarian (Price 1998).

Although **reproductive rate** can be used as a welfare indicator, in the case of neutered animals (e.g., beef steers) where the desire to mate is reduced or eliminated, long-term welfare may not be adversely affected by not being able to reproduce. Neutered males still may be able to experience a good quality of life (once the pain of castration has subsided). Nor are vigor and reproductive rate in general sufficient indicators of welfare, as the welfare of farm animals also depends on how they are managed by people. For example, a vigorous and reproductively fit animal may nevertheless be confined to a small space or a barren or inhospitable environment, reducing its welfare by affecting its mental health and degrading its physical condition.

Animal histories are based in the two life processes **phylogeny** (the biological history of a species as laid down in its genetic program or pattern, i.e., by process of natural selection) and **ontogeny** (the animal's own individual history as experienced during its interactions with its own environment and laid down in its individual memory) (Halverson 1991). Through the process of ontogeny, animals form "expectations about the dynamics of their environment." Both genetic makeup and experiential learning ensure adaptive behavior, "the former by selection operating during the history of a species, the latter during the history of an individual" (Manning 1967).

It is often said that 'natural behaviors' have been bred out of contemporary farm animals by millennia of captivity and selective breeding. Scientific studies have discredited this notion. In the mid-1970s, an experiment to raise feral fowls was conducted on an island near the coast of Scotland by Wood-Gush and colleagues and they found that the domestic fowl, or chicken, retains many of the abilities and behavioral patterns of its ancestors that are relevant for survival in nature (Vestergaard 1981a).

Two experiments with domestic pigs have been made. The first, called the Pig Park, was an experimental laboratory set up as a large, partially wooded, partially pasture and marsh enclosure at the University of Edinburgh in 1978 (Stolba 1982, 1983, 1984). Ethologists David Wood-Gush and Alex Stolba introduced domesticated Large White pigs into the enclosure. The Stolba-Wood-Gush experiment was the first experiment designed specifically to observe the natural behavior of domesticated pigs for the purpose of determining which behaviors seemed most important to the animals and what functions they served.

Among the most important activities Wood-Gush and Stolba observed were nest site seeking and nest building by pregnant sows and the formation of family groupings by mothers, their young,

[14] Difficult birth.

and their "youngs' young." From their work Stolba and Wood-Gush drew conclusions about what elements might be changed in the production environment to improve pigs' welfare.

A similar park to the Edinburgh Pig Park was set up outside Stockholm in 1985 by ethologist Per Jensen of the Swedish University of Agricultural Sciences (Jensen 1986, 1988; Jensen, et al., 1987). The objective of this research was to study the maternal behaviors of Swedish Landrace sows. In this study, domesticated pregnant sows were released into a wooded enclosure and observed between 1983 and 1987. Jensen and his colleagues identified six different stages in the maternal behaviors of the sows in their park:

isolation from the group and nest site seeking;
nest building;
farrowing;
nest occupation;
nest abandonment followed by social integration of the piglets into the larger group of pigs; and
weaning.

Nest-building activities are very specific and sequential in nature across all sows. While the sow may be aware of the human observer, she is not easily interrupted from her task (Algers 1996). Each stage of nest building coincides with the release of a different hormone, indicating the strong internal motivations for nest building. The "pig park" sows showed behaviors that have importance for individual and species survival. They form a very strong part of the sow's motivational system.

Besides its innate, inherited characteristics or genetic makeup (sometimes manifested, as above, in "fixed" behavioral responses), the animal adjusts its environment and/or adjusts *to* its environment by means of **learning**. A sow is motivated by internal factors to build a nest, but she responds to (external) cues from the environment when deciding how elaborate a nest to build. The sow also can improve her nest building through learning (Campbell and Lasley 1985). Jensen (1986, 1988) and Jensen, et al. (1987) found and Thodberg, et al. (1999) confirmed that domestic sows' responses to exogenous factors (amount of material available for nest building, climate, degree of shelter already provided by the environment) influenced what kind of nests they made. If the spot she selected was well-sheltered, she would build a less elaborate nest than if the spot had been located in a more barren area.

There are several types of learning, a fact that has implications for the suitability of a production environment for specific animal species (Campbell and Lasley 1985). **Habituation** allows an animal to adjust to constant stimuli in its environment. In **instrumental conditioning**, animals learn to perform a behavior because of a result. As an example of **classical conditioning**, lactating cows may let down their milk when they enter the milking parlor. **Imprinting** is the tendency to respond and form an attachment to the first object to which the animal is exposed, an important form of learning for mother-young bonds and for animals-human associations. **Motivation** is the internal state of an animal that causes a particular, immediate behavioral response. Motivations are sometimes referred to as drives (Campbell and Lasley 1985). In the central nervous system, the hypothalamus controls certain behaviors and contains stimulatory and inhibitory centers. Endocrine gland secretions are also involved in certain behavioral responses. Environmental stimuli may release certain behaviors and inhibit others.

Every animal has a motivational system that consists of both learned and inherited behaviors and governs its interaction with the environment. Compatible with the animal's motivational system

is its physiology. **Physiology** includes body characteristics that are genetic in origin, and the internal mechanisms by which an animal achieves homeostasis, or physiological harmony with its environment.

Body structure is both naturally and artificially selected in farm animals (Campbell and Lasley 1985). On the one hand, animal species have adapted to their environments through natural selection and heredity. On the other, humans have artificially selected animals, changing their body characteristics or affecting their ability to act effectively on their environments. For example, since pigs do not perspire, they must lose excess heat in warm environments by other methods (Dutch Society for the Protection of Animals 1996). Following a mud bath, water evaporates from the mud as it dries, removing heat from the pig's body surface. Sparse hair growth allows body heat to escape by means of radiation or direct conduction, such as to a wet floor. Pigs also lose heat by evaporation from the respiratory system, but this capacity has been reduced by domestication (Dutch Society for the Protection of Animals 1996).

This implies that an optimal production environment will contain key environmental stimuli simulating those in the animal's species or evolutionary history and also will incorporate any changes in the natural environment that may have become necessary due to the artificial selection processes imposed by humans.

Newberry (1995) and Price (1998) describe the importance of biologically-relevant environmental enrichment. Newberry (1995) defines environmental enrichment as "an improvement in the biological functioning of captive animals resulting from modifications to their environment." She notes that enrichment attempts will fail if the environmental modifications have little functional significance to the animals, are not sufficiently focused to meet a specific goal, or are based on an incorrect hypothesis regarding the causes and mechanisms underlying a problem. To enrich environments of farm animals (such as pigs), that in a natural environment would spend a great part of the day foraging, destructible items with nutritional value would be more relevant substrates for foraging behavior than chains and toys.

Two environmental conditions must be satisfied in order to prevent distress to the animal (Stolba, 1982; Bresson, 1982; Dantzer, Mormède, and Henry 1983b). These are **predictability** and **control**, in particular, control over stimuli occurring in the environment.

Predictability implies that actions and events have an outcome the animal expects based on its own history or experience (its ontogeny) and the biological history of its species, or its genetic pattern (phylogeny). Predictability usually occurs in nature because, over time, through natural selection, the species has adjusted to the natural environment and, through learned behaviors, the individual becomes familiar with the conditions of its own immediate natural environment (Dantzer, Mormède, and Henry 1983). In the production environment, predictability needs to be provided for by conscious human design and management (Halverson 1991). Dantzer (1993) gives the example of the temporal distribution of food. When food is given every day at the same time, following reliable signaling cues, animals gain more weight than when they are given the same amount of food at different times every day, without any clue to predict when food will be distributed next.[15]

[15] However, weight gain is not the only criterion for welfare since it may imply obesity in confined animals and be associated with lethargy and depression. Under such conditions, increasing the food searching and handling time may be beneficial, especially for carnivores (Dr. R. Newberry, December 2000, personal communication).

Control over stressors is more important than the physical characteristics of the stressor itself. Control implies that the animal is able to perform certain behaviors with respect to its environment that may be necessary for survival, for comfort, to relieve stress or boredom, or to escape from undesirable stimuli. In the production environment, this implies that the animal should be able, for example, to move from shade into the sun if the temperature is too cool, or to wallow or turn on sprinklers, if the temperature is too hot, and to root or scratch in straw or litter or chew it and move it about, for occupation. Animals will adjust their environments to fit their preferences if given the opportunity. Baldwin and Ingram (1967) described a means by which pigs themselves controlled the thermal settings in their housing environments.

Providing ability for animals to exercise control may mean, for example, providing space and materials for a sow to build a nest before farrowing. This implies the environment must be enriched to allow engaging in these behaviors. Animals should be able both to receive and to react effectively to feedback from their actions. Stimuli should not occur in the environment in such a way that the animal cannot react to them effectively, e.g., constant loud noise that may cause stress to which the animal cannot adjust and is unable to escape (Dr. T. Friend, personal communication, 1990). Control is not just the capacity to make appropriate active responses in the presence of a threat to homeostasis. It requires the ability to learn about the consequences of acts (Dantzer 1993).

Other, more fundamental types of control include the animal's control over its own bodily functions. By genetic selection we have bred animals for certain characteristics that have, in turn, eliminated or severely reduced certain other capabilities that would be fundamental to their own and their species survival in a natural environment. An example is control over their movement and reproduction, such as in the Belgian Blue cow and domestic turkeys mentioned above. Animals have certain forms of motivation that contribute to rearing of offspring (nest-building) or behavioral development (e.g., play) and these should be taken seriously as welfare concerns. Animal rearing systems should accommodate them.

Too often, production systems are designed without knowledge of or regard for the basic biology and behaviors of farm animals. That is, they are incompatible with the animal's basic tools and resources, resulting in a production environment to which the animal cannot adapt without experiencing discomfort, pain, conflict, frustration, and distress.

In a survey of manufacturers, for example, Baxter and Schwaller (1983) learned that the first gestation stalls, or crates, for housing sows during and between their pregnancies were designed and built without the engineers ever having actually measured a sow. In the forty odd years since gestation crates came into use there have been no significant reforms to that form of housing and crates continue to be built that are too short for mature sows (i.e., force sows to be pressed against either end – Figures 2-1, 2-2).

Figure 2-1. Sows housed in gestation crates in an industrial pig breeding facility.

Photo credit: Diane Halverson, AWI

Figure 2-2. Pregnant sow in a too-short crate.

Photo credit: Diane Halverson, AWI

Behaviorally and biologically inappropriate production systems can lead to both acute and chronic injuries and illnesses and to premature death. In many cases, we may be "farming beyond [the animals'] ability to adapt" (Van Putten 1988).

III. A Model of the Individual's Relation to its Environment

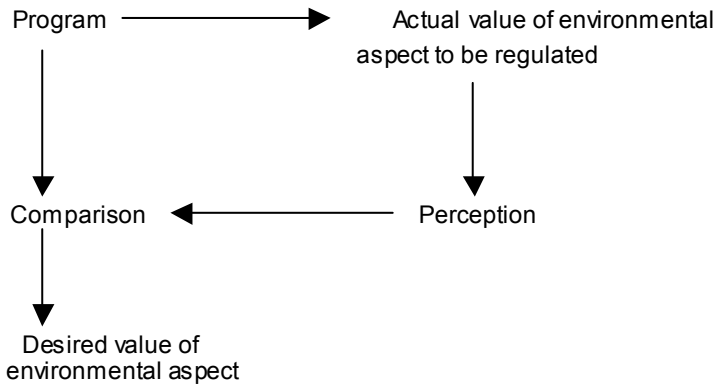
An animal can be said to be in harmony with its environment when its environment provides the means for satisfying both its needs and its desires or expectations; when the animal is sufficiently fit and unrestrained to act on its environment and make use of the means available in the environment so as to fulfill its needs and desires or expectations; when the animal is in control and can predict with reasonable certainty the reactions of objects in its environment or of other creatures to its actions; and when the animal is sufficiently fit and the environment is sufficiently benign for the animal to adapt without suffering to events that it cannot control.[16]

Several **models** of the animal's relationship with its environment are available. The model in Figure 2-3 is intuitively accessible. Through the process of ontogeny (defined above), individuals form "expectations about the dynamics of their environment." The term "desired" refers to expectations formed by both phylogeny and ontogeny.

In Figure 2-3, the individual perceives certain actual aspects of its environment and compares them to the values of the environment that it desires. It assesses its state and possibilities on the basis of its previous experience and present information (Wiepkema and Koolhaas 1992).

[16] Suffering is defined by Dawkins (1980, pp. 24-25) as "a particular kind of conscious awareness…of a wide range of unpleasant emotional states…[such as] fear, pain, frustration, and exhaustion…[and potentially includes]…other states…such as [result from] loss of social companions." Moreover, " there may be states of suffering which other animals experience and of which we humans have no knowledge." "These states likely have evolved by natural selection as a means of avoiding danger or restoring physiological deficits resulting from the animal's natural environment" (Dawkins 1990).

Figure 2-3. The Individual's Perception of the State of its Environment



If the value of the desired environmental aspects and the value of the actual environmental aspects are perceived to be incompatible, a program is set in motion in which the individual acts on the environment to remove the discrepancy between the actual and desired environmental aspects.

In addition to external stimuli, an animal's state and behavior are influenced by endogenous factors, such as hormonal changes. The periparturient sow, for example, is influenced initially by a sequential release of various hormones to isolate herself, seek a nest site, root a depression in the ground, gather materials, and make a nest (Algers 2000, Jensen 1988b, 1989, 1993). She responds to cues in the environment when deciding how elaborate a nest to make (in a sheltered area, she may make a less elaborate nest, while in an open area she may build a very well-structured, secure nest). Hormone changes influence when she leaves off nest-building and lies down to farrow.

Whether influenced by exogenous or endogenous factors or a combination of both, if the actions taken by the animal have been successful in bringing together the desired and actual environmental aspects, the animal will have achieved the desired harmony with its environment. The animal has coped with its environment and can go on about its tasks. If the animal has been unable to effect the desired change by means of its own behavior, the animal may continue in a state where it is strongly motivated to carry out behaviors that are not possible in their situation (Dr. D. Fraser, 2001, personal communication). Severe frustration results in the activation of internal mechanisms to adjust to the environment and achieve harmony with it.

For example, usually a behavioral coping response – an action taken by the animal – is sufficient to restore harmony with the environment. In modern, close confinement housing, opportunities for production animals to undertake any activity in response to their environments are severely diminished. Consequently, the animal's actions to bring the actual aspects of its environment into harmony with the desired aspects are bound to fail. Contemporary, space-intensive confinement production eliminates the opportunity for almost all normal activities except for eating, sleeping, defecating, urinating, growing, and reproducing.

If the animal fails by means of behavior to effect the desired changes in the environment, it must *adapt to* the environment (Dantzer, Mormède, and Henry 1983a; Wiepkema, 1983). It must try to achieve some sort of harmony with its environment by internal mechanisms.

Autonomic and/or neuroendocrine responses will be activated.[17] For example, pigs may huddle for warmth in a cold building but when this behavioral effort does not achieve the desired end, an internal mechanism will take over and the animal begins to shiver. Shivering has been defined as a "short-term response to acute cold by an unadapted organism" [and] "it may increase heat production in humans and animals by three to four-fold" (Campbell and Lasley 1985, p. 419). But shivering is a short-term solution.

If the animal, through its behaviors, is unable to remove the gap between the desired and actual environmental aspects, if it is unsuccessful in repeated attempts to escape from a crate, for example, or to build a nest, it instead may engage in non-functional, stereotyped, repetitive, and/or redirected behaviors or movements. Thus, in an inadequate production environment, these internal efforts are sometimes outwardly observable as compensating activities.

Stereotypies are one type of abnormal behavior and are thought to result from frustration and lack of control. Repetitious bar-biting by crated sows, tongue rolling by confined cattle, and crib-biting by horses confined to stalls are examples of "stereotypies." Ödberg (1978) described a stereotypy as:

1) A sequence of morphologically identical movements that are
2) repeated frequently, and
3) are apparently meaningless to the animal.

Stereotypies thus are repeated, relatively invariant sequences of movements that have no obvious function and that occur so frequently in a particular context that they could not be considered part of one of the normal functional systems of the animal (Broom and Johnson 1993).

Farm animals are not the only captive animals that show stereotypies nor are stereotypies restricted to non-humans. In zoos, caged animals may show repetitive route tracing while human prisoners kept in solitary confinement for long periods of time also perform stereotypies (Broom and Johnson 1993). Mason (1991) described a female mink in a farm cage that would repeatedly rear up, cling to the cage ceiling with her front paws and then crash down onto her back (Mason 1991, cited in Broom and Johnson 1993). Rocking and weaving movements of children with autism or other psychiatric disorders are well-known (Broom and Johnson 1993). Dantzer (1986) hypothesized that stereotypies "reflect a cutoff of higher nervous function."

Stereotypies are generally believed to result from stress in the animal's situation with which it has not been able to cope. Stereotypies may be mistaken as normal behavior by individuals who have only seen disturbed animals (Broom and Johnson 1993) – e.g., zoo keepers may think of repetitive route-tracing by caged cats and bears as normal, laboratory staff may perceive twirling around drinkers by rodents as normal, and farmers may perceive repetitive bar-biting by stall housed sows as normal.

Outcomes of investigations by the Scottish Farm Buildings Unit (1986) indicate that stereotypic behavior in farm animals is similar to repetitive behavior (such as handwringing) performed by mentally ill humans.

[17] However, behavioral responses to challenge do not necessarily come before autonomic changes (Dr. D. Fraser, 2001, personal communication).

As early as 1983, behaviors considered abnormal in farm animals (and therefore indicators of disturbed welfare) were listed and divided by a consensus group of scientists into 5 categories with examples in each category (Commission of the European Communities 1983):

1) Injurious behaviors (e.g., tail-biting (pigs), urine sucking (calves), and featherpecking (laying hens)).
2) Stereotyped behaviors (fixed in form and orientation, performed repetitively, no obvious function – e.g., bar-biting (crated sows), weaving (crated or tethered sows), tongue playing (crated calves), stereotyped pacing (laying hens).
3) Abnormal body movements and/or locomotion (apart from those resulting from wounds, disease and so forth (e.g., abnormal lying down or standing up (cattle in slatted floor housing)).
4) Redirected behaviors performed in the absence of adequate substrate and/or occurring with abnormal high frequency or intensity (e.g., licking (veal calves in crates), sham ruminating (veal calves in crates).
5) Apathetic behavior (the animal appears to be uninterested in what happens in its environment (possible, unproven: motionless sitting on hindquarters (tethered sows)).

These behaviors had to be performed by many animals in a given husbandry system and when performed had to take up a substantial amount of time (hours per day) in order to be considered abnormal. Such behaviors were seen to result from deficiencies in the humanmade environment and likely to "indicate severe abnormality or disturbance of the animals involved" (Commission of the European Communities 1983).

IV. Welfare Assessment

Scientists can determine what environmental factors (including management) may cause disease, injury, or distress, all of which reduce welfare, using various measures. These include physical measures of general health and soundness; clinical detection of disease and injury;[18]observations of an animal's behaviors, for example, looking for evidence of redirected or stereotypical activities or helpless behaviors; and neuroendocrine analysis. It is most reliable to use as many of these methods as feasible. As mentioned earlier, when taken alone, quantitative indices of productive or reproductive performance do not constitute a necessary or sufficient indicator of welfare, although if it is noticed that either of the two is impaired, it could be an indication that welfare is poor.

Improving the overall welfare of animals used in agricultural production must start from "first principles" (Baxter 1983). Starting from first principles, scientists begin with the basics of animal behavior and physiology.

As behavior is a fundamental tool used by the animal to cope effectively with and adapt to its environment, and as behavior is influenced both by the genetic history (phylogeny) and by the life experience (ontogeny) of the animal, a grounding in species-specific, natural behaviors is needed to understand how the animal experiences contact with humans and, particularly, with respect to its welfare in contemporary livestock production, how it experiences intensive confinement. This fact has been recognized by the Council of Europe, as the statutes formed by its Standing Committee for

[18] Ekesbo, for example, has suggested "integrity of the integument" as one measure of welfare (DeKoning 1985). Hurnik has suggested longevity as another (Hurnik 1988).

the Prevention of Cruelty to Animals Kept for Farming Purposes included sections about the biological characteristics of farm animals (Dr. B. Algers, December 2000, personal communication).

Reference was made earlier to **ecology** and **ethology**. In its contemporary use, ethology arose out of **zoology**, which, in turn, was heavily influenced by the theory of natural selection. Ethology was one of two main disciplines developed to study and interpret "the behaviour of the whole, intact animal organism—in contrast to the working of its parts which is of course mainly the task of the physiologist" (Thorpe 1979). The other of these "two main disciplines" is comparative or experimental psychology, which studies animal behaviors primarily with the point of understanding human behaviors better. The latter, according to Thorpe, tends to concentrate on learned behaviors, as may be appropriate to the study of humans (Thorpe 1979). These two schools, which might be termed, respectively, the naturalistic and the humanistic, were divided into, roughly, the English, or European, and the American schools of behavior study (Fraser, A.F. 1985, Manning 1967, Thorpe 1979). It is of interest to establishing the importance of this science that the founders of ethology, Lorenz, Tinbergen, and von Frisch were awarded the Nobel Prize in Medicine.

Ethology, therefore, took a naturalist's approach early on, which is "to know, as exactly as possible, the environmental characteristics to which the animal was adapted, the kind of situation in which it had to achieve a successful response, and the means available to it of making these responses" (Thorpe 1979). Because ethology is the study of animals' behaviors for their own sake, and not for shedding light on humans, the need to remain objective is paramount. It was recognized early in ethology's development that it was necessary to observe animals closely with a minimum of interference, to mark individuals so that they can be recognized throughout long stretches of their lives, and to develop techniques in line with the general demands of scientific studies that could aid the recording of animals' consequent actions and behavior (Thorpe 1979).

"On an empirical level [welfare can be assessed] by studying an animal in an environment that is assumed to be ideal, and then comparing it with an animal in the environment under investigation" (Hughes 1984). In applied ethology, domesticated animals are usually studied in manmade environments constructed so as to resemble as closely as possible the biotopes to which the particular animal species was originally adapted.

Examples of ethological research that begins with basic behavior and biology include: studies on red junglefowl, the ancestor of all modern chickens, to determine the effect domestication has had on underlying motivations and behaviors that might explain abnormal behaviors in confinement (Hart 1985,Vestergaard 1980, 1994, Wood-Gush 1959, 1971), the previously mentioned ethological experiments observing domesticated pigs released into semi-natural environments or parks (Arey 1997; Brambell 1974; Jensen, P. 1986; Jensen, P. 1988; Jensen, P., et al. 1987; Jensen and Wood-Gush 1984; Newberry and Wood-Gush 1985, 1986, 1988; Newberry, et al. 1988; Stolba 1982, 1983, 1984; Wood-Gush, Jensen, and Algers 1990), and domesticated pigs and fowl in relation to the wild boar and red junglefowl, respectively (Andersson, M. 2000, Vestergaard 1981a).

These studies provide information about what key stimuli from the biotopes to which the ancestors of contemporary farm animal species adapted over many millennia are needed in the production environment to prevent boredom, stress, fear, physical discomfort, and other factors involved in poor welfare, as may be reflected in redirected or abnormal behaviors (vices) and psychoendocrine responses.

Farm animals may also be studied in simulations of actual production situations or on actual farms to evaluate their adjustment to the environment. A description of proper observational and recording procedures for the applied ethologist is given in Jensen, et al. (1986).

For the understanding of animal behavior, the ethologist's first task is to make "as complete an inventory as possible of the whole repertoire of actions available to the animal in its normal environment" (Thorpe 1979) – that to which its species adapted. An **ethogram** is a "behavioral profile" compiled by ethologists through carefully detailed and objective observations of the animal in its natural or manmade environment. The objective is to religiously record behaviors themselves. Interpretation of the behaviors, for example, ascribing motivations to the behaviors or describing them in terms of motivations, must be scrupulously avoided during the recording process.

Ethograms are not used to measure welfare, but they can be used to gain an understanding of the main components of these survival and other evolved behaviors. In welfare research, recognizable abnormal behavior, avoidance behavior and behavior in preference tests are the main measures involving behavior (Dr. D. Broom, December 2000, personal communication).

In general, ethograms contain behavior patterns that have not disappeared in the course of domestication. These include behaviors that are important for the survival or reproductive success of the animal in its environment of evolution. These include types of behavior such as eating and drinking, which serve an obvious homeostatic function, and other examples, such as nest-building by sows (which determined whether her litter, and consequently the species, would survive) or dust-bathing by chickens (an important, inherited, self-maintenance behavior for grooming). The animals have evolved motivational systems to ensure that the animal does perform these important types of behaviors at appropriate times. Preventing the performance of these important behaviors, both by use of equipment or by management techniques, creates a stressful situation for the animal and results in the performance of abnormal, redirected, or stereotyped behaviors, giving rise to welfare concerns.

Animal welfare science thus studies animal needs and characteristics and discovers the critical attributes of the production environment that, when not provided, cause various degrees of distress and suffering to the animals and, when provided, help to ensure a positive welfare status. This information can be used to attempt to design production environments that are improvements over their predecessors in terms of providing for both the physical and mental well-being of the animal. Production system designers and farmers can incorporate materials and designs to create an enriched environment in which the animal can experience predictability and control and respond competently to the key stimuli presented. Farmers and other animal managers can learn the rules of husbandry based on each species' biology and behavior. Some examples of biologically and behaviorally appropriate (high welfare) production systems are given below in Chapter 10.

The findings of the research discussed so far also can be interpreted without entering into a debate about animal consciousness and animal cognition. Cognitive processes can be thought of as involving synthesis of information from diverse sensory and memory sources to produce appropriate responses (Allen 1998), that is, how animals take in, organize, reorganize, synthesize, and use information assimilated from their environments.

Recent cognitive ethology studies use hypotheses about the mental representation of capacities of the animals to make predictions about the kinds of responses the animals will make in different situations (Allen 1998). The predictions and experimental designs are guided by

close attention to the biological functions of the capacities involved. That is, animals are tested on "problems that involve the kinds of stimuli that their capacities evolved to handle rather than on arbitrary pairings of biologically meaningless stimuli such as lights and tones, that are common to many laboratory studies of animal behavior" (Allen 1998, p. 45). How this new research will affect previous findings from farm animal behavior studies is not known, although, given an emphasis on biologically meaningful stimuli, it could be hypothesized that of all the types of behavior studies, it will affect conclusions drawn from the studies of farm animals in semi-natural or natural environments the least.

Animal welfare science is a dynamic and growing discipline. As cognitive scientists are beginning to look into how domesticated animals alter and reclassify information before they put it into use (Nicol 1996), refinement of models of animal behavior that previously have relied on simple "programming" models of animals' response to stimuli in their environments can occur. However, enough is known to make significant improvements over current systems now. It takes the will to change.

V. Describing Welfare

Ewbank (1985) suggested there were three ways to mistreat animals: deliberate abuse resulting in fear, injury, pain, distress (suffering) and causing productive inefficiency and financial loss to the farmer; neglect through ignorance or overwork resulting in malnutrition, disease, or other forms of distress resulting from the animals' basic needs going unmet (suffering) and causing productive inefficiency and financial loss to the farmer; and deprivation of the possibility to fulfill behavioral and physiological needs, which we now know also causes distress to the animal (suffering) but may not always affect productive performance or cause financial loss.

Broom (2000) has listed some indicators of animal welfare. They include, but are not limited to, disease prevalence and reduced ability to grow and breed. The welfare of a diseased individual is poorer than that of an individual that is not diseased and reduced ability to produce offspring given appropriate opportunities also indicates poor welfare. Individuals that find it difficult to cope with their environment, or that are failing to cope may be more likely to become diseased, less likely to produce embryos, less likely to carry young to term and more likely to die early.

Broom (1994) lists some characteristics associated with good and poor welfare:

> Good welfare: variety of normal behaviors shown, extent to which strongly preferred behaviors can be shown, physiological indicators of pleasure, behavioral indicators of pleasure. No injury. Normal immune system functioning. Normal growth and reproduction.
>
> Poor welfare: reduced life expectancy, reduced ability to grow or breed, body damage, disease, immunosuppression, physiological attempts to cope, behavioral attempts to cope, behavior pathology, self-narcotization, extent of behavioral aversion shown, extent of suppression of normal behavior, extent to which normal physiological processes and anatomical development are prevented, injury – ranging between asleep or narcotized and awake and suffering

Indications of the level of welfare being experienced by the animal, on a continuum from very good to less good to very poor, might include the following (Broom 1994):

> Very good welfare: occasional bouts of adrenal cortex activity, occasional stereotypy caused by minor frustration, normal growth and reproduction, normal immune system functioning, no injury.
>
> Less good welfare: frequent adrenal activity, more frequent stereotypies, impaired growth or reproduction, substantial immunosuppression, injury - asleep or narcotized.
>
> Very poor welfare: pathological consequences of adrenal activity, eventually associated with reduced possibility of adrenal activity, substantive presence of stereotypies, impaired growth or reproduction and reduced life expectancy, substantial immunosuppression plus severe disease condition, injury - awake and suffering.

Longevity of the animal in the production environment has been suggested as a potential way of evaluating the welfare performance of husbandry and production systems, but is a less helpful criterion if animals are grown fast and sent to market before they die from poor welfare conditions (Hurnik 1988). Thus, high levels of premature mortality (e.g., Sudden Death Syndrome in broilers) can be an important sign of poor welfare, but should not be the only measure used. For example, producers of the geese used to produce fois gras are expert at force-feeding the geese to the limit where their livers will burst within a day or two. However, they sell them before that can happen, so the mortality of forcefed geese appears low. Nevertheless, the welfare of the geese had been poor for long before they were slaughtered (Dr. P. Jensen, December 2000, personal communication). Other livestock may be culled shortly before they would have died and this, Jensen argues, presents a case for including involuntary culling in mortality figures.

Duncan and Mench (1993) suggest that the extent to which the animal 'can afford to' engage in normal behaviors such as exploration and play, also may indicate how well the animal fares and the extent to which it is in harmony with the environment. And Mench (1998) has suggested applying the psychological concept of "flow" (Czikszentmilhalyi 1988, cited in Mench 1998) to assess the ability of a particular environment to contribute to the positive quality of life of the individual. This approach would give more emphasis in animal welfare science to positive aspects of welfare, such as fostering the animal's sense of control, ability to form social relationships, environmental challenges that are within the capability of the individual to meet successfully, active engagement, and the ability to fulfill one's goals, than to negative aspects such as preventing fear, frustration, stress, or, cumulatively, suffering.

Simply elaborating the presence or absence of coping responses is not enough to indicate level of welfare. It is the **cost of coping** incurred by the animal that counts (Sandøe, et al. 1996). This cost is not always immediately apparent (Dr. B. Algers, December 2000, personal communication).

References

Adler, H.C. (1978). Animal welfare in farm animal production. *The ethology and ethics of farm animal production*. Fölsch, D.W., ed. Basel & Stuttgart: Birkhauser.

Algers, B. (1996, Feb. 21). Managing alternative production systems: A European perspective. *Swine system options for Iowa. Proceedings of a conference held at Iowa State University*. Ames, IA: The Leopold Center for Sustainable Agriculture.

Algers, B. (2000). Nest-building behaviour in sows and the practicalities of farrowing systems. *Ruth Harrison Memorial Meeting, Farm Animal Care Trust, Fyvie Hall, University of Westminster, London, November 29, 2000.*

Allen, C. (1998). Assessing animal cognition: ethological and philosophical perspectives. Management of pain in production animals. *Journal of Animal Science, 76(1),* 42-47.

Andersson, M. (2000). *Domestication effects on behaviour: Foraging, parent-offspring interactions and antipredation in pigs and fowl, Doctoral thesis, Acta Universitatis Agriculturae Sueciae; Veterinaria 86.* Uppsala, Sweden: Swedish University of Agricultural Sciences.

Arey, D.S. (1995). The family system for pigs – from pig park to production system. *Pig News and Information, 16*, 123N-126N.

Arey, D.S. (1997). Behavioural observations of peri-parturient sows and the development of alternative farrowing accommodation: a review. *Animal Welfare, 6,* 217-229.

Arey, D.S., Petchey, A.M., & Fowler, V. (1991). The preparturient behaviour of sows in enriched pens and the effect of pre-formed nests. *Applied Animal Behaviour Science, 31,* 61-68.

Arey, D.S., Petchey, A.M., & Fowler, V. (1992a). The peri-parturient behaviour of sows housed in pairs. *Applied Animal Behaviour Science 34*, 49-59.

Arey, D.S., Petchey, A.M., & Fowler, V. (1992b). The effect of straw on farrowing site choice and nest building in sows. *Animal Production 54,* 129-134.

Baker, F.H., Busby, F.E., Raun, N.S., & Yazman, J.A. (1990, December). The relationships and roles of animals in sustainable agriculture and on sustainable farms. *The Professional Animal Scientist, 6 (3),* 36-49.

Baxter, M.R. (1983). Animal welfare from first principles. In S.H. Baxter, M.R. Baxter, & J.A.D. MacCormack, (Eds.), *Farm animal housing and welfare*. (pp.1-7) Boston: Martinus Nijhoff Publishers.

Baxter, M.R. & Schwaller, C. (1983). Space requirements for sows in confinement. *Farm animal housing and welfare: A seminar in the CEC programme of coordination of research on animal welfare, Aberdeen, Scotland, July 28-30, 1982.* Baxter, S.H., Baxter, M.R., & MacCormack, J.A.D., Scottish Farm Buildings Investigation Unit, eds. *Current topics in veterinary medicine and animal science.* Boston: Martinus Nijhoff Publishers.

Beauchamp, E.G. (1990, December) Animals and soil sustainability. *Journal of Agricultural Ethics*.

Bogner, H. (1981). Animal welfare in agriculture -- A challenge for ethology, in *The welfare of pigs: A seminar in the EEC program of coordination of research on animal welfare, 1980, Nov. 25-26.* W. Sybesma, (Ed.) Boston: Martinus Nijhoff Publishers.

Baldwin, B.A. & Ingram, D.L. (1967). Behavioral thermoregulation in pigs. *Physiology of Behavior, 2* (15-21).

Bresson, S. (1982, April 20-23). Influence of long-term psychical stress (noise, fighting, and electrical stimulation) on the physiology and productivity of growing-finishing pigs, in *Livestock environment II: Proceedings of the second international livestock symposium*. Iowa State University. St. Joseph, MI: American Society of Agricultural Engineers.

Broom, D. (2000). Does present legislation help animal welfare? Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Broom D.M. (1994). The effects of production efficiency on animal welfare. In *Biological basis of sustainable animal production Proc. 4th Zodiac Symp.* EAAP Publ. 67. Huisman, E.A., Osse, J.W.M., van der Heide, D., Tamminga, S. Tolkamp, B.L., Schouten, W.G.P., Hollingsworth, C.E., and van Winkel, G.L., eds. 201-210. Wageningen: Wageningen Pers.

Broom, D. (1988). The scientific assessment of animal welfare, in *Applied Animal Behaviour Science, 20 (1,2)*, 5-19.

Broom, D. & Johnson, K.G. (1993). *Stress and animal welfare.* New York: Chapman & Hall.

Callan, H. (1970). Ethology and society: Towards an anthropological view. Oxford: Clarendon Press.

Campbell, J.R. & Lasley, J.F. (1985). *The science of animals that serve humanity*. 3rd edition. New York: McGraw-Hill Book Company.

Castrén, H., Algers, B., de Passillé A.-M., Rushen, J., & Uvnæs-Moberg, K. (1993). Periparturient variation in progesterone, prolactin, oxytocin and somatostatin in relation to nest building in sows. *Applied Animal Behaviour Science, 38:* 91-102.

Commission of the European Communities. (1983). *Abnormal behaviours in farm animals. A report of the Commission of the European Communities (CEC).* CEC Expert Group Farm Animal Welfare, August 1983.

Crooker, B., Halvorson, D., Moon, R., Phillips, C., Noll, S., Johnston, L., Reneau, J., Chester-Jones, H., Hathaway, M., Goyal, S., Janni, K., Pijoan, C., Shields, T., Stromberg, T., Patterson, C., Dee, S., Blaha, T., and Wells, S. (1999). A summary of the literature related to animal agriculture health. *Generic environmental impact statement on animal agriculture, State of Minnesota*. St. Paul, MN: Environmental Quality Board.

Curtis, S.E. (1981). Stress related to animal handling," in *Systems approach to animal health and production: A symposium*. Fred W. Knapp, ed. Lexington: College of Agriculture, University of Kentucky: 196-202.

Csikszentmilhalyi, M. (1988). *Flow: The psychology of optimal exp*erience. New York: Harper and Row.

Dantzer, R. (1986). Behavioral, physiological, and functional aspects of stereotyped behavior: A review and reinterpretation. *Journal of Animal Science 62,* 1776-1786.

Dantzer, R. (1992). Behaviour, stress and disease. In *Livestock health and welfare*. Moss, R., ed. London: Longman Scientific and Technical, 87-117.

Dantzer, R. (1993). Research perspectives in farm animal welfare: The concept of stress. *Journal of Agricultural & Environmental Ethics,* 6, *Supplement 2,* 86-92.

Dantzer, R., Mormède, P., & Henry, J. P. (1983a). Physiological assessment of adaptation in farm animals. *Farm animal housing and welfare*. Baxter, S.H., Baxter, M.R., & J.A.D. MacCormack, J.A.D., (Eds.). Boston: Martinus Nijhoff Publishers.

Dantzer, R., P. Mormède & Henry, J.P. (1983b). Significance of physiological criteria in assessing animal welfare, in *Indicators Relevant to Farm Animal Welfare: A Seminar in the CEC Program of Coordination of Research on Animal Welfare, November 9-10, 1982*. Smidt, D. (Ed.) Boston: Martinus Nijhoff Publishers.

Dawkins, M.S. (1980). *Animal suffering: The science of animal welfare*. London: Chapman and Hall.

Dawkins, M.S. (1990). From an animal's point of view: Motivation, fitness and welfare. *Behavioral and Brain Sciences, 113,* 1-61.

Duncan, I.J.H. & Mench, J.M. (1993). Behaviour as an indicator of welfare in various systems. *Fourth European symposium on poultry welfare. Edinburgh, September 18-21, 1993.* Working Group IX of the European Federation of the World's Poultry Science Association. Potters Bar, UK: Universities Federation for Animal Welfare, pp. 69-80**.**

Dutch Society for the Protection of Animals. (1996). *Intensive livestock farming and animal protection: The vulnerable animal in intensive livestock farming. 13th report of the study committee on intensive farming*. The Hague: The Netherlands: Dutch Society for the Protection of Animals.

Ewbank, R. (1985). Behavioral responses to stress in farm animals. *Animal stress*, Moberg, G., ed. (pp. 71-79). Bethesda, MD: American Physiological Society.

Fraser, A.F. (1985). Background features in applied ethology. *Ethology of farm animals: A comprehensive study of the behavioural features of the common farm animals.* World Animal Science. Basic Information A, Number 5, A.F. Fraser, editor. New York: Elsevier Science Publishing Company, Inc.

Fraser, D., Weary, D.M, Pajor, E.A., & Milligan, B.N. (1997). A scientific conception of animal welfare that reflects ethical concerns. *Animal Welfare, 6(3*), 187-205.

Friend, T.H., Dellmeier, G.E. & Gbur, E.E.. (1987). Effects of changing housing on physiology of calves. *Journal of Dairy Science, 70,* 1595-1600.

Halverson, M. (1991). *Farm animal welfare: Crisis or opportunity for agriculture?* Staff Paper P1-91. St. Paul: Department of Applied Economics, University of Minnesota. On the internet at http://agecon.lib.umn.edu/mn/p91-01.pdf

Hart, B. (1985). *The behavior of domestic animals*. New York: W.H. Freeman and Company.

Hemsworth, P.H., Barnett, J.L., & Hansen. C. (1981a). The influence of handling by humans on the behavior, growth, and corticosteroids in the juvenile female pig. *Hormones and Behavior, 15,* 396-403.

Hemsworth, P.H., Brand, A., & Willems, P. (1981b). The behavioural response of sows to the presence of human beings and its relation to productivity. *Livestock Production Science, 8,* 67-74.

Hemsworth, P.H., Barnett, J.L., & Hansen, C. (1986). The influence of handling by humans on the behaviour, reproduction and corticosteroids of male and female pigs. *Applied Animal Behaviour Science, 15*, 303-314.

Hemsworth, P.H., Barnett, J.L., & Hansen, C. (1987). The influence of inconsistent handling by humans on the behaviour, growth, and corticosteroids of young pigs. *Applied Animal Behaviour Science, 17*, 245-252.

Hemsworth, P.H. & Barnett, J.L. (1987, June). The human-animal relationship and its importance in pig production, *Pig News and Information, 8, (2).*

Hemsworth, P.H., Barnett, J.L., Coleman, G.J., & Hansen, C. (1989). A study of the relationships between the attitudinal and behavioural profiles of stockpersons and the level of fear in humans and reproductive performance of commercial pigs. *Applied Animal Behaviour Science, 23,* 301-314.

Hughes, B.O. (1984). Behavior as an index of welfare. Proc. 5th European Conference, Malta, 1976, cited in Kilgour, R.C. (1984). *Livestock behavior*. Boulder, Colorado: Westview Press.

Hurnik, J. F. (1988). Welfare of farm animals. *Applied Animal Behaviour Science, 20*, 105-117.

Jensen, P. (1986). Observations on the maternal behaviour of free-ranging domestic pigs. *Applied Animal Behaviour Sciences, 16*, 131-142.

Jensen, P. (1988). *Maternal Behaviour of Free-Ranging Domestic Pigs: Results of a Three-Year Study.* Report 22. Skara: Swedish University of Agricultural Sciences, Faculty of Veterinary Medicine, Department of Animal Hygiene.

Jensen, P. (1989). Nest site choice and nest building of free-ranging domestic pigs due to farrow. Applied Animal Behaviour Science, 22, 13-21.

Jensen, P. (1993). Nest building in domestic sows: the role of external stimuli. *Animal Behviour 45,* 351-358.

Jensen, P. (1995). The weaning process of free-ranging domestic pigs: Within- and between-litter variations. *Ethology, 100,* 14-25.

Jensen, P. & Recén, B. (1989). When to wean – observations from free-ranging domestic pigs. *Applied Animal Behaviour Science 23,* 49-60.

Jensen, P. & Stangel, G. (1992). Behaviour of piglets during weaning in a semi-natural enclosure. *Applied Animal Behaviour Science 33,* 227-228.

Jensen, P., Floren, K. & Hobroh, B. (1987). Peri-parturient changes in behaviour in free-ranging domestic pigs. *Applied Animal Behaviour Science, 17.*

Jensen, P., Vestergaard, K., & Algers, B. (1993). Nestbuilding in free-ranging domestic sows. *Applied Animal Behaviour Science, 38,* 245-255.

Jensen, P. & Wood-Gush, D.G.M. (1984). Social interactions in a group of free-ranging sows. *Applied Animal Behaviour Science 12,* 327-337.

Jensen, P., Algers, B., & Ekesbo, I. (1986). Methods of sampling and analysis of data in farm animal ethology. Boston: Birkhäuser Verlag.

Jensen, P. & Wood-Gush, D.G.M. (1984). Social interactions in a group of free-ranging sows. *Applied Animal Behaviour Science 12,* 327-337.

Kelley, K.W. (1980). Stress and immune function: A bibliographic review. *Ann.Rech.Vet., 11, (4),* 445-478.

Kilgour, R. (1984). The role of human-animal bonds in farm animals and welfare issues. *The pet connection: Its influence on our health and quality of life.* (pp.58-74). *Proceedings of the Minnesota-California Conferences on the Human-Animal Bond.* Minneapolis: Center to Study Human-Animal Relationships and Environments.

Knowles, T.G. (1990). The effect of housing system on the activity level and bone strength of laying hens. *Applied Animal Behaviour Science, 26,* 290-291.

Knowles, T.G. & Broom, D.M. (1990). Limb bone strength and movement in laying hens from different housing systems. *Veterinary Record, 126,* 354-356.

Knowles T.G., Broom, D.M., Gregory, N.G., & Wilkins L.J. (1993). Effect of bone strength on the frequency of broken bones in hens. *Research in Veterinary Science, 54,* 15-19.

Krebs, J.R. & Davies, N.B. (1981). *An introduction to behavioural ecology*. Boston: Blackwell Scientific Publications.

Kruip, Th.A.M. & van Reenen, C.G. (2000). Biotechnology of reproduction and farm animals welfare. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Lund, V. (1999). *Components of the human-farm animal relationship: A literature review. Specialarbete 8.* Department of Animal Environment and Health, Swedish University of Agricultural Sciences, Skara, Sweden.

Manning, A. (1967). *An introduction to animal behavior.* London: Edward Arnold (Publ.) Ltd.

Marchant, J.N. & Broom, D.M. (1996b). Effects of dry sow housing conditions on muscle weight and bone strength. *Animal Science. 62*, 105-113.

Mason, G. (1991). *Individual differences in the stereotypies of caged animals.* University of Cambridge, Ph.D. thesis.

Mench, J. (1998). Thirty years after Brambell: Whither animal welfare science? *Journal of Applied Animal Welfare Science, 1 (2),* 91-102.

Moberg, G. (1985). Biological response to stress: Key to assessment of animal well-being? *Animal Stress,* Moberg, G., ed. Bethesda, MD: American Psychological Society.

Mormède, P. (2000). Stress and welfare: A psychoendocrine perspective. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Newberry, R.C. (1995). Environmental enrichment: Increasing the biological relevance of captive environments. *Applied Animal Behaviour Science, 44,* 229-243.

Newberry, R.C. & Wood-Gush, D.G.M. (1985). The suckling behaviour of domestic pigs in a semi-natural environment. *Behaviour, 95,*11-25.

Newberry, R.C. &Wood-Gush, D.G.M. (1986). Social relationships of piglets in a semi- natural environment. *Animal Behaviour, 34,*1311-1318.

Newberry, R.C. & Wood-Gush, D.G.M. (1988). The development of certain behaviour patterns in piglets under semi-natural conditions. *Animal Production, 46,*103-109.

Newberry, R.C., Wood-Gush, D.G.M., & Hall, J.W. (1988). Playful behaviour of piglets. *Behavioural Processes,* 17,205-216.

Nicol, C.J. (1996). Farm animal cognition. *Animal science, 62,* 375-391.

Petersen, V., Recén, B., & Vestergaard, K. (1990). Behaviour of sows and piglets during farrowing under free-range conditions. *Applied Animal Behaviour Science, 26,* 169-179.

Price, E.O. (1998). Behavioral genetics and the process of animal domestication. *Genetics and the behavior of domestic animals*. Grandin, T., ed. San Diego: Academic Press.

Price, E.O. (1999). Behavioral development in animals undergoing domestication. *Applied Animal Behaviour Science 65,* 245-271.

Sandøe, P. and Holtug, N. (1996). Ethical limits to domestication. *Journal of Agricultural and Environmental Ethics, 9(2)*, 114-122.

Scottish Farm Buildings Investigation Unit (SFBIU). (1986). *Does close confinement cause distress in sows? A review of the scientific evidence.* Commissioned by Athene Trust. Aberdeen, UK: SFBIU.

Seabrook, M. F. (1980). The psychological relationship between dairy cows and dairy cowmen and its implications for animal welfare. *International Journal for the Study of Animal Problems, 1(5),* 295-298.

Selye, H. (1936). A syndrome produced by diverse nocuous agents. *Nature, 238,* 32.

Selye, H. (1956). What is stress? *Metabolism: Clinical and experimental, V(5),*525-531.

Selye, H. (1973a). Homeostasis and heterostasis. *Perspectives in Biol. and Med.,Spring,* 442-445.

Selye, H. (1973b). Evolution of the stress concept. *American Scientist, 61,* 692-699.

Selye, H. (1975). Confusion and controversy in the stress field. *Journ. Human Stress,June,*37-44.

Siegel, H.S. (1974). Environmental stress and animal health: A discussion of the influence of environmental factors on the health of livestock and poultry. *Livestock Environment: Proceedings of the International Livestock Environment Symposium. April 17-19, 1974, Lincoln, Nebraska.* St. Joseph, Michigan: American Society of Agricultural Engineers.

Siegel, P.B. (1975). Behavioural genetics. *The behaviour of domestic animals*. Hafez, E.F.E., ed. (3rd edition.) London: Baillière Tindall.

Stolba, A. (1982). Designing pig housing conditions according to patterns of social structure. Presentation to a Conference on Pigs, Perth, organized by the Scottish Agricultural Colleges and the Meat and Livestock Commission.

Stolba, A., (1983, June). The pig park family system: Housing designed according to the consistent patterns of pig behaviour and social structure. Paper presented at the Conference on the Human-Animal Bond, Minneapolis, Minnesota.

Stolba, A. (1984). Lactational oestrus in sows kept in rich environments, in *Proceedings of the International Congress on Applied Ethology in Farm Animals*. Federal Ministry of Food, Agriculture and

Forestry, Bonn, West Germany. (pp. 226-228). Kiel: KTBL.

Thodberg, K., Jensen, K., Herskin, M., Jørgensen, E. (1999). Influences of environmental stimuli on nest building and farrowing behaviour in domestic sows. *Applied Animal Behaviour Science,63,*131-44.

Thorpe, W. (1979). *The origins and rise of ethology*. New York: Praeger Publishers, Inc.

Van Putten, G. (1988). Farming beyond the ability of pigs to adapt. *Applied Animal Behaviour Science, 20,* 63-71.

Vestergaard, K. (1981a). Aspects of the normal behaviour of the fowl. In Fölsch, D.W. and Vestergaard, K. (1981). *The behaviour of fowl: The normal behaviour and the effect of different housing systems and rearing methods.* Basel: Birkhäuser Verlag.

Vestergaard, K.S. (1994). *Dustbathing and its relation to feather pecking in the fowl: Motivational and developmental aspects*. Frederiksberg, Denmark: Jordbrugsforlaget.

Vestergaard, K. (1981b). Influence of fixation on the behaviour of sows, in *The Welfare of Pigs: A Seminar in the EEC Programme of Coordination of Research on Animal Welfare. November 25-26, 1980*. Sybesma, W. (Ed.). Boston: Martinus Nijhoff Publishers.

Vestergaard, K. (1980). The regulation of dustbathing and other behaviour patterns in the laying hen: A Lorenzian approach. In *The laying hen and its environment: A Seminar in the EEC Programme of Coordination of Research on Animal Welfare*, Moss, R. (Ed.) Luxembourg, March 11-30, 1980. (pp. 101-120). Boston: Martinus Nijhoff Publishers.

Wemelsfelder, F. (1983). Animal boredom: Is a scientific study of the subjective experience of animals possible? Doctoral thesis. Leiden: Uitgave Instituut voor Theoretische Biologie.

Wiepkema, P.R., Cronin, G.M., & Van Ree, J.M. (1984). Stereotypies and endorphins: Functional significance of developing stereotypies in tethered sows. *In the Proceedings of the International Congress on Applied Ethology in Farm Animals, pp. 93-96.* Federal Ministry of Food, Agriculture and Forestry, Bonn, Germany. Kiel: KTBL.

Wiepkema, P.R. (1985). Abnormal behaviours in farm animals: ethological implications. *Netherlands Journal of Zoology, 35(1,2),* 279-299.

Wiepkema, P.R. (1983). Umwelt and animal welfare, in *Farm animal housing and welfare.* Baxter, S.H., Baxter, M.R., & MacCormack, J.A.D. (Eds.). (pp.45-50) Boston: Martinus Nijhoff Publishers.

Wiepkema, P.R. & Koolhas, J.M. (1992). The emotional brain. *Animal Welfare, 1992 (1),* 13-18.

Wood-Gush, D.G.M. (1959). A history of the domestic fowl from antiquity to the 19th century. *Poultry Science, 38,* 321-326.

Wood-Gush, D.G.M. (1971). *The behaviour of the domestic fowl*. London: Heinemann Educational Books, Ltd.

Wood-Gush, D.G.M. (1983). *Elements of Ethology*. London: Chapman and Hall.

Wood-Gush, D.G.M., Jensen, P. & Algers, B. (1990). Behaviour of pigs in a novel semi-natural environment. *Biology & Behaviour, 15,* 62-73.

Ödberg, F.O. (1978). Abnormal behaviours: Stereotypies. In *Proceedings of the first World congress in ethology applied to zootechnics, Madrid,* 475-480.

CHAPTER 3

SOME CONTEMPORARY MANAGEMENT AND HOUSING PRACTICES GENERAL WELFARE IMPACTS

I. Introduction

In 1965, the Brambell Committee called upon farmers and production system designers to allow animals at least freedoms:

1) to turn around;
2) to groom themselves;
3) to get up;
4) to lie down; and
5) to stretch their limbs.

In disapproving of contemporary livestock confinement's restrictions on animals' ability to behave normally, the Brambell Committee also effectively recommended that animals be able to perform their species-specific, natural behaviors. In 1965, few farm animals on intensive farms had even the five basic freedoms listed above. Today it is still the case that not all of these five freedoms are experienced by livestock in intensive confinement -- laying hens confined to battery cages, pregnant sows confined to gestation crates, calves raised for veal in narrow stalls, and dairy cows and bulls when confined by ties, tethers, or stanchions. All farm animals except pastured species and those in enriched, extensive confinement are denied the possibility of performing species-specific natural behaviors, such as dustbathing (an important grooming activity for chickens) or nest-building (an important maternal activity for sows).

II. General Impacts of Contemporary Management Practices on Welfare of Farm Animals

These sections describe, in general, some welfare impacts of contemporary farming practices. More specific information is given, species-by-species, in Chapters 5, 6, and 7 for poultry, pigs, and cattle.

At least three classes of problems arise when the animal cannot make use of its resources and tools to meet the challenges of its current environment (Fraser, et al. 1997).

1) If animals possess adaptations that no longer serve a function in the new environment, they may still remain strongly motivated to perform certain behaviors, even though failure to perform them may not be accompanied by significant disruption to biological functioning. Their example is the bucket fed calf that nevertheless experiences a strong, frustrated desire to suck.

2) If the environment poses challenges for which the animal has no corresponding adaptation, the animal may have trouble functioning in its environment without showing it. Such may be the case with a pig in a polluted environment that develops lung damage without appearing to notice or mind.

3) Where animals do have adaptations corresponding to the kinds of environmental challenges they face, they may experience problems if their adaptations prove inadequate. An animal's thermoregulatory adaptations may be insufficient in a very cold environment such that the animal feels poorly and functions poorly.

Fraser, et al. (1997) propose that, together, the three classes of problems identified above define the subject matter of animal welfare science.

All livestock species are the product of selective breeding and most livestock at some point meet their deaths at the hands of humans. Impacts of animal production on farm animals begin with selective breeding for traits desirable to humans and end with slaughter. Animal welfare concerns arise at four stages in animal production.

1) Animal welfare concerns can arise because of factors acting before the animal enters the production system. This depends on the extent to which domestication and genetic selection have removed or reduced the viability of important natural capacities that equip the animal to control, function normally in, or adapt to its environment.

2) Animal welfare concerns can arise while the animal while in the production system. This depends on how genetic selection has affected its ability to physically cope with its environment, on management (for example, adequate planning to have quality feed and medications and other essential inputs on hand and day-to-day attentiveness of farmer/workers to the needs of the animals, as well as the quality of the attention given), and on facility design, quality, and operation.

3) Animal welfare concerns can arise when the animal goes to slaughter – is it fit or is it crippled, injured or weak from lack of exercise? Loading, crowding during transport, care in driving (or lack of it), and unloading are the critical points for physical injury and prolonged fear, pain, and suffering.

4) Animal welfare concerns can arise at the slaughterplant, where they can be left to wait in extreme temperatures and abandoned to die if injured, and during the slaughter process itself, which depends on the design of the plant and the sympathy and competence (or lack of sympathy and competence) of workers and the time allotted to them to do their jobs. The slaughter process itself is frequently poor, as line speeds in modern beef packing plants can be up to 400 animals an hour and in modern pork packing plants up to 1,000 animals per hour, risking both animal and human well-being. (Slaughter is outside the Scoping Document categories and will not be discussed extensively in this paper.)

Between conception and slaughter, farm animals are strongly influenced by (1) management (including husbandry) and (2) production environment (or housing) (a) design, (b) construction, and (c) operating components. The production environment could be relatively unconfined as in pasture or loose indoor housing systems or greatly confined as in industrialized, mass animal farming.

The social structure of animal populations may change when space becomes limited. The inability of subordinate animals to escape from more dominant conspecifics may result in the

formation of more highly polarized social hierarchies than would otherwise occur in nature (Price 1999). Put more simply, animals in confinement affect each other more intensely. When humans do not "compromise" by increasing space allowance or enriching living spaces appropriately, the result can be reduced ability of animals to avoid aggression, which can lead to injuries and, which, in some cases, has influenced the industry to adopt even more restrictive management practices such as individual housing.

Animals need a certain amount of space for signaling their intentions to conspecifics in their environment. Scientists have recognized that adult pigs, for example, need to face each other at a minimum set distance in order for the less dominant individual to turn its head aside and signal its superior of its submissive intentions, thereby avoiding a fight (Jensen, P. 1980, 1982). In practical experience in confinement situations, this distance appears to be about two meters (Dr. B. Algers, 1991, personal communication). Failure to appreciate such simple "rules of engagement" when designing their experiments frequently leads researchers to conclude that group housing of breeding sows results in poorer welfare for the sow than individual stall housing. In reality their research design violates one of the most basic of behavior characteristics on which successful group housing of sows depends. Alternative designs must actually improve welfare by building on current knowledge and research needs to be built on principles previously revealed.

Certain adverse impacts are common in all livestock production and these, welfare groups insist, must be minimized as much as possible by attentive and caring management. In nearly all livestock production, farm animals undergo painful procedures, have their autonomy restricted, are selectively bred for traits desirable to humans, and sometimes are injured. The vulnerability of ill and injured animals requires patience, if not empathy, on the part of handlers to protect them from suffering.

All farm animals rely on humans to provide nutritious food, clean water, shelter appropriate to the climate and predator situation, timely treatment for illnesses and injuries, and timely adjustments to the production environment to keep it safe, clean and healthful (hygienic), comfortable, predictable, and "meaningful" to the animal. By "meaningful" is meant enrichment with species-appropriate space, lighting, and materials for constructive occupation. Constructive occupation, such as unraveling a bale of straw and rooting in it, in the case of swine, can prevent the development of abnormal behaviors, such as tail-biting, that can have adverse effects on both welfare and production.

Unintentional negligence and suffering occurs at some time in every farming system with regard to some aspect of animal welfare. Farmers cannot always be observant, on time with feed or medication, etc., and these situations will compromise welfare, but the good stockperson will make every effort to be so in order to prevent needless suffering and promote well-being in his or her animals.

As livestock industries intensify, and individual firms grow in size, often increasing to multiple enterprises, the attention paid to individual animals decreases (Dawkins 1980, Loula 2000). Excessive growth limits the owners' or managers' ability to keep day-to-day operations under their span of control while high capital costs force them to hire unskilled workers at low cost. Farm animals bear the cost of untrained workers.[19]

[19] In early 2001, *The Des Moines Register* (February 10) reported that 375 sows at a Swine Graphics hog facility in Iowa died of thirst. Although low-level employees had checked the barn daily, the water had not been turned on for ten days. Employees, mistakenly fearing the ailing sows had contracted a deadly disease,

III. Impacts of Domestication

Domestication is defined as "that process by which a population of animals becomes adapted to man and to the captive environment by genetic changes occurring over generations" (Price 1999). While artificial selection in captivity facilitates adaptation to the captive environment over generations, the unique experiences of individuals foster adaptation within their lifetime.

In other words, domestication is the process by which captive animals adapt to humans and the environment they provide. Domestication can be viewed as both an evolutionary process and a developmental phenomenon.

When domestic animals are provided with an environment that is physically similar to the habitat of their wild ancestors, behavioral and physiological adaptations to the environment will be readily achieved (Price 1999). Very often the captive environment does not match the ancestral environment and adaptation is challenged. Such a situation gives rise to welfare concerns as described above and by Fraser, et al. (1997) and as evidenced in animals' inability to adapt to agricultural practices without suffering or without loss of performance when welfare pressures are extreme.

Domestication includes not only captivity and the application of various procedures to animals but also to the genetic mechanism of artificial selection for characteristics desirable to humans.

Selection may be defined as "causing or permitting certain individuals within a population to produce the next generation" (Campbell and Lasley 1976). The selection that nature achieves through survival of the fittest and through the survivors passing on their genes to subsequent generations is natural selection. Unlike natural selection, artificial selection is goal-oriented (Price 1998, 1999). Artificial selection occurs prior to reproduction. People artificially select animals and allow them to reproduce in order to increase the proportion of desirable genes in a population for a particular purpose. Natural selection is an outcome of differential reproduction. In some cases, the natural selection process can be "relaxed" by domestication when humans act as buffers between the natural environment and domestic animals (animals will survive that would not have survived if subjected to the natural environment without human assistance).

In nearly all cases, artificial selection is accompanied by natural selection (Dr. P. Jensen, 2000, personal communication). Animals artificially selected by human managers to be parents of the next generation do not always reproduce. "Inbreeding depression" is the lowering of vigor and fitness brought about by expression of deleterious genes that had previously been masked (Price 1998, 1999). Inbreeding depression can increase the intensity of natural selection in

---

killed the remaining sows to stop its spread. The February 3 *Register* reported neighbors' concerns about dead hogs and described one complaint concerning 200 dead hogs left outside within view of public roads. In January 2001, 500 hogs died when electricity was cut to the building during snow removal. Backups did not work. An Iowa farmer called an animal welfare group in February 2001 to express concern about problems at a neighboring farm where for two and one half weeks no one fed the pigs, as two consecutive hired workers quit. When a serviceman visited the facility live pigs had fallen from 220 pounds at his last visit to 180 pounds, some pigs were dead and were being eaten by the living pigs that had no feed (Animal Welfare Institute, March 2001).

captivity. Detrimental side effects such as increased susceptibility to disease and mortality may accompany artificial selection. Loss of vigor can result in failure to thrive and reproduce (Price 1998, 1999).

Intense artificial selection and husbandry practices may have produced populations of domestic animals with reduced potential for survival in nature due to reduced vigor or inability to reproduce naturally. Breeding for rapid growth in broilers has resulted in leg deformities (Dr. D. Fraser, 2001, personal communication). Selection for increased egg production has caused a prolonged oestrogen dominance, and since brooding requires progesterone dominance, hens raised for laying eggs may not get into the broody motivation under farming conditions (Dr. P. Jensen, 2000, personal communication). Consequently, artificial selection for continuous egg-laying has resulted in "strains of chickens that normally do not incubate eggs or brood chicks" (Price 1998). However, "there is little evidence that domestication has resulted in the loss of behaviors from the species repertoire or that the basic structure of the motor patterns for such behaviors has been changed" (Price 1998). Duncan (1994), for example, notes that, in preference tests, hens were shown to work extremely hard to reach a nest box, implying that nesting remains an important component of domestic poultry's behavioral repertoire.

In nearly all cases, behavioral differences between wild and domestic stocks are "quantitative in character and best explained by differences in response thresholds" (Andersson, M. 2000, Price 1998).

A. Welfare impacts of selection

Crooker, et al. (1999) disagreed with the "suggestions by some (Rauw and others 1998; Broom 1999) that genetic selection results in stressed animals that have [sic] 'their normal biological functioning controls are overtaxed' (Broom 1999)." Crooker, et al. (1999) contended that Rauw, et al. (1998) and Broom (1999) "fail to recognize that genetic selection is successful because it results in improvements in the biological control and coordination of mechanisms in the entire animal. To do otherwise would result in a non-sustainable biological system and would indeed be detrimental to animal health and well-being" (Crooker, et al. 1999, p. L-16).

For an example of successful genetic selection, the authors suggest the high-producing dairy cow:

> The contemporary cow produces considerably more milk than her distant ancestors and nearly twice as much milk as cows did 40 years ago. Despite this tremendous increase in productivity and the increased metabolic activity associated with milk production, the contemporary cow compensates (just as her ancestors did) by reducing the quantity of milk she produces when she is confronted with adverse environmental conditions, poor health, or poor management. She also decreases her milk production when she becomes pregnant. The physiological adaptations of pregnancy result in the diversion of nutrients away from milk production and toward those processes that support fetal growth and development.
>
> These alterations clearly indicate the biological mechanisms within the contemporary high-producing cow continue to function in a coordinated manner to support the dominant physiological function. The fact that the cow decreases

> the quantity of milk she produces when confronted with less than ideal conditions clearly indicates that selection for milk yield has not made the cow an appendage to her mammary gland and does not force the cow to produce milk at the expense of her health, well-being and survival.

Crooker, et al. (1999) appear not to consider the high "current levels of lameness, mastitis and infertility" in the dairy herd as a result of artificial selection for high milk yield (Rushen 2000, also see Chapter 5). They cite Bauman and Currie (1980) for a model of adaptation (homeorrhesis) in which "biological mechanisms within the high-producing cow…function in a coordinated manner to support the dominant physiological function." However, it will become clearer in Chapter 5 that the "dominant physiological function" is milk yield and the cow's "biological mechanisms" support it at the expense of her welfare.

Crooker, et al. (1999, p. L-16) continue: "[t]hese observations magnify the importance of developing management systems that match the genetic potential of livestock to the environment within which they are housed."

If exploiting the "genetic potential of livestock" has resulted in the observed greater occurrences of lameness, mastitis, and infertility in the dairy cow population, it had adverse welfare consequences. Invention (artificial selection for higher milk production) becomes the mother of necessity if we create the propensity toward infirmities that require altered management. To limp in one sense may be thought of as an adaptation; the behavior itself indicates difficulty in coping with the environment and, hence, poor welfare (Broom 2000). Discussing leg problems in turkeys resulting from genetic selection for heavier breasts and fast growth, Hirt, et al. (1997) recommend that selection criteria be determined not only by economics, but also by physiological and ethological parameters that take into account the animal's needs.

The outcome of artificial selection predetermines the state of the individual animal *going into* the production system by modifying the initial endowment of tools and resources the animal possesses for coping with its environment, which include both its body characteristics and behavior.

Kruip and van Reenen (2000) provide evidence that new biotechnologies may have profound and negative effects on essential biological functions and systems in the animals involved, in turn detrimentally affecting animal welfare. They recommend that the introduction of new biotechnologies into farm animal husbandry be accompanied by systematic and scientifically valid studies into the effects on animal welfare. Among the biotechnologies they consider as having actual or potentially adverse welfare effects are estrus synchronization and estrus induction, multiple ovulation and embryo transfer, electroejaculation of bulls in artifical insemination, ovum pickup, in vitro reproductive technologies and transgenesis.

Additional evidence will be presented later under the specific livestock species for the case that adaptation and vigor (and welfare) are being compromised in contemporary production animals by more and more extreme selection practices for such human preferences as fast growth rate, high milk production, and lean carcass characteristics (see, especially, Grandin 1998). The result of production goal-directed artificial selection for the animal going into the production system is that in some cases it has become incapable of adaptation without suffering.

B. Fear and animal welfare

Fear is an adaptive state, with fear behavior functioning to protect an animal from injury (Jones 1996a). The problem for farm animals in contemporary farming systems is that many systems prevent animals from responding in an adaptive fashion to potentially threatening stimuli. "Under these circumstances, fear can be a powerful and potentially damaging stressor, particularly if it is intense or persistent" (Jones 1996a, p. 131).

Fear is a complex concept, covering at least five different processes or states (Jones 1997).

Common physiological and behavioral responses to danger occur both between animals of different species and within individual animals of a species (Boissy 1998). Both genetics and developmental experience affect responsiveness. Fear-related reactions that occur when animals are confronted with human beings are observed in poultry, pigs, sheep, and cattle. Fear and anxiety behaviors compete with, and inhibit, behavioral patterns motivated by other systems such as learning and reproductive behaviors. Fear inhibits learning in horses (Boissy 1998) and impairs the ability of poultry to adapt to environmental change, interact successfully with each other or the stock person, and utilize new resources (Jones 1996a). Fear and anxiety adversely influence maternal behaviors, which are a major determinant of the welfare of the young.

The impact of human interactions with farm animals is the subject of an extensive literature on farm animal welfare (Hemsworth, et al. 1981a&b, Hemsworth, et al. 1986, 1987, 1989, Hemsworth & Barnett 1987, Seabrook 1980). Routine management procedures can elicit fear responses, especially if pain has been experienced in the past in association with them. Jones (1997, p. 80) suggests that prolonged fear and loss of control may "lead to psychosomatic symptoms or even death, at least in man and other mammals."

Fear can be assessed functionally in terms of the animals' attempts to avoid danger and by use of physiological measures of alarm or distress such as heart rate and concentration of plasma catecholamines and glucocorticoids (Jones 1997).

Fear is a matter of concern in contemporary animal production because the adaptive (innate) fear responses of animals are often inappropriate in confined situations, resulting in injury, pain, or even death (Jones 1996a). When poultry are frightened, a wave of escape behavior can pass through the house and result in a pile-up of birds against the walls of the barn and many may suffocate. Such behavior is often anthropomorphized by people as "stupidity," but it is, in fact, a case when animals are confronted by aversive situations to which they have not adapted or formed appropriate behavioral responses. The escape behavior would be adaptive in the natural environments in which the species was selected.

The fight or flight responses to danger are present in all vertebrates. Chickens handled by humans may not move for some time (Jones 1986b). One form of this phenomenon is termed "tonic immobility." Tonic immobility is submissive inertia (Fraser, A.F. 1960, Fraser, A.F. and Broom 1990).

All animals possess species-specific behavior patterns that interact with experience and learning in the formation of behavior (Grandin 1998). Fearfulness, or temperament, social behavior, maternal behavior, and aggression are traits strongly influenced by genetics. Rearing in an environment with a variety of different objects improves learning. Environmental enrichment provides animals the opportunity to explore novel aspects of their environment, which is thought to

have value for the animals (Jones 1996a, Mench 1994, Newberry 1999). Raising young animals in environments that are devoid of variety and sensory stimulation will have an effect on development of the nervous system and can cause an animal to be more reactive and excitable when it grows up. They are more likely to overreact to novel events and may find it difficult to cope with subsequent changes in the environment and to acquire new knowledge (Jones 1996a). "This is long-lasting, environmentally induced change in how the nervous system adapts to various stimuli" (Grandin 1998).

In general, domestic animals have attenuated flight responses as a result of many years of selective breeding, but taming full-grown animals to be accustomed to people will not diminish their responses to sudden, novel stimuli (Grandin 1998). Hence, reducing fear in farm animals is both a matter of genetics and of handling.

Animals tend to generalize aversive experiences with one handler to all people (Rushen, et al. 1999). Cattle have wide angle vision and will notice and be afraid of objects as simple as a dangling chain on the side of a fence. "Details are important to animals" (Grandin 2000). Understanding what makes animals fearful and acting to reduce the occurrence of fearful stimuli in the environment makes management easier and improves humans' abilities to ensure the welfare of the animals. (See, for example, "Understanding Flight Zone and Point of Balance" and other articles by Temple Grandin, http://www.colostate.edu/Depts/AnimSci/ or http://www.grandin.com.)

Poor, fear-inducing handling during movement is thought to contribute to lameness in a major way, and impatience by stockpersons when moving animals has been found to be one of the single most important factors determining level of lameness within a herd (Rushen, et al. 1999). For example, a much higher level of lameness was found in dairy heifers that were handled roughly before and after milking than in dairy heifers handled pleasantly.

Jones (1996a, 1998) presented a list of undesirable consequences of inappropriate fear responses, chronic fear states, and heightened fearfulness, particularly with respect to poultry. These consequences include:

- Wasted energy
- Injuries, pain and death
- Feather-pecking, feather damage
- Behavioral inhibition, social withdrawal, reduced ability to adapt to change and new resources
- Difficulties in handling and management
- Delayed maturation
- Decreased reproductive performance and egg production
- Reduced growth and food conversion efficiency
- Abnormalities of the egg shell, compromised hatchability
- Downgrading of eggs and carcasses
- Serious financial losses.

Humans can evoke fear in animals by virtue of their relative size, and their propensity for quick or unpredictable movements. In traditional, small-scale agriculture, animals habituate to the presence of humans by virtue of routine, neutral exposure during the course of the day-to-day management (Rushen, et al. 1999). Contemporary, industrial methods have reduced much of the opportunity for frequent, benign contact between farm animals and people. Farms are larger, and have a lower ratio of people to animals. Labor-saving technologies further reduce these

opportunities. Many of the opportunities for positive human interaction with livestock have been replaced by mechanical technologies, e.g., feeding in person has been replaced by mechanized feeding equipment, while many of the aversive tasks, such as catching and restraint for medicating and transport, still require human intervention.

Jones (1997) concluded that we must find ways of improving the human-animal relationship to maximize mutual benefits. This objective possibly could be met by careful psychological screening of employees, by training to increase farmers' or stockpersons' knowledge and appreciation of species-specific behaviors, and by (employee) behavior modification.

C. Pain and animal welfare

Pain is the subjective interpretation of nerve impulses induced by a stimulus that is actually or potentially damaging to tissues (Molony and Kent 1997, Sneddon and Gentle 2000). Sneddon and Gentle (2000) provide a review of the scientific literature regarding pain in farm animals. Pain is comprised of both a physiological sensory and a psychological or emotional component. Many procedures to which farm animals are subjected result in acutely painful conditions and lead to injury, disease and other noxious events and this will have negative consequences for the animal and on production (Table 1, Sneddon and Gentle 2000; Bath 1998).

These procedures include so-called "mutilations" such as castration, tail docking, disbudding or destruction of the horn bud, dehorning, branding, and beak-trimming as well as shackling and transport that can result in acutely painful states (Sneddon and Gentle 2000). Acute, or short-term, pain is that which lasts a few hours or days and should not outlast the healing process (Molony & Kent 1997).

Cattle may undergo other procedures made necessary by intensive production practices. Double-muscled, or heavily muscled, cattle, such as Piedmontese and Belgian Blue cows and cows crossed with large, heavily muscled bulls are subject to dystocia and surgical operation for removal of their calves (caesarian operations) (Figure 3-1) (Kruip and van Reenen 2000).

Figure 3-1. Cow showing evidence of multiple caesarian surgeries.

Photo credit: Ruth Harrison

"Ovum pickup" is a procedure used to harvest eggs from dairy cattle. A probe is passed through the vagina of the cow and a needle is inserted through the wall of the ovary to aspirate the eggs. An epidural may be given into the tail vertebrae to help the cow relax during the procedure and alleviate discomfort. Nevertheless, it is likely that this procedure causes significant acute pain to cows (particularly if it is conducted on them often) and it can cause other welfare problems such as chronic pain in the tail head and fused vertebrae (Farm Animal Welfare Council 1997).

Laying hens, broiler breeder chickens, and turkeys are typically beak-trimmed prior to 10 days of age by having their top beak (and sometimes the lower beak) partially amputated with a hot blade. In this procedure, one-third to one-half of the top beak is cut and cauterized (or a small hole is placed in the beak using a laser that causes the tip to fall off several days later) and then the bottom half of the beak is also slightly trimmed so that the two halves are of similar length. Laying hens may be beak-trimmed twice, the second time at about 10-12 weeks of age.

A number of acutely painful procedures on farm animals are justified by the industry on the basis that not performing them could lead to injuries and greater pain in later life and could adversely affect productive efficiency. Removing parts of the beak is one such procedure (Figure 3-2).

Figure 3-2. Chick undergoing beak-trimming procedure.

Photo from the website of United Poultry Concerns (http://www.upc-online.org)

Similarly, castration is performed in part to prevent fighting that could result in injury and difficulties in animal management. Pigs' tails are docked to prevent penmates from biting their tails, a habit that, once started, can lead to severe injuries and infection in the bitten pig. Simonsen, et al. (1991) found a high incidence of traumatic neuromas[20] in the tail stumps of docked pigs (resulting from the docking procedure). This raises the possibility that docking tails also has a negative welfare impact on pigs, because amputation neuromas may continue to cause significant pain to the pig for much of its life. Amputation neuromas can be a source of chronic pain, as can infections or disabilities resulting from procedures originally expected to cause only short-term pain. This includes neuromas that form in the trimmed beaks of laying hens, broiler breeders, turkeys, and ducks.

Cows being treated with recombinant bovine somatotrophin (rBST) are subjected to repeated injections, that may cause localized or wide ranging painful effects, and have a higher incidence of mastitis (a painful disease of the udder) and laminitis (lameness) than cows not treated with rBST (E.U. Scientific Committee on Animal Health and Animal Welfare 1999, E.U.

[20] A neuroma is a tumor composed of nerve tissue.

Scientific Committee on Veterinary Measures Relating to Public Health 1999). Painful leg disorders that can occur in cows kept in tie stalls on concrete may be exacerbated by rBST use (E.U. Scientific Committee on Animal Health and Animal Welfare 1999).

Do we know if animals experience these procedures as being painful in the same way we could imagine experiencing them as painful? Humans can tell each other how they are feeling, although even in this case it is not easy for one person to know exactly how another person is feeling and to some extent understanding another's pain must depend upon the observer's subjective experience of his or her own pain. Some people do not feel that animals can feel pain in the way that humans do (Molony and Kent 1997). "The human perception of pain is influenced very much by psychological factors, and so its perception by animals is difficult to assess" (Wood-Gush 1983, p. 198). The issue also raises the question of self-awareness and the extent to which this capacity is present in non-human animals. Some people believe animals are not capable of self-awareness or of knowing their place in time, i.e., not aware of the past or future but only the present. Rollin (1989) believes that the argument that animals live in the present only compounds the problem of pain if animals cannot imagine a time when it will cease—every moment represents an eternity. However, evidence from cognitive ethology suggests that mammalian and avian farm animals are capable of basing decisions about current behavior upon past events and on expectations of future outcomes (Dr. R. Newberry, December 2000, personal communication).

Bradshaw (1990) suggested that the question of whether subjective experience exists in animals is as old as the subject of philosophy itself, and scientifically insoluble. In this case, he says, for animal welfare scientists, whose professional interest concerns what is best for the animal, acceptance of the assumption that subjective experience in animals exists may be justified simply on the grounds that an assumption that it does not may be wrong. Other scientists state that physiological data can only confirm observations. By themselves they are not sufficient to determine welfare. Van Rooijen (1990) noted that physics confirmed the existence of atoms long after they were used as a model to explain chemical data.

The question of whether animals experience pain in a way that is significant for their welfare may be more of a philosophical than a scientific question. Physiologically, the responses to painful stimuli between humans and other mammals and birds are similar. On the other hand, the exact *behavioral responses* themselves differ dramatically between different species of animals and between individuals in the same species (Dr. J. Mench, December 2000, personal communication). Sheep, for example, are "utterly stoic" when subjected to even quite invasive procedures that would cause very overt behavioral reactions in humans but that does *not* mean they do not experience and feel the pain. It has been suggested that species-specific differences in pain behaviors have an evolutionary basis – a prey animal would not want a predator to know it is in pain or disabled.

It is likely that pain for these animals, at the least, is an "unpleasant sensory and emotional experience" (Sneddon and Gentle 2000). Molony and Kent (1997) assume that animal pain serves the same general purpose as human pain and that the *experiences* are similar, but that human pain and animal pain are not the same. Molony and Kent's (1997, p. 266) definition of animal pain is as follows:

> Animal pain is an aversive sensory and emotional experience representing an awareness by the animal of damage or threat to the integrity of its tissues; it changes the animal's physiology and behavior to reduce or avoid damage, to reduce the likelihood of recurrence and to promote recovery; unnecessary pain occurs when the intensity or duration of the experience is inappropriate for the

> damage sustained or when the physiological and behavioral responses to it are unsuccessful at alleviating it.

Fraser (Dr. D. Fraser, 2001, personal communication) notes that skeptics have long raised the philosophical issue of whether other species, or even other human beings, have experiential lives. Science has yet to reach a consensus about where, in the phylogenetic scale, organisms can be said to experience states such as pain, fear, boredom, and self-awareness. However, many concerns about farm animal welfare involve animals with very complex nervous systems (mammals, birds) and relatively elementary states such as pain and fear. In the case of pain, for example, there are major homologies between other mammals and humans; states thought to cause pain result in observable disruptions of animal behavior; and these disruptions can often be abolished by analgesia. For reasons such as these, there appears to be a widespread (albeit not unanimous) assumption by scientists that mammals and birds do experience pain. The abundance of research on animal pain, the veterinary use of anaesthesia and analgesia, and the use of pain-control measures in animal research all attest that the scientific community largely acts on the assumption that animals do feel pain.

Algers (Dr. B. Algers, December 2000, personal communication) calls pain and anxiety feedback mechanisms caused by evolution to increase fitness. The sensation of pain is a response to a noxious stimulus and should elicit protective motor (e.g. withdrawal reflex, escape) and vegetative responses (e.g. cardiovascular responses, inflammation). Zimmerman (1986) suggested that in animals a painful experience should result in learned avoidance. Therefore both behavioral and physiological criteria can be used to determine whether an experience is painful to an animal.

Two main methods are used to castrate cattle and sheep (Sneddon and Gentle 2000):

> 1) Application of a tight rubber ring around the scrotum that causes scrotal necrosis and eventual shedding of the structures including the testes.
> 2) Emasculator that crushes the spermatic cord and causes irreversible damage to the vessels supplying the scrotum.

In response to castration, calves and lambs demonstrate increased rates of kicking, rolling, restlessness, foot stamping, and abnormal postures (Sneddon and Gentle 2000). Castration has negative effects on behavior and weight gain and leads to reduced suckling, reduced standing, and increased lying times. Relating observations in lambs, for example, Sneddon and Gentle (2000) describe tail docking as an intense noxious stimulation that leads to periods of inert lateral lying.

Describing tail docking of young animals, Sneddon and Gentle (2000) state:

> The intense noxious stimulation by tail docking leads to periods of inert lateral lying and the analgesic, xylazine has been shown to reduce the behavioural and physiological consequences of tail docking. Both castration and tail docking can lead to chronic pain due to inflammation and the onset of infection at the lesion after the procedure. Kent, *et al.* (2000) has shown that abnormal behaviours indicative of pain persist for up to 41 days after castration and tail docking.

The result that administering pain relievers can reduce performance of abnormal behaviors resulting from these procedures is evidence that animals experience pain, as defined above, when subjected to them.

D. Effects of housing and management

Once in the agricultural enterprise, the animal must survive to produce or grow. It is assumed by some that animals that produce well are "happy." In practice, little attention is given to how the animal itself experiences potential problems. Two management factors are especially important to the welfare of the animal – degree and nature of confinement and intensity of production.

As noted above, when domestic animals are provided with an environment that is physically similar to the habitat of their wild ancestors, behavioral and physiological adaptations to the environment will be readily achieved (Price 1999). The more the production environment departs from the habitat of their wild ancestors, the more difficult will be the process of adaptation.

Writing in 1988, Ekesbo (p. 95) stated that "in the joint history of man and his farm animals,… no other definable and limited period during the last 10,000 years is characterized by such drastic changes in farm animal phenotypes and farm animal environments, including management, as the period since the 1950s….[I]n this respect the last three decades are unique in history." During those decades, "we have also witnessed a dramatic change in the disease-panorama in farm animals, with a considerable increase in new health problems" (Ekesbo 1988).

Duncan (1983) noted that, while old traditional environments too were artificial and involved confinement, they nevertheless proffered more freedom and variety to animals than current production systems and they had been more or less constant for hundreds of years. During the 1950s and 1960s, new artificial environments rapidly replaced the traditional housing. Rather than fitting the system to the animal, they alter the animal to fit the system (Andersson 2000). Rapidly changing environments have negative welfare effects because animals cannot cope with the changes.

As will become plain in the discussion of specific livestock species in Chapters 5, 6, and 7, the result has been that in many cases farming systems are pushing animals beyond their ability to adapt (Van Putten 1988).

References

Andersson, M. (2000). *Domestication effects on behaviour: Foraging, parent-offspring interactions and antipredation in pigs and fowl, Doctoral thesis, Acta Universitatis Agriculturae Sueciae; Veterinaria 86.* Uppsala, Sweden: Swedish University of Agricultural Sciences.

Bath G.F. (1998). Management of pain in production animals. *Applied Animal Behaviour Science*, 59(1-3), 147-156.

Bauman, D.E. & Currie, W.B. (1980). Partitioning of nutrients during pregnancy and lactation: A review of mechanisms involving homeostasis and homeorrhesis. *Journal of Dairy Science, 63,* 1514-1529.

Boissy, A. (1998). Fear and fearfulness in determining behavior. *Genetics and the behavior of domestic animals.* Grandin, T., ed. San Diego: Academic Press.

Bradshaw, R.H. (1990) The science of animal welfare and the subjective experience of animals. *Applied Animal Behaviour Science, 26*, 191-193.

Broom, D.M. (2000). Effects of dairy cattle breeding and production methods on animal welfare. Proceedings of the XXI World Buiatrics Congress Punta del Este, Uruguay.

Broom, D.M. (1999). The welfare of dairy cattle. In *Proceedings of the 25th International Dairy Congress, Aarhus, 1998, III, Future Milk Farming,*,32-39. K. Aagaard, Ed. Aarhus: Danish National Committee of International Dairy Federation.

Campbell, J.R. & Lasley, J.F. (1985). *The science of animals that serve humanity*. 3rd edition. New York: McGraw-Hill Book Company.

Carpenter, E. (1980). *Animals and ethics*. London: Watkins.

Crooker, B., Halvorson, D., Moon, R., Phillips, C., Noll, S., Johnston, L., Reneau, J., Chester-Jones, H., Hathaway, M., Goyal, S., Janni, K., Pijoan, C., Shields, T., Stromberg, T., Patterson, C., Dee, S., Blaha, T., and Wells, S. (1999). A summary of the literature related to animal agriculture health. *Generic environmental impact statement on animal agriculture, MN*. St. Paul, MN: Environmental Quality Board.

Duncan, I.J.H. (1983). Assessing the effect of housing on welfare, (pp. 27-35) in Farm animal housing and welfare. Baxter, et al., (Eds.). Boston: Martinus Nijhoff Publishers.

Duncan, I.J.H. (1994). Practices of concern. *Journal of the American Veterinary Medical Association, 204 (3),* 379-384.

Ekesbo, I. (1988). Animal health implications as a result of future livestock and husbandry developments. *Applied Animal Behaviour Science, 20,* 95-104.

E.U. Scientific Committee on Animal Health and Animal Welfare. (1999a, March 10). *Report of the Scientific Committee on Animal Health and Animal Welfare on animal welfare aspects of the use of bovine somatotrophin*. Brussels: Health and Consumer Protection Directorate, European Commission, Health and Consumer Protection branch.
http://europa.eu.int/comm/dg24/health/sc/scah/out21_en.pdf

E.U. Scientific Committee on Veterinary Measures Relating to Public Health. (1999, March 15-16). *Report on public health aspects of the use of bovine somatotrophin*. Report of the Scientific Committee on Veterinary Measures Relating to Public Health. Brussels: Health and Consumer Protection Directorate, European Commission.
http://europa.eu.int/comm/dg24/health/sc/scv/out19_en.html

Farm Animal Welfare Council. (1997). *Report: Welfare of dairy cattle.* London: MAFF, FAWC.

Fraser, A.F. (1960). Spontaneously occurring forms of "tonic immobility" in farm animals. *Canadian Journal of Comp. Med. 24:* 330-332.

Fraser, A.F. & Broom, D.M. (1990). *Farm animal behaviour and welfare*. London: Ballière Tindall.

Fraser, D., Weary, D.M, Pajor, E.A., & Milligan, B.N. (1997). A scientific conception of animal welfare that reflects ethical concerns. *Animal Welfare, 6(3*): 187-205.

Grandin, T. (2000). Can we make transport and slaughter tolerable to farm animals? Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Inst. for Animal Sci. and Animal Behav., Mariensee, Germany.

Grandin, T. (1998). *Genetics and the behavior of domestic animals.* New York: Academic Press.

Gregory, N.G., Wilkins, L.J., Eleperuma, S.D., Ballantyne, A.J., & Overfield, N.D. (1989). Broken bones in domestic fows: Effect of husbandry system and stunning method in end-of-lay hens. *British Poultry Science, 31*, 39-49.

Hemsworth, P.H., Barnett, J.L., & Hansen. C. (1981a.). The influence of handling by humans on the behavior, growth, and corticosteroids in the juvenile female pig. *Hormones and Behavior, 15,* 396-403.

Hemsworth, P.H., Brand, A., & Willems, P. (1981b). The behavioural response of sows to the presence of human beings and its relation to productivity. *Livestock Production Science, 8*, 67-74.

Hemsworth, P.H., Barnett, J.L., & Hansen, C. (1986). The influence of handling by humans on the behaviour, reproduction and corticosteroids of male and female pigs. *Applied Animal Behaviour Science, 15*, 303-314.

Hemsworth, P.H., Barnett, J.L., & Hansen, C. (1987). The influence of inconsistent handling by humans on the behaviour, growth, and corticosteroids of young pigs. *Applied Animal Behaviour Science, 17*, 245-252.

Hemsworth, P.H. & Barnett, J.L. (1987, June). The human-animal relationship and its importance in pig production, *Pig News and Information, 8(2).*

Hemsworth, P.H., Barnett, J.L., Coleman, G.J., & Hansen, C. (1989). A study of the relationships between the attitudinal and behavioural profiles of stockpersons and the level of fear in humans and reproductive performance of commercial pigs. *Applied Animal Behaviour Science, 23,* 301-314.

Hirt, H. Reinmann, M., & Oester, H. (1997). Leg problems in fattening turkeys. *Proceedings of the Fifth International Symposium on Poultry Welfare*. Koene, P. and Blokhuis, H.J., eds. Wageningen, NE: Wageningen Agricultural University, pp. 80-82.

Jensen, P. (1980). An ethogram of social interaction patterns in group-housed dry sows. *Applied Animal Ethology,* 341-350.

Jensen, P. (1982). An analysis of agonistic interaction patterns in group-housed dry sows – aggression regulation through an "avoidance order". *Applied Animal Ethology, 9,* 47-56.

Jones, R.B. (1996a, July). Fear and adaptation in poultry: insights, implications and imperatives. *World's Poultry Science Journal, 52*, 131-174.

Jones, R.B. (1996b). The tonic immobility reaction of the domestic fowl: A review. *World's Poultry Science Journal, 42,* 82-96.

Jones, R.B. (1997). Fear and distress. In *Animal Welfare*, Appleby, M. & Hughes, B., eds. New York: CAB International.

Kent J.E., Jackson R.E., Molony V. & Hosie B.D. (2000). Effects of acute pain reduction methods on the chronic inflammatory lesions and behaviour of lambs castrated and tail docked with rubber rings at less than two days of age. Vet. J. 160 (1), 33-41.

Kruip, Th.A.M. & van Reenen, C.G. (2000). Biotechnology of reproduction and farm animals welfare. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Loula, T. (2000). Increasing sow longevity: The role of people and management. *Proceedings of the 2000 Allen D. Leman Swine Conference, Volume 27*, St. Paul, MN, Scruton, W.C. & Claas, S., eds. St. Paul, MN: Veterinary Outreach Programs, College of Veterinary Medicine, University of Minnesota.

Mench, J.A. (1994). Environmental enrichment and exploration. *Lab Animal, February*, 38-41.

Molony, V. & Kent, J.E. (1997). Assessment of acute pain in farm animals using behavioral and physiological measurements. *Journal of Animal Science, 75*, 266-272.

Newberry, R.C. (1999). Exploratory behaviour of young domestic fowl. *Applied Animal Behaviour Science, 63,* 311-321.

Price, E.O. (1999). Behavioral development in animals undergoing domestication. *Applied Animal Behaviour Science 65:* 245-271.

Rauw, W.M., Kanis, E., Noordhuizen-Stassen, E.N., & Grommers, F.J. (1998). Undesirable side effects of selection for high production efficiency in farm animals: a review. *Livestock Production Science, 56,* 15-33.

Rollin, B.E. (1989). *The unheeded cry: Animal consciousness, animal pain, and science.* New York: Oxford University Press.

Rushen, J. (2000). The welfare of the high-producing animal. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Rushen, J., Taylor, A.A., de Passillé, A.-M. (1999). Domestic animals' fear of humans and its effect on their welfare. *Applied Animal Behaviour Science, 65,* 285-303.

Seabrook, M.F. (1980). The psychological relationship between dairy cows and dairy cowmen and its implications for animal welfare. *International Journal for the Study of Animal Problems,1(5),*295-298.

Simonsen, H.B., Klinken, L., and Bindseil, E. (1991). Histopathology of intact and docked pigtails. *British Veterinary Journal, 147:* 407-411.

Sneddon, L.U. & Gentle, M.J. (2000). Pain in farm animals. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Van Putten, G. (1988). Farming beyond the ability of pigs to adapt. *Applied Animal Behaviour Science, 20:* 63-71.

Van Rooijen, J. (1990) Physiology, behaviour and well-being. *Applied Animal Behaviour Science 27,* 367-368.

Webster, J. (1995). *Animal welfare: A cool eye towards Eden*. Cambridge: Blackwell Science, Ltd.

Wood-Gush, D.G.M. (1983). *Elements of Ethology*. London: Chapman and Hall.

Zimmerman, M. (1986). Physiological mechanisms of pain and its treatment. *Klinische Anästhesiologie und Intensivtherapie*, 32, 1-19.

CHAPTER 4

SPECIFIC MANAGEMENT PRACTICES ANTIBIOTIC USE AND FOOD SAFETY

I. Antibiotics and animal welfare

An overwhelming body of evidence exists indicating that the livestock industry's continued, routine use of antibiotic feed additives at subtherapeutic levels contributes to antibiotic resistance (WHO (World Health Organization) 1997a&b). Reduced effectiveness of antibiotics for treatment of bacterial diseases is not only a human health issue, but also an animal welfare issue because:

- the development of resistance to antibiotics by bacterial pathogens reduces the efficacy of antibiotics for treatment of animal diseases and
- the subtherapeutic use of antibiotics to promote growth and control disease in farm animals permits industry to keep farm animals in conditions that are detrimental to their health and well-being.

II. Background

Almost as soon as the first antibiotics were introduced, even prior to their use in farm animals, concerns were raised that with their increased use, some bacteria were becoming resistant (Harrison 1964). Antibiotics were first introduced into veterinary use in the 1940s to cope with diseases that resulted from crowding large numbers of farm animals into confinement buildings.

By 1950, it had been discovered that small amounts of antibiotics, below therapeutic levels (i.e., subtherapeutic[21]), added to the feed of pigs and poultry increased their growth rates and the efficiency with which they converted feed into meat (JSC 1960). Interest soon arose concerning these "unknown growth factors" that caused more rapid growth and better feed utilization in pigs and poultry. The interest was especially keen in the United States (JSC 1960).

Concerns about buildup of resistance increased when antibiotics began to be used "preventatively" at subtherapeutic levels in animal feeds to control disease outbreaks. The United States began to use specific antibiotics to promote growth and prevent disease in farm animals in 1949, Great Britain in 1953 (JSC 1960).

[21] Subtherapeutic also implies non-therapeutic, as the amounts used are too small to treat disease.

The National Research Council (NRC 1999) has defined subtherapeutic use in the US as:

> the use of an antibiotic as a feed additive at less than 200 grams per ton of feed [that] delivers antibiotics that have therapeutic effects but *at dosages below those required to treat established infections* (emphasis added)…

while

> up to 50 grams of an antibiotic or antibiotics are added to a ton of animal feed *to promote growth in the animals eating it* (emphasis added).

Either of these subtherapeutic levels is sufficient to allow resistance to develop (Franklin 1997).

Early on it was recognized that improvements in growth performance following subtherapeutic antibiotic feeding appeared to be greatest on farms that lacked good hygiene in the barns or good health management (JSC 1960). Although subtherapeutic levels of antibiotics do not prevent bacterial pathogens from infecting animals, they can prevent subclinically present diseases from becoming clinical (JSC 1960). Today it is recognized that the disease-controlling and growth-promoting effects of subtherapeutic levels of antibiotics are strongest in herds on farms with low hygienic standards and crowded, stressful conditions that put animals at a high risk of infectious diseases (Franklin 1997). According to the National Research Council (NRC 1999),

> the [disease control or prophylactic] effect is less pronounced in clean, healthful, and stress-free environments [while] beneficial effects of subtherapeutic antibiotic feed additives are greatest in poor sanitary conditions.

Absence of clinical disease symptoms in herds where low levels of antibiotics are regularly added to the animals' feed as "preventives" does not necessarily indicate that no disease is present in the herd, only that it is controlled and outbreaks of subclinically present diseases are possibly being prevented.

In the US today, nearly 30 antibiotics and chemotherapeutics are approved for use in farm animals as subtherapeutic feed additives to promote growth and feed efficiency and to control diseases (Backström 1999, Franklin 1997). Eleven of these antibiotics -- including penicillin and the tetracyclines -- are identical to those used in treatment of human disease (Backström 1999). Feed additives also include the so-called antibiotics of last resort for treatment of human diseases, such as vancomycin.

Medical scientists have estimated that about 40% to 45% of antibiotics produced in the United States is used in animals (Levy 1998). Eighty percent of this is used subtherapeutically in feed or water of farm animals to make them grow faster and to control disease under less than optimal environmental and management conditions from the animals' welfare standpoint. Only 20% of antibiotic feed additives are used to treat actual animal illnesses.

Recently, the U.S. Animal Health Institute, a trade association representing companies that develop and manufacture pharmaceuticals and other animal health products, reported that 83% of feed additive antibiotics are used for prevention and treatment of disease while only 6.1% are used for growth promotion (Anonymous 2000). On the face of it, these figures appear to contradict the figures of medical scientists noted above (Levy 1998), but the claim may be

misleading. It is difficult to distinguish between the growth promoting and disease controlling effects of subtherapeutic antibiotic use. This is because prophylaxis itself promotes growth (Franklin 1997) for the following reason (NRC 1999):

> when antibiotics stabilize animal health, food animals can reduce the portion of nutrient requirements associated with the immune response to fight infection and [instead] use those nutrients for growth and reproductive purposes.

More recently, noting that current estimates of antibiotic use in animal production as between 40% and 50% of total antibiotic use in the US are based on data that are over 20 years old, the public interest group Union of Concerned Scientists investigated antibiotic use in US agricultural animals. In January 2001, it published a report concluding that overall use of antimocrobials for nontherapeutic purposes in animals has increased by about 50% since 1985 and that the quantities of antimicrobials used for nonthereaputic purposes in livestock account for 70% of total antimicrobial use. With all agricultural uses (crop pesticides included) this figure could be 84% (Mellon, et al. 2001).

Antibiotics were used in the diets of breeding females (sows) on 45.5% of US hog operations in 1995 and in the diets of breeding males (boars) on 38.4% of US hog operations (APHIS 1995). Both figures increased in 1995 over 1990 figures – for sows by 6.1% and for boars by 27.5%. Subtherapeutic antibiotic use in the breeding herd helps overcome problems in the production system by increasing conception rates, pigs born per litter, and piglet birth weights, and reducing the incidence of mastitis in sows (National Research Council 1999). Nearly 93% of pigs in the United States received antibiotics in the diet at some time during the grow/finish period (APHIS 1995).

The Union of Concerned Scientists (Mellon, et al. 2001) estimated that 3,693,017 pounds of antibiotics were used non-therapeutically in production of cattle and (veal) calves for meat, 10,348,596 pounds of antibiotics were used in the swine industry, and 10,535,926 pounds of antibiotics were used in the poultry industry in 1998. Nearly all of the subtherapeutic use of antibiotics in the dairy industry is in the raising of veal calves. Of the estimated, nearly 3,700,000 pounds of antibiotics used at subtherapeutic levels in beef production, only about 7,000 pounds of that amount were used for production of veal, or about 0.2% of total cattle use.

Between 1985 and the late 1990s, total pounds of antibiotics fed to poultry increased by 307% on a per-bird basis, while tetracycline use increased by 92%. During that time the broiler industry grew from 4.5 billion per year to 7.8 billion per year (Mellon, et al. 2001).

III. Obstacles to curtailing subtherapeutic use of antibiotics as animal feed additives

The market for antibiotics is influenced by the levels of resistance that exist in the microbial population (Decision Resources, Inc. 2000). Because it costs a great deal to bring a new antibiotic on the market, drug companies have a strong incentive to sell as much of it as possible, contributing to the resistance problem that calls forth new efforts to develop a substitute. Shareholders and investors in pharmaceutical companies demand high returns on their shares, putting additional pressure on sales (Burstall and Reuben 1999). Pressures from the pharmaceutical industry, the animal feed industry, and commodity organizations have delayed government efforts to regulate the use of antibiotics in US animal production (for a history of the antibiotic debates, see Halverson 2000).

A further obstacle is a shortsighted view on the part of policymakers of the economic impacts of curtailing antibiotic use as animal feed additives. This view looks only at the private and social costs of ending antibiotic use in animal feeds and fails to weigh against them (1) the private and social costs of continuing subtherapeutic antibiotic use in animal feeds and (2) the benefits from better animal health that would follow the needed industry adjustments (i.e., as a result of more preventive health management).

According to the National Research Council (NRC 1999):

> researchers in some European countries would suggest that a shift to less intensive rearing and increased attention to hygiene can resolve many of the situations where the disease and stress load on animals might warrant the use of antibiotics and augment the risk to human health.

For example, Wegener (1999) recommended "better feeding practices and production systems that promote animal health and welfare"; Witte (1998) stated that "[s]imilar benefits [to subtherapeutic antibiotic feed additives] can be generated by improving other aspects of animal care, such as hygiene"; and the World Health Organization (1997a) recommended improving production environments by raising the level of hygiene and reducing stress.

However, the NRC report authors, noting the difference in magnitude and scale of animal agriculture in the United States compared to Europe, as well as the economic importance of subtherapeutic antibiotic use to current industry practices advised *against* banning the prophylactic and growth-promoting use of antibiotics in animal feeds, concluding that the costs would exceed the benefits and be disruptive to today's packing industry (NRC 1999).

III. Pressure to curtail non-therapeutic antibiotic use in animal feeds

A. Europe

Over the past two to three decades, worldwide pressure has been mounting to put an end to antibiotic use as feed additives. In 1997, the World Health Organization recommended that the use of any antimicrobial agent for growth promotion in farm animals should be terminated if it is used in human therapeutics or known to select for cross-resistance to antimicrobials used in human medicine (WHO 1997a, b).

The United Kingdom restricted to veterinary prescription the use of antibiotics used to treat disease in humans and animals in 1971 (GAO 1977). In 1977, Sweden instituted a similar restriction. In response to a renewal of the debate in the early 1980s, Sweden's farmers asked the government to institute a ban on all antibiotic animal feed additives in 1985 and the ban went into effect in 1986. In 1997, Sweden defended its ban to the EU and the scientific evidence presented can be found on the internet (Swedish Ministry of Agriculture 1997, November).

In January 1998, Denmark banned the use of virginiamycin as an animal growth promoter and the European Union (EU) followed suit, citing scientific evidence presented by Sweden, Finland, and Denmark. The EU banned four antibiotic feed additives: virginiamycin,

spiramycin, tylosin phosphate, and bacitracin-zinc, and granted exceptions to the ban for antibiotics not used in human or animal therapy (European Community 1998).

The makers of virginiamycin and bacitracin-zinc, Pfizer, Inc. and Alpharma, sued Denmark and the EU seeking a reversal of the decision and asking for an immediate suspension of the regulation's "operation" (European Court of First Instance 1999). On June 30, 1999, the President of the European Court of First Instance found against the companies' request for immediate suspension, because the companies had not shown that the ban on sales in the European Union would cause them serious and irreparable damage, and because the "public health must take precedence over economic considerations." Denmark now has a voluntary ban to stop use of all growth promoters.

B. The U.S.

On January 26, 1999, the Food and Drug Administration (FDA) released for comments *A Proposed Framework for Evaluating and Assuring the Human Safety of the Microbial Effects of Antimicrobial New Animal Drugs Intended for Use in Food Producing Animals* (FDA 1999a). The FDA noted that the weight of the evidence, particularly in the past decade, indicates there is a relationship between use of antibiotic feed additives as growth promoters and resistance buildup in bacteria previously susceptible to the antibiotics and that this evidence is sufficient to take the measures it proposed. The agribusiness and animal health industry interpreted the published framework as an overreaction by the FDA and called for more research (FDA 1999b).

In support of its proposal, the FDA noted European studies published since 1993, which showed that comparisons of vancomycin resistance in organically reared poultry and in conventionally reared poultry fed avoparcin as a growth promoter found no vancomycin resistant enterococci in organically reared birds (organic standards forbid feeding antibiotics) and detected vancomycin resistant enterococci in the majority of conventionally reared birds (FDA 1999b). The investigators also compared conventional swine and poultry flocks that did and did not use avoparcin, and found a strong, statistically significant association between the presence of vancomycin resistant enterococci in the animals and use of avoparcin as a growth promoter (FDA 1999b).

In March 1999, fifty scientists and forty-one public interest groups called on the FDA to ban the use of certain antibiotics as growth promoters (CSPI 1999).

On November 9, 1999, Representative Sherrod Brown of Ohio, along with Representatives Henry Waxman and Louise Slaughter, introduced H.R. 3266, "to direct that essential antibiotic drugs not be used in livestock unless there is a reasonable certainty of no harm to human health" (U.S. Congress 1999).

1. The Case of Fluoroquinolones

The case of fluoroquinolones demonstrates how difficult it is to overcome industry resistance to efforts by medical scientists, the Federal government, and consumer, animal welfare and environmental groups to end industry's reliance on subtherapeutic antibiotic use to control animal diseases and promote growth.

In 1995, FDA approved subtherapeutic use of one of the fluoroquinolone antibiotics in poultry drinking water to control illnesses caused by *E. coli* bacteria (McLearn 1995). The fluoroquinolones are used to treat *Campylobacter* and other bacterial infections in humans. The FDA approval was given under strong industry pressure and in spite of evidence from Europe that *Campylobacter* had become resistant to fluoroquinolones after they were added to animal feeds. The low levels of fluoroquinolone added to poultry drinking water to control *E. coli* do not kill *Campylobacter*, a bacterium that is also present in chickens. As had happened in Europe, *Campylobacter* in the United States developed resistance to fluoroquinolones (Kronemyer 1999).

Trends are *indirect*, not *direct*, evidence of linkage or causation. In May 1999, *The New England Journal of Medicine* published a Minnesota study that went further in establishing the sought after direct link (Smith, et al. 1999). The Minnesota study documented that DNA fingerprints in quinolone-resistant *Campylobacter jejuni* from domestically produced poultry were identical to those in the resistant *C. jejuni* from domestically-acquired infections in humans (Smith, et al. 1999).

Following the study's release, the animal health industry contended "no significant risk to humans [stemming from antibiotic feed additives for animals] has been documented" and warned farmers and veterinarians to "remain informed about *potential political threats* to drug availability, threats based on fear and speculation rather than science and data" (Kronemyer 1999).

On October 26, 2000, the FDA's Center for Veterinary Medicine (CVM) announced that it is considering withdrawing approval of the new animal drug application (NADA) for the use of the fluoroquinolone enrofloxacin in poultry (FDA 2000, Muirhead 2000), stating that:

- The use of fluoroquinolones in poultry causes the development of fluoroquinolone-resistant campylobacter, a pathogen to humans, in poultry;
- fluoroquinolone-resistant campylobacter is transferred to humans and is a significant cause of the development of fluoroquinolone-resistant campylobacter infections in humans, and
- fluoroquinolone-resistant campylobacter infections are a hazard to human health.

FDA-CVM further noted that although fluoroquinolones have been available for human use since 1986 and are commonly prescribed for gastrointestinal illnesses, resistance to fluoroquinolones did not increase among campylobacter organisms until 1996 and 1997, shortly after the approval and use of the fluoroquinolones in poultry. Fluoroquinolone-resistant campylobacter infections (including *C. jejuni*) in humans had reached 13.5% by 1998 and 17.6% for *C. jejuni* alone in 1999.

Based on its investigations the CVM concluded that:

- the primary cause of the emergence of domestically acquired fluoroquinolone-resistant campylobacter infections in humans is consumption of or contact with contaminated food;
- poultry are a predominant source of campylobacteriosis in humans;
- poultry carrying fluoroquinolone-resistant campylobacter are the predominant source of fluoroquinolone-resistant campylobacteriosis in humans, and

- the administration of fluoroquinolones to chickens leads to the development of fluroquinolone-resistant campylobacter in chickens.

The industry continued to oppose the CVM conclusions (Muirhead 2000).

IV. Living without subtherapeutic antibiotic feed additives, Sweden's experience

Chapter 10 describes the ban and other regulations related to animal welfare in Sweden, including the Swedish salmonella control law.

A. Adjustment to the ban on subtherapeutic antibiotic feed additives

In 1985, as a way of increasing consumer confidence in Swedish meat and other animal products in response to the debate that was occurring in the 1980s regarding antibiotic resistance, Swedish farmers approached the government through their national organization the Lantbrukarnas Riksförbund (LRF) and asked the government to place a permanent ban on the non-therapeutic use of antibiotics in animal agriculture (Scan 1992). Swedish farmers were proud of their high herd health situation and felt they could easily survive such a ban.

While the poultry and cattle industries made comparatively smooth transitions, piglet producers had no way of anticipating the health and economic effects that were to follow in piglet production. On many piglet-producing farms, withdrawal of antibiotics from the feeds unmasked disease pressures that low-level antibiotic feed additives had kept "hidden." Small pigs became sick and died from weaning diarrhea, or "scours." Because there was a law, they could not go back. It would have been possible simply to substitute another kind of additive (such as zinc) for the missing antibiotics, and some farmers did this. But these substitutions have the potential to create pollution problems. It had been observed that farms having a high level of hygiene and using straw in the pens escaped the adverse impacts and had few problems adjusting. Making use of this observation, and to cope with the ban in more natural ways, Swedish farmers who were having problems changed facilities and management to provide a higher level of welfare to the animals than before (Wierup 1998).

Changes included increasing the space allotted to each individual animal and providing straw (Wierup 1998). The straw was a natural source of warmth, dietary fiber, and occupation for the animals. Fresh straw, continually added to the beds, kept the livestock separated from their waste. Farmers weaned pigs at five to six weeks of age. This length of time allowed small pigs to build their own antibodies by exposure to microorganisms in the environment and accustom their guts to solid feed before weaning.

These improvements helped keep the pigs' natural immunity high by reducing the stress of weaning and confinement and increasing the hygiene level in the barns. Among other farmer adjustments in response to the ban were adoption of deep-straw farrowing and nursing systems, grow-finish systems where piglets were weaned onto straw beds, all in-all out production schedules, where pigs were reared in stable groups and rooms were cleaned after every group was moved, and different feed contents and rations (Wierup 1998). Weaning piglets on deep straw

beds dramatically reduced the incidence of weaning diarrhea and use of therapeutic antibiotics (Dr. B. Algers, December 2000, personal communication, Holmgren and Lundeheim 1994).

B. Animal health impacts

Today, total antibiotic use for food animals in Sweden is 55% lower than before the ban, the incidence of antibiotic resistant bacteria has been reduced, animal health is very high, and production levels are close to pre-ban levels (Wierup 1998). For example, resistance to antibacterial agents in Salmonella typhimurium in Swedish animals is shown in the following table from the Swedish Ministry of Agriculture (1997):

Table 4-1. Percentage of resistance to antibacterial agents in Salmonella typhimurium in Swedish animals.

Substance	Inflection Point µg/ml[1]	Percentage 1978-86	1988-91	1992-94
Ampicillin	>8	2	2	0
Streptomycin	>32	78	32	17
Tetracycline	>8	14	6	0
Trimetoprim-Sulpha	>0.5	0	0	2[2]
Enrofloxacin	>0.5	-	0	0

[1]Breakpoint: value above which the isolate is considered resistant
[2]Isolated from pigeons

Lowered resistence means animals respond better to treatment with antibiotics, reducing the time they are ill or unproductive.

C. Economic impacts

Post-ban production costs have been only slightly higher than pre-ban costs, due in part to improved animal health requiring fewer veterinary consultations and better productivity and in part to Swedish farmers' innovative adjustments (Andersson and Jonasson 1997, Wierup 1998). Andersson and Jonasson (1997) also estimated benefits to farmers from better animal health when they figured the farmers' costs of the ban. In their study, net increase in production cost per pound of pork produced was around 3.6¢ for producing under the Swedish model, which includes Sweden's animal and environmental protection laws as well as the feed-additive antibiotics ban. Considering only the feed-level antibiotics ban, cost of producing one pound of pork increased by less than 1¢ (0.72¢) (Swedish Ministry of Agriculture 1997) (using 6.5 SEK to $1 conversion rate).

The Ministry noted that some have criticized the Swedish ban on the basis that banning antimicrobial feed additives increases the consumption of animal feed and thus emissions of nitrogen and phosphorus (Swedish Ministry of Agriculture 1997). However, 1997 figures from industry data showed that fattening pigs' feed consumption was an average 36.0 MJ/kg in

Sweden, while fattening pigs' feed consumption data in Denmark, where antibiotic growth promoters were still used, averaged 36.4MJ/kg.

In return for perceived public health benefits, consumers in Sweden have been willing to pay the slightly higher price needed for Swedish farmers to produce meat and poultry products without growth promoting and prophylactic antibiotic use (Swedish Consumers' Association 1998; George 2001).

Swedish farmers do not operate in an easier economic environment than American farmers. Since entering the European Union, Sweden dropped trade barriers against imports from the EU. Swedish farmers must produce under much stricter environmental and community standards than US farmers. They must provide animals the space and high professional level of management that allows them to produce without antibiotic prophylactics and growth promoters and in accordance with strict standards of farm animal welfare, and they must be profitable. They must rely on the market for disposal of their products and cannot rely on the government to purchase surpluses. In addition, they must conform to a number of very strict environmental laws, including qualitative placed upon buildings by local communities.

The Swedish regard improved animal welfare, particularly five to six week weaning and the addition of straw to small pigs' environments, as central to Swedish pig farmers' successful adjustment to antibiotic restrictions (G. Ståhle, 1992, personal communication). No major housing and management adjustments were necessary for keeping sows and boars without antibiotic feed additives. The majority of Swedish farmers have, since the mid-1980s, kept their sows loose-housed in groups on deep straw.

V. Implications for the US

In a controlled study reported by the Institute of Medicine, fecal coliform from a herd of pigs fed and treated with antibiotics continuously for 13 years exhibited a 90% resistance level to tetracycline (IOM 1989). The herd was then kept antibiotic free and closely monitored. It took an additional 13 years for resistance levels to drop to 30%. If this experience applies generally, it may be that the first 10 years of a ban on subtherapeutic antibiotic feed additive use in the United States would see only minor revival of the efficacy of antibiotics that have been used by the animal industry for growth promotion and disease control since 1949.[22]

In another U.S. study, bacteria from participating hog farms where antibiotic use was limited had significantly lower incidence of resistance than bacteria from control farms where antibiotics were routinely used at subtherapeutic levels in the feed (Mathew, et al. 1998).

Figures given for costs to consumers of removing antimicrobials from production systems -- $3.5 billion annually – are initially alarming (Crooker, et al. 1999, citing Hays (1991)) although they work out to a little over $13 per capita per year in the United States. A common

[22] Sweden's efforts to retain its ban on subtherapeutic antibiotic feed additives should be viewed in this context. Given the struggle and economic costs of their successful adjustment to the ban and the animal and human health benefits they are now experiencing, it would not be fair to Swedish farmers to weaken the law now, allow them to go through a regression in animal health, and then subject them to new restrictions once the rest of the world has caught up to where Swedish farmers started out in 1986.

problem with such estimates is that they do not estimate the benefits to consumers of improved efficacy of antimicrobial treatments of bacterial illnesses infecting humans. Nor do they estimate the eventual benefits to animal agriculture of increased effectiveness of antibiotics for treating animal diseases (in the form of lowered resistance of pathogens to antibiotics). They do not include the high costs of antimicrobial resistance to human and animal health and well-being.

A 1999 Iowa State University (ISU) study estimated the economic impact of a ban on the use of over-the-counter (non-prescription) antibiotics for hog farming in the United States (Hayes, et al. 1999). The authors estimated outcomes from three different scenarios over a ten-year period from 2000 to 2010. Under all three scenarios, costs to both hog producers and pork consumers increased. Under their most likely scenario, the authors estimated that such a ban would add 5.2¢ to the retail price of a pound of pork and would cost the farmer an additional $6.05 per market hog to produce in the first year of the ban and $5.24 per hog by the end of the ten year period. Based on their per hog costs to producers of $6.05 the first year of a ban and $5.24 by the end of the year, Hayes, et al. (1999) projected a $1.039 billion decline in present value of the industry over the 10-year period. This was the sum of "foregone" profits over 10 years on hogs marketed, discounted to the present at a seven percent rate.

Put in a different way, the human population of the United States (1995 Census data) is approximately 263.814 million, while consumer demand for pork has ranged between 48-53 pounds per capita each year since 1982 (the per capita, domestic consumer demand for pork as a commodity is typically inelastic, meaning that historically there have been only three ways to increase sales of pork: population growth, government purchases, and export (Boehlje, et al. 1997)). At the Hayes, et al. (1999) projected additional 5.2¢ per pound, and assuming an average of 50 pounds of pork consumed per person each year, each consumer would pay $2.60 additional per year, amounting to an additional $686 million for U.S. consumers for eliminating agricultural over the counter use and routine feed additive antibiotic use.

If 100,000,000 hogs were produced the first year of the Hayes ban, at a cost of $6.05 extra per hog, the price of an antibiotic feed additive ban would be $605 million to producers, so the additional costs to consumers and producers would be $1.286 billion (piglet mortality prior to full adjustment could reduce the number of hogs produced).

With respect to where the impacts of an antibiotic feed additive ban would fall, Hayes, et al. (1999) noted that it is estimated that as much as 20 percent of U.S. hog production still originates on farms that have not yet adopted all in-all out [i.e., use continuous flow systems].

Hayes, et al (1999) predicted:

> It seems likely that many of the remaining continuous flow systems are owned by individuals who are financially marginal, or who plan to stop production in the future. A likely possibility is that a ban would cause the majority of these producers to exit the industry. From a purely economic perspective the closing down of these older farms makes sense…. However, many of these operations are owned by small to medium family farms and some exist on farms that would not otherwise justify the full-time input of the producer. The ongoing trend away from this type of production unit has created social tensions and any acceleration of this trend will only increase these tensions.… The largest impact would be expected on densely populated farms in counties with large numbers of hog farms who have older buildings and who do not follow sound management practices…. Anecdotal evidence suggests that the impact of the ban on the very

largest producers would be minimal.… These producers would likely improve their competitive position should a ban be implemented.

The arguments of Hayes, et al. (2000) are counterintuitive to the prevailing wisdom that antibiotic use made possible the trend away from smaller farms towards intensive confinement operations (Levy 1998, IOM 1980, National Research Council 1980, 1999). There already are a number of small, independent farmer ventures that have successfully made the transition to producing without any antibiotics, even for therapeutic purposes (for example, in the Minnesota-Iowa-Wisconsin area, CROPP (organic milk), MOMS (organic milk), and Niman Ranch (antibiotic-free pork). (See, also, Marbery 1999, as well as Behr 1999, Burros 1999, Looker 2000, and Unterman 1999). (Here, treated animals (or their products) go into generic markets.)

Smaller producers may be able to adjust by management and husbandry improvements and not necessarily by large capital investments, while for highly-capitalized investors the costs of retrofitting and management changes are likely to be relatively higher. Cheap labor which delivers many economies of scale to industrialized hog producing firms would need to be replaced by educated and experienced workers that are skilled in husbandry and able to diagnose diseases quickly to stay on top of infectious outbreaks. Skilled workers would cost more. Hence, the potential impacts of a ban on use of antibiotic feed additives on the US animal agriculture sector are not so obvious *ex ante*.

A number of alternative disease preventive measures exist. Management- rather than capital-oriented measures based on enhancing the immune status of the animal rather than on compensating for reduced immune status caused either by stressful and unhygienic production environments or by stressful early weaning programs (Chapters 7, 10) could be made available to small farmers.

In a separate analysis, Wade and Barkley (1992) concluded that both consumers and hog producers would receive net benefits slightly overall from a ban on feed-grade antibiotics. They allowed for the likelihood that an increase in pork demand would result from consumer perceptions of safer meat offsetting increased production costs.

Finally, when conducting cost benefit studies of a ban on subtherapeutic antibiotic feed additives or other socially-oriented reforms to agricultural practices, the costs of maintaining the status quo with respect to the practice need to be figured into the calculations. For example, in the case of cost-benefit analysis of an antibiotic feed additive ban, it should be considered that the cost of infections to society as a whole caused by drug-resistant organisms in the United States, at least some of which originate in agriculture, has been estimated to be $4 billion, annually (Boggs 1999), or a little over $15 per person.

References

Andersson, H. & Jonasson, L. (1997). *Den Svenska Modellen: Hävstång eller ok für Svensk svinproduktion*? Uppsala, Sweden: Swedish University of Agricultural Sciences.

Anonymous. (2000, February 14). Survey indicates most animal antibiotics used for treating, preventing disease. *Feedstuffs Magazine*, p. 4.

APHIS (Animal Plant Health Inspection Service). (1995). *Antibiotic usage in premarket swine. National Animal Health Monitoring System factsheet*. Washington, D.C.: U.S. Department of Agriculture, Animal Plant Health Inspection Service, Veterinary Services.

Backström, L. (1999, November 22). Sweden's ban on antimicrobial feed additives misunderstood. Feedstuffs. Vol. 71, No. 48, pp. 8, 15-20.

Behr, E. (1999, Summer). The lost taste of pork: Finding a place for the Iowa family farm. *the Art of Eating* magazine.

Boehlje, M., Clark, K., Hurt, C., Jones, D., Miller, A., Rickert, B., Singleton, W., Schinckel, A. (1997). *Food system 21: Gearing up for the new millennium – the hog/pork sector. Staff Paper 97-19*. West Lafayette, IN: Purdue University, Department of Agricultural Economics.

Boggs, W.M. (1999, September 10). *Antimicrobial susceptibility testing: Emerging technologies. Study No. 5*. Waltham, MA: Decision Resources, Inc. (Abstract).

Burros, M. (1999, September 22). Eating well: Pork with a pedigree. *New York Times,* D9.

Burstall, M.L., Reuben, B. (1999, December 1). *Outlook for the world pharmaceutical industry to 2010. Study No. 72*. Waltham, MA: Decision Resources, Inc.

Crooker, B., Halvorson, D., Moon, R., Phillips, C., Noll, S., Johnston, L., Reneau, J., Chester-Jones, H., Hathaway, M., Goyal, S., Janni, K., Pijoan, C., Shields, T., Stromberg, T., Patterson, C., Dee, S., Blaha, T., and Wells, S. (1999). A summary of the literature related to animal agriculture health. *Generic environmental impact statement on animal agriculture*. St. Paul, MN: Environmental Quality Board.

CSPI (Center for Science in the Public Interest). (1999, March 9). News Release: FDA should ban the use of certain antibiotics to fatten farm animals, groups ask. Farm use of antibiotics squanders precious drugs. Washington, DC: Center for Science in the Public Interest.

Decision Resources, Inc. (2000, February 14). *The market for community-acquired pneumonia therapies will be significantly influenced by increasing levels of antibiotic resistance states: A Decision Resources study*. Press release, PRNewswire.com.

European Community Press release. (1998, December 10). Commission proposes ban on the use of some antibiotics as animal feed additives. Brussels: European Commission. http://europa.eu.int/comm/dg06/com/htmfiles/ips/ip1013en.htm

European Court of First Instance. (1999, June 30). The President of the Court of First Instance rules that economic interests cannot outweigh the need to protect public health. Orders of the President of the Court of First Instance in Case T-13/99 R Pfizer Animal Health SA/NV v Council of the European Union and Case T-70/99 R Alpharma Inc. v Council of the European Union. Press Release No. 48/99. Brussels: Council of the European Union. http://europa.eu.int/cj/en/cp/cp99/cp9948en.ht

FDA (Food and Drug Administration). (1999a, January 26). *A proposed framework for evaluating and assuring the human safety of the microbial effects of antimicrobial new animal drugs intended for use in food producing animals*. Washington, DC: Center for Veterinary Medicine, Food and Drug Administration, U.S. Department of Health and Human Services.

FDA (Food and Drug Administration). (1999b). *FDA response to comments on: A proposed framework for evaluating and assuring the human safety of the microbial effects of antimicrobial new animal drugs intended for use in food producing animals*. Washington, DC: Center for Veterinary Medicine, Food and Drug Administration, U.S. Department of Health and Human Services.

FDA (Food and Drug Adminstration). (2000). Notice: Enrofloxacin for poultry: Opportunity for hearing. Docket No. 00N-15711. Washington, DC: Center for Veterinary Medicine, Food and Drug Administration, U.S. Department of Health and Human Services. On-line at http://www.fda.gov/OHRMS/DOCKETS/98fr/cv0076.pdf.

Franklin, A. (1997, November 13). Antibiotic resistance in animal production: A threat to human and animal health. Scheele Symposium, 1997. *The threat of antibiotics resistance: A Nordic perspective.* Stockholm: Swedish Academy of Pharmaceutical Sciences.

GAO (U.S. General Accounting Office). (1977). *Report of the Comptroller General of the United States on the need to establish safety and effectiveness of antibiotics used in animal feeds*. Food and Drug Administration, Department of Health, Education, and Welfare. Washington, DC: Gen. Accounting Office.

George, N. (2001, February 20). Sweden's caring farmers are rewarded with public's trust: Europe's mad cow disease has failed to infect Sweden, where intensive farming practices were rejected in the 1980s. [*London] Financial Times*.

Halverson, M. (2000). *The price we pay for corporate hogs.* Minneapolis, MN: Institute for Agriculture and Trade Policy.

Harrison, R. (1964). *Animal machines: The new factory farming industry*. London: Vincent Stuart, Ltd.

Hayes, D.J., Jensen, H.H., Backström, L., and Fabiosa, J. (1999, December). *Economic impact of a ban on the use of over-the-counter antibiotics. Staff Report 99-SR 90*. Ames, IA: Iowa State University, Center for Agricultural and Rural Development.

Hays, V. (1991). Effects of antibiotics. *Growth Regulation in Farm Animals, Advances in Meat Research, Vol 7*, Ed.: A.M. Pierson and T.R. Dutson. New York: Elsevier Applied Science.

Holmgren, N. & Lundeheim, N. (1994). Djurhälsomässiga behovet av fodermedelsantibiotika i smågrisproducerande besättningar. *Sv. Vet. Tidn. 46:* 57-65.

IOM (Institute of Medicine). (1989). *Human health risks with the subtherapeutic use of penicillin or tetracyclines in animal feed.* Risk Assessment of Using Subtherapeutic Antibiotics in Animal Feeds. Washington, DC: National Academy Press.

JSC (Joint (Swann) Committee). (1960). The Use of Antibiotics in Animal Husbandry and Veterinary Medicine. *Report to Parliament*. London: Her Majesty's Stationery Office.

Kronemyer, B. (1999, April). Resistance concerns prompt FDA to rethink antibiotic use in poultry. *Infectious Disease News*.

Levy, S. (1998, May 7). Multidrug resistance – A sign of the times. *The New England Journal of Medicine (338),* 19, 1376-1378.

Looker, D. (2000, February). Surviving the hog shakeout: One young couple's strategy builds on the natural foods market. *Successful Farming,* 22-23.

Marbery, S. (1999, January 18). Traditional values driving upscale pork market. *Feedstuffs,18,* 21.

Mason, J. and Singer, P. (1980). *Animal factories: The mass production of animals for food and how it affects the lives of consumers, farmers, and the animals themselves*. New York: Crown Publishers.

Mathew, A.G., Upchurch, W.G., and Chatlin, S.E. (1998). Incidence of antibiotic resistance in fecal escherichia coli isolated from commercial swine farms. *Journal of Animal Science, 76*, 429-434.

McLearn, D. (1995, August 18). FDA approves fluoroquinolone antibiotic for poultry. Washington, DC: Food and Drug Administration, press release.

Mellon, M., Benbrook, C., & Benbrook, K.L. (2001). *Hogging it! Estimates of antimicrobial use in livestock.* Cambridge, MA: Union of Concerned Scientists.

Muirhead, S. (2000, October 30). CVM proposes to withdraw fluoroquinolones for poultry. *Feedstuffs Magazine.*

NRC (National Research Council, National Academy of Sciences). (1980). *The effects on human health of subtherapeutic use of antimicrobials in animal feeds.* Committee to Study the Human Health Effects of Subtherapeutic Antibiotic Use in Animal Feeds, Division of Medical Sciences, Assembly of Life Sciences. Washington, DC: National Academy of Sciences, Office of Publications

NRC (National Research Council, National Academy of Sciences). (1999*). The use of drugs in food animals: Benefits and risks*. Washington, DC: National Academy Press.

Scan. (1992). *The Swedish model for meat production: A 30-year fight against salmonella*. Stockholm: Scan-the Swedish Farmers Meat Marketing Cooperative.

Smith, K.E., Besser, J.M., Hedberg, C.W., Fe, T.L., Bender, J.B., Wicklund, J.H., Johnson, B.P., Moore, K.A., Osterholm, M.T. (1999, May 20). Quinolone-resistant *Campylobacter jejuni* infections in Minnesota, 1992-1998. *The New England Journal of Medicine, (340)* 20.

Swedish Consumers' Association. (1998). *Antibiotics in animal Feed: A threat to public health*. Stockholm: Swedish Consumers' Association.

Swedish Ministry of Agriculture. (1997). *Can we use less antibiotics? A brochure on antibiotics in animal feed and how they affect animals and humans*. Svensk Information, Stockholm, Sweden. (Available from Swedish Ministry of Agriculture, Food and Fisheries, fax # 468206496.

Swedish Ministry of Agriculture. (1997, November). *Report of the Commission on Antimicrobial Feed Additives.* Antimikrobiella fodertillsatser/Antimicrobial Feed Additives. Betänkande av utredningen Antimikrobiella fodertillsatser.
SOU 1997:132 Del 1 (pdf-format) (400K)
SOU 1997:132 Del 2 (pdf-format) (235K)
SOU 1997:132 Del 3 (pdf-format) (360K)
SOU 1997:133 (pdf-format) (260K)
Also see:
http://www.jordbruk.regeringen.se/propositionermm/sou/index.htm

U.S. Congress. (1999). H.R. 3266, 106th Congress, 1st Session. To direct that essential antibiotic drugs not be used in livestock unless there is a reasonable certainty of no harm to human health.

Unterman, P. (1999, June 27). On food: This little piggy… *San Francisco Examiner,* 64-66.

Wade, M.A. & Barkley, A.P. (1992) The economic impacts of a ban on subtherapeutic antibiotics in swine production. *Agribusiness, 8(2)*, 93-107.

Wegener, H.C. (1999, May 20). The consequences for food safety of the use of fluoroquinolones in food animals. *The New England Journal of Medicine (340),20,* 1581-1582.

Wierup, M. (1998). Preventive methods replace antibiotic growth promoters: Ten years experience from Sweden. *Alliance for the prudent use of antibiotics newsletter, 16(2),* 1-4.

Witte, Wolfgang. (1998, February 13). Medical consequences of antibiotic use in agriculture. *Science, Vol. 279,* 996-997.

WHO (World Health Organization). (1997a). Emerging and other communicable diseases: antimicrobial resistance. *Report by the Director-General. Executive Board, 101st Session, Provisional Agenda Item 10.3, 22 October 1997*. Geneva, Switzerland: World Health Organization.

WHO (World Health Organization). (1997b). *The medical impact of the use of antimicrobials in food animals: Report of a WHO meeting, Berlin, Germany.* Document No. (WHO/EMC/ZOO/97.4.)

PART II

SPECIES BY SPECIES IMPACTS OF MANAGEMENT AND PRACTICES ON FARM ANIMAL WELFARE

When domestic animals are provided with an environment that is physically similar to the habitat of their wild ancestors, behavioral and physiological adaptations to the environment will be readily achieved (Price 1999). Very often, the captive environment does not match the ancestral environment and adaptive ability is challenged. Such a situation gives rise to welfare concerns as described above by Fraser, et al. (1997) and as evidenced in animals' inability to adapt to agricultural practices without suffering, without constant medication, or without loss of performance when welfare pressures are extreme.

Chapters 5, 6, and 7 are organized by species and describe (1) the natural histories of the livestock species of major economic and environmental importance in Minnesota -- poultry, swine, and cattle—which can be used as reference points in designing welfare-compatible production systems and (2) major welfare concerns expressed by groups concerned with the protection of farm animals and by animal welfare scientists, including the welfare impacts of artificial (genetic) selection, housing or production environment, and management for these species.

CHAPTER 5

POULTRY

The primary farmed poultry are laying hens, broilers (chickens raised for meat), and turkeys. As with other farm animals, poultry suffer from disabilities induced by extreme genetic selection for various characteristics desired for production or meat quality and from various routine practices and procedures such as intensive confinement (by caging and crowding) and beak trimming and, in the case of laying hens, forced molting by a period of starvation.

I. The natural history of poultry

Modern chickens are descended from the red jungle fowl (*Gallus gallus* Linneaus) of Southeast Asia (Campbell and Lasley 1985, Hart 1985, Vestergaard 1994), which still inhabits the jungles of Burma and Thailand. Fowl have a highly organized social life and if possible they will arrange themselves in small groups, each group within a territory of its own, bordering on territories of other groups (Vestergaard 1981). Observations of feral[23] chickens on an island near Australia showed a number of territories, each with a flock of fowls consisting of 1-4 cocks and up to 10 hens (Vestergaard 1981). The borders of the territories were well-established and patrolled by the cocks that defended the territories against cocks from neighboring territories. A dominant cock ranked above all other cocks in the group and all cocks outranked the hens in the group.

The pecking order is a well-known phenomenon (Vestergaard 1981). If the pecking order is linear, which is often the case in small groups, the most dominant birds will peck or threaten all others in the flock. The second bird in the pecking order will peck all others except number one, and so forth, until the "omega" bird, which is pecked by all the other birds in the flock, but pecks no other birds. The maintenance of the pecking order requires that each hen and cock recognize every individual in the flock and remember its own status relative to the others. Under these circumstances, once a group pecking order is established there are few changes. The purpose of the pecking order appears to be to reduce aggression in the group, because once the pecking order is established there normally appears to be very little aggression.

The Red junglefowl lays about 8 to 10 eggs per "clutch" and has one "clutch" per season. After incubation of about 21 days, all eggs hatch within 15 hours (Andersson 2000).

When the hen is about to lay her egg, she moves around, often in a direction away from other hens. She vocalizes what has been termed the "pre-laying call" during this time (Vestergaard 1981). The cock (rooster) escorts her to potential nesting sites and by a certain behavior attracts her attention to the site. When she has accepted a nesting site, she begins nest building. The cock assists her in the beginning by scratching a nest cup in the ground. The hen gathers small twigs, leaves, and other materials and throws them onto her back. When she squats on the nest and makes the nest building movements, these materials fall off her back and line the

[23] Feral animals are domesticated animals that have escaped and become wild.

nest. Thereafter, while setting on the nest, she gathers more material from around her and throws it on her back. These patterns of behavior are common to nesting hens (Vestergaard 1981). Nest sites are usually well defined, in places such as the foot of a slope or under a bush, secluded from disturbance and enclosed for protection from predators (Appleby, et al. 1992).

Domestic hens observed by Wood-Gush (1983) in a pen experiment, where litter and feathers were spread on the floor, also performed the nest building behaviors described in the paragraph above, albeit without the accompaniment of a cock. Egg laying behavior of domestic hens usually starts one to two hours before actual laying (Wood-Gush 1983) and is evidenced by restlessness on the part of the hen as she paces and looks around and investigates the nest box (if provided). Wood-Gush (1983) noted that the hens in his experiment were very "conservative," using the same nest each time they lay and often staying with it for a period of years.

Wood-Gush (1983) tested whether the hens were loyal to the nest or the site by moving the nest to a different area of the pen and putting the egg they had laid in the nest. Hens went to the old site, not the nest, and they also rolled the previous egg to the old site, from which he concluded that their loyalty was to the site rather than the nest. In battery cages, many hens show the same restlessness and pre-laying calling; however, their behaviors are severely restricted and this frustrates normal nest-building behaviors (Brantas 1980). Nest site selection in domestic hens is affected by rearing conditions, housing conditions, nest box design and management, and human intervention (Appleby, et al. 1992).

Much behavior associated with egg laying is under genetic control, which may contribute to the consistency in which the behavior is expressed (Appleby, et al. 1992). The genetic mechanisms that control nesting are not fully understood. However, a considerable amount is known about physiological control. Pre-laying behavior is triggered by ovulation, approximately 24 hours before the egg-laying behavior begins. Luteinizing hormone affects ovulation, after which progesterone and estrogen are released from the follicle and act on the central nervous system to cause nesting behavior to be initiated after a suitable time interval (it takes around 24 hours for an egg to develop). The egg is ready to be laid by the time nesting behavior has begun.

Once pre-laying behavior has been triggered, birds have a very strong motivation to find a suitable place for laying. Timing of egg laying is strongly influenced by the ambient light in open systems and by the lighting schedule in closed buildings.

After an egg is laid, the hen sits on it for a short while before resuming normal activities. After a number of eggs have been laid (and the clutch is complete), the hen becomes broody and sits on the nest almost continuously, leaving the nest only about one hour each day to drink, feed, and defecate. Time away from the nest allows light to penetrate the shells and influence embryo and central nervous system development (Rogers 1995). Only after incubation begins do the embryos start to develop, so all chicks are hatched within about 15 hours of each other. This is important because chicks are mobile soon after hatching, and if hatched too far apart, could become separated. During the period just before hatching, the embryos communicate with the hen (Rogers 1995). In response to the embryo's distress calls the hen rises to turn the eggs, which may provide additional opportunity for light to reach the eggs.

The chicken's as well as the jungle fowl's main exploratory organ is the beak, which they use to check out their environments. Jungle fowl spend up to 61% of their time ground pecking and their domestic descendants also spend a large proportion of their day pecking and scratching. Feeding behavior consists of a number of patterns that appear identical in the Red Junglefowl and the domestic chicken (Vestergaard 1981). Feeding pecks are gentle and often followed by

swallowing. Ground-scratching is performed once or twice, with each leg in turn, whereafter the hen moves one step backwards and pecks the ground where she has scraped.

Chickens exhibit a number of "comfort" behaviors such as stretching, shaking, yawning and care of the plumage, including preening and dustbathing (Vestergaard 1981). Dustbathing is thought to remove excess lipids from the feathers. Wing-stretching is often accompanied by leg-stretching. Wing-flapping is similar to stretching. During wing-flapping the wings touch each other above the back of the bird. Preening consists of six basic movements. Both preening and yawning can occur as displacement activities during conflict situations. Dust-bathing consists of initial scraping, pecking and a number of behavioral elements that only occur during dust-bathing. These include vigorous movements with legs and wings during which the dust is thrown into the plumage. Stretching and head-rubbing occurs when hens are lying on the side. Finally, the bird rises to her feet, raises the feathers, and removes the dust by vigorous shaking movements.

As prey species, jungle fowl and chickens are well designed to detect and avoid predators. On the other hand, they are also well designed to be predators and use their vision to detect insect prey (Dr. R. Newberry, December 2000, personal communication). Vision is well developed, if slightly farsighted, with a visual field of about 300° (Fischer 1975). There are separate calls to alert others to aerial predators versus ground predators (Wood-Gush 1983). Recognition of other individuals appears to be based on features of the head, because a subordinate bird may not avoid its superior until the latter's head is raised and becomes visible. If hens' combs are removed or are not visible, the hens are attacked as strangers, even by inferiors (Fischer 1975).

Under feral conditions, hens roost on branches in trees at night, seeking out these places well before dark (Olsson and Keeling 2000). The afternoon light decreasing below a certain intensity has been shown to be the cue for going to roost (Olsson and Keeling 2000). The high percentage of nighttime perching by domestic hens kept in cages or aviaries with perches has been taken as an indicator that hens are motivated to roost also when housed under commercial conditions. Therefore, roosting has psychological benefits for the hens, as well, contributing further to improved welfare (Olsson and Keeling 2000). When hens in Olsson's and Keeling's study had access to perches, they always used them as the location for night-time roosting and were never seen to roost at other sites.

Jungle fowl were amenable to domestication for several reasons. Like the other farm animal species, they are social, which allowed them to be managed in groups (Vestergaard 1981, E.U. Scientific Committee on Animal Health and Animal Welfare 2000). Jungle fowl are promiscuous, which allows any male to be mated with any female, contributing to the efficiency of artificial selection. There is a hierarchical structure in the group, believed by most scientists to be based on individual recognition. They have flexible dietary requirements, being omnivores, and adapt to a wide range of environments. These characteristics have been successfully exploited in contemporary poultry production.

It is believed that chickens were domesticated about 8,000 years ago, first in India and China, and then along trade routes (E.U. Scientific Committee on Animal Health and Animal Welfare 2000). Duncan (1980) notes that the first chickens probably were not domesticated for food production but for decorative characteristics – plumage colors, shapes, and lengths, for example – and for cockfighting. Hence, at least in the beginning, chickens were not bred for tameness (Duncan, in Moss 1980).

The chicken's potential as an agricultural animal and the development of laying strains did not occur until the Roman times, when a poultry industry was established (Wood-Gush 1959). When the Roman Empire collapsed, large-scale selection of chickens for commercial use was not well organized again until the nineteenth century (Dr. D. Broom, December 2000, personal communication).

Welfare problems of laying hens in commercial egg production result from artificial selection for high egg production, specific practices such as forced molting and beak trimming, and from restrictions on hens' movements and natural behavioral patterns.

The welfare of broiler chickens is a matter of concern due to high densities of birds in broiler houses and their selection for rapid growth by breeding companies (Vestergaard and Sanotra 1999). During recent years increasing competition in the broiler industry has increased the welfare effects of these problems so that "today leg problems caused by rapid growth, and dermatitis caused by environmental pollution with faeces, wet litter, noxious gases and high temperatures, are commonplace" (Vestergaard and Sanotra 1999, p. 205).

In modern broiler and turkey facilities, poultry are kept in large flocks, with populations of thousands in a single large building. Both the high populations and the high spatial density are unnatural. Identifying familiar birds and maintaining dominance relationships through individual recognition is difficult in a flock of such size for birds that adapted to their environment by running in small groups.

Welfare consequences of confining so many birds densely together include feather pecking and vent pecking, both of which can lead to cannibalism. Feather pecking can be gentle or it can be aggressive, with aggressors using their beaks to pull the feathers out of their victims (Duncan 1994). Vent pecking (pecking at the posterior of other hens when pullets reach sexual maturity) starts with pecking and ends with contents of the abdomen being pulled out. Feather pecking increases with group size, and there is evidence that intensity of feather pecking also increases with group size (Bil► ík 2000). Feather pecking and vent pecking have obvious welfare impacts, including pain, injury, and potential death of the victim.

Although, due to selective breeding, contemporary broilers are much larger than jungle fowl, there are remarkably few differences in the behavioral repertoires. As with the other agricultural animals, behavioral changes in broilers that are apparent seem to be in threshold of response rather than a change in behavior per se (E.U. Scientific Committee on Animal Health and Animal Welfare 2000).

Physiological problems of broilers resulting from artificial selection for growth rate and performance can prevent the performance of normal behavior patterns as shown, for example, in studies where feeding, drinking, walking, scratching, pecking, and dustbathing behaviors were inhibited while time lying down, resting, and sleeping increased (Vestergaard and Sanotra 1999). Selection for bone and muscle strength has been a low priority compared to growth rate and productive performance. This has led to an increasing incidence of skeletal problems as the demand for increased weight has outstripped the capacity of the skeleton to support the animal (Loveridge 1999).

Inability to perform normal behaviors, whether due to restraint or to physical incapacity, can result in frustration, physiological stress, and chronic fear under conditions prevailing in commercial production.

Domestic turkeys (*Meleagris gallopavo*) originated in the wild turkey population of North America. *Meleagris gallopavo* includes five subspecies of wild turkeys and all domestic varieties. While turkeys ranged from southern Mexico to the north-eastern US, domestication occurred only with the Aztec Indians of Mexico (Hale, et al. 1969). It is thought that the first turkeys were taken to Europe by Spaniards via Spain in the 16th century (Berg 1998, citing Odèn 1994).

Thereafter several European varieties were developed. The first domestic turkeys returned from Europe and in the early 19th century crosses were made with native turkey in New England. Hence, compared to other livestock species, turkeys were subjected to artificial selection for traits desirable to people only relatively recently.

Welfare concerns with turkeys include lameness, beak-trimming and toe clipping, reproductive problems, stocking density in barns, "shaky-leg syndrome," excessive weight in breeding males, and degenerative hip disease.

II. The welfare of laying hens

Prior to the 1920s, poultry were produced by natural incubation (by the hen) and small flocks of a variety of species were kept as part of most mixed farming operations (Craig and Swanson 1994).

As knowledge of artificial incubation, nutritional requirements, and disease control developed, flocks were increased in size and kept in houses with roosts, nests, litter to scratch in, and access to outdoor areas except during inclement weather (Craig and Swanson 1994). Selective breeding developed one branch of bird for egg production and the other for meat production – laying hens and broiler chickens.

In the years just prior to World War II, farmers living near large cities began to specialize in year-round production of chickens to meet demand for eggs and chicken meat. Discovery of Vitamins A and D had enabled farmers to raise large flocks indoors because using these vitamins made exposure to sun and exercise unnecessary for proper growth and bone development (Mason and Singer 1980).

Farmers built large buildings and increased flock sizes (Mason and Singer 1980). But the birds had trouble using their natural coping abilities to adjust to the unnatural conditions of life in these buildings: poor ventilation, crowding, and lack of fresh air and sunlight. The density of the bird populations inside buildings permitted infectious diseases to spread throughout the flock. Diseases soon spread to other poultry farms. Financial and bird losses multiplied throughout the industry and many intensive poultry farmers went bankrupt.

Pharmaceutical companies turned their attention to resolving the disease problems (Mason and Singer 1980). Advances in microbiology made it possible to recognize infectious agents and systematically test for disease. Suspected disease carriers could be identified and eliminated (Gunnarsson 2000). Vaccines against diseases were developed. Birds housed on wire mesh over the manure area were less likely to get intestinal parasites because they could not peck in the manure, but this meant also they did not have access to litter or perches and this encouraged abnormal behaviors such as cannibalism and feather pecking (Appleby, et al. 1992, cited in Gunnarsson 2000).

Partitioning of compartments to reduce group size was applied, culminating in multiple-hen cages. Soon after World War II, the number of breeds kept for commercial production decreased drastically and selection for high productivity increased (Craig and Swanson 1994). The discovery of antibiotics and the introduction of subtherapeutic antibiotic use to promote growth and control disease in the 1940s solved the disease problems that plagued earlier intensive producers.

A. Battery cages

In the mid-1920s, the first cages for laying hens were developed in the US and Great Britain. These homemade cages and the first manufactured cages introduced in 1930 had enclosed nesting compartments. In 1934, the first wire cage systems without nests for single hens were introduced. In the 1950s, small battery cages for three to six hens in rows on top of each other were regarded as the most efficient for production and for automated feeding and drinking systems. Today battery cages are the predominant housing system in the industrialized world.

Today, chickens raised for egg production are hatched in incubators at commercial hatcheries. About half of chicks born are male and these are destroyed one to two days after hatching because they are of no use in egg-laying. Because chickens selected for laying are not also selected for growth rate or muscle mass, the males also have no use for meat production. Male chicks are disposed of by gassing, crushing, or instant maceration by a high-speed grinder. Although it sounds unpleasant, it is believed that, if it occurs quickly, maceration is the most humane way currently available for destroying masses of chicks (Dr. J. Mench, November 2000, personal communication).

In commercial egg production, the age at which hens begin to lay is approximately 18-22 weeks and at this age hens are moved to intensive production facilities and placed in cages, several hens to a cage. Figure 5-1 shows a typical commercial layer operation, with rows of cages side by side and the rows stacked on top of each other in "batteries." Typical space allowance in a "battery cage" is between 48 and 60 square inches per bird. About 99% of hens producing table eggs in the United States are being kept in battery cages (Dr. R. Newberry, December 2000, personal communication).

Figure 5-1. Laying hens in a battery.

Photo credit: Humane Farming Assn.

While cage manufacturers may specify a recommended number of birds per cage, the incentive of the producer is to include as many birds to a cage as possible to maximize egg output per cage. Researchers have concluded that when egg prices are high and feed prices are low, profitability is higher when hens are crowded, even though they lay fewer eggs, have higher mortality, and consume more feed per hen. "Under these conditions the number of hens per cage that produces the maximum profit is greater than the number that would be justified on the basis of biological responses" (Craig and Swanson 1994, p. 932, 933).

As the practice took hold, cages made for two birds were filled with four and five birds because the hens, genetically programmed to lay eggs, continued to perform their dominant economic function even though it was recognized early on in the industry's transformation to battery cages that osteoporosis and "cage layer fatigue" were results unique to hens in systems using cage housing. However, the cause was first attributed to nutritional deficiencies (Couch 1955, cited in Gunnarsson 2000).

Laying hens in cages suffered "a certain degree of bone atrophy" and "cage layer fatigue" that sometimes led to sudden death: "The calcium reservoir in the bones is smaller than in penned fowls. When laying begins this calcium reservoir is strained to the limit." (*The Farmer and Stockbreeder*, December 19, 1961, cited in Harrison (1964)).[24]

Lack of exercise leads to osteoporosis, muscle weakness, and bone breakage (Knowles and Broom 1990a,b, Broom 1990, Knowles, et al 1993, Rowland, et al. 1968, 1970, 1972). Bone breakage occurs when hens are removed from the cages and transported to slaughter and when shackled/hung on the line for slaughter (Elson 1992, Newberry, et al. 1999). Bones are living and constantly undergo changes in response to nutrition, hormone balance and exercise (Elson 1992, Loveridge 1999, Orth 1999). Bone breakage is likely to cause severe and prolonged pain and suffering (Gentle and Tilston 2000). Especially in transport, vibration in typical commercial poultry transporters causes movement at fracture sites and forces birds to use muscles to maintain postural stability, contributing to tissue damage around broken bones (Newberry, et al. 1999). Injured birds are unable to avoid other birds that may step on injured tissue.

Laying hens have two types of bone considered relevant to the development of osteoporosis (Thorp and Maxwell 1993). These are medullary and cortical/trabecular. Medullary bone serves as a source of labile calcium, providing calcium for eggshell formation and cortical/trabecular bone maintains the physical integrity or structure of the skeleton.

When insufficient calcium is available from medullary bone to support eggshell formation, calcium is obtained by breakdown of structural bone tissue and this structural bone lost during lay does not appear to be replaced while hens are in lay (Thorp and Maxwell 1993). The longer hens are in lay, the more structural bone they may lose. Each egg requires 2.0 to 2.2 grams of calcium, representing 10 to 15% of the calcium in a hen's body (Newberry, et al. 1999). There is evidence that shell quality is maintained at the cost of bone strength. Complicating the problem is the situation that in the United States, nutrient requirements identified by the Subcommittee on Poultry Nutrition of the National Research Council are adequate for eggshell thickness, but not always adequate for maintaining bone strength (Newberry 2000), once again providing evidence that production values are not sufficient predictors of hen welfare.

[24] It is quite remarkable that 40 to 45 years after this serious issue affecting health and well-being of caged layers was first recognized, the US egg industry, left to its own devices, still has felt sufficiently motivated to find welfare-improving alternatives to cage housing.

Severe osteopenia (thinning and weakening of bones) can lead to death or paralysis leading to death from dehydration. In 1992, it was estimated that 15 to 30% of cage layer mortality in the United States was due to osteopenia. The bones of hens kept in battery cages are more fragile than those of hens in other husbandry systems; bone loss is reduced when bones are loaded during exercise (Newberry, et al. 1999). The bones of battery cage hens were lesser in weight and strength than those of hens in a semi-intensive alternative system and a deep-litter system (Nørgaard-Nielsen 1990).

In a study published in 1998, when 69-week old caged hens were moved to an aviary, their tibia strength increased from that typical of caged hens to that typical of aviary-housed hens in 20 days. In another study, when sampled just before stunning, 31% of caged layers had broken bones compared with 14% of free-range hens. At the same time, hens in some loose/colony housing systems may have more broken bones during lay than caged hens due to crash landings when the distance between perches and nest boxes is too great or if they collide with equipment and other hens after a sudden alarm (Newberry, et al. 1999). Better design of loose housing systems, for example, to take into consideration flight distances or leg condition, may help to alleviate some of these problems occurring in "colony" systems.

Providing caged layers with more space allows more movement, which can help maintain bone strength during lay (Newberry 2000). In one study, lowering the stocking density of a cage by placing three rather than four hens in it resulted in stronger leg bones. Cages with ceiling heights of 62.5 cm allowed hens to flap their wings and resulted in stronger wing bones than hens kept in cages 40 cm high even though hens in the 40 cm high cages were able to extend their heads through the tops of the cages.

While many of the injury problems of hens in battery cages have been solved by cage design such as solid partitions between cages that reduce feather abrasion and refining construction details that trapped birds by their feet and heads (Gunnarsson 2000), nevertheless serious welfare problems remain. For example, poorly designed wire cage flooring can cause foot deformities.

The welfare problems of laying hens in close confinement include the inability to exercise wings or legs adequately, or perch. They cannot dust-bathe in a battery cage (an important grooming procedure to maintain the feathers). They cannot walk around and scratch in the dust, perform exploratory pecking, select a nest site or build a nest. In some cage designs, they cannot stand fully upright because the wire ceilings are too low. They will, however, perform stereotyped pacing, a vacuum activity, and try to "dust-bathe" even on the wire floor.

Increasing knowledge about the natural behavior of the domestic chicken (Wood-Gush 1955, cited in Gunnarsson 2000) led to concerns about the conditions for chickens in battery cages. Hence, since the early 1960s, substantial scientific work has been directed toward investigations into how battery cage housing affects behavior of battery hens. Especially since the publication of Ruth Harrison's 1964 work *Animal Machines: The New Factory Farming Industry,* substantial discussions about the welfare of hens in battery cages have taken place. The failure of battery cage housing to allow chickens even the basic five freedoms articulated by the Farm Animal Welfare Council and the observation of injuries and abnormal behaviors on the parts of hens in cages have been behind the discussions.

An important function that animals perform for themselves is body care. The behavior of grooming in chickens has elements that are common to all animals and elements that are peculiar to chickens. Dust-bathing is thought to be an important grooming behavior to eliminate ectoparasites and reduce excess lipids from the feathers, although it also has its social aspects. When chickens dust-bathe together, they will frequently brush against each other. From a welfare perspective, hens should be provided space and materials for dust-bathing, and in European countries researchers are designing cages and perchery systems that have substrates suitable for dust-bathing.

A behavior system is an organization of perceptual, central, and motor mechanisms that acts as a unit in some situations (Hogan, et al. 1991, Vestergaard, et al. 1990). Dust-bathing in the adult fowl is a system that satisfies this definition. Chickens recognize particular substrates (perceptual mechanisms) in which they dust-bathe with a coordinated series of motor patterns (motor mechanisms) and the frequency and timing of this behavior is controlled by internal factors (central mechanisms). Chickens are highly motivated and will work very hard to be able to dust-bathe. They will dust-bathe if sand or other suitable material is available but will bathe in dry food if no sand is available. When prevented from dust-bathing, chickens will show the behavior anyway, even in battery cages, although at a lower rate (Vestergaard 1980).

Another important welfare problem associated with battery cages is that hens are not allowed to nest (Duncan 1994). Domestic fowl show elaborate nest searching, nest building and other behavior before egg-laying that is essentially the same as the behavior of the wild fowl (Fraser, A.F. and Broom 1990). Research has identified inability to make nests as a source of stereotyped behaviors, indicating frustration and stress. In preference tests, hens were shown to work as hard to reach a nest box as they worked to reach food after 24 to 30 hours of food deprivation. Gunnarsson (2000) and colleagues have also shown hens will work for straw.

Conditions in which birds are reared affect mobility, which limits birds' ability to reach nest boxes if they are high off the floor. Chickens learn most readily to jump or flap from the ground to higher levels if they have had the opportunity to do so when young. Giving birds this opportunity and also providing perches when they are young avoids problems of "floor" eggs – eggs that are laid on the floor and therefore are more subject to breakage than eggs laid in nest boxes.

B. Surgical procedures/mutilations

Certain management procedures also create welfare problems. In poultry, these include beak-trimming, toe clipping to prevent skin scratches, and forced molting. Each has been demonstrated to be stressful and/or to cause pain for varying lengths of time (Breward and Gentle 1985, Gentle 1989, Gentle and Hunter 1988, Gentle, et al. 1991, Duncan and Mench 2000).

The propensity of densely populated or crowded poultry to engage in injurious behavior has led to beak-trimming (Wiepkema 1989). It is interesting to note that this practice did not originate in science, but with a California farmer who first used a blowtorch to sear the beaks of his birds to prevent feather pecking and cannibalism (Mason and Singer 1980). However, it became a routine practice in the industry worldwide. Today, laying hens, broiler breeders, turkeys, and intensively confined ducks generally are beak-trimmed. In some cases, laying hens, and broiler breeders, who live longer than chickens sold into the broiler market, may be beak trimmed twice in their lifetimes.

It is routine for beak-trimming to be performed on newly hatched or several-day-old chicks by use of machines "in which the end of the upper beak is pushed through a hole of precise dimensions in a metal plate and a powerful electric arc or laser beam burns a tiny hole through the tip of the beak. After about six to eight days the end of the beak sloughs off" (Duncan 1994, p. 380). The purpose of removing parts of the beak is to prevent cannibalism, which can be exacerbated in intensive confinement housing of laying hens, broiler breeder hens, and turkeys.

One study has shown that beak trimming does not decrease feather pecking but makes the pecking much less efficient, thereby reducing the damage done (Blokhuis and van der Haar 1989, cited in Duncan 1994). Craig and Muir (1991) showed that a long-term solution to feather pecking and cannibalism in chickens is artificially selecting birds with a low tendency toward feather pecking and cannibalism. Duncan (1994, p. 380) also noted that breeders are reluctant to include selection against feather pecking in their genetic programs "because they would have to relax selection on other commercially desirable traits, which would put them at a disadvantage, compared with their competitors." In Keeling (1994), under 9% of hens in floor pens accounted for over 50% of severe pecking. Effects of early rearing also have been shown to influence hens' ability to adjust to unfamiliar environmental conditions in later life (Gunnarsson, et al. 2000).

While there are welfare benefits to chickens from beak trimming if the practice prevents cannibalism, the practice also has a welfare cost.

The motor patterns of the chicken that are involved in picking up and swallowing particles of food are as follows. The bird strikes at the food particle with considerable force from a distance of 1-3 centimeters. Just before contact the bill is opened and the lower mandible strikes the substrate first. The particle is then grasped, usually by the upper mandible being moved to the lower, and the head is drawn back in several jerking movements that result in the food particle being thrown backwards into the pharynx. Removing one-third to one-half of the upper mandible causes a marked reduction in feeding efficiency and a temporary fall in food intake (Duncan 1980b).

The beak, as the main exploratory organ of the bird, has an extensive nerve supply with mechanoreceptors (for pressure), thermoreceptors (for temperature), and nociceptors (for noxious stimuli) (Sneddon and Gentle 2000). Gentle (1986) describes evoked responses in the pain system after beak-trimming, so the action of cutting the beak must result in pain. There also is evidence for chronic pain following beak trimming (Duncan 1994). Amputation results in extensive neuroma formation in the healed stump (Gentle and Breward 1986) and neuromas give rise to abnormal spontaneous nerve activity (Breward and Gentle 1985). Gentle, et al. (1991) found that there is a significant reduction in preening and especially in environmental pecking after amputation. This is thought to be guarding behaviour in response to pain or discomfort where the animal reduces the use of an affected area (Gentle, et al. 1997).

Neuromas can last up to two months, continuing to cause chronic pain, although healing occurs more quickly when beak trimming is done while birds are very young. Neuroma formation also may occur less if the beak-trimming occurs in very young birds (Gentle, et al. 1997).

C. Induced molting

Molting is a timed sequence of feather loss caused by feather regeneration (Gildersleeve, et al. 1983). The termination of egg laying under natural conditions is in some instances followed

by formation of a new generation of feathers that pushes old feathers out of the follicles (Jensen, J.F. 1980). According to Jensen (1980) it is hormonally regulated and hormone production is influenced by variation in the length of the day.

Molting is only incidentally tied to reproduction (Dr. J. Mench, December 2000, personal communication). Molting is necessary for birds to shed worn feathers and replace them with feathers in good condition. Birds molt before winter and before migration for the purpose of having plumage with good insulating capabilities for the winter. Producers use the molt process to cause regression of the reproductive tract followed by a return to reproductive condition.

Under natural conditions, natural molting with fasting accompanies broodiness or nest-sitting. This *self-imposed* fasting occurs during the 21 days it takes for the eggs to hatch. During this time, a hen will leave her nest for ten to fifteen minutes each day to drink, eat, defecate, and exercise.

While forced molting was used for a long time to improve feathering, the first mention of forcing a molt in order to improve egg production was in a 1936 extension service bulletin from the State College of Washington (Bai, et al. 1994). Today the majority of laying hens providing table eggs in the United States are induced to molt one or more times during their productive lives (Zimmerman and Andrews 1990).

The U.S. commercial Leghorn industry maintains approximately 240,000,000 hens in production (Lyons and Vandepopuliere 1996). The egg-laying period of domestic hens in commercial production is from 9-16 months (Jensen, J.F. 1980, Keshavarz 1995). It is achieved by the regulation of day length in the barns (artificial lighting) so that egg production occurs regardless of seasonal variation in day length (Jensen, J.F. 1980).

Egg production, shell quality, and internal egg quality decline with age, with the result that every year in the United States, over 100 million spent laying hens must be replaced (Webster, et al. 1996). Lyons and Vanderpopuliere (1996) estimate that 144,000,000 spent hens are culled every year. Unlike broilers, laying hens have been artificially selected for egg production rather than body weight. Hence, laying hens have little food value when spent. Processors purchase them for use in food products such as soups and further processed meats or they may be ground up and put back into chicken feed (Dr. Melanie Adcock 1998, Humane Society of the U.S., personal communication; Lyons and Vandepopuliere 1996).

Markets for spent hens have declined due to competition from the growing broiler breeder industry, whose spent broiler breeder (laying) hens are larger than spent laying hens, have more muscle, and yield more meat (Webster, et al. 1996). Modern White Leghorn hens, which form the majority of hens used in egg production, are small-framed with a minimum of muscle mass. During slaughter the bones of spent laying hens shatter, further reducing their value because bone fragments can be found in the meat and reduce its value.

By forcing molting to occur when hens are around 65 weeks of age, egg production can be stopped for the purpose of recycling laying hens for another season of egg production (Gildersleeve, et al. 1983, Webster 2000). Then, "when hens are stimulated to return to egg production, the rejuvenated reproductive tract usually produces eggs at a higher rate and with better shell and interior quality than had been the case during the latter part of the first cycle of production" (Webster 2000). A second laying period spreads hen replacement and disposal costs over a longer timeframe.

For economic reasons, therefore, there are incentives for the producer to extend the egg-laying life of hens kept for egg production past the first lay.

Declines in egg production, shell quality, and internal egg quality that occur naturally with age can only be reversed temporarily by forcing molt. The "benefits diminish with each successive molt" (Webster, et al. 1996, p. 191). In the United States, commercial laying hens are usually replaced after 2 years of age and after they have gone through two or three production cycles with one or two induced molts.

That induced molting by food removal increases the length of the hen's life, egg quality and egg numbers during the subsequent lay cycle has been researched and documented (Zimmerman and Andrews 1990). "Force-molted" flocks usually produce more and larger eggs with improved shells and internal egg quality post-molt than their non-force-molted counterparts (Keshavarz 1995).

Molting is a natural biological process of birds, but forcing a molt is a welfare concern due to the methods used. The words "pause" and "rest" are frequently used to characterize forced molting (e.g., the U.S. Department of Agriculture National Animal Health Monitoring System describes molt simply as "[t]hat period of time when birds are taken out of production (usually around 65 weeks of age) until they return approximately to their 18-week weight. After a *rest* period, they are returned to production for another laying cycle" (U.S. Department of Agriculture 1999, emphasis added).

The process of forced molting is neither voluntary nor natural for the bird and it is not restful. Rather, it is highly stressful (Holt 1995) and, like other stressed animals, molted hens shed more pathogens in their feces, which has ramifications for the health of other birds in the flock and the environment (WHO 1988). "The most common molt programs use feed withdrawal to cause hens to cease egg production and induce the hens' reproductive tracts to regress to a nonreproductive state" (Webster 2000, p. 192). The starvation period can last from 10 to 14 days and even longer in the summer. In a 1982 study, Baker, et al. determined that feed withdrawal sufficient to achieve a bodyweight loss of approximately 27% to 31% during the molt induction produced optimum post-molt performance. Such a goal usually requires a feed withdrawal period of 14 or more days.

Webster (2000), concluded that hens in his study were better off after a prolonged forced molt, stating that the birds remained alert and in good health and did not engage in abnormal behaviors and that the thinned-down birds were healthier than counterparts that had not molted. Duncan and Mench (2000), noted that the behavioral observations that would have detected displacement and stress behavior in hens in the Webster (2000) study were not taken during the best time of day with respect to peak feeding motivation.

In commercial production, sick and injured birds die *during* the molt, implying that hens do suffer from the practice. Hens that survive are the ones that were fittest going into the molt (Dr. J. Mench, November 29, 2000, personal communication). Additionally, birds that are thinner, as were Webster's force-molted birds, for whatever reason, may be healthier because hens put on some excess body fat due to limited exercise opportunities in battery cages.

The scientific literature has produced evidence of physiological stressor effects and behavioral changes associated with extended feed removal programs (Cunningham and Mauldin

1996). Forced molting also may increase susceptibility of hens to *Salmonella enteritidis* infection (Cunningham and Mauldin 1996).

In September 2000, McDonalds Corporation notified its suppliers that it would no longer accept eggs from producers using forced molting procedures.

In 2000, US groups United Poultry Concerns and Association of Veterinarians for Animal Rights petitioned the US Department of Agriculture and Food and Drug Administration to eliminate forced molting in laying hens on the basis that it is cruel and causes disease.

A number of other authors have cited public concerns over animal welfare as reasons to find alternatives to prolonged feed withdrawal as a means of forcing molt (Keshavarz 1995, Cunningham and Mauldin 1996). Rolon, et al. (1993) found that alternative forced molting methods involving periods of feed withdrawal of 24 hours or less could be as economically effective as methods using longer periods of feed withdrawal. Feeding a low-energy and low-density molt diet also supported shorter feed restriction methods as effective alternatives to the traditional longer feed removal techniques. Hen frustration associated with intermittent feed delivery and not feeling full when she has eaten could still be stressful (Dr. J. Mench, December 2000, personal communication).

Nevertheless, Keshavarz (1995, p. 263) noted that feed withdrawal used to achieve a body weight reduction of about 30% "still remains the method of choice for the induction of force-rest by the industry because of its efficacy and the convenience of its application" although "alternative methods…should be investigated further."

D. Forcing Lay

Laying hens are forced into lay at younger and younger ages, through hyperstimulation with light (Fox 1997). A consequence to some hens of beginning lay at too young an age is referred to in the industry as "blowout," where the cloaca remains everted after egg-laying, which can lead to cannibalism by other birds.

E. Handling of "spent" hens

Hens that are past their usefulness are called "spent" hens.

The welfare problems of spent hens are severe. Osteopenia (the thinning and weakening of bones) and muscle weakness leading to bone breakage when caged hens are handled are unplanned, but not unpredictable, outcomes of crowding, lack of exercise, and selective breeding.

Studying four different breeds of chicken, Gregory, et al. (1989) found that the incidence of bone damage prior to stunning in free range birds was about half that for battery hens and that battery hens had 2.1 times higher incidence of broken bones than hens raised in percheries. In each case, different bones were affected between percheries, free-range, and battery cage birds, possibly due to the different obstacles in different forms of housing, and perchery and free-range birds had a higher proportion of healed bone fractures than laying hens whose breaks were more

recent, indicating that improvements needed to be made in perchery and free-range systems in this study also.

Electrical stunning at slaughter is one of the more important causes of bone breakage during processing; high frequency stunning at 1500 Hz causes fewer broken bones than stunning at 50 Hz. Low intensity stunning requires less energy and is cheaper for the processor.

Elson (1992) reported research into bone breakage in caged layers and in layers having access to multi-tiered perches. The findings were taken at the point of entry to the slaughterhouse. Broken wings occurred in the caged layers more often than it occurred in birds having access to perches. Broken legs occurred in birds from both housing systems during handling and transport, but more broken legs occurred in hens reared in cages, reflecting the difference in vigor between the cage-reared birds and birds moving about freely with access to perches. In caged layers, breakage occurs primarily when the hens are being removed from the cages to go to slaughter. Haste makes handling rough; frequently birds are pulled out by one leg and handed several at a time to another worker before being stuffed into transport crates.

Further bone breakage occurs at the slaughter plant during the processes of shackling and stunning. In studies, as many as 88% of caged layers had broken bones after scalding and 98% by the end of processing while corresponding results for free range hens were 30% and 91%, respectively (Newberry 2000). Using a lower electrical current for stunning often does not render birds unconscious and also does not decrease bone breakage.

Almost one third of spent hens have at least one broken leg by the time they have reached the end of the processing line (Elson 1992). According to Elson, not only does this contribute to unnecessary suffering for the hens, it is an economic problem because labor time is required to remove bone splinters from poultry products.

The rates of antemortem and postmortem condemnations of poultry slaughtered in U.S. Department of Agriculture-inspected establishments are higher for spent hens than for any other class of poultry (Newberry 2000), implying that spent hens are exposed to life-threatening conditions during pre-slaughter handling and transportation, including exposure to temperature extremes and injuries from handling. In the United States, a breakdown of the causes of postmortem condemnations of spent hens shows relatively high levels due to septicemia/toxemia, tumors, contamination, cadavers (almost dead when hung on shackles), and bruises, implying that hens unfit for travel are being shipped rather than being killed on the farm (Newberry 2000).

Numerous factors affect bone breakage (Newberry 2000). Calcium, phosphorus or vitamin D_3 deficiency can result in poor mineralization of bone (osteomalacia). As noted above, osteoporosis is strongly associated with lack of exercise (Knowles and Broom 1990) and refers to thinning of the bones. Osteopenia refers to weak bones from either or both osteomalacia and osteoporosis.

Cage design and handling can affect bone breakages and bruises. For example, many cages have feeders at the front, partially obstructing the cage door, with the result that when hens are pulled through the door they hit or get caught on the feeder.

In the United Kingdom, studies of spent hens indicate that catching is the primary source of injury prior to arrival at the slaughter plant. Bodily impact against hard surfaces inside and outside the cage and struggling contribute to bruising, joint dislocation and bone breakage, especially when pulling hens backward out of their cages (Newberry, et al. 1999). Thirteen to

41% of caged layers being shipped to two slaughter plants in England had one or more freshly broken bones just after having been removed from the layer house by commercial crews and 45.3% on average had broken bones at the slaughter plant after removal from crates and hanging on shackles (prior to stunning).

Newberry (2000) notes that the most common method of removing hens from the layer house is for the catchers to carry them upside down by one leg, five to seven hens at a time, for loading into coops on the truck. Extra care in handling can reduce bone breakage, in one study from 24% to 14% and another from 45.3% to 31.4% by more careful handling. The British egg industry adopted a welfare guide to handling spent hens that recommended that hens be removed from cages individually by both legs, carried by both legs, and be supported on the breast either by hand or a special slide that rests on and covers the lips of the feed trough, providing a smooth angled surface to slide the bird out.

In North America, conversations with processing plant managers indicate that broken bones are common and contribute to the low economic value of spent hens by contaminating the meat, increasing the cost of processing, and limiting products in which the meat can be used due to concerns about consumers choking on them (Newberry 2000).

Bone characteristics differ between layer strains, suggesting that artificial selection for improved bone strength in layers might be possible. It was shown that it is possible to increase wing bone strength of broilers through genetic selection in three generations; however, the selected birds still had weaker wing bones when kept in cages than in floor pens (Newberry 2000).

The low economic value of spent hens has further welfare implications for laying hens. According to Newberry (2000): "The low economic value of spent hens has provided little incentive for investment in genetic selection for increased bone strength. Nor has there been much economic incentive to develop and adopt equipment, feeding programs, and handling and management techniques that maintain bird welfare during transportation and slaughter."

There is an upward trend for U.S. producers to ship spent hens to Canada, with most exported hens slaughtered in Ontario and small numbers going to Manitoba and Quebec (Newberry 2000). Few plants accept spent hens (nine in the United States routinely process spent hens), so transport from the production facility to a slaughter plant may take a relatively long time (estimated by one processor to be around 30 hours) (Newberry 2000).

Percentage of dead on arrivals and condemnation rates increase as the transport time increases (Newberry, et al. 1999). Hens should be killed within two hours of arriving at the plant, although cases where spent hens were made to wait much longer while more valuable loads of broilers are processed have occurred.

Spent hens from Minnesota laying companies were shipped to Campbells' Soup Company in Worthington until that company moved out of state in 1997. Today, spent hens from Minnesota farms are either killed on the farm or they travel by truck hundreds of miles to soup companies in Canada (Dr. Keith Friendshuh, Minnesota Board of Animal Health, November 2000, personal communication).

The trend for a relatively high rate of condemnation of spent hens in Canada is similar to that in the U.S. Higher condemnation rates of spent fowl in Canada appear to result from

emaciation than from any other cause (i.e., more than from 'found dead', peritonitis, tumors, contamination, bruises, cyanosis (equivalent to cadavers in U.S. terms, or "almost dead")). Dead on arrivals (DOAs) were most prevalent in January and February and a limited survey by the Canadian Food Inspection Agency on 7.1 million spent hens at plants in Ontario and Quebec found that DOAs were more prevalent in winter than other seasons. The Meat Hygiene Veterinarian often observed excessive broken bones and contusions but causes were not investigated. Of hens originating from the United States, 9.2% of hens were condemned, of which 2.4% were dead on arrival, mainly due to emaciation, thought to be due to excessive feed and water withdrawal times and/or poor health (Newberry 2000).

Animal welfare scientists and welfare advocates prefer euthanasia on the farm to sending spent hens to slaughter when there is potential for intense suffering on long journeys. Bird welfare is adversely affected by thermal stress during transport – including extremes of freezing or too hot temperatures. But good methods of euthanasia must be developed to be humane and environmentally acceptable.

According to Newberry (2000), there is a strong need for further development of equipment for the humane on-farm euthanasia of hens and the salvaging of carcasses for rendering. The term euthanasia, she notes, meaning "a good death", can only be used for methods that result in rapid unconsciousness, and death prior to the regaining of consciousness.

Efforts have been made to determine what methods of euthanasia are humane. In the United Kingdom, the use of 90% argon gas with 2% residual oxygen, or 60% argon with 25-30% carbon dioxide is approved for humane killing of poultry (Newberry 2000, citing UK Ministry of Agriculture, Fisheries & Food, 1995). Argon appears to be the most humane, with hens showing little aversion to breathing it. Hens do show aversive behaviors when exposed to carbon dioxide alone, indicating that it is causing discomfort. Argon is also more expensive than carbon dioxide to use and would require the development of special equipment not currently available to producers. It would be difficult to kill tens of thousands of hens while keeping a container sealed tightly enough that there is less than 2% residual oxygen in it (Dr. J. Mench, December 2000, personal communication).

III. Welfare issues with poultry raised for meat – broilers and turkeys

The welfare issues with broiler production are extensively described in the European Union Scientific Committee on Animal Health and Animal Welfare report *The Welfare of Chickens Kept for Meat Production (Broilers)*, adopted on March 21, 2000.

Broilers, or chickens raised for meat, have been selected for fast growth rate, body weight and conformation (large breasts), and feed conversion ratio. This has led to large breast size relative to leg development resulting in welfare problems in broilers ranging from difficulty walking, increasing with age and weight, leg deformities, and starvation or dehydration if birds cannot reach feeders and waterers. Eventually, there may be an inability or unwillingness to stand at all (Weeks, et al. 2000). They may lie for hours with one leg outstretched (Figure 5-2). Lameness worsens as the chicken grows (Weeks, et al. 2000).

Figure 5-2. Lame broiler.

Photo credit: United Poultry Concerns(http://www.upc-online.org)

Lameness is an endemic disorder of all contemporary livestock species in which genetic selection for high production, fast growth rate, and feed efficiency has not been balanced by selection for increased strength. Selection for good bone growth or structure does not appear to correlate well with overall growth performance (Orth 1999). Turkeys selected for walking ability had reduced breast widths as compared to breast widths in turkeys in commercial lines, for example (Orth 1999).

The welfare problems associated with musculoskeletal disorders in poultry are the pain or discomfort experienced by affected birds and the consequences of impaired locomotion (E.U. Scientific Committee on Animal Health and Animal Welfare 2000). Leg problems can be diagnosed by observing abnormal or poor walking ability and by clinical and post mortem diagnosis (Vestergaard and Sanotra 1999).

Leg weakness covers a range of problems in the skeletal and locomotor systems of broilers (E.U. Scientific Committee on Animal Health and Animal Welfare 2000). Indicators of pain include standing on their legs while propping themselves with the wingtips.

Bone disorders can be grouped under three headings indicative of the production stresses applied to the skeleton (Thorp and Maxwell 1993). These groupings are bone growth disorders in young broilers, arthritis in turkey and broiler breeders, and bone fractures in adult hens selected for egg production. Bone disorders include deformity, manifest as abnormal angulation. Growth plate defects can cause bone distortion. Growth plate lesions may also be a consequence of deformity. Deformity of vertebrae leads to spondylolisthesis, pressure on the spinal cord, hind limb ataxia and paralysis.

Tibial dyschondroplasia occurs in broilers, turkeys, and ducks in commercial production. (Thorp and Maxwell 1993). Tibial dyschondroplasia is a leg disorder involving abnormal growth of cartilage and the lack of ossification in the head of the tibiotarsus (Vestergaard 1999), that is, growth plate cartilage is not properly degraded and accumulates at the expense of bone formation (Orth 1999). It results from selection for accelerated growth (Orth 1999). While 30 years ago it was an insignificant concern, today its prevalence is estimated at 50% in the broiler industry (Orth 1999). Incidence of lameness from tibial dyschondroplasia varies from less than 1% to 40% (Thorp and Maxwell 1993). Subclinical lesions affect 20% to 60% of birds and it is likely that these subclinical lesions contribute to the incidence and severity of bone deformities in the broiler. Lameness, increased fractures in the fibula, and an increased susceptibility to osteomyelitis are outcomes of tibial dyschondroplasia and in turkeys it also increases the incidence of breast blisters (Orth 1999).

Arthritis is due to degenerative changes in articular cartilage (Thorp and Maxwell 1993). Broilers show reduced activity and perching compared to laying hens. Degenerative disorders of joints are more prevalent in birds grown to greater ages and weights for breeding purposes. Abnormalities resulting in degeneration or inflammation are likely to be painful. Large numbers of broilers have impaired walking abilities and experience pain or discomfort (E.U. Scientific Committee on Animal Health and Animal Welfare 2000). A study reported by Sneddon and Gentle (2000) indicated that 90% of broilers at 7 weeks of age have detectable gait abnormalities and surveys of commercial flocks in Denmark show that about 30% of these abnormalities are high moderate to severe (Sanotra 1999). These fast growing birds have more breast muscle and shorter, wider legs with immature bones. They become too heavy for their legs to carry their bodies and their skeletons become distorted, placing unnatural stress on joints and resulting in abnormal gaits. In one study, normal chickens took an average of 11 seconds to walk a set distance, whereas lame chickens took 34 seconds (Sneddon and Gentle 2000). The time was reduced to 18 seconds if an analgesic was administered, indicating that pain is associated with lameness.

Osteoporosis is rare in broilers, but it is thought that continued genetic selection for fast growth may be resulting in poor bone quality, accounting for bone breakages to which broilers are susceptible. Bone fractures occur during catching of birds and when they are hung on shackles before slaughter and can result from workers forcing deformed limbs into shackles. Rough handling can also dislocate hips. The major welfare concerns at the catching and shackling stages are pain and fear. Bruises occur during catching, loading, and unloading broilers (Ekstrand 1998). Factors increasing the risk of bruising in broilers on the farm include higher body weight, warmer temperatures, more active birds, brighter lighting, and presence of obstacles in the building (Newberry 2000). Among broilers condemned at the slaughter plant, 90% of condemned bruises occur within 12 hours prior to slaughter, and 98% within 24 hours prior to slaughter (Newberry 2000).

Broilers are also subject to a number of muscle abnormalities that are both genetic and nutritional in origin (E.U. Scientific Committee on Animal Health and Animal Welfare 2000).

Most of the health problems encountered in broilers are either cardiac (ascites and sudden death) or leg problems that are more prominent in heavy lines, hence are influenced by both selection and nutrition. The increase of metabolic diseases such as heart failure syndrome, ascites, hypertrophy of the right ventricle, edema in lungs and heart can be directly related to an insufficient oxygen supply in metabolism causing primarily pulmonary hypertension (Scheele, et al. 1997). Artificial selection has emphasized a high growth rate and a low feed conversion ratio. An inhibited consumption of oxygen leading to reduced heat production is one mechanism by which a low feed conversion ratio in fast-growing chickens can be achieved (Scheele, et al. 1997).

Ascites occurs in young, fast-growing broilers and is a common cause of death or carcass condemnation (Thorp and Maxwell 1993). Ascites refers to accumulation of serum-like fluid in the abdomen of the bird. Clinical signs include distended abdomen, recumbency, dyspnoea, retarded growth, listlessness, and possible cyanosis. Some birds, Thorp and Maxwell (1993) note may die of convulsions during handling. Post-mortem examinations reveal large accumulations of abdominal fluid, severe and widespread muscle congestion, pericardial effusion, and “a large flaccid heart.” Edges of the liver are poorly defined and rounded and the liver is generally congested with plasma protein clots. Kidneys may be enlarged and congested and lungs may be congested and edema may be present. Incidence and severity of ascites can be reduced by improving ventilation and/or reducing growth rate (Thorp and Maxwell 1993).

Sudden death (flip-over) also is considered an outcome of genetic selection for fast growth (Duncan 1994).

Dermatitis and other skin disorders also have increased in broilers. Between 1969 and 1998, observed skin diseases in broilers increased from 1.4% to 34.5% (E.U. Scientific Committee on Animal Health and Animal Welfare 2000). Lesions occur on the breast, legs, and feet, and can become infected by bacteria and fungi when exposed to feces and dirty litter. Infection can be spread through the blood stream. Behavioral restrictions (space available due to stocking density, etc.) constrain locomotor and litter-directed activities potentially resulting in leg weakness, poor litter quality and skin lesions.

Mench (1991, 1993) noted that the welfare of broiler breeders (broiler hens and roosters kept for producing stock) is particularly at risk. Broiler breeding hens, in particular, show a higher percentage of defective eggs (of concern to broiler breeding companies), reduced capacity for antibody production, reduced egg, sperm, and embryo quality (possibly due to fatness of heavy lines) (Mench 1993).

Mench (1991, 1993) reviewed a number of practices that have been shown to compromise the overall welfare of broiler breeders, while at the same time maintaining health and productivity. One is food restriction. Selection of broilers for increased growth rate has resulted in increased appetite. Increased food intake results in obesity, which must be controlled in broiler parent stock in order to maintain reproductive competence.

Food restriction is started when birds are between one and three weeks of age. It results in a reduction in the body weight of adults to approximately 45-50% that of birds fed *ad libitum* (at will). Broiler breeders fed on a commercial ration eat only a quarter to a half as much as they would with free access to food, and they are highly motivated to eat at all times (Savory, et al. 1993). Savory, et al. (1993) point out that the modern broiler breeder industry is caught in a welfare dilemma: on the one hand broiler stock appear to be chronically hungry, while on the other hand less severe food restriction leads to reduced fertility and health problems. The dilemma created by genetic selection for fast growing broilers (broilers with large appetites) coupled with the health problems resulting from ad libitum feeding, make it impossible for broiler breeding companies to meet the basic welfare requirement of freedom from thirst, hunger, and malnutrition.

The two most commonly used feed restriction programs are skip-a-day feeding, wherein amounts of food are calculated to achieve desired body weights and fed on alternate days, and limited feeding in which half the skip-a-day amount is fed every day (Mench 1993). Food is consumed in a very short period of time compared to the length of time food is absent from the environment.

Production benefits of feed restriction in fast-growing broilers include higher peak egg production and persistency of lay, improved fertility and hatchability, improved shell quality, and reduction in number of defective eggs (Mench 1993). Health benefits include improved antibody responses and disease resistance, fewer joint, bone and foot problems and significantly decreased mortality as compared to fully fed birds. Food restricted broilers show evidence of chronic hunger, behavior that is indicative of frustration of feeding motivation, elevated stress hormones, and behaviors such as overdrinking, which results in water rationing. Feed-restricted males are more aggressive than fully-fed males, while feed-restricted hens and pullets are more fearful and active and display pecking stereotypies.

Physiological indicators of broiler welfare, as with all agricultural animals, include body temperature, heart rate, blood cell counts, hormones and enzymes in plasma (E.U. Scientific Committee on Animal Health and Animal Welfare 2000). Behavioral indicators include panic, violent escape, freezing, panting, suppression of normal behavior, and various abnormalities of sound, self-maintenance, and locomotion. There are genetic influences in the relationship between physiological and behavioral responses to stress.

Vestergaard (1999) listed a number of ways to assess animal welfare in broiler production systems. These included gait score, tonic immobility (fear), tibial dyschondroplasia, and dustbathing occurrences (reduced in lame broilers). Other stressors include deprivation of dark periods for replenishing sleep (because light encourages growth), disability, pain, fear, increasing bird density, and heat stress which kills millions of broilers in the US every summer.

Most commercial turkeys are kept on litter in controlled environment or partially open housing. As with meat chickens, the welfare of turkeys is a matter of concern due to often high densities of birds in turkey houses and the selection for rapid growth by breeding companies.

The flight response to a fright can lead densely confined turkeys to pile against a far wall and suffocate when presented with an unexpected, novel stimulus they have perceived as threatening. (For similar reasons, on a human level, it is not recommended to yell "Fire!" in a crowded theatre.)

A number of surgeries are practiced on young turkey poults. Beak trimming is performed at the hatchery to reduce the possibility of cannibalism (Hocking 1993).[25] A hot blade or a laser device is used. The laser device uses a high voltage to burn a small hole through the upper beak. After several days, the tip of the beak falls off. Studies suggest that birds experience chronic pain following beak trimming for at least two to six weeks after the operation (Hocking 1993). The majority, if not all, turkeys in Minnesota are beak-trimmed (Dr. Keith Friendshuh, Minnesota Board of Animal Health, personal communication).

Toe clipping is practiced to avoid down-grading of the carcass as a result of scratches on the skin of the breast and legs that may be incurred when the flock "panics" or during capture and transport to slaughter (Hocking 1993). Higher mortality, lower body weights and improved feed conversion, combined with changes in behavior immediately following toe clipping suggest that turkeys experience pain from the operation, although long-term consequences were not clear because one study that examined neural changes after toe removal indicated that, in contrast to beak trimming, extensive neuroma formation did not occur (Gentle and Hunter 1988, cited in Hocking 1993). Newberry (1992) observed higher early mortality and reduced standing time throughout the rearing period in toe-clipped turkeys.

Management of the production environment is critical for turkey welfare. Maintenance of litter so that it is dry and birds are not exposed to ammonia or other noxious materials on the surface of the bed, including fecal enzymes, may prevent development of focal ulcerative dermatitis, or blisters, also known as breast buttons (Hocking 1993). Photoperiod and litter coarseness can also affect development of breast buttons (Newberry 1992, 1993). It is reasonable to assume that the presence of breast buttons reduces welfare.

[25] The majority, if not all, turkeys in Minnesota are beak-trimmed (Dr. Keith Friendshuh, Minnesota Board of Animal Health, personal communication).

A common condition that affects both broilers and turkeys is footpad dermatitis, thought to be caused by a combination of wet litter, high ammonia content and other chemical factors in the litter (Ekstrand, et al. 1997, Geraedts, 1983). Lesions can develop in less than a week and progress to ulcers. Crusts formed by exudates, litter, and fecal material often cover ulcers. The lesions may heal, especially if the litter quality is improved.

Footpad dermatitis tends to be a neglected problem because the feet generally are not used for human consumption, but they may provide an entry for bacteria that reduce carcass quality. In severe cases, lesions may also cause pain to the birds, which, together with reduced health, is a welfare issue. Footpad dermatitis is hard to detect in commercial conditions because birds tend to get lesions on both feet and hence do not limp, although reduced mobility may be evident. Improving the litter may allow broilers' feet to heal, as broilers also scratch in the litter and aerate it. Young turkeys are less prone to scratch in the litter, which may contribute to a soggier bed and explain why turkeys seem more susceptible to the ailment (Ekstrand, et al. 1997). The findings of a very high rate of footpad dermatitis should raise also questions from a welfare point of view (Hocking 1993).

Genetic predisposition, nutrition, infection, mycotoxins, medication, husbandry practices, and interactions between these have been associated with different forms of leg weakness (Hocking 1993). Degenerative hip disorders in adult male turkeys have been shown to result in a state of chronic pain that, in turn, inhibits locomotion (Duncan 1994).

Welfare problems also occur due to fear and injuries incurred in catching and transport to slaughter, and at the slaughterplant prior to and during stunning.

An issue that has come to the forefront recently in the US is on-farm culling of sick or injured turkeys. Market-age turkeys are very difficult to handle and kill, and producers seem to generally kill them using blunt force trauma to the head. At the University of California, Davis, researchers are evaluating the potential for a poultry captive bolt pistol developed in the UK to be used as a more reliable alternative (Dr. J. Mench, December 2000, personal communication). Not only for turkeys, but also for other agricultural animals on-farm culling is a major welfare concern because producers and/or staff are not always well equipped or trained to do it in the most humane manner.

As with broilers, pigs, and dairy cattle, breeding for larger size and performance in turkeys has occurred at the expense of good bone growth or structure (Orth 1999). Selection for high body weight (large breasts) for some years has prevented domesticated turkeys from mating normally and without the potential of injury to the female. Commercial males may be three times heavier than females, with the consequence that all contemporary, commercial turkey reproduction is by artificial insemination (Kruip and van Reenen 2000, Price 1998).

As long as turkeys can survive and grow, continued selection for growth and breast size is economical for the industry, while selecting on other traits would not be. Turkeys selected for walking ability had reduced breast width compared to commercial lines (Ye, et al. cited in Orth 1999). As discussed by Hirt, et al. (1997), the question of whether breeding efforts may genetically alter an animal to such an extent that pathological changes are almost inevitable, and in such a way that not even optimum housing conditions will result in a decrease of the symptoms, must be considered according to ethical and legal criteria. Therefore, selection criteria for all agricultural animals must be determined not only by economics, but also by physiological and ethological parameters that take into account the animal's needs.

References

Andersson, M. (2000). *Domestication effects on behaviour: Foraging, parent-offspring interactions and antipredation in pigs and fowl.* Acta Universitatis Agriculturae Sueciae. Veterinaria 86. Skara, Sweden: Swedish University of Agricultural Sciences, Department of Animal Environment and Health.

Appleby, M.C. (1998). Modification of laying hen cages to improve behavior *Poultry Science, 77,* 1828-1832

Appleby, M.C. (2000). Laying hen welfare and developments in enriched cages. *Ruth Harrison Memorial Meeting, Farm Animal Care Trust, Fyvie Hall, University of Westminster, London, November 29, 2000.*

Appleby, M.C., Hughes, B.O., & Elson, H.A. (1992). *Poultry production systems: Behaviour, management and welfare*. Oxon, UK: CAB International.

Bai, Y., Sunde, M.L., and Cook, M.E. (1994). Egg production of laying hens before and after force-molting is not correlated. *Journal of Applied Poultry Research, 3,* 127-132.

Baker, M., Brake, J., & McDaniel, G.R. (1983). The relationship between body weight loss during an induced molt and postmolt egg production, egg weight, and shell quality in caged layers. *Poultry Science, 62,* 409-413.

Bell, D. (1993). The egg industry of California and the USA in the 1990s: A survey of systems. *World's Poultry Science Journal, 48,* 58-64.

Berg, C.C. (1998). *Foot-pad dermatitis in broilers and turkeys – Risk factors and prevention. Acta Universitatis Agriculturae Sueciae, Veterinaria 36.* Uppsala, Sweden: Swedish University of Agricultural Sciences.

Berry, W.D. & Brake, J. (1987). Postmolt performance of laying hens molted by high dietary zinc, low dietary sodium, and fasting: Egg production and eggshell quality. *Poultry Science, 66,* 218-226.

Bil► ík, B. (2000). *Feather pecking in laying hens: Social and developmental factors. Doctoral thesis. Acta Universitatis Agriculturae Sueciae. Veterinaria 82*. Uppsala, Sweden: Swedish University of Agricultural Sciences.

Blokhuis, H.J. & van der Haar, J.W. Effects of floor type during rearing and of beak trimming on ground pecking and feather pecking in laying hens. *Applied Animal Behaviour Science, 22,* 359-369.

Brantas, G.C. (1980). The prelaying behaviour of laying hens in cages with and without laying nests. *The laying hen and its environment: A seminar in the EEC Programme of Coordination of Research on Animal Welfare, March 11-13, 1980.* R. Moss (ed.). Boston: Martinus Nijhoff Publishers, for The Commission of the European Communities.

Breward, J. (1984). Cutaneous nociceptors in the chicken beak. *Journal of Physiology, 346,* 56.

Breward J. & Gentle M.J. (1985). Neuroma formation and abnormal afferent nerve discharges after partial beak amputation (beak trimming) in poultry. *Experientia, 41(9),*1132-1134.

Broom D.M. (1990). Effects of handling and transport on laying hens. *World's Poultry Science Journal, 46,* 48-50.

Buhr, R.J. & Cunningham, D.L. (1994). Evaluation of molt induction to body weight loss of fifteen, twenty, or twenty-five percent by feed removal, daily limited, or alternate-day feeding of a molt feed. *Poultry Science, 73,* 1499-1510.

Campbell, J.R. & Lasley, J.F. (1985). *The science of animals that serve humanity*. 3rd edition. New York: McGraw-Hill Book Company.

Craig, J.V. & Muir, W.M. (1991). Research note: Genetic adaptation to multiple-bird cage is less evident with effective beak trimming. *Poultry Science, 70,* 2214.

Craig, J.V. & Swanson, J.C. (1994). Review: Welfare perspectives on hens kept for egg production. *Poultry Science, 73,* 921-938.

Cunningham, D.L. & Mauldin, J.M. (1996). Cage housing, beak trimming, and induced molting of layers: A review of welfare and production issues. *Journal of Applied Poultry Research 5,* 63-69.

Danbury T.C., Weeks C.A., Chambers J.P., Waterman-Pearson A.E. & Kestin S.C. (2000). Self-selection of the analgesic drug carprofen by lame broiler chickens. *Veterinary Record, 146,* 307-311.

Duff, S.R.I. (undated ms.) *Degenerative changes in turkey hipjoints*. (Agricultural Food Research Council Institute of Animal Physiology and Genetics Research, Edinburgh Research Station, Roslin, UK).

Duncan I.J.H., Beaty E.R., Hocking P.M. & Duff S.R.I. (1991). Assessment of pain associated with degenerative hip disorders in adult male turkeys. *Res. Vet. Sci*. 50, 200-203.

Duncan, I.J.H. (1994, February 1). Practices of concern. *JAVMA, 204(3),* 379– 384.

Duncan, I.J.H. (1993, January-March). The science of animal well-being. U.S. Department of Agriculture National Agriculture Library, *Animal Welfare Information Center Newsletter, 4(1).*

Duncan, I.J.H. (1980). The ethogram of the domesticated hen. *The laying hen and its environment: A seminar in the EEC Programme of Coordination of Research on Animal Welfare, March 11-13, 1980.* R. Moss (ed.). Boston: Martinus Nijhoff Publishers, for The Commission of the European Communities.

Duncan, I.J.H. (1981b). Animal Welfare: Lessons from Work on Poultry. *Research and development in relation to farm animal welfare*. London: Birkhauser Verlag.

Duncan, I.J.H and Mench, J. (2000). Does hunger hurt? *Poultry Science, 79.*

Ekstrand, C. & Algers, B. (1977). Rearing conditions and foot-pad dermatitis in Swedish turkey poults. *Acta Veterinaria Scandinavica, 38,* 167-174.

Ekstrand, C. (1998). An observational cohort study of the effects of catching method on carcase rejection rates in broilers. *Animal Welfare 7,* 87-96.

Ekstrand, C., Algers, B., & Svedberg, J. (1997). *Preventive Veterinary Medicine, 31,* 167-174.

Elson, A. (1992). Bone breakage in laying hens is an economic and welfare problem. *MISSET-World Poultry, 8 (1)*, 20-21.

E.U. Scientific Committee on Animal Health and Animal Welfare. (2000). The welfare of chickens kept for meat production (broilers). Report of the Scientific Committee on Animal Health and Animal Welfare, Adopted March 21, 2000. Brussels: European Commission Health and Consumer Protection Directorate-General.

Fischer, G. (1975). The behaviour of chickens. (pp. 454-489.) *The behaviour of domestic animals*. (3rd ed.) London: Baillière Tindall.

Fox, M.W. (1997). *Eating with conscience: The bioethics of food*. Troutdale, OR: New Sage Press.

Fraser, A.F. & Broom, D.M. (1990). *Farm animal behaviour and welfare*. London: Ballière Tindall.

Fraser, D., Weary, D.M, Pajor, E.A., & Milligan, B.N. (1997). A scientific conception of animal welfare that reflects ethical concerns. *Animal Welfare, 6(3*), 187-205.

Fölsch, D.W. & Vestergaard, K. (1981). *The behaviour of fowl: Normal behaviour and effect of different housing systems and rearing methods*. Boston: Birkhauser Verlag.

Geraedts, L.H.J. (1983). Leg disorders caused by litter conditions and the influence of the type of litter and of litter cultivations on the results of turkeys. *Turkeys (September-October),* 20-25.

Gentle M.J. (1989). Cutaneous sensory afferents recorded from the nervus intramandibularis of Gallus gallus var domesticus. *Journal of Comparative Physiology A. 164 (6),* 763-774.

Gentle, M.J. (1992). Pain in birds. *Animal Welfare, 1992 (1),* 235-247.

Gentle M.J. & Breward J. (1986). The bill tip organ of the chicken (*Gallus gallus var. domesticus*). *J. Anat*. 145, 79-85.

Gentle, M.J. & Hughes, B.O. (undated ms.) *Anatomical consequences of beak trimming (partial beak amputation) in turkeys.* (Agricultural Food Research Council Institute of Animal Physiology and Genetics Research, Edinburgh Research Station, Roslin, UK).

Gentle, M.J. & Hunter, L.H. (1988). Neural consequences of partial toe amputation in chickens. *Res. Vet. Sci. 45,* 374-376.

Gentle M.J., Hunter L.N. & Corr S.A. (1997). Effects of caudolateral neostriatal ablations on pain-related behaviour in the chicken. *Physiol. Behav.* 61 (4), 493-498.

Gentle M.J., Hunter L.N. & Waddington D. (1991). The onset of pain related behaviours following partial beak amputation in the chicken. *Neurosci. Lett.* 128 (1), 113-116.

Gentle M.J. & Tilston V.L. (2000). Nociceptors in the legs of poultry: implications for potential pain in pre-slaughter shackling. *Animal Welfare* 9 (3), 227-236.

Gildersleeve, R.P., Satterlee, D.G., Johnson, W.A., and Scott, T.R. (1983). The effects of forced molt treatment on blood biochemicals in hens. *Poultry Science, 62,* 755-762.

Green, L., Poetzsch, C., Nicol, C., Lewis, K., & Kimpton, A. (2000). Population studies of feather pecking on commercial farms. *Featherpecking in laying hens: Exploring solutions*. Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science.

Gregory, N.G., Wilkins, L.J., Eleperuma, S.D., Ballantyne, A.J., Overfield, N.D. (1990). Broken bones in domestic fowls: effect of husbandry system and stunning method in end-of-lay hens. *British Poultry Science, 31,* 59-69.

Grigor, P.N., Hughes, B.O., & Gentle, M.J. (undated ms. (later than 1993)). *Should turkeys be beak trimmed? An analysis of the costs and benefits of different methods.* (Agricultural Food Research Council Institute of Animal Physiology and Genetics Research, Edinburgh Research Station, Roslin, UK).

Gunnarsson, S. (2000). *Laying hens in loose housing systems: Clinical, ethological and epidemiological aspects. Acta Universitatis Agriculturae Sueciae. Veterinaria 73. Doctoral Thesis*. Uppsala: Swedish University of Agricultural Sciences.

Gunnarsson, S., Yngvesson, J., Keeling, L., and Forkman, B. (2000). Rearing without access to perches impairs the spatial skills of laying hens. In Laying hens in loose housing systems: Clinical, ethological and epidemiological aspects. Acta Universitatis Agriculturae Sueciae. Veterinaria 73. Skara, Sweden: Swedish University of Agricultural Sciences, Department of Animal Environment and Health.

Hale, E.B., Schleid, W.M., and Schein, M.W. (1969). The behaviour of turkeys. In *The behaviour of domestic animals*. 2nd Edition. E.S.E. Hafez, Ed. London: Ballière, Tindall and Cassell.

Hart, B. (1985). *The behavior of domestic animals*. New York: W.H. Freeman and Company.

Hirt, H. Reinmann, M., & Oester, H. (1997). Leg problems in fattening turkeys. *Proceedings of the Fifth International Symposium on Poultry Welfare*. Koene, P. and Blokhuis, H.J., eds. Wageningen, NE: Wageningen Agricultural University, pp. 80-82.

Hocking, P. (1993). Welfare of turkeys. *4th European Symposium on Poultry Welfare, Working Group IX of the European Federation of the World's Poultry Science Association, Edinburgh, September 18-21, 1993,* Savory, C.J. & Hughes, B.O., eds. Herts, UK: Universities Federation for Animal Welfare.

Hogan, J.A., Honrado, G.I., & Vestergaard, K. (1991). Development of a behavior system: Dustbathing in the Burmese Red Junglefowl (Gallus gallus spadiceus): II. Internal factors. *Journal of comparative psychology, 105(3),* 269-273.

Holt, P.S. (1992). Effects of induced molting on immune responses of hens. *British Poultry Science 33,* 165-175.

Holt, P.S. (1995). Horizontal transmission of *Salmonella enteritidis* in molted and unmolted laying chickens. *Avian Diseases 39,* 239-249.

Holt, P.S. & Porter, R.E. (1992). Effects of induced molting on the course of infection and transmission of *Salmonella enteritidis* in White Leghorn hens of different ages. *Poultry Science 71,* 1842-1848.

Huber-Eicher, B. (2000). Poultry production in Switzerland: The problem of feather pecking. *Featherpecking in laying hens: Exploring solutions*. Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science.

Hughes, B.O. (1980). The assessment of behavioral needs *The laying hen and its environment, March 11-13, 1980.* R. Moss (ed.). Boston: Martinus Nijhoff Publishers, for The Commission of the European Communities.

Jensen, J.F. (1980). Moulting in the domestic hen (*Gallus domesticus*) and its use and effect. *The laying hen and its environment, Moss, R., ed.*, pp. 259-262, discussion pp. 263-268. Boston: Martinus Nijhoff Publishers, for the Commission of the European Communities.

Jones, R.B. (1996, July). Fear and adaptation in poultry: insights, implications and imperatives. *World's Poultry Science Journal, 52*, 131-174.

Keeling, L. (2000). A summary of Swedish research on feather pecking. *Featherpecking in laying hens: Exploring solutions*. Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science.

Keeling, L. (1994). Feather pecking: Who in the group does it, how often and under what circumstances? *Proceedings of the 9th European Poultry Conference, Glasgow,* 288-289.

Kempsey, R. (2000). Feather pecking from the farmer's perspective. *Featherpecking in laying hens: Exploring solutions*. Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science.

Keshavarz, K. (1995). Impact of feed withdrawal and dietary calcium level on force-rested hens. *Journal of Applied Poultry Research, 4,* 254-264.

Kestin S.C., Knowles T.G., Tinch A.E. & Gregory N.G. (1992). Prevalence of leg weakness in broiler chickens and its relationship with genotype. *Vet. Rec. 131,* 190-194.

Kjaer, J.B. (2000). Selection on feather pecking behaviour: Direct and indirect responses. *Featherpecking in laying hens: Exploring solutions*. Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science.

Knowles, T.G. (1990). The effect of housing system on the activity level and bone strength of laying hens. *Applied Animal Behaviour Science, 26,* 290-291.

Knowles, T.G. & Broom, D.M. (1990). Limb bone strength and movement in laying hens from different housing systems. *Veterinary Record, 126,* 354-356.

Knowles T.G., Broom, D.M., Gregory, N.G., & Wilkins L.J. (1993). Effect of bone strength on the frequency of broken bones in hens. *Research in Veterinary Science, 54,* 15-19.

Knowles T G, 1994. Handling and transport of spent hens. *World's Poultry Science Journal, 50,* 60-61.

Koene, P. & Blokhuis, H.J. (1997). *Proceedings of the fifth European symposium on poultry welfare, 1997.* June 7-10, 1996. Working Group IX of the European Federation of the World's Poultry Science Association. Wageningen, The Netherlands: Wageningen Agricultural University and the Institute of Animal Science and Health.

Kruip, Th.A.M. & van Reenen, C.G. (2000). Biotechnology of reproduction and farm animals welfare. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Loveridge, N. (1999). Bone: More than a stick. *Journal of Dairy Science 82, Supp. 2,* S190 ff.

Lyons, J.J. & Vanderpopulaire, J.M. (1996). Spent Leghorn hens converted into a feedstuff. *Journal of Applied Poultry Research, 5,* 18-25.

Marion, J.E. (1968). An evaluation for processing of layers housed in cages and on the floor. *Poultry Science, 47(4),*1250-1254.

Mason, J., & Singer, P. (1980). *Animal factories: The mass production of animals for food and how it affects the lives of consumers, farmers, and the animals themselves.* New York: Crown Publishers.

Mench, J.A. (1991). Research note: Feed restriction in broiler breeders causes persistent elevation in corticosterone secretion that is modulated by dietary tryptophan. *Poultry Science, 70,* 2547-2550.

Mench, J.A. (1993). Problems associated with broiler breeder management. *Fourth European Symposium on Poultry Welfare. Working Group IX of the European Federation of the World's Poultry Science Association, Edinburgh, September 18-21, 1993,* Savory, C.J. & Hughes, B.O., eds. Herts, UK: Universities Federation for Animal Welfare.

Mench, J.A. (1993). The welfare of poultry in modern production systems. Maryland Agricultural Experiment Station. College Park, MD: University of Maryland, Dept. of Poultry Science.

Mench, J.A. & van Tienhoven, A. (1986). Farm animal welfare: Behavioral and physiological studies are providing a basis for the development of innovative housing. *American Scientist, 74,* 598-603.

Moss, R., ed. (1980). *The laying hen and its environment: A Seminar in the EEC Programme of Coordination of Research on Animal Welfare.* Luxembourg, March 11-30, 1980. Boston: Martinus Nijhoff Publishers.

Mrosovsky, N. & Sherry, D.F. (1980). Animal anorexias *Science, 207,* 837-842.

Newberry, R. (2000, March 6). *Humane handling, transportation and slaughter of spent hens. Report to the United Egg Producers' Scientific Advisory Committee on Animal Welfare*. (unpublished ms.).

Newberry, R., Webster, A.B., Lewis, N.J., and Van Arnam, C. (1999). Management of spent hens. *Journal of Applied Animal Welfare Science 2,* 13-29.

Newberry, R.C. (1992). Influence of increasing photoperiod and toe clipping on breast buttons of turkeys. *Poultry Science 71,* 1471-1479.

Newberry, R.C. (1993). The role of temperature and litter type in the development of breast buttons in turkeys. *Poultry Science, 72,* 467-474.

Nørgaard-Nielsen, G. (1989a). *Rapport over Projekt for Afprøvning af Hans Kier Systemet til Alterativ Aegproduktion.* Køpenhavn: Royal Veterinary and Agricultural University.

Nørgaard-Nielsen, G. (1989b). Alternative systems in Scandinavia. *EUR11711-Alternative Improved Housing Systems for Poultry*. Luxembourg: Office for Official Publications of the European Communities.

Nørgaard-Nielsen, G. (1990). Bone strength of laying hens kept in an alternative system, compared with hens in cages and on deep-litter. *British Poultry Science, 31*, 81-89.

Odén, K. (1994). Höns och andra fjäderfän. Stockholm, Lts förlag AB.

Olsson, A.S. and Keeling, L.J. (2000). Night-time roosting in laying hens and the effect of thwarting access to perches. *Applied Animal Behaviour Science, 68,* 243-256.

Orth, M.W. (1999). The regulation of growth plate cartilage turnover. *Journal of Dairy Science, 82, Supplement 2,* S183 ff.

Perry, T. (2000, September 7). Egg producers are McMiffed . *Los Angeles Times*.

Preisinger, R. (2000). Selection against abnormal behaviour from a commercial breeder's perspective. *Featherpecking in laying hens: Exploring solutions.* Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science.

Price, E.O. (1999). Behavioral development in animals undergoing domestication. *Applied Animal Behaviour Science 65,* 245-271.

Rodenburg, B. & Koene, P. (2000). Feather pecking and coping style in the laying hen. *Featherpecking in laying hens: Exploring solutions*. Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science.

Rogers, L.J. (1995). *The development of brain and behaviour in the chicken*. Oxon, UK: CAB International.

Rolon, A., Buhr, R.J., and Cunningham, D.L. (1993). Twenty-four-hour feed withdrawal and limited feeding as alternative methods for induction of molt in laying hens. *Poultry Science 72,* 776-785.

Rowland, L.O. & Harms, R.H. (1970). The effect of wire pens, floor pens and cages on bone characteristics of laying hens. *Poultry Science, 49,* 1223-1225.

Rowland, L.O. & Harms, R.H. (1972). Time required to develop bone fragility in laying hens. *Poultry Science, 51,* 1339-1341.

Rowland, L.O., Wilson, H.R., Fry, J.L. & Harms, R.H. (1968). A comparison of bone strength of caged and floor layers and roosters. *Poultry Science, 47,* 2013-2015.

RSPCA. (1989). Osteopenia in laying hens: Report of a conference sponsored by the RSPCA at Streatley on Thames. 4 April 1989. London: Royal Society for the Prevention of Cruelty to Animals.

Said, N.W., Sullivan, T.W., Bird. H.R., and Sunde, M.L. (1983). A comparison of the effect of two force molting methods on performance of two commercial strains of laying hens. *Poultry Science, 63,* 2399-2403.

Savory, J. (2000). Four separate traits associated with feather pecking and related factors. *Featherpecking in laying hens: Exploring solutions*. Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science.

Savory, C.J. & B.O. Hughes, eds. (1993). *Fourth European symposium on poultry welfare. Edinburgh, September 18-21, 1993.* Working Group IX of the European Federation of the World's Poultry Science Association. Potters Bar, UK: Universities Federation for Animal Welfare.

Savory, C.J., Maros, K., and Rutter, S.M. (1993). Assessment of hunger in growing broiler breeders in relation to a commercial restricted feeding programme. *Animal Welfare, 2,* 131-152.

Scheele, C.W., Kwakernaak, C. & van der Klis, J.D. (1997). The increase of metabolic disorders in poultry affecting health, stress and welfare. *Proceedings of the Fifth International Symposium on Poultry Welfare*. Koene, P. and Blokhuis, H.J., eds. Wageningen, NE: Wageningen Agricultural University, pp. 26-28.

Sneddon, L.U. & Gentle, M.J. (2000). Pain in farm animals. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Sparrey J.M. & Kettlewell P.J. (1994). Shackling of poultry – is it a welfare problem? *World's Poultry Science Journal, 50 (2),* 167-176.

Spicer, B. (2000). Feather pecking from the commercial breeder's perspective. *Featherpecking in laying hens: Exploring solutions*. Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science.

Steiger. A. (2000). Aviary systems for laying hens in Switzerland. *Ruth Harrison Memorial Meeting, Farm Animal Care Trust, Fyvie Hall, University of Westminster, London, November 29, 2000.*

Thorp, B.H. & Maxwell, M.H. (1993). Health problems in broiler production. *Fourth European Symposium on Poultry Welfare. Working Group IX of the European Federation of the World's Poultry Science Association, Edinburgh, September 18-21, 1993,* Savory, C.J. & Hughes, B.O., eds. Herts, UK: Universities Federation for Animal Welfare.

U.S. Department of Agriculture. (1999, October). Part I: Reference of 1999 table egg layer management in the U.S. Washington, DC: National Animal Health Monitoring System, Animal and Plant Health Inspection System.

Van Liere, J.K., & P.R. Wiepkema, P.R. (1990). Dustbathing behaviour of laying hens as related to quality of dustbathing material. *Applied Animal Behaviour Science, 26,* 127-141.

Vergerson, J. (2000). Feather pecking—on farm experiences (Free range hens). *Featherpecking in laying hens: Exploring solutions*. Meeting at the Department of Clinical Veterinary Science, Langford House, Langford, North Somerset, sponsored by the RSPCA. June 21, 2000. Bristol: University of Bristol, School of Veterinary Science

Vestergaard, K. (1980). The regulation of dustbathing and other behaviour patterns in the laying hen: A Lorenzian approach. In *The laying hen and its environment: A Seminar in the EEC Programme of Coordination of Research on Animal Welfare*, Moss, R. (Ed.) Luxembourg, March 11-30, 1980. (pp. 101-120). Boston: Martinus Nijhoff Publishers.

Vestergaard, K. (1981). Aspects of the normal behaviour of the fowl. *The behaviour of fowl: The normal behaviour and the effect of different housing systems and rearing methods*. Fölsch, D. and Vestergaard, K., eds. Basel: Birkhäuser Verlag.

Vestergaard, K.S. (1994). *Dustbathing and its relation to feather pecking in the fowl: Motivational and developmental aspects*. Frederiksberg, Denmark: Jordbrugsforlaget.

Vestergaard, K.S. , Hogan, J. & Kruijt, J. (1990). The development of a behavior system: Dustbathing in the Burmese Red Junglefowl. I. The iinfluence of the rearing environment on the organization of bathing. *Behaviour, 112(1-2),* 35-52.

Vestergaard, K.S. (1999). Ways of assessing animal welfare in broiler production systems. *Assessment of Animal Welfare at Farm or Group Level, International Workshop organized by Danish Institute of Agricultural Sciences and The Royal Veterinary and Agricultural University, 27-28 August 1999, Abstracts, oral, contributed papers, contributed posters.*

Vestergaard, K.S. & Sanotra, G.S. (1999, February 20). Relationships between leg disorders and changes in the behaviour of broiler chickens. *The Veterinary Record, 144,* 205-209.

Webster, A.B. (2000). Behavior of White Leghorn laying hens after withdrawal of feed. *Poultry Science, 79,* 192-200.

Webster, A.B., Fletcher, D.L., & Savage, S.I. (1996). Humane on-farm killing of spent hens. *Journal of Applied Poultry Research, 5,* 191-200.

Weeks, C.A., Danbury, T.D., Davies, H.C., Hunt, P., Kestin, S.C. (2000). The behaviour of broiler chickens and its modification by lameness. *Applied Animal Behaviour Science, 67,* 111-125.

WHO (World Health Organization). (1988). *Salmonellosis Control: The role of animal and product hygiene. Report of a WHO expert committee. WHO Technical Report Series 774*. Geneva: World Health Organization.

Wiepkema, P.R. (1989). Alternative housing of laying hens: why and how? In: *Alternative improved systems for poultry*. Kuit, A.R., Wöhlhardt, D.A. & Blockhuis, H.J. (Eds). (pp. 8-25). Luxembourg: Commission of the European Communities.

Wiepkema, P.R. (1989). Alternative housing of laying hens: why and how? In: *Alternative improved systems for poultry*. Kuit, A.R., Wöhlhardt, D.A. & Blockhuis, H.J. (Eds). (pp. 8-25). Luxembourg: Commission of the European Communities.

Wood-Gush, D.G.M. (1955). The behaviour of the domestic chicken: A review of the literature. *British Journal of Animal Behaviour, 3,* 81-110.

Wood-Gush, D.G.M. (1959). A history of the domestic fowl from antiquity to the 19th century. *Poultry Science, 38,* 321-326.

Wood-Gush, D.G.M. (1971). *The behaviour of the domestic fowl*. London: Heinemann Educational Books, Ltd.

Wood-Gush, D.G.M. (1983). *Elements of ethology*. New York: Chapman and Hall.

Zimmerman, N.G. & Andrews, D.K. (1987). Comparison of several induced molting methods on subsequent performance of Single Comb White Leghorn hens. *Poultry Science, 66,* 408-417.

Zimmerman, N.G. & Andrews, D.K. (1990). Performance of Leghorn hens induced to molt by limited feeding of diets varying in nutrient density. *Poultry Science 69,* 1883-1891.

CHAPTER 6

CATTLE

I. The Natural History of Cattle

Domestic cattle belong to the genus *Bos*, which is commonly separated into four major categories: the taurine group (domestic cattle), the bibovine group (gaur, gayal, and banteng), the bisontine group (yak and bison), and the bubaline group (Eurasian buffalos). *B. taurus* includes cattle of the temperate and warm temperature zones, or European cattle, and *B. indicus*, the Zebu or humped cattle of India. Although they have different origins, the behavior patterns of European and Zebu cattle are similar (Hafez and Bouissou 1975).

Cattle are "large, hairy ruminants" that evolved to graze and browse grasses, herbs, and leaves of the bush and open plains (Hafez and Bouissou 1975, Kilgour 1985, Webster 1995). They are genetically programmed to spend much time eating and ruminating (Stricklin and Kautz-Scanavy 1983). The behavioral pattern of grazing is the same among all the Bos animals. Each one keeps its muzzle close to the ground as it uses its tongue to tear off mouthfuls of grass that it swallows without much chewing (Hafez and Bouissou 1975). Each may take between 50 and 80 bites a minute (Kilgour 1985). Cattle generally stand to graze and, as they consume the preferred herbage immediately under their muzzles, they shift to the left, right, or forward for the next bite, describing an arc of about 60-90º and, on a uniform sward, each cow mows a path about twice its body width. Cows are equipped with long tails with brushes or switches at the ends, which they use to keep away flies and other winged pests.

In the wild, while grazing, cattle travel, on an average, about 2.5 miles per day. In warm, wet, or windy weather and where flies and external parasites prevail, cattle will travel farther. In general, cattle will graze up to nine hours a day (or, in exceptional cases where grass is sparse, up to 15 hours per day). They graze in about three major bursts starting or ending with morning or evening twilight and up to one hour of intensive grazing near midnight (Kilgour 1985). The most continuous grazing periods are in the early morning and near sundown (Fraser, A.F. 1980, Hafez and Boissou 1975). Cattle may spend two hours per day going to or searching for suitable grazing sites.

When grazing, cattle show evidence of being selective in their intake (Fraser, A.F. 1980). Their degree of selectivity can be high, showing a preference for plants of particular species and even of certain growth stages within the plant species. Herbage contaminated with feces is usually rejected. However, if the pasture is widely contaminated [e.g., by liquid manure spread on it], the grass finally is eaten despite its having been contaminated (Tribe, 1955, cited in Hafez and Bouissou 1975). Laws, et al. (1996) allowed steers a choice between a control sward (C) on which no liquid manure/slurry was spread, a sward on which liquid manure was injected (I) and a sward on which liquid manure was sprayed (S), and found that the steers spent more time examining and eating C, took a greater proportion of bites on C, and reduced the sward surface height more on C compared with S or I. Similarly, cattle avoid plants with hairy or coarse appearance (Fraser, A.F. 1980). When plants are scarce, they are less selective.

During grazing, large quantities of slightly chewed herbage are swallowed and stored in the rumen. This herbage undergoes fermentation in the rumen and is later regurgitated in the form of boluses, thoroughly chewed, and reswallowed. Rumination is an adaptive trait: grazing permits the animal to gather a maximum amount of feed with a minimum amount of exposure in an open area while rumination allows it to finish eating the gathered feed at its leisure in a possibly less vulnerable environment.

Sixty-five to 80% of total rumination time is spent lying down. Cattle may ruminate from four to nine hours per day, with between 15 and 20 ruminating periods in a day, and the peak period for ruminating is just after nightfall (Fraser, A.F. 1980, Hafez and Boissou 1975). Time spent ruminating differs depending on the amount and structure of the food they have eaten, more structure leading to longer rumination times (Balch 1971, cited in Lidfors 1992).

Cattle rest for 9 or more hours each day (Kilgour 1985). Rest is an important behavior for cattle.

Dairy cattle breeds[26] differ in their grazing ability (Blakely and Bade 1979), primarily due to selection during breed development before cattle became confined indoors. Thus, Ayrshires, a breed developed in a county in Scotland noted for cold damp climate and little available forage, were selected for hardiness and excellent grazing ability. Brown Swiss, similarly, were selected for excellent grazing ability, having been developed on the mountain slopes of Switzerland.

On the other hand, Holstein-Friesian cattle were developed in the Netherlands in an area noted for excellent pastures (Blakely and Bade 1979). Jerseys and Guernseys were developed in the Channel Islands where pastures also were excellent. In the selection of these species, it was not necessary to select for good grazing abilities because forage was in plenty. Hence, the grazing abilities of Holstein, Jersey, and Guernsey cattle are only fair to good, while Ayrshires and Brown Swiss are excellent grazers.

As herbivores, cattle are adapted to high fiber, low density diets and do not adapt easily to high grain diets or to manufactured diets with high protein and low fiber.

In free-ranging cattle the herd usually has four to five main activity periods per 24-hour period (Arnold and Dudzinski 1978, cited in Lidfors 1992). During these times the animals feed, move, and have social interactions.

Getting up and lying down movements are performed according to species-specific movement patterns (Lidfors 1992). Before cattle lie down they walk slowly while sniffing the ground with sweeping head movements. Preparation for lying down consists of search for a place, checking of the place chosen, and introduction of lying down leading to a kneeling position (i.e., resting on the carpal joint). Lying down itself takes place in three stages: the animal bends its front legs, it lowers itself onto its front knees, and it lowers the abdomen with a backwards motion.

[26] A breed is a group of animals possessing certain characteristics that are common to the individuals within the group and that distinguish them from other groups of animals within the same species (Campbell and Lasley 1985). These characteristics are the trademark of that breed and are transmitted from one generation to another.

These species-specific movement patterns have relevance for the welfare-appropriate design of cattle and calf housing. Injuries occur when floor or pen or stall design is incompatible with cow needs. Hultgren (1988) found that electric cow trainers affected lying down behavior in dairy cattle, extending the time to perform the behavior, implying some difficulty performing the movements. This is of consequence if it prevents dairy cows from getting sufficient rest.

Choice of lying place also takes place according to species-specific rules (Lidfors 1992). At night, free-ranging cattle rest on higher ground than the surroundings. In the winter they select resting places out of the wind and in the summer they select resting places primarily in shade.

Cattle are social animals. Under natural or semi-natural conditions they usually live in groups with a few older cows, their daughters and calves (Reinhardt and Reinhardt 1975). The most common spontaneous group is the "matriarchal" herd built from a permanent association of an old female, her adult female offspring and their young (Hafez and Boussiou 1975). The social hierarchies established by cattle are linear or linear-tending in smaller groups of cattle with less than 10 individuals and complex in larger herds (Hafez and Boissou, 1975). Cattle have well-developed sight and hear tones at least up to 18,000 Hz. (Kilgour 1985). According to Kilgour (1985), a cow can recognize over 100 other animals in a herd and respond socially as subordinate or dominant to each herd member. Fraser, A.F. and Broom (1990) put the recognizable number at between 50 and 70 other individuals.

It was once thought that social order was the result of social dominance through aggression (Fraser, A.F. and Broom 1990). However, the use of dominance should be restricted to the phenomenon that can occur between every pair of animals in which one can inhibit the behavior of the other. The order is the sum of all such inhibitory relationships. While a dominant position may have been attained by aggression, a dominant animal need not be aggressive subsequently (Reinhardt and Reinhardt 1982).

Once a dominance order is established it is fairly permanent. To maintain a stable social relationship is required: recognition among individual animals, established social positions, and memory of social encounters that establish social status (Fraser, A.F. and Broom 1990). Social rank determines the order in which cows enter the milking barn or parlor and in which they feed. Among housed dairy cows that have choices of stalls available to them lower ranking cows avoid stalls previously occupied by dominant cows. The existence of dominance relationships in dairy cows implies that the housing must be ample, for example, in cubicle housing there should be extra cubicles so that low-ranked cows are not forced to stand in alleyways and be deprived of critical rest or to stand, particularly if in manure, for long periods of time so that their feet can become damaged (Newberry and Bergsten 1999).

Being social animals, cows like to have other cows around them. Being isolated from her conspecifics, e.g., tied up alone in a barn, will be stressful for her.

Mature males range either solitary or in bachelor herds that join the females only during mating season. By two and a half years of age, bulls dominate all the females and join the adult male rank order (Lidfors 1992). In other species such as bison and musk ox a closer association of sexes is seen.

Especially under intensive husbandry conditions, this social structure is modified by elimination of the maternal bond, rearing in one sex group of the same age, reduction of the home range to a few square meters and so forth. However, a social organization can be observed and a number of natural behaviors persist (Hafez and Bouissou 1975).

For cattle, living in a social group has a great impact on the members (Lidfors 1992). Behavior such as eating, resting, moving, and playing is synchronized. Distances between subgroups in cattle increase as forage conditions deteriorate, but individual space is maintained even on rangeland and intensive pasture (Fraser, A.F. and Broom 1990). Cattle keep a space around their heads protected from other cows (Kilgour 1985). The linear hierarchy enables higher social ranking animals first access to food or water under production conditions when these resources are limited in feed troughs or hay feeders.

Under intensive pasture conditions, dairy cows have a modal distance to their nearest neighbor of 8.8 meters (Fraser, A.F. and Broom 1990). Cows when lying tend to keep within two to three meters of one another compared to four to ten meters when grazing. Under crowded conditions, cows low in social rank may move about more than those in higher rank, apparently to avoid impinging on the individual space of dominant animals. Under these conditions, the individual distance of high-ranking cows is greater than that of low-ranking cows.

Bulls in small enclosures become strongly territorial, a feature of bull behavior that emerges at about 4 years of age. Aggressive behavior in cows takes the form of head butting and social behavior takes the form of licking, with submissive cows most frequently licking dominant cows (Lidfors 1992).

At parturition, cows withdraw from the herd to give birth. The strategy that cows have evolved to protect their calves is to leave them lying in the grass at a distance from the main herd and to return, four to six times a day, to let them suckle (Webster 1995). In a free-ranging beef herd, it is common for the calf to feed from its mother for at least the first six months of life. In commercial dairy production, the calf may be taken from its mother immediately, or it may be left with its mother for one to three days to suckle and obtain from the colostrum the antibodies to protect it from disease, and thereafter be removed from the cow and taken to a rearing accommodation where it is fed rationed amounts of milk or milk replacer. After about six weeks, the calf is weaned onto solid food. In the natural environment, grass and/or other roughage were always available to the calf. In a feedlot or commercial dairy setting, calves must be given roughage from the first week in order for their stomachs to develop normally.

Fossil remains of animals resembling the cow have been found in Asia dating back three to four million years (Blakely and Bade 1979). It is thought that early mountain man domesticated trailable species (cattle, sheep, horses, goats), following them as they grazed, while plains farmers domesticated other species (pigs, chickens, geese, ducks) driving them into their villages during the night. Most sources state that cattle were domesticated between 6 and 8,000 years ago, but cattle bones found in East Africa and dated by radiocarbon techniques indicate that cattle husbandry may have been practiced there 15,000 years ago (Campbell and Lasley 1985).

Columbus brought domesticated animals – horses, cattle, sheep, and hogs – to America on his second voyage, having found none the first time (Blakely and Bade 1979). Vera Cruz brought cattle from Spain to Mexico in 1521. Cattle were used primarily for milk, butter, hides, and draft because the presence of abundant game meant there was little need to use them for meat.

The introduction of barbed wire in the 1870s together with the end of the Indian wars and the killing of the buffalo, ended the long trail drives of Texas longhorns from Texas to the rail lines in Kansas, opening the Midwest for cattle production and marking the end of the open range. Closer supervision and business practices dictated heavier concentrations of more efficient

animals on smaller acreages. Cattle began to be bred for efficient and specialized meat and milk production.

Early dairy husbandry in North America relied mainly on one or two cows cared for by family labor (Blakely and Bade 1979). Growth of farms was limited by the perishability of dairy products and difficulty in transporting fluids. With the advent of refrigeration, the first rail shipment of milk in 1941 from Orange County, New York, to New York City was a major achievement and, along with other developments such as pasteurization and the cream separator, helped shape the early dairy industry.

While some beef breeds have been selected for both meat and milk production, dairy cow breeds were selected primarily to be docile milk producers. Dairy cattle conformation is well-adapted for milk production (Leaver 1999). However, it is important that selection be undertaken on more than one trait. Dairy cattle have been selected for udder conformation, body size and angularity as well as milk yield, but major emphasis of selection goals has been on docility and yield traits (Dr. I. Ekesbo, 2001, personal communication; Hansen 2000). Norway, Sweden, Denmark and Finland include female fertility in the selection criteria for profitability in their countries (Groen, et al. 1997, cited in McAllister 2000). These countries also select for increased mastitis resistance (Heringstad 2000), Norway using records on clinical mastitis incidence, Sweden and Finland using both somatic cell counts and clinical mastitis records, and Denmark using somatic cell count data.

In the United States, selection programs have increased the body size of Holstein cattle even though evidence shows that smaller cows have survival and efficiency advantages (Hansen 2000). Heavy body weight increases the likelihood that prolonged standing on hard surfaces will contribute to lameness. Hansen, et al. (1999) determined that productive life is longer for "small-line" Holstein cows than for "large-line" Holstein cows.

Dairy cattle that have been selected for high milk production seem particularly susceptible to stress and are at more risk of behavioral, physiological and immune problems (Rushen and de Passilé 1999). They require high levels of care and management.

Rushen (2000) noted that in 1948, Holstein cows accounted for no more than 48% of all registered milk cows in the United States (citing Petersen 1950). Today, the predominant dairy breed in the United States is the Holstein-Friesian, accounting for over 95% of dairy cows in the United States (U.S. Department of Agriculture 1996). In the United States, in the Holstein breed, selection for size and milk yield has been particularly aggressive. Over the last 200 years, milk production in the dairy cow has increased. In the last 40 years, artificial insemination and progeny testing of bulls has accelerated the rate of selection for performance within dairy breeds, while the development of cross-breeding schemes, used in other farm animal species to exploit hybrid vigour, has been small in comparison in dairy breeding (Leaver 1999). Rushen (2000) also noted that Thompson, et al. (2000) reported a fourfold increase in the inbreeding coefficient of dairy cows in the US from 1970 to 1998. They also reported that survival decreased as level of inbreeding increased.

Scientific investigations have shown a positive correlation between increase in milk yield and increase in disease incidences (e.g., Bendixen, et al. 1987, 1988). As will be discussed below, relationships between milk yield level and susceptibility to welfare-reducing diseases are and have been observed for over two decades and "appear to be included in the definition of the dairy herd of the future" (Barnouin and Karaman 1986).

II. The welfare of dairy cattle and calves

Until relatively recently, it had been assumed that the welfare of dairy cattle on farms in the United States and other countries has been good. Among the livestock species that have been submitted to increasing intensity of production, it was thought that dairy cattle were best off. However, in more recent years, with increased intensity of production and changes in dairy management, size, and structure, animal welfare scientists have expressed serious concerns related to the high-producing dairy cow and her calf.

A. General

Mastitis, foot and leg problems, conditions that lead to impaired reproduction, inability to show normal behavior, emergency physiological responses that consume energy needed for maintenance, and injury are the major welfare problems of dairy cattle (EU Scientific Committee on Animal Health and Animal Welfare 1999a). In the literature, some comprehensive accounts are given for animal health and welfare risk factors (Ekesbo 1988, 1989). These welfare problems include those originating in the production environment (slippery flooring contributing to splay leg injuries, rough flooring contributing to hoof damage, wet and manure contaminated floors contributing to foot infections) and management (high employee turnover contributing to lack of specialized care and to inattention to disease or stress symptoms or to overt abuse) as well as in artificial selection for single traits that has predisposed modern dairy cattle to particular welfare problems. Thus, high milk yield, for example, has been connected to mastitis (Bendixen, et al. 1988), parturient paresis (Bendixen 1987), and increased foot and leg disorders (see below).

Rushen (2000) notes that the finding that many of these maladies are heritable (even if heritabilities are relatively low) has renewed interest in including such health parameters in selection indices for dairy cattle (Boettcher, et al. 1998). He states that it remains to be seen whether the genetic correlations between high production and most health problems can be uncoupled, or whether they are inevitable, as Rauw, et al.. (1998) suggest. The successful Swedish official breeding program, in which, besides production traits, some diseases are considered (Philipsson and Lindhé 2000), show that it is possible to diminish the risk for inherited disposition for some disorders, for example, dystocia and mastitis. This has been possible because Swedish veterinarians since the 1930s have applied a disease monitoring system (Ekesbo 1992, Ekesbo, et al. 1994), which, since the 1970s, includes not only diagnosis, but also cow identity. Via cow identity, the sires also can be traced. Thus, sires showing high numbers of daughters with disorders can be excluded from breeding at an early stage (Dr. I. Ekesbo, 2001, personal communication).

A trait's heritability determines the rate at which it can be improved by selection. Milk, and milk fat and protein yields and milk composition have moderate heritabilities while traits concerned with viability and health, such as fertility, disease resistance and longevity, have low heritabilities. Having a low heritability, traits such as fertility, disease resistance and longevity are difficult to improve by selection and only management can bring significant improvements (Leaver 1999).

The normal lactation curve for the cow shows that milk production increases for approximately four to six weeks until the cow reaches maximum production and then gradually

declines until the cow is dried up at around 44 weeks. If she has been bred in a timely manner at the first heat after calving, she will have a new calf nearly 13 months after giving birth to the previous one and will begin the next lactation. High-producing cows are those that have good persistence, or ability to maintain relatively high levels of production throughout the entire lactation period. Writing in 1979, Blakely and Bade noted that most cows reach maximum production at between six and eight years of age, or between their fourth and sixth lactation. Given the intensity with which they have been genetically selected and are used today, dairy cows today seldom last that long before they are culled.

Ideally, the normal lactation is 305 days with a 60-day dry period. In practice, a lactation period may vary in length. Shorter periods result when a cow is rebred soon after calving or dried up due to illness while longer periods result primarily from failing to get the cow rebred (Blakely and Bade 1979). During the first part of her lactation, the dairy cow is in negative energy balance and must make up the balance of energy needs that are left unsatisfied by eating with body stores.

The life of the typical beef cow that lives outside on open range is similar to that of the wild ruminant producing a calf once per year and feeding it until it is weaned at an age of six to eight months (Webster 1995). The beef cow will secrete milk at the rate of about seven and a half to nine quarts per day and the calf will drink it in about four to six meals per day. In her total lactation period she may produce 950 quarts of milk and the maximum amount of milk in her udder at any one time will be a little less than two quarts (Webster 1995).

Compared to the beef cow, in 1999, 135,000 high-producing Israeli dairy cows produced 1,186,000 metric tons of whole fresh milk (19,360 lbs of milk per cow) per year on average while 9,156,100 dairy cows in the U.S. produced 73,804,000 metric tons of whole fresh milk (17,760 lbs per cow) per year on average (UNFAO 2000). Unlike the beef cow whose calf suckles several times a day, a dairy cow's udder must expand between milkings to hold up to 20 extra liters (~19 quarts) of milk (Webster 1995), and often more than 25 liters (Dr. I. Ekesbo, 2001, personal communication).

Compared to the average yield figures for the top 2 milk producing countries Israel and the US, per cow average of milk production was 7,186 pounds per cow and year in New Zealand in 1999 (UNFAO 2000). New Zealand's dairy industry is primarily seasonal and grass-based and, therefore, comparatively low cost. In production systems with a high capital investment (in contrast to more extensive production systems that have lower fixed costs), in order to convert high gross profit into net profit, the dairy cow must be worked to the limits of her productivity to meet the high costs of labor, housing, machinery and other costs (Webster 1995).

Webster (1995) raises the question of how hard production animals – especially lactating animals -- work to meet human needs. A dairy cow yielding 33 quarts of milk per day must sustain a work rate twice that of maintenance and must process nearly four times the amount of food required for maintenance. The high-producing dairy cow in Israel or California possibly producing 28,000 pounds of milk per lactation has a work rate equivalent to a human's jogging 6 to 8 hours continuously, in terms of metabolic intake and expenditure. The dairy cow must sustain this and comparable work rates for months on end, even while she is pregnant with the next calf. Thus, the most abnormal features of the work required of the dairy cow are not just the intensity of the metabolic load, *but also the length of time it must be sustained* (Webster 1995).

The main welfare problems of the dairy cow are not necessarily related to production alone but to forms of nutrition, housing, and management that are inadequate for the high performance animals that selective breeding has created (Webster 1995). Science indicates that

in countries where recombinant bovine somatotropin (rbST), a genetically-engineereed, injectable hormone, is being used, dairy cows are under additional stress, as rbST apparently influences nutrient partitioning to increase milk yield. Use of rbST is banned in Canada and the EU due to human and animal safety concerns (Health Canada 1998, EU Scientific Committees: Animal Health and Animal Welfare 1999a; Veterinary Measures Relating to Public Health 1999).

The limits of the dairy cow's productivity are defined by (Webster 1995):

(1) the genetic and physiological potential of the mammary gland to synthesize and secrete milk;
(2) the capacity of the cow to forage for, consume, digest and metabolize nutrients required for maintenance, lactation and simultaneous pregnancy; and
(3) the capacity of the dairy cow to meet the sustained metabolic demands of lactation without succumbing to exhaustion or production diseases.

The potential welfare problems associated with breeding and manipulating dairy cows for high productivity include (Webster 1995):

(1) hunger or acute metabolic disease, due to an imbalance between nutrient supply and demand (and physiological capacity to meet the demand);
(2) chronic discomfort, through bad housing, loss of condition, etc.
(3) chronic pain or restricted movement due to distortion of body shape, lameness, and bad housing or management,
(4) increased susceptibility to infectious or metabolic disease,
(5) metabolic or physical exhaustion after prolonged high production.

The high genetic merit, lactating dairy cow must meet an intense, sustained demand for nutrients to sustain the capacity of the mammary gland to synthesize milk (Webster 1995). She must meet this demand within the practical constraints determined by the:

(1) quantity and quality of the available food;
(2) capacity of her digestive system to process the food into metabolizable nutrients; and
(3) time available for eating without seriously eroding her conflicting need to rest.

If the quality of the food is poor, the cow will fill up her rumen with feedstuffs that provide insufficient nutrients, feeling full but creating a conflict between metabolic hunger and digestive overload (Ewbank, et al. 1999, Webster 1995).

Many genes are responsible for controlling milk yield, including those concerned with food intake, digestion and metabolism, blood supply to the udder, the amount of secretory tissue and udder size (Leaver 1999).

There are obvious breed differences for several diseases in dairy cows, for example, mastitis, trampled teats, foot disorders, parturient paresis, dystocia, ketosis, and retained placenta (Ekesbo 1966, Bendixen, et al. 1987, 1988).

Rushen (2000) notes that the role of genetic factors in production diseases is emphasised by the fact that contemporary Holstein cattle suffer from a higher incidence of both mastitis (Washburn, et al. 1998) and lameness (Harris, et al. 1988; Alban 1995) than Jersey cattle (Rushen 2000). Selection for increased milk yield appears to also result in increased incidence of

lameness (Rauw, et al. 1998, van Dorp, et al. 1998, cited in Rushen and de Passillé 1999). In conventional and organic dairy herds in Denmark, a higher incidence of acute sole hemorrhages were found among Danish Holsteins than among other dual purpose breeds (Vaarst, et al. 1998, cited in Rushen 2000). The increasing incidence of inbreeding that has been noted on US farms seems likely to have led to reduced survival of dairy cattle (Thompson, et al., 2000, cited in Rushen 2000). Hansen (1999) has recommended turning from the high intensity of current selection that results in inbreeding and going to more cross breeding in dairy cattle (Hansen 1999, cited in Rushen 2000).[27]

The quality as well as availability of the food (and the level of management and quality of the production environment) must be very high to sustain the welfare of the high-producing dairy cow. "In most practical circumstances, the capacity of the mammary gland to synthesize milk exceeds the capacity of the cow upstream to find, eat and digest enough food to supply the mammary gland with nutrients" (Webster 1995).

Selective breeding for higher milk yields is known to result also in larger udders (Knight 2000). Growth of the udder/mammary gland occurs in two distinct phases, growth prior to first conception and then cyclical waves of proliferation, secretion, and involution during recurring lactational cycles. As noted above, during lactation, the udder must enlarge enough to hold 20 to 25 liters of milk between milkings. Growth of the udder during the cow's lifetime forces the cow increasingly to walk with her back legs apart, causing her to walk with an uneven load on the inner and outer claws of the back feet and resulting in lameness (Webster 1995). Gait abnormalities such as this and those of broilers (above) can be important indicators of pain and poor welfare.

Selection of dairy cows for higher milk yields may possibly select for cows with at least some improved ability to consume, digest and metabolize food. The exogenous stimulation of production, such as regular injections of rbST, simply increases the capacity of the mammary gland to synthesize milk without adjusting the physiological ability of the cow to process nutrients. This is likely to intensify the cow's conflict between the problems of hunger, digestive overload and physical exhaustion "and increase the risk that some cows will be made to suffer to meet these conflicting demands" (Webster 1995). Research indicates that rbST-treated cows have reduced body fat and reduced body condition compared to non-treated cows (EU Scientific Committee on Animal Health and Animal Welfare 1999a).

Many of the adverse health effects of rbST administration are best viewed as a consequence of extending the phase of metabolic stress that normally accompanies the onset of lactation (Kronfeld 1994, cited in EU Scientific Committee on Animal Health and Animal Welfare 1999a). The maximal response to rbST is achieved within 2-5 days, but the increase in feed intake takes 5-7 weeks to match the requirement for extra milk synthesis. Therefore, the bodies of rbST-treated cows remain in negative energy and protein balance longer than in non-treated cows, and changes to live weight, body composition, and condition score occur, as the requirement for extra nutrients to support lactation is met by mobilization of body stores or other tissues. "Consequently, rbST administration extends the period of metabolic stress from 2-3 months to 4-6 months" (EU Scientific Committee on Animal Health and Animal Welfare 1999a).

[27] Some producers are taking this route. Dairy Business Communications (September 1999) reported on MNDAK (Western Minnesota) dairy's program of breeding all Holsteins back to Jerseys and breeding crossbreds back to European Ayrshires to improve milk components and avoid inbreeding costs.

B. Injuries and lameness

Ekesbo (1966) noted that environmentally-related dairy cow injuries and lameness increased in Sweden shortly after introduction in that country of new methods not adapted to the biological needs of the cattle, e.g., liquid dung handling that caused hydrogen sulfide intoxication, loose-housing systems on fully slatted floors to handle liquid dung, shortening the stalls for tied cows, introducing gratings over the gutter behind tied cows, and discontinuing the use of bedding in the stalls or cubicles. Studying 707 herds between 1961 and 1965, Ekesbo (1966) found that the lowest total incidence of disease and injury occurred in the loose housing systems with soft bedding in the lying area and access to outdoors, the next lowest total incidence of disease and injury occurred in the loose housing systems with soft bedding but without access to outdoors, and the most injuries and disease occurred in closed buildings with slatted or concrete floors and without bedding, regardless of whether the animals were loose or tied. The incidence of trampled teats and traumatic injuries of the udder was lowest when the animals had soft bedding and maximum freedom of getting up and lying down. The incidence of mastitis was higher in buildings with hard lying areas. Traumatic injuries of the hoofs were more common in loose housing with fully slatted floors and in buildings for tied cattle with gratings or slatted floors over the dunging channel.

Almost all animals that walk with a limp, reduce walking to a low level, or avoid it whenever possible suffer from some leg or foot pain. Their ability to carry out various preferred behaviors is generally impaired and there may be adverse consequences for other aspects of their normal biological functioning (Broom 1999).

When kept in loose housing, cattle, if given a choice in the cubicles between hard and soft lying areas, choose the soft lying areas (Ekesbo 1966, Jensen, et al. 1988).

Referring to Munksgaard and Løvendahl (1993), Rushen (2000) notes that resting is clearly important for dairy cows, and continues with the following discussion:

> Resting can be greatly affected by the design of stalls (e.g. Haley et al., 2000). In a survey of UK dairy herds, Faull et al (1996) noted a widespread use of stalls that were either too small or poorly designed. It seems possible that by reducing resting time in cattle the use of such stalls is a contributing factor to the high incidence of lameness. Incidence of lameness was high in one group of heifers that showed reduced time lying down, presumably because the stalls were uncomfortable. Leonard et al (1994; 1996) found that when cows were kept either in uncomfortable stalls, or with too few stalls per cow, both the time spent lying down was reduced and the incidence of hoof lesions increased. Furthermore, there were significant negative correlations across individual cows between lying time and the incidence of hoof lesions. This correlation was likely due to reduced lying time leading to increased hoof problems, rather than the reverse, because at pasture lame cows lie down longer than healthy cows (Hassall et al. 1993). This correlation between reduced lying time and increased hoof problems has recently been confirmed (Chaplin et al., 2000).

Lameness is recognized as one of the greatest welfare problems of the dairy cow because it results in chronic pain and the incidence of lameness is very high (Greenough 1996, Vet Agro 2000). On individual farms in Washington State, close examination of the hooves of each cow showed that over 50% of cows may have some degree of hoof disease (Newberry and Bergsten

1999). The majority of lesions occurred in the rear feet (Bergsten, et al., 1998, cited in Newberry and Bergsten 1999). Measurements of lameness occurring in dairy cows include 35 - 56 cases per 100 cows per annum in the US, 59.5 cases per 100 cows per annum in the UK, and more than 83% of examined cows in the Netherlands (Broom 1999). Many cases likely go unreported.

Rauw, et al (1998, cited in Rushen 2000) found small but important positive genetic correlations between the level of milk production and the incidence of ketosis, mastitis and lameness. This has been confirmed in more recent studies for lameness (Van Dorp, et al. 1998, in Rushen 2000).

Foot disorders can include sole hemorrhages, bruised soles, heel erosion, white line disease, digital dermatitis, interdigital dermatitis, coronary band abscess, septic arthritis, foot rot, and sand cracks (vertical split or crack in the claw wall) (VetAgro International 2000). Leg lameness can result from arthritis, cellulitis, fractures, hematoma, muscle disorders, tendon problems, and wounds.

Housing design and management procedures have considerable effects on cow welfare (Broom 1999, 2000a, Ekesbo 1966, 1973, 1980). Cattle in cubicle houses, particularly when cubicles are too short or otherwise poorly designed, tend to have lameness and other problems (Rushen and de Passillé 1999). Well-managed straw beds are generally better for welfare (Broom 1999), but they must be well-managed to avoid mastitis, that is, the tops of the beds must be replenished with fresh straw daily to keep them dry and protect the udder from disease causing organisms (Farm Animal Welfare Council 1997), and the straw must be long or uncut rather than chopped (see below p. 115). Lameness is rare in cows at pasture although special paths are needed in areas with sharp stones.

Mogensen, et al. (1999) compared the effects on milk production of dairy heifer housing during second year rearing having either low space allowance ($1.5m^2$) or high space allowance ($3m^2$) and either straw bedded floors or fully slatted floors. They found that a low space allowance or access to bedding was more favorable for milk production than a higher space allowance or fully slatted floors, with no effect of either treatment on somatic cell counts (indication of mastitis). Access to bedding during rearing increased energy-corrected milk yield by 2.1 kg over fully slatted floor during rearing and also tended to increase fat yield per day by 0.11 kg, and protein yield per day, by 0.07 kg.

Regarding walking surfaces, Rushen (2000) contains the following discussion:

> The main walking surfaces for cows play a major role in affecting the incidence of lameness, with concrete surfaces being seen as a particular problem. Philipot, et al. (1994) assessed risk factors for chronic and subacute laminitis as well as heel horn erosion and found that conditions such as high steps were risk factors linked to subacute laminitis. Inappropriate flooring can increase the incidence of lameness by causing excessive and uneven wear of the hoof, by direct damage as a result of uneven surfaces or protrusions, or by causing skin breaks which increase the risk of infectious diseases such as footrot. An epidemiological survey of farms concluded that lameness was prevalent where walking surfaces were smooth concrete (Faull, et al. 1996). Cow walking surface has also been related to the incidence of apparently infectious foot diseases: the incidence of papillomatous digital dermatitis (foot warts) was found to be substantially higher on farms where cows walked on grooved concrete compared to farms where cows walked on dirt, pasture or smooth concrete (Wells, et al. 1999). This is

possibly because the abrasive properties of the flooring caused damage to the hooves through which pathogens could enter.

The behavior of limping indicates that the cow *does feel* pain. Limping, reducing the length of the stride, stiffness and stilted gait, resting the affected foot and spending more time lying down are guarding behaviors against damages of the kind that are signaled by pain (Newberry and Bergsten 1999). This has a secondary effect on their welfare. Lame cows become less competitive, drop in social rank, become more fearful and are three times more likely to be culled than sound cows (Newberry and Bergsten 1999). They also have more difficulty standing up and lying down, resulting in an increased risk of teat trampling and associated mastitis.

Lameness also directly affects production and economic returns (Newberry and Bergsten 1999). Reduced competitiveness of lame cows, and increased resting times, result in reduced feed intake, loss of condition and reduced milk yield (Tranter and Morris, 1991). Lameness increases time open, resulting in longer calving intervals (Collick, et al., 1989, Barkema, et al., 1994).

Wet, slippery, concrete floors, especially floors wet with acid slurry, floors in disrepair, breeding that results in poor hind leg conformation, lack of clean, dry straw, poor cubicle design (too short, not enough for all cows), poor foot care, twice-daily milking (which allows ten times the normal amount of milk to accumulate in the udder, affecting locomotion), overconditioning (too heavy cows) have been listed as predisposing factors to lameness (see, for example, VetAgro 2000 and Webster 1995). Stress (caused by aggression, insufficient space, noise or isolation) also plays an important role (VetAgro International 2000).

Foot and hoof injuries can allow pathogens to enter the bloodstream, causing infections such as foot rot, a disease caused by *Fusobacterium necrophorum,* which survives in soils, slurry, and the gut. Bacterial erosion of the hooves can compromise foot stability. Hoof erosion is most prevalent under wet, cold, and filthy conditions and the action of irritants in liquid manure is likely to be a predisposing cause (VetAgro 2000). Subclinical laminitis softens the (hoof) horn and standing in excessive moisture further softens the horn, making it vulnerable to further injury. Prolonged exposure to moisture and exclusion to air gives infections a chance to take hold.

Diet can lead to lameness in many ways (VetAgro 2000). For example, dairy diets should correctly balance fiber and carbohydrates. Unbalanced diets can lead to subclinical laminitis. Ground and moist grains are more digestible than dry, rolled grain. Large amounts of easily digestible carbohydrates are available to lactic acid producing bacteria. These eventually displace other organisms beneficial to the cow leading to acidosis in the rumen. Acidosis in turn is controlled by sodium bicarbonate in the saliva. Fiber plays an important role in stimulating salivation. Depending on fiber intake, a mature dairy cow can produce 50 gallons of saliva per day. When carbohydrate intake is particularly high, acidity increases faster than saliva can neutralize it. Acidosis of the rumen has been associated with production of poisons that attack small blood vessels between the claw capsule and the bone underneath it. These blood vessels that supply the horn-producing tissues then expand and increase the pressure inside the claw and cause discomfort. Damage to the blood vessels causes clots to form, in turn, reducing the blood supply to the horn-producing tissues, producing horn that is softer than normal. Danish workers have shown that deleterious changes can also take place in other body organs. Subclinical acidosis is not eliminated in high-producing, well-managed herds; rather, it is managed (Vet Agro 2000).

Newberry and Bergsten (1999) suggest that it is false economy to skimp on stall numbers. Cows tend to synchronize their resting times. They have favored stalls and may avoid resting next to certain (especially more dominant) cows. Some cows displace others from their stalls by butting them until they get up and leave. Having too few cubicles in loose housing may result in submissive cows being forced to stand for long periods in passageways when they should be resting. Too uncomfortable stalls in free-stall barns lead cows to refuse to use them, usually preferring to lie in the dunging area or standing with only their front legs in the stall (Rushen and de Passillé 1999). A similar problem exists with cubicles when cows stand half in-half out, with their hind legs in the manure channel (Farm Animal Welfare Council 1997). Heel erosion and subclinical laminitis in the back feet can result. These behaviors are signs that there is a problem with the housing system and its compatibility with the needs and natures of the animals.

As noted above, cattle have fixed patterns of getting up and lying down (Lidfors 1989). They lie down by kneeling on their front legs first and then slowly lowering the rest of their body. In getting up, they normally lunge forward and rise first on their back legs (Lidfors 1989, and Kämmer and Tschanz 1975, Hoffman and Rist 1975, and Oester 1978, cited in Lidfors 1989). Too short stalls or too short neck ties will prevent the cow from being able to lunge forward, impeding her getting up and lying down behavior, disturbing rest, and contributing to injuries. Trampled teats, leading to mastitis (Bendixen 1988) are common in too short stalls (Ekesbo 1966, Oltenacu and Ekesbo 1994). In getting up, the cow may attempt to rise on her front legs first, giving her less control over her back legs and more opportunity to injure the udder.

In a number of studies, it has been shown that cattle on slatted floors and tied have significantly more common occurrences of interrupted lying down and getting up behaviors than in straw beds or deep litter (Lidfors 1992, Andreæ and Smidt 1982) and more getting up and lying down by sitting behaviors (Graf 1979, 1984, cited in Lidfors 1992). Cattle perform the lying down sequence more slowly on hard slatted floors than on deep litter.

Before cattle lie down, they perform an "intention movement," lowering their heads to the ground as if to investigate the surface under them. While cattle on deep straw or pasture show the intention movement, on average, one time before lying down, cattle on slatted floors perform the intention movement, on average, three times prior to lying down (Ladewig and Borell 1988). Ladewig and Borell (1988) found that the time interval between the first intentional behavior (to lie down) and the actual lying was, on average, 9 seconds in cattle on deep litter and 59 minutes in tethered cattle. Ladewig and Smidt (1989, cited in Rushen and de Passillé 1999) found that bulls kept tethered on concrete floors were much more hesitant to lie down, lay down less, and had higher levels of cortisol than bulls that were kept on deep straw. Muller, et al. (1989, cited in Rushen and de Passillé 1999) found that cattle tethered on concrete floors showed longer periods of sniffing the floor before lying down and more frequent bending of the front knees that were not followed by the cow lying down.

Under no circumstances should dairy cattle be expected to lie on bare concrete (Ekesbo 1966, 1973, 1988, Rushen and de Passillé 1999). The shape and weight of dairy cows means that soft flooring is critical to avoid injury and allow adequate rest.

Disturbed rest leads to physiological changes in cattle that are usually indicative of stress and likely to affect both welfare and milk production (Rushen and de Passillé 1999). For example, these physiological changes can reduce the effectiveness of the immune system. Skimping on individual, electronic feeding stations, where these are used, also results in subordinate cows spending long periods standing in the alley waiting until more dominant cows

are out of the way (Newberry and Bergsten 1999). Hence, lameness can be related to behavior, which, in turn, can be affected by social position (Broom 1999, Galindo, et al. 2000).

Cows need to spend time lying, standing, and moving. Rest, rumination, and exercise, respectively, are important activities at which adequate time must be spent for good welfare. Prolonged standing leads to blood collection in the feet, reducing exchange of oxygen and nutrients, and potentially compromising foot health (VetAgro International 2000). When cows move, blood is pumped back into circulation, fresh blood brings oxygen and nutrients back to the feet and cleanses the tissues of poisonous materials. Cows should lie in their stalls for 9-14 hours each day to provide adequate time for ruminating which increases saliva production. Blood passing through the udder provides nutrients for milk production and almost an additional liter of blood passes through the udder of a cow when she is lying compared to when she is standing (VetAgro International 2000). However, lying on hard floors such as passageways or dunging alleys contributes to udder injuries, as noted above, and potential for infections to take hold if bacteria enter wounds or the teat opening. The lying area should be kept soft and dry, either with suitable litter (long straw or mats, for example).

Cermak (Moss 1992) published research results showing the effects of different floor surfaces in cubicles on the lying down/resting time of Friesian dairy cows. Selected results are shown in Table 6-1.

Table 6-1. Effect of cubicle beds on time spent lying down by Friesian dairy cows.

Cubicle floor surface	Lying down time (hours)
Concrete	7.0
Rubber mat	9.8
Straw (50 mm) on concrete	15.3

Bergsten (1995) found it beneficial to provide cows with individual feeding stalls fitted with rubber mats for foot relief during feeding and predicted that providing rubber mats in the holding pens at the milking parlor would also be beneficial for foot health. Cows housed in tie-stalls with concrete floors had a higher incidence of sole haemorrhages than cows housed in tie-stalls with rubber mats (Bergsten and Frank 1996, cited in Rushen 2000). Stalls that are too small or are designed in a way that make it difficult for the cow to get up and lie down have been found to be associated with an increased incidence of lameness or sole disorders and conditions such as high steps were risk factors linked to subacute laminitis (Philipot, et al. 1994; Faull, et al. 1996, cited in Rushen 2000).

Comparing 20 farms using either sawdust, sand, or geotextile mattresses for the appearance of skin lesions on the hocks of dairy cows, Weary and Taszkun (2000) found at least one hock lesion on 1,267 out of 1,752 lactating dairy cows, 87% had lesions on both legs, 76% had lesions on more than one location on the hock, and 78% had a lesion of at least moderate severity. Incidence was greatest on farms that used geotextile mattresses and least on farms that used sand for bedding, while the prevalence of lesions on farms using sawdust was intermediate. The number and severity of lesions increased with age.

Comparing behavior and injuries in dairy cows housed in cubicles with straw bedding with behavior and injuries of cows housed in cubicles with four types of soft mattress, Wechsler,

et al. (2000) found the cows lying down and resting behaviors similar but a significantly higher incidence of hairless patches and small scabs or wounds in the tarsal and carpal joints in cows kept on mattresses. However, the researchers concluded that the injuries were slight enough that the cows did not suffer.

A number of alternative flooring surfaces have been studied to reduce injuries. In Switzerland, where the law mandates that new technologies for animal production be tested before they are allowed to be adopted commercially, researchers at Tanicon Research Center investigated alternative floor surfaces to concrete in free stall housing to add both softness and non-slip surfaces, while keeping surfaces smooth (Figure 6-1).

Figure 6-1. Example of ethological study on experimental, non-slip asphalt flooring for loose-housed dairy cows (1992)
Tanicon research station, Switzerland.

Photo credit: Marlene Halverson

The EU Scientific Committee on Animal Health and Animal Welfare (1999a), reviewing literature on the impacts of rbST use on the health of dairy cattle, noted a number of studies that associated increased incidence of foot and leg disorders with long term administration of rbST, including a post-approval monitoring program (PAMP) study conducted by Monsanto, the manufacturer of Posilac. In this, the largest scale study, the number of multiparous cows (cows in their second or later parity) having foot disorders was increased during rbST administration by a factor of 2.2 and the number of days affected was increased by a factor of 2.1. Information obtained via Freedom of Information Act from the U.S. Food and Drug Administration showed a similar association to the PAMP study between the use of rbST and an increased incidence and duration of knee calluses, hock disorders, and foot disorders and more multiparous treated cows were lame and suffered over a longer period of time. Lameness and foot disorders in dairy cattle are some of the major causes of poor welfare and economic losses in dairy farming (EU Scientific Committee on Animal Health and Animal Welfare 1999).

Knowledge and awareness possessed by the producer and his or her employees profoundly affect incidence of lameness (Mill and Ward 1993) and other management and environment-related diseases (Webster 1995, Rushen and dePassillé 1999). In this respect, understanding and awareness of behaviors and their meanings are necessary for optimal management (Ekesbo 1966, VetAgro 2000). Rougoor, et al (2000) showed that milk production per cow is related to success factors of the producer, farm size, breeding value for production and conformation and that milk production per cow was influenced by the attitude of the farmer as

well as the genetic capacity of the cow. In high producing farms, producers put relatively more emphasis on the quality of the udder than on the quantity of milk produced.

VetAgro (2000) publishes a "cow comfort table" aimed at assisting producers to determine their farm's "cow comfort index" as well as suggested guidelines for cow comfort and for minimizing diseases. Its easily-accessible website (http://www.cowdoc.net) is coordinated by veterinarians and is dedicated to informing producers about lameness causes and solutions.

C. Mastitis

Mastitis is a complex and very painful disease that can be defined simply as an inflammation of the udder/mammary gland resulting from the introduction and multiplication of pathogenic microorganisms into the mammary gland (Heringstad, et al. 2000). Clinical mastitis is characterized by swelling or pain in the udder, milk with an abnormal appearance, and in some cases, increased rectal temperature, lethargy, anorexia and even death (Harmon 1994). Bacteria are present in the milk and yield is much reduced, and milk content is altered. The sensitivity to touch of affected tissues is clearly evident and there is obvious damaging of normal function (Broom 1999, 2000). Hence, mastitis, however it occurs, is a severe welfare problem.

Mastitis is caused by disease organisms that enter the udder via the teat opening (Ewbank, et al. 1999) or through the bloodstream if wounds or abrasions elsewhere on the body are infected (Dr. I. Ekesbo 2001, personal communication). These pathogens can be contagious or environmental. That is, contagious bacteria can spread from parts of an infected udder to other parts or from one cow to another via the stockperson milking the cows, the milking machine, or dirty bedding. Mastitis caused by environmental pathogens is usually associated with dirty, wet bedding and frequently occurs in poorly ventilated housing areas (Farm Animal Welfare Council 1997). Stress can predispose cattle to mastitis (Farm Animal Welfare Council 1997). Other predisposing factors to mastitis are faulty milking and a dirty environment (King 1981) or bad feed and poor water quality (Dr. I. Ekesbo, 2001, personal communication).

Mastitis has been described as the most economically imposing disease facing dairy producers in the United States and continues to cost dairy producers in the US at least $2 billion annually (Oliver, et al. 2000). Oliver, et al. (2000) note that even cows from well-managed dairy herds, utilizing the most recent and most effective mastitis control measures, experience a high rate of mastitis especially during the first 90 days of lactation and that mastitis has also been implicated in decreasing reproductive performance of dairy cattle. Ekesbo and Lund (1994) have investigated costs for some diseases, among them mastitis.

Mastitis can be clinical, where signs are visible. Mild signs include flakes or clots in the milk and slight swelling in an infected part of the udder. More severe signs include abnormal secretion, hot, swollen udder, fever, rapid pulse, loss of appetite, dehydration and depression, and death. Mastitis also can be subclinical, where there are no visible signs of the disease. Detection occurs through testing milk for somatic cell counts. It can be acute, where the cow is seriously

ill, or it can be chronic, where the cow may show no outward sign of ill health. However it occurs, mastitis causes poor welfare.

High levels of milk production are widely associated with high levels of mastitis (Faye, et al. 1997, Emanuelson and Oltenacu 1998, Oltenacu and Ekesbo 1994, Waage, et al. 1998). In the United States genetic trend for milk yield has accelerated and selection goals continue to place major emphasis on yield traits (Hansen 2000). Hansen (2000) cautioned that eventually undesirable levels of inbreeding will occur as a result of the high intensity of current selection practices in the United States.

A comparison of a line of dairy cattle selected for high yield with a line not selected for high yield, since 1964, showed that health care costs per lactation were $49 per cow greater for the selected line, with the difference in mastitis cost accounting for about 50% of this (Hansen 2000, as cited in McAllister 2000). Milk yield in the selected line rose from 12,941 lbs/cow/year in 1957 to 24,921 lbs/cow/year in 1997.

Mastitis prevalence should have declined greatly with improved methods of prevention and treatment but it has not declined as much as it should have done (Broom 1999, 2000). In a 1990 study of 370 cow herds and 45,133 cows, Oltenacu, et al. found that trampled teats and udder injuries were the most serious risk factors for clinical mastitis in tied or stanchioned cows. Tied cows in herds with liquid manure systems were at higher risk of udder injuries and mastitis than tied cows in herds with solid manure systems, lower risk of udder injuries and mastitis was found for tied cows in herds with stalls less than 180 cm long compared to stalls 205-219 cm in length, and cut (short, or chopped) straw or sawdust bedding in solid manure housing systems was found to increase the risk of trampled teats and mastitis relative to uncut (long) straw. Oltenacu and Ekesbo (1994), studying Swedish Friesian cows, found that high production predisposed cows for mastitis and that the risk of mastitis was greater for calving in July and August and increased with age at calving. The most important cause for the first case of mastitis in a quarter is teat trampling (Ekesbo 1966, Bendixen 1988).

Webster (1995) suggested that increasing the frequency of milking to three or more times daily might reduce the incidence of mastitis. By reducing the amount of milk in the cistern of the udder and the duration of storage, more frequent milking could clear potential pathogens more quickly and reduce udder distension, also potentially reducing lameness caused by wide udders.

The mounting evidence of genetic correlations between high milk production and the incidence of foot and leg disorders and mastitis, combined with the worrying trend to higher levels of inbreeding in dairy cattle herds, suggest that some thought be given to selecting animals primarily on the basis of health related traits and to considering greater use of breeds other than the Holstein (Rushen 2000). The susceptibility of contemporary dairy cattle to these maladies emphasizes the importance of ensuring welfare-appropriate housing conditions for high producing animals.

Rauw, et al. (1998) suggested that strong artificial selection for a trait such as milk production leads to the animal using its biological resources to the maximum leaving few resources left to respond to other demands or to various stressors. Continuing selection towards increased milk production and feed conversion efficiency should not be continued unless it can be insured that welfare is good (Broom 1994). Recombinant bovine somatotrophin (rbST) use results in high milk yields and higher levels of mastitis, lameness, reproductive disorders and other problems such as those at the injection site (Broom 1993, Kronfeld, et al. 1997, Willeberg 1993, 1997).

The EU Scientific Committee on Animal Health and Animal Welfare (1999a) reviewed the various studies that had been conducted until that time on the physical effects of rbST use on dairy cattle in experimental and commercial dairy herds. They found a number of unfortunate deficiencies in the methods and materials used in these studies. These deficiencies included:

(1) insufficient sample sizes to say for certainty (as some studies did) that rbST has no or insignificant effects on incidence of mastitis, foot disorders, or other health problems, (2) pre-treatment differences in mastitis incidence between control and test herds that were not controlled for in the subsequent analyses, and (3) inclusion of intermediate variables in a causal pathway as co-variates in multivariate analyses (e.g., such as milk yield – which is influenced by rbST use and which is known to affect incidence of mastitis – as a co-variate in a regression analysis to determine the influence of rbST on mastitis incidence).

The EU Scientific Committee scientists noted that a number of meta-analyses[28] of these studies (e.g., Willeberg 1993) have concluded that there are significant effects on animal health and well-being from rbST use, including increases in the risk of clinical mastitis above the risk in non-treated cows by magnitudes variously estimated at 15-45%, 23%, 25%, 42%, and 79%. They noted that studies obtained from the U.S. Food and Drug Administration through the Freedom of Information Act sum up the facts about rbST impacts on mastitis in dairy cattle as follows: The use of rbST increases the risk of clinical and subclinical mastitis, the number of cases of clinical mastitis, and milk somatic cell counts in some herds (an indicator of subclinical mastitis).

Some studies have claimed that pathological lesions evident in rbST-treated cows are merely the result of increased milk yield. However, while milk yield increases with increasing rbST dose up to twice the recommended commercial dose, the frequency of several lesions increases with increasing rbST dose up to (at least) five times the commercial dose (e.g., kidney cysts, lung-pleural adhesions, kidney fibrosis, muscle fibrosis, and joint inflammation) (EU Scientific Committee on Animal Health and Animal Welfare 1999a). Therefore, implying genetic selection for high milk yield is similar to exogenous administration of rbST is of doubtful validity.

Regardless of whether the effect of the genetically engineered hormone is a consequence of the milk yield induced by treatment or a consequence of the treatment itself, the poorer welfare caused by the use of rbST is still unacceptable.

D. Reproductive Problems

As selection has led to higher milk production per cow, there have been steady increases in reproductive problems. Reproductive problems in dairy cows have become very common in recent years. Studer (1998) notes that while milk production has greatly increased, dairy cow conception rates have in general declined from 55-66% 20 years ago to 45-50% recently.

In many countries with high-yielding dairy herds, large numbers of cows are being culled because of failure to get in calf (Broom 2000a). In a study of 50 dairy herds in England, Esslemont and Kossaibati (1997) found that farmers reported failure to conceive as the predominant reason for culling with 44% of first lactation, 42% of second lactation and 36.5% of

[28] Meta-analysis is a quantitative review of a collection of studies done on a similar topic to detect patterns or effects that were not conclusively available from the individual studies.

cows in total being culled for this reason. Mastitis, feet and leg problems, ketosis and other disease conditions can lead to reproductive problems. It is difficult to discover their initial cause from farmers' records. A report by Plaizier, et al. (1998) studying Canadian herds indicated that reproductive culling risk varied between 0 and 30% with a mean of 7.5%.

Reproductive disorders are multifactorial. Infertility itself need not be a welfare problem but reduced rate of reproductive success can be an indicator of poor welfare stemming from metabolic stress, various perinatal diseases, twinning, dystocia (difficult birthing), retained afterbirth and endometritis. However, as noted in the following, it is well documented that the increase in infertility has gone hand in hand with high milk yield, which predisposes dairy cattle to a number of welfare problems.

Royal, et al. (2000) noted that the calving rate of the modern dairy cow is declining at approximately 1% per year and first service conception rates are below 40%. Citing reasons for lower fertility, they noted that in at least one case the problem may be amenable to selective breeding for non-yield traits.

Washburn, et al. (2000) noted a marked decline in reproductive performance in dairy herds over the past 25 to 30 years. They described a 1998 report on over 70 Kentucky dairy farms in which average days open had increased by 27 days between 1976 and 1996 and the number of services per pregnancy increased from 1.62 (with a 62% conception rate) to 2.91 (with a 34% conception rate).

To test whether results were similar all over the Southeastern US, Washburn, et al. (2000) studied data from 316 Holstein herds, 17 Jersey herds, 2 Guernsey herds, 2 Ayrshire herds, and 1 Brown Swiss herd across 8 time intervals between 1974 and 1999. All breed groups increased in herd size, milk fat, days open, and services per conception over time. While all breed groups had similar days open of 126-127 in the mid 1970s, by the late 1990s, days open had increased by 20% in Jersey herds, 35 days in Holstein herds, and 47 days among other breeds. The rate of decline in reproductive efficiency is more evident in recent years compared to earlier. Somewhere in the late 1980s to early 1990s both services per conception and days open began to increase at a greater rate than in the 1970s and early 1980s.

Broom (2000a) cites studies from various countries documenting the relationship between increasing milk production and lower conception rates, reproductive disorders or reduced fertility in dairy cattle: Spalding, et al. (1975), Foote (1978), Ferguson (1988), Butler, et al. (1989), van Arendonk, et al. (1989), Oltenacu, et al. (1991), Nebel and McGilliard (1993), Hoekstra, et al. (1994), Pösö and Mäntysaari (1996), Pryce, et al. (1997), and Pryce, et al. (1998).

In New Zealand, milk production is primarily seasonal to take advantage of the pattern of pasture growth (Beatson 2000). In a study of comparing confinement-housed cows in the US, fed a total mixed ration, compared to pasture-grazed cows in New Zealand, researchers found that on average the US cows produced 75 pounds of milk a day while the New Zealand cows produced 37 pounds (American Society of Animal Science 1998). At the same time, US Holstein cows weighed 1,379 pounds compared to 869 for Holstein cows in New Zealand and first-service conception rates were typically 60-70% for cows in New Zealand and 35-40% for cows in the US.

Studer (1998) explains that high producing cows whose body condition score declines by 0.5 to 1.0 during lactation often experience anoestrus. A loss of condition score of about 1.0 during lactation was normal in the review presented by Broster and Broster (1998). An ideal

body condition score is 3.0. Dechow, et al. (2001) found that higher body condition scores were favorably related genetically to reproductive performance during lactation while higher body scores during lactation were moderately negatively related to milk production, both genetically and phenotypically.

Washburn, et al. (2000) note that fertility and reproductive problems appeared somewhat before the introduction of recombinant bovine somatotropin (rbST) into U.S. dairy herds. However, the ability to use rbST may offset the losses from failure to reproduce by extending the lactation periods of cows while they are not pregnant. As long as cows can be kept lactating with rbST use, the practical need to solve the fertility/reproduction problems of high-yielding dairy herds may not appear as severe to an industry concerned with short-run profits. However, one emerging consequence of both fertility/reproductive disorders in dairy cattle and the use of rbST to extend lactations in compensation for those disorders is the dwindling source of replacement heifers, which cannot be produced by these affected dairies. A midwestern veterinarian noted that large dairies with which he works are having difficulties finding replacement heifers and are buying them from small farmers leaving the business and from farms in Canada. In these dairies' case, one cause of cows' failure to conceive appears to be uterine infections caused by exposure of the cattle's reproductive organs to muck on the slatted floor pens during and after delivery.

A trend appears to be to compensate for declining reproductive efficiency by using rbST in mid-lactation to extend "economic" lactation performance, with lactation periods increasingly exceeding 400 days (Macmillan 2000). Extending lactations with rbST also increases labor efficiency because less time per cow is spent in dry period management, transition feeding, calving monitoring, calf rearing and early lactation metabolic management and more time is spent on routine milking and feeding, aiding the drive to reduce costs under intensive management systems (Macmillan 2000). Reproductive efficiency is replaced by labor efficiency as a priority. The intensity with which dairy cattle are used in industrialized dairy systems reduces the value of the individual cow relative to other costs.

"Even though herds with intensive management systems may have fewer lactations/cow/lifetime, their longer lactations can mean that annual animal replacement cost will be less" than a "pasture production system which has a single seasonally concentrated calving which must be divided by lactations/cow/lifetime to derive an annual replacement cost per cow" (Macmillan 2000).

Lucy (2000) cites a study by Nebel and McGilliard in which they concluded that most studies completed prior to 1975 failed to show an antagonistic relationship between milk yield and reproduction while most studies after 1975 demonstrated the relationship. Before 1975, most improvements to milk yield were achieved by improved management, especially feeding. Since 1975, greater milk production caused by genetic selection for milk yield appears to have created reproductive deficiencies in dairy herds (Lucy 2000). Lucy (2000) also noted that a study of cows in different lactation yield groups – low, intermediate, and high – failed to find a relationship between reproduction and milk yield in the lowest producing cows, implying the effects of milk yield on reproduction may become more pronounced as the average milk production per cow exceeds 7,250 kg/lactation.

At the end of her single lactation, extended by administration of rbST, a mature "spent" cow can be culled and replaced with an impregnated heifer. Milk production has been extended and more performance has been gotten out of the cow. The impact on her welfare has not been determined, but it is likely to have been poor.

Studies already mentioned have linked rbST use with a number of disorders. In a study of two producing herds in Arizona and California, Luna-Dominguez, et al. (2000) found that in the 180 days after calving, 65.4% of cows not receiving rbST were diagnosed pregnant, while 48.5% of the rbST-treated cows were diagnosed pregnant. Studies of the extent to which rbST is being used in dairy herds in the US to compensate for failures of cattle to conceive and bear young by extending their current lactation periods indefinitely, as far as this author has been able to discern, have not yet been conducted. Care must be taken with anecdotal evidence, but in responses this author posted to an agricultural list serve, several anecdotal accounts were proffered, including that on some high-intensity farms pregnant heifers are purchased and lactations are sustained by rbST administration for 750 days or more (one figure related was over 1,300 days) without any attempt to rebreed. The cows are then culled from the herd when yield falls below acceptable levels and are replaced with new pregnant heifers. One respondent related that in that individual's state small dairies leaving farming sell their herds to these high-intensity dairies, which are eager to get them.

Research should be undertaken to verify these anecdotal reports because, if true, they shed light on another ethical/welfare issue associated with rbST use.

The Freedom of Information Act summary obtained from the U.S. Food and Drug Administration and the PAMP study provide evidence that rbST treatment can adversely affect reproduction (EU Scientific Committee on Animal Health and Animal Welfare 1999a). Pregnancy rate dropped from 82 to 73% in multiparous cows (cows in their second or later parity) and from 90% to 63% in primiparous cows (cows in their first parity). Pregnancy rate indicates the proportion of animals inseminated that become pregnant. Since, in the allocation of resources within an animal, reproduction is given high priority, conditions must be stressful before conception is inhibited (Broom 2000, EU Scientific Committee on Animal Health and Animal Welfare 1999a). A reduced pregnancy rate reveals how many animals are so severely affected by metabolic demands and external effects on the individual that they cannot conceive. Failure to conceive by cows given appropriate opportunity, is an indicator that the cow is having difficulty in attempting to cope with conditions in which it finds itself and hence that its welfare is poor (EU Scientific Committee on Animal Health and Animal Welfare 1999a).

McAllister (2000) noted that estimated genetic trend in milk yield of Holsteins based on milk records of cows born from 1958 until today represented 1.7% change per year, with about 25% of the total change in milk yield coming in the last seven years and about 50% in the last 15. He also noted that selection for increased milk yield apparently results in a decline in fertility but that the outcome is economically desirable because the economic benefit of increased milk yield far outweighs the economic cost of impaired reproduction (and the resulting poor cow welfare).

However, from a welfare standpoint, the documented reduction in fertility and increase in reproductive disorders must be evaluated from its effect on the cow. Are they having adverse impacts on her longevity, health, and well-being?

E. Specific rbST associated problems of dairy cows

As noted, rbST related welfare problems of dairy cows include lameness and foot disorders, pathological lesions, reproductive problems including reduced pregnancy rates, and increased mastitis incidence. The frequent use of antibiotics to control or treat mastitis may increase the resistance of bacterial pathogens to antibiotic treatment, which is a welfare problem

for farm animals as well as humans (EU Scientific Committee on Animal Health and Animal Welfare 1999a, Health Canada 1998).

Injection site problems occur in most cows injected with rbST but control groups of cows injected with placebos do not experience them. In a 1992 study, Pell, et al. reported that out of 367 injections of 23 cows, 10.1% of cows had severe lesions post injection while 49.9% had moderate lesions post injection. Out of 358 placebo injections of 23 cows in the same group, none had severe reactions and 0.6% had moderate reactions, indicating that rbST or another component of the preparation was the cause of the problem.

Injection site problems are exacerbated by repeated injections. In 4% of cows injection site swellings are severe, meaning swellings repeatedly open and drain (EU Scientific Committee on Animal Health and Animal Welfare). Damaged injection sites can become infected, causing disease.

Further evidence that injection site reactions are due to rbST, is provided by the U.S. Food and Drug Administration Freedom of Information report on Posilac (Monsanto). On a "severity scale" of 0 to 160, weekly severity scores of injection site swellings due to biweekly (every other week) injections (starting with the week following the first injection) were reported to be: 106, 85, 145, 97, 149, 99, 151, implying that severity of swellings increased with each subsequent injection, while between injections swellings went down, but at a decreasing rate.

The EU Scientific Committee on Animal Health and Animal Welfare *Report on Animal Welfare Aspects of the Use of Bovine Somatotrophin* (1999a) was criticized in the University of Minnesota Literature Summary on Animal Agriculture-Health (Crooker, et al. 1999), which stated the Committee's results are inconsistent with:

> the numerous other reports of bST use and animal health…, the continued use of bST by producers, sustained increases in milk yield achieved by use of bST … and lack of change in culling of U.S. dairy cows (NASS, 1998; NAHMS, 1996)

In a number of the reports it reviewed, the EU Scientific Committee noted problems in either the research methodology or in the size of the databases used in those reports. The reader may read and evaluate the EU report for him/herself. It can be found at: http://europa.eu.int/comm/dg24/health/sc/scah/out21_en.pdf

A concern expressed by the EU scientists (EU Scientific Committee on Animal Health and Animal Welfare 1999a) is that the makers of commercial rbST and farmer advisory services strongly imply that any problems producers may encounter are due to "management" inadequacies. This may discourage producers from reporting problems they might be having with rbST. (At the same time, it may encourage them to keep using rbST until *they* "get it right").

With regard to concerns about cow welfare being inconsistent with "the sustained increases in milk yield achieved by use of bST," many of the studies already mentioned in this report demonstrate that good animal welfare and high production yield are not necessarily synonymous and may even be antagonistic to one another. In the case of dairy cows, high milk yield has been shown to correlate positively with increased mastitis, foot disorders, decreased longevity, and reproductive and other health problems and, consequently, with poorer welfare.

Etherton and Bauman (1998) discuss their model of homeorrhetic control with respect to rbST use. They do not imply directly that the cow's welfare is improved. Rather, they state that

rbST use results in a "coordinated series of changes involving both nutrient supply and mammary utilization, including increased blood flow to the mammary gland (udder), *enhancing the efficiency of nutrient use and performance*" (emphasis added). The "effects are on the postabsorptive use of nutrients and involve the orchestration of many physiological processes in different tissues and organs to *enable more nutrients to be used for…milk synthesis*. …[T]he overall effects of [r]bST are to both *enhance the ability of …mammary tissue…to utilize nutrients while simultaneously coordinating other physiological processes and tissues (such as adipose tissue), in a manner that supports this enhanced performance*" (emphasis added).

Hence, a greater proportion of the nutrient intake is used for milk synthesis, i.e., is used to support the dominant physiological/economic function (that which has been selected for – milk yield) than before rbST use, which means that there are fewer nutrients for use by the other body functions. In addition, other tissues are "coordinated" to support increased milk yield.

As noted above, during lactation there is evidence that the high-producing dairy cow's other functions suffer from the diversion of nutrients. Measuring dairy cattle 14 days before, 14 days after, 1 month after, and 1.5 months after parturition, Liesegang, et al. (2000) found that cows with higher milk yields had a higher mobilization rate of calcium from the bone than cows with lower milk yield. At the same time, they found indications that less calcium went to form bone in higher yielding cows. Collard, et al. (2000) found increased digestive and locomotive problems associated with longer and more extreme periods of negative energy balance. The laminitis, foot disorders, and body score deterioration experienced by dairy cattle as a result of genetic selection for high milk yield may be exacerbated by rbST use, which demands resources without affording the time for the physiology to adjust (Webster 1995).

Etherton and Bauman (1998) note how drastic this demand is: "In fact, the gain in productive efficiency obtained with bST use would take 10-20 years to achieve using a combination of artificial insemination (semen from superior sires) and embryo transfer."

At this time, there seems to be insufficient evidence to conclude there has been a "lack of change in culling of dairy cows" over the approximately 8 years of commercial rbST use. The NAHMS 1996 and special NASS 1998 reports each contain data for only one year, NAHMS for 1995 and NASS for 1996 (and the latter only for the Midwest). The NASS data system does not collect yearly statistics on culling rates (Jim Morris-Knower, Mann Library Reference, Cornell University, January 2001, personal communication). The USDA Center for Animal Health Monitoring (CAHM), which conducts the NAHMS studies is not aware of yearly or other periodic US data being collected from which conclusions about changes in dairy cow culling rates could be drawn at this time (Brian McCluskey, CAHM, January 2001, personal communication). The CAHM is undertaking a new national dairy survey. When results are available it would be possible to compare the more recent results to the 1996 CAHM report (Brian McCluskey, CAHM, January 2001, personal communication).

F. Welfare of the downed cow

Welfare is poor in any animal if it is ill-treated or neglected. This can be a problem occasionally but most dairy farmers value their animals too much to allow either of these causes of poor welfare to occur. It should be noted, however, that many producers' concern for the welfare of their animals stops at the farm gate, when the animal ceases to be productive or to contribute to the profitability of the farming operation. Culled cattle may be sent to auction,

stockyards, or downed animal centers injured, hungry or thirsty, pregnant, debilitated, or with full udders, yet they are not milked again before slaughter and they may not watered or fed before slaughter, contributing to their pain and distress.

Figure 6-2. Dairy cow and her newborn calf dead on an offloading ramp at a Minnesota stockyard. The cow was killed after she went down while disembarking from the truck.

Photo: Defending Farm Animals, Inc.

Dr. Ian Duncan has described the period just before slaughter as the worst 24 hours of any animal's life. For animals that have been injured on the farm or in transport, or have taken ill and are culled, this description takes on special meaning (see Chapter 9). Cattle that are sent to slaughter pregnant may give birth on the truck or at the stockyard. Injured cattle wait for hours to be slaughtered after being dropped off at private companies that advertise for sick or injured animals. During this time and while being transported, it must be clear that they at least suffer pain, and possibly fear, and their welfare is very poor. Minnesota has no law requiring producers to have downed animals euthanized on the farm rather than send them to slaughter or requiring transport, stockyard or cull facility workers to euthanize them immediately if they are injured during transport. There is no law or government agency protecting the welfare of ill, injured, or incapacitated animals.

G. Welfare of calves

Welfare issues of dairy calves include the effects of difficult birth, insufficient colostrum, and poor housing, dehorning or debudding, and the handling and disposal of "surplus" (male) calves (bobby calves) that are not retained by the dairy producer but are culled and sold into the slaughter market or to veal producers.

Beef calves generally remain with the mothers during the full lactation period, as the mother's milk is not required for income. Consequently, a number of the welfare problems of dairy calves do not occur with beef calves. However, beef cattle frequently are in feedlots or on pasture or range, and face problems associated with exposure to the elements – e.g., sun, wind, snow, rain, muddy or dung covered ground, temperature extremes and predators – and such painful management procedures as castration and hot iron branding.

1. Dairy heifers

At parturition, cows withdraw from the herd to give birth. The strategy that cows have evolved to protect their calves is to leave them lying in the grass at a distance from the main herd and to return, four to six times a day, to let them suckle (Webster 1995).

The newborn animal must take on three vital functions previously carried out by the dam via the placenta: respiration, thermoregulation, and nutrition (Grongnet 1982). As a consequence, birth is not only the beginning of life but also a significant stressor and an extremely violent metabolic disturbance.

As soon as a calf is born, its dam turns around to it and begins to lick it, while vocalizing softly. The cow's first task is to lick the calf dry, which establishes the bond between them and also reduces the risk of the calf becoming chilled through excessive heat loss by evaporation of the fetal fluids. Licking the calf during the first hours after birth also stimulates the calf to appropriate behaviors (Dr. D. Broom, 2000, personal communication). That is, licking stimulates the calf to stand up and start suckling (Krohn, et al. 1999) and it stimulates urination and defecation as well as digestion (Kovalcik, et al. 1980, Metz 1984).

Very shortly after the calf is born, it begins to investigate grass and other objects in its environment with its mouth, at first in play, but later, when it has learned what is edible, for nutrition (Webster 1984). By two weeks of age, calves can be eating appreciable amounts of solids and taking up from the soil and grass the microorganisms that will colonize the developing rumen and ferment the grass, stimulating rumen development.

In a free-ranging beef herd, it is common for the calf to feed from its mother for at least the first six months of life. In commercial dairy production, the calf may be taken from its mother immediately, or it may be left with its mother during part or all of the 4-day colostrum period (period of time during which the cow transfers antibodies to her calf through her milk) and thereafter be removed from the cow and taken to a rearing accommodation where it is fed rationed amounts of milk or milk replacer from a bucket. After about four weeks, the calf is weaned onto solid food.

Calves are born practically without immunoglobulins or antibodies against neonatal infections (Hermann and Stenum 1982, Krohn, et al. 1999). It is essential for the newborn calf to drink an adequate amount of the cow's first milk, or colostrum, as soon as possible after birth and within the first 18 hours of life (Webster 1984). Colostrum carries the maternal antibodies to protect the calf from the infections to which it will be exposed before it has generated its own active system of immunity. The first 18 hours is the only time that the gut wall is sufficiently permeable to absorb the maternal antibodies unchanged (Webster 1984). The permeability of the gut to these antibodies starts to decline very shortly after birth and has almost disappeared by 18 hours.

Therefore, during the first day of life, a large transfer of immunoglobulins from the colostrum to the calf must take place.

The newborn calf has a very mature capacity to regulate its body temperature and combat the stresses of cold compared to a piglet, which in the natural state would be born and raised in nests that provide warmth and shelter (Webster 1984). Once it is dry and has had its first feed its

ability to resist cold becomes very impressive provided its coat doesn't become saturated with moisture from rain, snow or mud.

Out of doors with its mother, the calf is subject to a number of environmental stresses but in most circumstances the magnitude of the challenge by infectious organisms is low and it is within the capacity of the calf's immune system to mount an adequate defense (Webster 1984). The calf's running with its mother on its farm of birth is at a decided advantage because not only has it received antibodies in colostrum but the antibodies have been synthesized in the cow against the infectious agents that exist on that farm (Webster 1984). As a general rule, one can say that the further a calf is taken from the environment in which its mother lives, the less resistance to disease it can hope to derive from its mother's colostrum.

If calves are removed from the dam, they should be fed colostrum (and, later, milk) from buckets that have artificial teats they can suckle (Dr. I. Ekesbo, 2001, personal communication). Bucket fed calves are prone to non-nutritive suckling – e.g., suckling penmates or pen equipment -- which can spread disease. This frequently leads producers to isolate them in individual pens or tether them apart from other calves that might be a target for their suckling need. Individual housing of calves has been criticized when it prevents normal behaviors such as locomotion and self-grooming.

Nevertheless, there are reasons why it is best, if possible, for the calf to remain with the mother during at least the first 24 hours of its life and, preferably, throughout the colostrum period.

It is known that the presence of the mother has an effect on the absorption of antibodies by the calf (Selman, et al. 1971, Stott, et al. 1979). Calves absorb more colostral immunoglobulin when they are with their dam than when they are separated from her (Fallon 1978, Kelley 1980). Calves suckling dams have been shown to have higher serum immunoglobulin concentrations than bucket fed calves (Hermann and Stenum 1982).

Both the presence of the dam and suckling during the first four days after birth appear to be necessary to decrease the calf's subsequent fearfulness of other animals and therefore appear to be important in the establishment of the social bond (Krohn, et al. 1999). Calves that are reared in the same pen with the mother, whether bucket fed or allowed to nurse, grew twice as fast as calves penned separately from the mother immediately after birth and bucket fed, and they also started eating concentrates earlier (Krohn, et al. 1999). Calves that suckled also spent a longer time suckling than those that drank from the bucket spent in that activity.

Mothered calves have higher social activity levels than artificially reared calves, implying the first days of life are significant for social learning (Le Neindre & Sourd, cited in Krohn, et. al. 1999). Dairy calves that suckled their dams during their first days of life produced more milk as cows than artificially reared calves (Albright, and DeNise, cited in Krohn, et al. 1999). Suckling has benefits for the dam, reducing the amount of residual milk, frequency of mastitis, and risk of retained placenta (Krohn, et al. 1990, Krohn and Madsen, cited in Krohn, et al. 1999).

Weary and Chua (2000) noted that calves separated at older ages tended to require fewer days of treatment for scouring and, consequently, there may be health advantages associated with delaying separation that compensate for the increased behavioural response. They note that dairy producers have little to gain from separation at less than four days of age because the colostrum-rich milk cannot be sold and early separation involves a longer period during which the calves have to be fed by workers rather than by the cow.

Calves are highly motivated to suck and even non-nutritive sucking (sucking equipment or other calves in the environment, when the mother is not available) affects metabolic hormones, suggesting that deprivation of sucking behavior may interfere with digestive processes (de Passillé and Rushen 1995, 1997). Calves that drink from buckets engage in more non-nutritive sucking – i.e., suck more on equipment and penmates both during and after the colostrum period (Mees and Metz, cited in Krohn, et al. 1999). Teat buckets (buckets equipped with rubber nipples) satisfy this need to suck when feeding on milk. One reason producers give for not housing calves in groups is that they engage in non-nutritive sucking of penmates. However, cross-sucking can be reduced if the calves suck a teat immediately after the meal. Offering rubber teats to calves after each meal reduced cross-sucking between calves by over 75% (Rushen and de Passillé 1999).

Shortly after birth, calves begin to seek the udder at the level of their heads when standing. For the calves of beef cattle that have not been bred for high milk yield, it proves to be fairly easy to find the teat and begin suckling. However, the udders of high-yielding dairy cows, especially in their second lactation and beyond, tend to be low-hanging. (E.g., Lin, et al (1987) showed that height of the udder from the ground exhibited the highest degree of associations with yield traits, i.e., high producing heifers have lower udders.) Consequently, it takes the dairy calf much longer to find the teat than it takes the calves of cattle raised for beef (Hermann and Stenum 1982). This has consequences for nutrition and potentially survival, as it is so important for the calf to have the colostrum soon after birth.

A 1991-1992 US study of dairy heifer calves indicated that over 40% of dairy calves had immunoglobulin levels below a minimum level of adequate protection and these calves died twice as often as calves with higher immunoglobulin levels (NAHMS 1993). The study's authors concluded that at least 22 percent of all calf deaths in the US might be prevented by ensuring that calves received enough colostrum after birth.

In a study comparing the behavioral effects of separating the calf from its mother at birth or four days, Lidfors (1996) reported that 32% of the dairy calves kept with their dams did not suckle successfully during the first four hours after delivery. In a study of Canadian Holstein cows, 51% of the calves had not sucked their dams within the first 8 hours after delivery (Dr. L. Lidfors, 2001, personal communication). There is a greater risk for the calves of older cows (with lower hanging udders) to have difficulties getting milk than for calves of younger cows. Therefore, special attention must be given calves where the dam is in its third or higher lactation to see that the calf finds the teat and is able to get milk from it (Dr. L. Lidfors, 2001, personal communication).

"It is important that the calf gets colostrum very soon after the delivery and as soon as it wishes. Therefore, if the calf can suck the dam it should be given this opportunity. That means that the calf should be given the opportunity to stay with its dam during the [4-day] colostrum period. However, the owner therefore always must control that the calf finds the teat and really can suck and that the calf really gets milk" (Dr. I. Ekesbo, 2001, personal communication).

When the calf is unable to suck its dam due to not being able to reach the udder or similar reasons, it is necessary to remove the calf from its mother, but in all cases where the calf is taken from the dam before being weaned to solid feed, the calf needs to receive colostrum if it is removed during the colostrum period (Dr. I. Ekesbo, 2001, personal communication). It also needs a way to satisfy its natural behavior to suckle, for example, it needs a bucket equipped with artificial teats (e.g., rubber nipples) (Dr. D. Broom, 2000, personal communication).

Generally, the longer the dam and the calf are allowed to be together, the more intense is the reaction to the separation from both dam and calf. However, after four days the calves do not react too much to the separation (Dr. L. Lidfors, 2001, personal communication).

Weary and Chua (2000) found that cows separated from their calves when the calves were four days old called out for them at approximately four times the rate of cows that had been separated from their calves at six hours or 24 hours, and their calls had a higher fundamental frequency and lower emphasized harmonic than the calls of the cows separated from calves soon after birth. Hopster, et al. (1995) examining heart rate and behavior of cows separated from their calves after three days of nursing found that heart rate effects lasted only the first few minutes after separation and, while cows vocalized initially, they began feeding shortly afterwards.

In ruminant digestion, solid food passes through the esophagus into the rumen where it ferments (Webster 1984). During fermentation, liquids and smaller particles made up of microbes and highly fermented materials rise to the top and pass into the abomasum (stomach). The fermentation process is essential for utilization of plant cell walls. Milk need not be subject to rumen fermentation. In the calf's early development, a mechanism called the esophogeal groove allows milk to bypass the rumen and go directly to the abomasum. When the calf sucks milk from its mother, a nervous reflex is stimulated that causes a specialized muscle to contract and close the roof of the esophageal groove, converting it into a "pipe." The pipe delivers milk from the esophagus into the abomasum, bypassing the rumen. A calf running with its mother on pasture for the first six months of its life is able to direct all food to where it will be best utilized – solid food to the rumen and milk to the abomasum.

During the first week of life, the calf may drink 7-10 times per day from its mother and will seldom consume more than a litre of milk at a session (Webster 1984). In normal circumstances, therefore, the calf is unlikely to overload the abomasum at any one time. The flow of nutrients to the duodenum and small intestine is regulated at a steady rate, making for good digestion and reducing the risk of the calf succumbing to enteritis, leading to scours (diarrhea), or enterotoxemia, a disease in the small intenstine that liberates toxins that invade the entire body. The calf's feeding behavior and physiology is very different from that imposed by many rearing systems (Webster 1984).

Due to dystocia, calves may suffer from anoxia (or insufficient oxygen) and be weak and disoriented after birth (Webster 1984). A weak calf or a calf that has not been able to find the teat is unlikely to have suckled during the first 18 hours after birth and this poses a severe threat to its subsequent health and welfare. In this extreme case, Webster (1984) recommends feeding a weak calf three to four times in the first 18 hours with two pints of colostrum through a tube placed in the oesophagus.

Today, producers are more likely to separate calves from the dam at birth, before nursing, and feed colostrum by either bucket or esophageal feeder (NAHMS 1996). In the NAHMs (1996) study, as herd size increased, bucket feeding declined while "esophageal feeding" increased, not because the calves are ill or weak, but because it saves the labor of helping the calf to find the mother's teat and staying by to make sure the calf gets the colostrum. Esophageal feeding involves using a three-foot tube attached to a plastic bag in which the colostrum is placed. When the calf takes the tube in its mouth it quickly swallows it and the colostrum is fed directly into the rumen, reaching the abomasum within about three hours. Feeding by esophageal feeder tends to result in lower serum immunoglobulin concentrations compared to calves fed similar

amounts by nipple bottle. However, it "allows delivery of large volumes in a rapid and efficient manner" (Bovine Alliance on Management and Nutrition undated).

Other welfare issues include dehorning and calf housing. Behavioral and physiological responses indicate that dehorning of calves is accompanied by considerable pain and stress, which can be relieved during and up to two hours post dehorning by administering a local anaesthetic (Graf and Senn 1999).

2. Surplus calves

Because they are not needed, male dairy calves may be neglected after birth. Frequently, surplus calves are shipped for sale when they are too weak for transport and arrive at the stockyard injured, bewildered by their surroundings, or in pain.

In the past, male (bobby) calves were either kept or sold for production of veal. However, veal production is characterized by its own serious calf welfare problems and, because the public has become aware of those problems, demand for veal has dropped off, decreasing the economic value of bobby calves. Specialized dairy operations, unlike the more generalized traditional dairy farms, do not usually keep male calves and raise them for meat.

Millman (2000) estimated that somewhat over 1,000,000 neonatal calves were transported during 1999, either to a formula fed veal production unit or directly to slaughter. These calves are particularly vulnerable during transport and marketing.

Calves have behavioral needs that differ from needs of older livestock (Millman 2000). They spend 18 hours per day resting and are especially sensitive to pathogens and environmental temperatures. They have specialized feeding requirements and may not recognize milk and water, even when they have been provided. They also respond differently to methods used to handle other types of livestock – they lack strong motivation to herd and lack strong fear reactions and consequently cannot be driven. They are vulnerable to the impatience of inexperienced handlers.

While countries in the European Union have developed legislation covering the welfare of calves during transport and Canada has developed recommended codes of practice, protection of calves in the US is limited and the low value of surplus calves provides producers with little incentive to improve the situation (Millman 2000).

3. Calf housing

Young, et al. (1972), using a preference test where calves could choose between four floor types, showed that calves preferred sawdust bedding first, straw second, slatted wood floor third, and steel screen floors fourth. When calves could choose between deep litter beds and a slatted floor, they preferred deep litter and no calf chose the slatted floor (Bäckström 1977).

Housing for calves, if the space is too small, creates problems for calf welfare. Limiting the space available to individually housed animals leads to physiological and immune signs of

stress and reduced growth rates, if the degree of spatial restriction is large enough (Rushen and de Passillé 1999). In a comparison of calves reared until five months of age in identical individual pens either 2.1m or 0.6 m wide, calves' growth rates were significantly reduced over 20 weeks and showed reduced growth hormone.

Rushen and dePassillé (1999) state that individual housing for calves must be spacious and comfortable enough to allow the heifers to get up and lie down easily and to adopt the normal resting postures. Slatted concrete floors without bedding are not suitable for heifers and can increase incidence of hoof problems. Heifers reared in groups have better welfare when grouped with a space allowance of 2.7 to 3.6m^2 per calf versus 1.5 to 1.8m^2 per calf.

4. Painful procedures

Other issues affecting dairy calves include comfort and painful procedures, in particular, tail docking. Increasingly in industrialized dairy production, the tails of dairy heifers are being docked for the convenience of the milker and as a way of keeping udders clean in slatted floor housing or poorly maintained solid floor housing systems where the brushes of the cows' tails frequently get covered with manure when the cow lies down. Failure to maintain a clean environment is not compensated for by docking cows' tails, however, as udder and uterine infections can still occur from exposure to filthy floors.

As with the docking of pigs' tails, it is likely that, in addition to the acute pain the calf experiences when its tail is docked, neuromas can form in the tail end resulting in longer-term pain (Dr. D. Broom, 2000, personal communication). Tail docking also decreases the efficiency with which the cow will be able to defend herself against flies and other winged insect pests. A study reported in New Zealand where the practice of tail docking dairy cattle originated concluded that tail docking was no longer acceptable inasmuch as results of monitoring a group of cows that had their tails docked, a group that had only the switches removed, and a group that had in tact tails, showed no real benefits to tail docking for the farmer and there were no differences in milk yield, somatic cell count level, body weights or the frequency of mastitis between treatments. Cows without tails also had the highest number of flies on the rear compared to other cows and worked harder than cows with tails did to get rid of flies (Anonymous 1998). Researchers suggested that farmers trim the tail switches instead of tail docking.

III. Beef cattle and calves[29]

Welfare issues of beef cattle have to do with exposure to the elements, particularly in the extreme temperatures and when snowstorms prevent range fed cattle from getting hay when they need it. Beef cattle in feedlots are exposed, unprotected, to the sun and have relatively impoverished environments – that is, are unable to graze because they are standing in dirt and their movements may be restricted due to crowding. On feedlots, standing in muck and moist conditions can lead to hoof and foot disorders, such as hoof rot.

[29] Note update: On April 25, 2001, three days after this GEIS report was initially submitted, the report of the Scientific Committee on Animal Health and Animal Welfare, Health & Consumer Protection Directorate-General, *The Welfare of Cattle kept for Beef Production*, was adopted in the European Commission. The reader is referred to: http://europa.eu.int/comm/dg24/health/sc/scah/out54_en.pdf

Feedlot cattle are fed a variety of antibiotics at subtherapeutic levels to reduce diseases that could break out in stressful, densely confined conditions. A number of these are fed continuously throughout the growth period to reduce liver condemnations due to abscesses, control bacterial pneumonia associated with shipping fever complex, prevent and control coccidiosis, and to improve feed efficiency and rate of gain (Mellon, et al. 2001).

Double muscled breeds such as Piedmontese and Belgian Blue cattle, especially bulls, are so heavily muscled they may have difficulty walking, however, the double-muscled quality is economically desirable due to beef yield. Cows bred to or artificially inseminated with semen from double-muscled bulls (so as to produce large calves) are subject to dystocia (difficult births) and most require caesarian surgeries in order to deliver their calves. This is a serious welfare concern due to pain and possibility of infection.

Calves from heavily-muscled cattle may experience anoxia in the birthing process, especially if their mothers experience dystocia, or difficult birth. In cattle, the large size of the foetus results in a difficult passage through the birth canal and the pelvic opening which is often narrow (Grongnet 1982). As a result the calves have low "vigor" and take longer to find the teat and gain nourishment (Stephens 1982).

In general, the welfare issues associated with calves from cows raised for beef are similar to the welfare issues of their parents, including exposure to the elements when reared in feedlots and open range or pasture and predators when reared on range or pasture. Males are subject to castration (discussed in Chapter 3) and hot iron branding, which is very painful (Schwartzkopf-Genswein, et al. 1997, 1998, Schwartzkopf-Genswein and Stookey 1997) and to which freeze-branding appears to be a less painful alternative (Goodrich and Stricklin undated).

References

Anonymous. (1998). *New Zealand study says trim tail switch*. Agricultural Publishing Company.

Alban, L. (1995). Lameness in Danish dairy cows: frequency and possible risk factors. *Preventive Veterinary Medicine, 22,* 213-225.

Alban L., Agger J.F. & Lawson L.G. (1996). Lameness in tied Danish dairy cattle: The possible influence of housing systems, management, milk yield and prior incidents of lameness. *Preventive Veterinary Medicine, 29 (2),* 135-149.

Albright, J.L. (1982). Early experience effects upon maternal behavior, temperament and milk production in dairy cattle. 21st International Dairy Congress, 37 (abstract).

American Society of Animal Science. (1998). U.S. vs. New Zealand dairy study reveals big differences. *News from the National Meeting--Denver, Colorado, July 27-31, 1998.*

Andreae, U. & Smidt, D. (1982). Behavioural alterations in young cattle on slatted floors. *Hohenheim Arb., 121,* 51-60.

Arnold, G.W. & Dudzinski, M.L. (1978). *Ethology of free ranging domestic animal*s. Elsevier Scientific Publishing Company, Amsterdam.

Balch, C.C. (1971). Proposal to use time spent chewing as an index of the extent to which diets for ruminants possess the physical property of fibrousness characteristic of roughages. *British Journal of Nutrition, 26,* 383-392.

Barkema, H.W., Westrik, J.D., van Keulen, K.A.S., Schukken, Y.H. & Brand, A. (1994). The effects of lameness on reproductive performance, milk production and culling in Dutch dairy farms. *Preventive Veterinary Medicine, 20,* 249-259.

Barnett J.L., Coleman G.J., Hemsworth P.H., Newman E.A., Fewings Hall S. & Ziini C. (1999). Tail docking and beliefs about the practice in the Victorian dairy industry. *Australian Veterinary Journal*, 77 (11), 742-747.

Barnouin, J. & Karaman, Z. (1986). Continuing eco-pathological survey: 9. Influence of the level of production on the pathology of the dairy cow (abst.). *Ann Rech Vet, 17(3)*, 331-346.

Bar-Peled, U., Maltz, E., Bruckental, I., Folman, Y., Kali, Y., Gacitua, H., Lehrer, A.R., Knight, C.H., Robinzon, B., Voet, H., et al. (1995). Relationship between frequent milking or suckling in early lactation and milk production of high producing dairy cows. *Journal of Dairy Science, 78(12),* 2726-36.

Beatson, P. (2000). Profitability trends under pasture production systems. 10th World Holstein Conference, Proceedings. Sidney, AU: The Holstein-Friesian Association of Australia, Inc. http://holsteinaust.une.edu.au/2000/1Beatson.html.

Bendixen, P.H., Vilson, B., Ekesbo, I., & Åstrand, D.B. (1987). Disease frequencies in dairy cows in Sweden, II. Retained placenta. *Preventive Veterinary Medicine, 4,* 377-387.

Bendixen, P.H., Vilson, B., Ekesbo, I., & Åstrand, D.B. (1987). Disease frequencies in dairy cows in Sweden, III. Parturient paresis. *Preventive Veterinary Medicine, 5,* 87-97.

Bendixen, P.H., Vilson, B., Ekesbo, I., & Åstrand, D.B. (1987). Disease frequencies in dairy cows in Sweden, IV. Ketosis. *Preventive Veterinary Medicine, 5,* 99-109.

Bendixen, P.H., Vilson, B., Ekesbo, I., & Åstrand, D.B. (1988). Disease frequencies in dairy cows in Sweden, V. Mastitis. *Preventive Veterinary Medicine, 5,* 263-274.

Bendixen, P.H., Vilson, B., Ekesbo, I., & Åstrand, D.B. (1988). Disease frequencies in dairy cows in Sweden, VI. Tramped teat. *Preventive Veterinary Medicine, 6,* 17-25.

Bergsten, C. (1995). *Digital disorders in dairy cattle with special reference to laminitis and heel horn erosion: the influence of housing, management and nutrition*. Skara, Sweden: Department of Animal Environment and Health, Swedish University of Agricultural Sciences.

Bergsten, C. & Frank, B. (1996). Sole haemorrhages in tied primiparous cows as an indicator of periparturient laminitis: effects of diet, flooring and season. *Acta Veterinaria Scandinavia 37,* 383-394.

Blakely, J. & Bade, D.H. (1979). *The science of animal husbandry*. 2nd Ed. Reston, VA: Reston Publishing Company, Prentice-Hall, Inc.

Boettcher, P.J., Dekkers, J.C.M., Warnick, L.D., & Wells, S.J. (1998). Genetic analysis of clinical lameness in dairy cattle. *Journal of Dairy Science, 81,* 1148-1156.

Bovine Alliance for Management & Nutrition. (undated). A guide to colostrum and colostrum management for dairy calves. U.S. Department of Agriculture, Animal Plant Health Inspection Service, Center for Animal Health Management.

Broom D.M. (1994). The effects of production efficiency on animal welfare. In *Biological basis of sustainable animal production Proc. 4th Zodiac Symp.* EAAP Publ. 67. Huisman, E.A., Osse, J.W.M., van der Heide, D., Tamminga, S. Tolkamp, B.L., Schouten, W.G.P., Hollingsworth, C.E., and van Winkel, G.L., eds. 201-210. Wageningen: Wageningen Pers.

Broom D.M. (1993). Assessing the welfare of modified or treated animals. *Livestock Production Science, 36*, 39-54.

Broom, D.M. (1999). The welfare of dairy cattle. In *Proceedings of the 25th International Dairy Congress, Aarhus, 1998, III, Future Milk Farming,* pp. 32-39. K. Aagaard, Ed. Aarhus: Danish National Committee of International Dairy Federation.

Broom, D.M. (2000a). Effects of dairy cattle breeding and production methods on animal welfare. Proceedings of the XXI World Buiatrics Congress Punta del Este, Uruguay.

Broom, D. M. (2000b). Calf welfare: history and current issues. *Ruth Harrison Memorial Meeting, Farm Animal Care Trust, Fyvie Hall, University of Westminster, London, November 29, 2000.*

Broster W.H. & Broster V.J. (1998). Body score of dairy cows. *J. Dairy Res.*, 65, 155-173.

Butler W.R. & Smith R.D. (1989). Interrelationships between energy balance and post partum reproductive function in dairy cattle. *J. dairy Sci.*, 72, 767-783.

Bäckström, M. (1977). *Miljöns invedrkan på beteendet hos kalvar och ungdjur av mjölkkoras.* Examensarbete, Swedish University of Agricultural Sciences. Uppsala: Institutionen för husdjurens utfodring och vård.

Campbell, J.R. & Lasley, J.F. (1985). *The science of animals that serve humanity*. 3rd edition. New York: McGraw-Hill Book Company.

Castrén, H. (1988). Behaviour disturbances in cattle. *Nötkreaturens beteende – litteraturkompendium (Cattle Behaviour – literature compendium).* The Nordic Group for Cattle Ethology, Nordiskt Kontaktorgan för Jordbruksforskning. ISBN 91-576-3367-3.

Chaplin, S. J, Ternent, H. E., Offer, J. E., Logue, D. N. & Knight, C. H. (2000). A comparison of hoof lesions and behaviour in pregnant and earlylactation heifers at housing. *Veterinary Journal 159,* 147-153.

Collard, B.L., Boettcher, P.J., Dekkers, J.C.M., Petitclerc, D., & L.R. Schaeffer. (2000). Relationships between energy balance and health traits of dairy cattle in early lactation. *Journal of Dairy Science, 83,* 2683-26990.

Collick, D.W., Ward, W.R. & Dobson, H. (1989). Associations between types of lameness and fertility. *Veterinary Record, 125,* 103-106.

Crooker, B., Halvorson, D., Moon, R., Phillips, C., Noll, S., Johnston, L., Reneau, J., Chester-Jones, H., Hathaway, M., Goyal, S., Janni, K., Pijoan, C., Shields, T., Stromberg, T., Patterson, C., Dee, S., Blaha, T., and Wells, S. (1999). A summary of the literature related to animal agriculture health. *Generic environmental impact statement on animal agriculture, State of Minnesota*. St. Paul, MN: Environmental Quality Board.

Dechow, C.D., Rogers, G.W., and Clay, J.S. (2001). Heritabilities and correlations among body condition scores, production traits, and reproductive performance. *Journal of Dairy Science, 84,* 266-275.

Dellmeier, G., Friend, T., & Gbur, E. (1990) Effects of changing housing on open-field behavior of calves. *Applied Animal Behaviour Science, 20*, 215-230.

dePassillé, A.-M. & Rushen, J. (1997). Motivational and physiological analysis of the causes and consequences of non-nutritive sucking by calves. *Applied Animal Behaviour Science, 53(1-2),* 15-31.

dePassillé, A.-M. & Rushen, J. (1995). The motivation of non-nutritive sucking in calves, Bos Taurus. *Animal Behavior, 49,* 1503-1510.

Ekesbo, I. (1966). Disease incidence in tied and loose housed dairy cattle and causes of this incidence variation with particular reference to the cowshed type. *Acta Agriculturæ Scandinavica, Supplementum 15.*

Ekesbo, I. (1973). Animal health, behaviour and disease prevention in different environments in modern Swedish animal husbandry. *Veterinary Record, 93,* 36-40.

Ekesbo, I. (1980). Some environmentally evoked animal health and welfare problems in modern husbandry. *Animal Regulation Studies, 3,* 119-128.

Ekesbo, I. (1988). Health and welfare of farm animals and their impact on the livestock industry. *Proceedings of VI World Conference on Animal Production, Helsinki 1988*, 102-111.

Ekesbo, I. (1989). Animal health as a function of animal husbandry. *Proceedings, World Association of Veterinary Food Hygiene (WAVFH), 10th International Symposium 2-7 July 1989, Stockholm*, 35-41.

Ekesbo, I. (1992). Monitoring systems using clinical, subclinical and behavioural records for improving health and welfare. *Livestock health and welfare*. Moss, R., ed. Essex, England: Longman Scientific & Technical..

Ekesbo, I. (1998). Risk factors for teat tramp and mastitis in the dairy cow environment and management. *Proceedings "Veterinaarmeditsin 98, Estonian Veterinary Association Annual Meeting, Tartu, 17-19 September 1998*, 108-114.

Ekesbo, I. & Lund, V. (1994). Different standards in animal welfare legislation: Consequences for animal health and production economy. *Proceedings of 8th International Congress on Animal Hygiene, St. Paul, Minnesota,* PA-1 to PA-5.

Ekesbo, I., Oltenacu, P.A., Vilson, B., & Nilsson, J. (1994). A disease monitoring system for dairy herds. *The Veterinary Record, 134,* 270-273.

Emanuelson, U. and Oltenacu, P.A. (1998). Incidences and effects of diseases on the performance of Swedish dairy herds stratified by production. *Journal of Dairy Science, 81,* 2376-2382.

Esslemont R.J. (1990). The cost of lameness in dairy herds. Update in cattle lameness. *Proc. 6th Int. Symp. On Diseases of the Ruminant Digit, Liverpool*, 237-251.

Esslemont, R.J. & Kossaibati, M.A. (1997). Culling in 50 dairy herds in England. *Vet.Rec,140*, 36-39.

Etherton, T.D. & Bauman, D.E. (1998). Biology of somatotropin in growth and lactation of domestic animals. *Physiological Reviews, 78(3),* 745-762.

E.U. Scientific Committee on Animal Health and Animal Welfare. (1999a, March 10). *Report of the Scientific Committee on Animal Health and Animal Welfare on animal welfare aspects of the use of bovine somatotrophin*. Brussels: Health and Consumer Protection Directorate, European Commission, Health and Consumer Protection branch.
http://europa.eu.int/comm/dg24/health/sc/scah/out21_en.pdf

E.U. Scientific Committee on Veterinary Measures Relating to Public Health. (1999, March 15-16). *Report on public health aspects of the use of bovine somatotrophin*. Report of the Scientific Committee on Veterinary Measures Relating to Public Health. Brussels: Health and Consumer Protection Directorate, European Commission.
http://europa.eu.int/comm/dg24/health/sc/scv/out19_en.html

Ewbank, R., Kim-Madslien, F., & Hart, C.B. (1999). *Management and welfare of farm animals*. 4th edn. Herts, UK: Universities Federation for Animal Welfare.

Fallon, R.J. (1978). The effect of immunoglobulin levels on calf performance and methods of artificially feeding colostrum to the new born calf. *Ann. Rech. Vet., 9,* 347-352.

Farm Animal Welfare Council. (1997). *Report on the welfare of dairy cattle.* London, UK: UK Ministry of Agriculture, Fisheries, and Food, Farm Animal Welfare Council.

Faull, W. B., Hughes, J. W., Clarkson, M. J., Downham, D. Y., Manson, F. J., Merritt, J. B., Murray, R. D., Russell, W. B., Sutherst, J. E., & Ward, W. R. (1996). Epidemiology of lameness in dairy cattle: the influence of cubicles and indoor and outdoor walking surfaces. *Veterinary Record 139,* 130-136, cited in Rushen 2000.

Faye, B., Lescourret, F., Dorr, N., Tillard, E., MacDermott, B., & McDermott, J. (1997). Interrelationships between herd management practices and udder health status using canonical correspondance analysis. *Preventive Veterinary Medicine, 32,* 171-192.

Ferguson J.D. (1988). Feeding for reproduction. In *Proc. dairy prod. Med. contn. Edu. Group ann. Mtg.,* 48-56. Trenton, N.J.: Vet. Learning System Co. Inc.

Foote R.H. (1978). Reproductive performance and problems in New York dairy herds. *Search Agric. (Geneva N.Y.)*, 8, 1.

Fraser, A.F. (1980). *Farm animal behaviour*. 2nd Ed. London: Bailliere-Tindall.

Fraser, A.F. & Broom, D.M. (1990). *Farm animal behaviour and welfare*. London: Ballière Tindall.

Friend, T.H., Dellmeier, G.R., & Gbur, E.E. (1987). Effects of changing housing on physiology of calves. *Journal of Dairy Science,70*, 595-1600.

Friend, T.H., Dellmeier, G.R., & Gbur., E.E. (1985). Comparison of four methods of calf confinement. I:Physiology. *Journal of Animal Science, 5*, 1095ff.

Friend, T.H., Dellmeier, G.R., & Gbur, E.E. (1985). Comparison of four methods of calf confinement. II:Behavior." *Journal of Animal Science, 5*, 1102ff.

Galindo, F., Broom, D.M., & Jackson, P.G.G. (2000). A note on possible link between behaviour and the occurrence of lameness in dairy cows. *Applied Animal Behaviour Science 67*: 335–341.

Goodrich, R. &Stricklin, W.R. (undated). *Animal welfare issues: Beef.* U.S. Department of Agriculture website.

Graf B. & Senn M. (1999). Behavioural and physiological responses of calves to dehorning by heat cauterization with or without local anaesthesia. *Applied Animal Behaviour Science, 62(2-3),* 153-171.

Greenough, P.R. & Weaver, A.D. (1996). *Lameness in cattle*. 3rd edition. Philadelphia: Saunders.

Groen, A.F., Steine, T., Colleau, J.J., Pederson, J. Pribyl, J., & Reinsch, N. (1997). Economic values in dairy cattle breeding with special reference to functional traits. Report of EEAP Working Group. *Livestock Production Science, 49*, 1-21.

Grongnet, J.F. (1982). Some aspects of the metabolic adaptation of the calf to aerial life. *Welfare and husbandry of calves. Signoret, J.P., ed. A seminar in the Commission of the European Communities Programme of Coordination of Research on Animal Welfare, Brussels, 9-10 July 1981.* The Hague: Martinus Nijhoff Publishers.

Hafez, E.S.E. & Bouissou, M.F. (1975). The behaviour of cattle. *The behaviour of domestic animals.* Hafez, E.S.E., ed., 3rd edn. London: Baillière Tindall.

Haley, D. B., Rushen, J., & de Passillé, A. M. (2000). Behavioural indicators of cow comfort: activity and resting behaviour of dairy cows in two types of housing. *Canadian Journal of Animal Science 80,* 257-263.

Hansen, L. (1999). Increased inbreeding and relationships of Holsteins- How much further should we go? In: Kennelly, J. J., Editor. *The Tools for Success in the new Millenium: Advances in Dairy Technology.* Red Deer, Alberta, Edmonton: University of Alberta, 1-12.

Hansen, L.B. (2000). Consequences of selection for milk yield from a geneticist's viewpoint. *Journal of Dairy Science, 83(5),* 1145-1150.

Hansen, L.B., Cole, J.B., Marx, G.D., & Seykora, A.J. (1999). Productive life and reasons for disposal of Holstein cows selected for large versus small body size. *Journal of Dairy Science, 82,* 795-801.

Harmon, R.J. (1994). Physiology of mastitis and factors affecting somatic cell counts. *Journal of Dairy Science, 77,* 2103-2112.

Harris, D. J., Hibburt, C. D., Anderson, G. A., Younis, P. J., Fitspatrick, D. H., Dunn, A. C., Parsons, J. W., & McBeath, N. R. (1988). The incidence, cost and factors associated with foot lameness in dairy cattle in south-western Victoria. *Australian Veterinary Journal, 65,* 171-176.

Hassall, S.A., Ward W.R. & Murray R.D. (1993). Effects of lameness on the behaviour of cows during the summer. *Veterinary Record, 132 (23),* 578-580.

Health Canada. (1998). RBST (Nutrilac) "Gaps Analysis" Report. RBST Internal Review Team, Health Protection Branch, *Health Canada*, Ottawa, Canada.

Hemsworth P.H., Barnett J.L., Beveridge L. & Matthews L.R. (1995). The welfare of extensively managed dairy cattle – a review. *Applied Animal Behaviour Science, 42 (3),* 161-182.

Heringstad, B., Klemetsdal, G. & Ruane, J. (2000). Selection for mastitis resistance in dairy cattle: A review with focus on the situation in the Nordic countries. *Livestock Production Science, 64(2-3)*, 95-106.

Hermann, E. & Stenum, N. (1982). Mother-calf behaviour during the first six hours after parturition. *Welfare and husbandry of calves. Signoret, J.P., ed. A seminar in the Commission of the European Communities Programme of Coordination of Research on Animal Welfare, Brussels, 9-10 July 1981.* The Hague: Martinus Nijhoff Publishers.

Hoekstra J., van der Lugt A.W., van der Werf J.H.J. & Ouweltjes W. (1994). Genetic and phenotypic parameters for milk production and fertility traits in up-graded dairy cattle. *Livest. Prod. Sci.*, *40,* 225-232.

Hoffman, H. & Rist, M. (1975). Tiergerechte und arbeitswirtschaftlich günstige anbindevorrichtungen für kühe. *Schweiz. Landwirt. Monatshefte, 53,* 119-126.

Hopster, H., O'Connell, J.M., and Blokhuis, H.J. (1995). Acute effects of cow-calf separation on heart rate, plasma cortisol and behaviour in multiparous dairy cows. *Applied Animal Behaviour Science, 44(1),* 1-8.

Hultgren, J. (1988). *The function of electric cow-trainers and effects of them on behaviour and physiology: A review and methodological study*. Report 24. Skara, Sweden: Swedish University of Agricultural Sciences, Faculty of Veterinary Medicine, Department of Animal Hygiene.

Jensen, P., Recén, B., & Ekesbo, I. (1988). Preference of loose housed dairy cows for two different cubicles floor coverings. *Swedish Journal of Agricultural Research, 18,* 141-146.

Kelley, K.W. (1980). Stress and immune function: A bibliographic review. *Ann.Rech.Vet., 11, (4),* 445-478.

Kiley-Worthington, M. (1983). The behaviour of confined calves raised for veal: Are these animals distressed? *International for the Study of Animal Problems, 4 (3),* 198-213.

Kilgour, R. (1985). Defining the behavioural characteristics of farm animals. *Ethology of farm animals: A comprehensive study of the behavioural features of the common farm animals.* World Animal Science. Basic Information A, Number 5, A.F. Fraser, editor. New York: Elsevier Science Publishing Company, Inc.

King, J.O. (1981). Husbandry methods predisposing to production diseases in dairy cows. *Veterinary Record, 108(26),* 557-560.

Knight, C.H. (2000). The importance of cell division in udder development and lactation. *Livestock Production Science, 66,* 169-176.

Kovalcik, K., Kovalcikova, M. & Brestensky, V. (1980). Comparison of the behaviour of newborn calves housed with the dam and in the calf-house. *Applied Animal Ethology, 6,* 377-380.

Krohn, C.C., Foldager, J., & Mogensen, L. (1999). Long-term effect of colostrum feeding methods on behaviour in female dairy calves. *Acta Agriculturae. Scandinavica, Section A, Animal Science, 49,* 57-64.

Krohn, C.C., Jonasen, B., & Munksgaard, L. (1990). Cow-calf relations. 2. The effect of 0 vs 5 days suckling on behaviour, milk production and udder health of cows in different stabling. 678. Report of Danish Institute of Animal Science.

Kronfeld, D.S. (1994). Health management of dairy herds treated with bovine somatotropin. *Journal of the American Veterinary Medical Association, 204(1),* 116-130.

Kronfeld D.S. (1997). Recombinant bovine somatotropin: ethics of communication and animal welfare. *Swedish veterinary Journal, 49*, 157-165.

Kämmer, P. & Tschanz, (1975). Untersuchungen zur tiergerechten haltung von milchvieh in boxenlaufställen. *Schweiz. Landwirt. Forschung, 14,* 203-223.

Ladewig, J. & Borell, E.V. (1988). Ethological methods alone are not sufficient to measure the impact of environment on animal health and animal well-being. Proceedings of the International Congress on Applied Ethology in Farm Animals, Skara, Sweden, Unshelm, J., Van Putten, G., Zeeb, K., & Ekesbo, I., eds. Darmstadt, Germany: KTBL.

Ladewig, J. & Smidt, D. (1989). Behaviour, episodic secretion of cortisol and adrenocortical reactivity in bulls subjected to tethering. *Hormones and Behaviour, 23,* 344-360.

Laws, J.A., Rook, A.J., & Pain, B.F. (1996). Diet selection by cattle offered a choice between swards treated or untreated with slurry: effects of application method and time since application. *Applied Animal Behaviour Science, 48(3-4),* 131-141.

Lay D.C., Friend T.H., Grissom K.K., Bowers C.L. & Mal M.E. (1992). Effects of freeze or hot-iron branding of angus calves on some physiological and behavioral indicators of stress. *Applied Animal Behaviour Science, 33 (2-3),* 137-147.

Leaver, J.L. (1999). Dairy cattle. In Ewbank, R., Kim-Madslien, F., & Hart, C.B. (1999). *Management and welfare of farm animals*. 4th edn. Herts, UK: Universities Federation for Animal Welfare, 18-47.

Leonard, F. C., O'Connell, J. M. & O'Farrell, K. J. (1996). Effect of overcrowding on claw health in first-calved Friesian heifers. *British Veterinary Journal 152,* 459-472.

Leonard, F. C., O'Connell, J. & O'Farrell, K. (1994). Effect of different housing conditions on behaviour and foot lesions in Friesian heifers. *The Veterinary Record 134,* 490-494.

Lidfors, L. (1989). The use of getting up and lying down movements in the evaluation of cattle environments. *Veterinary Research Communications, 13,* 307-324.

Lidfors, L. (1992). *Behaviour of bull calves in two different housing systems: Deep litter in an uninsulated building versus slatted floor in an insulated building. Thesis. Report # 30.* Skara, Sweden: Dept. of Animal Hygiene, Faculty of Veterinary Medicine, Swedish University of Agricultural Sciences.

Lidfors, L. (1996). Behavioural effects of separating the dairy calf immediately or 4 days post-partum. *Applied Animal Behaviour Science, 49(3),* 269-283.

Liesegang, A., Eicher, R., Sassi, M.L., Risteli, J., Kraenzlin, M, Riond, J.L., & Wanner, M. (2000). Biochemical markers of bone formation and resorption around parturition and during lactation in dairy cows with high and low standard milk yields. *Journal of Dairy Science, 83,* 1773-1781.

Lin, C.Y., Lee, A.J., McAllister, A.J., Batra, T.R., Roy, G.L., Vesely, J.A., Wauthy, J.M., & Winter, K.A. (1987). Intercorrelations among milk production traits and body and udder measurements in Holstein heifers. *Journal of Dairy Science, 70(11),* 2385-2393.

Lucy, M.C. (2000). Reproductive physiology in high-yielding dairy cows. The Holstein-Friesian Association of Australia.

Macmillan, K.L. (2000). Can reproductive efficiency be sustained under high production systems? The Holstein-Friesian Association of Australila.

McAllister, A.J. (2000). Breeding for profitability and reproduction. *Proceedings, Managing Reproduction in Southeastern Dairy Herds: A program for managers of dairy herds and dairy professionals in the Southeastern states, February 23-24, 2000.*

Mellon, M., Benbrook, C., & Benbrook, K.L. (2001). *Hogging it! Estimates of antimicrobial use in livestock.* Cambridge, MA: Union of Concerned Scientists.

Metz, J. (1984). Behaviour and state of health of cows and calves kept together or separately in the post-partum period. *Proceedings of the International Congress of Applied Ethology of Farm Animals, Kiel 1984,* 358-362.

Mill & Ward. (1993). Lameness in dairy cattle and farmers' knowledge, training and awareness. *Veterinary Record, 134,* 162-164, cited in VetAgro International 2000.

Millman, S.T. (2000). Welfare of surplus calves in the dairy industry. *Journal of Animal Science, 78, Suppl. 1,* 32-33.

MN-DHIA. (1999). *Annual Summary of the Minnesota Dairy Herd Improvement Association*. Buffalo, MN 55313.

Mogensen, L., Sorensen, J.T., Hindhede, J., Nielsen, L.H. & Kristensen, A.R. (1999). Effect of space allowance and access to bedding in slatted-floor housing systems during second-year rearing on subsequent milk production of primiparious dairy cows. *Acta Agricultura Scandinavica, Section A., Animal Science, 49,* 49-56.

Moss, R., ed. (1992). *Livestock health and welfare*. Essex, England: Longman Scientific & Technical.

Muller, C., Ladewig, J., Thielscher, H.H., & Smidt, D. (1989). Behavior and heart rate of heifers housed in tether stanchions without straw. *Physiology and Behavior, 46,* 751-754.

Munksgaard, L. & Løvendahl, P. (1993). Effects of social and physical stressors on growth hormone levels in dairy cows. *Canadian Journal of Animal Science 73,* 847-853.

NAHMS. (1996). Dairy 96. US Department of Agriculture, Animal Plant Health Inspection Service, Center for Animal Health Management.

NAHMS. (1993, February). Transfer of maternal immunity to calves. National Dairy Heifer Evaluation Project, US Department of Agriculture, Animal Plant Health Inspection Service.

Nebel R.L. & McGilliard M.L. (1993). Interactions of high milk yield and reproductive performance in dairy cows. *J. dairy Sci.*, 76, 3257-3268.

Newberry, R.C. & Bergsten, C. (1999). Well-being issues in dairy production. In: *Proceedings of the Northwest Dairy Shortcourse, Jan. 22-23, 1999, Blaine WA*, 109-114.

Oester, H. (1978). Ethologische beurteilung von laufställen für milchkühe. *First World Congress on Ethology Applied to Zootechnics, Madrid 1978,* 195-203.

Oliver, S.P., Schrick, F.N., Hockett, M.E., and Dowlen, H.H. (2000). Interaction of mastitis and reproductive function in lactating dairy cows. *Proceedings, Managing Reproduction in Southeastern Dairy Herds: A program for managers of dairy herds and dairy professionals in the Southeastern states, February 23-24, 2000.*

Oltenacu, P.A. & Ekesbo, I. (1994). Epidemiological study of clinical mastitis in dairy cattle. *Veterinary Research, 25(2-3),* 208-212.

Oltenacu, P.A., Bendixen, P.H., Vilson, B. & Ekesbo, I. (1990). Tramped teats – clinical mastitis disease complex in tied cows. Environmental risk factors and interrelationships with other diseases. *Acta Veterinaria Scandinavica, 31(4),* 471-478.

Oltenacu P.A., Frick, A. & Lindhe B. (1991). Relationship of fertility to milk yield in Swedish cattle. *Journal of Dairy Science*, 71, 264-268.

Pell, A.N., Tsang, D.S., Howlett, B.A., Juyle, M.T., Meserole, V.K., Samuels, W.A., Hartnell, G.F. & Hint, R.L. (1992). Effects of a prolonged-release formulation of smetribove (n-methionyl bovine somatotropin) on Jersey cows. *Journal of dairy science, 75,* 3416-3431.

Petersen, W.E. (1950). *Dairy Science*. 2nd Edition. Chicago: J. B. Lippincott Company.

Philipot, J. M., Pluvinage, P., Cimarosti, I., Sulpice, P., & Bugnard, F. (1994). Risk factors of dairy cow lameness associated with housing conditions. *Veterinary Research 25,* 244-248, cited in Rushen (2000).

Philipsson, J. & Lindhé, B. (2000). Experiences of including categorical traits such as reproduction and health in Scandinavian cattle breeding programmes. *51st Annual Meeting Genetic Commission, Session IV. EAAP, The Hague, Netherlands, 21-24 August*.

Plaizier J.C.B., Lissemore K.D., Kelton D. & King G.J. (1998). Evaluation of overall reproductive performance of dairy herds. *Journal of Dairy Science, 81,* 1848-1854.

Pryce J.E., Veerkamp R.F., Thompson R., Hill R.G. & Simm G. (1997). Genetic aspects of common health disorders and measures of fertility in Holstein Friesian dairy cattle. *Animal Science*, *65,* 353-360.

Pryce J.E., Esslemont R.J., Thompson R., Veerkamp R.f., Kossaibati M.A. & Simm G. (1998). Estimation of genetic parameters using health, fertility and production data from a management recording system for dairy cattle. *Animal Science 66,* 577-584.

Pösö J & Mäntysaari E.A. (1996). Genetic relationships between reproductive disorders, operational days open and milk yield. *Livestock Production Science*, *46,* 41-48.

Rauw, W.M., Kanis, E., Noordhuizen-Stassen, E.N., & Grommers, F.J. (1998). Undesirable side effects of selection for high production efficiency in farm animals: a review. *Livestock Production Science 56,* 15-33.

Reinhardt, V. & Reinhardt, A. (1975). Dynamics of social hierarchy in a dairy herd. *Z. Tierpsychol., 38,* 315-323.

Riley C.B. & Farrow C.S. (1998). Partial carpal arthrodesis in a calf with chronic infectious arthritis of the corpus and osteomyelitis of the carpel and metacarpel bones. *Canadian Veterinary Journal, 39 (7),* 438-441.

Rougoor, C.W., Sundaram, R., and van Arendonk, J.A.M. (2000). The relation between breeding management and 305-day milk production, determined via principal components regression and partial least squares. *Livestock Production Science, 66,* 71-83.

Royal, M., Mann, G.E., & Flint, A.P. (2000, July). Strategies for reversing the trend towards subfertility in dairy cattle. *Veterinary Journal, 160(1),* 53-60.

Rushen, J. (2000). The welfare of the high-producing animal. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Rushen, J. & de Passillé. (1999). Environmental design for healthier and more profitable cows, in *Solving Problems of New Barns and Introducing New Stock*, University of Alberta, CA. http://www.afns.ualberta.ca/wcds/wcd99/chap28.htm

Schwartzkopf-Genswein K.S., Stookey J.M., Crowe T.G & Genswein B.M.A. (1998). Comparison of image analysis, exertion force and behaviour measurements for use in the assessment of beef cattle responses to hot-iron and freeze branding. *Journal of Animal Science, 76 (4),* 972-979.

Schwartzkopf-Genswein K.S., Stookey J.M., dePassille A.M. & Rushen J. (1997). Comparison of hot-iron and freeze branding on cortisol levels and pain sensitivity in beef cattle. *Canadian Journal of Animal Science, 77,* 369-374.

Schwartzkopf-Genswein K.S. & Stookey J.M. (1997). The use of infrared thermography to assess inflammation associated with hot-iron and freeze branding in cattle. *Canadian Journal of Animal Science, 77 (4),* 577-583.

Seabrook, M.F. (1980). The psychological relationship between dairy cows and dairy cowmen and its implications for animal welfare. *International Journal for the Study of Animal Problems, 1(5),* 295-298.

Selman, I.E., McEwan, A.D., & Fisher, E.W. (1971). Studies on dairy calves allowed to suckle their dams fixed times post partum. *Res. Vet Sci., 12,* 1-6.

Shearer J.K. & Hernandez J. (2000). Efficacy of two modified non-antibiotic formulations (Victory) for treatment of papillomatous digital dermatitis in dairy cows. *Journal of Dairy Science, 83 (4),* 741-745.

Spalding R.W., Everett R.W. & Foote R.H. (1975). Fertility in New York artificially inseminated Holstein herds in dairy improvement. *Journal of Dairy Science*, 58, 718-723.

Stephens, D.B. (1982). A review of some behavioural and physiological studies which are relevant to the welfare of young calves. *Welfare and husbandry of calves. Signoret, J.P., ed. A seminar in the Commission of the European Communities Programme of Coordination of Research on Animal Welfare, Brussels, 9-10 July 1981.* The Hague: Martinus Nijhoff Publishers.

Stott, G.H., Marx, D.B., Menefee, E.B. & Nightengale, G.T. (1979). Colostral immunoglobulin transfer in calves. IV. Effect of suckling. *Journal of Dairy Science, 62,* 1908-1913.

Stricklin, W.R. & Kautz-Scanavy, C.C. (1983). The role of behavior in cattle production: A review of research. *Applied Animal Ethology, 11,* 359-390.

Studer, E. (1998). A veterinary perspective of on farm evaluation of nutrition and reproduction. *Journal of Dairy Science, 81,* 872-876.

Thompson, J. R., Everett, R. W., & Hammerschmidt, N. L. (2000). Effects of inbreeding on production and survival in Holsteins. *Journal of Dairy Science, 83,* 1856-1864.

Tranter, W.P. & Morris, R.S. (1991). A case study of lameness in three dairy herds. *New Zealand Veterinary Journal, 39,* 88-96.

United Nations Food and Agriculture Organization (UNFAO) (2000). *FAOSTAT Database, Agriculture, Livestock Production.* http://apps1.fao.org

U.S. Congress. (1989). Joint Hearing before the Subcommittee on Livestock, Dairy, and Poultry and the Subcommittee on Department Operations, Research, and Foreign Agriculture of the Committee on Agriculture, United States House of Representatives, 101st Congress, First Session on H.R. 84, June 6, 1989. Serial No. 101-18. Washington, DC: U.S. Government Printing Office.

U.S. Department of Agriculture. (1996). *Dairy '96*. Washington: U.S.Department of Agriculture, National Animal Health Monitoring System, Animal and Plant Health Inspection Service.

Vaarst M., Hindhede J., & Enevoldsen C. (1998). Sole disorders in conventionally managed and organic dairy herds using different housing systems. *Journal of Dairy Research 65,* 175-86.

Van Arendonk J.A.M., Hovenier R & de Boer W. (1989). Phenotypic and genetic association between fertility and production in dairy cows. *Livestock Production Science, 21,* 1-12.

Van Dorp, T.E., Dekkers, J.C.M., Martin, S.W., & Noordhuizen, J.P.T.M. (1998). Genetic parameters of health disorders, and relationships with 305-day milk yield and conformation traits of registered Holstein cows. *Journal of Dairy Science, 81,* 2264-2270.

VetAgro International. (2000). *Your cattle lameness encyclopedia*. Greenough, P., Bergsten, C., Blowey, R., and Brizzi, A., editors. Website: http://www.cowdoc.net

Waage, S., Sviland, S., & Ødegard, S. A. (1998). Identification of risk factors for clinical mastitis in dairy heifers. *Journal of Dairy Science 81,* 1275-1284.

Washburn, S.P., Brown, C.H., McDaniel, B.T., & White, S.L. (2000) Fertility trends in Southeastern dairy herds. *Proceedings, Conference on Managing Production in Southeastern Dairy Herds: A program for managers of dairy herds and dairy professionals in the Southeastern states, February 23-24, 2000, Salisbury, North Carolina.* North Carolina State University, Dept. Animal Science.

Washburn, S.P., White, S.L., Green, J.T., & Benson, G.A. (1998). Reproduction, udder health and body condition scores among spring and fall calving dairy cows in pasture or confinement systems. *Journal of Dairy Science 81, (Supplement 1),* 265.

Weary, D.M. & Chua, B. (2000). Effects of early separation on the dairy cow and calf, 1. Separation at 6 h, 2 day and 4 days after birth. *Applied Animal Behaviour Science, 69,* 177-188.

Weary, D.M. & Taszkun, I. (2000). Hock lesions and free stall design. *Journal of Dairy Science, 83,* 697-702.

Webster, J. (1995). *Animal welfare: A cool eye towards Eden*. Cambridge: Blackwell Science, Ltd.

Webster, J. (1984). *Calf husbandry, health and welfare*. London: Granada Publishing Ltd.

Wechsler, B., Schaub, J., Friedli, K., & Hauser, R. (2000). Behaviour and leg injuries in dairy cows kept in cubicle systems with straw bedding or soft lying mats. *Applied Animal Behaviour Science, 69:* 189-197.

Wells, S. J., Garber, L. P., & Wagner, B. A. 1999. Papillomatous digital dermatitis and associated risk factors in US dairy herds. Preventive Veterinary Medicine 38, 11-24.

Whay, H.R. (1997). Pain in the lame cow. *Veterinary Record, 50 (10):* 603-609.

Willeberg P. (1993). Bovine somatotrophin and clinical mastitis: epidemiological assessment of the welfare risk. *Livestock Production Science, 36,* 55-66.

Willeberg P. (1997). Epidemiology and animal welfare. *Epidemiol. Santé anim.,31,* 3-7.

Yeruham I., Avidar Y., Bargai U., Adin G., Frank D, Perl S. & Bogin E. (1999). Laminitis and dermatitis in heifers associated with excessive carbohydrate intake: skin lesions and biochemical findings. *Journal of the South African Veterinary Association, 70 (4),* 167-171.

Young, H.G., Hellickson, M.A., Reeves, J.L. & Owens, J. (1972). A time-laps photography study of free stall housing for dairy calves. *Transactions of the American Society of Agricultural Engineers, 15,* 751-753.

CHAPTER 7

PIGS

I. The natural history of pigs and its implications for production systems

From its beginning, the pig was a forest dwelling animal and was distributed widely in the Old World (Signoret, et al. 1975). The wild boar is a variable species within the genus *Sus,* which contains five recognized species and several sub-species (Groves 1991). The European and Asian wild boar diverged about 500,000 years ago (Andersson 2000). The European breeds of domestic pig were derived from *Sus scrofa*, the local wild boar (Signoret, et al. 1975). Herds ranged in pastures and forests and were kept indoors only for fattening. Far Eastern breeds were derived from another wild pig *Sus vittatus*, a smaller animal with shorter legs and a higher reproductive ability.

The modern breeds of pig *Sus scrofa vittatus* evolved from different crossings between these two types (Giuffra, et al. 2000). Under domestication, the pig was modified from a "pugnacious," free-ranging, foraging beast to a more docile animal that is handled readily in large groups under conditions of confined rearing (Signoret 1975). Certain wild types of pig-like animals, however, have never been domesticated. Archaeological records indicate that pigs were likely used as food from the beginning of husbandry (Andersson 2000).

Studies of Wild boars, feral[30] and domestic pigs kept in semi-natural "parks" are the main sources for understanding the natural behavior of pigs (EU Scientific Veterinary Committee 1997). From the point of view of behavior, Signoret, et al. (1975) remarked that even in 1975, the pig was the best-known species among domestic mammals. Many subsequent studies have been carried out on the natural behaviors of pigs. The pig has been studied extensively as a model for studies of human physiology (e.g., Anderson, et al. 1971).

Some aspects of the physiology and behavior of pigs relevant to husbandry have been discussed already above; this section will expand further on why it is important in pigs, as in all of the farm animal species, to study the wild relatives and understand their basic "design" and thereby understand the welfare requirements of their species, including their domesticated counterparts.

Although domestication and selection have altered basic aspects of pigs' physiology and anatomy, studies have shown that no major changes in behavioral systems have occurred during domestication. Instead, as with the other agricultural animals, behavioral differences between the different genetic lines of pigs are of a quantitative nature (Frädrich 1974). Some behavioral characteristics in the modern domestic pig, such as the threshold for anti-predator responses, have changed, but by degree (EU Scientific Veterinary Committee 1997). With respect to behavioral needs of modern domestic pigs, an observation in only Wild boar is suggestive, whereas observations from Wild boar as well as feral pigs and domestic pigs under semi-natural conditions are more likely to reflect a fundamental evolutionary adaptation that is still present in modern, domestic pigs. When studied these animals provide insights into possible environmental needs of pigs raised for food and bases against which to interpret welfare problems that occur in the contemporary production environments.

[30] Domestic pigs that have gotten loose and are running wild in the environment.

The basis of the social structure in feral swine is the matriarchal herd consisting of one or several females with their offspring (Signoret, et al. 1975). The males are not permanently attached to such herds but range either solitary or in bachelor groups.

Pigs are gregarious in nature (Adcock and Finelli 1996, Frädrich 1974, Graves 1984) and form stable, linear-approaching hierarchies within groups. Individual recognition is largely based on smell, while vision becomes relatively unimportant once the basic social order in the group has been established. As discussed above, dominance relationships between each two individuals form the basis for the hierarchy of the group as a whole. In pigs, at least, these dominance relationships are based on an "avoidance order" (Jensen, P. 1980, 1982), in which, for example, by turning her head aside, a submissive sow signals her intention not to challenge a sow that is dominant over her when they meet.

As discussed earlier (p. 47), the social structure of animal populations may change when space becomes limited. The inability of subordinate animals to escape from more dominant conspecifics may result in the formation of more highly polarized social hierarchies than would otherwise occur in nature (Price 1999). A sow confined to a pen with other sows, to signal her submissive intentions to a dominant sow in time to avoid a fight, must be afforded the space to do so in the pen design and, in confinement situations, the distance she needs for this purpose appears to be a minimum of two meters (Dr. B. Algers, 1991, personal communication).

Wild boar and feral pigs live in restricted areas ("home ranges") and show a high degree of site fidelity (Graves 1984). Different studies report varying sizes of home ranges – from less than 100 hectares to over 2,500 hectares (EU Scientific Veterinary Committee 1997). Size of the home range appears to be determined by food availability.

The daily activity pattern of wild pigs is highly variable, becoming more nocturnal in areas where it is heavily hunted. It also varies with the weather. Domestic pigs in experimental pig parks were most active in the morning and late afternoon to early evening with resting periods in mid-day and during the night (Wood-Gush, et al. 1990). Wood-Gush, et al. (1990) found that pigs foraged in selected areas during periods of activity and rested on one of several commonly used resting sites during the resting period. Sometimes these nests were bedded by the pigs with grass, twigs and other bedding material (Stolba 1984).

Pigs are omnivorous and readily adapt their diets to prevailing environmental conditions. However, even when fed full rations of commercial feed, they have been noted to spend 6-8 hours searching for food post-feeding when kept in a semi-natural enclosure (Dr. P. Jensen, 2000, personal communication). These post-feeding activities included foraging with rooting, grazing, and browsing behaviors (Wood-Gush, et al. 1990). Exploration forms a substantial part of the time budget of free-ranging domestic pigs, even at an early age (Petersen 1994).

Pigs reach sexual maturity at about 18 months of age and are fully grown at five years of age (Andersson 2000). The gestation period is about 113 days. The maternal behaviors of pigs are similar among wild boar, feral pigs, and domestic pigs in semi-natural environments, with pre-farrowing behaviors (restlessness, isolation from the rest of the herd) beginning about 24-48 hours before farrowing (Gustafsson, et al. 1999, Jensen 1987, et al.). Onset of nest building precedes farrowing by about 16-20 hours in wild boar and feral and domestic sows (Gundlach 1968, Jensen 1989, Jensen, et al. 1993). The nest is generally finished and the sow lies still in the finished nest by two to four hours before birth begins. Specific features of farrowing sites in the pig parks included that they were far from the main flock, were protected horizontally towards at least one side by slopes or large stones, and were protected vertically by branches (Jensen 1989).

Even though features of the environment (including temperature (Dellmeier & Friend 1986)) influence the size and type of nest that is built, nestbuilding is essentially governed by internal mechanisms, as discussed above, on pages 35 and 37-38. When she is about to farrow, various hormones are released in the periparturient sow that strongly influence her to isolate herself from the group of sows, seek the best possible nest site given the environment she is in, root in the ground to form a depression, go out and seek and collect nesting materials in the form of branches, twigs, and grass (Figure 7-1) and return with them to the nest site to build the nest and, when it is finished, to lie down and give birth to her young (Figure 7-2).

Figure 7-1. The Swedish Pig Park Studies: Periparturient domestic sow gathering nesting materials.

Photo credit: Per Jensen

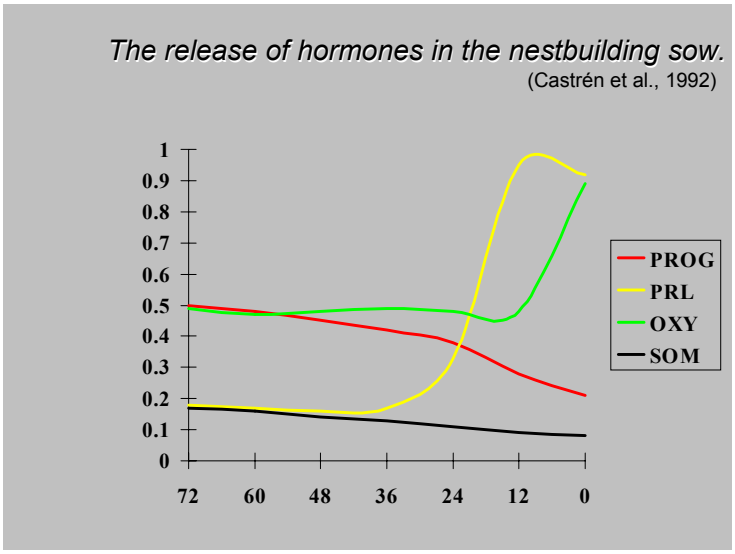
Only when the nest is satisfactory, does the sow lie down and begin to give birth. These behaviors differ only by degree among sows, reflecting the sow's capability and experience. However, what the nest looks like will also depend on exogenous factors such as available materials and the sow's assessment of the quality of the nest site. When the site is already well-sheltered, she builds a less elaborate nest than if the site had been more open to the elements.

Figure 7-2. The Swedish Pig Park Studies: Domestic sow in well-constructed winter nest, with piglets.

Photo credit: Bo Algers

Figure 7-3 shows how these hormonal influences coincide with specific actions taken by the sow in the hours before giving birth (from 72 hours before birth to time 0) (Algers 2000).

Figure 7-3. The release of hormones in the nestbuilding sow (from Castrén, et al. (1993a), in Algers (2000).



Vertical axis shows mean concentrations of the hormones before parturition (time 0).
Key: PROG = progesterone; PRL = prolactin; OXY = oxytocin; and SOM = somatostatin.

This experiment by Castrén, et al. (1993a), studied the hormone activity associated with prepartum behaviors in 10 multiparous sows housed individually in pens with straw freely available. Blood samples were collected at varying intervals via a catheter surgically fitted into the sows' jugular veins. Time of various activities was recorded as were the times of each piglet's birth.

Around 20 hours before farrowing, the hormone prolactin began to rise, which influenced the sows to begin nest site seeking behaviors and to use the available straw to start nest building. Only concentrations of prolactin on days 2 and 1 were significantly and positively correlated with the start of nest building (around 14 to 15 hours before parturition).

Prolactin peaked during nest building. Shortly before prolactin peaked, oxytocin started to rise and continued to rise after prolactin started to fall. Uterine contractions increased in frequency about four hours before parturition and possibly caused the sows to stop nest building. (Spontaneous uterine contractions occur only when oxytocin concentrations are elevated.) With the rise of oxytocin the sows shut off their nest building and settled into the nest. Shortly after, farrowing began. Somatostatin regulates maternal metabolism during lactation (Algers, et al. 1991). Here it was shown that the percentage of time spent carrying and depositing straw was also significantly, independently and positively correlated with progesterone and that it was negatively correlated with somatostatin on day 2 prior to farrowing. Sows that spent more time carrying straw and building nests had higher progesterone and lower somatostatin concentrations two days before parturition.

Oxytocin affects the duration of parturition and probably the vitality of piglets (prolonged parturition leads to anoxia and weakness at birth) (Castrén, et al. 1993b). A number of studies link confinement to farrowing crates, tethers, and stalls to prolonged farrowing times (Backström 1973, Vestergaard 1981). In turn, prolonged farrowings have been linked to higher rates of stillbirth. In Lawrence, et al. (1995), confining sows to crates at farrowing time inhibited oxytocin release.

Unlike sows on pasture or in enriched environments, sows in crates get no functional feedback from trying to root and make a nest (Algers 1996). This lack of functional feedback affects sows' well-being. Stress hormone levels in crated sows begin rising the day before farrowing, whereas in sows that are free to move around and make a nest during that time, relatively even levels of stress hormone are shown until they rise when the stress of farrowing itself begins. Among the wild boar, finding a secure nest site away from the group avoided accidental injury to piglets by other members of the group and allowed the piglets to bond with the mother. The sow's behavior at this time had survival value to her litter, the group as a whole, and the species. Jensen (1988b) found that more piglets died when farrowings were not well isolated from the rest of the group.

When the sow is unable to comply with the internal stimuli of hormonal changes because she is confined to a crate and has no material for building a nest, she experiences frustration and unrelieved stress that can lead to much digging and pawing at the floor and sides of the crate. Eventually this may lead to the sow's performing stereotyped behavior (see Chapter 2), implying her state of welfare is poor. Stress during this time and subsequent to farrowing increases the sow's susceptibility to illness, including mastitis, metritis, agalactia (MMA) (Lawrence, et al. 1995). For a review of the literature and a comparison of maternal behaviors of restrained and unrestrained sows and effects on piglet survival, see Alonso-Spilsbury (1994).

Wild boar and feral sows give birth to up to 9 piglets (domestic sows may give birth to 15 or more) (Andersson 2000). Domestic sows under free-range conditions remain in the nest and its close surroundings with their piglets for about 10 days, during which time a teat order is formed (each piglet selects a teat it sticks with throughout the nursing period) and the unused teats atrophy or dry up (Gundlach 1968, Jensen, et al. 1991). The sow leaves the nest periodically to eat, drink, explore, and defecate. The piglets remain exclusively in the nest the first 36 hours (Schmid 1991).

It has been observed that the sow and piglets "coordinate their behavior" when the sow returns to the nest (Schmid 1991). She grunts to alert them to her presence and usually approaches them with her snout. Before she lies down, the piglets group on one side of the nest. When entering the nest, the sow creates a furrow in front of her with her snout and in lying down, the sow first kneels at the front and then slowly lowers the hind portion of her body, laying her hind quarters on the opposite side of the piglet group. If a piglet is in the way and gets caught, it begins to scream and the sow either stands or lifts the appropriate part of her body (Schmid 1991). To do this, the sow must be alert and her legs must be in good physical condition and she must show good maternal behaviors (which can be influenced both by genetics and by her own early rearing conditions, see, e.g., Schouten (1986)). She must also have the space for freely maneuvering her large body. If the sow does not respond to the piglet's screams, the piglet is usually able to get loose and away by vigorous struggling if there is a soft springy nest beneath him and the sow (Schmid 1991).

Particularly in the early stage of lactation, the sow lies down while the pigs suckle. Suckling is characterized by distinct phases, including pre-massage of the udder (40-60 seconds), milk ejection (20 seconds), and after-massage (30 seconds to 10 minutes) (Fraser 1980). Wechsler and Brodman (1996) protocolled the sequence of behaviors used by both sows and piglets to initiate nursing bouts.

Pigs possess a repertoire of different vocalizations – scientists have identified over 20 – although the purpose of all of them is not known (Adcock and Finelli 1996, Kiley 1972, Klingholz 1979). Knowledge of distinct maternal and piglet vocalizations during suckling has been useful in designing communal or group nursing systems for sows and their piglets (a.k.a. multi-suckling systems) in that it has demonstrated the need for quiet ventilation systems in the barns (Algers 1991, Algers and Jensen 1985) so nursing pigs can (1) detect their own mother's voice among all the other sows when the sows call their pigs to nurse and (2) recognize the different grunting sounds she makes as suckling begins and when milk letdown is about to occur (Algers 1993, Algers and Jensen 1991, Weary and Fraser 1995). During the lactation, the sow grunts rhythmically with an increasing grunt rate, reaching a peak about 20 seconds before the milk ejection and alerting pigs to letdown.

Weaning was accomplished gradually in domestic pigs in the pig parks. It began in the first week of life but was not finished until the pigs were at a weaning age of 13-22 weeks (on average 17 weeks), occurring similarly to wild boars (EU Scientific Veterinary Committee 1997). Weaning in domestic pigs in the pig parks was characterized by a gradual decrease in suckling frequency, a gradual changeover between sow-initiated to piglet-initiated sucklings, increased pre-massage time and shortened post-massage time and an increased frequency of sucklings with the sow standing, interpreted as the sow's inferring an increased cost from maintaining lactation (Jensen and Recén 1989, Jensen and Stangel 1992).

About 10 to 14 days after piglets were born, their mothers guided them to the larger group of sows and piglets and they abandoned the nests (Jensen 1986, 1988b). Before that point each sow and her piglets had usually not met any pigs apart from their mother and littermates. Piglets then became gradually socialized into the group, with a high level of social activity but little overt fighting.

Play behavior while young, including play fighting, apparently teaches piglets how to manage aggression when they become adults. This social activity stabilizes at about 8 weeks post partum and it is inferred by this that the pigs are then fully integrated into the group (Petersen, et al. 1990). Newberry and Wood-Gush (1986) showed that social interactions are important for young pigs as well as adults. In their study, piglets were shown to form strong associations with littermates that persisted after natural weaning. These bonds were stronger than the bonds that had formed between them and non-littermates in the group (Newberry and Wood-Gush 1988).

As noted earlier in this report, compared to "free-range" animals, animals in confinement affect each other more intensely. When humans do not "compromise" by increasing space allowance or enriching living spaces appropriately, the result can be reduced ability of animals to avoid aggression, which can lead to injuries and, which, in some cases, has influenced the industry to adopt even more restrictive management practices such as individual housing.

Especially in the design of loose housing systems for pigs conflict avoidance, maternal, and other basic behavioral patterns must be understood and built upon or loose housing systems will fail and animals will be continuously stressed, and possibly injured, sometimes severely. Loose housing systems for the breeding herd can be highly advantageous for sow and prospective piglet welfare over systems in which members of the breeding herd are singly-housed (for example, a sow in better physical condition will be better able to avoid crushing her pigs by interrupting the lying down process when they scream) but only if the facilities have been designed with basic behaviors of the pig in mind and everyone managing or laboring in the facilities understands the basic behavior patterns of pigs and their biological needs.

To illustrate, since the mid-1980s, over half of Swedish piglet producers have used loose housing systems managing large groups of dry/pregnant sows in deep-straw. Tethers for restraining

dry and farrowing sows had been banned in Sweden in 1971, when it was shown that tethered sows were "afflicted with an extremely high incidence of traumatic injuries" (Ekesbo 1973; Högsved 1991). Research by Bäckström (1973) showed a higher incidence of morbidity among dry sows housed in crates than in dry sows loosely housed in groups (Ekesbo 1995). Although Bäckström's research did not lead to a ban on gestation crates in Sweden at the time, it may have influenced farmers. The transition in Sweden to deep-bedded loose housing systems for the breeding herd began around 1973 and by 1985, the majority of Swedish producers had made the transition. Reasons given were excellent results of such systems for sow vigor and well-being, and high conception and farrowing rates. Sweden banned the use of sow stalls or crates for gestation and farrowing effective in 1994. The Farm Animal Protection Act of 1988 required all livestock to have access to litter, and straw for cattle and pigs (Djurskyddslagen 1988). Animals were to be managed and housed so as to permit them to perform most of their natural behaviors.

The looser housing systems appear to be successful to the degree that they conform to known aspects of pig behavior. Characteristics that Swedish facilities for breeding sows have in common are:

- An individual feeding stall for each member of the group. These can be locked, usually four at a time, during cleaning out and feeding times, so that all sows can eat at once, but slower eating and submissive sows still are protected from faster eating or more aggressive sows. (Figure 7-4a). The individual feeding stalls allow producers to inspect sows during the mealtime and individually treat sows that may need to be treated. Producers can see that each sow eats. When batch farrowing, farmers can use the gates at the front of each stall to take sows that are close to farrowing from the larger group and move them to the farrowing area.

Figure 7-4a&b. Swedish deep-bedded group housing system for dry sows, with individual feeding stalls and freshly-maintained straw cover to accommodate social behavior.

a.

b.

Photo credits: Jerry DeWitt

- Behaviorally appropriate management. For example, new or reentering sows are never introduced to a stable, larger group of sows either as individuals or in groups of fewer than five or six sows. The "strangers" would be attacked. However, sows in the larger group seem to "respect" other sows more when they are introduced as a group of five or more sows and do not attack them (B. Mattsson, farm advisor, Scan-Farmek, 1992, personal

communication; see also discussion about Swedish farmers' experiences in Halverson and Honeyman 1997, Halverson 1998).

- A well-maintained, deep-bedded area composts and provides comfort for lying and warmth in cold temperatures (Figure 7-b).
- Fresh straw added every day that materials to keep sows occupied by chewing, rooting, and consuming fresh roughage reduces stress levels and helps sows focus on constructive behaviors. Ladewig and Matthews (1996) showed that straw is an appealing natural material for manipulation and occupation. Consuming it gives bulk to the diet (Arey 1993). Straw around farrowing provide a natural substrate for nest building (Arey 1992, 1997, Jensen 1988b). Burne, et al. (2000), found that providing straw to gilts is beneficial for their welfare before farrowing while they are motivated to build nests. Straw must be hygienic. Wet or moldy straw leads to illness and has been known to cause stillbirths.
- To support peaceful social relationships, minimum recommended space per sow in the bedded area is 27 to 28 ft^2 (Halverson and Honeyman 1997a&b, reporting Swedish results). It is also important not to keep too small groups of sows. Högsved (1988) noted that in Swedish deep-bedded housing for gestating sows, ten sows in a group with 27 ft^2 of space per sow is not enough space per sow to prevent fighting, perhaps because of the reduced total area available to each sow. Groups of 30 to 40 at 27 to 28 ft^2 per sow seem to result in a good "total space" for peaceful relations (Högsved 1988). If groups are smaller than that, Högsved recommended that floorspace should be increased to between 30 and 40 ft^2 per sow.
- Clean, fresh water should be freely available at all times.
- Indoor air should be clean and free of gasses. Dust levels from the bedding depend on length and type of straw, with longer cut straw being less dusty and more suitable for composting than chopped straw. Ventilation systems need to be adequate to remove excessive heat and moisture produced by the animals and the composting beds while maintaining comfortable room temperatures, air quality, and humidity levels.
- Close, daily physical inspection of the animals. Walking around in the beds with the animals is important to catch problems and to maintain the trust of the animals. Spending 30 seconds each day petting or scratching each sow and boar has been recommended as a way of maintaining a positive relationship between the producer or stockperson and the animals, which is important in loose housing. In large pens where sows and piglets are kept together during the lactation period, to be sure the health of every piglet is monitored, it is recommended that the producer or stockperson walk in the beds at least once a day to scare up piglets that may have buried themselves in the straw so they do not escape scrutiny.

Descriptions of alternative systems and operating principles exist (see, for example, Algers, et al. 1991, Bergh, et al. 2001, Connor, et al. 1997, Ekesbo 1995, Högsved 1988, Halverson 1998, Halverson and Honeyman 1997, Halverson, et al. 1997, Holmgren and Lundeheim 1994, Honeyman and Weber 1996, Kent 1998, Schmid 1991, Thornton 1988, Wechsler 1991, Wilson and Wilson 1998). In the US, animal welfare research centers specializing in farm animals now exist at the University of California, Davis, Washington State University and Purdue University; in Canada at the University of British Columbia and University of Guelph. At the University of Minnesota, an alternative swine systems program has been created to research animal- and environment-friendly pig production systems suitable for Minnesota producers. As mandated by the State legislature, it will be investigating pasture farrowing, deep-bedded hoop housing, and a version of a model of deep-bedded group farrowing and lactation developed in Sweden. Research directed toward solving the problems of producers trying to adopt alternative systems is a central aim of the Minnesota program.

II. Welfare of pigs in the contemporary breeding herd

An aim of artificial selection in pig breeding has been to increase growth rate and the proportion of valuable cuts in the carcass, which in turn has led to longer and leaner pigs that are more susceptible to leg weakness (Van Steenbergen 1990, Marbery 2001b). Van Steenbergen (1990) noted the longer length of modern sows and resulting lameness problems as they grow. López-Serrano, et al. (2000) found an inverse relationship between growth performance and sow survival. Selective breeding for leanness has also been implicated in "thin sow syndrome" in which young female pigs do not eat enough to maintain their body weight and may not experience estrus (Owen 1999, Treasure and Owen 1997).

Housing also affects pig welfare. On most industrialized pig breeding farms, boars and sows are housed permanently in crates (boars are moved only to be used in detecting heat in the sows or to be stimulated for collection of semen while sows are alternated between crates for gestation and crates for farrowing and lactation) (Figure 7.5-7.7). Whereas individual crate housing of boars also used to be common practice in Europe, today it is forbidden by Council Directive 91/630 (EU Scientific Veterinary Committee 1997). A new European Union directive for welfare of pigs was adopted in June 2001, that would require pregnant sows to be loose-housed in groups rather than individually in crates or tethers and to be provided with materials for rooting.

Originally, stalls for pigs were used for feeding. Many farms in Europe used them in their indoor and outdoor yards to ensure that all sows ate at once and fast-eating sows did not also get the share of a slower eating sow. The economy of using an expanded crate as "permanent" housing for pregnant sows became obvious once confinement housing came into vogue and pigs were moved indoors. Their use as pregnant sow housing increased in Europe and soon spread to the United States, where gestation stall housing was taken up by the investors in the large, capital-intensive production facilities of the early 1970s.

Figure 7-5 Housing of the breeding herd in industrialized pork production. Pregnant sow in a gestation crate.

Photo credit: Diane Halverson

Figure 7-6. Housing of the breeding herd. Crate housing for boars in intensive confinement.

Photo credit: Marlene Halverson

Figure 7-7. Pregnant sow housing in crates.

Photo credit: Diane Halverson, AWI

Today, gestation stall sow housing predominates in the U.S. hog industry. During their approximately 113-day pregnancies, sows are immobilized and fed concentrates once a day. To prevent constipation resulting from lack of exercise and roughage in the diet, sows housed in crates are given laxatives in the feed (Fisher 1995).

Domesticated sows that were released by scientists into "semi-natural" environments for the purpose of observing their behaviors spent much of the day foraging and eating in social groups (Stolba 1982). Nature has endowed them with short, sturdy legs for walking long distances. Keeping sows in stalls for the major part of their productive lives, causes sows to lose condition and vigor. Comparing post-slaughter muscle weight and bone strength of sows housed in stalls during their pregnancies with sows housed in large communal groups during their pregnancies, Marchant and Broom (1996b) found that stall-housed sows had lower absolute and proportional muscle weights than group-housed sows and their bones had breaking strengths only two-thirds those of group-housed sows.

Disuse of the skeletomuscular system leads to atrophy and, in time, development of osteoporosis (Anderson, et al. 1971). Studying two groups of swine – an "exercise" group and a "non-exercise" group, Anderson, et al. (1971) found that "exercise" pigs attained a "more muscular" appearance during exercise, that gains in body weight were steepest during the exercise period, and that the stress of physical exercise resulted in conservation of bone.

Premature sow mortality is a significant and growing problem in the US swine industry (sows die or are killed on the farm) (Marbery 2000). Estimates range from 10% (Irwin and Deen 2000) to 20% (Grimes 1998) of sows on intensive confinement operations dying while still in production. A recent study reported by Marbery (2001b) surveyed 74 midwestern farrowing operations of about 1,100 sows each and found sow mortality averaging 13.2%, with a range of from 8 to 17%.

Factors besides immobilization in crates that are thought to contribute to sow mortality include poorly trained workers, inadequate diet (including low fiber), low backfat (thin sow syndrome resulting from genetic selection for leanness), segregated, multiple-site production (sows do not get the exposure to disease organisms that could provide immunity), poor air quality, rough transport, and floor surface (Baidoo, et al. 2000, Irwin and Deen 2000, Loula 2000). Employee production quotas and bonuses focused on pigs weaned per sow can increase mortality (Marbery 2001b).

Obviously, the welfare of crated and downed sows is poor. They may be in constant pain. They may be abused by impatient, angry, and poorly trained workers (see, for example, People for the Ethical Treatment of Animals 1998). They may need to be dragged from crates to the cull truck.

Even if they are not injured, sows permanently confined to crates show evidence of being in distress. When confined throughout pregnancy to individual crates and fed concentrated rations, it takes sows only a few minutes to eat the day's meal, whereas their natural behavior is to forage for long periods during the day (Stolba 1982, 1983). The animals are left hungry and thus motivated to forage, but they are restricted from moving. Perhaps as a result, elements of foraging behavior become combined into relatively fixed sequences of behavior such as repetitious barbiting that may go on for several hours each day (Dr. D. Fraser, 2001, personal communication).

A restricted diet combined with restriction of foraging opportunities leads to the development of stereotyped oral behaviors in some animals whereas locomotor stereotypies (e.g., repetitive pacing) are more likely to be related to lack of space (Dr. R. Newberry, December 2000, personal communication).

Stereotypies were described in Chapter 2 by Ödberg (1978) as:

1) A sequence of morphologically identical movements that are
2) repeated frequently, and
3) are apparently meaningless to the animal.

Ekesbo (1980) described research conducted in 1969 that showed a reduction in abnormal behaviors and improved health of loose housed sows when straw was provided, as compared to sows that were housed in crates during pregnancy without access to straw.

III. Welfare of farrowing/lactating sows

Sows farrowing outdoors will construct nests prior to farrowing and they will remain relatively still in them during farrowing and up to a week afterward (Arey 1995, Haussmann, et al.

1999, Jensen 1986, 1988, 2000, Jensen, et al. 1987, 1993, Stolba 1982, 1983, Stolba and Wood Gush 1984). In commercial pasture swine production, portable huts serve as shelters for sows and piglets and the sow uses available straw and hay to make nests in the huts. She is free to come and go from the nest.

As pig farming became more intensive following World War II, many systems moved indoors and used individual farrowing pens. As pig farms grew larger and became more space- and management-intensive, they made the pens smaller to offset the increased costs associated with investments in confinement buildings (Marchant, et al. 1994) and they also eliminated the use of straw in the pigs' environment and increased the use of concrete and slatted floors. To save space, pens for farrowing sows were made smaller, making it difficult for sows to maneuver naturally and increasing the number of pigs accidentally crushed.

Confined sows unable to perform nesting behaviors are more restless than free-range sows (Cronin, et al. 1998, Damm, et al. 2000, Fraser, et al. 1995, Haussmann, et al. 1999). Because position changes by the sow in a space-restricted environment are considered primary causes of piglet mortality from crushing, estimated to be between 4.8% and 18% (Haussmann, et al. 1999), tethers and farrowing crates were introduced into piglet production in the early 1960s to restrict the movements of the sow still further (Blackshaw, et al. 1994). The crates kept the sow facing in one direction and made her continuously available to the pigs for nursing. Later the farrowing crates were equipped with bars that would control the sows' getting up and lying down movements more closely.

Although farrowing crates reduce piglet mortality, they do not eliminate it. U.S. Department of Agriculture figures showed an 8.3% increase in piglet crushing between 1990 and 1995 (Haussmann, et al. 1999), even as the percentage of pig-producing firms using farrowing crates increased relative to those still using farrowing pens.

Schouten (1986) examined the influences of early rearing conditions (first eight weeks of life) on the behavior and welfare of pigs in two later stages of their lives -- the fattening period and, for females, at farrowing time. He compared behaviors of pigs born to gilts under two situations: born and reared for 8 weeks in a farrowing crate, in which the gilt was tethered to the floor (barren environment), and born and reared for 8 weeks in a small pen bedded with straw, in which the gilt could move around freely (enriched environment). Piglets born in the farrowing crates (barren environment) to tethered mothers spent more time than their counterparts in the enriched environment in the performance of alternate standing and sitting behaviors. By this means, they avoided unpleasant experiences such as being nibbled or massaged by littermates. Alternately standing and sitting was a coping behavior in response to the stress of being nibbled or massaged by penmates and was "adaptive" in the barren environment. At the end of the eight-week growing period, piglets from both the enriched and the barren pens were moved to more spacious straw pens and raised there until bred. At farrowing time, the new gilts were again placed in the two experimental situations. Despite having been raised from eight weeks in strawed pens, gilts born in barren environments and subsequently placed in barren farrowing pens and tethered to the floor, reverted to the standing and sitting behaviors they used as coping behaviors when young, presumably in response to the stress of tethering. However, the restless coping behaviors these gilts had developed as piglets were "not adaptive" in terms of survival value for their own piglets. Alternatively standing and sitting by the gilts in the restricted space put their piglets in danger of being crushed or stepped on (Schouten 1986).

Equipment in production facilities can cause lesions on the integument when it persistently rubs against the skin. Sows lying on concrete and plastic-coated, hard, perforated metal or slatted

floors can develop pressure sores on hips and shoulders (Willequet and Sourdioux 1991). Sows whose movements are constrained by bars also can be abraded by the equipment when rising from a lying down position, resulting in sores on the back, hips, and shoulders (Figure 7-8). The latter problem is especially evident in "ultra-lean" sows who have little backfat to absorb the abrasion (Haussmann, et al. 1999). As these sores appear to cause few production losses, their existence was taken for granted in the production environment, and they were seldom treated.

Haussmann, et al. (1999) have shown that the existence of pressure sores causes sows to change positions more frequently while nursing, increasing the chances for sows to crush piglets. When an analgesic was administered, treated sows changed positions less often than untreated sows. The ability of an analgesic to eliminate or reduce the occurrence of such behaviors indicates that the sores are painful to the sows. Haussmann, et al. (1999) concluded that when they become more cost-effective than they are today, analgesics administered to sows post-farrowing could reduce piglet mortality from crushings. They also concluded that using more comfortable flooring or increasing sows' bodyfat would allow them to lie more comfortably and change positions less frequently.

In intensive hog operations, sows are kept in constant, often accelerated production (Britt and Flowers 1997). This becomes a problem in sows genetically selected for leanness, that have few body stores to fall back on. Lean sows, especially, are not built for the pressure of production systems in which they are pushed through the breeding-gestation-farrowing-nursing-weaning-rebreeding cycle at top speed.

Figure 7-8. Sow showing lesions on shoulders and back from being abraded by farrowing crate equipment. Reduced backfat on ultra-lean sows compounds injury problems.

Photo credit: Marlene Halverson

"Sow mortality has risen with selective pressure for leaner, more productive sows. Like a high producing dairy cow, sows burn out, osteochondrosis, resulting from years of selecting animals for growth, muscle mass and feed conversion, and the stress of intensive production methods is a common cause of leg weakness in young breeding stock" are conclusions of research results reported in Marbery (2001b). Grimes (1998), too, attributed the high premature mortality (up to 20% in some herds) of sows in industrialized US hog operations to the stress of being pushed closer and closer to their biological limit. Replacement and opportunity costs of $500 or more per dead sow are reported (Marbery 2000).

Despite years of selecting pigs for adaptability to slatted flooring and crates, sow mortality rates are increasing. About 50% of sow mortality occurs in the first three weeks after

sows have given birth or farrowed and approximately 27% of mortality is in sows that have not farrowed, as sows are bred at younger and younger ages (Marbery 2000).

Antibiotics were used in the diets of breeding females (sows) on 45.5% of US hog operations in 1995 and in the diets of breeding males (boars) on 38.4% of US hog operations (APHIS 1996). Both figures increased substantially in 1995 over 1990 figures – for sows by 6.1% and for boars by 27.5%. Subtherapeutic antibiotic use in the breeding herd helps overcome problems in the production system by increasing conception rates, pigs born per litter, and piglet birth weights, and reducing the incidence of mastitis in sows (National Research Council 1998).

IV. The welfare of piglets and grow-finish pigs

A. Welfare of piglets

Concerns sometimes arise that sows that are housed loose in groups with other sows may lose some of their embryos due to fighting, and for that reason, sows should be individually stalled and restrained during their pregnancies. The window of critical days for the pig embryo, while it is fastening itself to the uterine wall, is approximately from the 10th to the 28th day after conception (Dr. J. Svendsen, Lund, Sweden, 1992, personal communication).

In Sweden, where most gestation is based on a loose-form of housing, sows going into loose housing usually are assembled into groups immediately after breeding and these groups are allowed to stabilize (initial fights to establish dominance relationships and a group structure may last up to one and a half days). Conflicts are settled before attachment of the embryos is endangered. If this newly stabilized group is kept separate from the larger group of pregnant sows for the next four weeks, (1) the producer will be able to tell if any sows are not pregnant – if they return to heat – and can remove them from the group and (2) the embryos will be firmly fastened to the uterine wall and the newly-formed group can then enter the larger group of already pregnant sows in the gestation unit safely from the perspective of embryo protection. As long as sows form a stable group of familiar individuals and each knows her ranking with respect to the sow she meets and loose housing systems are managed in ways that figure the natural characteristics and behaviors of pigs into the procedures, e.g., their need for space and a suitably enriched environment and the behavioral process of establishing dominance relationships, embryo endangerment does not appear to be a problem.

Welfare problems of neonatal piglets include getting sufficient nutrients and colostrum within the first hours and days after birth (English and Smith 1975, cited in Algers 1989, Fraser and Broom 1990). Algers (1989) and Algers and Jensen (1985) showed that a key factor in getting sufficient nourishment seems to be clear and undisturbed communications between the mother and her piglets – e.g., when her grunting calls them to the udder and synchronizes their suckling behavior. Algers (1989) found that piglets exposed to the common and routine noise of a ventilation fan while nursing received less milk from the udder than did piglets from litters that were not exposed to fan noise while nursing. This is especially important because milk letdown in pigs lasts approximately 20 seconds (Fraser, D. 1980). As there is no chance to make them up, it is better to prevent missed nursings.

Pigs that are undernourished or have had an insufficient intake of colostrum are vulnerable to crushing and chilling (Fraser and Broom 1990). Sows normally have 14 teats (English, et al.

1984). Not all teats are similarly productive (Algers 1989). Unproductive teats are avoided, if there are enough teats (or sufficiently few pigs) to make that possible. Pigs that have poor-producing teats will not thrive. In large litters, therefore, there is a chance that some piglets will die if they cannot get proper nourishment, for example, by being cross-fostered on other mothers. There are recommended techniques for cross-fostering, for example, regarding how much time can elapse after a sow farrows before she will reject an addition to her litter.

In a farrowing crate, the sow is always available to the piglets for suckling, and so artificial weaning, when it takes place, will be abrupt. In loose housing or outdoor production, where sows can get away from the piglets, weaning takes place more gradually, with sows initially calling pigs to nurse less often, then lying down for fewer and fewer nursings while piglets take over the job of initiating nursing bouts, and finally standing while pigs try to suckle. Being gradual, the sow-initiated weaning process encourages a gradual transition by the piglets to solid feed and to chewing and eating straw bedding or sticks and grass (if outside), making weaning less physiologically stressful for the piglets. Farmers operating extensive systems often express the belief that a five to six week lactation gives the pigs a better start "because the sow's milk is the best feed for a young pig while he is growing" (P. Willis, Thornton, IA, speaking to the Allen D. Leman Swine Conference, August 2000). A weaning process that is under control of the sow also helps her retain condition during the lactation period.

While there are clear advantages to the sow to be unrestricted during farrowing and lactation, Barnett, et al. (2001) suggest these advantages may in some instances be traded off against higher pig mortality from crushing than if the sow were restrained. Other scientists point to causes in design and management and genetics as potential remediating factors against a piglet-welfare tradeoff in more extensive farrowing systems, where sows have freedom of movement around their piglets (Algers 1998). Barnett, et al. (2001) noted that there have been improvements in "extensive" farrowing systems that have helped to reduce piglet crushing by the sow. Earlier in this chapter, research was described that indicated the solution to piglet crushing in more extensive systems is to *increase* rather than reduce the area of the pen so the sow can maneuver naturally around her piglets (Schmid 1991).

Wechsler and Hegglin (1997) identified sows' responsiveness to piglet distress calls and sows' lying down behaviors (with lying down vertically resulting in lowest crushing rate) as important determinants of piglet safety in loose farrowing pens. They noted that individual behavior differences they observed among sows could account for a significant share of the variation found between different studies in which crushing losses in farrowing crates and farrowing pens have been compared. They also suggested that, compared to the wild boar, the behavior of domestic pigs may have been altered by selection for large sows that tend to be less agile and for docile sows that may be less responsive to piglet calls, while the use of farrowing crates for the past 25 years may have promoted the reproductive success of sows that would have crushed pigs in loose housing systems. Insofar as behavioral traits responsible for crushing are heritable, selective breeding of gilts from sows having few piglet losses due to crushing could reduce piglet mortality in a herd (Wechsler and Hegglin 1997).

If the sow's movements were unrestricted in the farrowing space, Schmid (1991) found that only 2.4% of the piglets born alive were crushed. Based on his findings, Schmid (1991) recommended that the minimal space in the farrowing pen for undisturbed behavior of the sow should be 7.5 m^2 and suggested that, in contrast to intensive production, where the sows' movements are increasingly restricted to prevent crushing, the appropriate action in more extensive systems appears to be to give her more rather than less space to enable her to maneuver naturally and avoid crushing her piglets.

Research reported in Honeyman and Weber (1996), found this pen size influence with respect to floor space in outdoor farrowing huts as well. In a comparison of seven outdoor commercial farrowing hut types of different sizes (279 total litters born and overall 11% crushing rate), crushing losses tended to be smallest in the huts with the largest floor space: 12%, 21%, and 16% mortality for hut floor sizes of 33.8, 36, and 37.4 ft^2, respectively, and 8%, 7%, 9%, and 7% mortality for hut floor sizes of 42, 42.6, 32.5 (plastic hut with wall space extensions at the bottom for piglets to get away from the sow), and 49.5 ft^2, respectively.

In another study, Honeyman, et al. (1998) compared piglet crushing mortality rates in seven commercial floorless farrowing huts, in a total of 438 litters, from birth to the time piglets began to leave the hut (10 to 14 days). Crushing death rates in the huts ranged from 3.5% to 20.9%. Huts with floor spaces of 33.8 to 37.4 ft^2 had crushing losses of 10% to 21%, while huts with floor spaces of 42 to 49.5 ft^2 had crushing losses of 3.5% to 6.9%, with the lowest rates being in the "English style steel" hut (3.5%) and a plywood "Pig Saver" hut (3.6%). The authors noted that these lowest rates were were far lower than industry standards of 10% crushing losses for farrowing crates. Huts with the lowest mortality had steep angled walls, side rails, or low-placed side extensions in the wall to help protect the piglets. The English style and plywood Pig Saver huts also had the lowest crushing rates in the earlier (1996) report (7% each).

Honeyman, et al. (1998) speculated that doors placed toward the corners of the huts rather than directly in the middle of the hut front may have been important for creating space in the huts for the piglets because the sow tended to lie on a diagonal in those huts.

Such research indicates that increasing the space for the sow, if it is done in a way that incorporates all the relevant information concerning sow and piglet behaviors, need not result in a tradeoff with increased piglet mortality as compared to keeping her movements restricted in farrowing crates.

1. Tooth-clipping

Piglets are born with eight "needle-sharp" teeth that they use to compete with other piglets for teats at nursing time. Hog producers generally clip these teeth off with hand-held pincers to prevent piglets from causing injury to each other and to the sow during fights at the udder.

Needle teeth are clipped during the routine processing that takes place following birth and that includes tail docking and castration. Because these procedures are done speedily, it is often the case that teeth are clipped at the gumline, rather than taking more care to clip off only the sharp ends of the teeth (Weary and Fraser 1999). Then, they may crack, exposing the pulp and resulting in chronic toothache.

Teeth clipping can reduce a piglet's ability to compete with litter-mates during teat disputes, expose the pulp cavity allowing for pulpitis and gingivitis to occur, damage the gums, and cause teeth to splinter (Weary and Fraser 1999). Weary and Fraser (1999) showed that partial tooth-clipping was as effective as total tooth-clipping in reducing facial injuries among littermates.

Weary and Fraser (1999) also described a study published in a French veterinary medical journal that teeth and gum problems occur less frequently when needle teeth are ground than when they are clipped (Hutter, et al. 1994). Data collected in Sweden support this conclusion (Dr. B.

Algers, December 2000, personal communication). Although clipping is the commonly used procedure in the United States, in other countries, such as Sweden, farmers prefer to file down needle teeth with an electric file because filing allows them to remove only the sharp points and eliminates the cracking that can occur when the teeth are clipped. The farmers are advised in this practice by the national veterinary service in Sweden – the Swedish Animal Health Services (Dr. B. Algers, December 2000, personal communication).

The new European Union directive on the welfare of pigs requires that needle teeth should be required to be ground or filed rather than clipped (Chapter 10).

2. Tail-docking and castration

The tails of piglets are docked shortly after birth, during routine post-farrowing procedures of teeth clipping, castration, and tail docking to avoid later problems of tail-biting in intensive confinement. Tail-biting is sporadic in appearance, but where it occurs, it can lead to cannibalism and is not only a welfare problem, but is a significant management, health, and economic problem in the industry.

The behavior is primarily seen in growing pigs grouped in pens and was recognized as a problem in pig rearing for many years but it did not become significant until the confinement pig industry became established after World War II (Dougherty 1976). Tail-biting first appears when a pig takes another's tail in its mouth and chews slightly, with the other pig tolerating it (Fraser, A.F. and Broom 1990). Soon it becomes more severe, leading to wounds on the tail and hemorrhage, which in turn causes more active chewing and causes other pigs to become interested in the tail. When the tail is finally eaten away to its root, the pigs begin to bite other parts of the afflicted pig's body. The afflicted pig becomes submissive and then depressed in behavior, reacting only slightly to being bitten. Wounds may become contaminated and result in abcesses in the hindquarters and end of the spinal column, with secondary infections in the lungs, kidneys, joints and other parts of the body (Fraser, A.F. and Broom 1990). Mortality may result eventually, but not before the afflicted pig has suffered immensely.

It is thought that tail biting takes hold because the afflicted pig may not at first be aware a penmate is chewing its tail – the tip and brush portion of the tail are apparently not sensitive enough to the first chewing efforts that the afflicted pig notices or minds (Simonsen, et al. 1991). When these parts of the tail are removed by docking, the incidence of other pigs trying to manipulate the tail does not drop off but the afflicted pig notices (appears to feel it) and does not tolerate it (Simonsen, et al. 1991). Thus, tail docking is usually successful in preventing cannibalism that stems from tail biting. Tail biting also does not appear to be related to aggression or hierarchy. It is often the smaller pigs that bite tails (Van Putten 1978). And, it is known that male pigs are more often the target of tail biting (Simonsen 1995).

Oral activity is greater in the pig than in other farm species and it is by chewing and rooting that the pig learns about its environment. Under extensive husbandry systems, pigs engage in considerable mouthing activities such as picking up and carrying sticks and chewing up bedding material (Fraser, A.F. and Broom 1990). Tail biting in pigs is thought to arise from boredom, climatic, or other deficiencies in the production environment, such as poor hygiene and ventilation, suggesting that better animal management and facility design and operation can obviate the need for tail docking. Tail biting is less seen in clean, dry, hygienic environments where pigs are provided

with straw or other materials to manipulate. Animals that have the opportunity to root in earth seldom show tail biting behavior (Fraser, A.F. and Broom 1990). On Swedish pig farms, where by law tails cannot be docked and clean straw must be provided to every farm animal, tail biting is almost never seen, so it is possible by improvements in the growing environment to prevent the behavior.

Pig welfare provides a reason for finding another solution. Simonsen, et al. (1991) found that even in docked pigs' tails there was a high incidence of traumatic neuromas.[31] This indicates that tail docking may continue to cause significant pain to the pig for much of its life.

Amputation neuromas can be a source of chronic pain, as can infections or disabilities resulting from procedures originally expected to cause only short-term pain.

Castration of pigs is a surgery where the scrotum is cut to reveal the testes and the testes then are removed by tearing, twisting and pulling, or cutting. Castration can lead to chronic pain due to inflammation and the onset of infection at the lesion after the procedure. Piglets vocalize loudly when castrated and call at a higher frequency especially during the severing of the spermatic cord (Weary, et al. 1998). The new European Union directive on the welfare of pigs requires that castration not entail ripping or tearing and that it should be done before the pigs are 7 days of age or else be performed by a veterinarian with proper anaesthesia.

3. Weaning

Prior to intensification in the hog industry, farmers weaned pigs at eight to 10 weeks of age and the sows were not rebred until their farrowing date could fit into the schedule of other farm activities, such as harvesting, or expected mild weather. With specialization and capitalization, it became necessary to increase the number of litters a sow could farrow in a year and spread a larger number of produced pigs over a fixed investment (National Research Council 1980). The industry began to wean small pigs earlier, at three to four weeks of age.

Pigs are born without protective immunity. Maternal antibodies are transferred to small pigs through colostrum in the milk during approximately the first two weeks of life (English, et al. 1984). There follows a period of about one week during which the piglet is "unprotected" from microorganisms in the environment. At the end of this third week, when the piglet is most vulnerable to disease organisms, its immune system begins to develop antibodies in response to exposure to microorganisms in the environment, but this process is gradual. If weaned before the immune system begins to develop, the pig is devoid of these natural antibodies to disease.

Today it is common for pigs to be weaned at between five and 15 days of age and transported offsite to "nurseries" under strict "biosecurity" arrangements. This process is called segregated early weaning (SEW), or sometimes medicated early weaning (MEW). It is used to reduce piglets' exposure to disease by weaning them before the colostrum in the mother's milk runs out and the piglets get exposed, unprotected, to the microorganisms in their environment. It also has the effect of increasing the number of litters to which individual sows give birth in a year because the sows can be rebred sooner (Crooker, et al 1999).

[31] As noted earlier, a neuroma is a tumor composed of nerve tissue.

Segregated, early-weaned pigs are taken from their mothers when they are between five and 15 days old and transported to a secured and sterile nursery site. This site may be on the same farm but most often is several miles away. In the US, early-weaned pigs may be transported hundreds of miles from the site where they were born. When they are 60 pounds, they are moved from the nursery, to a finishing site.

Weaning is stressful for pigs at any age, usually entailing moving to another pen and sometimes mixing with pigs from other litters, but it is especially stressful for pigs under three weeks of age and, particularly, earlier. At five to 15 days of age, many piglets are not developed enough to have learned to eat solid feed (Dr. P. Jensen, 2001, personal communication) and they have not had the chance to develop their own natural immunity by being exposed to microorganisms in the mother's environment.

The first stress relates to unexpected loss of the mother. Stress slows the natural contracting movements of the stomach and a complete cessation of stomach movement may occur (English, et al. 1984). Blood flow to the gut increases with stress, leading to congestion of the blood vessels supplying it. The gut lining may get small hemorrhages and ulcerations. A second stress results from the abrupt change in diet from milk to solid feed, which compounds the problems of the early-weaned pig by leading to digestive upsets or "malabsorption syndrome" (English, et al. 1984). Weaning diarrhea, known as "scours," damages the gut lining, interfering with the production of a substance that normally protects it, IgA (immune globulin A).

In the case of scours, *E. coli* pathogens take advantage of the lowered gut immunity and multiply rapidly (National Research Council 1980, English, et al. 1984). The addition of antibiotic feed additives to the water suppresses scours and other enteric illnesses in early weaned pigs (National Research Council 1980).

Segregated early weaning (SEW) pigs are called "high-health" pigs (Crooker, et al. 1999). However, in off-site nurseries there can be high morbidity and mortality rates. Small pigs may waste and die from starvation and from unknown causes.

"Post-weaning multi-systemic wasting syndrome" is the name given to a disease that emerges toward the end of the SEW nursery phase (five to seven weeks) and also in the early finishing phase (up to 14 weeks of age). Piglet death loss can range from five to 15% (Dudley 1998).

Scientists have known for years that when pigs are weaned at less than five weeks of age, physiological changes detrimental to cellular immune reactivity occur (Blecha, et al. 1983). By studying changes in catecholamine excretion rather than relying on blood cortisol measures alone (which, in this case, gave misleading results), Mormède (2000) showed that piglets' adaptive mechanisms are considerably taxed by early weaning at six days of age.

Nurseries in industrialized farming operations are comparatively barren environments, often with the feeder and waterer as the only manipulable features, apart from the other pigs (Figure 7-9). Air quality in the vicinity of the piglets is typically poor from a welfare standpoint due to location of perforated-floor pens over manure storage. Belly-nosing and other redirected behaviors are indicators that the environment is not optimal from the standpoint of pig welfare (Schouten 1986). Some of the welfare-improving implications of enriching pig environments are briefly discussed in section V (below).

Figure 7-9. Weaned pigs in intensive nursery.

Photo credit: Marlene Halverson

B. Welfare of grow/finish pigs

When early-weaned pigs are moved out of the protective environment of the nurseries to the finishing barns, they continue to depend on subtherapeutic antibiotic feed additives to control disease (APHIS 1996). This is also true for pigs weaned directly from confinement farrowing units into conventional grow-finish units. The grow-finish units are characterized by barren pens over concrete slatted floors. As the pigs grow, the space per pig is reduced to the point that little free movement is possible, resulting in high stress levels. As previously noted, barren environments result in abnormal behaviors, sometimes destructive, such as tail biting, redirected toward penmates (Van Putten 1980).

Concentration and intensification in the hog industry and other livestock industries have resulted in a changed "disease panorama" across animal agriculture (Ekesbo 1988, Marbery 2000). With confinement, new animal diseases, especially enteric and respiratory diseases, have emerged that are difficult to treat. Animal scientists have expressed concern that controlling respiratory diseases in swine has become more challenging than ever before as the "global industry has evolved into ever larger, more intensely managed production units, especially true in the United States" (Clark 1998). There is pervasive porcine reproductive and respiratory syndrome (PRRS) in the US, and the emerging postweaning multisystemic and wasting syndrome, for which experts have a hard time discovering precise causes and solutions, as well as other problems (Marbery 2000, 2001). Poor health is by definition poor welfare.

Salmonellosis in the US hog industry is a costly disease whose production costs were estimated by American Cyanamid in 1994 to total $100,000,000 per year in major pig producing states (Smith 1994). Death loss from salmonellosis in weaned pigs sometimes exceeded 20 per cent; in Iowa, costs of these death losses were estimated at $27,000,000 per year (Smith 1994). Salmonellosis usually takes hold when a pig's immune system is overloaded by stress, possibly due to exposure to new pigs, relocation, overcrowding, poor ventilation, or inadequate feeding and watering places. *Salmonellae* are ingested, attach themselves to intestinal walls, multiply and roam via the blood or lymph to the lungs and other vital organs. An illness similar to flu -- aches, pains, chills, fevers, diarrhea -- salmonellosis also causes non-death losses, such as slow growth.

While SEW and multi-site procedures have been thought to reduce salmonella incidence in the nation's hogs, Beran (1997) noted that it appears only to have delayed the age at which its onset in pigs occurs. In North Carolina, Davies et al. (1997) investigated fecal samples from finishing pigs and feed samples from swine herds on farrow-to-finish continuous production herds (not multiple site farms) and compared them to fecal samples from pigs in finishing sites at multiple site systems with all in/all out production. Multiple-site systems using all in/all out management of finishing pigs did not appear to have an advantage compared with conventional farrow-to-finish systems when it came to reducing prevalence of *Salmonella*.

Morbidity rates for pigs in finishing facilities from porcine respiratory disease complex can be 30 to 70% in some herds, and mortality rates can be from 4 to 6 percent from this type of respiratory disease alone. Problems of industrialized finishing farms include onset of acute pneumonia in 16- to 20-week-old SEW pigs (Clark 1998). A high proportion of finishing hogs go to market with lung lesions/enzootic pneumonia and papular dermatitis (Davies et al. 1995). A lesser proportion goes to market with atrophic rhinitis and peritonitis.

Lung lesions from poor air quality, as they seem not to cause sufficient production losses, appear to fall into the second category of welfare problems identified by Fraser, et al. (1997) (above, page 47):

> If the environment poses challenges for which the animal has no corresponding adaptation, the animal may have trouble functioning in its environment without showing it. Such may be the case with a pig in a polluted environment that develops lung damage without appearing to notice or mind.

The high morbidity and mortality rates that appear to characterize industrial farming systems may seem grossly uneconomical. However, the economies of space gained by crowding and immobilizing farm animals are among the most significant economies contributing to the industrialization of livestock farming, as long as ways can be found to compensate for the stresses, such as continuous, low-level administration of antibiotics to control disease.

To be economical, highly capitalized operations rely on a high volume of output because they receive a low gross profit margin per unit of output sold (Dawkins 1980). To lower costs per unit of investment, there is a strong incentive to enclose the highest population of animals physically possible inside buildings. As a consequence, little value is placed on the individual animal in high population herds. Economies of space and labor per unit of capital make up for losses of individuals (Dawkins 1980). These incentives were recognized early on in the intensification of animal agriculture. Harrison (1964) quoted the Farmer and Stockbreeder (UK) journal of January 22, 1963:

> …A few pigs have died from unexplained reasons, which might be due to the stress conditions associated with high density stocking. These deaths in no way nullify the extra return obtained from the higher total output.

In a simulation model to "determine the economic tradeoff between space allocation and production efficiency for grower-finisher…hogs," Powell, et al. (1993, pp. 132, 140) determined "that additional crowding over that previously recommended for optimum pig performance may be warranted economically [since falloffs in performance] can be more than offset by spreading the fixed costs over greater output."

V. Richer lives for domesticated pigs

The recently adopted European Union directive on the welfare of pigs requires that pigs have a minimum space allowance of enough area to lie down simultaneously in lateral recumbancy, about 50% more space than the previous directive, that at least one third of the pen floor is solid, not slatted, and that pigs be provided with bedding material and materials for investigation and manipulation.

Van Putten (1980) found that provision of a handful of straw per pig per day to finishing pigs living on slats provided an occupation for about one and one half hours a day for every pig. Conflict behaviors indicating reduced well-being had a frequency three times as great in the barren situation without straw compared to that with straw. Van Putten (1980) concluded that the well-being of finishing pigs is adversely affected by the absence of even a small amount of straw. Ekesbo (1973) found that a handful of straw per pig added to a pen each day reduced cannibalism to one-sixth of its previous frequency.

Wemelsfelder (1983) cited a number of studies that showed, for example, lower antibody levels and therefore greater disease susceptibility of tethered sows in pens without straw compared to free-going sows in pens with straw and that for sows and piglets there is a direct correlation between disease susceptibility, restraint, and the absence of straw. She also concluded from her review that boredom is a significant stressor.

In his comparison studies of piglets born to gilts tethered in farrowing crates and gilts in straw bedded pens where they were free to move about, Schouten (1986) noted that activities of the piglets depended on the presence or absence of straw. When straw was not available, piglets' activities were directed toward littermates and the mother, piglets were more restless, alternating between standing and sitting to avoid the redirected exploratory behavior of their littermates, and they started agonistic behaviors more easily. When straw bedding was present, piglets performed more exploratory behaviors toward the environment, including the straw. The total amount of exploratory behavior by piglets on straw was greater than the total amount of exploratory and redirected (to littermates and mother) behaviors shown by piglets in the barren environment. Schouten (1986) concluded that barren environments that induce redirected exploratory behavior and prevent the development of social skills do not contribute in a positive way to the welfare of pigs.

De Jonge, et al. (1998), too, found that growing pigs housed with straw bedding spent more time exploring the substrate while pigs housed in a barren environment spent increased time exploring pen walls and other pigs. As discussed above, on page 156, Ladewig and Matthews (1996) found straw to be important to pigs for resting, feeding, and rooting behaviors. Ladewig and Matthews (1996) used operant conditioning techniques to study the role of straw and its importance to pigs. Demand functions were generated using operant conditioning procedures to measure quantitatively the importance of various aspects of the pig's environment. Demand functions were generated by training pigs to do a variable amount of work – pressing a lever once, twice, and up to sixty times -- to obtain constant amounts of a reward such as food, straw, social contact, locomotion. Consumption of rewards was plotted against workload and steepness of the demand curves indicated the importance of the particular reward plotted.

The pigs in Ladewig and Matthews (1996) also engaged in a significant amount of straw chewing – gathering straw, chewing on it, and spitting it out. The investigators suggested that rooting in and chewing straw were not only explorative or feeding behaviors but could have entertainment value to the pigs. "Although entertainment may not…be…on the list of requirements

of farm animals, it is important to realize that having something sensible to do is exactly what keeps farm animals from developing stereotypies, tail-biting, feather pecking, and similar undesired behaviors" (Ladewig and Matthews, p. 67).

Spoolder, et al. (2000) found that providing straw as bedding to growing pigs resulted in higher levels of manipulation of the substrate. Straw enriched the environment, stimulating exploratory and foraging behavior and resulting in significantly altered time budgets. Pigs with straw spent less time manipulating substrates other than straw such as walls, dung, or penmates compared with pigs that had no straw. Pigs in the pens with straw were cleaner than pigs in the pens on fully-slatted and solid floors without straw.

The key to animal well-being in loose-housing systems that provide ample straw to pigs, is that the enrichment attempts have functional significance to the animals and are similar to substrates they would encounter and use in nature to root through, manipulate, and use to make nests. They fit Newberry's (1993) definition of environmental enrichment as "an improvement in the biological functioning of captive animals resulting from modifications to their environment."

To assess effects of environmental enrichment on the behavior, performance and meat quality of growing pigs, Beattie, et al. (2000) compared three hundred and twenty pigs reared from birth to slaughter (at 21 weeks) in two environments: intensive housing with slatted floors and minimum recommended space allowances and enriched environments with extra space and an area with peat for rooting and straw in a rack. Pigs in the enriched environment spent more time (a quarter of their time, total) in exploratory behavior and less time inactive or engaged in aggressive behaviors toward penmates than pigs in the slatted floor housing. Pigs in the barren environments persistently nosed and chewed penmates. Growth rates were higher for pigs in the enriched environments and they had heavier carcass weights than pigs from the non-enriched environment. Pigs from enriched environments also had more backfat at slaughter than the pigs in the non-enriched environment and pork from pigs reared in enriched environments showed lower cooking losses and shear force value than pork from pigs reared in barren environments.

Increasingly, there are markets for pigs raised in enriched environments, with consumers' attraction to the products lying in the quality of the meat from pigs in those environments and the assurance of knowing that how the pigs were raised meets their expectations (Marbery 1999, as well as Behr 1999, Burros 1999, Looker 2000, Unterman 1999, Martin and Wheatley 2001)). An important part of the attraction of these alternative meats, based on results from taste panels, appears to be improved flavor and texture in meat from pigs that have an increased level of backfat and have been free to exercise.

It is reasonable to conclude that a future emphasis on pig welfare will require changes in the industry and will precipitate them as well, but will not signal its demise.

Figure 7-10a & b. Enriched environments for pigs (Dan and Colin Wilson Farms, Iowa, modeled on a Swedish system):

a. Deep-bedded breeding facility (in hoop building).

b. Deep-bedded sow-pig nursery.

Photo credits: Marlene Halverson

References

Adcock, M. & Finelli, M. (1996, Spring). Against nature: The sensitive pig versus the hostile environment of the modern pig farm. *HSUS News*. Washington, DC: Humane Society of the U.S.

Algers, B. (1998). Behaviour of the sow and litter in relation to welfare: Is there a conflict between productivity and welfare? Proceedings of the 15th IPVS Congress, Birmingham, England, 5-9 July 345-348.

Algers, B. (1989). *Vocal and tactile communication during suckling in pigs: Aspects on functions and effects of continuous noise.* Report 25. Skara, Sweden: Swedish University of Agricultural Sciences, Faculty of Veterinary Medicine, Department of Animal Hygiene.

Algers, B. (1991). Group housing of farrowing sows: Health aspects of a new system. *Proceedings VII International Congress on Animal Hygiene, Leipzig,* p. 851.

Algers, B. (2000). Nest-building behaviour in sows and the practicalities of farrowing systems. *Ruth Harrison Memorial Meeting, Farm Animal Care Trust, Fyvie Hall, University of Westminster, London, November 29, 2000.*

Algers, B. (1993). Nursing in pigs: Communicating needs and distributing resources. *Journal of Animal Science, 71*, 2826-2831.

Algers, B. (1996). Managing alternative production systems: A Swedish perspective. *Swine System Options for Iowa, Proceedings of a conference held February 21, 1996, at Iowa State University, Ames, Iowa.* Leopold Center for Sustainable Agriculture, ISU Pork Industry Center, ISU Extension, Iowa Pork Producers Association, ISU Beginning Farmers Center, sponsors.

Algers, B., Bergström G., & Löfstedt, M. (1991). Nursing sows in groups: a presentation of Västgötamodellen. *Svensk Veterinärtidning (43)7*, 309-311.

Algers, B. & Jensen, P. (1985). Communication during suckling in the domestic pig: effects of continuous noise, in *Applied Animal Behaviour Science,14*, 49-61.

Algers, B. & Jensen, P. (1991). Teat stimulation and milk production during early lactation in sows: effects of continuous noise. *Canadian Journal of Animal Science, 71:* 51-60.

Alonso-Spilsbury, M.L. (1994). *Characterizing maternal abilities in restrained multiparous sows.* Ph.D. thesis. St. Paul, MN: University of Minnesota.

Anderson, J.J.B., Milin, L., & Crackel, W.C. (1971). Effect of exercise on mineral and organic bone turnover in swine. *Journal of Applied Physiology, 30 (6)*, 810-813.

Andersson, M. (2000). *Domestication effects on behaviour: Foraging, parent-offspring interactions, and anti-predation in pigs and fowl. Acta Universitatis Agriculturae Sueciae. Veterinaria 86*. Skara, Sweden: Swedish University of Agricultural Sciences, Department of Animal Environment and Health.

APHIS. (1996, January 1). Antibiotic usage in premarket swine. *Veterinary Services Factsheet*. National Animal Health Monitoring System. Washington, DC: U.S. Department of Agriculture, Animal and Plant Health Inspection Service.

Arey, D.S. (1995). The family system for pigs – from pig park to production system. *Pig News and Information, 16*: 123N-126N.

Arey, D.S. (1997). Behavioural observations of peri-parturient sows and the development of alternative farrowing accommodation: a review. *Animal Welfare, 6,* 217-229.

Arey, D.S. (1993). The effect of bedding on the behaviour and welfare of pigs. *Animal Welfare, 2,* 235-246.

Arey, D.S. (1992a). Straw and food as reinforcers for prepartal sows. *Applied Animal Behaviour Science 33:* 217-226.

Arey, D.S., Petchey, A.M., & Fowler, V. (1992b). The effect of straw on farrowing site choice and nest building in sows. *Animal Production, 54,* 129-134.

Baidoo, S. K., Kiehne, R., & Batista, L. (2000). Increasing sow longevity: Body conditioning and feeding. *Proceedings of the 2000 Allen D. Leman Swine Conference*, St. Paul, MN, Scruton, W.C. & Claas, S., eds. St. Paul, MN: Veterinary Outreach Programs, College of Veterinary Medicine, University of Minnesota.

Barnett, J.L., Hemsworth, P.H., Cronin, G.M., Jongman, E.C., and Hutson, G.D. (2001). A review of the welfare issues for sows and piglets in relation to housing. *Australian Journal of Agricultural Research, 51:*1-8.

Beattie, V.E., O'Connell, N.E., & Moss, B.W. (2000). Influence of environmental enrichment on the behaviour, performance and meat quality of domestic pigs. *Livestock Production Science,65(1-2)* 71-9.

Behr, E. (1999, Summer). The lost taste of pork: Finding a place for the Iowa family farm. *the Art of Eating* magazine.

Beran, G. (1997, Spring). In food safety technologies aid producers. *Food Safety Consortium Newsletter, 7 (2),* 6.

Bergh, P., Reese, P. Gunnink, D. & Dalbec, T. (2001). Hogs your way: Choosing a hog producton system in the upper Midwest. BU-7641-S. St. Paul: Minnesota Institute for Sustainable Agriculture, University of Minnesota Extension Service, and Minnesota Department of Agriculture.

Blackshaw, J.K., Blackshaw, A.W., Thomas, F.J., and Newman, F.W. (1994). Comparison of behaviour patterns of sows and litters in a farrowing crate and a farrowing pen. *Applied Animal Behaviour Science, 39,* 281-295.

Blecha, F., et al. (1983). Weaning pigs at an early age decreases cellular immunity. *Journal of Animal Science, 56(2),* 396-400.

Britt, J. H., & Flowers, W. L., (1997). *Development of methods for precise control of reproduction in early-weaned sows*. NPPC 1997 Research Investment Report. Des Moines, IA: National Pork Producers Association.

Burne, T.H.J., Murfitt, P.J.E., & Gilbert, C.L. (2000). Deprivation of straw bedding alters $PGF_{2\alpha}$-induced nesting behaviour in female pigs. *Applied Animal Behaviour Science, 69(3),* 215-225.

Burros, M. (1999, September 22). Eating well: Pork with a pedigree. *New York Times,* D9.

Castrén, H., Algers, B., de Passillé A.-M., Rushen, J., & Uvnæs-Moberg, K. (1993b). Early milk ejection, prolonged parturition and periparturient oxytocin release in the pig. *Animal Production 57*:465-471.

Castrén, H., Algers, B., de Passillé A.-M., Rushen, J., & Uvnæs-Moberg, K. (1993a). Periparturient variation in progesterone, prolactin, oxytocin and somatostatin in relation to nest building in sows. *Applied Animal Behaviour Science, 38:* 91-102.

Clark, L.K. (1998, November-December). Quoted in Swine respiratory disease: IPVS Special Report, Section B, P6-P7), Pharmacia & Upjohn Animal Health. *Swine Practitioner*.

Connor, M.L., Fulawka, D.L., and Onischuk, L. (1997). Alternative low-cost group housing for pregnant sows. *Livestock Environment V: Proceedings of the Fifth International Livestock Environment Symposium, May 29-31, 1997, Bloomington, MN.* Vol. 1: 393-400. St. Joseph, MI: American Society of Agricultural Engineers.

Crooker, B., Halvorson, D., Moon, R., Phillips, C., Noll, S., Johnston, L., Reneau, J., Chester-Jones, H., Hathaway, M., Goyal, S., Janni, K., Pijoan, C., Shields, T., Stromberg, T., Patterson, C., Dee, S., Blaha, T., and Wells, S. (1999). A summary of the literature related to animal agriculture health. *Generic environmental impact statement on animal agriculture, State of Minnesota*. St. Paul, MN: Environmental Quality Board.

Damm, B.I., Vestergaard, K.S., Schrøder-Petersen, D.L., and Ladewig, J. (2000). The effects of branches on prepartum nest building in gilts with access to straw. *Applied Animal Behaviour Science, 69:* 113-124.

Davies, P. R., Bahnson, P.B., Marsh, W.E., & Dial, G.D. (1995). Prevalence of gross lesions in slaughtered pigs -- the PigMON Database 1990-1993. *National Pork Producers Council, 1995 Research Investment Report*. Des Moines, IA: National Pork Producers Council.

Davies, P. R., Morrow, W.E.M., Jones, F.T., Deen, J., Fedorka-Cray, P.J., & Harris, I.T. (1997). Prevalence of salmonella in finishing swine raised in different production systems in North Carolina, USA. *Epidemiol. Infect. 119*, 237-244.

DeJonge, I.C., Ekkel, E.D., Van de Burgwal, J.A., Lambooij, E., Korte, S.M., Ruis, M.A.W., Koolhaas, J.M., & Blokhuis, H.J. (1998). Effects of straw bedding on physiological responses to stressors and behavior in growing pigs. *Physiol. Behav. 64,* 303-310.

Djurskyddslagen. (1988:534). Statens Jordbruksverk.

Dougherty, R.W. (1976). Problems associated with feeding farm livestock under intensive systems. *World Rev. Nutr. Diet., 25,* 249-275, cited in Fraser, A.F. & Broom (1990).

Dudley, S. (1998, July 15). Vets on Call: Wasting woes of early weaning. *National Hog Farmer, 43(7),* 28.

Ekesbo, I. (1973). Animal health, behaviour and disease prevention in different environments in modern Swedish animal husbandry. *The Veterinary Record, 93(2),* 36-39.

Ekesbo, I. (1980). Some environmentally evoked animal health and welfare problems in modern husbandry. *Animal Regulation Studies, 3,* 119-128.

Ekesbo, I. (1988). Animal health implications as a result of future livestock and husbandry developments. *Applied Animal Behaviour Science, 20,* 95-104.

Ekesbo, I. (1995). Swedish deep-bedded housing systems for gestating sows. *Module II: Breeding Herd Facilities Management, Swine Breeding Herd Management Certification Series*. Ames, Iowa: Iowa Pork Industry Center, Iowa State University Extension.

English, P.R. & Smith, W.J. (1975). Some causes of death in neonatal piglets. *Vet.Ann.,15:*95-104.

English, P.R., Smith, W.J., MacLean, A. (1984). *The sow: Improving her efficiency.* Ipswich, Suffolk, Great Britain: Farming Press Ltd.

E.U. Scientific Veterinary Committee. (1997, September 30). *The welfare of intensively kept pigs.* Brussels: Health and Consumer Protection Directorate, European Commission.

Fisher, R. (1995). Efficacy of laxative agents and their effect on nutrient balance in sows. *National Pork Producers Council (NPPC) 1995 Research Investment Report.* Des Moines: NPPC.

Fraser, A.F. (1980). *Farm animal behaviour*. 2nd Ed. London: Bailliere-Tindall.

Fraser, A.F. & Broom, D.M. (1990). *Farm animal behaviour and welfare*. London: Ballière Tindall.

Fraser, D. (1980). A review of the behavioural mechanism of milk ejection of the domestic pig. *Applied Animal Ethology, 6:* 247-255.

Fraser, D., Philips, P.A., Thompson, B.K., Pajor, E.A., Weary, D.M., & Braithwaite, L.A. (1995). Behavioural aspects of piglet survival and growth. *The neonatal pig.* Varley, M., ed. Developmentand Survival CAB, pp. 287-312.

Fraser, D., Weary, D.M, Pajor, E.A., & Milligan, B.N. (1997). A scientific conception of animal welfare that reflects ethical concerns. *Animal Welfare, 6(3*): 187-205.

Frädrich, H. (1974). *A comparison of behaviour in Suidae*. IUCN Publications New Series 24: 133-143.

Graves, H.B. (1984). Behaviour and ecology of wild and feral swine (*Sus Scrofa*). *Journal of Animal Science 58:* 482-492.

Giuffra, E., Kijas, J.M.H., Amarger, V., Carlborg, Ö., Jeon, J.-T. & Andersson, L. (2000). The origin of the domestic pig: independent domestication and subsequent introgression. *Genetics, 154*, 1785-1791.

Grimes, G. (1998). Videotaped Interview. *And On This Farm*. Burnsville, MN: Field Pictures, Inc.

Groves, C.P. (1991). Suid and Dicolytid systematics today. In, *Biology of suidae,* Barrett, R.H. & Spitz, F. IRGM, Toulouse, pp. 20-29.

Gundlach, H. (1968). Brutfürsorge, Brutplfege, Verhaltensontogenese und Tagesperiodik beim Europäischen Wildschwein (Sus Scrofa, L.*). Z. Tierpsychology 25:* 955-995, cited in E.U. Scientific Veterinary Committee (1997).

Gustafsson, M., Jensen, P., de Jonge, F., Illman, G. & Spinka, M. (1999). Maternal behaviour of domestic sows and crosses between domestic sows and wild boar. *Applied Animal Behaviour Science, 65,* 29-42.

Halverson, M. (1998). Management in Swedish deep-bedded swine housing systems: Background and behavioral considerations. *Proceedings: Manure Management in Harmony with the Environment and Society, February 10-12, Ames, IA.* Soil and Water Conservation Society.

Halverson, M. & Honeyman, M. (1997). Humane, sustainable feeder pig production: Transferring a technology developed in Sweden to Midwestern hog farms. *Livestock Environment V: Proceedings of the Fifth International Livestock Environment Symposium, May 29-31, 1997, Bloomington, MN.* Vol. 1: 401-408. St. Joseph, MI: American Society of Agricultural Engineers.

Halverson, M., Honeyman, M., & Adams, M. (1997). Swedish deep-bedded group nursing systems for feeder pig production. *Sustainable Agriculture Series: Swine System Options for Iowa, SA-12*. Ames, Iowa: Iowa State University Extension.

Haussmann M.F., Lay D.C., Buchanan H.S. & Hopper J.G. (1999). Butorphanol tartrate acts to decrease sow activity, which could lead to reduced pig crushing. *Journal of Animal Science,77 (8):* 2054-2059.

Hemsworth, P.H. & Barnett, J.L. (1987, June). The human-animal relationship and its importance in pig production, *Pig News and Information, 8, (2).*

Hemsworth, P.H., Barnett, J.L., Coleman, G.J., & Hansen, C. (1989). A study of the relationships between the attitudinal and behavioural profiles of stockpersons and the level of fear in humans and reproductive performance of commercial pigs. *Applied Animal Behaviour Science, 23,* 301-314.

Holmgren, N. & Lundeheim, N. (1994). Djurhälsomässiga behovet av fodermedelsantibiotika i smågrisproducerande besättningar. *Sv. Vet. Tidn. 46:* 57-65.

Honeyman, M.S., Roush, W.B., & Penner, A.D. (1998). Pig crushing mortality by hut type in outdoor farrowing. *Iowa State University Research Farms Reports, Western Research and Demonstration Farm. ISRF98-10*, 16-18

Honeyman, M. & Weber, L. (1996). Outdoor pig production: An approach that works. *Sustainable Agriculture Series: Swine System Options for Iowa, SA-9*. Ames, Iowa: Iowa State University Extension.

Hutter, St., Heinritzi, K., Reich, E., Ehret, W. (1994). Efficacité de différentes methods de resection des dents chez le porcelet non sevré. *Revue Méd. Vét. 145:* 205-213.

Högsved, O. (1988). Loose housing systems for dry sows in uninsulated buildings. *Environment and Health: Proceedings of the Sixth International Congress on Animal Hygiene, Skara, Sweden, V.1*. Skara: Swedish University of Agricultural Sciences, Faculty of Veterinary Medicine, Department of Animal Hygiene, 340-344.

Irwin, C.K., & Deen, J. (2000). Levels of culling in commercial herds. *Proceedings of the 2000 Allen D. Leman Swine Conference, Volume 27*, St. Paul, MN, Scruton, W.C. & Claas, S., eds. St. Paul, MN: Veterinary Outreach Programs, College of Veterinary Medicine, University of Minnesota.

Jensen, P. (1986). Observations on the maternal behaviour of free-ranging domestic pigs. *Applied Animal Behaviour Sciences, 16*, 131-142.

Jensen, P. (1989). Nest site choice and nest building of free-ranging domestic pigs due to farrow. Applied Animal Behaviour Science, 22: 13-21.

Jensen, P. (2000). Natural behaviour and behavioural needs of farm animals. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Jensen, P. & Stangel, G. (1992). Behaviour of piglets during weaning in a semi-natural enclosure. *Applied Animal Behaviour Science 33:* 227-228.

Jensen, P. & Recén, B. (1989). When to wean – observations from free-ranging domestic pigs. *Applied Animal Behaviour Science 23:* 49-60.

Jensen, P. (1988b). *Maternal Behaviour of Free-Ranging Domestic Pigs: Results of a Three-Year Study.* Report 22. Skara: Swedish University of Agricultural Sciences, Faculty of Veterinary Medicine, Department of Animal Hygiene.

Jensen, P., Floren, K. & Hobroh, B. (1987). Peri-parturient changes in behaviour in free-ranging domestic pigs. *Applied Animal Behaviour Science, 17.*

Jensen, P., Vestergaard, K., & Algers, B. (1993). Nestbuilding in free-ranging domestic sows. *Applied Animal Behaviour Science, 38:* 245-255.

Kent, D. (1998). Breeding herd management and performance in a Swedish deep-bedded gestation and group lactation demonstration, Armstrong Farm, Iowa State University. *Proceedings: Manure Management in Harmony with the Environment and Society, February 10-12, Ames, IA*. Soil and Water Conservation Society.Kiley, M. (1972). The vocalization of ungulates, their causation and function. *Zeitschrift für Tierpsychologie 31:* 171-222, cited in E.U. Scientific Veterinary Committee (1997).

Klingholz, F., Siegert, C. & Meynhardt, H. (1979). Die akustische Kommunikation des Europäischen Wildschweines (Sus scrofa L.). *Der Zoologische Garten 49:* 277-303, cited in E.U. Scientific Veterinary Committee (1997).

Ladewig, J. & Matthews, L.R. (1996). The role of operant conditioning in animal welfare research. *ACTA Agriculturae Scandinavica. Welfare of domestic animals: Concepts, theories, and methods of measurement. Section A: Animal Science. Supplementum 27.* Boston: Scandinavian University Press.

Lawrence, A.B., Petherick, J.C., McLean, K.A., Deans, L., Chirnside, J., Vaughan, A., Gilbert, C.L., Forsling, M.L. & Russell, J.A. (1995). The effects of chronic environmental stress on parturition and on oxytocin and vassopressin secretion in the pig. *Animal Reproduction Science, 38,* 251-254.

Levy, S. (1998, May 7). Multidrug resistance – A sign of the times. *The New England Journal of Medicine (338), 19*, 1376-1378.

Looker, D. (2000, February). Surviving the hog shakeout: One young couple's strategy builds on the natural foods market. *Successful Farming,* 22-23.

Loula, T. (2000). Increasing sow longevity: The role of people and management. *Proceedings of the 2000 Allen D. Leman Swine Conference, Volume 27*, St. Paul, MN, Scruton, W.C. & Claas, S., eds. St. Paul, MN: Veterinary Outreach Programs, College of Veterinary Medicine, University of Minnesota.

López-Serrano, M., Reinsch, N., Looft, H., and Kalm, E. (2000). Genetic correlations of growth, backfat thickness and exterior with stayability in large white and landrace sows. *Livestock Production Science, 64(2-3):* pp. 121-131.

Marbery, S. (1999, January 18). Traditional values driving upscale pork market. *Feedstuffs,18,* 21.

Marbery, S. (2000, January 24). Hog industry insider: Post-industrial challenge. *Feedstuffs Magazine*.

Marbery, S. (2001a, March 12). Hog industry insider: Post-weaning pointers. *Feedstuffs Magazine.*

Marbery, S. (2001b, April 19). Hog industry insider: Sow mortality update. *Feedstuffs Magazine.*

Marchant, J. & Broom, D. (1996a). Factors affecting posture-changing in loose-housed and confined gestating sows. *Animal Science 63,* 447-485.

Marchant, J.N. & Broom, D.M. (1996b). Effects of dry sow housing conditions on muscle weight and bone strength. *Animal Science. 62*, 105-113.

Marchant, J.N., Ruud, A.R., & Broom, D.M. (1994). The effects of dry sow housing conditions on welfare at farrowing. Ph.D. thesis. Cambridge, UK: University of Cambridge.

Martin, W. & Wheatley, W.P. (2001). Consumer preferences, premiums, and the market for natural and organic pork: Locating a niche for small-scale producers. St. Paul, MN: Alternative Swine Systems Program, Minnesota Institute for Sustainable Agriculture and Department of Animal Science, University of Minnesota.

Mormède, P. (2000). Stress and welfare: A psychoendocrine perspective. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

National Research Council, Committee to Study the Human Health Effects of Subtherapeutic Antibiotic Use in Animal Feeds, Division of Medical Sciences, Assembly of Life Sciences. (1980). *The*

effects on human health of subtherapeutic use of antimicrobials in animal feeds. Washington, DC: National Academy of Sciences, Office of Publications, p. 331.

Newberry, R.C. &Wood-Gush, D.G.M. (1986). Social relationships of piglets in a semi- natural environment. *Animal Behaviour, 34:*1311-1318.

Newberry, R.C. & Wood-Gush, D.G.M. (1988). The development of certain behaviour patterns in piglets under semi-natural conditions. *Animal Production, 46:*103-109.

Owen, J.B. (1999). Cited in Sutton, J. (1999, September 11). Thin time for pigs. *New Scientist.*

People for the Ethical Treatment of Animals. (1998). Lawsuit against Belcross Farms, North Carolina. At the PETA website: http://www.petaonline.org

Petersen, V. (1994). The development of feeding and investigatory behaviour in free-ranging domestic pigs during their first 18 weeks of life. *Applied Animal Behaviour Science, 45:* 215-224.

Petersen, V., Recén, B., & Vestergaard, K. (1990). Behaviour of sows and piglets during farrowing under free-range conditions. *Applied Animal Behaviour Science, 26:* 169-179.

Rushen, J. (1984). Stereotyped behaviour, adjunctive drinking and the feeding periods of tethered sows. *Animal Behaviour, 32*, 1059-1067.

Schmid, H. (1991). A practicable, behaviour specific housing system for farrowing and lactating sows. *Alternatives in animal husbandry: Proceedings of the international conference, E. Boehncke and Molkenthin, eds. Witzenhausen, July 22-25, 1991, University of Kassel, Witzenhausen, Germany.*

Schouten, W.G.P. (1986). *Rearing conditions and behaviour in pigs*. Doctoral thesis. Wageningen Agricultural University, Wageningen, NE.

Signoret, J.P., Baldwin, B.A., Fraser, D. & Hafez, E.S.E. (1975). The behaviour of swine. (pp. 295-329.) *The behaviour of domestic animals*. (3rd ed.) London: Baillière Tindall.

Simonsen, H.B. (1995). Effect of early rearing environment and tail docking on later behaviour and production in fattening pigs. *Acta Agriculturae Scandinavica, Sect. A. Animal Sciences, 45:* 139-144.

Simonsen, H.B., Klinken, L., and Bindseil, E. (1991). Histopathology of intact and docked pigtails. *British Veterinary Journal, 147:* 407-411.

Smith, R. (1994, February 28). 'Commander's tour,' good management urged to prevent Salmonella in swine. *Feedstuffs, 14.*

Spoolder, H.A.M., Edwards, S.A., & Corning, S. (2000). Legislative methods for specifying stocking density and consequences for the welfare of finishing pigs. *Livestock Production Science, 64(2-3),* 167-173.

Stolba, A. (1982). Designing pig housing conditions according to patterns of social structure. Presentation to a Conference on Pigs, Perth, organized by the Scottish Agricultural Colleges and the Meat and Livestock Commission.

Stolba, A. (1984). Lactational oestrus in sows kept in rich environments, in *Proceedings of the International Congress on Applied Ethology in Farm Animals*. Federal Ministry of Food, Agriculture and Forestry, Bonn, West Germany. (pp. 226-228). Kiel: KTBL.

Stolba, A., (1983, June). The pig park family system: Housing designed according to the consistent patterns of pig behaviour and social structure. Paper presented at the Conference on the Human-Animal Bond, Minneapolis, Minnesota.

Thornton, K. 1988. *Outdoor pig production*. Suffolk: Farming Press Ltd.

Treasure, J.L. & Owen, J.B. (1997, May). Intriguing links between animal behavior and anorexia nervosa. *International journal of eating disorders, 21(4):* 307-311.

Unterman, P. (1999, June 27). On food: This little piggy… *San Francisco Examiner,* 64-66.

Van Putten, G. (1980). Objective observations on the behaviour of fattening pigs. *Animal Regulation Studies, 3,* 105-118.

Van Putten, G. (1978). Schweine. *In Nutztierethologie*. Sambraus, H.H. Ed. Berlin: Paul Parey, cited in Fraser, A.F. & Broom (1990).

Van Steenbergen, E.J. (1990). Relevance of exterior appraisal in pig breeding. Thesis, Wageningen Agricultural University, Wageningen, NE, cited in López-Serrano, et al. 2000.

Vestergaard, K. (1981). Influence of fixation on the behaviour of sows, in *The Welfare of Pigs: A Seminar in the EEC Programme of Coordination of Research on Animal Welfare. November 25-26, 1980*. Sybesma, W. (Ed.). Boston: Martinus Nijhoff Publishers.

Weary, D. & Fraser, D. (1999, May). Partial tooth-clipping of suckling pigs: effects on neonatal competition and facial injuries. *Applied Animal Behaviour Science, 65:* 21-27.

Weary, D. & Fraser, D. (1995). Signalling need: Costly signals and animal welfare assessment. *Applied Animal Behaviour Science, 44:* 159-169.

Weary D.M., Braithwaite L.A. & Fraser D. (1998). Vocal responses to pain in piglets. *Applied Animal Behaviour Science, 56 (2-4):* 161-172.

Wechsler, B. (1991). A combined husbandry system for breeding sows and fattening pigs in an enriched pen. *Alternatives in animal husbandry: Proceedings of the international conference, E. Boehncke and Molkenthin, eds. Witzenhausen, July 22-25, 1991, University of Kassel, Witzenhausen, Germany.*

Wechsler, B. & Brodmann, N. (1996). Synchronization of nursing bouts in group-housed sows. *Applied Animal Behaviour Science, 47,* 191-199.

Wechsler, B. & Hegglin, D. (1997). Individual differences in the behaviour of sows at the nest-site and the crushing of piglets. *Applied Animal Behaviour Science, 51*, 39-49.

Wemelsfelder, F. (1983). *Animal boredom: Is a scientific study of the subjective xperience of animals possible?* Doctoral thesis. Leiden: Uitgave Instituut voor Theoretische Biologie.

Wierup, M. (1998). Preventive methods replace antibiotic growth promoters: Ten years experience from Sweden. *Alliance for the prudent use of antibiotics newsletter, 16(2),* 1-4.

Wierup, M. (2000). Strategies for avoiding health problems of farmed animals. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Wierup, M. (2000). The Swedish experience of the 1986 year ban of antimicrobial growth promoters with special reference to animal health, disease prevention, productivity and usage of antimicrobials. Johanneshov, Sweden: Swedish Animal Health Service.

Willequet, F. P., & Sourdioux, Q. & M. (1991). Foot, limb and body lesions in swine, influence of containment in farrowing crates and flooring characteristics of the housing. *Proceedings of the Seventh Annual Congress of Animal Hygiene, Vol. I.* (pp. 145-151). Leipzig.

Wilson, D., & Wilson, C., (1998). Experiences with a Swedish deep-bedded swine system. Soil and Water Conservation Service annual meeting: *Manure Management in Harmony with the Environment and Society, February 10-12, 1998*. (142-145). Ames, Iowa: Iowa State Center, Scheman Building.

Wood-Gush, D.G.M., Jensen, P. & Algers, B. (1990). Behaviour of pigs in a novel semi-natural environment. *Biology & Behaviour, 15:* 62-73.

PART III

> 1. What are the current regulations and routine practices in Minnesota and other places relating to animal agriculture that are aimed at the health and well being of animals? What is known about the use of these practices, or in the case of regulation, what is known about compliance
> 4. What monitoring techniques and standards are available to determine and address the effects on animals in Minnesota and other places?
> 5. What are the current and potentially available prevention and mitigation measures for addressing any negative effects on animal health and well-being in Minnesota and other places and to what extent are these measures effective?
>
> *Scoping Document, Generic Environmental Impact Statement on Animal Agriculture in Minnesota*

Questions 1, 4, and 5 of the GEIS Scoping Document concerned the existence and effectiveness of available and potentially available mitigation measures, including regulations, monitoring techniques and standards, for addressing negative impacts of animal agriculture on animal health and well-being. In the case of regulation, they asked what is known about compliance.

Chapter 8 looks at the performance of the market mechanism with respect to its capability to prevent and mitigate negative effects on animal health and well-being and describes circumstances under which animal welfare conveys social and private economic benefits when required by consistent and evenly enforced regulation.

When the market fails to provide a good at its optimal level, other institutions intervene, including governments, and other mechanisms are implemented, including regulations. Chapter 9 looks at US regulations – i.e., Federal and state – and notes where Minnesota animal agriculture has an opportunity to make improvements in how farm animals are treated.

Chapter 10 describes regulations in the European Union and selected other countries, i.e., the United Kingdom, Sweden, and Switzerland and the implications of different standards and country goals.

CHAPTER 8

DOES THE MARKET WORK? THE POLITICAL ECONOMY OF FARM ANIMAL WELFARE

I. Existing conceptualizations of farm animal welfare

As currently conceptualized in economics, the values of animal welfare are negative. That is, they are unmitigated costs to producers and to consumers and providing animal welfare [goods] results in net losses to producers and society (Wilcox 1989, Lazarus, et al. 1991, Tweeten 1993). Bennett (1994, 1995) and McInerney (1991a, b) conceptualize providing for the welfare of animals as a tradeoff for society between animal welfare and animal productivity. Bennett (1995) states that some economic benefits may come out of treating farm animals more humanely even though they have not been quantified.

In the minds of agriculturalists, property rights are also vested in the production sector while the consuming sector of the population bears the liabilities for practices that cause poor animal welfare (for example, poultry specialist Don Bell of University of California Cooperative Extension, called McDonalds' notice to egg suppliers concerning its forced molting policy a "drastic departure from the standard ways of treating poultry, the idea of buyers dictating to ranchers how to treat their flocks" (Perry 2000)).

Economists tend to favor market solutions to the animal welfare problem, in which animal-based products from systems characterized by high welfare standards can be provided via market niches and where consumers who care about farm animal welfare pay more to obtain welfare-friendly products. The farm animal's welfare problem is that reliance on human altruism is not enough. Economist Peter Hinrichs (1989, p. 7) noted

> [T]he … opinion proclaimed by some economists as the 'economic approach' of animal welfare problems, says that the consumers would like to buy products originating from welfare-[compatible] systems… at a higher price. Indeed, such a market segment… already exist[s] in several countries… but until now it covers only a very small part of the total demand, and we cannot expect that even a booming expansion would result in a share greater than 10 or 15 per cent. Consequently, as much as this "economic approach" may look favourable from the economists' point of view, *it will not improve the welfare of the remaining majority of animals, and therefore cannot be taken as an operable alternative to welfare regulations* (emphasis added).

Similarly, economist E.J. Mishan (1993) argues that property rights[32] and the market

[32] The philosophy of *caveat emptor* (consumer beware) is consistent with property rights being vested in the producer/seller and liabilities (impacts of adverse results and costs of alleviating them) being borne by consumers/buyers. The philosophy of *caveat venditor* (seller beware) is consistent with property rights (to safe food, clean environment, animal welfare) being vested in the consumer/buyer and liabilities (responsibility for preventing adverse results and paying for cleanup and abatement when they occur) being assumed by the producer/seller. With respect to livestock production, the distribution (or ownership) of

mechanism cannot provide the level of farm animal welfare desired by society. Rather, he argues the "strictest government controls will always be necessary."

II. The political economy of industrial animal farming[33]

The process of technology change and adoption in agriculture that followed World War II and enabled the production of greater and greater amounts of output per number of workers was called "rationalization." The "rationalization" process in livestock farming was characterized by a switch from reliance on husbandry to reliance on mechanized techniques of restricting and controlling animals' behavior and biological processes (Ekesbo 1988). Agricultural scientists focused on refining the mechanical techniques that could substitute for labor, reducing the number of workers (and farmers) needed for animal production. Specialization and capital-intensive technologies increased output per number of workers to a great extent by substituting machines, drugs, and unskilled labor for farmers and workers skilled in the husbandry of animals. Herd and flock sizes were increased to spread fixed costs over a higher volume of output. The changes transformed animal agriculture from a primarily biological to a primarily technical process.

The new, more intensive confinement technologies were not scale neutral with respect to the substitution of capital for labor. They were adopted to greater advantage by larger farms than by smaller ones (Halverson 1991). Fewer, less skilled personnel worked with more animals. Smaller producers who adopted the new methods soon found that they had to "get bigger or get out." They also became more dependent than before on technology and other input suppliers for the materials to operate their businesses: genetics firms, animal breeders, equipment manufacturers, feed companies, drug suppliers, and others took on a dominant role in animal agriculture.

During some of the most formative years of this transformation in the US, farm programs were put in place that promoted the industrialization of animal agriculture (Hassebrook 1981, Penn 1979). These included investment tax credits for confinement building technology, rapid depreciation on confinement facilities, write-offs of capital investments as cash expenses, inclusion of closely held corporations in the definition of family farms eligible to use cash accounting, capital gains exemptions on sales of breeding stock, price support programs that made land more profitable for growing crops than for raising animals and reinforced the move to intensive confinement, and crop deficiency payments that served as "de facto" subsidies from taxpayers to livestock farmers by keeping grain (feed) prices low, further encouraging expansion.

The farm programs awarded support on the basis of production volume rather than income, stewardship of natural resources, or other, desirable social goal. This philosophy had the effect of channeling aid into the hands of the highest volume farmers, further concentrating production into the hands of relatively few producers (U.S. Congress 1986).

The farm policy programs and the new mass production technologies had the additional effect of bringing outside investors into agriculture. Major expansion occurred in the US swine

---

property rights in a society will determine whether and how farm animal welfare reforms will come about in that society and ultimately how effective those reforms will be.

[33] A part of this section relies on Halverson (2000). For a definition of industrial farming see footnote 2, page 5.

industry, for example, between 1975 and 1980. In 1978, more than half of U.S. farms selling 5,000 or more hogs had not been in hog production in 1975, and some had not been in the business of farming at all in 1975 (Van Arsdall and Nelson 1984). Two-thirds of the total building capacity was in capital-intensive structures specialized to hog production. Specialization permitted greater separation of ownership, management, and labor. Between 1950 and 1980, the number of U.S. hog farms declined by nearly 80%, while average hogs produced per farm increased six-fold (Van Arsdall and Nelson 1984). In 1980, US hog farms numbered 644,000. By 1999, there were only a little over 90,000.

The economies of space gained by crowding and immobilizing farm animals are among the most significant economies contributing to the industrialization of livestock farming. To be economical, highly capitalized operations rely on a high volume of output because they receive a low gross profit margin per unit of output sold (Dawkins 1980). To lower costs per unit of investment, there is a strong incentive to enclose the highest population of animals physically possible inside buildings. As a consequence, little value is placed on the individual animal in high population herds. Economies of space and labor per unit of capital make up for losses of individuals (Dawkins 1980).

The emphasis on unit cost efficiencies per farm size or scale as opposed to production or output efficiencies is an extension of the economy of plant size concept for non-farm industries (Halverson 1991). Physically, some forms of agriculture, such as animal production, are amenable to the plant type of structure, although, as has been shown, not without costs to the animals. Technology and genetic selection have enabled concentration of production in the turkey, broiler and laying hen, hog, and increasingly the dairy and beef industries, and have reduced the need for land and space still critical to crop agriculture. But they have deliberately not considered the needs of farm animals.

Harrison (1964) quoted the Farmer and Stockbreeder (UK) journal of January 22, 1963:

> …A few pigs have died from unexplained reasons, which might be due to the stress conditions associated with high density stocking. These deaths in no way nullify the extra return obtained from the higher total output.

Powell, et al. (1993, pp. 132, 140) determined "that additional crowding over that previously recommended for optimum pig performance may be warranted economically [since falloffs in performance] can be more than offset by spreading the fixed costs over greater output."

In industrial organization theory, every production technology has associated with it a minimum efficient scale (MES) of production (Halverson 1991). That means there should be a "natural" limit to growth in size of firms because there is an output level up to which added size (of capital investment) brings added efficency and beyond which size conveys no additional advantages (Greer 1984). Up to the MES, average cost of production associated with the same technology at consecutively larger output levels decreases rapidly and levels off after the MES is reached.

It is assumed that at very large firm sizes for a given technology, diseconomies set in and the long-run average cost curve of the industry starts to bend upward. These diseconomies might be the high costs of disposing of manure, medical wastes, and animal carcasses; of odor prevention; of worker health and safety; or the difficulties of managing the operations at larger sizes.

To the extent the firm deals with the problems, they will raise the firm's costs. To the extent that the firm does not assume responsibility for the problems, they will result in externalities, or costs displaced by the firm onto society (Halverson 1991). Society's costs may include but not be limited to higher taxes to clean up water pollution caused by manure runoff, health problems due to nitrate pollution of groundwater; antibiotic resistance; costs of dealing with disease outbreaks; neighbors' loss of property values or enjoyment of property by odor not controlled at the farm source; or health problems experienced by neighbors resulting from the firm's impact on air quality. Lower prices to consumers from industry expansion only benefit consumers if consumers are not already also paying for the lower cost output with increased risks to health, resource depletion or contamination, or higher taxes for other externalities.

However, as illustrated throughout this report, the first ones on which the externalties of animal production fall are the animals themselves. A major factor in diminished farm animal welfare in highly capitalized firms, which are driven by low prices to reduce costs in other areas such as labor costs, can be size of operation. This is because beyond some size, as in other industries, size and tasks grow to exceed the owner/managers' *span of control* and spillover effects or externalities are inevitable. Although welfare problems can occur on small farms as well, size of farming operation *relative to available resources* is relevant to animal welfare in an important way. As livestock industries intensify, and individual firms grow in size, often increasing to multiple enterprises, the attention paid to individual animals decreases. Growth beyond the owners' or managers' ability to keep day-to-day operations under their ***span of control*** and high capital costs that force owners to hire unskilled workers at low cost and substitute cheaper feed inputs, often mean farm animals bear the costs, as described in footnote 18, page 47, above.

III. The part of the consumer

Do consumers care about the welfare of the animals that produce food and other goods and services for them? Some consumers already pay more for meat and other products from animals raised with respect for their natures. However, demand for secondary characteristics or metapreferences (preferences over preferences), such as how the animals are produced, are not readily revealed in the marketplace (Jeffrey 1974, Hirschman 1984). For example, a consumer may have a preference for energy that is not produced by nuclear power. However, if that is all that is available, and the consumer needs energy in order to be effective and make a living, he or she has no choice but to purchase what is available. The consumer's purchase may be misconstrued as a signal to energy producers that the consumer does not care how the energy he or she uses is produced.

Only rarely are animal products labeled as to their methods of production, with the result that consumers ordinarily cannot discriminate among goods at the food counter on that basis. To continue the metaphor, if other energy sources are available but the energy consumer has no information about them, the consumer may perceive that he or she has no choice but to purchase the known product. Again, the consumer's purchase may be misconstrued as a signal to energy producers that the consumer does not care how the energy he or she purchases is produced. The market does not easily allow consumers to reveal their preferences over preferences.

Many consumers who care about farm animals' welfare are vegetarians or vegans out of principle. Most vegetarians and vegans would agree that, if animals are to be produced, they should be produced in ways that are respectful of their biological and behavioral needs.

However, their abstinence from using animal products means their preferences regarding how farm animals should be treated are not reflected by purchases in the market, either. Except insofar as producers change practices because they are concerned that more consumers will choose not to use animal products, the choice of a few consumers, does not, therefore, contribute to improvements in the welfare of the vast majority of farm animals.

Swanson and Mench (2000) note that a number of US opinion polls have revealed that the public cares about how farm animals are raised. Animal Industries Foundation, a trade association for feed companies, commodity groups, and pharmaceutical interests, polled consumers in 1993 and 1998 and found that 51% (1993) and 44% (1998) were willing to pay at least 5% more for food from animals raised humanely and 27% (1993) and 20% (1998) were willing to pay up to 10% more.

In a Zogby America poll (Swanson and Mench 2000), 80% of respondents indicated they would be willing to pay more for eggs from hens treated humanely. A 1995 poll by Opinion Research Corporation found that 92% of Americans disapproved of crate housing for veal calves, 91% disapproved of confinement systems for pigs, and 90% disapproved of keeping hens in cages that did not provide enough space for the hens to stretch their wings. In 1999, a poll by Lake Snell Perry and Associates found strong public concerns about a range of problems associated with industrialized agriculture including water and air pollution and animal welfare.

Still, despite the many willingness-to-pay studies in which consumers have indicated they would pay more for welfare-friendly products, it has been shown that for a majority of consumers, when they get to the market, price counts more, signaling retailers, possibly erroneously, that animal welfare does not matter to consumers (Huirne 2000).

Another interpretation of this situation is that consumers believe that good welfare should be built into the product and already reflected in the price they pay. Producers ought to be providing their animals a good life anyway. Why should consumers have to pay more for them to do this?

Finally, many consumers are sufficiently content with generic meat, dairy and poultry products or sufficiently unfamiliar with the problem or sufficiently confused about conflicting claims, that animal products differentiated by characteristics such as method of production are not provided at a socially optimal level by the market mechanism.

IV. Animal welfare as a public good

Insofar as welfare is comprised of the physical and psychological health of the individual, it is true that aspects of animal health and well-being over and above those strictly needed for animals to produce could be appear to be uncompensated costs of production.

As described in the case of the musk deer in Chapter 2, welfare has public good aspects (Halverson 1991). Those aspects of the deer's welfare that are needed for production (and the farmers' profits) – food, water, shelter (confinement), and medication – are usually provided, at least on a minimal basis, and must be provided if there is to be a product. Those aspects of the deer's welfare not needed for production – the ability to stand, walk, run, browse, stretch its limbs, see the change from daylight to night, and associate with its conspecifics, that is, the

animal's welfare for its own sake – to a point, are optional for the producer, because the animal will produce musk whether these are provided or not.

As noted, too, the preferences of consumers with respect to welfare characteristics of food products are imperfectly represented in the marketplace such that welfare-friendly products may not be produced. These are the public good aspects of animal welfare from the perspectives of production and consumption.

A public good is not provided through the ordinary supply-demand apparatus of the market. National defense, police protection and street repair are often given as examples of public goods, for which no one individual has an incentive to pay even though he or she benefits, among other reasons because the goods are nonexclusive – that is, if he or she pays, others will enjoy them too, possibly without having paid their fair share for them. And, because each believes the others will pay, many will not pay and the socially optimal amount of the good will not be produced because insufficient resources have been allocated for its production. Goods such as national defense, police protection, and street repair are goods whose provision must be coordinated by the public sector – i.e., government. They are "publicly produced."

A more apt example for animal welfare may be public television:

With taxes paid by the public, the government provides a minimal level of service. The service is satisfactory to the majority of public television viewers.

Theoretically, individual citizens were to have contributed to the excellence of public television programming through contributions that supplemented the government's support. By means of these extra contributions, the program schedule could achieve excellence and yield greater benefits to all than if the government provided only enough to pay for the minimum service.

However, because a minimum amount of programming is already provided, because some members of the public do pay and contribute to an enhanced service, and because many public television viewers are satisfied enough with the level of programming provided to not wish to contribute themselves, all of the extra programs that could make public television an excellent service are not purchased or produced and public television falls short of its promise.

Programming is provided, but, like the basic health needed for animal production, it is provided at a basic or minimal level that does not reflect its potential, or in case of animals, does not reflect their needs for healthy productive lives or the social benefits that could accrue due to better farm animal health and well-being.

In this example, those who watch public television and do not subscribe are called "free-riders." The ramifications of their unwillingness to pay their fair share are not obvious because it is impossible to compare the existing service with one that might be better but has not come into being.

In the case of animal welfare, the natural resilience of living organisms, i.e., farm animals, enables free-ridership by humans (consumers who do not purchase the higher priced animal welfare-friendly products and producers who provide only the minimum care) on the aspects of farm animal welfare that are not needed for short-term profits. This resiliency has limits and the possibility that humans can continue to free ride on the resiliency of farm animals cannot be infinite. In some cases, we are nearing the limits of animals' ability to adapt. The

results may be obvious, lameness of dairy cattle that goes hand in hand with selection for high yield. In others, they may be functional disorders, such as "functional infertility," in which there is a failure to reproduce but no detectable pathology of the reproductive system (Fraser, A.F. 1988).

In the case of public goods that the society has deemed important but that the market place cannot provide, incentive mechanisms are put in place by governments to ensure these goods are produced. When equitably enforced, rules provide assurance that every consumer of the public good pays for it and that the producers of the good have a level playing field and all meet the same standards (and incur the same costs) through some mechanism or set of incentives or penalties, such as subsidies, taxes, and transfers. Enforcement and assurance are key factors in making public goods solutions work.

The public television analogy is useful to illustrate the idea of separating what is public and what is private about economic goods such as animal welfare. However, mechanisms for providing the public good aspects of animal welfare in the absence of market incentives to produce them may be different for animal production from the mechanisms needed for public television service. The extent to which public television falls short of its promise is not an externalized cost of production. No one's production activity is having spillover effects on another agent's utility such that the other agent is forced to bear part of the costs of the first agent's production. No one is directly harmed by less public television (although they may be less well off in some sense than they would be if more were available to them).

Externalities displaced onto animals by highly intensive production and artificial selection ultimately affect human welfare because (1) cruelty and unmitigated exploitation of sentient individuals who are incapable of informed consent are offensive to many humans and (2) because experience is showing that current practices that disregard the well-being of agricultural animals are having direct, adverse impacts on the survivability of domestic animals, and on human health, the economy, the shared natural environment, and the sustainability of agriculture. The welfare of farm animals is in many ways a common property resource. The genetic endowment of farm animals is a resource on which current and future human health and welfare depend, for example, and when it is degraded by artificial selection for satisfaction of immediate human wants at the potential loss of future benefits, this is an externality displaced onto future generations.

Whether or not to produce animals and whether or not to internalize the costs of production that market failure allows them to displace onto animals, the environment, neighbors, workers, and society in general are private decisions undertaken by animal producers. Some producers undertake the internalization process willingly, out of conscience.[34] Others will not do it without external incentives, payments, or externally imposed regulations. In contrast to public

[34] D. and C. Wilson (1998) of Paullina, Iowa explained the rationale behind their families' decision to adopt a more animal-friendly farrow-to-grow piglet production system they had seen in Sweden: "The sows and piglets are in a much more natural environment so they are very content and easy to work with…. We have always felt you should treat your animals with respect and patience. Now we are looking at a pork industry in this country that looks at their pigs in terms of how much money they will generate first and the pigs' well-being second. I see an industry that is quickly alienating its customers and is starting to worry about the quality of its product too late." The Wilsons are now part owners with the other farmer members of the Niman Ranch Pork Company and can sell their pork, which follows the Animal Welfare Institute's (US) standards of practice, for a premium price. However, the families' decisions about their farming practices were taken years before the Niman Ranch program was created.

television and road repair, production of animal welfare requires *internalization of an externality by the producer.*

Why in one economy, such as the US, externalization of diseconomies by the production sector should be the rule and, in another country, such as Sweden, producers voluntarily take on the role of producing animal welfare, food safety, environmental quality and other goods at considerable cost is a relevant question for policymaking in the area of farm animal welfare and the other topics in the Generic Environmental Impact Statement.

The political-economic incentive structure in one country must be radically different from the other to achieve the result that what producers in one country perceive as a cost is perceived by producers in another as a value (Halverson 2001). It is worth knowing what is taking place and how and why the perceptions differ to see if such an analysis would be pertinent to policymaking in the area of animal welfare and feedlot regulation in Minnesota.

V. Does Improved Farm Animal Welfare Pay?

A. Price

Most cost-benefit analyses of adopting farm animal welfare protections show a net loss to producers and society, primarily because they fail to look for or calculate any benefits from improving farm animal welfare. If society perceives that better farm animal welfare also has extenuating benefits, such as food safety or environmental quality, it may be inclined to value animal welfare even more highly than if the only benefits were to animals. Thus, not only animal welfare, but also a whole range of public goods can be produced from improving how we raise and care for farm animals.

On another level, the producer may receive benefits in the form of better growth or improvements in other production goals as a result of improving animal welfare. As an example, a 1997 Swedish study quantified the impacts of the "Swedish model" of meat production (no subtherapeutic use of antibiotics, high level of animal welfare, strict environmental rules) on the production costs of Swedish pork as compared to where Sweden might be if it had stayed on an industrial path (Andersson and Jonasson 1997). Comparing a representative Swedish hog farm with a Danish (more industrial) style hog farm operating under Swedish conditions, the authors found that the extra production cost of incorporating all aspects of the Swedish model amounted to around 3.6¢ per pound (at an exchange rate of 6.5 SEK/$1) of pork produced. Extra production costs of implementing the antibiotic ban alone were less than 1¢ per pound (at 6.5 SEK/$1). Unlike most cost-benefit studies of the impacts of animal welfare and other food-related legislation, these authors also quantified the economic benefits of improved animal health and well-being resulting from implementation of the "Swedish model" and balanced them against the extra production costs. The benefits included healthier pigs and reduced veterinary medical costs over the Danish model.

In evaluating net welfare costs/benefits from imposition of restrictions on animal production, the potential social benefits from implementing changes need to be identified and balanced against the social costs of retaining the status quo and all that it entails. With respect to costs of production, some of these have already been mentioned: In Chapter 6 a study was reported that showed per-lactation health care costs for mastitis in the US were $49 per cow greater for a line of dairy cattle selected for high yield than for an unselected line; and Chapter 7 a figure of $500 was given for the replacement/opportunity costs for a dead sow in the US. When determining costs to producers of adopting alternative technologies, it is important to identify potential reductions in current costs that can be expected from implementing production methods that are compatible with the biological and behavioral needs of farm animals. For example, one should include the reductions in costs from reduced mastitis incidence and the reductions in costs from reduced sow mortality that can be expected from implementing production methods that are more compatible with the welfare of cows and sows. Social costs of maintaining the status quo are also relevant.

2. Case examples from Swedish investigations

a. Producer costs and benefits

These comparisons have been estimated in Sweden (Ekesbo and Lund 1994). The costs per case of injury in dairy cattle due to teat trampling was estimated to be $255 if not treated by veterinarian and $527 if veterinary treated. The cost for mastitis resulting from teat trampling was $700 per case and the cost for each recurrence was $416. The cost for each case of ketosis was estimated to be $277. Each MMA (metritis mastitis agalacteia) case was estimated to cost $176. The cost per case of tailbiting in finishing pigs was estimated to be $8.60. The estimations were for 1993, when the exchange rate was 5.80 SEK/US dollar, and included the prices of labor, buildings, medicines, and veterinary costs in 1992.

As noted in Chapter 6, these diseases and abnormal behaviors can be highly correlated to problems in the production environment and with artificial selection that directly relate to the welfare of the animal and its ability to behave normally with respect to its environment. Trampled teats in dairy cattle can be exacerbated by the size and quality of the surface of the lying area, type and amount of bedding, confinement or pasture in summer, and use of electrical cow trainers which cause abnormalities in how cows lie down (Ekesbo 1999b). Artificial selection, shown to result in lower hanging udders with each parity, also can affect the risk of teat trampling while the cow lies down and gets up, but was not included in the Ekesbo and Lund (1994) cost-benefit study.

Because under Swedish conditions trampled teats are the most important risk factor for mastitis, the factors for the two together are the same. Incidence of fertility disorders in dairy cattle have been linked to artificial selection for high milk yield. Incidence of fertility disorders in dairy cattle is greater in total confinement than when cows have access to pasture in the summer. Incidence of ketosis also is greater in confinement and less when there is accessibility to pasture during summer. Incidence of MMA in sows is greater in restrictive confinement of farrowing crates and less in loose housing with access to straw during the pre-farrowing, farrowing, and lactation periods. Tail biting in finishing pigs has been related to lack of straw, slatted floors in the lying areas, as well as low area per pig and poor ventilation. Reliable information on exactly what percentage of other diseases are caused by environmental factors or

information regarding their costs with which to confidently compare the effect of management factors were not available to the authors for the cases of hoof diseases or injuries, parturient paresis, urinary infections in sows, diarrhea and respiratory diseases in calves, or all poultry diseases, although these are known to be influenced by the production environment (Ekesbo 1999b).

When Ekesbo and Lund (1994) balanced the costs of the requirement to provide cows with access to pasture in summer against the health benefits, they found that the requirement led to an annual increase in profit of $33.88 to $40.59 per cow in a 100 cow herd (dependent on the breed of cow), due to fewer cases of ketosis, trampled teats, and mastitis. In addition, there were benefits from longer productive lives, which gave an extra $73.96 to $96.32 per year, depending on breed of cow, as the rearing costs per cow were spread over more productive months. The cost-benefit result of the ban on electric cow trainers was a net profit of $55.04 to $77.40 per year due to the reduced mastitis incidence and longer average cow productive life (decreased rearing cost per productive month) from not using electric cow trainers.

The ban on permanent confinement of sows to gestation or farrowing crates combined with the requirement of access to straw or similar material for sows increased the net return per sow in a 150-sow herd by $41.28 to $239.08 through reduced costs for the diseases noted above and reduced piglet losses due to prolonged farrowing times (Ekesbo 1999b). The requirement for access to straw or similar material together with a ban on slatted floors in the lying area of finishing pigs increased net return per pig place by $12 to $16 due to reduced incidence of tail biting.

Ekesbo (1999b) notes that when cost-benefit evaluations of measures against farm animal diseases caused by housing or management are made, it is easy to determine costs but the benefits are seldom addressed. As a result, farmers and others are left with the impression that giving the animals more biologically correct environments will result in greater costs of production. But animal welfare rules, which are based on the animals' needs and designed to protect their health and provide opportunity to perform their normal behaviors, result in better animal health and reduce losses due to animal diseases that are considered "routine" in intensive confinement, providing farmers with higher profits.

Transport of farm animals is also strictly regulated in Sweden. It is not allowed to transport any pregnant ruminant, mare, or sow during the last three weeks of pregnancy, nor is it allowed to do so after delivery for ruminants during the first three weeks and for sows and mares during the first week. Formal rules for transport time are those of the EU, for example, the 8-hours rule for slaughter animals. The Swedish Federation of Farmers has voluntarily agreed that no calves weighing fewer than 50 kg shall be transported. This has resulted in improved health figures in intensive calf rearing units so that it is now difficult to sell a calf that weighs fewer than 60 kg (Ekesbo 1999b).

The Farmers' Cooperative Slaughter Association has tried to arrange that most cattle and pigs destined for slaughter are transported fewer than three hours. Since 1986, most slaughter transport and transport from breeding units to further production units (as from piglet producing farms to finishing farms) that are coordinated by the Association have been in climate-controlled trucks so that animals will not be exposed to high temperatures during transport or when the truck is standing. In these trucks, the driver has equipment that allows him to monitor the temperature in the animals' compartment while driving. Broilers may travel further than cattle and pigs and so all broiler transport is climate controlled since 1986.

Slides showing live transport vehicles for farm animals in Sweden follow.

Figure 8-4. Swedish slaughter transport vehicle.

Photo credit: Jerry DeWitt

Figure 8-5, 8-6. Interior of Swedish slaughter transport vehicles, subdivided into compartments for different aged, sized, and sexed animals.

Photo credits: Marlene Halverson

Large animals that go down on the farm by law must not be transported alive. They must be killed and bled on the farm. A trained employee of the slaughter plant does this and the carcasses are returned by a special refrigerated truck or "ambulance" to a special "sanitary" area of the slaughterplant where they are tested for disease. If there is no disease and the animal was injured but otherwise healthy, the meat can be sold through the regular market. (See figures 8-7-8-10.)

Figures 8-7, 8-8. Sanitary slaughter truck (djurambulans).

Photo credit: Marlene Halverson

Figure 8-9. Interior of sanitary slaughter truck.

Photo credit: Marlene Halverson

Figure 8-10. Interior of a sanitary slaughter facility.

Photo credit: Marlene Halverson

The costs involved in transporting animals in Sweden obviously are high compared to other countries (Ekesbo 1999b). Costs for the transport vehicles, annual capital costs, and costs of extra equipment in comparison to the wholesale price of meat per kg received by the slaughterhouse are: Broiler transport, cost $0.0098 per kg, price $1.96 per kg (the cost for putting the label on the meat when it leaves the slaughterhouse is $0.014); pig transport, cost $0.0043 per

slaughtered pig, price $2.42 per kg; beef (young bulls of 270 kg slaughtered weight), cost $0.0050 and price per kg, $3.78.[35]

The gains from lower mortality during transport as well as decreased condemnations of part or whole carcasses are not yet counted against the costs of transport in the above figures. Hence according to the industry's estimates, the gains balance the extra costs of high-welfare transport. There are also gains in consumer confidence, as the industry uses the quality of its transport in its public relations.

b. Social costs and benefits

Social costs and benefits as well must be calculated when calculating the economic impact of animal welfare regulations. In Chapter 4, we compared one study's projection of increases of $6.05 per hog cost of production for the first year of a ban on subtherapeutic use of antibiotics and a 5.2¢ per pound increase in cost of pork to consumers (Hayes, et al. 1999), which added to a total cost to consumers and producers of $1.291 billion the first year of a ban, to the estimated $4 billion annual cost of infections caused by drug-resistant organisms in the United States (Boggs 1999), at least some of which originate in agriculture.

Practices that contradict the biology and behavior of farm animals have consequences, not only in respect to reduced immunity, vigor, longevity, and reproductive capabilities, but also in the form of zoonotic diseases such as bovine spongiform encephalopathy (thought to result from feeding animal remains to ruminant herbivores) and salmonella (exacerbated by stressful and unhygienic management and environment) and the spread of diseases by transport of infected live animals. Costs paid to make production, transport, and slaughter environments more considerate of the animals may be seen as investments against such future events.

Few may want to pay the price for improving the welfare of farm animals, but society and individuals do bear the costs of the reduced effectiveness of antibiotics, soil and water pollution by manure spills, foodborne illnesses associated with contaminated animal products and the costs of cleanup when the system breaks down. Examples of such costs are an estimated $90.39 million needed in Germany to destroy meat and bonemeal (MBM), fat and other feed in the aftermath of the BSE epidemic (Reuters 2001); $244.8 million needed by Belgium to burn one million tons of animal-based animal feed; and the additional money needed to store tons of cattle carcasses until they can be destroyed (Reuters 2000). Some suggest that the Europeans are learning the hard way that the price of cheaply produced food is high (Fort 2001).

Studies that predict potential costs and benefits of technology changes that might be imposed by adopting new regulations, or any technology changes, will never be precise and may not be accurate if unforeseen potential costs and the benefits of avoiding them are not recognized. Retrospective studies can represent costs and benefits more accurately provided these are known and dollar figures can be attached to them. However, when conducting retrospective studies, both privately and socially borne costs and benefits must be identified and it is always easier to measure the costs than to identify and measure the benefits that resulted from change.

[35] On April 9, 2001, the EU announced proposed new rules for transport of live farm animals, including requirement that trucks be equipped with monitoring and climate control devices, similar in nature to Sweden's live transport vehicles. The rules were expected to cost between 3-5% of the cost of a truck (Reuters newswire, April 9, 2001).

The immense private and social costs of preserving the status quo in modern, highly intensive animal production have gone largely unacknowledged heretofore. Similarly, the social and economic benefits of change in this area have been unacknowledged. While other countries have been affected by disease outbreaks -- BSE, swine fever, and hoof and mouth disease – in the past few years, Sweden has so far avoided the problems, with the greatest disease threat to animal and human health coming from imports and visitors from other countries.

Many farm and food policy steps that Sweden has taken since the 1950s have placed it on a different path from industrialization. Consumers and farmers have benefited (George 2001).

It seems clear from these calculations that *all* the relevant economic and material costs and benefits of animal welfare are not represented in the simple "productivity-welfare tradeoff" models of McInerney (1991a&b) and Bennett (1994, 1995) (page 182) or in benefit-cost analyses that take into account only the added costs of animal welfare regulations.

Sweden, and in some respects, the other Scandinavian societies, which operated according to the precautionary principle in many of these areas starting some years ago,[36] now appear to be reaping the longer term benefits. By paying the extra costs of providing for farm animal welfare up front, Sweden so far avoided the consequences of farming without regard to the adaptive limitations of animals, while other countries did not escape the catastrophes and are incurring the monetary costs.

In Sweden, animal welfare laws function as animal health laws and that is how they are perceived (Ekesbo 1999b). That is, "animal welfare laws give guidelines for prevention of management- and environmentally-evoked [manmade] diseases by 'adapting animals' environments to their biological needs and by eliminating disease-evoking factors in the environment. To do so instead of just trying to treat or prevent symptoms is in accordance with classical ethical and medical principles" (Ekesbo 1999b).

It may become significant for US agriculture and trade that the European Union, as a consequence of the heavy costs being inflicted by the BSE and hoof and mouth emergencies, is looking toward adopting the kinds of agricultural and environmental policies (particularly the preventive, "healthy animal" policies) that have been guiding Sweden for the past few decades. The EU has expressed its intention to press for inclusion of animal welfare in WTO negotiations. As a self-preservation measure, the EU may feel justified in demanding like reforms on the part of its trading partners. This could have consequences for Minnesota livestock producers that wish to trade with Europe. Before adopting a defensive posture, the potential benefits of improving our own agricultural systems with respect to animal health and well-being should be assessed to ascertain whether in the long-run, cooperation rather than conflict may pay off.

References

Andersson, H. & Jonasson, L. (1997). *Den Svenska Modellen: Hävstång eller ok für Svensk svinproduktion*? Uppsala, Sweden: Swedish University of Agricultural Sciences.

[36] Sweden banned the use of animal remains in farm animal feeds in 1986, banned the use of antibiotics at subtherapeutic levels in animal feeds in 1986, banned the use of meat and bone meal in animal feeds in 1987, and banned the import of live cattle, embryos and semen from the UK in 1988 (See Chapter 10).

Bennett, R.M. (1994, Sept. 30). Theoretical and practical considerations for the valuation of farm animal welfare (pp. 27-50) *Valuing Animal Welfare: Proceedings of a Workshop held at the University of Reading.*

Bennett, R. (1995). The value of farm animal welfare. *Journal of Agricultural Economics, 46(1)*, 46-60.

Dawkins, M.S. (1980). *Animal suffering: The science of animal welfare*. London: Chapman and Hall.

Ekesbo, I. (1988). Animal health implications as a result of future livestock and husbandry developments. *Applied Animal Behaviour Science, 20:* 95-104.

Ekesbo, I. (2000). Animal welfare and the Council of Europe. *Ruth Harrison Memorial Meeting, Farm Animal Care Trust, Fyvie Hall, University of Westminster, London, November 29, 2000.*

Ekesbo, I. (1999a). Council of Europe Standing Committee for Farm Animal Welfare -- A presentation. *European Union Animal Welfare Course*, *Dublin*, *Ireland, August 27, 1999.*.

Ekesbo, I. (1999b). The Swedish experience: Animal welfare legislation – an instrument also for health protection. *European Union Animal Welfare Course, Dublin, Ireland, August 27, 1999.*

Ekesbo, I. & Lund, V. (1994). Different standards in animal welfare legislation: Consequences for animal health and production economy, *Proceedings, International Society for Animal Hygiene Congress, International Society for Animal Hygiene, St. Paul, MN, September 12-16, 1994, University of Minnesota and Washington State University, sponsors,* PA1-PA5.

Ekesbo, I. & Lund, V. (1993). Svensk djurskyddslagstiftning I EG-perspektiv. *Statens Jordbruksverk, Bilaga till Rapport, 21.*

Fort, M. (2001, February 25). Paying the price for cheaper food: The state of Britain's abattoirs represents a failed quest to produce ever cheaper food. Observer Focus special: Britain's food scandal, Special report: Foot and mouth disease. Guardian special report: countryside in crisis. *The Observer.*

Fraser, A.F. (1988). Behavioural needs in relation to livestock maintenance, in *Behavioural Needs of Farm Animals: Proceedings of a Workshop Sponsored by the Farm Animal Care Trust and the Universities Federation for Animal Welfare. Applied Animal Behaviour Science, 19,* 339-386.

George, N. (2001, February 20). *Sweden's caring farmers are rewarded with public's trust: Europe's mad cow disease has failed to infect Sweden, where intensive farming practices were rejected in the 1980s.* Financial Times, Feb 20, 2001.

Greer, D.F. (1984). *Industrial organization and public policy*. New York: MacMillan.

Halverson, M. (2001). *Elucidating a framework for provision of a privately-produced public good: Animal welfare and the case of Swedish swine production*. Ph.D. dissertation. St. Paul, MN: University of Minnesota, Department of Applied Economics.

Halverson, M. (1991). *Farm animal welfare: Crisis or opportunity for agriculture? Staff Report P91-1 (Rev. September 1991).* St. Paul, MN: University of Minnesota, Department of Agricultural and Applied Economics.

Halverson, M. (2000). The price we pay for corporate hogs. Minneapolis: Institute for Agriculture and Trade Policy.

Harrison, R. (1964). *Animal machines: The new factory farming industry.* London: Vincent Stuart Ltd.

Hassebrook, C. (1981, March 25). Tax policy nets hog surplus. *Omaha World Herald.*

Hayes, D.J., Jensen, H.H., Backström, L., and Fabiosa, J. (1999, December). *Economic impact of a ban on the use of over-the-counter antibiotics. Staff Report 99-SR 90*. Ames, IA: Iowa State University, Center for Agricultural and Rural Development.

Hinrichs, P. (1989). Animal welfare options and regulations in European pig production: Impacts on productivity, production costs, and competition. *Session I. Welfare regulations in Europe, and their effects on physical and economic aspects of pig production*. European Association of Animal Production. 40th Annual meeting, Dublin, 28-21 August.

Hirschman, A.O. (1990). Interview. *Economics and sociology redefining their boundaries: conversations with economists and sociologists*, (152-166). Richard Swedberg, rapporteur. Princeton: Princeton University Press.

Huirne, R. & den Ouden, M. (2000). Farm animal welfare in an economic context. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Jeffrey, R.C. (1984, July 18). Preferences among preferences. *The Journal of Philosophy, 71 (13):076* 377-391.

Lake Snell Perry and Associates. (1999). *Results of a nationwide survey of 1,000 adults conducted March 23-25, 1999. Commissioned by several environmental and animal welfare organizations*. Humane Society of the U.S. Press Release.

Lazarus, W., Nordquist, D. & Eidman, V. (1991, November). *Economics of some swine production systems with reference to animal welfare. Staff Paper P91-49.* St. Paul, MN: University of Minnesota, Department of Applied Economics.

Marbery, S. (1999, January 18). Traditional values driving upscale pork market. *Feedstuffs,* 18, 21.

Mason, J. & Singer, P. (1980). *Animal factories: The mass production of animals for food and how it affects the lives of consumers, farmers, and the animals themselves.* New York: Crown Publishers.

McInerney, J. (1991a). Assessing the benefits of farm animal welfare. *Farm animals: It pays to be humane*. CAS Paper 22. Reading: Centre for Agricultural Strategy, pp 15-31.

McInerney, J.P. (1991b). Economic aspects of the animal welfare issue. (pp. 83-91) *Society for Veterinary Epidemiology and Preventive Medication Proceedings. April 17-19. London.*

Mishan, E.J. (1993). Economists versus the Greens: An exposition and a critique. *The Political Quarterly, 64(2):* 222-242.

National Research Council, Committee to Study the Human Health Effects of Subtherapeutic Antibiotic Use in Animal Feeds, Division of Medical Sciences, Assembly of Life Sciences. (1980). *The effects on human health of subtherapeutic use of antimicrobials in animal feeds.* Washington, DC: National Academy of Sciences, Office of Publications.

Newberry, R., Webster, A.B., Lewis, N.J., and Van Arnam, C. (1999). Management of spent hens. *Journal of Applied Animal Welfare Science, 2,* 13-29.

North Central Regional Center for Rural Development. (1999). *Bringing home the bacon: The myth of the role of corporate hog farming in rural revitalization.* A report to the Kerr Center for Sustainable Agriculture. Weatherford, OK: The Kerr Center for Sustainable Agriculture.

Opinion Research Corporation. (1995). *Results of a nationwide telephone survey of 1,012 adults conducted August 17-20, 1995*, for Animal Rights International.

Penn, J.B. (1979). The structure of agriculture: An overview of the issue. *Structure Issues of American Agriculture. AER 438*. Washington, DC: Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture.

Powell, T.A., Brumm, M.C., & Massey, R.E. (1993). Economics of space allocation for grower-finisher hogs: A simulation approach. *Review of Agricultural Economics, 15(1),* 133-141.

Reuters. (2000, December 16). Belgian expert bemoans EU panic over BSE.

Reuters. (2001, January 31). Germany to pay one third of MBM destruction costs.

Smith, R. (1994, February 28). 'Commander's tour,' good management urged to prevent salmonella in swine. *Feedstuffs,* 14.

Swanson, J.C. and Mench, J.A. (2000). *Animal welfare: Consumer viewpoints*. University of California Poultry Symposium and Egg Processing Workshops, Modesto, CA (11/7/00) and Riverside, CA (11/8/00).

Tweeten, Luther. (1991). Public policy decisions for farm animal welfare. *Journal of agricultural and environmental ethics. Special supplement 1, 6*:87-104.

U.S. Congress. (1986, November 24). *Selling out the family farm: a classic case of good intentions gone awry. A report prepared for the use of the Subcommittee on Agriculture and Transportation of the Joint Economic Committee, Congress of the United States by the Republican staff.* Washington, DC: U.S. Government Printing Office.

Van Arsdall, R.N. & Nelson, K.E. (1984). *U.S. hog industry. AER 511*. Washington, DC: Economic Research Service, U.S. Department of Agriculture.

Van Putten, G. (1973). Resources under pressure. *Proceedings of a symposium, 44-49. Reference lost.*

Van Putten, G. (1988). Farming beyond the ability of pigs to adapt. *Applied Animal Behaviour Science, 20,* 63-72.

Wade, M.A. & Barkley, A.P. (1992) The economic impacts of a ban on subtherapeutic antibiotics in swine production. *Agribusiness, 8(2)*, 93-107.

Wilson, D. & Wilson, C. (1998). Experiences with a Swedish deep-bedded swine system. Soil and Water Conservation Service annual meeting: *Manure Management in Harmony with the Environment and Society, February 10-12, 1998.* (pp. 142-145). Ames, Iowa: Iowa State Center, Scheman Building.

Wilcox, C.J. (1989). Social costs of regulation of primary industry: An application to animal welfare regulation of the Victorian pig industry. *Australian Journal of Agricultural Economics, 33 (3),* 187-202.

CHAPTER 9

MITIGATION MEASURES: ANIMAL WELFARE REGULATIONS IN THE US, WITH SPECIAL REFERENCE TO FARM ANIMAL PROTECTION IN MINNESOTA

Legislation and regulation based on up-to-date scientific knowledge about the biological and behavioral needs of farm animals are the most reliable available and potential mitigation measures for improving the welfare of animals raised for food or food production, *if strictly and equitably enforced*, because they are capable of providing a high level of welfare to farm animals and they ensure a level playing field for all producers.

There is very little legislation protecting farm animals in the United States and what laws there are carry weak penalties, as will be discussed below in Part I. Whereas pet animals are well represented by the state's humane organizations, Minnesota's farm animals have few organized defenders. In all but a handful of agricultural states, farm animals have been legislated out of the state anticruelty acts that originally protected all animals. Frequently agribusiness-initiated legislation exempting farm animals from state anticruelty acts has been supported by pet animal organizations who see the move as an acceptable tradeoff for getting stronger penalties for cruelty to pets. There is no scientific evidence that farm animals suffer any less than pet or companion animals do from cruelty or neglect nor is there evidence that, morally speaking, it is defensible that they should be less protected under the law than pet or companion animals.

Opponents of legal farm animal protections appeal to consumers' faith in the traditional farmers' concern for their animals as a reason why legal protection of farm animals is unnecessary. However, as Chapters 2-7 have shown, current industry practices are not traditional in the sense that most consumers that are removed from agriculture envision when they think of traditional agriculture. Part II addresses whether Minnesota has a farm animal welfare problem, giving special attention to the fate of downed (injured, lame, and untreatable) farm animals.

I. Animal Welfare Regulations in the United States

A. Federal Regulation

The seminal US Federal Law that regulates treatment of animals is the Animal Welfare Act (7 U.S.C. et. Seq. 1970 as amended). However, as stated in the "Literature Summary for the GEIS on Animal Agriculture", University of Minnesota,

> …animals raised for food or fiber, the animals of animal agriculture, are specifically excluded from the Animal Welfare Act and the regulations promulgated thereunder. The farm animal exclusion states:
>
> > but such term excludes horses not used for research purposes and other farm animals, such as, but not limited to livestock or

> poultry, used or intended for use as food or fiber, or livestock or poultry used or intended for improvingl animal nutrition, breeding, management or production efficiency, or for improving the quality of food or fiber (7 U.S.C. 2132)

This Federal exclusion of farm animals from protection under the Animal Welfare Act is partially ameliorated by the Federal Laws governing treatment of animals during transportation and at slaughter and killing facilities. Section 1901 of United States Code 7 states that,

> The Congress finds that the use of humane methods in the slaughter of livestock prevents needless suffering; results in safer and better working conditions for persons engaged in the slaughtering; brings about improvement of products and economies in slaughtering operations; and produces other benefits for producers, processors, and consumers which tend to expedite an orderly flow of livestock and livestock products in interstate and foreign commerce. It is therefore declared to be the policy of the United States that the slaughtering of livestock and the handling of livestock in connection with Slaughter shall be carried out only by humane methods.

Section 80502 Transportation of animals of U.S.C. 49 sets forth some standards for the welfare of livestock in transit. According to this section an animal may not be confined in a vehicle or vessel for more than 28 hours without being unloaded for food, water and rest. However, the owner may request an extended 36 hour period of confinement. Contrast this with the 8 hour time limit in the EU Directive.

Further, the section requires that the animals be unloaded in a "humane" way into pens for at least 5 consecutive hours. The penalty for violation of these provisions in $100-$500 for each violation. Animals that are not transported across state lines are not protected by this Code.

Neither of these Codes protects the animals while they are on the farm.

B. State Laws

1. Other States

Every state has an anticruelty statute that protects animals in a general way from inhuman treatment. However, according to Beyond the Law by David J. Wolfson, Esq.

> …thirty states have enacted laws that create a legal realm whereby certain acts, no matter how cruel, are outside the reach of anticruelty statutes as long as the acts are deemed "accepted", "common", "customary" or "normal" farming practices. These statutes have given the farming community the power to define cruelty to animals in their care.
>
> …Moreover, of these 30 states, 18 amended their statutes in the last ten years to place agribusiness beyond the statutes reach. In the last four years alone, Connecticut, Idaho, Michigan, New Jersey, North Carolina, and Wyoming

> enacted amendments to their anticruelty statutes to exclude animals raised for food or food production. Clearly a definite trend exists. (Wolfson, 1999)

In discussing these laws, Wolfson quotes Mr. Justice Bell in the "McLibel" verdict:

> [the argument was presented that] any practice which accorded with the norm in modern farming or slaughter practices was thereby acceptable and not to be criticized as cruel. I cannot accept this approach…. To do so would be to hand the decision as to what is cruel to the food industry completely, moved as it must be by economic as well as animal welfare considerations.
> In a number of states only veterinarians or agricultural extension agents are allowed to make a determination of cruelty with respect to a farming practice, while state humane societies retain jurisdiction over acts committed against non-farm animals.

The creation of legal exemptions for acts specifically toward farm animals indirectly is an admission that, prior to the exemptions, the acts were considered cruel under the law and thus would have been legal offenses.

Because scientific evidence does not support the notion that farm animals suffer any less from these customary acts than companion animals do, the effort to exempt farm animals from anti-cruelty acts is political and not science-based. In fact, this legislative trend toward exempting farm animals from anticruelty standards is in opposition to popular opinion, as the public opinion polls described elsewhere attest.

Idaho's amendment illustrates the language used in the legislation (Wolfson 1999):

> The anticruelty statute shall not be construed as interfering with normal or accepted practices of animal identification and animal husbandry and any other activities, practices, or procedures normally or commonly considered acceptable. IDAHO CODE, §25-3514(5)(9)1997….

> any other…activities normally or commonly considered acceptable…[are exempted]…all activities described in this section are not construed to be cruel nor shall they be defined as cruelty to animals, nor shall any person engaged in the practices, procedures, or activities be charged with cruelty to animals. IDAHO CODE, §25-351(5)(9) 1997

The law is enforced by the Idaho Department of Agriculture.

2. Minnesota

Minnesota's laws were described in Crooker, et al. (1999). Minnesota, as do other states, has an anticruelty statute (Minn. Stat.343.20 Subd. 2). Unlike the Federal Code, the Minnesota statute defines animal as "…every living creature except members of the human race," so that its provisions protect farm animals. Minnesota is one of only a handful of agricultural states that treats farm animals and companion or pet animals equally. However, amendments have been proposed which would exempt farm animals from the protections of the statute, while strengthening penalties for pet animals. For example, legislation proposed by Rep. Jim Rostberg,

R, Isanti in the 1999 session made an exemption for "accepted husbandry" ("Rep. Rostberg's animal cruelty bill reworded and sent to agricultural committee", Capitol Roundup website).

An effort in 2001 to introduce legislation to strengthen penalties for cruelty to pet animals (SF 197) has been accompanied by attempts on the part of some legislators to add an amendment exempting farm animals from the state anticruelty act. Language was added to SF 197 to exempt pet animals in agricultural zones from protection. H 1330, the House bill does not contain the agricultural language. The bills are still under consideration as of this writing.

II. How well do farm animals fare in Minnesota?

One could come away from Crooker, et al. (1999) with the viewpoint that there are no farm animal welfare problems in modern animal agriculture, in Minnesota or elsewhere. There is much to be proud of in Minnesota agriculture, but Minnesota cannot afford to be complacent about its farm animals. It should be understood that consumers are watching, they are seeing problems as well as successes, and their concerns are legitimate.

Often, the traditional farmer's concern for his or her animals is cited as a reason why it is not necessary to have laws protecting farm animals. With respect to contemporary, industrial farming practices this claim can be challenged, among other things, by evidence of the many sick and injured farm animals that are sold by producers for modest economic gain and transported tens and hundreds of miles despite the suffering entailed on the journey and prior to slaughter. The ability of animals to suffer does not end when their productivity ends. To be credible, the industry's concern for the welfare of farm animals must extend past their usefulness so that animals that have served their interests are not just discarded when their productive life is over. The opinion should not be "out of sight, out of mind." It is also claimed that animals must be well or they would not be producing so well. As previous chapters have indicated, production parameters, alone, are neither necessary nor sufficient indicators of welfare. The costs to the animal of maintaining production at levels that return a profit to producers' given technology choices need to be weighed, as well, and they can be considerable.

The welfare of farm animals needs to be the responsibility of the producer from birth to slaughter. Ways should be found to enable the producer to exercise that responsibility effectively. For example, the producer should have the power to demand from genetics suppliers animals that are genetically sound and vigorous and not merely prolific and fast growing and the price paid to producers for their animals and animal products should make it possible for them to produce them ethically.

The following photos are reprinted by permission from Defending Farm Animals, Inc., a Minnesota volunteer group whose mission is to "reduce the suffering of food animals through investigations, exposés, and public education." They are not included to shock, condemn, or "polarize". The photos demonstrate how some segments of Minnesota agriculture behave toward farm animals and how the public perceives this behavior. They show that there is a need for pro-active self-examination and reform, not defensiveness, on the part of Minnesota agribusiness. Commentary from the group's brochure accompanies some of the photos to further illustrate the nature of public concerns.

The Defending Farm Animals, Inc. website and mobile exhibits are used to bring public attention to the need for reforms (http://www. defendingfarmanimals.org).

Figure 9-1. Hens in a Minnesota egg factory, 9 to a cage built for 2-3.

© *Defending Farm Animals, Inc.*

"Have you ever wondered how an egg can cost only a few cents? Millions of Minnesota hens live … crammed in battery cages…. placed in huge arrays where conveyer belts deliver feed and carry eggs away. After intensive egg laying the hens are considered spent. They are then packed into trucks and shipped to a slaughterhouse. This is the first exposure to sun and outside temperatures in many of their lives."

Figures 9-2. Spent laying hens outside a Minnesota egg factory, packed and waiting for transport to slaughter.

© *Defending Farm Animals, Inc.*

Figure 9-3. Spent laying hens waiting outside a Minnesota slaughter facility. Having been there overnight in below zero weather, some have frozen to death.

© *Defending Farm Animals, Inc.*

Figure 9-4. Pregnant sows at a Minnesota pig breeding facility.

© *Defending Farm Animals, Inc.*

"Sows are as smart as dogs and suffer in animal factories."

Figure 9-5. Crated, pregnant sow with prolapsed uterus going unattended in Minnesota breeding hog facility.

© *Defending Farm Animals, Inc.*

Figure 9-6. Farrowed sow with piglets at another Minnesota pig breeding facility.

© *Defending Farm Animals, Inc.*

Figure 9-7. Pregnant sow at a Minnesota pig breeding facility.

© *Defending Farm Animals, Inc.*

"In Minnesota, thousands of female breeding pigs live in small crates for most of their lives"

Figures 9-8, 9, 10, and11. Downed dairy cattle waiting for slaughter at a Minnesota "downer" facility. The animal on the right has a splay leg injury, indicating a broken pelvis, a common injury when cows are kept on slick floors covered with wet manure.

© *Defending Farm Animals, Inc.*

"Downers – animals too sick, weak, or injured to walk – are often dragged and bulldozed to slaughter, or left to die."

© *Defending Farm Animals, Inc.*

"Downed cow waiting for slaughter outside a Minnesota plant (-18°F)"

© Defending Farm Animals, Inc.

"Cow dumped on a dead pile at a Minnesota stockyard (-20°F). This unwanted downed cow was unable to walk into the slaughter auction ring, so she was dumped on a dead pile at the end of the day. After suffering for hours she was found frozen to death."

Figure 9-12. Injured dairy Holstein waits for packing house pickup after having given birth at a Minnesota stockyard.

© Defending Farm Animals, Inc.

Figure 9-13. Rendering truck loaded with dead animals from an auction house.

© Defending Farm Animals, Inc.

"A day's load of animals that did not survive to be auctioned in Minnesota."

Another Minnesota cruelty issue that is of concern to Minnesota residents who aware of it is animal suffering associated with slaughter practices at a number of Hmong slaughter facilities around the state (KARE-11 2000b&c, KSTP-TV 2000). Because of a cultural preference shared by many Hmong for the taste of meat from animals that are butchered and bled without having been stunned prior to killing (KARE-11 2000a), a growing number of Minnesota citizens are expressing concern that animals slaughtered at many Hmong plants in the state undergo great suffering before they die (Figure 9-14). Defending Farm Animals, Inc. has documented and brought the issue to public awareness through its mobile exhibits (Holston 2001).

Figure 9-14. Pig being bled at a Hmong slaughter facility, Minnesota: Strung-up while conscious, this pig's throat was cut without prior stunning, a violation of the Federal Humane Slaughter Act, to which many Hmong plants are not subject because they are not inspected by the U.S. Department of Agriculture.

Photo credit: Defending Farm Animals, Inc.

D. Enforcement in the United States and Minnesota.

In the United States, farm animals are exempt from the Federal animal welfare Code. The USDA inspects zoos, laboratories, and circuses, but not the farms where eight billion animals are raised yearly.

In Minnesota, no governmental agency is responsible for inspecting facilities for compliance with or enforcing such farm animal protection standards as there are. The mandate of the Minnesota Board of Animal Health is to "protect the health of Minnesota domestic animals." However, the majority of their inspections (98% of 2,000 inspections annually) deal with the detection and eradication of infectious diseases of farm animals (Crooker, et al. 1999) to prevent their spread. While this contributes to reducing welfare problems resulting from epizootic illnesses, it does not cover the impacts on animals of what was defined in earlier chapters as resulting from deficiencies in the production environment or in management, for example, injuries, lameness, infertility, cruelty in handling, and behavioral deprivation.

No state agency is mandated to oversee or ensure the welfare of individual animals on Minnesota farms. This is an important gap in animal protection that should be filled. While Minn. Stat. 343.01, et seq., as of now covers all animals in Minnesota, the statute provides weak penalties for violations against farm animals, no matter how severe the violation. For example, a farmer who neglects to feed his animals to the point that they starve to death is subject to a possible misdemeanor penalty of only $700 and a possible 90 days in jail (See Minn. Stat. 343.21 Subd.9 and Minn. Stat. 609.02 Subd. 3) (Crooker, et al. 1999).

III. Development of alternative production methods.

When an existing technology is entrenched, as is the case with the industrial model of livestock production, it is unlikely to be uprooted except by regulations. These regulations should require research, development, and adoption of scientifically-based alternatives. It is also appropriate for the State legislature to authorize funding for research into scientifically-based alternatives.

The availability of successful alternative models of production is critical to abandonment or reform of existing models. However, the institutional framework must be "hospitable" to adoption of new methods. Hence, the existence of alternative production systems providing more biologically and behaviorally appropriate management and environments can be included among available and potentially available mitigation measures for addressing negative impacts of animal agriculture on animal health and well-being, as the existence of technology choices provides the opportunity for reform. However, the framework of laws and policies must reflect society's preferences for more humane animal farming.

Crooker, et al. 1999 described a welfare-compatible production method for dairy cows known as intensive rotational grazing that has gained favor among a segment of Minnesota dairy farmers and has been the subject of research at the University of Minnesota West Central Research and Outreach Center (WCROC) at Morris, Minnesota. Since 1998, a task force made up of farmers, researchers and independent consultants has been setting up a research and demonstration program at the WCROC to investigate and demonstrate alternative models of swine production using funds authorized and appropriated by the Minnesota state legislature. The Land Stewardship Project of Minnesota, working with several State legislators, was instrumental in securing legislation to create the program.

Research at the WCROC will focuses on swine production methods that reduce gaseous emissions, improve the welfare of the animals, use other natural resources sustainably, and are profitable to the farmer. Among alternative methods to be studied are pasture farrowing, using "hoop" barns with deep-straw bedding for growing and finishing hogs and housing pregnant sows, and deep-bedded, group farrowing and lactation systems developed by farmers in Sweden.

References

Broom, D.M. 1999. Welfare and how it is affected by regulation. In *Regulation of Animal Production in Europe*, ed. M.Kunisch and H.Ekkel, 51-57. Darmstadt : K.T.B.L.

Crooker, B., Halvorson, D., Moon, R., Phillips, C., Noll, S., Johnston, L., Reneau, J., Chester-Jones, H., Hathaway, M., Goyal, S., Janni, K., Pijoan, C., Shields, T., Stromberg, T., Patterson, C., Dee, S., Blaha, T., and Wells, S. (1999). A summary of the literature related to animal agriculture health. *Generic environmental impact statement on animal agriculture, State of Minnesota*. St. Paul, MN: Environmental Quality Board.

Grandin, T. (2000). *Improvements in Handling and Stunning of Beef Cattle in Slaughter Plants During 1999*. Grandin Livestock Handling Systems, Inc.

Holston, N. (2001, April 21). Animal activists go multimedia. *Minneapolis Star-Tribune*.

KARE-11 News. (2000a, April 28). Farm animal rally today. Minneapolis, MN: Gannett News Service, KARE-11.

_____. (2000b, May 16). Slaughterhouse decision tabled.

_____. (2000c, June 6). Hugo city council rules on slaughterhouse.

KSTP-5 News. (2000, May 8). State shuts Hmong slaughterhouse in Hugo. St.Paul/Minneapolis, MN: KSTP-TV.

Wolfson, D.J. (1996). *Beyond the law: Agribusiness and the systemic abuse of animals raised for food or food production*. New York: Archimedian Press.

CHAPTER 10

MITIGATING MEASURES: REGULATIONS AND ROUTINE PRACTICES IN MINNESOTA AND OTHER PLACES THAT ARE AIMED AT THE HEALTH AND WELL-BEING OF ANIMALS:

I. The Regulatory approach

Ekesbo (1999b) noted:

> Animal welfare rules are the only instrument for protecting farm animals against the most common diseases: those caused by factors in the environment or the management and which cause the great majority of today's farm animal diseases. This means that modern animal welfare legislation, if carefully formulated and based on scientific evidence and practical experience, is also a farm animal health law. However, such [animal welfare] legislation is also the only instrument for the society to protect not only the health and well-being of individual animals or groups of animals, but also to protect the microbiological environment against threats from unethical and unbiological environments and management measures that can exist in modern animal production. Thus these rules have gradually received a broader ethical importance than is generally perceived, as they also diminish the risk for human diseases.

Anti-cruelty laws are not necessarily comparable to animal welfare laws, in that, while *proscribing* certain harmful acts toward animals, they do not necessarily *prescribe* scientifically-based measures to be taken or avoided to make animals' lives better. The European laws (including Scandinavia) are characterized by not only proscribing acts but encouraging practices that improve animals' lives.

In general, with respect to the formulation of laws based on respect for animals, the US lags behind Western Europe and Scandinavia. However, EU directives are not consistently or strongly enforced, meaning that many countries in Western Europe have not benefited from the good animal health situation that prevails in countries such as Sweden, where the society has been united behind regulations and both rules and enforcement have been comparatively strong.

A. Europe

Prior to the 1950s, animal welfare problems mainly were about cruelty against animals in single cases. The interest usually was focused on treatment of farm animals – particularly horses and dogs – but also on laboratory animals.

Starting in the late 1950s, when agriculture began to be industrialized, animal welfare under the new conditions of intensive production became an issue in several European democracies. In countries under communist dictatorship animal welfare legislation was not allowed.

1. The Council of Europe[37]

The Council of Europe is a policy making body that decides binding rules for its member states within the field of ethics. The Council of Europe was founded in 1949 and was originally proposed by Sir Winston Churchill who wanted Europe's democracies to come together to defend freedom and democracy against such threats as Communist and Fascist dictatorships. The Council of Europe has three main tasks:

to protect and strengthen democracy and human rights,
to try to find solutions to society's problems, and
to promote the development of a genuine European cultural identity.

The Council of Europe, which has 40 member countries, considers matters relating to the social health of Europe. The Council decides binding rules within the field of ethics. The rules or policy instruments of the Council of Europe are called "conventions" and they cover such issues as human rights, animal welfare, and freedom of the press. Conventions have the force of law. Nations that sign Council of Europe conventions are bound by them. The observance of the conventions is to be made within the framework of each country's national legislation.

Earlier chapters made mention of the strong public reaction in Europe to Ruth Harrison's *Animal Machines: The New Factory Farming Industry*, published in 1964 and the report of the scientific committee chaired by Dr. F. Rogers Brambell, which had been charged by the British government "to examine the conditions in which livestock are kept under systems of intensive husbandry and to advise whether standards ought to be set in the interests of welfare, and if so what they should be." The Brambell committee's findings yielded the "Five Freedoms" of movement:

> In principle we disapprove of a degree of confinement of an animal which necessarily frustrates most of the major activities which make up its natural behavior… An animal should at least have sufficient freedom of movement to be able without difficulty to turn around, groom itself, get up, lie down, stretch its limbs.

Harrison's book and the Brambell Committee's findings together with domestic public debate caused many parliaments in the Council of Europe's member states to discuss and decide on legislation regarding farm animals. Following a request from the General Assembly in the Council of Europe, the Committee of Ministers in 1971 decided that an ad hoc committee should be formed by delegates and experts from the member states for the task of elaborating a farm animal welfare convention.

[37] The narrative portion of the Council of Europe description is taken largely from Ekesbo (1999a), with the permission of the author, who is a former chair of the Council of Europe Standing Committee for Farm Animal Welfare.

Since then, the Council of Europe has issued a number of conventions concerning animal welfare, including animal transport (December 1968), farm animals (March 1976), slaughter (May 1979), experimental animals (March 1986), and pet animals (November 1987), and a convention on biotechnology is being planned.

The work of this ad hoc committee was performed between 1972 and 1975 and culminated in the European Convention for the Protection of Animals Kept for Farming Purposes, which was issued by the Council of Europe and signed in Strasbourg in 1976. The Convention makes unambiguous reference to the principles of the Brambell Committee when it requires that animals be allowed freedom of movement as well as freedom to behave according to their species characteristics.

Article 3 of the Convention states:

> Animals shall be housed and provided with food, water, and care in a manner which – having regard to their species and to their degree of development, adaptation and domestication – is appropriate to their physiological and ethological needs in accordance with established experience and scientific knowledge.

Article 4 of the Convention states:

> 1. The freedom of movement appropriate to an animal, having regard to its species and in accordance with established experience and scientific knowledge, shall not be restricted in such a manner as to cause it unnecessary suffering or injury.
>
> 2. Where an animal is continuously or regularly tethered or confined, it shall be given the space appropriate to its physiological and ethological needs in accordance with established experience and scientific knowledge.

The Convention speaks of animals as beings that are capable of suffering, aware of their surroundings and motivated by natural desires, in short, as sentient beings. This assumption that animals are knowing and feeling creatures underlies most of the laws now being written on the European continent concerning the treatment of animals.

The European Convention for Protection of Animals Kept for Farming Purposes was a Council of Europe document. It was this convention that was essentially ratified by the European Union's Council of Ministers as Council Directive 98/58/EC, concerning the protection of animals kept for farming purposes. The EU was able to create the Directive because the Treaty of Maastricht in 1992 expanded the scope of the EU somewhat and the Amsterdam Treaty of 1998 required a protocol on animal welfare.

Table 10-1 lists selected articles in the Convention.

Table 10-1. Selected articles from the Council of Europe Convention for Protection of Animals Kept for Farming Purposes.

European Convention For the Protection of Animals Kept for Farming Purposes	Article 3 Animals shall be housed and provided with food, water and food in a manner which-- having regard to their species and to their degree of development, adaptation and domestication -- is appropriate to their physiological and ethological needs…	Article 4 1.The freedom of movement appropriate to an animal…shall not be restricted in such a manner as to cause it unnecessary suffering or injury 2. Where an animal is continuously or regularly tethered or confined, it shall be given the space appropriate to its physiological and ethological needs…	Article 5 The lighting, temperature, humidity, air circulation, ventilation, and other environmental conditions such as gas concentrations or noise intensity in the place in which an animal is housed shall…conform to its physiological and ethological needs…	Article 6 No animal shall be provided with food or liquid in a manner, nor shall such food or liquid contain any substance, which may cause unnecessary suffering or injury.	Article 7 1. The condition and state of health of animals shall be thoroughly inspected at intervals sufficient to avoid unnecessary suffering and in the case of animals kept in modern intensive stock-farming systems at least once a day. 2. The technical equipment used in modern intensive stock-farming systems shall be thoroughly inspected at least once a day, and any defect discovered shall be remedied…

The European Convention for Protection of Animals Kept for Farming Purposes also created a Standing Committee on the Welfare of Farm Animals that would be responsible for elaborating and adopting recommendations to member states regarding implementation of the principles of the Convention "to be based on scientific knowledge concerning the various species of animals" and following "developments in scientific research and new methods in animal husbandry."

While the conventions issued by the Council of Europe regarding transport, slaughter, pet animals, and experimental animals contain detailed rules, the Convention for Protection of Animals Kept for Farming Purposes is general, serving more as a framework for rulemaking, because the Convention presupposes that the Standing Committee will elaborate detailed rules with the same legal status as the Convention itself.

All countries that have ratified the Convention for Protection of Animals Kept for Farming Purposes have full membership in the Standing Committee and are considered "contracting parties". Ratification in most cases is carried out by a decision of the national parliament. Each contracting party has the right to appoint a member to the Standing Committee. The European Union also has ratified the Convention and so it is a contracting party. There were 25 contracting parties in 1999.

In preparing its recommendations, the Standing Committee consults the contracting parties, observers, and experts. Several hundred scientific papers may be studied relating to the issue and animal species at hand. The recommendations state requirements for breeding, housing, and management in order to fulfill the biological characteristics of each species. For example, for pigs, the Standing Committee's recommendations state their keeping should allow performance of exploratory behavior and fulfill their need to differentiate between a lying, feeding, and dunging area.

2. European Union

The European Union (EU) originated in the European Economic Community (EEC), founded in 1957 by six European countries with the aim to promote free trade over state borders in accordance with the Treaty of Rome, which was regarded as a sort of constitutional law for the EEC. European Union directives are as a rule founded on the Council of Europe's conventions, or, for farm animals, on the recommendations elaborated and decided by the Council of Europe Standing Committee for Animal Welfare.

The motivation for EU directives on animal welfare is to facilitate the common market's function by introducing obligatory minimum animal welfare standards. These are intended to prevent competition between member countries caused by differences in national animal welfare laws, and, should the occasion arise, they remove technical hindrances for trade of live animals while at the same time trying to attain a satisfactory level of protection for the animals involved. The European Union can also exercise control in the member countries to ensure compliance with the directives and such controls have occurred, for example, with respect to conditions in French slaughterhouses (see below, Enforcement).

The policy making body of the European Union is the Council of Ministers on which the government of each member nation has a seat. Decisions on important matters are usually made by unanimous agreement. Those policy directions adopted by the Council of Ministers indicate the state of current political and social thought in Europe. They embrace principles that have matured beyond controversy to general acceptance.

The executive organ that supports the Council of Ministers and the European Parliament is the European Commission. It is divided into Directorates General that have responsibility for a variety of policy areas. The Directorate General that has responsibility for policy concerning the treatment of animals raised for food is the Directorate General for Health and Consumer Protection. It is significant that the treatment of animals raised for food has, in the thinking that organizes the European Commission, an effect on the health of the humans who eat them. Its policies govern the treatment of animals on the farm, during transportation and during slaughter.

Other Directorates General that create policy on the treatment of animals are The Directorate General for Enterprise which issues policies concerning the treatment of animals used

for testing in the cosmetics industry and the Directorate General for Environment which issues policies concerning wild animals and those used for scientific experimentation.

The European Commission maintains several scientific committees. The Directorate General for Health and Consumer Protection maintains the Scientific Committee on Animal Health and Animal Welfare (formerly Scientific Veterinary Committee, Animal Welfare Section).

The Scientific Committee on Animal Health and Animal Welfare consists of 18 members, 11 in the subcommittee Animal Health, and 7 in the subcommittee Animal Welfare. Each subcommittee drafts reports based on questions/requests from the commission, but every report has to be approved by the whole committee. The members are scientists, not representatives of their countries or of any organization. Each member is appointed for a term of three years after a formal application following announcement from the European Commission. Members are assigned on the basis of scientific competence. The committee is independent of the Commission and any national or other interests and there is no input from any national bodies.

In addition to the Scientific Committee on Animal Health and Animal Welfare, there is, under the Health and Consumer Protection Branch a Scientific Committee on Veterinary Measures related to Public Health. The two Committees may work in parallel, hence, with respect to public implications of the use of rBST in dairy cattle, for example, the Scientific Committee on Animal Health and Animal Welfare was asked to assess the effects and risks of using rBST on dairy cow welfare, including incidence of mastitis and other disorders in dairy cows, while the Scientific Committee on Veterinary Measures related to Public Health was asked to report on possible direct and indirect adverse effects on consumer health caused by the use of rBST, including from increased levels of IGF-1 in milk and increased antibiotic use.

a. How policy is made by the European Union

Motions for a resolution are made in the European Parliament where they are tabled for further study and recommendations by an appropriate expert committee. If the committee decides to draw up a report a rapporteur is appointed. The rapporteur will have responsibility for researching the matter and writing a resolution based on the report's conclusions.

The Committee reads and discusses the draft report presented by the rapporteur and its accompanying resolution. The members can comment on the report and resolution and ask questions. The report is voted on at the following meeting. The whole committee must approve it. The report might be rejected and dropped, revised and resubmitted or recommended to the plenary session of the European Parliament. If the Parliament accepts the resolution it can ask the Commission to prepare a proposal for a directive to be forwarded to the Council of Ministers.

The Commissioners (17 of them chosen by the member nations), who each head up a Directorate General, will vote on whether or not to create a proposal for a directive based on the resolution passed by the Parliament. If they decide affirmatively, the directive is voted on by the Council of Ministers. Once adopted, the directive is binding on member states and its provisions are to be reflected in changes in national laws.

b. Current law governing animal welfare in the European Union

From the following list of EU directives concerning animal welfare, one can see the range of animal welfare topics that have been adopted or are under consideration by the Europeans.

Directives:

1. Council Directive 88/166/EEC, revising the 1986 directive concerning the protection of laying hens
2. Council Directive 91/629/EEC, concerning the protection of calves
3. Council Directive 91/630/EEC, concerning the protection of pigs.
4. Council Directive 93/119/EC, concerning methods of slaughter that minimize the pain and distress of animals
5. Council Directive 95/29/EC amending 91/928/EC, concerning the protection of animals during transport includes loading densities and traveling time limits.
6. Council Directive 98/58/EC, concerning the protection of animals kept for farming purposes is based on the European Convention for the Protection of Animals Kept for farming purposes. The rules in the directive reemphasize the Five Freedoms: Freedom from hunger and thirst, Freedom from discomfort, Freedom from pain, injury and disease, freedom to express normal behavior, freedom from fear and distress.
7. Council Directive 99/74/EC, laying down minimum standards for the protection of laying hens.

The Council of Ministers also issues Regulations. Regulations have the direct force of law in all member states. If there is a conflict with national law the Regulation prevails. Examples are:

1. Council Regulation (EC) No 411/98, additional protection standards applicable to road vehicles used for carriage of livestock on journeys exceeding eight hours.
2. Council Regulation (EC) No 615/98, laying down specific detailed rules of application for the export refund arrangements as regards the welfare of live bovine animals during transport.

Decisions can issue from the Council of Ministers or the Commission. They are addressed to specific parties such as an individual, a company or a nation. The following are addressed to member nations

1. Council Decision 88/306/EEC, based on the Convention for the Protection of Animals for Slaughter
2. Commission Decision 97/182/EC amending annex to Directive 91/629/EEC laying down minimum standards for the protection of calves

Table 10-2 shows provisions of some documents that form the foundation of current European Union law concerning treatment of animals kept for farming purposes and Tables 3, 4, and 5 show provisions of law covering specific species, laying hens, cattle, and swine.

Table 10-2. European Union law concerning the Treatment of Animals Kept for Farming Purposes.

Council Directive 91/628/EEC on the protection of animals during transport	Article 3, b) No animal shall be transported unless it is fit for the intended journey and unless suitable provisions have been made for its care during the journey and on arrival at the place of destination…	Article 3, c) animals that fall ill or are injured during transport shall receive first-aid treatment as soon as possible; they shall be given appropriate veterinary treatment and if necessary undergo emergency slaughter in a way which does not cause them any unnecessary suffering.	Article 4, Member states shall ensure that animals are identified and registered throughout their journey… -their origin and their ownership -their place of departure and place of destination -their date and time of departure	Article 5, 2. The person in charge of the animal transport undertaking:…b) draws up, for journeys exceeding 24 hours from the place of departure and taking account of the place of destination, and itinerary…whereby it can be ensured that the animals are rested, fed and watered and if necessary, unloaded and given accommodation…	Article 5, 2, c) is able, according to the species transported and where the journey takes more than 24 hours, to demonstrate that steps have been taken to meet the animals' needs for food and water during the journey even where the route plan is changed or where the journey is interrupted for reasons beyond his control:
Council Directive 93/119/EC on the protection of animals at the time of slaughter or killing	Annex A I, 2. Animals must be unloaded as soon as possible after arrival. If delay is unavoidable they must be protected from extremes of weather and provided with adequate ventilation	Annex A I, 3. Animals which might injure each other on account of their species, sex age or origin must be kept and lairaged (confined prior to slaughter) apart from each other	Annex A I, 4 Animals must be protected from adverse weather condition. If they have been subjected to high temperatures in humid weather they must be cooled by appropriate means.	Annex A I, 5 The condition and health of the animals must be inspected at least every morning and evening.	Annex A I, 6 …animals which have experienced pain or suffering during transport or upon arrival at the slaughterhouse, and unweaned animals, must be slaughtered immediately…Animals which are unable to walk must not be dragged to the p[lace of slaughter, but must be killed where they lie or, where it is possible and does not entail any unnecessary suffering, transported on a trolley or movable platform to the place of emergency slaughter

	Annex A II, 1 Where slaughterhouses have equipment for unloading animals, such equipment must have non-slip flooring …Bridges, ramps and gangways must be fitted with sides, railings or some other means of protection to prevent animals falling off them…	Annex A II, 2 During unloading, care must be taken not to frighten, excite or mistreat the animals, and to ensure that they are not overturned. Animals must ;not be lifted by the head, horns, ears, feet, tail or fleece in such a way as to cause them unnecessary pain or suffering	Annex A II, 3 Animals must be moved with care. Passageways must be so constructed as to minimize the risk of injury to animals, and so arranged as to expl9it their gregarious tendencies…electric shocks may be used only for adult bovine animals and pigs which refuse to move, provided that the shocks last no more that 2 seconds…	Annex A II, 5 Animals must not be taken to the place of slaughter unless they can be slaughtered immediately. If they are not slaughtered immediately on arrival they must be lairaged.	Annex B, 2 Animals legs must not be tied, and animals must not be suspended before stunning or killing. However, poultry and rabbits may be suspended for slaughter provided that appropriate measures are taken to ensure that, on the point of being stunned, they are in a sufficiently relaxed state for stunning to be carried out effectively…

Table 10-3. Poultry

LAYING HENS	Council Directive 99/74/EC Preamble Shall not be kept in battery cages after 1999.	Council Directive 99/74/EC Article 4 Will have 10 cm/bird on linear feeders, 4cm on circular feeders	Council Directive 99/74/EC Article 4 Will have 2.5 cm/bird on continuous drinking trough, 1 cm on circular troughs or one nipple/ 10 birds	Council Directive 99/74/EC Article 4 Will have at least one nest (separate space for egg laying) for every 7birds	Council Directive 99/74/EC Article 4 Will not exceed a stocking density of 9 birds/ M^2 of usable area (excluding nests)
	Council Directive 91/628/EEC Food and water shall be available for journeys of 12 hours or more	Council Directive 93/119/EC Shall be stunned before slaughter or killed instantly Manual back-up must be available where poultry is bled by means of automatic neck-cutters so that, in the event of a breakdown, birds may be slaughtered immediately.	Council Directive 99/74/EC Annex All buildings shall have light levels sufficient to allow all hens to see one another and be seen clearly, to investigate their surroundings visually and to show normal levels of activity….the lighting regime shall be such as to prevent health and behavioral problems…it must follow a 24-hour rhythm and include an adequate uninterrupted period of darkness	Council Directive 99/74/EC Annex The design and dimensions of the cage door must be such that an adult hen can be removed without undergoing unnecessary suffering or sustaining injury	Council Directive 99/74/EC Annex The sound level shall be minimized. Constant or sudden noise shall be avoided. Ventilation fans, feeding machinery or other equipment shall be constructed, placed, operated and maintained in such a way that they cause the least possible noise.

Table 10-4. Protection for Bovines

Calves	Council Directive 97/2/ EC Preamble Whereas it is recognized scientifically that calves should benefit from an environment corresponding to their needs as a herd-living species; whereas for that reason, they should be reared in groups; whereas calves…must have sufficient space for exercise…and for normal movement when standing up or lying down…	Council Directive 97/2/ EC, Article 1,3 No calf shall be confined in an individual pen after the age of eight weeks…The width of any individual pen for a calf shall be at least equal to the height of the calf at the withers…and length shall be at least equal to the body length of the calf	Commission Decision 97/2/ EC, preamble Whereas tethering of calves causes problems…whereas calves should be fed fermentable…material to maintain the microbial flora of the gut…	Commission Decision 97/2/ EC, preamble whereas in order to ensure adequate immunoglobin levels in the blood calves should receive sufficient colostrum within first six hours of life	Commission Decision 97/2/ EC, Article 1,4 All calves shall be provided with an appropriate diet adapted to their age, weight and behavioral and physiological needs…their food shall contain sufficient iron to ensure an average blood haemoglobin level of at least 4.5 mmol/litre…
Cows	Council Directive 91/628/EEC on the protection of animals during transport, Annex, A, 7, b Cows in milk shall be milked at intervals of about 12 hours but not exceeding 15 hours.	Council Directive 91/628/EEC on the protection of animals during transport, Annex, A, 2, f When animals are tied, the ropes of other attachments used shall be long enough to allow the animals, if necessary to lie down and to eat and drink, and shall be designed in such a way as to eliminate any danger of strangulation or injury. Animals shall not be tied by the horns, or by nose rings.			

Table 10-5. Current protections for pigs (Council Directive 91/630/EEC) (A new EU directive, proposed in January 2001 and agreed upon in June 2001 makes these protections stricter. It is described in paragraphs following the table).

pigs	Council Directive 91/630/EEC, Article 3,1 …the unobstructed floor area available to each weaner or rearing pig reared in a group must be at least -0,15 m^2 for a pig of an average weight of 10 kg or less -0,20 m^2 for a pig of an average weight of 10 kg and 20 kg 0,30 m^2 for a pig of an average weight of 20 kg and 30 kg… 1,00 m^2 for a pig of an average weight of 110 kg	Council Directive 91/630/EEC, Article 3,2 The construction or conversion in which sows and gilts are tethered shall be prohibited after 31 December 1995	Council Directive 91/630/EEC, Annex,4 All automated or mechanical equipment… Must be inspected at least once a day. Where and artificial ventilation system is used, provision must be made for an appropriate back-up system to guarantee sufficient air renewal…in the event of failure of the system, and an alarm system must be provided…	Council Directive 91/630/EEC, Annex, 5 Pigs must not be kept permanently in darkness. To meet their behavioral and physiological needs, provision must be made, allowing for the different climatic conditions in the Member States, for appropriate natural or artificial lighting; if the latter, it must function for a period at least equivalent to the period of natural light normally available between 9 am and 5 pm	Council Directive 91/630/EEC, Annex,7 If pigs are kept together, measures must be taken to prevent fighting which goes beyond normal behavior. Pigs which show persistent aggression towards each other or are victims of such aggression must be isolated or kept separate from the group
	Council Directive 91/630/EEC, Annex,8 The accomodation for pigs must be constructed in such a way as to allow each pig to: -lie down, rest and stand up without difficulty, -have a clean place in which it can rest, -see other pigs	Council Directive 91/630/EEC, Annex, 13 All pigs must be fed at least once a day. Where pigs and housed in groups and not fed ad libitum, or by an automatic feeding system, each pig must have access to the food at the same time as the others…	Council Directive 91/630/EEC, Annex, 16 In addition to the measures normally taken to prevent tail-biting and other vices…all pigs…must be able to obtain straw or any other suitable material or object	Council Directive 93/119/EC on the protection of animals at the time of slaughter or killing The chamber in which pigs are exposed to the gas…must be designed…as to avoid injury to the pigs…and enable them to remain upright until they lose consciousness. Adequate lighting must be provided in the conveying mechanism and the chamber to allow pigs to see other pigs or their surroundings	Council Directive 93/119/EC on the protection of animals at the time of slaughter or killing, 4 Pigs must be placed in pens or containers in which they can see each other and conveyed into the gas chamber within 30 seconds from their entry into the installation

Sows	Council Directive 91/630/EEC, Annex, Chap. II, 1 Pregnant sows and gilts must, if necessary, be treated against external and internal parasites. If they are placed in farrowing crates they must be thoroughly cleaned.	Council Directive 91/630/EEC, Annex, Chap. II, 2 They must be provided with clean, adequately drained, comfortable lying area and must, if necessary, be given suitable nesting material	Council Directive 91/630/EEC, Annex, Chap. II, 3 An unobstructed area behind the sow or gilt must be available for the ease of natural or assisted farrowing.	Council Directive 91/630/EEC, Annex, Chap. II, 4 Farrowing crates where sows are kept loose must have some means of protecting the piglets such as farrowing rails	Council Directive 91/628/EEC on the protection of animals during transport, A.1 Pregnant animals likely to give birth during carriage or animals having given birth during the preceding 48 hours, and newborn animals in which the navel has not completely healed, shall not be considered fit for transportation.
Boars	Council Directive 91/630/EEC, Annex Ch. 1I Boar pens must be sited and constructed so as to allow the boar to turn round and to hear, smell and see other pigs, and to provide for clean resting areas. The lying area must be dry and comfortable. The minimum pen size for an adult boar shall be 6 m^2. However, a larger area must be provided where pens are used for service.				
Piglets	Council Directive 91/630/EEC, Annex, Chap. III, 1 …piglets must be provided with a source of heat and a solid, dry and comfortable lying area away from the sow where all of them can rest at the same time.	Council Directive 91/630/EEC, Annex, Chap. II, 2 Where a farrowing crate is used, the piglets must have sufficient space to be able to be suckled without difficulty.	Council Directive 91/630/EEC, Annex, Chap. II, 3 If practiced, the castration of male pigs aged over four weeks may be carried out only under anaesthetic by a veterinarian or a person qualified in accordance with national legislation.	Council Directive 91/630/EEC, Annex, Chap. II, 4 Neither tail docking nor tooth clipping must be carried out routinely but only when there is evidence, on the farm, that injuries… have occurred …Where tooth clipping appears necessary, this must be carried out within seven days of birth.	Council Directive 91/630/EEC, Annex, Chap. II, 5 Piglets must not be weaned from the sow at less than three weeks of age unless the welfare or health of the dam or piglets would otherwise be adversely affected.
weaners and rearing pigs	Council Directive 91/630/EEC, Annex, Chap. IV, 1 Pigs must be placed in groups as soon as possible after weaning. They should be kept in stable groups with as little mixing as Possible.				

c. Revision of EU Council Directive 91/630/EEC on the Welfare of Pigs in Intensive Farming Systems

The Council Directive 91/630/EEC required that the Commission issue a report to the Council of Ministers rendering an opinion as to the welfare of pigs in intensive rearing conditions, based on a report by the Scientific Veterinary Committee, Animal Welfare. On September 30, 1997, the Scientific Veterinary Committee, Animal Welfare, submitted its report and scientific opinion.

Based on this Opinion, in January 16, 2001, the Commission put forth a proposal (COM(2001)20 Final) to amend the current Directive 91/630/EEC laying down minimum standards for the protection of pigs.[38] Noting that five member states already had adopted legislation providing additional requirements for the welfare of pigs over and above 91/630/EEC, the Commission proposed to the Council of Ministers and the European Parliament that current legislation be amended in line with new scientific evidence and the experience acquired in the field by the five member states. The amendments will put in place an EU-wide framework of acceptable welfare standards for pigs.

The proposal for a Council Directive aimed to:

- Ban the use of individual stalls or crates for pregnant sows and gilts and the use of tethers (91/630/EEC had already banned new construction of individual tether systems).
- Increase the living space available for sows and gilts and allow them to live in social groups
- Allow sows and gilts to have permanent access to materials for rooting and high-fiber food as well as high-energy food in the diet
- Improve the flooring surfaces, in particular, requiring part of the area to be solid (rather than slatted or drainage) and provide pigs separate areas for performing different behaviors
- Introduce a higher level of training and competence on welfare issues for the personnel in charge of the animals, and
- Order the Commission to submit to the Council a report drawn up on the basis of an opinion from the Scientific Committee on Animal Health and Welfare (formerly Scientific Veterinary Committee, Animal Welfare) in relation to certain issues of pig farming, if necessary accompanied by new legislative proposals.

The specific articles amended were: Article 3 establishing new flooring standards and space requirements, and phasing out tethers and individual sow stalls in which the sows cannot turn around easily.

With respect to pregnant or dry sows and gilts:

[38] On June 19, 2001, the Agriculture Council of the European Union adopted the reforms in substantial part. However, reforms for pregnant sow housing would not have to be completed until 2013, and pregnant sows could be kept in individual stalls during the first four weeks of pregnancy. Food and agriculture Commissioner David Byrne expressed appreciation to the Swedish EU-presidency for moving the EU to adoption of the principles in record time. The new rules become applicable as of January 1, 2003.
http://europa.eu.int/comm/food/fs/aw/press_releases/aw_farm_init_press01_en.html
http://europa.eu.int/comm/food/fs/aw/aw_farm_init_en.html

- Housing facilities must include communal lying areas, in addition to the dunging area and any feeding stalls or boxes, of at least 1.3m^2 per sow (0.95m^2 per gilt) of unobstructed floor area
- Where sows are kept in groups, the shortest side of any pen must not be less than 2.8 meters in length
- All sows must have permanent access to soil for rooting or to manipulable material at least complying with the relevant requirements of the Annex
- Sows in groups must be fed using a system which ensures that each individual can obtain sufficient food without being attacked, even when competitors for the food are present
- All sows must be given high fiber food as well as high-energy food in order to reduce hunger as well as provide for the need to chew. The high-energy food can be fed once a day in a single meal but high fiber food must be available for longer periods

When a directive is issued by the Council of Ministers, Member states will be obliged to bring into force the laws, regulations and administrative provisions to comply with the directive by January 1, 2002. The specific requirements of the proposed amendment are phased in over time, with existing systems given varying periods of time to come into compliance and all new construction or remodeling of building to be in compliance from the beginning.

The issues to be covered in the new scientific report due January 1, 2008 are:

- effects of stocking density in different farming systems on welfare, including health of the pigs
- further developments of group housing systems for pregnant sows
- determination of space requirements for individually-housed adult breeding boars (currently 6m^2 plus service area if sows are served in pens)
- further developments of loose housing systems for sows in the service area and for farrowing sows that meet the needs of the sow without compromising piglet survival
- development of alternatives to surgical castration, and
- analysis of consumers' attitudes and behavior toward pigmeat in the event of no improvement or only minor improvement being achieved in the welfare of animals

Additionally, the new scientific report may be accompanied by appropriate legislative proposals.

The Proposal for a Council Directive amending Directive 91/630/EEC laying down minimum standards for the protection of pigs notes that animal protection is a central issue in relation to the development of future farming policies in the EU to bring public image together with efficient farming systems.

The recognition on the part of the EU that the production sector must change to become acceptable in the eyes of European consumers is in stark contrast to the US approach, which has been consistently defensive of the status quo and instead has emphasized educational programs to convince consumers of the need for industry to continue its current animal production methods.

Upon announcement of the proposals, Director of Eurogroup for Animal Welfare, David Wilkins, "Several member states have already accepted that the very intensive pig production systems are cruel and have no place in modern Europe" (from Reuters, Brussels, Sept. 19, 2000).

3. Enforcement in the European Union

Writing and passing laws is only the first step. Laws are only effective if the population complies with them and any government must budget some amount to pay for inspections, reporting and legal action to punish or correct non-compliance.

Problems arise with enforcement of the laws (or lack thereof). The Council of Europe recommendations are not always implemented by the European Union as directives. When they are implemented, enforcement may be lax so that farm animals in Europe still are not sufficiently protected.

In June 2000, Compassion in World Farming (UK) held a press conference at which Margareta Winberg, the Swedish Minister of Agriculture, called on her colleagues on the EU Agriculture Council to insist on rigorous enforcement of the Transport Directive concerning transport of food animals throughout the EU and start the process of adopting a fundamental change of policy where by the long distance transport of live farm animals is abandoned and replaced by a trade in meat (CIWF 2000). According to CIWF, the EU Transport Directive is totally failing to protect animals transported across Europe, both because (i) it is routinely broken in France, Italy, Greece, Belgium and Ireland, and (ii) because its rules are so weak that they do nothing to prevent animals being transported on journeys of 50 hours or more across Europe.

In March 2001, German farm minister Renate Kuenast linked the spread of the latest costly outbreak of foot and mouth disease to the long distance transport of live animals over great distances in Europe and on April 9, 2001, the European Community's Health Commissioner David Byrne announced new live animal transport rules for the Community, focusing on transport of horses, cattle, sheep, goats, and pigs traveling within the EU: "Long distance transport should be the exception rather than the rule. When it is necessary, it must take place under conditions that do not endanger the animals or cause unnecessary suffering." New requirements include controls on the vehicles used, the adequate loading of animals, health checks of animals before and during transport, with obligatory steps to improve conditions if the animals are found to be suffering. From December 31, 2003, new vehicles must be equipped with monitoring and warning systems for humidity and temperature as well as other standards for loading and feeding animals. The new rules cost three to five percent of the total cost of a truck (Reuters, April 9, 2001, "EU plans to improve animal welfare on long trips).

The EU agriculture ministers also met in Sweden in April 2001 to discuss concerns drafted by the Swedish EU presidency regarding the impacts of industrialized farming techniques on animal welfare, the environment, and spread of disease.

A. Enforcement Powers of the EU

The EU can exercise control in the member countries to ensure that its directives are complied with and has administrative structures in place to enforce animal welfare laws. In addition, the competent authorities in the member states are responsible to:

1. Transpose directives into national legislation.
2. Implement Community rules at a national level.

3. Enforce Community rules through national legislation and day-to-day control activities. Responsibilities and Tasks of Directorate General of Health and Consumer Protection", European Union website, http://www.europa.eu.int. Though no government can be everywhere all the time, a well publicized report of an inspection can inspire compliance by those who have reason to fear an inspection in the future.

B. Case Example – French Slaughterhouses

A recent case provides an illustration of EU enforcement methods, when they are in fact applied.

In the spring and summer of 2000, the European Commission's Food and Veterinary Office undertook an inspection of French slaughterhouses. One of the elements of the inspection was a check of compliance with the provisions of Directive 91/628/EEC which regulates the welfare of animals during transport. Some excerpts follow.

5. Main findings
5.1 Poor livestock vessels

Two livestock vessels used for transporting cattle from a French Port towards Mediterranean third countries

- Showed very rough surfaces on pens and passageways (very rusty metal, worn-out wood),
- Had decks with very narrow passageways through which animals could not pass to be evacuated in case of illness or injury,
- Had no adequate systems for the removal of liquid excreta and effluent water,
- Showed many places where animals could be hurt and where their limbs could be entangled. ("Mission Report on a veterinary mission to France…, Directorate General for Health and Consumer Protection)

The report also found deficiencies in trucks and ferryboats used for animal transport and in the amount of time that animals were rested fed and watered during travel. Also, many pregnant animals were found in the loads. The report makes conclusions about the prevalence of non-compliance within France and ends with recommendations to improve compliance. The following is a sample of the recommendations.

8.5. It is recommended to invite representatives of Member States to the services of the Commission to discuss how progress could be achieved to improve cooperation between Member States in the field of long-distance transports…

8.6. It is recommended to modify EC Legislation in the following areas:
- New forms for route plans should be elaborated
- A more precise definition for animals in advanced pregnancy should be formulated

The document also contains assurances of planned corrections from the French Ministry of Agriculture and Fisheries.

In addition to the administrative effect, the EU report had an effect on the general population because its release was covered by major news sources such as Reuters. Food quality is very much on the public's mind because of the number of victims of bovine spongiform encephalopathy (BSE) in France. The report, which was released, in October, raised concerns about sanitary conditions and animal welfare within French slaughterhouses and farms.

> …At one slaughterhouse, inspectors from the EU's Veterinary Office said that blood from pigs was collected for human consumption in an unclean way.

"The animals were stabbed on a conveyor belt and blood was collected in an open system with high risk of contamination from unclean skin"

…The report also detailed how animals with chronic diseases and old infected fractures were seen at one site.

> Some of these animals had been transported to the slaughterhouses despite the fact that they were obviously not fit for human consumption. In some cases sick animals in obvious pain were left for several hours in the pens before being inspected by a veterinarian and killed." (Paris, Dec. 29 (Reuters))

Adverse publicity leading to consumer pressures potentially aids in getting laws that have the support of the people equitably enforced. This opens the way for "extra-governmental" enforcement. While consumers are insufficiently organize to have major countervailing power against an industry that fails to meet their expectations, retailers have considerably more power and can be a positive force for reforms.

III. Extra-governmental Enforcement

"Many members of the European Parliament have stated that they receive more letters about animal welfare than about any other subject and the coverage of animal welfare topics in newspapers, on television and on radio is much greater in recent years" (Broom 1999).

The most potent force for animal welfare standards may be food retailers and institutional buyers who are responding to the demands of their customers. "At present, the greatest effects on animal welfare are the standards set by purchasers of animal products, principally supermarkets and fast food chains…. The standards set by the supermarket chains are determined by what people will buy and by their reputation with the public" (Broom 1999). "…The increase in direct selling to supermarket chains has led to considerable power being placed in the hands of those supermarket companies. It is possible for these purchasers to lay down conditions for animal production and to enforce these by inspection."

Albert Hein in the Netherlands and elsewhere in Europe limits sales of eggs to "scharreleie," which means that the hens were reared in conditions where they could scratch in litter. Marks and Spencer in the U.K. and elsewhere stopped selling eggs from battery cages. In other cases, elaborate standards have been described and sent to suppliers (Broom 1999).

In the US, a recently emerging force for enforcement of animal welfare standards is McDonald's Corporation, which is notifying its suppliers that they must change some of their routine practices (end forced molting of laying hens and phase out beak trimming and battery cages) in order to continue selling to them. Inspections of slaughter plants supplying the company have yielded some of the desired effects, for example, audits conducted by McDonald's Corporation have motivated the beef industry to improve handling and stunning of cattle (Grandin 2000).

Difficulties remain in detecting problems, as inspection visits are usually announced ahead of time, meaning a company has time to make temporary changes prior to the actual visit. Even if unannounced, it takes some time to get dressed to go into the plant and during this time adjustments can be made (Warrick 2001). Another way of determining what goes on inside the plants has been through the use of worker affidavits and undercover video, which was the method used by Gail Eisnitz of the Humane Farming Association in exposing the butchering of live cattle at a slaughterplant in Washington state (Warrick 2001).

A growing number of upscale restaurants and natural food stores purchase pork from the Niman Ranch Pork Company, which uses a protocol devised by the Animal Welfare Institute (AWI) to support the welfare of pigs raised on the Midwestern farms supplying Niman Ranch Pork Company (P. Willis, Niman Ranch Pork Company, 2001, personal communication). In a few years, the Niman Ranch Pork Company has grown from one supplier to 150 and new stores continue to join its customers. Several Minnesota farmers and a small Minnesota slaughterplant either already are participants in the company or are considering it.

II. Animal welfare regulations in the United Kingdom, Sweden, Switzerland

A. United Kingdom

Many of the provisions concerning the welfare of agricultural animals in European laws were first adopted in the UK.

> In many areas of animal welfare the United Kingdom leads the way, and we wish to ensure that these standards are also applied throughout the EU. The Directives therefore represent a welcome way forward for the improvement of animal welfare on a wider scale.
>
> Elliot Morley, Animal Welfare Minister, Ministry of Agriculture, Fisheries and Food (News Release 8/2/2000 regarding new European Council Directives on animal welfare)

The UK continues to advocate for improvement of animal welfare regulations within the EU. As animal welfare standards are harmonized across the continent by EU Directives, the agricultural sector in the United Kingdom will not be alone in bearing the costs of improvements in animal husbandry and handling. Morley stated:

> This also represents good news for our own farmers ensuring their counterparts in some parts of the EU, have to meet the same minimum standards and create a more level playing field.

However, because of its membership in the EU, the UK can no longer do exactly as it pleases in lawmaking. As is stated in a cover letter written by David Lees of the Animal Welfare Division for a consultation document (report with recommendations for amendments to an existing Order, in this case the Welfare of Animals (Transport) Order 1977),

> The consultation document makes clear that the scope of any possible amendments to WATO is constrained to a large extent by the fact that we are bound by EC Directive 91/628, as amended by 95/29, which WATO directly implements. Several of the areas of WATO, which we know are of concern to interested parties, such as maximum journey times and stocking densities can not be altered unilaterally. These issues will have to be raised in the context of a review of the Directive…

This is because the Council of Europe's recommendations are "minimum standards" and the EU directives must be followed in detail. For example, a country cannot demand higher standards from its animal transporters than what is stated in the directives (Dr. I. Ekesbo, 2001, personal communication).

UK's The Agriculture (Miscellaneous Provisions) Act 1968 is essentially the same as the EU Directive for the Protection of Animals Kept for Farming Purposes and the European Convention for the Protection of Animals Kept for Farming Purposes. It is the parent of those documents and was the first law inspired by the report of the Brambell Committee in 1965.

In addition to Laws, Acts and Orders adopted by Parliament for the protection of animals, Ministers are authorized to publish codes of recommendations on the welfare of livestock (welfare codes). Failure to follow a code can be used as evidence if a charge is brought for an illegal abuse of an animal.

The UK shows an ongoing effort to improve the welfare of animals in its animal welfare codes. For example, the codes concerning the welfare of poultry cover the following topics.

1. Codes of Recommendation for the Welfare of livestock, Domestic Fowls

paragraphs 1-8	General
paragraphs 9-17	Housing
paragraphs 18-23	Fire and other emergency precautions
paragraphs 24-28	Ventilation and temperature
paragraphs 29-30	Lighting
paragraphs 31-32	Mechanical equipment and services
paragraphs 33-36	Stocking rates
paragraphs 37-39	Feed and water
paragraphs 40-46	Management, general
paragraphs 47-49	Beak trimming
paragraph 50	Dubbing
paragraph 51	Toe-Cutting
paragraph 52	De-winging
paragraph 53	Blinkers

paragraph 54	Castration and devoicing
paragraphs 55-58	Disposal of unwanted chicks and hatchery waste
paragraph 59	Handling and transport of stock on the premises
paragraphs 60-62	Day-old chicks
paragraphs 63-74	Additional recommendations: range birds

In a report on the Ministry website, Elliot Morley, Animal Welfare Minister assures the citizens that the government of the UK is making progress on animal welfare. He lists these accomplishments:

> 1. We have secured agreement on the farm animal welfare Directive. We have started EU negotiations on proposals to improve standards for laying hens.
> 2. We are seeking a Europe wide ban on close confinement stalls, and tethers for pigs will be banned in the UK from the end of 1998.
> 3. We are reminding pig farmers that tail docking of pigs should only be carried out as a last resort to prevent a worse welfare problem.
> 4. We are updating welfare codes and providing free advice to farmers on welfare problems such as heat stress.
> 5. We are funding R&D to find practical answers to welfare problems such as lameness in sheep, cattle, pigs and chickens.
> 6. We are ensuring that the highest possible welfare standards are in place and enforced when animals are transported.
>
> The government is committed to the highest standards of welfare. We have convinced our European partners of the importance of giving legal recognition to the fact that live animals are not just commodities to be traded but sentient beings- fellow creatures capable of sensation and feeling. Thanks to the Government's success in achieving agreement to a new Treaty Protocol that recognizes this, EU policies on agriculture, transport, research and the single market will in future be legally required to take proper account of their welfare. A key success of the 1998 UK Presidency built on this protocol by securing agreement to a new Directive setting minimum welfare standards for all farm animals thoughout the European Community. By working with our European partners we can broaden the international consensus on welfare standards.

B. Animal welfare legislation in Sweden and Switzerland

Three countries – Sweden, Switzerland, and the Netherlands -- are unique in the world in that an evaluation of the animal welfare impacts of new farming systems and technologies is legally compulsory before the systems and technologies can be marketed to farmers. This has been a longstanding legislative requirement in Sweden and Switzerland, dating in Sweden from 1970 (violators pay a steep fine) and in Switzerland since 1980. The Dutch legislation requiring testing of new technologies from an animal welfare point of view came into effect in 1994 (Ekesbo 1999b). Only the Swedish and Swiss situation will be covered here and Switzerland only with respect to laying hens.

Sweden and Switzerland are in many respects models for other countries in respect to adoption of strict animal welfare regulations for their own agriculture. Switzerland, because of an animal welfare law enacted in 1980, which effectively, although indirectly, banned the use of battery cages for laying hens, has led the world in the development of alternative systems of production for laying hens. Sweden's 1988 Protection of Farm Animals Act is arguably the strongest law protecting animals in the world and was preceded by a long history of legislative and farmer support for a higher standard of farm animal welfare. Reforms there were well on schedule prior to Sweden's entry into the EU.

1. Sweden

Sweden's animal welfare laws reflect cooperation among Swedish farmers, consumers, animal welfare advocacy groups, scientists, farm advisory groups and government. They have been non-partisan – that is the political parties have also been in agreement (Dr. B. Nordbløm, Board on Agriculture, 1992, personal communication). The Swedish farm animal health and well-being policy is well-coordinated and the most comprehensive in the world, so it is given more detail here. There is misunderstanding in the US that Swedish farmers are oppressed by laws and regulations, however, the legislation has had the support of most Swedish farmers who perceive it as a step forward and a safety mechanism to ensure that the playing field is level and all abide by the same rules and incur the same costs. The recognition that human and animal welfare are inseparable also underlies the law and its broad public support.

The first regulations in Sweden regarding protection of animals from cruelty were by a Royal Ordinance in 1857 (Ekesbo 1999b). A Slaughter of Domestic Animals Act (1937:313) was enacted in 1937. The first animal welfare law went into effect in 1944 (Animal Welfare Act 1944:219) and the latest farm animal welfare law was enacted in 1988, which repealed the 1937 and 1944 Acts.

The 1950s saw the beginning of many changes in the way farm animals were raised. In particular, there was a trend toward rationalization and industrialization of animal production, in which manufacturing principles such as enterprise specialization (with respect to species and age groups), indoor confinement of animals, and mechanization of labor were applied as efficiency measures to animal production. Veterinarians and farmers in Sweden were expressing concerns about the effects of new, intensive confinement methods on the welfare of farm animals as early as 1960. Certain new techniques were observed to increase the incidence of diseases such as mastitis in cattle (Ekesbo 1992). A research program was put in place at the Veterinary College of the Swedish University of Agricultural Sciences (SLU) in Skara, Sweden, where these observations were subjected to scientific study. In 1966, a study resulting from this research program established the contribution of new housing systems to increases in diseases of dairy cattle (Ekesbo 1966); in 1973, another study did the same for piglet production (Backström 1973); and, in 1974, the relationship was also shown for finishing pigs (Lindqvist 1974).

However, farmers were expected to increase their production efficiency, which forced them to adopt the new technologies, which, in turn, often appeared to cause animal health problems. Veterinarians protested the way in which new technologies were introduced because they increased the therapeutic measures that needed to be taken to treat these "man-made" diseases (Ekesbo 1992). It should be noted that the government traditionally employed veterinarians in Sweden. Hence, Swedish veterinarians had no links to producer interests or the

food industry (Swedish Ministry of Agriculture 1997). There was a government monopoly on medical products whereby all medical products were to be supplied by the National Corporation of Swedish Pharmacies (Apoteksbolaget), with the implication that veterinarians could not sell medical products for economic gain (Swedish Ministry of Agriculture 1997). This situation greatly aided the possibility to ban nontherapeutic uses of antibiotics in 1986 (Backström 1999) and also maintained animal health on a preventative course (preventing disease organisms from taking hold) rather than a control (keeping them subclinical by subtherapeutic additions to feed) or treatment (dosing after infection) course.

Publication of Ruth Harrison's *Animal Machines: The New Factory Farming Industry* in Great Britain in 1964 provoked a strong public reaction in Sweden and marked the start of the public debate on animal welfare (Ekesbo 1992).

In the late 1960s, a study program for provincial veterinarians from each of Sweden's 24 provinces was established at the Veterinary campus of SLU and focused on animal hygiene,[39] epidemiology, and ethology, and on adapting the new techniques to the health and well-being needs of the animals (Ekesbo 1992). In 1968, veterinarians at the Department of Animal Hygiene, SLU Skara, began testing new methods such as early weaning of piglets in cages, with respect to their suitability for the biological and behavioral needs of the animals and with respect to their potential for inducing injuries and disease (Ekesbo 1992, 1999). In 1969, this Department began an education and training program for county veterinarians on these special topics.

In 1968, a series of critical articles in the largest Swedish morning newspaper decried the consequences of the transformation of Swedish animal husbandry into mass production, i.e., the industrialization of animal agriculture. The series was followed by radio programs, debates in the Swedish parliament resulting in improved animal welfare legislation, and the Swedish Church issuing a study on "Animal Ethics."[40] The articles, programs, and debates were stimulated by *Animal Machine*s and the public activities it spawned in England and by scientific studies in Sweden that were unequivocally showing that the new labor- and space-saving technologies for animal production were having adverse consequences for the animals.

In 1970 and 1971, farm animal welfare was debated in the Swedish parliament. The Minister of Agriculture proposed that no farm animal buildings given state financial support should be built, or modernized, without the plans having passed the scrutiny of animal health experts. The idea behind the approach was to "design into" buildings the animals' needs for good health and to eliminate poor design as regards animal health and well-being (Algers 1999, Ekesbo 1992). In 1971 this proposal became part of the Swedish animal welfare regulations. After a year's evaluation, the Swedish Farmers' Union approved the system for sustaining farm animal

[39] Animal hygiene is defined as "the science regarding the influence on animal health and disease by factors in the animal environment and measures taken with such factors in order to promote and prevent disease" (Ekesbo 1992). These factors include such things as buildings, pasture, waste and feed handling methods, climate, noise, light, dust and straw, in combination with microbiological factors or not. Also, the animal's influence on the environment, such as soil and water pollution and preventive measures against manmade diseases is part of hygiene. Animal hygiene is one of the most important areas of preventive veterinary medicine and animal welfare (Ekesbo 1992).

[40] The Swedish Church followed up with two new Church studies on animal ethics during the 1990s (Dr. I. Ekesbo, 2000, personal communication).

health and recommended that each farm should be evaluated when planning modernization or construction of animal housing.

The Farmers' Union recommendation came into force in 1973 and the 1988 Animal Welfare Ordinance (specifications for provisions in the 1988 Animal Welfare Act) states: "Buildings… and structures for…animals must not be built, extended or altered without prior approval of the building with regard to animal welfare and health. The same shall apply when a building or structure is modified in such a way as to have significant effects on animal health and welfare or when a building which was previously used for another purpose is put to use or equipped as a livestock building" (SFS 1988:539).

In 1983, in response to environmental and animal welfare problems the public perceived as arising from increasing industrialization of the animal agriculture sector, Sweden instituted a 10-year moratorium on new building construction for expansion of beef, swine, and poultry production (SFS 1983:147). Violators were subject to fines. Although this law did not stop new building, it slowed Swedish agriculture's move toward the type of industrialization that was characterizing agricultural development in other countries. Thus, since the early 1960s, Swedishfarming has been channeled in directions that are demonstrated to be positive for animal healthand well-being by a policy of pre-testing technologies for their compatibility with animals priorto marketing and by avoiding uncontrolled industry growth. Thus building policy, also, contri-butes to Sweden's higher animal health situation relative to that in other countries.

The decision as to whether to undertake an evaluation of a technical innovation by a firm or an individual farmer will be made by the regional veterinarian in connection with his scrutiny of the new building or remodelling project (Ekesbo 1992). In the case of an individual farmer, most of the cost of the evaluation usually is taken care of by state funds.

Evaluation of new technologies usually is undertaken on a contract basis with commercial farms so that realistic situations can be modelled, for example, it is possible to use large groups of animals. However, care has to be taken to control factors that might confound the results. Each evaluation follows established scientific routines (Ekesbo 1992).

Although there was some early opposition by equipment manufacturers, this approach to design the facilities and evaluate new technologies for their compatibility with the animals' biological and behavioural needs prior to adoption was agreed upon by farmers, veterinarians, consumers, and the government, which made it easier both politically and practically to implement the ban on subtherapeutic use of antibiotics in animal feeds in 1986 and the farm animal welfare act of 1988 (Ekesbo 1992). It was the Swedish farmers' organization LRF that requested the antibiotic feed additive ban on behalf of farmers in Sweden to make their products more acceptable to Swedish consumers.

Ekesbo (2001, personal communication) describes other rules:

"Sweden

- banned the use of carcasses from dead animals[1)] in farm animal feeds for cattle and other ruminants in 1986;
- banned antibiotics as growth promoters in animal feeds in 1986[2)];
- banned the import of live ruminants, semen and meat- and bonemeal[3)] from the UK in 1988;

- banned also the use in ruminants' feed of meat- and bonemeal[3)] made from healthy[4)] animals slaughtered and after veterinary scrutiny accepted for human consumption in 1991;
- as in all EU countries, there applies since 1 January 2001 a temporary (until 30 June 2001 but can be prolonged) ban on using meat- and bone meal for all farm animals.

[1)] Dead animals means animals that have died a "natural death" or have been killed because of disease (in those days, carcasses of dead horses, dogs and cats were used in Sweden as in other European countries). Even meat and bone meal from animals slaughtered and after inspection not accepted for human consumption were in this category.

[a)] The motive was mainly ethical, cattle as herbivores shall not eat animal remains

[2)] The motives were medical and ethical because

[a)] the use of antibiotics as growth promoters could serve as an protective umbrella in herds with bad husbandry practices as it was proven that there was an antimicrobial effect by these antibiotics.

[b)] the use of antibiotics as growth promoters could increase the spread of bacteriological resistance which could be a threat for animals and humans

[c)] both these reasons had thus also an ethical dimension.

[3)] Meat and bone meal means meat and bones from healthy animals slaughtered and after inspection accepted for human consumption.

[4)] In Sweden each animal since 1959 must be 'veterinary-clinically-inspected' at the slaughterhouse before it can be slaughtered. Unhealthy animals will not be accepted for use. The background for the Swedish meat inspection is the following: Since 1897 it was legally possible for a community to demand that the carcass must be veterinary inspected from food hygiene point of view after the slaughter and before it was allowed to be used for human consumption. This law was applied but not obligatory in most cities and communities from 1910. It became obligatory in all communities with more than 4000 inhabitants in 1934. However, in all Sweden, also the purely rural areas, it first became obligatory in 1959."

Farmers saw the 1986 antibiotic feed additive ban, the 1986 ban on use of meat and bone meal in animal feeds, and the 1988 farm animal welfare act as assurance to consumers that their meat, dairy, and poultry products were produced according to high ethical standards. Many of the 1988 farm animal protection law's provisions were already in practice and had been part of the Swedish meat marketing association's "Responsibility in Husbandry" program and other industry codes of practice prior to the Act. Thus, only a few farmers were out of compliance with the Act's ban of sow gestation crates by the time that restriction in the Act was phased in, in 1994. The majority of piglet producers were keeping their sows in loose housing on deep straw by the middle of the 1980s.

Another difference in Swedish agriculture is that for many years assistance to farmers was not made on the basis of volume, but on the basis of farmers' costs of production. Prior to

dismantling farm aid programs before entering the EU in 1993, producers' organizations in Sweden had the right to go to the government and bargain for the price of farm products on the basis of farmers' costs. Government programs did not promote the trend toward "rationalization" and larger and larger farms as they did (intentionally or not) in the United States (see above).

Thus, the Swedish ban in 1986 on antibiotics as growth promoters or the 1988 decision on a new, radical, animal welfare act were not only consequences of scientific research, but were, like the 1986 ban on meat and bone meal to ruminants, caused by a strong demand for ethics in animal husbandry.

Establishing legislation and compliance entails three steps, the Act, the Ordinance, and the detailed enumeration of guidelines for procedures and practices that farmers are to follow.

a. Key provisions of the 1988 Farm Animal Welfare Act and subsequent amendments

The 1988 law has been described as Astrid Lindgren's law because the Swedish author wrote a series of humorous articles in the newspaper *Expressen* chiding the Swedish agriculture minister about how farm animals were being raised. As a beloved author of children's books, Lindgren is an institution in Sweden. Most people in Sweden had grown up on her books. The articles roused the Swedish public and encouraged the farm sector to establish responsible husbandry programs. The 1988 Farm Animal Welfare Act was "presented" to Lindgren on her birthday by the Swedish Minister of Agriculture as a kind of honorary tribute. However, it is a mistake to infer that the law did not have broad public support. Lindgren's writings drew public attention to problems in animal production of which the broader public had been unaware.

The Swedish Farm Animal Welfare Act is unique in several respects. First, it decrees "animals shall be treated well and shall be protected from unnecessary suffering and disease." Protection from disease is a unique provision. The animal welfare law thus clearly includes the health of animals (Ekesbo 1999).

Second, it decrees "Animals…shall be accommodated and handled in an environment that is appropriate for the animals and in such a way as to promote their health and permit natural behaviour" (SFS 1988:534). Included are requirements for environmental enrichment. For example, all animals are required to be provided with straw.

Third, it establishes that the government may give regulations regarding details of housing design to ensure animal health and welfare; sets forth an obligation on the part of the producer to have the plans and drawings for new or remodelled premises scrutinized by state regional veterinarians from an animal health and well-being perspective before they are built; and sets forth an obligation to have new technology related to animal husbandry pre-tested from an animal health and well-being perspective.

Practically speaking, this scrutiny is undertaken by the veterinarian in consultation with a regional agricultural engineer and the farmer. The aim is to protect the animals and the farmer from drawbacks of disease and animal welfare problems (Ekesbo 1999b). The scrutiny of plans for remodelling or building and the evaluation of new techniques and methods save the farmer

effort that would otherwise be expended in counteracting environmental factors that negatively influence the animals' health. Eliminating negative health and well-being factors enables the farmer to concentrate on positive measures for farm animal health and well-being.

People who violate the law are subject to fines and imprisonment of less than one year. If a person builds a building without the approval of the appropriate scrutiny and authorities, the person will be fined or charged for having done so. If it is determined by the county administrative board that a person has failed to comply with a decision by a supervisory authority, or if a person seriously neglects the supervision or care of an animal, or if a person mistreats an animal, the law is that they shall be prohibited from having animals in their care for either a fixed period or until further notice.

In 1988, the Swedish Farm Animal Protection Act required the gradual phase-out of battery cages for laying hens with a deadline of the year 1999 for all battery cage systems to be replaced. Following the ban researchers at two locations in the Swedish University of Agricultural Sciences began investigating alternatives to battery cages and conducting research on their ability to improve the welfare of the hens.

In 1997, based on the research, the Swedish Farm Animal Protection Act was redefined and at that time functional refinements such as the need for early access to perches and litter material (in order for hens to adjust well to non-cage systems later in life) were incorporated in the legislation. The new definition included stipulations that a hen should be able to perch, nest, and dust bathe in all types of housing systems (Gunnarsson 2000). Only housing systems where hens had access to perches, nest boxes, and dust baths were allowed. In 1999, the European Union required that all new cages installed from the year 2003 provide hens with a nest, litter for pecking and scratching, and appropriate perching space.

b. 1988 Farm Animal Welfare Ordinance

The Act provided general rules concerning the keeping and treatment of farm animals (including animals farmed for fur), while the Ordinance becomes more explicit concerning specific practices. For example, where the Act states "animals shall be … protected from … disease" and "accommodated … in such a way as to promote their health," the Ordinance specifically forbids the use of electric cow trainers (an electrified wire hung above the backs of tied cows that prevents them from hunching their backs too much when they urinate and defecate so that dung lands in the gutters and not in the stall). Studies had found that the use of electric cow trainers affected how cattle lay down, causing them to tramp on their teats more often, which led to infections such as mastitis, and that they have been connected to infertility in dairy cows (Ekesbo 1999b).

c. The National Board of Agriculture

The National Board of Agriculture is charged with the responsibility of providing guidelines and procedures for producers of the different species of livestock as to how to meet the letter and intent of the law. These detailed guidelines are critical to successful adoption and adjustment by farmers.

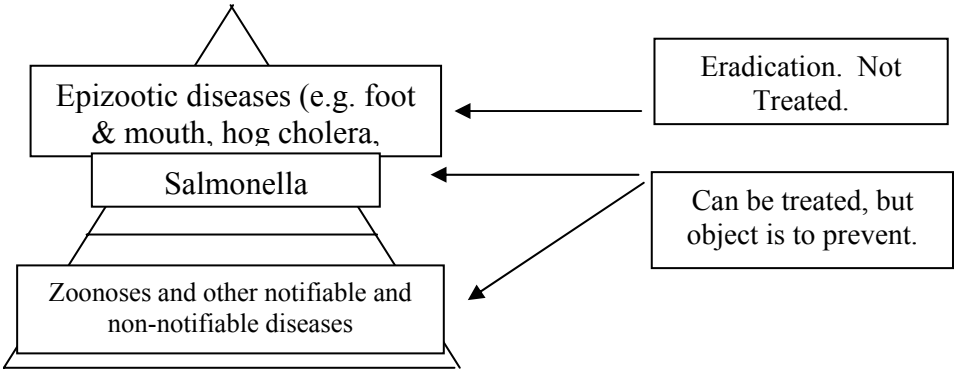
d. Sweden's Program of Health Control

In the first part of the 20th century, Swedish veterinarians did their usual work, which was to treat sick animals. However, they came to realize that when the animals were sick it was too late (Ekesbo 1999b, Wierup 2000). Therefore Sweden organized a health control program aimed at eradicating or drastically reducing the presence of disease in the country by strict control measures and then, once a satisfactory level was reached, embarking on a national disease-preventive veterinary program (Wierup 2000).

The following description of the Health Control Program is taken from the presentation of Dr. Martin Wierup, Head of Sweden's Animal Health Service, at the September 4-5, 2000, European seminar entitled Sustainable Animal Production: Animal Welfare and Animal Health, Mariensee, Germany, which the author attended as part of this GEIS technical working paper project.

Dr. Wierup described Sweden's health control as being based on treating different types or levels of diseases differently (Figure 10-2 and following).

Figure 10-2. Three levels or types of diseases and their handling under Sweden's health control program.



For prevention, it is critical to have (1) a proper diagnosis, for which a qualified diagnostic laboratory is needed; (2) knowledge of the epidemiology of pathogenesis and ways of controlling it; (3) complete knowledge of the disease situation in the entire country at the farm, county, regional levels and for this is needed a *disease recording system* to detect, for example, presence of lesions at slaughter, farrowing rates, weight gain, and other measurable indicators of disease; and (4) strategies for control, that is, the causative agent to be controlled must be pinpointed and then dealt with.

1. Strategies for control: Choices

i. Microbial Exposure

Total and partial exclusion of the target animal from exposure to infectious doses of the pathogen are generally used against disease (Wierup 2000). Sweden's approach is total exclusion.

Total exclusion: This is the most extreme and safest way to prevent an infectious disease – by eradication of the pathogenic microbe. An eradication procedure needs access to an organizational capacity and the technical resources necessary to stop the spread of the infection and to combat its source. It is possible economically and the knowledge is available to control also diseases other than epizootic diseases with the aim of eradication, e.g., Aujeszky's disease in swine or BVDV in cattle. It is possible and economically justified to maintain an already disease-free status in a herd or area by preventing the introduction of disease, e.g., by control of imported animals or animal products into the herd, area, or country. For herds of special importance, such as boar and bull stations and hatcheries, this (disease free status) is officially regulated in Sweden.

A severe threat to total exclusion arises with the idea of "free" international trade as discussed within the European Union and the World Trade Organization. The measures aimed at controlling and eradicating diseases are in conflict with "free trade." If these problems are not solved, we will tend to a situation where ambitions to improve animal health are discouraged and instead we may end up in a situation where the lowest disease status of a participating country will be considered the standard. This becomes a serious problem for countries such as Sweden with hard-won disease-free or near-disease-free status in important diseases, including zoonoses.

Partial exclusion: In the case of partial exclusion, one lives with the microbe. This is essentially decreasing the intensity of animal exposure to pathogenic organisms in a similar manner as for total exclusion. But additional health supporting actions are necessary. *Efforts must be continually implemented and improved, whereas with a total exclusion program, once the disease is excluded, efforts can cease.*

For partial exclusion, the idea is to obtain a microbial exposure that is below the infective dose, or decreased to such an extent that immunity is induced but no clinical disease occurs in exposed animals. Thus, a possible further spread of the infectious agent from the animals that were first exposed is limited to such an extent that secondary clinical outbreaks in contact animals are prevented. Some tactics are: to optimise hygiene, isolate sick animals, quarantine new animals, and not introduce sick ones into the herd, replace live breeding animals by semen and embryos.

ii. Antibiotics

Implementation of disease prevention measures to decrease the need for antimicrobials is strongly recommended. Antibiotics can decrease or eliminate pathogens, but due to the emergence of antibiotic-resistant strains of bacteria, control of bacterial infections cannot uncritically be based only on the use of antibiotics. The use of antibiotics should be considered as an integrated and usually the last part of other disease-preventive methods. It should be used only when all other approaches have failed and not as a substitute for them. If growth promoters that have a disease preventing effect are removed, other disease preventing measures must be introduced.

In Sweden, the law prevents using antibiotics to control disease and promote growth. The farming industry adjusted, with restrictions on antibiotic use contributing to another solution: disease prevention by improving health and immunity and by reduction or eradication of diseases.

Antibiotic resistance has been reduced, making antibiotics more effective for treating bacterial diseases when they occur.

iii. Host Defense (Resistance)/Immunity

A strong immunity is required in the target animal to meet and resist disease. Correct feeding, housing, ventilation, and other environmental factors should optimise the physiological general resistance of healthy animals. Management routine is also important to keep on top of disease and recognize the signs of potential ill health. Reduction of stress by implementing production methods and facilities that are compatible with the animal's biological and behavioural needs improves immunity. Natural defense mechanisms are enhanced by vaccinations. Control and eradication of immune-depressant diseases such as Bovine Virus Diarrhea, Bovine Lucosis, and Aujeszky's disease in pigs help animals maintain resistance and have a beneficial effect beyond preventing illnesses from these diseases alone.

e. Sweden's Salmonella Control Law

A voluntary control program for control of fowl typhoid had been running in Sweden since 1941. But in 1953-54, serious salmonella outbreaks drew attention to the inadequacy of a voluntary program. In 1953, Sweden's largest outbreak involved the illnesses of almost 9,000 people, 90 of whom died. The source was *Salmonella Typhimurium* spread from a slaughterhouse. In a 1954 epidemic, 500 people were infected by *Salmonella Montevideo*, most likely from meat imported from South America. As a result of these two outbreaks, in 1961 a Salmonella Control Law was passed setting up official control of Salmonella. Now, statistics and comments on Salmonella isolations from animals, feed and food products in Sweden are continuously published.

The objective of the Swedish Salmonella control program is that "animal products delivered for human consumption shall be free from Salmonella" (Wierup 1993). That is, food delivered to consumers shall be Salmonella-free. The concept for achieving this objective is that the animals delivered for slaughter shall be free from Salmonella themselves. That is, Salmonella control goes all the way back to the farm (and even beyond it, to grandparent flocks which are quarantined and tested upon import to Sweden and birds with Salmonella are destroyed (Wierup 1993, Svedberg 1994)). The strategy is to prevent Salmonella introduction through breeders, feed or the environment. Accordingly, broad steps for achieving the objective are

1) Prevent Salmonella contamination of all parts of the production chain.
2) Monitor the production chain at critical points to detect if Salmonella contamination occurs there.
3) Undertake actions necessary to fulfil the objective of the control when Salmonella contamination is detected.

Wierup (1993) notes: "It is also found to be of basic importance to create a legal framework and motivations to ensure cooperation and compliance with the program." Of basic importance for the control of Salmonella in food-producing animals is that meat products

contaminated by any servovar of Salmonella are by law (Food Act. SFS 1971:511) declared unfit for human consumption.

All veterinary laboratories are required to report isolations of Salmonella immediately to the Swedish Board of Agriculture (SBA) and the county administration. Isolations are sent to the National Veterinary Institute (NVI) for confirmation and registration. In all suspected and confirmed cases, the SBA will instruct a veterinary officer to investigate the occurrence and supervise the clearance of the farm from the Salmonella infection or contamination.

Infected farms are subject to restrictions including a total ban on movement of animals except to sanitary slaughter (sanitary slaughter is a special facility separated from the rest of the slaughterplant and is used for downed or ill animals) (Wierup 1993). The veterinary officer supervising the clearance will give specific instructions to each farm, for example, to destroy all carrier animals that may be long-term shedders of Salmonella. Restrictions remain in place until all animals are declared free from Salmonella following a bacteriological examination. For *Salmonella Typhimurium* two negative samples with a one-month interval from all animals are required before the herd is declared Salmonella-free. For broilers, in which the shedding period for Salmonella is longer than the rearing period, the alternative to clear Salmonella from an infected flock has been to destroy the entire flock. Thereafter, the farm must be sanitized by finding the source of the bacterial contamination and getting rid of it.

On most pig farms on which salmonella is found the herd must be eradicated or, if the contamination is minor, or localized to a single part of the herd, some farms may be required to kill only those animals. However, the source of contamination must be found and eradicated. Pig farms on which the whole herd has been slaughtered can restart production only after the farm is clean of salmonella. If the farm belongs to a voluntary salmonella program, the government pays 70% of the producers' costs of depopulating and restarting. Producers not in the program receive only 50% of the costs and must rely on insurance to pay the rest.

Under Swedish circumstances, removal of infected animals in combination with control of feed and other hygienic methods is sufficient to remove Salmonella infection from most infected herds (Wierup 1993). In larger herds, however, an environmental Salmonella contamination, when it occurs, seems to be established and this may be the source of new outbreaks in the herd. Hence, eradication is the control procedure used.

Since the late 1980s, Sweden's animal production, including egg production, has been almost salmonella-free. This significant achievement has been attained with a high level of personal responsibility on the part of Swedish farmers (Ekesbo 1999b).

In the European Union, Finland and Sweden have the lowest incidence of salmonella. To help them protect their farmers, the European Union granted a special derogation allowing Sweden and Finland to refuse imports of animal-based consumer products contaminated with salmonella bacteria (G. Ståhle, 2000, personal communication). The burden, however, is on Sweden and Finland as importers to catch salmonella coming into the country. Local authorities at the borders had to improve their detection and control.

Imports are to be certified by a veterinarian in the country of origin to be free of salmonella. Nevertheless, many instances of foreign veterinarian-certified salmonella-free animal products that came into the country were discovered to be contaminated with salmonella anyway, creating a risk for Swedish farmers (and supporting the concern of countries with high health and welfare status

about the impact of obligatory free trade on their herd health and economy). To minimize the problem of contaminated feedstuffs, Sweden heats and pelletizes the imported feed, killing the pathogens, and treats shipping containers.

Continuous control and monitoring in both swine and cattle is based on the clinical control of the herds (consistent veterinary attention) and bacteriological examinations for Salmonella of all animals sent to sanitary slaughter. Specific controls on carcasses at normal slaughter are now also performed regularly to monitor the Salmonella situation and results confirm that Salmonella incidence in Sweden is very low.

The following figures show Salmonella incidence in Sweden over the past three decades in poultry (broilers), cattle and swine.

Figure 10-3. Salmonella incidence in broilers, Sweden 1970-1999 (Wierup 2000).

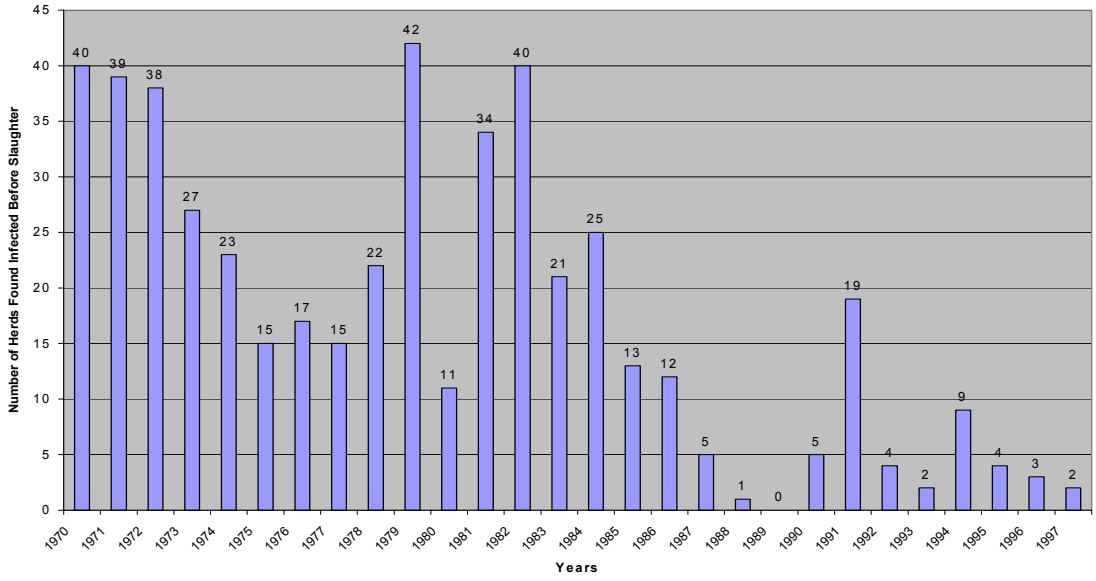


Figure 10-4. Salmonella incidence in cattle, Sweden 1968-1995 (Wierup 2000).

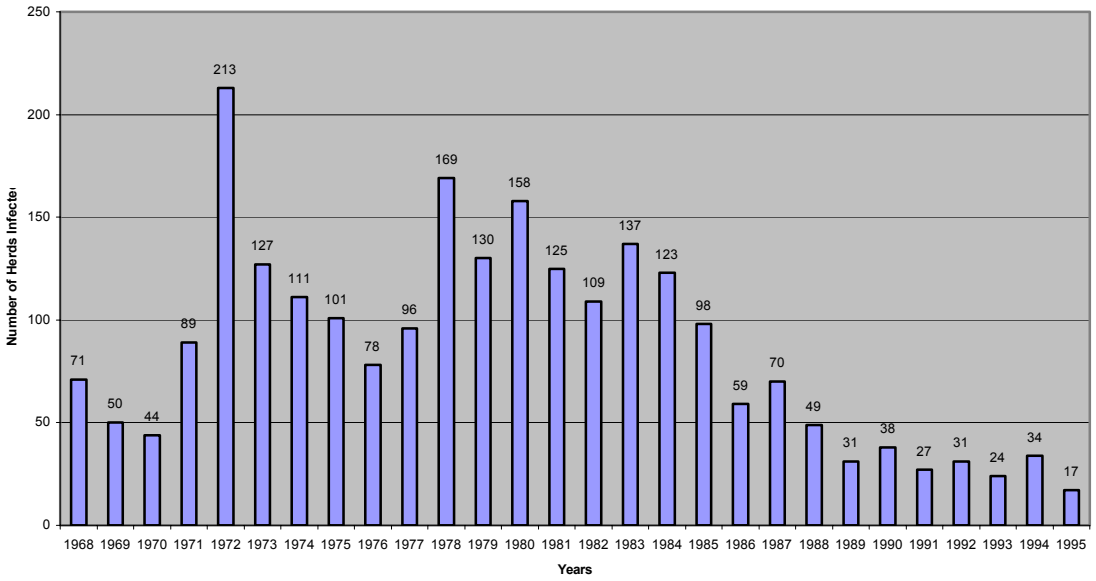
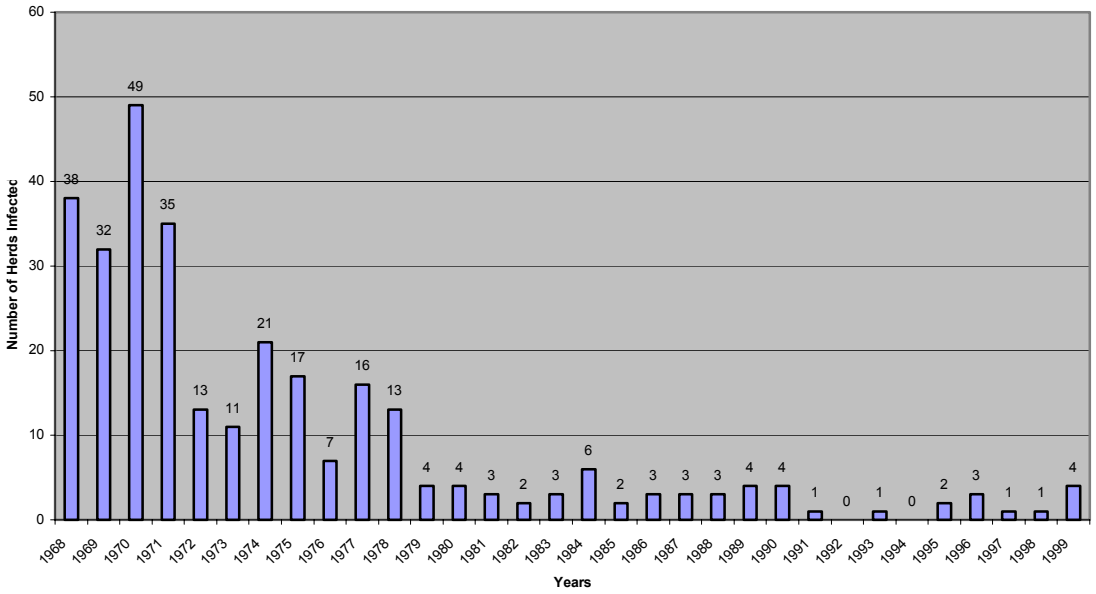


Figure 10-5. Salmonella incidence in swine, Sweden 1968-1999 (Wierup 2000).



When Sweden entered the EU, it did not relax the high standards for Swedish farmers to help them compete on a price basis with the lower priced products from abroad. Swedish farmers continue to be competitive with other producers in the European Union on a quality basis, including recognized high standards for animal welfare, the environment, and food safety.

Today, Sweden is a model for the European Community in achieving animal health and well-being and, consequently, human health and well-being. This was recognized at the Sustainable

Animal Production Seminar in Animal Welfare and Animal Health at Mariensee, Germany, in September 2000, where Dr. Wierup was introduced as the last speaker "because Sweden has solved so many of the problems presented at the conference and can point the way." It was also recognized in the 1993 National Veterinary Institute/World Health Organization International Course on Salmonella Control in Animal Production and Products entitled A Presentation of the Swedish Salmonella Program.

The difficulty is for animal health and welfare that not many other countries are ready and willing to take the strong and proactive position Sweden has taken on animal welfare and food safety. At the same time, the imposition of "free" trade threatens Sweden's preferred approach to disease of microbial exclusion and also threatens to reduce world animal health and well-being status to the level of capability of the country with the lowest animal health and well-being.

C. Switzerland

The Swiss legislation on animal welfare (1981) specifies general and detailed requirements for the housing of farm animals, including minimum dimensions for size of boxes, stalls, pens, and so forth and maximum stocking densities for cattle, swine, and poultry. Transition periods were provided for existing producers. The Federal Veterinary Office Animal Welfare Division supervises application of the law, while enforcement of the law is primarily the responsibility of the 26 cantons in Switzerland, in most cases the canton veterinary offices there.

Swiss law and the Regulations for the Protection of Animals require that animals be kept according to their needs, without disorders of the behavioural and bodily functions and that the capacity to adapt must not be overtaxed (Tierschutzgesetz Schweiz 1992, Tierschutzverordnung Schweiz 1991, cited in Hirt, et al. (1997).

The Swiss animal welfare law requires all new production methods in animal agriculture to be tested by federal testing stations with respect to their effects on the welfare of farm animals. Each firm wanting to bring a new production technology into the market first submits it for testing by one of two Swiss research farms and also defrays the costs of the testing (Ekesbo 1992). Only commercially purchased technical devices are tested and not a new device a farmer introduces on his own farm but does not sell. Testing of husbandry systems such as loose housing for laying hens (see Chapter 9), by the research stations is supplemented by monitoring systems that use clinical records from a limited number of commercial herds or flocks where the system is used for the testing period (Ekesbo 1992). Each evaluation of a new technical device or management system for its animal health and welfare implications follows established scientific routines. These are described in Ekesbo (1992) and Steiger (1994).

Direct payments are given to farmers keeping dairy cows in housing systems that are especially adapted to the animals' behavioral needs (Wechsler, et al. 2000). Two programs for housing systems corresponding to defined standards that exceed the minimal requirements of Swiss animal welfare legislation have been launched.

For cattle, consequences of the animal welfare law have included replacing extremely short tie-stalls with longer ones, development of new and improved tethering systems for dairy cattle with more liberty of movement and a ban on the sale of rigid yokes, a move away from housing calves in individual stalls and towards housing them in groups on deep litter, adding iron

to milk powder fed to calves improving haematological values and immunological status of the calves, and development of improved cubicles in loose housing for cattle and improvement of floors (Steiger 1994). However, there have been difficulties incorporating the rule to provide regular outdoor exercise for tethered cattle.

For pigs, the law resulted in provision of materials for occupation, such as straw, hay, and silage, a ban on tier cages for piglets and neck tethering of sows, development of group housing systems for sows and improvement of floors, and new and more natural housing systems such as open front housing of finishing pigs and group housing of sows (Steiger 1994). However, there were difficulties with implementing the rule to give pigs occupational materials and permit regular outside exercise for sows in tethers or crates.

Switzerland has been the most successful country in the development and widespread adoption of welfare-compatible alternatives to the battery cage for laying hens (Steiger 1994, Swiss Society for the Protection of Animals 1994). During the 1970s, growing consumer criticism of battery cage housing led the University of Zurich and the Federal Institute of Technology ETH in Zurich carried out extensive studies on the behavior and health of laying hens kept in battery cages, "sloping-mesh" houses, and floor and free-range systems between 1972 and 1975. The research found that laying hens retained the behavioral repertoires of junglefowls and that cages and sloping-mesh systems restricted the natural behavior of the hens and led to behavioral abnormalities and poor health. This led to further research to find systems that conformed to the needs of the hens and were economical.

Photographic illustrations of alternatives to battery cages, Switzerland and elsewhere (*Source: Ruth Harrison collection*).

Figure 10-6. Aviary system. Swiss aviary systems, with tiers, nest boxes, litter, automatic feeding, watering and egg collection, and making good use of "the third dimension," achieve high productivity and bird welfare, consistent use of nest boxes by the hens, and a low incidence of "floor-laid" eggs.

Figure 10-7. Straw yard with litter, nest-boxes, outdoor access. Straw yards provide a compromise between outdoor and indoor conditions. They house groups of 400-600 birds at ambient temperatures under natural ventilation and light and now are usually covered and suited to use in temperate climates.

Figure 10-7. Intensive free-range laying hen system, with portable, plastic-covered steel frame, nest boxes in center, feeders and waterers evenly spaced throughout building, outdoor access to pasture.

Figure 10-8. Perchery system with nest boxes, litter and natural ventilation

Figure 10-9. Tier system with wire floored tiers, nest boxes, and litter below. The floors are sloped toward the nest boxes so that eggs laid on the floor will roll to the front of the boxes.

Preparatory work for the new animal welfare legislation that was to come into force in 1981 initiated development of new housing systems for laying hens in 1978 with construction of the first "get-away" cages at the Swiss Poultry Breeding school and in 1979 with the first housing of laying hens in an aviary system at Klingentalmühle experimental station in Weiningen (Swiss Society for the Protection of Animals 1994). The work on the get-away cage was abandoned when it was seen that it was not working and work went ahead on the aviary systems.

By prescribing sheltered, darkened nest boxes, perches or slatted grids for all hens and a minimum area of 800 cm^2 on mesh floors, the 1981animal welfare law effectively prohibited the battery cage housing of laying hens, which had been customary in Switzerland. A ten-year transition period was granted to poultry keepers to bring existing hen housing into line with the new regulations (Steiger 1994). The law also stipulated that new technologies for animal production and new housing and management techniques must be tested for their compatibility to animal welfare before they were put on the market. Already by the end of 1981, building contractors were submitting their new designs for hen housing to the Federal Veterinary Office for testing. By January 1, 1992, the Swiss poultry keepers had completed the changeover and had done so without state subsidies (Steiger 1994, Swiss Society for Protection of Animals 1994).

A number of laws in Switzerland are deemed important for the keeping of laying hens (1-11 below) (Swiss Society for the Protection of Animals 1994).

1) The Agriculture Act of 1951 aim is to maintain a thriving farming population and an efficient agricultural sector, promoting agriculture while taking due account of the interests of the Swiss economy as a whole.

2) The Order of 1962 on Poultry Breeding and Poultry Keeping requires breeders and keepers of poultry to take such self-help measures as can reasonably expected of them, and particularly to improve the productivity, health and resistance of their stock by appropriate selective breeding, feeding and management. The Federal Government promotes the breeding and keeping of poultry by giving support to measures relating to selective breeding – in particular education and experimentation, productivity tests and advisory services – through such agencies as the Swiss Poultry Breeding School and the Central Poultry Establishment.

3) The Order of 1990 on the Egg Market and Egg Supply is to maintain and direct onto appropriate lines an economically efficient egg production adapted to the needs of the home market, primarily in agricultural undertakings which are in need of upgrading, and to promote the sale of a limited number of eggs from such undertakings. Importers of shell eggs must purchase a quantity of Swiss eggs that bears an acceptable relation to the volume of their imports.

4) The purpose of the Order of 1980 on Animal Feed Price Surcharges is the maintenance of arable farming and the adjustment of the numbers of livestock. The Swiss Cooperative for Cereals and Animal Feeds levies price surcharges on imported animal feeds.

5) New buildings and conversions of housing for cattle and calf fattening, pig breeding and fattening, chicken and turkey meat production, the raising and the keeping and breeding of laying hens over a certain population are subject to a permit from the Federal Office for Agriculture under the 1988 Order on Permits for Livestock Housing.

6) The 1988 Order on Maximum Livestock Numbers is aimed at quantitative regulation of meat and egg production and reduces the numbers of livestock kept by large-scale holdings and "thus has the character of a structural regulation measure." The maximum livestock

numbers in 1994 were 12,000 laying hens, 12,000 breeding hens, and 12,000 rearer pullets. Farms that breed their own stock in special cases may keep 12,000 laying hens and 6,000 pullets.

7) The 1993 Order on Supplementary Direct Payments in Agriculture requires the Federal Government to make supplementary direct payments to farmers operating agricultural enterprises on an area of at least 3 hectares on their own account and at their own risk.

8) The Order on Contributions for Special Ecological Measures in Agriculture (1993) obliges the Federal Government, on application, to grant contributions to farmers for operating agricultural undertakings for ecological compensatory measures; integrated production; organic farming; and controlled free-range keeping of livestock.

9) The Protection of Lakes and Rivers Act (1971) protects bodies of water from polluton and eliminates existing pollution. Agriculture must help achieve these aims by such measures as bringing the numbers of livestock into line with the available land area. A maximum of 3 Large Livestock Manure Units (LLMU) per hectare of agriculturally employed land are tolerated. One LLMU corresponds to the annual liquid manure and dung production of a cow weighing 600 kg., 100 laying hens, or 250 rearer pullets.

10) The 1960 Federal Law on Protected Goods Prices and the Price Compensation Fund for Eggs and Egg Products provides for price monitoring to prevent excesses in the development of prices and margins while the price compensation fund supports sales of Swiss-produced eggs and is itself financed by a levy imposed on imported shell eggs. The Swiss Federal Council fixes the guaranteed producer price for the purpose of price compensation. It also makes contributions to the appointed organizations for collection, transport, and intermediary costs for Swiss-produced eggs. It is also empowered to grant other price-reducing subsidies or make contributions from the price compensation fund to support sales promotion measures.

11) The Animal Protection Act of 1978 regulates the treatment of animals in the interest of their protection and welfare. Animals must be treated in such a way as to make the best possible allowance for their needs. Certain types of battery cage systems and housing where birds are kept in the dark are prohibited. Commercial housing systems may not be advertised and sold unless a body designated by the Federal Council has approved them. Approval is granted only if the systems and equipment conform to the requirements of behaviourally appropriate husbandry.

The Animal Protection Order of 1981 defines the minimum requirements for appropriate animal husbandry, including the general regulations of keeping animals together with regulations more specifically concerned with the keeping of domestic and wild animals, the transport of animals, and animal experiments.

For laying hens, buildings in which the birds are continuously housed must be lit, if possible, by natural daylight. The strength of illumination must be at least 15 lux during the day and the period of illumination may not be artificially extended to more than 16 hours per day. For breeding and laying birds of all species sheltered, darkened nest boxes with litter or a soft base must be provided. Perches or suitable slatted grids for perching must be provided, for young pullets as well as laying hens (if not reared with access to perches early in their lives, hens will not be capable of jumping up to perches in the aviary or perchery). Ducks must be given a suitable bathing facility. The facilities must be within easy reach of the birds.

Beaks must not be trimmed to such a degree that the birds are unable to feed normally. Culled chicks must not be stacked upon each other as long as they are alive.

The Federal Veterinary Office formulates procedures for the industry to adapt to the Animal Protection Order and get approval of buildings for livestock housing. It also prepares guidelines concerning stocking densities in housing for laying hens and in rearing operations for laying breeds.

3. China, Taiwan, and Japan

At the request of a member of the CAC, the principal investigator looked into animal protection laws of Asian countries. Three countries, in view of their potential as trading partners, were selected: China, Taiwan, and Japan. For all intents and purposes there is no law protecting farmed animals in **China**, so China will not be discussed further here.

In 1998, an Animal Protection Law was promulgated in **Taiwan** "to protect animals and to show respect for their lives." In the case of conflicts with other laws, those laws are given priority.

Farm animals – animals kept for commercial – for the supply of fur, leather, meat, milk, labor and other economic purposes, are protected under the law, however, no specific directions are laid out in the main body of the law with respect to them.

Activities regarding animals such as organized fights, competitions for gambling, and other activities against social ethics are prohibited. An animal protection committee is established under a central governmental organization to take charge of formulating animal protection policies and examining the enforcement of the law. The committee is to be made up of at least two thirds experts, scholars, and members of private animal protection groups not representing any governmental organization.

Farm animals, therefore, are protected in a general sense and, this law belongs to the category of law that prevents cruelty rather than the category of law that prescribes and promotes specific good husbandry practices.

No information was available as to enforcement of the Taiwanese animal protection law.

The **Japanese** law for the protection of animals consists of 13 articles enacted in 1973. It is entitled Animal Protection Law and it is based on the principle that people will not kill or hurt animals without an accepted reason. The law promotes the protection of animals among Japanese people and establishes a Council for Animal Protection under a governmental Advisory Committee. The law states that any animal that must be destroyed must be destroyed in the most painless way and that if an animal is found that is sick or injured or dead, the finder must inform the appropriate authorities who will collect it.

The principle of the Japanese law applies to farm animals and pets. The penalty for harming an animal without reason (appropriate reasons are not specified and may be left to judicial review) is 30,000 yen or about $300.

Protected animals are: cows, horses, hogs, sheep, dogs, cats, rabbits, ducks, hens, and other birds and mammals.

No information was available as to enforcement of the Japanese animal protection law.

References

Algers, B. (1999). Pre-testing of new farm animal management technologies in Sweden—Scientific aspects. *International Seminar on Pretesting of New Farm Animal Management Technologies, Jönköping, Sweden, 20-21 October 1999*.

Backström, L. (1973). Environment and animal health in piglet production: A field study of incidences and correlations. *Acta Veterinaria Scandinavica. Supplementum 41,* 1-240.

CIWF (Compassion in World Farming). (2000, June 19). *Swedish Agriculture Minister calls on EU Agricultural Council to end long distance transport of farm animals*. News Release - NR7888. Invitation to a press conference held at the Swedish Delegation Office in the Council of Ministers Building, Centre de Conference, Plateau Kirchberg, Luxembourg.

Ekesbo, I. (1999a). Council of Europe Standing Committee for Farm Animal Welfare -- A presentation. *European Union Animal Welfare Course*, *Dublin*, *Ireland, August 27, 1999.*.

Ekesbo, I. (1966). Disease incidence in tied and loose housed dairy cattle and causes of this incidence variation with particular reference to the cowshed type. *Acta Agriculturæ Scandinavica, Supplementum 15.*

Ekesbo, I. (1992). Monitoring systems using clinical, subclinical and behavioural records for improving health and welfare. In *Livestock health and welfare*, Moss, R., ed. Essex, England: Longman Scientific and Technical, Longman Group UK Limited, pp. 20-50.

Ekesbo, I. (1999b). The Swedish experience: Animal welfare legislation – an instrument also for health protection. *European Union Animal Welfare Course, Dublin, Ireland, August 27, 1999.*

Hirt, H. Reinmann, M., & Oester, H. (1997). Leg problems in fattening turkeys. *Proceedings of the Fifth International Symposium on Poultry Welfare*. Koene, P. and Blokhuis, H.J., eds. Wageningen, NE: Wageningen Agricultural University, pp. 80-82.

Ekesbo, I. & Lund, V. (1994). Different standards in animal welfare legislation: Consequences for animal health and production economy. *Proceedings, Environmental and management systems for total animal health care in agriculture, 8th International Congress on Animal Hygiene, International Society for Animal Hygiene, September 12-16, 1994, St. Paul, MN,* University of Minnesota and Washington State University, sponsors., PA-1 to PA-5.

Lindqvist, J.O. (1974). Animal health and environment in the production of fattening pigs: A study of disease incidence in relation to certain environmental factors, daily weight gain and carcass classification. *Acta Veterinaria Scandinavica, Supplementum 51*, 1-78.

Moss, R., ed. (1992). *Livestock health and welfare*. Essex, England: Longman Scientific and Technical, Longman Group UK Limited.

Steiger, A. (1994). Effects of the Swiss animal welfare legislation since 1981, in particular concerning the ban of battery cages for laying hens and research on animal welfare. *Proceedings,*

Environmental and management systems for total animal health care in agriculture, 8th International Congress on Animal Hygiene, International Society for Animal Hygiene, September 12-16, 1994, St. Paul, MN, University of Minnesota and Washington State University, sponsors. AW-53 to AW-56.

Swedish Ministry of Agriculture. (1997). *Can we use less antibiotics? A brochure on antibiotics in animal feed and how they affect animals and humans*. Svensk Information, Stockholm, Sweden. (Available from Swedish Ministry of Agriculture, Food and Fisheries, fax # 468206496.

Swiss Society for the Protection of Animals. (1994). Laying hens: 12 year sof experience with new husbandry systems in Switzerland. Report of the Poultry Working Group, Swiss Society for the Protection of Animals STS.

Warrick, J. (2001, April 10). 'They die piece by piece': In overtaxed plants, humane treatment of cattle is often a battle lost. *The Washington Post.* Tuesday, April 10, 2001, A1.

Wierup, M. (2000). Strategies for avoiding health problems of farmed animals. Invited presentation, *Focus Group 5, Animal health and animal well-being. Sustainable Animal Agriculture Series*. September 4-5, 2000, Convened by the Research Consortium Sustainable Animal Production, Federal Agricultural Research Center (FAL). Institute for Animal Science and Animal Behaviour, Mariensee, Germany.

Wierup, M. (2000). The Swedish experience of the 1986 year ban of antimicrobial growth promoters with special reference to animal health, disease prevention, productivity and usage of antimicrobials. Johanneshov, Sweden: Swedish Animal Health Service.

Wierup, M. (1993). The Swedish salmonella control program; The current Swedish salmonella situation. *Proceedings: A presentation of the Swedish Salmonella Programme, International course on Salmonella control in animal production and products, National Veterinary Institute of Sweden and World Health Organization, Malmo, August 1993.*

PART IV

This final section contains conclusions and recommendations concerning improving animal health and well-being in Minnesota.

Chapter 11 addresses the relevance of farm animal health and well-being to other GEIS Scoping Document questions on impacts of animal agriculture in Minnesota.

Chapter 12 contains a point-by-point summary of material from Chapters 1-7 in the text and suggested policy recommendations.

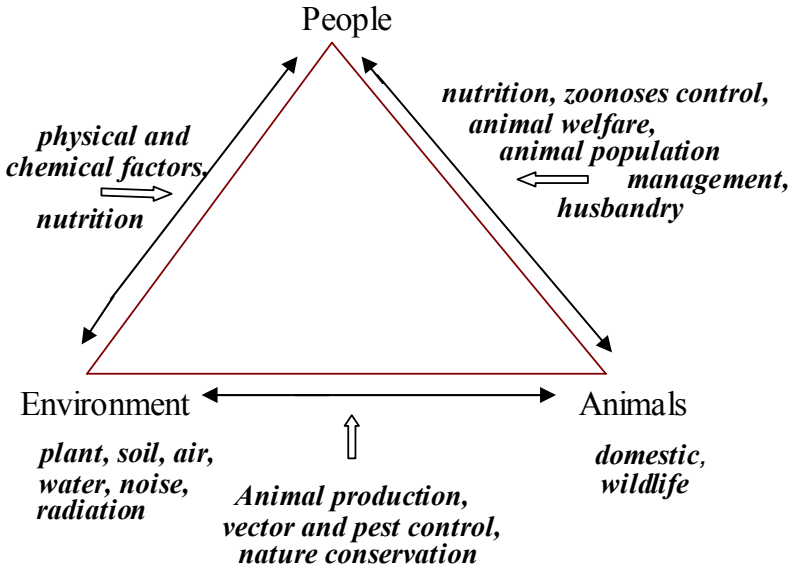
CHAPTER 11

ANIMAL WELFARE IN THE CONTEXT OF OTHER GEIS SCOPING DOCUMENT QUESTIONS:
ITS RELEVANCE TO HUMAN HEALTH AND THE ENVIRONMENT

I. Introduction: The Health Triad

In Chapter 1, a model proposed by scientists at the Veterinary Public Health Division, World Health Organization, Geneva, Switzerland was presented that depicts the reciprocal nature of the human-animal-environment relationship (Kaplan and Bögel 1991). The model, the health triad, proposes that in order for animal agriculture to be supportive of human health and the environment, human management of the agricultural animal and its environment must promote not only the function the animal performs, but its state of being – its welfare. There is, or there should be, reciprocity among the three elements. Animals and the environment are at the base of the triangle because human health cannot be sustained unless animals and the environment are healthy as well.

Figure A-1. The Health Triad. Structure, function, interaction: Components of sustainable systems. (Veterinary Public Health Division, World Health Organization, Geneva, Switzerland).



This chapter suggests some ways this reciprocal, animal-human-environment health relationship plays out and could play out in animal agriculture, using examples of two common technologies in animal agriculture: subtherapeutic feed additive antibiotic use and liquid manure handling.

II. Animal production and human health

Some 150 diseases can be passed between animals and humans (Diesch 1974, Strauch and Ballarini 1994). Diseases that can be passed between animals and humans are called **zoonoses**.

Many zoonoses are increasing rather than decreasing in prevalence with modernization and industrialization of animal farming (Mead, et al. 1999). An estimated 76-80 million cases of food borne disease occur annually in the United States and an estimated 5,020 deaths result (Buzby, et al. 1996, Mead, et al. 1999). Research completed by the U.S. Department of Agriculture's Economic Research Service (ERS) indicates that meat and poultry sources account for an estimated $4.5 to $7.5 billion in costs stemming from food borne illnesses in the United States each year (Buzby, et al. 1996). These costs include medical costs and costs of lost productivity resulting from both acute and chronic illnesses and death.

The number of people in the United States who are highly susceptible to microbial food borne illnesses is growing due to a higher number of elderly people and children in the population (Buzby, et al. 1996). Some pathogens such as *Campylobacter*, associated with consumption of contaminated poultry and pork products, leave behind legacies in the form of chronic, debilitating syndromes and illnesses that have high personal and social costs. This aspect of food borne illnesses is being newly appreciated (Lindsay 1997). For example, Guillain-Barré Syndrome, which may follow some *Campylobacter* infections and infection by other enteric pathogens, is an autoimmune reaction of the body that affects the peripheral nerves and causes weakness, paralysis, and occasionally death.

A number of potential pathways between humans and animals exists for these diseases. Workers who come into contact with contaminated animal feces, either on the farm or in slaughterhouses, can become infected. Fecal contamination of carcasses at the slaughterhouse also can allow pathogens to slip through to final retail packaging, infecting consumers of the meat. Liquefied manure or inadequately composted solid manure, if used as a fertilizer for plants or fruits intended for direct human consumption, can transmit pathogens such as *E. coli* to humans (Tauxe 1997).

Beginning in the late 1960s and early 1970s, as intensive confinement methods became prevalent, and animal numbers per farm were increasing, to save labor, larger pig and dairy producers began to liquefy manure by the addition of water and handle it as slurry. By the late 1990s, it was almost conventional in US animal agriculture to handle manure as a liquid, particularly in pig and dairy production, and to a lesser extent in some feedlot beef and poultry production (most poultry production uses litter and handles manure as a solid). How manure is handled has consequences for human and animal health and the environment.

During storage, slurry undergoes anaerobic decomposition (Strauch 1987). The cold process of anaerobic decomposition does not kill fecal pathogens, although they may die out as nutrients in the feces are exhausted. However, manure from the enterprise is continuously added to the storage structures, with the results that in liquid manure storage there is always a new supply of nutrients for pathogenic organisms to feast on and new pathogenic organisms are added continuously with the fresh waste as well. Consequently, in liquid storage, pathogens, parasites, and antibiotic residues are preserved until they are released to the environment. Plants using anaerobic digestion of slurry to produce biogas also generally operate at temperatures too low to destroy pathogens in slurry (L'Hermite 1993, Strauch 1987).

These substances are spread along with the manure on cropland and pastures, and, with growing frequency, are being leaked into rivers, streams, and lakes (Frey, et al. 1999, Marks and Knuffke 1998, Strauch 1987, Strauch and Ballarini 1994, Novick 1985, Linton 1986). Once in the environment, pathogenic organisms multiply in number as they pass through various vectors (Dr. L. Plym-Forshell, Analysen, Sweden, 1992, personal communication). Bacterial pathogens, as well as parasites and viruses in the feces, can persist and infect wildlife and livestock that ingest them (Franklin 1997, Kluczek, et al. 1988). These infections may go undetected (i.e., remain subclinical).

An expert panel convened by the World Health Organization identified liquid manure spreading as a critical pathway by which salmonellae and other pathogens are spread to the natural environment (World Health Organization 1988). Stress lowers animals' immunity to disease (Levy 1992). Animals that are stressed, for example, by transport, slaughter, or by intensive living situations, excrete more pathogens in their feces than unstressed animals (World Health Organization 1988).

To help farm animals' immune systems cope with stressful production environments, producers give them continuous, subtherapeutic doses of antibiotics in feed or water (See Chapter 4). Antibiotic feed additives are perceived as especially beneficial when animals are stressed either by intensive husbandry or by shipment (NRC 1980).[41]

At low levels, antibiotics have growth promoting and disease controlling effects in the animals. However, repeated subtherapeutic doses of antibiotics disrupt animals' normal bacterial flora and promote the growth of antibiotic resistant bacteria. As noted in Chapter 4, the National Research Council (NRC) defined a disease-controlling level of antibotics as "less than 200 grams per ton of feed, [which] delivers antibiotics that have therapeutic effects but *at dosages below those required to treat established infections*" (emphasis added), while "up to 50 grams of an antibiotic or antibiotics are added to a ton of animal feed *to promote growth in the animals eating it*" (NRC 1999).

Microbial pathogens are adapting, as in the case of antibiotic resistance, to conditions in their environments (Lindsay 1997). For nearly 50 years, medical scientists have expressed the concern that subtherapeutic usage of antibiotics in farm animals, at levels *too low to treat bacterial diseases but high enough to control them*, creates a selective pressure on bacteria, causing them to develop resistance to the antibiotics (JSC 1960).

The bacterial pathogens that survive the guts of animals fed antibiotic supplements in the diet are the resistant ones (Levy 1992). These bacteria end up in airborne dust, on the floors, and in manure storage.

[41] Antibiotics are also used as pesticides in fruit and vegetable production. Data on use of antibiotics in crop production are compiled via producer surveys and are available from the US Department of Agriculture. In contrast, data on use of antibiotics in livestock production are difficult to come by and commonly cited figures may underestimate their use in livestock production by a significant amount. For example, the US organization Union of Concerned Scientists (UCS) recently mined available sources of data on antibiotic use in animal agriculture and came up with an estimate that "8 times more antimicrobials are used for nontherapeutic purposes in the three major livestock sectors than in human medicine." The group notes that "industry's estimates suggest that two pounds of antimicrobials are used in treating human disease for every pound used in livestock" (Mellon, et al. 2001).

Antibiotic-resistant bacterial pathogens selected in animals can reach humans and pass their resistance to bacteria pathogenic to humans or, if pathogenic themselves, they can cause disease that is not easily treatable, prolonging patients' recovery time (NRC 1999). When resistant bacteria infect animals or people, treatment with the same antibiotics (or close relatives of those antibiotics) to which the bacteria have become resistant cannot kill them. When pathogens are resistant to antibiotics, especially for the elderly, young children, and immune compromised individuals, the delay caused during repeated efforts to find an antibiotic effective against the given pathogens can be fatal.

Because some bacteria are resistant to more than one antibiotic, it may take even longer for medical professionals to find an antibiotic that is effective against them than if the bacteria were resistant to only one antibiotic (Levy 1998, MMWR 1997). An untreated or poorly-treated infection increases the risk that the patient will die. Longer periods of infectivity increase the pool of infected people that are moving in the community and are exposing the general population to the risk of infection with resistant strains of bacteria and as older antibiotics become ineffective due to resistance, newly patented and more costly private-label antibiotics need to be used (Salyers 1995).

New or alternative drugs may be more toxic, i.e., have stronger side effects, or be less effective than those that would be used if the infecting organisms had not become resistant to them (Wegener 1999). Even alternative new drugs may be compromised, especially if they are related to drugs originally approved for use as growth promoters in animals because they were thought to have little potential for human use (Levy 1998). For example, the use of virginiamycin in animal feeds selected for enterococci that are resistant to it and to Synercid, a related antibiotic newly approved for treatment of animal and human diseases. Use of avoparcin as a growth promoter in poultry production selected for enterococci that are resistant to all glycopeptides, a group that includes vancomycin, which is an antibiotic of last resort for certain human diseases. The same vancomycin-resistant clone of enteroccocci has been found in animals and people (NRC 1980).

Antibiotic resistant infections show up regularly in hospitals, a circumstance that has led to restrictive antibiotic policies in hospitals (Huovinen 1997). Consequently, medical practitioners are being urged to limit their prescriptions of antibiotics. Yet, it is still possible (in the US) for anyone to walk into a farm supply store and purchase penicillin and other antibiotics without prescription and administer them to animals without veterinary supervision or other restrictions.

Antibiotic resistant bacteria can reach humans by direct transmission via contaminated meat, transmission of the gene mediating resistance to other bacterial strains capable of infecting humans, and indirect transmission of resistant strains via the accumulation of such strains in the environment (Franklin 1997). Slaughterhouse workers, producers, and farm workers can harbor antibiotic resistant bacteria and transmit them to their families.

Antibiotics provided to animals in feed or water also are excreted and are widely dispersed, contributing to resistance in bacteria they meet (NRC 1980). They may be excreted as active metabolites or "parent substances" or else they may be metabolized and excreted as inactive components (Meyer, et al. 1999, Eirkson 1999, Kolpin, et al. 1999). There is concern that widespread dispersal of antibiotics in the environment may increase the numbers of antibiotic resistant bacteria in the environment (Kolpin, et al. 1999).

In late 1998, scientists for the federal Centers for Disease Control and Prevention studied nine Iowa hog lagoon sites, each with 1,000 or more hogs (Beeman 1999, Campagnolo, et al. 1998). The investigators found pathogens, including antibiotic-resistant bacterial pathogens, metals, antibiotics commonly fed to hogs, nitrates, and parasites, including cryptosporidium, in the manure lagoons and surrounding wells, drainage ditches, and underground water. The contaminants were also found in agricultural drainage wells that empty into underground aquifers.

Scientists with the US Geological Survey and the US EPA detected antibiotics in liquid waste from eight hog manure lagoons and in well samples and surface water samples near the lagoons (Meyer, et al. 1999). One or more classes of antibiotics were detected in the liquid waste. Tetracycline was the most frequently detected class of antibiotics followed by the sulfonamides, beta-lactams, and macrolides. Estimated concentrations of individual antibiotic screens of samples from the hog manure lagoon samples ranged from less than 1 to more than 700 micrograms per liter (mg/L). In ground water, the tetracycline class of antibiotics was detected in a well sample collected near a hog manure lagoon, and the sulfonamide class was detected in another well sample near a different hog manure lagoon.

The farms on which animals and animal products destined for food originate are critical control points for zoonoses, including salmonellosis (World Health Organization 1988). They also are "critical control points" for transfer of other substances of health importance, such as antibiotics, to the environment. Critical control points are areas of vulnerability to disease introduction and transfer and also represent opportunities for interventions to prevent development of the disease and further transmission. Another route to securing the safety of farms as critical control points for human disease and reducing the amount of animal drugs that reach the environment is to improve the health of animals on farms by maintaining animal vigor and high natural immunity levels. This approach is discussed in Chapter 10 with reference to Swedish health control programs.

As a health control measure, subtherapeutic antibiotic use in animal feeds is preventive only in the sense that it keeps diseases that may be subclinically present in the herd subclinical. It controls the bacterial diseases that are present. It is not preventive in the same sense that "host defense" and competitive exclusion models keep pathogens out of the herd or help animals resist infections by supporting high immunity levels in the animals. Preventive management, when it takes the form of using antibiotics to control disease is consistent with the disease being present. The animals are not necessarily healthy in the sense that they are capable of resisting disease should prophylactic antibiotic treatment be withdrawn. This was Sweden's experience in piglet production in 1986 when antibiotic feed additives were withdrawn. Solutions had to be found that kept disease out in the first place. Hygiene in animal environments was improved and environments were made more natural (K.E. Olsson, Minister of Agriculture, 1992, personal communication; Wierup (1998), Chapter 10). "And that is the first step towards better animal welfare. If you are not allowed to use antibiotics as prophylactic measures, you must correct your environment and have better management in order to prevent disease…. When you don't consider animal welfare you have to use antibiotics to cover the problems" (G. Ståhle, Swedish Federation of Farmers, 1992, personal communication).

How animal health control is approached has social effects. For example, the National Research Council (NRC), National Academy of Sciences, concluded that the introduction and use of feed-additive antibiotics "has been concurrent with change in production technology in the swine industry" (NRC 1980). It "is likely that the use of antimicrobial agents facilitated the development of the concentrated [livestock] operations" (Levy 1998).

B. Animal manure handling, animal comfort, and human health

How animal agriculture is conducted has other impacts on human health. Solid manure from well-bedded animal production systems is decomposed by the action of aerobic bacteria. Aerobic decomposition gives off ammonia, carbon dioxide, and water vapor. Maintaining a straw-dung mixture with a carbon/nitrogen ratio of at least 36/1 and not allowing wet spots to develop in the beds can limit ammonia emission from solid manure systems. Skillfully maintained deep beds compost and this process kills pathogens and parasites and helps maintain animal health.

For liquid manure handling systems of the type we have in the US to work efficiently, no bedding is used in the housing system. When manure is handled as a slurry or liquid, it is decomposed by the action of anaerobic bacteria. In Chapter 6, adverse health impacts of liquid manure handling identified in dairy cattle when this manure handling method was first introduced were described.

The decomposition of liquid manure by anaerobic bacteria during storage and treatment produces and emits nearly 400 volatile organic compounds (Schiffman 1999). Compounds identified in liquid manure emissions include sulfides, disulfides, organic acids, alcohols, aldehydes, amines, fixed gasses, nitogen heterocycles, mercaptans, carbonyls, and esters (Schiffman, et al. 1998). Carcinogens such as benzene (Strauch 1987), and the mutagen phosphane have been identified (Glindemann and Bergmann 1995). These compounds also may be found in emissions from cattle and hog slurry biogas processing plants. In addition to gasses, disease molecules can be carried on the wind for miles, potentially affecting the health of animals on other farms (Strauch 1987).

Gasses emitted from liquid manure storage structures and intensive livestock confinement buildings are reported to have had adverse effects on the quality of life and physical and mental health of neighbors to intensive livestock operations (Ison 1999, Schiffman, et al. 1998, Thu, et al. 1997, Wing and Wolf 1999). Manure gas accidents have taken place in which animals, farm workers and farm families have perished (Anonymous 1993, 1998, CDC 1990, 1993, Doss, et al. 1993, Lorimor, et al. 1993).

In Minnesota, 12 human fatalities in liquid manure waste storage structures occurred between the years 1989-1998 (Anonymous 1998). Gasses responsible for manure gas fatalities include hydrogen sulfide and methane. It is also possible to die from lack of oxygen when levels of other gasses are sufficiently high.

Hydrogen sulfide is highly toxic (CDC 1993). It is heavier than air and it concentrates just above manure level in the storage pit. Hydrogen sulfide is also explosive over a wide range of concentrations from 4.3% to 46% by volume in air (CDC 1993). Five parts per million of hydrogen sulfide is the recommended maximum exposure level for human health (Doss, et al. 1993). At 20 ppm in the atmosphere, hydrogen sulfide causes irritation to eyes, nose, and throat. At 50 to 100 ppm, it causes vomiting, nausea, and diarrhea. At 200 ppm, it causes dizziness, nervous system depression, and increased susceptibility to pneumonia. With prolonged exposure at 200 ppm, fluid accumulates in the lungs. At 500 ppm for 30 minutes, hydrogen sulfide causes nausea, excitement, and unconsciousness. At 600 ppm and above, death occurs.

At low levels in the atmosphere, hydrogen sulfide is highly odorous. At higher levels, hydrogen sulfide paralyzes the olfactory senses. Scientists believe that even at low, chronic concentrations, hydrogen sulfide is a potent neurotoxin and does lasting damage to human health (Dr. M. Legator, University of Texas Medical Branch, quoted in Morris (1997)). According to one scientist, "hydrogen sulfide poisons the brain and the poisoning is irreversible" (Dr. K. Kilburn, University of Southern California School of Medicine, quoted in Morris (1997)). It interferes with an enzyme necessary for cells to make use of oxygen. Neurological tests of residents living close to oil refineries, another industry whose operations give off hydrogen sulfide, are reported to show pronounced deficits in balance and reaction time, attention deficits, and inability to process information quickly.

The addition of straw to pig environments to promote health is one way that Swedish farmers coped with the 1986 ban on use of nontherapeutic antibiotic feed additives in their country (Chapters 4, 10; Wierup 1998). The National Veterinary Institute in Sweden has recorded perceptible reductions in antibiotic resistance of bacterial pathogens in Swedish animals since the ban (Chapter 10).

Bedding is an important source of comfort and occupation for both confined and unconfined animals and improves the health of animals as compared to those kept in intensive confinement without bedding (e.g., Chapters 3, 4, 6, 7). In preference tests and operant conditioning experiments, pigs and chickens have demonstrated willingness to work hard to acquire bedding materials, so straw and similar materials also have important other welfare benefits (Chapter 5 and 7). In welfare legislation, straw and similar organic bedding materials are mentioned as requirements for the animal's health and well-being (Chapter 10).

The straw-dung compost from deep-bedded production systems is often called "farmyard manure" to distinguish it from slurry, or liquid manure (Sequi and Voorburg 1993). The straw-manure mixtures build tilth and soil organic matter (Strauch 1987, Strauch and Ballarini 1994). The organic matter content of a soil serves as its energy reserve (Sequi and Voorburg 1993). About half of the organic matter added to soil in farmyard manure is incorporated into the native organic matter pool of soils while slurry (liquid manure) provides only a small fraction of that (Juste and Spallacci 1993).

When the carbon to nitrogen ratio in farmyard manure is ~20 to one, the soil microflora use the available ammonium and nitrate present to metabolize the carbon into biomass, preventing the buildup of nitrates in the soil and reducing the chance of nitrate leaching (Juste and Spallacci 1993).

Bedding is a byproduct of small grain production, which can contribute to a healthy crop rotation. The grain can be sold and/or fed to animals on the farm. It contributes to the overall economy and sustainability of the farming operation, aided by the blending of animal and crop enterprises on the farm.

Handling manure as a liquid, or slurry, storing it untreated, in open, earthen or clay-lined basins or lagoons, and spraying it onto the land are the least costly methods of handling and disposing of large amounts of animal manure and add significantly to the economy of handling large amounts of manure. The methods have costs that are easily distributed outside the farming operation, as when neighbors are affected by preventable emissions of manure gasses or manure spills.

Ammonia released from the surface of liquid manure storage structures is known to contribute to ammonia deposition in rainfall that can cause excessive growth of algae in surface waters and the loss of aquatic life due to oxygen depletion (Leavenworth and Shiffer 1998, Paerl undated). Methane, carbon dioxide, and nitrous oxide are known to contribute to global warming (Bird and Strange 1992).

Unstable organic matter in liquefied manure can have negative effects on the physical properties of soil, filling cavities between soil particles, excluding air from between soil particles and creating anaerobic conditions that lead to production of such gasses as methane and ethylene (Voorburg and Ciavatta 1993).

When manure is not liquefied and bedding is used, the soiled bedding is stored in a solid form. Sufficient bedding creates a porous mixture wherein free air space provides conditions suitable for aerobic microbes to flourish (Rynk 1992). Decomposition of solid manure by aerobic bacteria begins a heating process called composting that inhibits production of malodorous compounds (Strauch and Ballarini 1994). In contrast to the over 400 compounds released during anaerobic decomposition of liquid manure, aerobic decomposition produces heat, water vapor, carbon dioxide, and ammonia. Only the ammonia is odorous.

Carbon dioxide and ammonia are more easily taken up than methane, carbon dioxide by plants and ammonia by the bedding materials. Solid manure using straw or other grain-based bedding also replenishes the soil carbon.

Ammonia emissions are low or negligible if farmers use enough carbon-rich bedding to keep wet spots in the beds covered and maintain a high carbon/nitrogen (C/N) ratio in the manure-bedding mixture. Carbon/nitrogen ratios of 36 to one or greater permit carbon in the bedding to bind ammonia nitrogen and prevent it from volatilizing (Dr. R. Poincelot, 1999, personal communication). Generally, maintaining the top of the bedding pack by the addition of fresh straw in such a way as to provide a dry and comfortable environment for the animals and separate them from their dung is sufficient to maintain a high C/N ratio and keep ammonia emissions negligible.

When composting is poorly managed and parts of the manure become anaerobic, odors will be objectionable as with anaerobic decomposition of liquid manure. Where large amounts of animal waste are generated, composting can also produce odorous volatile compounds that create air pollution and, for this reason, requires a more highly-capitalized approach, i.e., “should be carried out in closed reactors with sufficient treatment of exhaust air” (Voorburg and Ciavatta 1993). At large outdoor compost sites, stacks are turned to ensure even composting and distribution of nutrients. Experimental results have indicated that turning the stacks, a process that takes considerable time and releases large amounts of ammonia, is not particularly useful on small farms for sustaining composting or for evening nutrient content of the compost (Dr. T. Richard, Iowa State University, 1998, personal communication).

III. Animal Welfare and Sustainability

A number of producers in Minnesota and other parts of the upper midwest are turning to composting within the housing system to reduce the pathogen levels in manure that go out of the barn, for example, and is increasingly being used on small and mid-sized US farms that finish

pigs in hoop buildings on deep straw. The presence of clean straw reduces the stress levels in the animals (Lay, et al. 2000). Maintenance of a clean, dry, straw surface on beds by the daily addition of fresh straw to wet spots in the bed separates the animals from their dung. When correctly managed, the deep beds heat or compost beneath the surface. The composting kills manure pathogens in the beds. Consistent composting requires attentive management of the beds to ensure that the ratio of straw to dung and urine is appropriate and the "mixture" is porous enough to maintain aerobic digestion. If composting is not sustained, the pathogen reducing effect is lost as the beds become anaerobic (Plym-Forshell and Ekesbo 1993).

The addition of straw to pig environments to promote health is one way that Swedish farmers coped with the 1986 ban on use of nontherapeutic antibiotic feed additives in their country (Chapters 4, 10; Wierup 1998). The National Veterinary Institute in Sweden has recorded perceptible reductions in antibiotic resistance of bacterial pathogens in Swedish animals since the ban (Chapter 4).

How agriculture is conducted has environmental, social, economic, ethical, and human dimensions. The costs associated with disinfecting liquid animal manure and containing manure gasses are prohibitive enough that liquid manure handling is not a scale neutral technology, once all users are forced to internalize the costs of operating so as to prevent polluting the environment.

Preventing stress, disease, and ill health in farm animals by the fostering of hygienic and biologically and behaviorally based farming practices that promote both animal health and well-being can help to secure a significant critical control point for the occurrence and spread of zoonotic diseases. Reducing or eliminating the industry's dependence on liquid manure handling and adopting production methods that are more conducive to the physical and mental comfort of animals can help eliminate some of the important sources of environmental and human health concerns associated with animal agriculture.

Animal welfare, which consists of both health and well-being and which, to be sustained, requires attention to the state of the animal (how it experiences and fares in its environment) and not only to maximizing its dominant economic function, can then be perceived as an important bridging concept between human health and animal health. It fills a gap that, if left unfilled, exposes human health and well-being vulnerable to preventable challenges.

References

Anonymous. (1993). Fatalities attributed to entering manure waste pits – MN 1992. CDC, (*MMWR, 42 (17),* 325).

Anonymous. (1998). *Farm Injury and Fatality Data*. St. Paul: University of Minnesota, Biosystems and Agricultural Engineering Department, Farm Safety Program.

Beeman, P. (1999, August 7). Pathogens found near hog lots. Researchers say they want to look closer for potential risks to humans. *The Des Moines Register.*

Bird, E. and Strange, M. (1992). *Mare's Tails and Mackerel Scales: The Stormy Prospect of Global Warming…What it Means to Farming in the Middle Border…And What Farmers and Farm Policy Can Do About It.* Walthill, NE: Center for Rural Affairs.

Buzby, J.C., Roberts, T., Jordan Lin, C.-T., and MacDonald, J.M. (1996, August) Bacterial foodborne disease: Medical costs & productivity losses. (Economic Research Service Report. AER No. 741). Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Campagnolo, E.R., Currier, R.W., Meyer, M.T., Kolpin, D., Thu, K., Esteban, E., Rubin, C.S. (1998). *Report to the State of Iowa Department of Public Health on the investigation of the chemical and microbial constituents of ground and surface water proximal to large-scale swine operations, October-December 1998. Final Draft.* Atlanta, GA: Centers for Disease Control and Prevention, Health Studies Branch, National Center for Environmental Health.

CEC (Commission of the European Communities). (2001). *Communication from the Commission to the Council and the European Parliament on the welfare of intensively kept pigs in particularly taking into account the welfare of sows reared in varying degrees of confinement and in groups. Proposal for a Council Directive amending Directive 91/630/EEC laying down minimum standards for the protection of pigs*. Brussels, January 16, 2001.

CDC (Centers for Disease Control and Prevention). (1990). *Request for assistance in preventing deaths of farm workers in manure pits*. Washington, DC: National Institute of Occupational Safety and Health.

CDC (Centers for Disease Control and Prevention). (1993, July). NIOSH warns: Manure pits continue to claim lives. *NIOSH publication 93-114.* Washington, DC: National Institute of Occupational Safety and Health.

Diesch, S.L. (1974). Survival of pathogens in feedlot waste. Unpublished results.

Doss, H.J., Person, H.L., and McLeod, W. (1993, May). Beware of manure pit hazards. East Lansing, MI: Michigan State University Extension, Agricultural Engineering.

Dove, R. (1999, September 16). Flood report: Thursday September 16, 1999. *Neuse River notes.* North Carolina: Neuse River Foundation. Website: http://www.neuseriver.com

Eirkson, C.E., III. (1999). Environmental consideration for animal pharmaceuticals. *Workbook for the AFO Workshop. Animal Feeding Operations: Effects on hydrologic resources and the environment*. August 30-September 1, Fort Collins, Colorado. U.S. Geological Survey.

Franklin, A. (1997, November 13). Antibiotic resistance in animal production: A threat to human and animal health. Scheele Symposium, 1997. *The threat of antibiotics resistance: A Nordic perspective.* Stockholm: Swedish Academy of Pharmaceutical Sciences.

Frey, M., Fredregill, A., Hopper, R. (1999, December). *Spilling swill: A survey of factory farm water pollution in 1999.* Clean Water Network and the Izaak Walton League of America.

Glindemann, D. and Bergmann, A. (1995). Spontaneous emission of phosphane from animal slurry treatment processing. *Zbl. Hyg. 198,* 49-56.

Huovinen, P. (1997, November 13). Immediate need for antibiotic policy in the community. Scheele Symposium, 1997, *The threat of antibiotics resistance: A Nordic perspective.* Stockholm: Swedish Academy of Pharmaceutical Sciences.

Ison, C. (2000, February 20). State Health Department acknowledges health risks of feedlots. *Minneapolis Star Tribune*.

JSC (Joint (Swann) Committee). (1960). The Use of Antibiotics in Animal Husbandry and Veterinary Medicine. *Report to Parliament*. London: Her Majesty's Stationery Office.

Juste, C. and Spallacci, P., rapporteurs. (1993). *Effect of animal effluent applications on soil behaviour (VIII).* Report of the scientific committee of the European Conference on Environment, Agriculture, Stock Farming in Europe, Numbers I-XVII, Mantua, Italy, 1990-1993. Mantova: Camera di Commercio, Industria Artigianato E Agricultura.

Kaplan, M. M. & Bögel, K. (1991). Systems approaches for animal and environmental health and consumer protection. (157-165) Selected Proceedings of the XXIV World Veterinary Congress.

Kluczek, J.P., Skinder, Z., Kluczek, B. (1988). Influence of the fertilization of liquid manure on the…forage crop and the state of the animals health. *Environment and Health. Proceedings of the VIth International Congress on Animal Hygiene. 14-17 June 1988.*

Kolpin, D., Riley, D., Meyer, M.T., Weyer, P., Thurman, M. Pharm-chemical contamination: A reconnaissance for antibiotics in Iowa streams, 1999. *Workbook for the AFO Workshop. Animal Feeding Operations: Effects on hydrologic resources and the environment.* August 30-September 1, Fort Collins, Colorado. U.S. Geological Survey.

Lay, D.C., Jr., Haussmann, M.F., & Daniel, M.J. (2000). Hoop housing for feeder pigs offers a welfare-friendly environment compared to non-bedded systems. *Journal of Applied Animal Welfare Science,(3)1*.

Leavenworth, S. and Shiffer, J.E. (1998, July 5). Airborne Menace. *The News & Observer*, Raleigh, North Carolina.

Levy, Stuart. (1992). *The Antibiotic Paradox*. New York: Plenum Press.

Levy, S. (1998, May 7). Multidrug resistance – A sign of the times. *The New England Journal of Medicine (338),* 19, 1376-1378.

L'Hermite, P. (1993). Hygienic aspects of the production and use of effluents from livestock and agro-industry (X). Report of the Scientific Committee of the European Conference on Environment, Agriculture, Stock Farming in Europe, Numbers I-XVII, Mantua, Italy, 1990-1993. Mantova: Camera di Commercio, Industria Artigianato E Agricultura.

Lindsay, J.A. (1997). Chronic Sequelae of Foodborne Disease. *Emerging Infectious Diseases.* Atlanta: Centers for Disease Control and Prevention. On line: http://www.cdc.gov/ncidod/EID/vol3no4/lindsay.htm

Linton, A.H. (1986). Flow of resistance genes in the environment and from animals to man. *Journal of Antimicrobial Chemotherapy. (18) Suppl. C.,* 189-197.

Lorimor, J., Schwab, C.V., & Miller, L. (1993). Manure storage poses invisible risks. *Factsheet Pm-1518k.* Ames, IA: Iowa State University Extension, Safe Farm Program.

Marks, R. and Knuffke, R. *America's animal factories: How states fail to prevent pollution from livestock waste.* (1998, December). Washington, DC: Clean Water Network and Natural Resources Defense Council.

Mason, J. and Singer, P. (1980). *Animal factories: The mass production of animals for food and how it affects the lives of consumers, farmers, and the animals themselves*. New York: Crown Publishers.

Mead, P.S., Slutsker, L., Dietz, V., McCaig, L.F., Bresee, J.S., Shapiro, C., Griffin, P.M., and Tauxe, R.V. (1999, Sept-October*). Food-related illness and death in the United States. Emerging Infectious Diseases.* Center for Disease Control and Prevention, 5(5). http://www.cdc.gov/ncidod/eid/vol5no5/mead.htm

Mellon, M., Benbrook, C. & Benbrook, K.L. (2001). *Hogging it: Estimates of antimicrobial abuse in livestock*. Cambridge, MA: Union of Concerned Scientists.

Meyer, M.T., Bumbarner,, J.E., Daughtridge, J.V., Kolpin, D., Thurman, E.M., Hostetler, K.A. (1999). Occurrence of antibiotics in liquid waste at confined animal feeding operations and in surface and groundwater. *Workbook for the AFO Workshop. Animal Feeding Operations: Effects on hydrologic resources and the environment.* August 30-September 1, Fort Collins, Colorado. U.S. Geological Survey.

MMWR. (1997, April 11). Multidrug-resistant salmonella serotype typhimurium – United States 1996. *Morbidity and Mortalities Weekly Review 46(14)*, 308-310.

Morris, J. (1997, November 12). New alarm over hydrogen sulfide. *The Brimstone Battles: A Houston Chronicle Special Report.*
http://www.chron.com/content/chronicle/nation/h2s/index.html

Novick, R. (1985, January 25). Testimony of Dr. Richard Novick, Public Health Research Institute, city of New York. *Public hearing on Natural Resources Defense Council petition to suspend approval for subtherapeutic use of penicillin and tetracyclines in animal feed*. Washington, DC: Department of Health and Human Services, Public Health Service, Food and Drug Administration.

NRC (National Research Council, National Academy of Sciences). (1980). *The effects on human health of subtherapeutic use of antimicrobials in animal feeds.* Committee to Study the Human Health Effects of Subtherapeutic Antibiotic Use in Animal Feeds, Division of Medical Sciences, Assembly of Life Sciences. Washington, DC: National Academy of Sciences, Office of Publications

NRC (National Research Council, National Academy of Sciences). (1999*). The use of drugs in food animals: Benefits and risks*. Washington, DC: National Academy Press.

Paerl, H.W. (Undated). *Atmospheric emission and deposition of nitrogen generated from animal wastes and fossil fuel combustion: The problem, water quality impacts, research and management considerations.* Chapel Hill: University of North Carolina, Institute of Marine Sciences.

Plym-Forshell, L. & Ekesbo, I. (1993). Survival of salmonellas in composted and not composted solid animal manures. *J. Vet. Med. B 40,* 654-658.

Rynk, R. (1992, June). *On-farm composting handbook. NRAES-54*. Ithaca, NY: Northeast Regional Agricultural Engineering Service. Cooperative Extension.

Salyers, A. (1995*). Antibiotic resistance transfer in the mammalian intestinal tract: Implications for human health, food safety and biotechnology*. Molecular Biology Intelligence Unit. Austin, TX: R.G. Landes Company.

Schiffman, S. (1999). Unpublished manuscript. Durham, NC: Duke University School of Medicine and Allied Health.

Schiffman, S.S., Sattely-Miller, E.A., Suggs, M.S., and Graham, B.G. (1998). Mood Changes Experienced by Persons Living Near Commercial Swine Operations. In Thu, K.M. and Durrenberger, E.P., (Eds.), *Pigs, Profits, and Rural Communities* (pp. 84-102). Albany: State University of New York Press.

Sequi, P. and Voorburg, J.H., rapporteurs. (1993). *Environment, agriculture, stock farming: The basic problem (IV). Report of the Scientific Committee of the European Conference on Environment, Agriculture, Stock Farming in Europe, Numbers I-XVII, Mantua, Italy, 1990-1993*. Mantova: Camera di Commercio, Industria Artigianato E Agricultura.

Strauch, D., (Ed.) (1987). *Animal production and environmental health*. New York: Elsevier Science Publishing, Inc.

Strauch, D. & Ballarini, G. (1994). Hygienic aspects of the production and agricultural use of animal wastes. *J. Vet. Med. B, 41,* 176-228.

Tauxe, R.V. (1997, June 4). Letters: Does organic gardening foster foodborne pathogens? *Journal of the American Medical Association, 277(21),* 1679.

Thu, K., Donham, K., Ziegenhorn, R., Reynolds, S., Thorne, P.S., Subramanian, P., Whitten, P., & Stookesberry, J. (1997). A control study of the physical and mental health of residents living near a large-scale swine operation. *Journal of Agricultural Safety and Health, 3,*13-26.

Voorburg, J.H. and Ciavatta, C. (1993). *The utilization of animal manure and the protection of the environment. Report of the Scientific Committee of the European Conference on Environment, Agriculture, Stock Farming in Europe, Numbers I-XVII, Mantua, Italy, 1990-1993.* Mantova: Camera di Commercio, Industria Artigianato E Agricultura.

Wegener, H.C. (1999, May 20). The consequences for food safety of the use of fluoroquinolones in food animals. *The New England Journal of Medicine (340),20,* 1581-1582.

WHO (World Health Organization). (1988). *Salmonellosis Control: The role of animal and product hygiene. Report of a WHO expert committee. WHO Technical Report Series 774*. Geneva: World Health Organization.

Wierup, M. (1998). Preventive methods replace antibiotic growth promoters: Ten years experience from Sweden. *Alliance for the prudent use of antibiotics newsletter, 16(2),* 1-4.

Wing, S. & Wolf, S. (1999, May 6). *Intensive Livestock Operations, Health and Quality of Life Among Eastern North Carolina Residents.* A Report Prepared for North Carolina Department of Health and Human Services, Division of Public Health. Chapel Hill: University of North Carolina School of Public Health, Department of Epidemiology.

CHAPTER 12

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS
CHAPTERS 1-7, SCIENTIFIC ASPECTS OF THE WELFARE OF FARM ANIMALS AND CHAPTER 8, THE POLITICAL ECONOMY OF ANIMAL WELFARE

The text is quite detailed. For the convenience of the reader, Chapter 12 contains, in addition to recommendations, a "running list" of the main technical points made in the paper. Citations and references are not given here so as to eliminate distractions and reduce space. This list is not meant to substitute for the main body of the text and should not be taken out of context. If citing any material, the reader is asked to please refer to wording and citations in the main body of the text so that the material can be attributed properly to the correct sources.

In Part II, this chapter lists a number of policy actions and recommendations the GEIS Citizens Advisory Committee might want to consider to improve the lives and welfare of farm animals in Minnesota.

I. Summary and points from the report

(Note: Please do not cite from this list. Please see original text for citations and proper attributions, as, for purposes of eliminating distractions and saving space, they are not included here)

A. Part I (including Introduction).

FARM ANIMAL WELFARE AND ANIMAL WELFARE SCIENCE

1. Animal welfare science is a distinct discipline that draws on the fields of anatomy, neurophysiology, immunology, neuroendocrinology, ethology, and other basic sciences and is on a higher integrative level than any of these sciences taken singly.

2. Like health, welfare is a complex concept involving many factors and variables. Different medical scientists may differ in which factors or variables they emphasize, but that does not prevent them from conducting meaningful research to identify and rectify health problems.

3. "The welfare of an individual is defined to be its state as regards its attempts to cope with its environment." "An ideal level of welfare is a state of complete mental and physical well-being in which the animal is in harmony with its environment."

4. Welfare is the commonly accepted scientific term that encompasses both health and well-being, which in turn are conceptualized as being for the animal's sake and not for human's sake, i.e., not for the purpose of maximizing production goals.

5. Health is not simply the absence of disease or injury but the presence of robust characteristics, that is, the animal's ability to cope with the environment. It includes the presence of vigor, defined as "physical energy or strength, the capacity for natural growth and survival." For example, a hen with osteoporosis (and possibly broken bones) due to lack of exercise from being confined to a battery cage and continuous egg production with insufficient nutrition to maintain the skeletal system, is healthy enough to lay eggs, but is without vigor and her welfare is poor.

6. Well-being can be thought of as the individual's subjective perception of its state -- how it feels about its welfare or its state as regards its attempts to cope with the environment. How the animal feels affects its mental health and potentially its physical health as well.

7. Homeostasis is an "approximately constant state which varies only within tolerable limits." At every instant of an animal's life, …adjustment of function is required so that the state of the body remains stable. "It is the fixity of the 'milieu intérieur' which is the condition of free and independent life."

8. There is consensus among animal welfare scientists on the meaning of animal welfare, a conceptual framework for welfare assessment, and its implications for priority welfare issues in livestock production. Based on a Delphi poll conducted by researchers at Wageningen University, animal welfare scientists:

a. identified natural selection and domestication as processes that have equipped animals with a number of behavioral and physiological control systems, including cognitive and emotional mechanisms, enabling them to deal with changes in their environment.

b. they agreed that welfare is reduced when animals cannot maintain discrepancies between actual states of their environment and the state they desire within acceptable limits by making appropriate behavioral and physiological responses.

c. they accepted that there are no major welfare problems when there are minimum mortality, low morbidity, little or no risk of injury, good body condition (sustaining adequate production and reproduction), the ability to perform species-specific activities (including social interactions, exploration, and play), and the absence of abnormal behaviors and physiological signs of stress including suppression of immune responses.

d. they agreed that animals can suffer from pain, hunger, anxiety, and can also experience pleasure, e.g., when playing or obtaining a reward.

e. they identified amount and quality of space, social conditions, and the provision of suitable substrates as primary design criteria for animal welfare.

9. Welfare is defined to be the state of the individual as regards its attempts to cope with its environment. This state of the individual is something apart from the function it performs (i.e., different from its role or purpose) in the agricultural system. Contemporary agricultural practices, animal science research, and veterinary health objectives focus heavily on maintaining and enhancing animal performance, placing primary importance on the dominant economic or physiological function served by the animal rather than on its state.

10. "Reproduction and health have been the main disciplines of interest in the field of animal science. Behavioral studies were carried out only in relation to those disciplines. The aim was to optimize those behavioral patterns that contributed positively to productivity (food intake, reproductive behavior) and to get rid of those behavioral patterns that were perceived as counterproductive (exploratory behavior, social activities)."

11. Animal welfare science differs from animal [production] science in several ways.

a. The emphasis of animal welfare science is on the state of the animal – health and well-being for the animal's sake, from the perspective of the animal, rather than to achieve some production (or profit) maximum or cost minimum to the industry

b. "Unlike many other scientific specialties, the field of animal welfare science owes its existence … to ethical concerns extant in society"

c. Animal welfare science is distinguished by its emphasis on the "whole" of the animal rather than the functioning of its separate parts. Further, although poor production can sometimes be an indicator of poor welfare; high production levels do not necessarily imply a good welfare state. High production levels may lead to poor welfare or be achieved at the expense of welfare.

d. Animal welfare can be thought of as a "bridging concept" that links scientific research to the ethical concerns the research is intended to address

e. "The concept of animal welfare used by animal welfare scientists needs to be amenable to scientific study while relating to (and directing scientific research toward) the relevant ethical issues"

f. In a similar way, the concept of animal production relates to (and directs scientific research toward) the relevant output-maximizing and production cost-minimizing issues.

12. Welfare is important for functioning, but in many cases animals can continue to produce while in a state of poor welfare. Animals are genetically programmed to produce; they have the ability to adapt to a significant degree to their environments, including painful or stressful ones; growth rate may also correlate positively with stressors in the environment; the use of antibiotic and hormonal growth promoters to augment performance in contemporary animal production and regulate or induce reproduction and parturition, further confounds the usefulness of productivity as an indicator of welfare.

13. Quantitative production performance can ***only*** signify that quality and quantity of nutrients, the water supply, and the microclimate are adequate; that the animal did not contract any clinically-proved illnesses which influenced production yield; and that there are possible genetic differences between animals. It cannot reveal whether or not the environmental requirements of the animals concerning locomotion, resting, comfort, social behavior, predictability, and control are being met.

14. Welfare is something experienced by the individual rather than by a herd or population. Thus, while measures of herd health can be excellent indicators of the overall herd condition, it is still possible for individuals in the herd to exist in a condition of poor welfare. Individual welfare is a higher standard than herd health because each and every animal in the herd must be experiencing it.

15. Welfare concerns the quality of the life *that is lived* and is not about *whether* the animal lives or dies. "If, in hunting, the animal is unaware of being hunted and is shot cleanly and death comes instantly so that the animal does not experience fear or pain, its welfare is not in question. If an animal dies a long and painful death, then its welfare *is* affected negatively."

16. "Some ethical concerns over the treatment of animals include concerns that certain species should be protected because they are endangered, or pigs should be housed so as to prevent pollution, or children should not mistreat animals because they may become cruel or destructive

adults. The primary concern in these cases centers on genetic conservation, environmental integrity, or human virtue, rather than the quality of life of the animals. Concerns over the welfare of animals arise when we consider that protecting the quality of life of animals under our control is not only of instrumental value but also is a goal of importance in itself."

WELFARE EFFECTS OF ANIMAL PRODUCTION

17. The basic biological and behavioral characteristics of an animal comprise the initial endowment of tools and resources the animal possesses for coping with its environment. Therefore, a grounding in species-specific, natural behaviors and biology is important to understanding how farm animals experience different production systems.

18. As behavior is influenced both by genetic or species history (phylogeny) and by the animal's life experience (ontogeny), both knowledge of natural behaviors of different livestock species combined with attentive husbandry to discern differences between individual animals are needed to maintain a high level of welfare in farm animals.

Domestication and Artificial (Genetic) Selection

19. Domestication is defined as that process by which a population of animals becomes adapted to man and to the captive environment by genetic changes occurring over generations. While artificial selection in captivity facilitates adaptation to the captive environment over generations, the unique experiences of individuals foster adaptation within their lifetime.

20. Intense artificial selection and husbandry practices may have produced populations of domestic animals with reduced potential for survival in nature due to reduced vigor or inability to reproduce naturally. Breeding for rapid growth in broilers has resulted in leg deformities. The outcome of artificial selection predetermines the state of the individual animal *going into* the production system by modifying the initial endowment of tools and resources the animal possesses for coping with its environment, which include both its body characteristics and behavior.

21. Selection may be defined as causing or permitting certain individuals within a population to produce the next generation. The selection that nature achieves through survival of the fittest and through the survivors passing on their genes to subsequent generations is natural selection. Unlike natural selection, artificial selection is goal-oriented. Artificial selection occurs prior to reproduction. People artificially select animals and allow them to reproduce in order to increase the proportion of desirable genes in a population for a particular purpose. Natural selection is an outcome of differential reproduction. In some cases, the natural selection process can be "relaxed" by domestication when humans act as buffers between the natural environment and domestic animals (animals will survive that would not have survived if subjected to the natural environment without human assistance).

22. In nearly all cases, artificial selection is accompanied by natural selection. Animals artificially selected by human managers to be parents of the next generation do not always reproduce. "Inbreeding depression" is the lowering of vigor and fitness brought about by expression of deleterious genes that had previously been masked. Inbreeding depression can increase the intensity of natural selection in captivity. Detrimental side effects such as increased susceptibility to disease and mortality may accompany artificial selection. Loss of vigor can result in failure to thrive and reproduce.

23. Lameness is an endemic disorder of all contemporary livestock species in which genetic selection for high production, fast growth rate, and feed efficiency has not been balanced by selection for increased strength.

24. There is little scientific evidence that domestication has resulted in the loss of behaviors from the species repertoire or that the basic structure of the motor patterns for such behaviors has been changed. Instead, in nearly all cases, behavioral differences between wild and domestic stocks are quantitative in character and best explained by differences in response thresholds.

25. When domestic animals are provided with an environment that is physically similar to the habitat of their wild ancestors, behavioral and physiological adaptations to the environment will be readily achieved.

26. At least three classes of problems arise when the animal cannot make use of its resources and tools to meet the challenges of its current environment.

> "a. If animals possess adaptations that no longer serve a function in the new environment, they may still remain strongly motivated to perform certain behaviors, even though failure to perform them may not be accompanied by significant disruption to biological functioning. An example is the bucket fed calf that nevertheless experiences a strong, frustrated desire to suck.
>
> b. If the environment poses challenges for which the animal has no corresponding adaptation, the animal may have trouble functioning in its environment without showing it. Such may be the case with a pig in a polluted environment that develops lung damage without appearing to notice or mind.
>
> c. Where animals do have adaptations corresponding to the kinds of environmental challenges they face, they may experience problems if their adaptations prove inadequate. An animal's thermoregulatory adaptations may be insufficient in a very cold environment such that the animal feels poorly and functions poorly."

27. Body structure is both naturally and artificially selected in farm animals. On the one hand, animal species have adapted to their environments through natural selection and heredity. On the other, humans have artificially selected animals, changing their body characteristics or affecting their ability to act effectively on their environments. This implies that an optimal production environment will contain key environmental stimuli simulating those in the animal's species or evolutionary history and also will incorporate any changes in the natural environment that may have become necessary due to the artificial selection processes imposed by humans.

28. The question of whether breeding efforts may genetically alter an animal to such an extent that pathological changes are almost inevitable, and in such a way that not even optimum housing conditions will result in a decrease of the symptoms, must be considered according to ethical and legal criteria. Therefore, selection criteria for all agricultural animals must be determined not only by economics, but also by physiological and ethological parameters that take into account the animal's needs.

Animal Environment

29. Farm animals rely on humans to provide nutritious food, clean water, shelter appropriate to the climate and predator situation, timely treatment for illnesses and injuries, and timely adjustments to the production environment to keep it safe, clean and healthful (hygienic), comfortable, predictable, and "meaningful" to the animal. By "meaningful" is meant enrichment with species-appropriate space, lighting, and materials for constructive occupation. Constructive occupation, such as unraveling a bale of straw and rooting in it, in the case of swine, can prevent the development of abnormal behaviors, such as tail-biting, that can have adverse effects on both welfare and production.

30. Environmental enrichment has been defined as "an improvement in the biological functioning of captive animals resulting from modifications to their environment." Enrichment attempts will fail if the environmental modifications have little functional significance to the animals, are not sufficiently focused to meet a specific goal, or are based on an incorrect hypothesis regarding the causes and mechanisms underlying a problem. To enrich environments of farm animals such as pigs, that in a natural environment would spend a great part of the day foraging, destructible items with nutritional value would be more relevant substrates for foraging behavior than chains and toys.

31. Two important aspects of animal environments are the animals' needs for predictability and control. Predictability implies that actions and events have an outcome the animal expects based on its own history or experience (its ontogeny) and the biological history of its species, or its genetic pattern (phylogeny). Control over stressors is more important than the physical characteristics of the stressor itself. Control implies that the animal is able to perform certain behaviors with respect to its environment that may be necessary for survival, for comfort, to relieve stress or boredom, or to escape from undesirable stimuli.

32. Welfare of farmed animals is a concern at four life stages.

a. Animal welfare concerns can arise because of factors acting before the animal enters the production system. This depends on the extent to which domestication and genetic selection have removed or reduced the viability of important natural capacities that equip the animal to control, function normally in, or adapt to its environment.

b. Animal welfare concerns can arise while in the production system. This depends on the animals' state as a result of selective breeding, management (for example, adequate planning to have quality feed and medications and other essential inputs on hand and day-to-day attentiveness of farmer/workers to the needs of the animals, as well as the quality of the attention given), and facility design, quality, and operation.

c. Animal welfare concerns can arise during transport, especially transport to of culled animals to slaughter, as animals are no longer "useful" and their welfare is almost universally disregarded from that point. Is the animal fit or is it crippled, injured or weak from lack of exercise? Loading, crowding during transport, care in driving (or lack of it), and unloading are the critical factors affecting physical injury and prolonged fear, pain, and suffering.

d. Animal welfare concerns can arise at the slaughterplant. While waiting for slaughter animals can be exposed to temperature extremes, if injured they may be left to die. The damages inflicted by the slaughter process itself depend on the design of the plant and the sympathy and competence (or lack of sympathy and competence) of workers and the time allotted to them to do their jobs.

Fear

33. All animals possess species-specific behavior patterns that interact with experience and learning in the formation of behavior. Fearfulness, or temperament, social behavior, maternal behavior, and aggression are traits strongly influenced by genetics. Rearing in an environment with a variety of different objects improves learning. Environmental enrichment provides animals the opportunity to explore novel aspects of their environment, which is thought to have value for the animals. Raising young animals in environments that are devoid of variety and sensory stimulation will have an effect on development of the nervous system and can cause an animal to be more reactive and excitable when it grows up. Such animals are more likely to overreact to novel events and may find it difficult to cope with subsequent changes in the environment and to acquire new knowledge. "This is long-lasting, environmentally induced change in how the nervous system adapts to various stimuli."

34. Certain adverse impacts are common in all livestock production and these must be minimized by attentive and caring management. In nearly all livestock production, farm animals undergo painful procedures, have their autonomy restricted, are selectively bred for traits desirable to humans, and sometimes are injured. The vulnerability of ill and injured animals requires patience, if not empathy, on the part of handlers to protect them from suffering. Injured animals should not be transported and downed animals should be euthanized on the farm. Unintentional negligence and suffering occurs at some time in every farming system with regard to some aspect of animal welfare. Farmers cannot always be observant, on time with feed or medication, etc., and these situations will compromise welfare, but the good stockperson will make every effort to be so in order to prevent needless suffering and promote well-being in his or her animals.

35 Size of farming operation is relevant to animal welfare in a very important way. As livestock industries intensify, and individual firms grow in size, often increasing to multiple enterprises, the attention paid to individual animals decreases. Excessive growth limits the owners' or managers' ability to keep day-to-day operations under their ***span of control*** while high capital costs force them to hire unskilled workers at low cost and substitute cheaper feed inputs. Farm animals bear the costs of these shortcuts. See footnote 18 summarized here:

> a. In early 2001, 375 sows at a Swine Graphics hog facility in Iowa died of thirst. Although low-level employees had checked the barn daily, the water had not been turned on for ten days. Employees, mistakenly fearing the ailing sows had contracted a deadly disease, killed the remaining sows to stop its spread.
>
> b. The February 3 *Register* reported neighbors' concerns about dead hogs and described one complaint concerning 200 dead hogs left outside within view of public roads.
>
> c. In January 2001, 500 hogs died when electricity was cut to the building during snow removal. Backups did not work.
>
> d. An Iowa farmer called an animal welfare group in February 2001 to express concern about problems at a neighboring farm where for two and one half weeks no one fed the pigs, as two consecutive hired workers quit. When a serviceman visited the facility live pigs had fallen from 220 pounds at his last visit to 180 pounds, some pigs were dead and were being eaten by the living pigs that had no feed

36. Humans can evoke fear in animals by virtue of their relative size, and their propensity for quick or unpredictable movements. In traditional, small-scale agriculture, animals habituate to the presence of humans by virtue of routine, neutral exposure during the course of the day-to-day management. Contemporary, industrial methods have reduced much of the opportunity for frequent, benign contact between farm animals and people. Farms are larger, and have a lower ratio of people to animals. Labor-saving technologies further reduce these opportunities. Many of

the opportunities for positive human interaction with livestock have been replaced by mechanical technologies, e.g., feeding in person has been replaced by mechanized feeding equipment, while many of the aversive tasks, such as catching and restraint for medicating and transport, still require human intervention.

37. Undesirable consequences of inappropriate fear responses, chronic fear states, and heightened fearfulness, particularly with respect to poultry. These consequences include:

- Wasted energy
- Injuries, pain and death
- Feather-pecking, feather damage
- Behavioral inhibition, social withdrawal, reduced ability to adapt to change and new resources
- Difficulties in handling and management
- Delayed maturation
- Decreased reproductive performance and egg production
- Reduced growth and food conversion efficiency
- Abnormalities of the egg shell, compromised hatchability
- Downgrading of eggs and carcasses
- Serious financial losses.

Pain

38. "Pain is the subjective interpretation of nerve impulses induced by a stimulus that is actually or potentially damaging to tissues." Acute or short-term pain is that which lasts a few hours or days and should not outlast the healing process.

39. "Animal pain is an aversive sensory and emotional experience representing an awareness by the animal of damage or threat to the integrity of its tissues; it changes the animal's physiology and behavior to reduce or avoid damage, to reduce the likelihood of recurrence and to promote recovery; unnecessary pain occurs when the intensity or duration of the experience is inappropriate for the damage sustained or when the physiological and behavioral responses to it are unsuccessful at alleviating it."

40. Pain is comprised of both a physiological sensory and a psychological or emotional component. Many procedures to which farm animals are subjected result in acutely painful conditions and lead to injury, disease and other noxious events and this will have negative consequences for the animal and on production.

41. Painful procedures include so-called "mutilations" such as castration, tail docking, disbudding or destruction of the horn bud, dehorning, branding, and beak-trimming as well as shackling and transport that can result in acutely painful states.

42. Cattle may undergo other procedures made necessary by intensive production practices. Double-muscled, or heavily muscled, cattle, such as Piedmontese and Belgian Blue cows and cows crossed with large, heavily muscled bulls are subject to dystocia and surgical operation for removal of their calves (caesarian operations).

43. Ovum pickup is a procedure used to harvest eggs from dairy cattle. A probe is passed through the vagina of the cow and a needle is inserted through the wall of the ovary to

aspirate the eggs. An epidural may be given into the tail vertebrae to help the cow relax during the procedure and alleviate discomfort. Nevertheless, it is likely that this procedure causes significant acute pain to cows (particularly if it is conducted on them often) and it can cause other welfare problems such as chronic pain in the tail head and fused vertebrae.

44. Injection site problems occur in most cows injected with rbST but control groups of cows injected with placebos do not experience them. Injection site problems are exacerbated by repeated injections. In 4% of cows injection site swellings are severe, meaning swellings repeatedly open and drain. Damaged injection sites can become infected, causing disease.

45. Amputation neuromas can be a source of chronic pain, as can infections or disabilities resulting from procedures originally expected to cause only short-term pain. This includes neuromas that form in the trimmed beaks of laying hens, broiler breeders, turkeys, and ducks. The intense noxious stimulation by tail docking leads to periods of inert lateral lying and the analgesic, xylazine has been shown to reduce the behavioural and physiological consequences of tail docking. Both castration and tail docking can lead to chronic pain due to inflammation and the onset of infection at the lesion after the procedure. Abnormal behaviours indicative of pain persist for up to 41 days after castration and tail docking.

46. The result that administering pain relievers can reduce performance of abnormal behaviors resulting from these procedures is evidence that animals experience pain, as defined above, when subjected to them.

Covering Up Production-Related Animal Welfare Problems

47. An overwhelming body of evidence exists indicating that the livestock industry's continued, routine use of antibiotic feed additives at subtherapeutic levels contributes to antibiotic resistance. Reduced effectiveness of antibiotics for treatment of bacterial diseases is not only a human health issue, but also an animal welfare issue because:

a. the development of resistance to antibiotics by bacterial pathogens reduces the efficacy of antibiotics for treatment of animal diseases and
b. the subtherapeutic use of antibiotics to promote growth and control disease in farm animals permits industry to keep farm animals in conditions that are detrimental to their health and well-being.

B. Part II. Welfare impacts of animal production on specific farm animal species

POULTRY

General

48. As do other farm animals, poultry suffer from disabilities induced by extreme genetic selection for various characteristics desired for production or meat quality and from various routine practices and procedures such as intensive confinement (by caging and crowding) and beak trimming and, in the case of laying hens, forced molting by a period of starvation.

49. Welfare problems of laying hens in commercial egg production result from artificial selection for high egg production which leads to a number of physiological and stress-related problems; specific practices such as forced molting and beak-triming; preventing performance of natural, maternal and self-maintenance behaviors such as nesting and dustbathing; and muscle weakness and osteoporosis due to confinement to battery cages.

50. Welfare problems of broilers include high housing densities and diseases. Leg weakness leading to immobility and subsequently to dehydration and starvation results from artificial selection by breeding companies for rapid growth. During recent years increasing competition in the broiler industry has increased the welfare effects of these problems so that today "leg problems caused by rapid growth, and dermatitis caused by environmental pollution with feces, wet litter, noxious gasses, and high temperatures are commonplace."

Welfare problems of broiler breeding hens include those of broilers in general plus the problem of chronic hunger due to selection for growth rate and the need to restrict feed so hens do not become obese (see below).

51. Welfare concerns with turkeys include painful effects of beak-trimming and toe clipping, stocking density, and results of genetic selection for growth and large breast size such as reproductive problems, lameness, "shaky-leg syndrome," excessive weight in breeding males, and degenerative hip disease. Welfare problems also occur due to fear and injuries incurred in catching and transport to slaughter, and at the slaughterplant prior to and during stunning. A recent, but growing concern is on-farm culling of sick or injured turkeys. Market-age turkeys are difficult to handle and kill and producers and/or staff are not always well equipped to do it in the most humane manner.

52. Modern chickens are descended from red jungle fowl, which still inhabit the jungles of Burma and Thailand. Jungle fowl have a highly organized social life and if possible they will arrange themselves in small groups, each group within a territory of its own, bordering on territories of other groups.

53. Although, due to selective breeding, contemporary broilers are much larger than junglefowl, there are remarkably few differences in the behavioral repertoires. As with other agricultural animals, behavioral changes in chickens that are apparent seem to be in threshold of response rather than a change in behavior per se.

54. Domestic turkeys originated in the wild turkey population of North America. Domestication occurred only with the Aztec Indians of Mexico. The first turkeys were taken to Europe by Spaniards in the 16th century and thereafter several European varieties were developed and returned to New England where they were crossed with native turkeys.

55. The pecking order in fowl is a well-known phenomenon whose purpose appears to be to reduce aggression in the group, because once the pecking order is established there normally appears to be very little aggression.

56. When the junglefowl hen is about to lay her egg, she moves around, often in a direction away from other hens, and vocalizes a pre-laying call. The rooster escorts her to potential nesting sites. Nest sites are usually well-defined, in places such as the foot of a slope or under a bush, secluded from disturbance and enclosed for protection from predators.

57. When the hen has accepted a nesting site, she begins nest building. The rooster assists in the beginning by scratching a nest cup in the ground. The hen gathers small twigs, leaves, and other materials and throws them onto her back. When she squats on the nest and makes the nest building movements, the materials fall from her back and line the nest. Thereafter, while sitting on the nest, she gathers more material from around her and throws it on her back. These behavior patterns are common to nesting hens.

58. Ethologists observed domestic hens in a pen experiment, where litter and feathers were spread on the floor, and found that domestic hens also performed the nest building behaviors described, although without the accompaniment of a rooster. Nest site selection in domstic hens is affected by rearing conditions, housing conditions, nest box design and management, and human intervention. Much behavior associated with egg laying behavior is under genetic control, which may contribute to the consistency in which the behavior is expressed. Pre-laying behavior is triggered by ovulation, approximately 24 hours before the egg-laying behavior begins. It takes around 24 hours for an egg to develop, and the egg is ready to be laid by the time nesting behavior has begun.

59. Once pre-laying behavior has been triggered, birds have a very strong motivation to find a suitable place for laying. In battery cages, many hens show the same restlessness and pre-laying calling; however their behaviors are severely restricted and this frustrates normal nest-building behaviors.

60. Conditions in which birds are reared affect mobility, which limits birds' ability to reach nest boxes if they are high off the floor. Chickens learn most readily to jump or flap from the ground to higher levels if they have had the opportunity to do sowhen young. Giving birds this opportunity and providing perches when they are young avoids problems of "floor laid" eggs when they are adults.

61. Under feral conditions, hens roost on branches in trees at night, seeking out these places well before dark. Hens are motivated to roost even under commercial conditions. Roosting has psychological benefits for the hens.

62. Chickens exhibit a number of "comfort" behaviors such as stretching, shaking, yawning. They also care for the plumage by preening and dustbathing, which is thought to remove excess lipids from the feathers and keep them in good condition. As chickens dustbathe with other chickens and sometimes touch, it is thought also to be a social behavior. Wing-

stretching is often accompanied by leg-stretching. Wing-flapping is similar to stretching. During wing-flapping the wings touch each other above the back of the head.

63. As prey species, junglefowl and chickens are well designed to detect and avoid predators. There are separate calls to alert others to aerial predators versus ground predators. They are also well designed to be predators and use their vision to detect insect pray.

64. Recognition of other individuals appears to be based on features of the head, because a subordinate bird may not avoid its superior until the latter's head is raised and becomes visible. If hens' combs are removed or are not visible, the hens are attacked as strangers, even by inferiors.

65. Junglefowl were amenable to domestication for several reasons: like other farm animal species they are social, which allowed them to be managed in groups; they are promiscuous, which allows any male to be mated with any female, contributing to the efficiency of artificial selection, there is a hierarchical structure in the group, believed to be based on individual recognition; they have flexible dietary requirements, being omnivores; and they adapt to a wide range of environments.

67. The chicken's as well as the junglefowl's main exploratory organ is the beak, which they use to check out their environments. Junglefowl spend up to 61% of their time ground pecking and their domestic descendants also spend a large proportion of their day pecking and scratching. Feeding behavior patterns appear identical in the junglefowl and domestic chicken. Ground scratching is performed once or twice, with each leg in turn, and then the bird moves one step backwards and pecks the ground where it was scraped.

68. In modern broiler facilities (and turkey facilities, as well), poultry are kept in large flocks, with populations of thousands in a single building. Both the high populations and the spatial density are unnatural. Maintaining dominance relationships through individual recognition is difficult in a flock of such size for birds that adapted to their environment by running in small groups.

69. Welfare consequences of confining so many birds together (and packed densely in battery cages, as well) include feather pecking and vent (cloacal) pecking, both of which can lead to cannibalism. Feather pecking and vent pecking have obvious welfare impacts, including pain, injury, and potential slow death of the victim.

70. Physiological problems of broilers resulting from artificial selection for growth rate and performance can prevent the performance of normal behavior patterns. Feeding, drinking, walking, scratching, pecking, and dustbathing are inhibited while time lying down, resting, and sleeping increases.

71. Inability to perform normal behaviors, whether due to restraint or physical incapacity, can result in poor welfare from frustration, physiological stress, and chronic fear under commercial rearing conditions.

72. In broilers, selection for bone and muscle strength has been a low priority compared to growth rate and productive performance. This has led to an increasing incidence of skeletal problems as the demand for increased weight has outstripped the capacity of the skeleton to support the animal.

73. About half the chicks born are male and these are destroyed one to two days after hatching. Because chickens selected for laying are not also selected for growth rate or muscle mass, the males have no use for either egg laying or meat. Male chicks are disposed of by gassing, crushing, or by instant (if they do not pile up) maceration in a high-speed grinder.

74. A behavior system is an organization of perceptual, central, and motor mechanisms that act as a unit in some situations. Dustbathing in adult fowl is a behavior system. Chickens recognize particular substrates (perceptual mechanisms) in which they dustbathe with a coordinated series of motor patterns (motor mechanisms) and the frequency and timing of the behavior is controlled by internal factors (central mechanisms). Chickens will work very hard to be able to dustbathe and will show the behavior even in battery cages, although at a lower rate.

75. Domestic fowl show elaborate nest searching, nest building and other pre-egg laying behavior that is essentially the same as that of the wild fowl. Research has identified inability to make nests as a source of stereotyped behaviors, indicating frustration and stress. In preference tests, hens were shown to work as hard to reach a nest box as they worked to reach food after 24 to 30 hours of food deprivation.

76. Nesting, as well as "comfort" and self-maintenance behaviors -- dustbathing for feather condition, and wing-flapping, wing-stretching, leg-stretching, and other exercise for muscle strength and bone density – are important to birds but are not so important to the intensive egg producer economically.

Battery Cages for Laying Hens

77. In the mid 1920s, the first cages for laying hens were developed in the US and Great Britain. These homemade cages and the first manufactured cages introduced in 1930 had enclosed nesting compartments. In 1934, the first wire cage systems without nests were introduced for laying hens. Farmers discovered two hens to a cage would put out nearly twice the output in half the space. In the 1950s, small battery cages for three to six hens in rows on top of each other were considered as the most efficient for production and for automated feeding and drinking systems. Today 99% of hens producing table eggs in the US are in battery cages.

78. Typical space in a battery cage in the US is between 48 and 60 square inches per bird (e.g., 6x8 inches or 6x10 inches).

79. While cage manufacturers may specify a recommended number of birds per cage, the incentive of the producer is to include as many as possible to a cage to maximize egg output per cage. Researchers have concluded that when egg prices are high and feed prices are low, profitability is higher when the hens are crowded, even though they lay fewer eggs apiece, have higher mortality, and consume more feed per hen. Under these conditions the number of hens per cage that produces the maximum profit is greater than the number that would be justified on the basis of biological responses.

Bone Thinning and Muscle Weakness

80. The hens, genetically programmed to lay eggs, continued to perform their dominant economic function, even though it was recognized early in the industry's transition to battery cages that osteoporosis and cage layer fatigue were unique to hens in systems using cage housing. However, the cause was first attributed to nutritional deficiencies.

81. As early as 1961 a farmers' magazine concluded that the calcium reservoir in the bones is smaller than in penned fowls. When laying begins this calcium reservoir is strained to the limit.

82. Lack of exercise leads to osteoporosis, muscle weakness, and bone breakage, which occurs when hens are removed from the cages and transported to slaughter and when shackled or hung on the line for slaughter. Bones are living and constantly undergo changes in response to nutrition, hormone balance, and exercise. Consequently bone breakage is likely to cause severe and prolonged pain and suffering.

83. Laying hens have two types of bone considered relevant to the development of osteoporosis. These are medullary and cortical/trabecular. Medullary bone serves as a source of labile calcium, providing calcium for eggshell formation and cortical/trabecular bone maintains the physical integrity or structure of the skeleton. When insufficient calcium is available from medullary bone to support eggshell formation, calcium is obtained by breakdown of structural bone tissue and this structural bone lost during lay does not appear to be replaced while hens are in lay. The longer hens are in lay, the more bone tissue they lose. Each egg requires 2.0 to 2.2 grams of calcium, representing 10 to 15% of the calcium in a hen's body.

84. The dietary requirements for laying hens identified by the Subcommittee on Poultry Nutrition of the National Research Council are adequate for eggshell thickness, but not always adequate for maintaining bone strength, meaning when the guidelines are followed hen diets are not sufficiently calcium-rich to preserve their bone structure.

85. Bones of hens in battery cages are more fragile than those of hens in other husbandry systems. In another study they were lesser in weight and strength than those of hens in a semi-alternative system and a deep-litter system.

86. Providing caged layers with more space allows more movement, which can help maintain bone strength during lay.

Beak-Trimming

87. The propensity of densely populated or crowded poultry to engage in injurious behavior has led to beak-trimming. The practice of removing part of the beak to prevent injurious pecking originated with a California farmer who first used a blowtorch to sear the beaks of his birds. However, "beak-trimming" is now a routine practice with battery hens, broiler breeders, and turkeys. Broilers usually are not beak-trimmed because they do not live long enough to create major problems.

88. Beak-trimming is practiced to reduce feather pecking and thereby prevent cannibalism. One study has shown that beak trimming does not decrease feather pecking but makes the pecking less efficient, reducing the damage that is done.

89. A long-term solution to featherpecking and cannibalism in chickens is artificially selecting birds with a low tendancy toward them. Breeders are reluctant to include selection against feather pecking in their genetic programs "because they would have to relax selection on other commercially desirable traits, which would put them at a disadvantage, compared to their competitors."

90. While there are welfare benefits to chickens from beak-trimming when the alternative is cannibalism, the practice has welfare costs.

a. Removing one third to one half of the upper mandible causes a marked reduction in feeding efficiency and a temporary fall in food intake.

b. Fitting with its role as the bird's main exploratory organ, the beak has an extensive nerve supply with mechanoreceptors (for pressure), thermoreceptors (for temperature), and nociceptors (for noxious stimuli).

c. There are evoked responses in the pain system after beak trimming, so the action of cutting the beak causes pain.

d. Amputation results in extensive neuroma formation in the healed stump and neuromas give rise to abnormal spontaneous nerve activity. There is a significant reduction in preening and especially in environmental pecking after amputation, which is thought to be "guarding" behavior in response to pain or discomfort upon use of the affected area.

e. Neuromas can last up to two months, continuing to cause chronic pain. There is indication that healing occurs more quickly and there may be less neuroma formation when beak trimming is done when birds are very young.

91. Besides laying hens, broiler breeders, and turkeys, beak-trimming is also practiced on intensively-housed ducks.

Forced Molting

92. Under natural conditions, natural molting with "fasting" accompanies broodiness or nest-sitting. This self-imposed fasting occurs during the 21 days it takes for the eggs to hatch. During this time, a hen will leave her nest for ten to fifteen minutes each day to drink, eat, defecate, and exercise.

93. The first mention of forcing a molt in order to improve egg production was in a 1936 extension service bulletin from the State College of Washington. Today the majority of laying hens providing table eggs in the US are induced to molt one or more times during their productive lives.

94. The benefits of molting are economic to the producer:

a. The egg-laying period of domestic hens in commercial production is from 9 to 16 months. There are roughly 240,000,000 egg laying hens in production. Egg production, shell quality, and internal egg quality decline with age, and over 100,000,000 "spent" hens must be replaced every year (one estimate is 144,000,000).

b. Unlike broiler chickens, laying hens have been artificially selected for egg production rather than body weight. Intensive egg production, with diets that are inadequate for maintaining bone strength, results in spent hens with little food value. Processors purchase them for use in food products such as soups and further processed meats or they may be ground up and put back into chicken feed.

c. Markets for spent hens have declined due to competition from the broiler breeder industry, whose spent broiler hens have more muscle, are larger, and yield more meat than spent layers.

d. Modern White leghorn hens, which form the majority of caged layers, are small-framed with a minimum of muscle mass. During catching, transport, and

slaughter, the bones break and shatter, further reducing their economic value because bone fragments can be found in the meat and must be picked out by hand.

e. By forcing molting to occur when hens are around 65 weeks of age, egg production can be stopped for the purpose of recycling hens for another season of egg production. The "rejuvenated reproductive tract" at the end of molting usually produces eggs at a hgher rate and with better shell and interior quality than during the latter part of the first production cycle.

f. A second laying period spreads hen replacement and disposal costs over a longer timeframe. However, the benefits diminish with each successive molt.

95. Molting is a natural biological process of birds, but forced molting is a welfare concern due to the methods used. Forced molting is highly stressful. Like other stressed animals, molted hens shed more pathogens in their feces, which has ramifications for the health of other birds in the flock and the environment.

96. Forced molting is achieved by feed withdrawal. Optimum post-molt performance was shown in one study to follow a feed withdrawal sufficient to achieve a bodyweight loss of approximately 27% to 31% during the molt induction, requiring feed withdrawal of 14 days or more.

97. The scientific literature has produced evidence of physiological stressor effects and behavioral changes associated with extended feed removal programs. One study indicated that forced molting may increase susceptibility of hens to *Salmonellla enteritidis* infection.

98. A number of authors have cited public concerns over animal welfare as reasons to find alternatives to prolonged feed withdrawal if forced molting is to continue to be used as a practice in the industry.

"Blowout"

99. Laying hens are forced into lay at younger and younger ages through hyperstimulation with light. Some hens experience "blowout" or a situation where the cloaca remains everted after egg-laying, which can lead to cannibalism by other birds.

Welfare of "Spent" Hens

100. "Spent" hens are either caged layers who no longer produce a sufficient number or quality of eggs or broiler breeder hens who no longer produce a sufficient or quality number of eggs for hatching broiler offspring.

101. The welfare problems of spent hens are severe. Osteopenia (the thinning and weakening of bones) and muscle weakness attributable to lack of exercise, poor nutrition, and selective breeding for egg production lead to considerable bone breakage in spent layers prior to slaughter.

102. Bone breakage occurs when hens are removed from the cages and transported to slaughter and when shackled/hung on the line for slaughter. Bones are living and constantly undergo changes in response to nutrition, hormone balance and exercise. Bone breakage is likely to cause severe and prolonged pain and suffering. Especially in transport, vibration in typical commercial poultry transporters causes movement at fracture sites and forces birds to use muscles

to maintain postural stability, contributing to tissue damage around broken bones. Injured birds are unable to avoid other birds that may step on injured tissue.

103. Incidence of bone damage prior to stunning in free-range birds is about half that for battery hens and battery hens have 2.1 times higher incidence of broken bones than birds raised in percheries.

104. Electrical stunning at slaughter is one of the more important causes of bone breakage during processing. High frequency stunning at 1500 Hz causes fewer broken bones than stunning at 50 Hz, however low intensity stunning requires less energy and is cheaper for the processor. Using a lower electrical current for stunning does not render birds unconscious.

105. In studies, as many as 88% of caged layer carcasses had broken bones after scalding and 98% by the end of processing while corresponding results for free range hens were 30% and 91%.

106. Besides suffering from broken bones, spent hens are exposed to life-threatening conditions during pre-slaughter handling and transport, including exposure to temperature extremes. In the US a breakdown of the causes of post-mortem condemnations of spent hens shows relatively high levels due to septicemia/toxemia, tumors, cadavers (almost dead when hung on shackles), contamination, and bruises, implying that hens unfit for travel are being shipped. In Canada, post-mortem condemnation rates result from emaciation first, then from "found dead", peritonitis, tumors, contamination, bruises, cyanosis (equivalent to cadavers, in US terms).

107. In North America, processing plant managers indicate that broken bones are common and contribute to the low value of spent hens by contaminating meat, increasing the cost of processing, and limiting products in which the meat can be used due to concerns about consumers choking on them.

108. Besides osteoporosis and muscle weakness from lack of exercise due to confinement in battery cages, factors that affect bone breakage in hens include:

a. Calcium, phosphorus, and/or vitamin D_3 deficiency.

b. Cage design and handling. Many cages have feeders at the front, partially obstructing the cage door, with the result that when hens are pulled through the door they hit or get caught on the feeder.

c. In the UK, studies of spent hens indicate catching is the primary source of injury prior to arrival at the slaugher plant. Bodily impact against hard surfaces inside and outside the cage and struggling contribute to bruising, joint dislocation, and bone breakage, especially when hens are pulled backward out of their cages.

d. Extra care in handling can reduce bone breakage, in one study from 24% to 14% and another from 45.3% to 31.4% by more careful handling.

109. Percent of dead on arrivals increases with transport time. Hens should be killed within two hours of arrival at the plant, but spent laying hens may have to wait for long periods in extreme temperatures while loads of more valuable spent broiler breeder hens are processed.

110. Animal welfare scientists prefer euthanasia on the farm when there is risk of intense suffering on long journeys. However, humane on-farm killing of spent hens requires development of good methods to be humane and environmentally acceptable.

111. Hens show aversive behaviors when exposed to carbon dioxide, indicating they are feeling discomfort. They show little aversion to argon gas. However, argon is more expensive to use and would require the development of special equipment currently not available to producers. In the UK, the use of 90% argon gas with 2% residual oxygen, or 60% argon, with 25% to 30% carbon dioxide is approved for humane killing of poultry.

Broilers and Turkeys

112. Welfare problems associated with musculoskeletal disorders in poultry raised for meat are the pain and discomfort experienced by the birds and the consequences of impaired locomotion, which include starvation and dehydration.

113. Bone disorders can be grouped under three headings indicative of the production stresses applied to the skeleton. These groupings are bone growth disorders in young broilers, arthritis in turkey and broiler breeders, and bone fractures in adult hens selected for laying. Bone disorders include deformity and growth plate defects that can cause or be a consequence of deformity. Deformity of vertebrae leads to spondylolisthesis, pressure on the spinal cord, hind limb ataxia and paralysis.

114. Broilers have been selected for fast growth rate, body weight and conformation (large breasts) and feed conversion ratio. This has led to large breast size relative to leg development, resulting in welfare problems ranging from difficulty walking, increasing with age and weight, leg deformities, and starvation or dehydration if birds cannot reach feeders and waterers. Eventually, they may be unwilling or unable to stand at all, and may lie for hours with one leg outstretched.

115. Broilers show reduced activity and perching compared to laying hens. Degenerative disorders of the joints are more prevalent in birds grown to greater ages and weights for breeding purposes. Large numbers of broilers have impaired walking abilities and show pain or discomfort. Fast growing broilers have more breast muscle and shorter, wider legs with immature bones. They become too heavy for their legs to carry their bodies and their skeletons become distorted, placing unnatural stress on joints and resulting in abnormal gaits.

116. Abnormal gaits in any animal are a potential sign of pain. In a comparison of locomotor activity between normal chickens and lame chickens, lame chickens took 34 seconds to walk a set distance while normal chickens took 11 seconds. The walking time for the lame chickens was reduced to 18 seconds by administering an analgesic, indicating that pain is associated with lameness.

117. Health problems encountered by broilers are either cardiac (ascites and sudden death) or leg problems prominent in more heavy lines, thus influenced by both selection and nutrition.

118. Artificial selection has emphasized a high growth rate and a low feed conversion ratio. An inhibited consumption of oxygen leading to reduced heat production is one mechanism by which a low feed conversion ratio in fast-growing chickens can be achieved. The increase of metabolic diseases such as heart failure syndrome, ascites, hypertrophy of the right ventricle, edema in lungs and heart can be directly related to an insufficient oxygen supply in metabolism causing primarily pulmonary hypertension.

119. Ascites refers to accumulation of serum-like fluid in the abdomen of the bird. Ascietes occurs in young, fast-growing broilers and is a common cause of death or carcass condemnation. Kidneys may be enlarged and congested and lungs may be congested and edema may be present. Incidence and severity of ascites can be reduced by improving ventilation and or reducing growth rate.

120. Sudden death (flip-over) is considered an outcome of genetic selection for fast growth.

121. Between 1969 and 1998, observed skin diseases in broilers increased from 1.4% to 34.5%. Lesions occur on the breast, legs, and feet, and can become infected by bacteria and fungi when exposed to feces and dirty litter.

122. Welfare of broiler breeders (chickens kept for producing stock) is particularly at risk due to selection. Broiler breeders show a higher percentage of defective eggs, reduced capacity for antibody production, reduced egg, sperm, and embryo quality.

123. Selection of broilers for increased growth rate has resulted in their having increased appetites as well. However, when allowed to eat ad libitim, which they want to do, increased food intake results in obesity, which must be controlled in parent stock in order to maintain reproductive competence.

124. The broiler industry is caught in a welfare dilemma: on the one hand broiler stock appear to be chronically hungry, while on the other less severe food restriction leads to reduced fertility and health problems. The dilemma created by genetic selection for fast growing broilers (birds with large appetites) coupled with the health problems attending ad libitum feeding, make it impossible for broiler breeder companies to meet the basic welfare requirement of freedom from thirst, hunger, and malnutrition.

125. Other stressors in broiler production include deprivation of dark period for replenishing sleep (because light encourages growth), disability, pain, fear, increasing bird density, and heat stress which kills millions of broilers in the US every summer.

126. Physiological indicators of broiler welfare (as with all agricultural animals) include body temperature, heart rate, blood cell counts, hormones and enzymes in plasma. Behavioral indicators include panic, violent escape, freezing, panting, suppression of normal behavior, and various abnormalities of sound, self-maintenance, and locomotion.

127. Tibial dyschondroplasia is a leg disorder that results from selection for accelerated growth and its prevalence in the broiler industry is estimated to be 50%, although it was an insignificant concern 30 years ago. Lameness, increased fractures in the fibula, and an increased susceptibility to osteomyelitis are outcomes of tibial dyschondroplasia, and in turkeys it increases incidence of breast blisters.

128. Most commercial turkeys are kept on litter in controlled environment or partially open housing. High densities of birds in turkey houses and selection for rapid growth are concerns.

129 Selection for good bone growth or structure does not correlate well with overall growth performance. Turkeys selected for walking ability had reduced breast widths as opposed to breast widths in turkeys in commercial lines.

130. The flight response to fright can lead densely confined turkeys to pile against a far wall and suffocate when presented with an unexpected or novel stimulus. Humans may anthropomorphize this as stupidity, but it is, in fact, a case when animals are confronted by aversive situations to which they have not adapted or formed appropriate behavioral responses. The escape behavior would be adaptive in the natural environments in which turkeys were selected.

131. A number of surgeries are practiced on young turkey poults, including beak-trimming with a hot blade or laser device (the majority of turkeys in Minnesota are beak-trimmed) and toe-clipping to avoid down-grading of the carcass as a result of scratches on the skin of the breast and legs that may be incurred when the flock "panics" or during capture and transprt to slaughter.

132. Higher mortality, lower body weights, and improved feed conversion, combined with changes in behavior immediately following toe-clipping suggest turkeys experience pain from the operation. Reduced standing time throughout the growth period has also been observed in toe-clipped turkeys.

133. A common condition that affects both broilers and turkeys is footpad dermatitis, thought to be caused by a combination of wet litter, high ammonia content, and other chemical factors in the litter. Footpad dermatitis tends to be a neglected problem because the feet generally are not used for human consumption. They may, however, be an entry point for bacteria that reduce carcass quality and in severe cases the lesions may cause pain to the birds which, together with reduced health, is a welfare issue.

134. Degenerative hip disorders in adult male turkeys have been shown to result in a state of chronic pain that, in turn, inhibits locomotion.

135. Selection for high body weight (large breasts) has for some years prevented domesticated turkeys from mating naturally and without the potential of injury to the male, with the consequence that all contemporary, commercial turkey reproduction is by artificial insemination.

CATTLE

General

136. "Cattle evolved to graze and browse grasses, herbs, and leaves of the bush and open plains." They are genetically programmed to spend much time eating and ruminating.

137. Cows are equipped with long tails with brushes or switches at the ends, which they use to keep away flies and other winged pests.

138. Cattle will graze up to nine hours a day (or in exceptional cases where grass is sparse, up to 15 hours per day. The most intense grazing periods are in the early morning and near sundown. They may spend two hours per day going to or searching for suitable grazing sites.

139. Cattle are selective in their intake when plants are not scarce, showing a preference for plants of particular species and even of certain growth stages within the plant species. Herbage contaminated with feces is usually rejected. However, if the pasture is widely contaminated (e.g., by liquid manure sprayed on it) the grass finally is eaten. Similarly cattle avoid plants with hairy or coarse experience.

140. As ruminant herbivores, cattle are adapted to high fiber, low density diets and do not adapt easily to high grain diets or to manufactured diets with high protein and low fiber.

141. During grazing, large quantities of slightly chewed herbage are swallowed and stored in the rumen, where it undergoes fermentation and is later regurgitated in the form of boluses, thoroughly chewed, and reswallowed. Rumination is an adaptive trait. Grazing permits the animal to gather a maximum amount of feed with a minimum amount of exposure in an open area, while rumination allows it to finish eating the gathered feed at its leisure in a possibly less vulnerable environment.

142. Cattle may ruminate from four to nine hours per day, with between 15 and 20 ruminating periods in a day. The peak period for ruminating is just after nightfall. Sixty five to 80% of total rumination time is spent lying down.

143. Cattle rest nine or more hours each day.

144. In free-ranging cattle the herd usually has four to five main activity periods per 24-hour period. During these times the animals feed, move, and have social interactions.

145. Getting up and lying down movements are performed according to species-specific movement patterns. There is an intention movement, where cows walk slowly while sniffing the ground with sweeping head movements. Preparation for lying down consists of search for a place, checking of the place chosen, and introduction of lying down leading to a kneeling position (i.e., resting on the carpal joint). Lying down itself takes place in three stages: the animal bends its front legs, it lowers itself onto its front knees, and it lowers the abdomen with a backwards motion.

146. Species-specific movement patterns have relevance for the welfare-appropriate design of cattle and calf housing. Injuries occur when floor or pen or stall design is incompatible with cow needs. Electric cow trainers affect lying down behavior in dairy cattle, extending the time to perform the behavior, implying some difficulty performing the movements. Interruption of lying down behavior is of consequence if it prevents dairy cows from getting sufficient rest.

147. Cattle are social animals. Under natural or semi-natural conditions they usually live in groups with a few older cows, their daughters and calves. The social hierarchies established by cattle are linear or linear-tending in smaller groups of cattle with less than 10 individuals and complex in larger herds. Some studies indicate a cow can recognize over 100 other animals in a herd and respond socially as subordinate or dominant to each herd member. Other studies indicate the recognizable number is between 50 and 70 other individuals.

148. Once a dominance order is established it is fairly permanent. To maintain a stable social relationship is required: recognition among individual animals, established social positions, and memory of social encounters that establish social status.

149. Dominance relationships have importance in dairy cow housing. Social rank determines the order in which cows enter the milking barn or parlor and in which they feed. Among housed dairy cows that have choices of stalls available to them the lower ranking cows will avoid stalls previously occupied by dominant cows.

150. The existence of dominance relationships in dairy cows implies that the housing must be ample, for example, in cubicle housing there should be extra cubicles so that low-ranked

cows are not forced to stand in alleyways and be deprived of critical rest or to stand, particularly if in manure, for long periods of time so that their feet can become damaged.

151. Being social animals, cows like to have other cows around them. Being isolated from her conspecifics, e.g., tied up alone in a barn, will be stressful to a cow.

152. Especially under intensive husbandry conditions, the social structure is modified by elimination of the maternal bond, rearing in one sex group of the same age, reduction of the home range to a few square meters and so forth. However, a social organization can be observed and a number of natural behaviors persist.

153. For cattle, living in a social group has a great impact on the members. Behavior such as eating, resting, moving, and playing is synchronized. Distances between subgroups in cattle increase as forage conditions deteriorate, but individual space is maintained even on rangeland and intensive pasture. Cattle keep a space around their heads protected from other cows.

154. The linear hierarchy enables higher social ranking animals first access to food or water under production conditions when these resources are limited in feed troughs or hay feeders.

155. At parturition, cows withdraw from the herd to give birth. The strategy that cows have evolved to protect their calves is to leave them lying in the grass at a distance from the main herd and to return, four to six times a day, to let them suckle.

156. In a free-ranging beef herd, it is common for the calf to feed from its mother for at least the first six months of life. In commercial dairy production, the calf may be taken from its mother immediately, or it may be left with its mother for one to three days to suckle and obtain from the colostrum the antibodies to protect it from disease, and thereafter be removed from the cow and taken to a rearing accommodation where it is fed rationed amounts of milk or milk replacer. After about six weeks, the calf is weaned onto solid food.

In the natural environment, grass and/or other roughage were always available to the calf. In a feedlot or commercial dairy setting, calves must be given roughage from the first week in order for their stomachs to develop normally.

Dairy Cattle Welfare: Inbreeding

157. While some beef breeds have been selected for both meat and milk production, dairy cow breeds were selected primarily to be docile milk producers. Dairy cattle conformation is well-adapted for milk production.

However, it is important that selection be undertaken on more than one trait. Dairy cattle have been selected for udder conformation, body size and angularity as well as milk yield, but major emphasis of selection goals has been on docility and yield traits. Exceptions are Norway, Sweden, Denmark and Finland, which include female fertility in the selection criteria for profitability in their countries and also select for increased mastitis resistance, Norway using records on clinical mastitis incidence, Sweden and Finland using both somatic cell counts and clinical mastitis records, and Denmark using somatic cell count data.

158. It has been possible in Sweden to diminish the risk for inherited disposition for some disorders, for example, dystocia and mastitis because veterinarians since the 1930s have applied a disease monitoring system, which, since the 1970s, includes not only diagnosis, but also cow identity. Via cow identity, the sires also can be traced. Thus, sires showing high numbers of daughters with disorders can be excluded from breeding at an early stage.

This kind of breeding program is incompatible with the US emphasis on immediate and sizeable productivity increases.

159. In the US, in the Holstein breed, selection for size and milk yield has been particularly aggressive. In the United States, selection programs have increased the body size of Holstein cattle even though evidence shows that smaller cows have survival and efficiency advantages. Heavy body weight increases the likelihood that prolonged standing on hard surfaces will contribute to lameness. Productive life has been shown to be longer for "small-line" Holstein cows than for "large-line" Holstein cows.

160. Dairy cattle that have been selected for high milk production seem particularly susceptible to stress and are at more risk of behavioral, physiological and immune problems. They require high levels of care and management.

161. In 1948, Holstein cows accounted for less than half of all registered milk cows in the United States. Today, the Holstein-Friesian breed accounts for over 95% of dairy cows in the US. A fourfold increase in the inbreeding coefficient of dairy cows in the US has been reported from 1970 to 1998, with survival rate decreasing as level of inbreeding increased. The development of cross-breeding schemes, used in other farm animal species to exploit hybrid vigour, has been small in comparison in dairy breeding.

162. Scientists have recommended turning from the high intensity of current selection that results in inbreeding and going to more cross breeding in dairy cattle.

163. Crooker, et al. (1999) dismiss scientists' conclusions that "biological functioning controls are overtaxed" by selection for high milk yield. Instead, they contend, animal welfare scientists "fail to recognize that genetic selection is *successful* because it results in *improvements in the biological control and coordination of mechanisms in the entire animal*."

164. However, the scientific studies covered in this report show that relationships do exist between genetic selection for production traits and animals' susceptibility to welfare-reducing diseases. With respect to dairy cows, relationships between artificial selection for milk yield and disease incidence have been observed for over two decades and "appear to be included in the definition of the dairy herd of the future."

Welfare Requirements of the High-Producing Dairy Cow

165. Mastitis, foot and leg problems, conditions that lead to impaired reproduction, inability to show normal behavior, emergency physiological responses that consume energy needed for maintenance, and injury are the major welfare problems of dairy cattle. High milk yield, for example, has been connected to mastitis, parturient paresis, and increased foot and leg disorders.

166. Animal health and welfare risk factors for dairy cattle include those originating in the production environment (slippery flooring contributing to splay leg injuries, rough flooring

contributing to hoof damage, wet and manure contaminated floors contributing to foot infections) and management (high employee turnover contributing to lack of specialized care and to inattention to disease or stress symptoms) as well as in artificial selection for single traits that has predisposed modern dairy cattle to particular welfare problems.

167. Small but important positive genetic correlations have been found between the level of milk production and the incidence of ketosis, mastitis and lameness. This has been confirmed in more recent studies for lameness.

168. Cows need to spend time lying, standing, and moving. Rest, rumination, and exercise, respectively, are important activities at which adequate time must be spent for good welfare. Prolonged standing leads to blood collection in the feet, reducing exchange of oxygen and nutrients, and potentially compromising foot health. When cows move, blood is pumped back into circulation, fresh blood brings oxygen and nutrients back to the feet and cleanses the tissues of poisonous materials.

Cows should lie in their stalls for 9-14 hours each day to provide adequate time for ruminating which increases saliva production. Blood passing through the udder provides nutrients for milk production and almost an additional liter of blood passes through the udder of a cow when she is lying compared to when she is standing. However, lying on hard floors such as passageways or dunging alleys contributes to udder injuries and infections can take hold if bacteria enter wounds or the teat opening. The lying area should be kept soft and dry, either with suitable litter (long straw), sand, or mats.

169. Disturbed rest leads to physiological changes in cattle that are usually indicative of stress, are likely to affect both welfare and milk production, and can reduce the effectiveness of the immune system.

170. The normal lactation curve for the dairy cow shows that milk production increases for approximately four to six weeks until the cow reaches maximum production and then gradually declines until the cow is dried up at around 44 weeks. If she has been bred in a timely manner at the first heat after calving, she will have a new calf nearly 13 months after giving birth to the previous one and will begin the next lactation.

171. Ideally, the normal lactation is 305 days with a 60-day dry period. In practice, a lactation period may vary in length. Shorter periods result when a cow is rebred soon after calving or dried up due to illness while longer periods result primarily from failing to get the cow rebred.

172. During the first part of her lactation, the dairy cow is in negative energy balance and must make up the balance of energy needs that are left unsatisfied by eating by drawing on body stores.

173. In comparison, the life of the typical beef cow that lives outside on open range is similar to that of the wild ruminant producing a calf once per year and feeding it until it is weaned at an age of six to eight months. The beef cow will secrete milk at the rate of about seven and a half to nine quarts per day and the calf will drink it in about four to six meals per day. In her total lactation period she may produce 950 quarts (1,900 pounds) of milk and the maximum amount of milk in her udder at any one time will be a little less than two quarts.

174. A dairy cow yielding 33 quarts of milk per day must sustain a work rate twice that of maintenance and must process nearly four times the amount of food required for maintenance. A dairy cow producing 28,000 pounds of milk per lactation has a work rate equivalent to a human's jogging 6 to 8 hours continuously, in terms of metabolic intake and expenditure. The dairy cow must sustain this and comparable work rates for months on end, even while she is pregnant with the next calf. Thus, the most abnormal features of the work required of the dairy cow are not just the intensity of the metabolic load, *but also the length of time it must be sustained.*

175. The main welfare problems of the dairy cow are not related to production alone but to forms of nutrition, housing, and management that are inadequate for the high performance animals that selective breeding has created.

176. "The limits of the dairy cow's productivity are defined by:

a. the genetic and physiological potential of the mammary gland to synthesize and secrete milk;
b. the capacity of the cow to forage for, consume, digest and metabolize nutrients required for maintenance, lactation and simultaneous pregnancy; and
c. the capacity of the dairy cow to meet the sustained metabolic demands of lactation without succumbing to exhaustion or production diseases."

177. "The potential welfare problems associated with breeding and manipulating dairy cows for high productivity include:

a. hunger or acute metabolic disease, due to an imbalance between nutrient supply and demand (and physiological capacity to meet the demand);
b. chronic discomfort, through bad housing, loss of condition, etc.
c. chronic pain or restricted movement due to distortion of body shape, lameness, and bad housing or management,
d. increased susceptibility to infectious or metabolic disease,
e. metabolic or physical exhaustion after prolonged high production."

178. "The high genetic merit, lactating dairy cow must meet an intense, sustained demand for nutrients to sustain the capacity of the mammary gland to synthesize milk. She must meet this demand within the practical constraints determined by:

a. the quantity and quality of the available food;
b. the capacity of her digestive system to process the food into metabolizable nutrients;
c. the time available for eating without seriously eroding her conflicting need to rest."

179. Quality and availability of food (and level of management and quality of the production environment) must be very high to sustain the welfare of the high-producing dairy cow.

If the quality of the food is poor, the cow will fill up her rumen with feedstuffs that provide insufficient nutrients, feeling full but creating a conflict between metabolic hunger and digestive overload.

"In most practical circumstances, the capacity of the mammary gland to synthesize milk exceeds the capacity of the cow upstream to find, eat and digest enough food to supply the mammary gland with nutrients."

180. Selection of dairy cows for higher milk yields may possibly select for cows with at least some improved ability to consume, digest and metabolize food. On the other hand, the exogenous stimulation of production, such as regular injections of recombinant bovine somatotropin (rbST), simply increases the capacity of the mammary gland to synthesize milk without adjusting the physiological ability of the cow to process nutrients. Exogenous stimulation of production is likely to intensify the cow's conflict between the problems of hunger, digestive overload and physical exhaustion "and increase the risk that some cows will be made to suffer to meet these conflicting demands." Research indicates that rbST-treated cows have reduced body fat and reduced body condition compared to non-treated cows.

181. Many of the adverse health effects of rbST administration are best viewed as a consequence of extending the phase of metabolic stress that normally accompanies the onset of lactation. The maximal response to rbST is achieved within 2-5 days, but the increase in feed intake takes 5-7 weeks to match the requirement for extra milk synthesis. Therefore, the bodies of rbST-treated cows remain in negative energy and protein balance longer than in non-treated cows, and changes to live weight, body composition, and condition score occur, as the requirement for extra nutrients to support lactation is met by mobilization of body stores or other tissues. "Consequently, rbST administration extends the period of metabolic stress from 2-3 months to 4-6 months."

182. High milk yield has been shown to correlate positively with increased mastitis, foot disorders, decreased longevity, and other health problems and, consequently, with poorer welfare.

183. During lactation there is evidence that the high-producing dairy cow's other functions suffer from the diversion of nutrients. Measuring dairy cattle 14 days before, 14 days after, 1 month after, and 1.5 months after parturition, one study found that cows with higher milk yields had a higher mobilization rate of calcium from the bone than cows with lower milk yield. At the same time, they found indications that less calcium went to form bone in higher yielding cows.

Dairy Cow Welfare: Laminitis (Lameness)

184. Selective breeding for higher milk yields is known to result also in larger udders. Growth of the udder during the cow's lifetime forces the cow increasingly to walk with her back legs apart, causing her to walk with an uneven load on the inner and outer claws of the back feet and resulting in lameness. Gait abnormalities can be important indicators of pain and poor welfare.

185. Almost all animals that walk with a limp, reduce walking to a low level, or avoid it whenever possible suffer from some leg or foot pain. Their ability to carry out various preferred behaviors is generally impaired and there may be adverse consequences for other aspects of their normal biological functioning.

186. Limping, reducing the length of the stride, stiffness and stilted gait, resting the affected foot and spending more time lying down are adaptive. They are guarding behaviors against damages of the kind that are signaled by pain.

187. With the first attempts at industrialization of the dairy farm in the 1960s, studies associated environmentally-related dairy cow injuries and lameness with liquid manure handling that caused hydrogen sulfide intoxication, loose-housing systems on fully slatted floors to handle liquid dung, shortening the stalls for tied cows, introducing gratings over the gutter behind tied cows, and discontinuing the use of bedding in the stalls or cubicles. Hence, the problems of modern intensive confinement housing with respect to dairy cattle welfare were known from the beginning.

188. In a study of 707 herds between 1961 and 1965, the lowest total incidence of disease and injury occurred in the loose housing systems with soft bedding in the lying area and access to outdoors, the next lowest total incidence of disease and injury occurred in the loose housing systems with soft bedding but without access to outdoors, and the most injuries and disease occurred in closed buildings with slatted or concrete floors and without bedding, regardless of whether the animals were loose or tied. Traumatic injuries of the hoofs were more common in loose housing with fully slatted floors and in buildings for tied cattle with gratings or slatted floors over the dunging channel.

189. Lameness (laminitis) is recognized as one of the greatest welfare problems of the dairy cow because it results in chronic pain and the incidence of lameness is very high. On individual farms in Washington State, close examination of the hooves of each cow showed that over 50% of cows may have some degree of hoof disease, with the majority of lesions occurring in the rear feet, indicating that housing design had an influence. Measurements of lameness occurring in dairy cows include 35 to 56 cases per 100 cows per annum in the US, 59.5 cases per 100 cows per annum in the UK, and more than 83% of examined cows in the Netherlands. Many cases likely go unreported.

190. Too uncomfortable stalls in free-stall barns lead cows to refuse to use them, usually preferring to lie in the dunging area or standing with only their front legs in the stall.

191. A similar problem exists with cubicles when cows stand half in-half out, with their hind legs in the manure channel. Heel erosion and subclinical laminitis in the back feet can result. These behaviors are signs that there is a problem with the housing system and its compatibility with the needs and natures of the animals.

192. Use of stalls that are either too small or poorly designed may be reducing resting time in cattle and contributing to the high incidence of lameness. When cows are kept either in uncomfortable stalls, or with too few stalls per cow, both the time spent lying down is reduced and the incidence of hoof lesions increases.

193. Cattle in cubicle houses, particularly when cubicles are too short or otherwise poorly designed, tend to have lameness and other problems. Well-managed straw beds are generally better for cow welfare, but they must be well-managed to avoid mastitis, that is, the tops of the beds must be replenished with fresh straw daily to keep them dry and protect the udder from disease causing organisms, and the straw must be long or cut rather than chopped. Lameness is rare in cows at pasture although special paths are needed in areas with sharp stones.

194. Inappropriate flooring can increase the incidence of lameness by causing excessive and uneven wear of the hoof, by direct damage as a result of uneven surfaces or protrusions, or by causing skin breaks which increase the risk of infectious diseases such as footrot.

195. Lame cows become less competitive, drop in social rank, become more fearful and are three times more likely to be culled than sound cows. They have more difficulty standing up and lying down, resulting in an increased risk of teat trampling and associated mastitis. Reduced competitiveness of lame cows, and increased resting times, result in reduced feed intake, loss of condition and reduced milk yield. Lameness increases time open, resulting in longer calving intervals.

196. Dairy diets should correctly balance fiber and carbohydrates. Unbalanced diets can lead to subclinical laminitis.

197. Cows tend to synchronize their resting times. They have favored stalls and may avoid resting next to certain (especially more dominant) cows. Some cows displace others from their stalls by butting them until they get up and leave. Having too few cubicles in loose housing may result in submissive cows being forced to stand for long periods in passageways when they should be resting.

198. Cattle lie down by kneeling on their front legs first and then slowly lowering the rest of their body. In getting up, they normally lunge forward and rise first on their back legs. Too short stalls or too short neck ties will prevent the cow from being able to lunge forward, impeding her getting up and lying down behavior, disturbing rest, and contributing to injuries. Trampled teats, leading to mastitis are common in too short stalls. In getting up, the cow may attempt to rise on her front legs first, giving her less control over her back legs and more opportunity to injure the udder.

199. Cattle on slatted floors and tied have significantly more common occurrences of interrupted lying down and getting up behaviors than in straw beds or deep litter. Cattle perform the lying down sequence more slowly on hard slatted floors than on deep litter.

200. Before cattle lie down, they perform an "intention movement," lowering their heads to the ground as if to investigate the surface under them. While cattle on deep straw or pasture show the intention movement, on average, one time before lying down, cattle on slatted floors perform the intention movement, on average, three times prior to lying down.

201. In one comparison study, the time interval between the first intentional behavior (to lie down) and the actual lying was, on average, 9 seconds in cattle on deep litter and 59 minutes in tethered cattle.

202. In one study, bulls kept tethered on concrete floors were much more hesitant to lie down, lay down less, and had higher levels of cortisol than bulls that were kept on deep straw. In another study, cattle tethered on concrete floors showed longer periods of sniffing the floor before lying down and more frequent bending of the front knees that were not followed by the cow lying down.

203. Under no circumstances should dairy cattle be expected to lie on bare concrete. The shape and weight of dairy cows means that soft flooring is critical to avoid injury and allow adequate rest.

204. A number of studies have associated increased incidence of foot and leg disorders with long term administration of rbST, including the largest scale study, a post-approval monitoring program (PAMP) study conducted by Monsanto, the manufacturer of Posilac.

205. In the Monsanto PAMP study, the number of multiparous cows (cows in their second or later parity) having foot disorders was increased during rBST administration by a factor of 2.2 and the number of days affected was increased by a factor of 2.1. Information obtained via Freedom of Information Act from the U.S. Food and Drug Administration showed a similar association to the PAMP study between the use of rbST and an increased incidence and duration of knee calluses, hock disorders, and foot disorders and more multiparous treated cows were lame and suffered over a longer period of time.

Dairy Cow Welfare: Mastitis

206. Mastitis is a complex and very painful disease, as an inflammation of the udder/mammary gland resulting from the introduction and multiplication of pathogenic microorganisms into the mammary gland. Clinical mastitis is characterized by swelling or pain in the udder, milk with an abnormal appearance, and in some cases, increased rectal temperature, lethargy, anorexia and even death. The sensitivity to touch of affected tissues is clearly evident and there is obvious damaging of normal function. Hence, mastitis is a severe welfare problem.

207. Trampled teats and udder injuries are the most serious risk factors for clinical mastitis in tied or stanchioned cows. Tied cows in herds with liquid manure systems are at higher risk of udder injuries and mastitis than tied cows in herds with solid manure systems; short, or chopped straw or sawdust bedding in solid manure housing systems was found to increase the risk of trampled teats and mastitis relative to uncut (long) straw.

208. In a study of 707 herds between 1961 and 1965 (#186, above), the incidence of trampled teats and traumatic injuries to the udder was lowest when the animals had soft bedding and maximum freedom of getting up and lying down. The incidence of mastitis was higher in buildings with hard lying areas.

209. Stress can predispose cattle to mastitis, as can faulty milking and a dirty environment or bad feed and poor water quality. High milk yields are widely associated with high incidence of mastitis.

210. Mastitis has been described as the most economically imposing disease facing dairy producers in the United States and continues to cost dairy producers in the US at least $2 billion annually.

211. A comparison of a line of dairy cattle selected for high yield with a line not selected for high yield, since 1964, showed that health care costs per lactation were $49 per cow greater for the selected line, with the difference in mastitis cost accounting for about 50% of this. Milk yield in the selected line rose from 12,941 lbs/cow/year in 1957 to 24,921 lbs/cow/year in 1997.

212. Recombinant bovine somatotrophin (rbST) use results in high milk yields and higher levels of mastitis.

213. Reproductive problems in dairy cows have become very common in recent years. While milk production has greatly increased, dairy cow conception rates have in general declined from 55-66% 20 years ago to 45-50% recently.

Dairy Cow Welfare: Fertility and Reproductive Problems

214. As selection has led to higher milk production per cow, there have been steady increases in reproductive problems. In many countries with high-yielding dairy herds, large numbers of cows are being culled because of failure to get in calf.

215. Studies from various countries document a relationship between increasing milk production and lower conception rates, reproductive disorders or reduced fertility in dairy cattle:

216. Reproductive disorders are multifactorial. Infertility itself need not be a welfare problem but reduced rate of reproductive success can be an indicator of poor welfare stemming from metabolic stress, various perinatal diseases, twinning, dystocia (difficult birthing), retained afterbirth and endometritis. However, as noted in the following, it is well documented that the increase in infertility has gone hand in hand with high milk yield, which predisposes dairy cattle to a number of welfare problems.

217. The rate of decline in reproductive efficiency is more evident in recent years compared to earlier. Somewhere in the late 1980s to early 1990s both services per conception and days open began to increase at a greater rate than in the 1970s and early 1980s.

218. Most studies completed prior to 1975 failed to show an antagonistic relationship between milk yield and reproduction while most studies after 1975 demonstrated the relationship. Researchers have explained these results by noting that before 1975, most improvements to milk yield were achieved by improved management, especially feeding. Since 1975, greater milk production caused by genetic selection for milk yield appears to have created reproductive deficiencies in dairy herds. A study of cows in different lactation yield groups – low, intermediate, and high – failed to find a relationship between reproduction and milk yield in the lowest producing cows, implying the effects of milk yield on reproduction may become more pronounced as the average milk production per cow exceeds 7,250 kg/lactation.

219. In production systems with a high capital investment such as highly capitalized firms in the US (in contrast to more extensive production systems that have lower fixed costs), in order to convert high gross profit into net profit, the dairy cow must be worked to the limits of her productivity to meet the high costs of labor, housing, machinery and other costs. New Zealand's dairy industry is primarily seasonal and grass-based and, therefore, comparatively low cost.

In a study comparing confinement-housed cows in the US, fed a total mixed ration, and pasture-grazed cows in New Zealand, researchers found that, on average, the US cows produced 75 pounds of milk a day while the New Zealand cows produced 37 pounds, US Holstein cows weighed 1,379 pounds compared to 869 pounds for Holstein cows in New Zealand, and first-service conception rates were typically 60-70% for cows in New Zealand and 35-40% for cows in the US.

220. Selection for increased milk yield apparently results in a decline in fertility but that the outcome is economically desirable because the economic benefit of increased milk yield far outweighs the economic cost of impaired reproduction (and the resulting poor cow welfare).

221. In a study of two producing herds in Arizona and California, in the 180 days after calving, 65.4% of cows not receiving rbST were diagnosed pregnant, while 48.5% of the rBST-treated cows were diagnosed pregnant.

222. A Freedom of Information Act summary obtained from the U.S. Food and Drug Administration and the Monsanto PAMP study also provide evidence that rbST treatment can adversely affect reproduction. Pregnancy rate dropped from 82 to 73% in multiparous cows (cows in their second or later parity) and from 90% to 63% in primiparous cows (cows in their first parity).

223. Pregnancy rate indicates the proportion of animals inseminated that become pregnant. Since, in the allocation of resources within an animal, reproduction is given high priority, conditions must be stressful before conception is inhibited. Failure to conceive by cows given appropriate opportunity, is an indicator that the cow is having difficulty in attempting to cope with conditions in which it finds itself and hence that its welfare is poor.

224. A trend appears to be to compensate for declining reproductive efficiency by using rbST in mid-lactation to extend "economic" lactation performance, with lactation periods increasingly exceeding 400 days. Anecdotal reports indicate some farms have extended lactation periods to 750 days and more with rbST administration.

Extending lactations with rbST increases labor efficiency because less time per cow is spent in dry period management, transition feeding, calving monitoring, calf rearing and early lactation metabolic management and more time is spent on routine milking and feeding, aiding the drive to reduce costs under intensive management systems.

Reproductive efficiency is replaced by labor efficiency as a priority. The intensity with which dairy cattle are used in industrialized dairy systems reduces the value of the individual cow relative to other costs.

225. At the end of her single lactation, extended by administration of rbST, a mature "spent" cow can be culled and replaced with an impregnated heifer. Milk production has been extended and more performance has been gotten out of the cow. The impact on her welfare has not been determined, but it is likely to have been poor. Studies of the extent to which rbST is being used in dairy herds in the US to compensate for failures of cattle to conceive and bear young by extending their current lactation periods indefinitely, as far as this author has been able to discern, have not yet been conducted, but should be, because it is an important welfare issue for the cow and an ethical question as well.

Dairy Cow Welfare: Other rbST-Related Problems

226. Specific rbST related welfare problems of dairy cows include lameness and foot disorders, pathological lesions, reproductive problems including reduced pregnancy rates, and increased mastitis incidence. The frequent use of antibiotics to control or treat mastitis may increase the resistance of bacterial pathogens to antibiotic treatment, which is a welfare problem for farm animals as well as humans

228. In a 1992 study, 10.1% of cows had severe lesions post injection while 49.9% had moderate lesions post injection. Out of 358 placebo injections of 23 cows in the same group, none had severe reactions and 0.6% had moderate reactions, indicating that rbST or another component of the preparation was the cause of the problem.

Evidence that injection site reactions are due to rbST, is provided by the U.S. Food and Drug Administration Freedom of Information report on Posilac. On a "severity scale" of 0 to 160, weekly severity scores of injection site swellings due to biweekly (every other week)

injections (starting with the week following the first injection) were reported to be: 106, 85, 145, 97, 149, 99, 151, implying that severity of swellings increased with each subsequent injection, while between injections swellings went down, but at a decreasing rate.

229. Crooker, et al. (1999) contended that reports of reduced welfare with administration of rbST are inconsistent with "the sustained increases in milk yield achieved by use of bST." Many of the studies already mentioned in this report demonstrate that good animal welfare and high production yield are not necessarily synonymous and frequently may be antagonistic to one another.

230. The laminitis, foot disorders, and body score deterioration experienced by dairy cattle as a result of genetic selection for high milk yield may be exacerbated by rBST use, which demands resources without affording the time for the physiology to adjust.

231. Scientists note how drastic this demand is: "In fact, the gain in productive efficiency obtained with bST use would take 10-20 years to achieve using a combination of artificial insemination (semen from superior sires) and embryo transfer."

Dairy Cow Welfare: The Downed Cow

232. Welfare is poor in any animal if it is ill-treated or neglected. Most dairy farmers value their animals too much to allow either of these causes of poor welfare to occur. However, many producers' concern for the welfare of their animals ends when they cease to be productive or to contribute to the profitability of the farming operation. Culled cattle may be sent to auction, stockyards, or downed animal centers injured, unfed, pregnant, debilitated, or with full udders, yet they are not milked again before slaughter and they may not watered or fed for many hours before slaughter. Cows under these circumstances are likely to feel pain and fear.

233. Cattle sent to slaughter pregnant have given birth on the trucks or at the stockyards. Injured cattle wait for hours to be slaughtered after being dropped off at private companies that advertise for sick or injured animals. During this time and while being transported, it must be clear that they suffer pain and their welfare is poor. Minnesota has no law requiring producers to take responsibility for giving their downed and culled animals decent deaths. There is no law or government agency protecting the welfare of ill, injured, or incapacitated animals.

Welfare of Dairy Calves

234. The newborn animal must take on three vital functions previously carried out by the dam via the placenta: respiration, thermoregulation, and nutrition. Birth is not only the beginning of life but also a significant stressor and an extremely violent metabolic disturbance.

234. The cow first licks the calf dry, which establishes the bond between them and also reduces the risk of the calf becoming chilled through excessive heat loss by evaporation of the fetal fluids. Licking the calf during the first hours after birth also stimulates the calf to stand up and start suckling and it stimulates urination and defecation as well as digestion

235. By two weeks of age, calves can be eating appreciable amounts of solids and taking up from the soil and grass the microorganisms that will colonize the developing rumen and ferment the grass, stimulating rumen development.

236. Calves are born practically without immunoglobulins or antibodies against neonatal infections. It is essential for the newborn calf to drink an adequate amount of the cow's first milk, or colostrum, as soon as possible after birth and within the first 18 hours of life. Colostrum carries the maternal antibodies to protect the calf from the infections to which it will be exposed before it has generated its own active system of immunity

237. The calf's running with its mother on its farm of birth is at a decided advantage because not only has it received antibodies in colostrum but the antibodies have been synthesized in the cow against the infectious agents that exist on that farm. The further a calf is taken from the environment in which its mother lives, the less resistance to disease it can hope to derive from its mother's colostrum.

238. Calves have strong sucking instincts. If calves are removed from the dam, they should be fed colostrum (and, later, milk) from buckets that have artificial teats they can suckle. Bucket fed calves are prone to non-nutritive suckling – e.g., suckling penmates or pen equipment -- which can spread disease.

239. Nevertheless, there are reasons why it is best, if possible, for the calf to remain with the mother during at least the first 24 hours of its life and, preferably, throughout the colostrum period.

a. Calves absorb more colostral immunoglobulin when they are with their dam than when they are separated from her. Calves suckling dams have been shown to have higher serum immunoglobulin concentrations than bucket fed calves.

b. Mothered calves have higher social activity levels than artificially reared calves, implying the first days of life are significant for social learning.

c. Dairy calves that suckled their dams during their first days of life produced more milk as cows than artificially reared calves.

d. Suckling has benefits for the dam, reducing the amount of residual milk, frequency of mastitis, and risk of retained placenta.

e. Calves separated at older ages tended to require fewer days of treatment for scouring.

f. Dairy producers have little to gain from separation at less than four days of age because the colostrum-rich milk cannot be sold and early separation involves a longer period during which the calves have to be fed by workers rather than by the cow.

240. Height of the udder from the ground has been shown to exhibit a high degree of association with yield traits. The udders of high-yielding dairy cows, especially in their second lactation and beyond, tend to hang low.

Consequently, it takes the dairy calf much longer to find the teat than it takes the calves of cattle raised for beef, which have not been selected for large udders. This has consequences for nutrition and potentially survival, as it is so important for the calf to have the colostrum soon after birth. This requires that the stockperson help the calf find the teat and watch to make sure the calf sucks and gets milk.

Welfare of Dairy Calves: Bobby Calves

241. In the past, male (bobby) calves were either kept or sold for production of veal. However, veal production is characterized by its own serious calf welfare problems and, because the public has become aware of those problems, demand for veal has dropped off, decreasing the

economic value of bobby calves. Specialized dairy operations do not generally keep male calves and raise them for meat.

242. Because they are not needed, male dairy calves may be neglected after birth. Frequently, surplus calves are shipped for sale when they are too weak for transport and arrive at the stockyard injured, bewildered by their surroundings, or in pain. Somewhat over 1,000,000 neonatal calves were transported during 1999, either to a formula fed veal production unit or directly to slaughter. These calves are particularly vulnerable during transport and marketing.

243. "Calves have behavioral needs that differ from needs of older livestock. They spend 18 hours per day resting and are especially sensitive to pathogens and environmental temperatures. They have specialized feeding requirements and may not recognize milk and water, even when they have been provided. They also respond differently to methods used to handle other types of livestock – they lack strong motivation to herd and lack strong fear reactions and consequently cannot be driven." These characteristics can make them vulnerable to the impatience of inexperienced handlers.

244. While countries in the European Union have developed legislation covering the welfare of calves during transport and Canada has developed recommended codes of practice, protection of calves in the US is limited and the low value of surplus calves provides producers with little incentive to improve the situation.

Welfare of Dairy Calves: Housing

245. Housing for calves, if the space is too small, creates problems for calf welfare. Limiting the space available to individually housed animals leads to physiological and immune signs of stress and reduced growth rates, if the degree of spatial restriction is large.

246. Calves prefer sawdust bedding first, straw second, slatted wood floor third, and steel screen floors fourth in a study of calf preferences for floor types. In another study, when calves could choose between deep litter beds and a slatted floor, they preferred deep litter and no calf chose the slatted floor.

Welfare of Dairy Calves: Dehorning, Tail Docking

247. Behavioral and physiological responses indicate that dehorning of calves is accompanied by considerable pain and stress, which can be relieved during and up to two hours post dehorning by administering a local anaesthetic.

248. Increasingly in industrialized dairy production, the tails of dairy heifers are being docked for the convenience of the milker and as a way of keeping udders clean in slatted floor housing or poorly maintained solid floor housing systems where the brushes of the cows' tails frequently get covered with manure when the cow lies down. Failure to maintain a clean environment is not compensated for by docking cows' tails, however, as udder and uterine infections can still occur from exposure to filthy floors.

As with the docking of pigs' tails, it is likely that, in addition to the acute pain the calf experiences when its tail is docked, neuromas can form in the tail end resulting in longer-term pain. Evidence of pain from tail docking was discussed in the text in Part I.

249. Tail docking decreases the efficiency with which the adult cow will be able to defend herself against flies and other winged insect pests. A study reported in New Zealand where the practice of tail docking dairy cattle originated concluded that tail docking was no longer acceptable inasmuch as results of studies showed no real benefits to tail docking for the farmer and no benefits with respect to milk yield, somatic cell count level, body weights or the frequency of mastitis between treatments. Cows without tails also had the highest number of flies on the rear compared to other cows and worked harder than cows with tails did to get rid of flies.

Welfare of Beef Cattle[42]

250. Beef cattle in the US are generally reared outdoors in feedlots, pastures, or range. Welfare can be at stake due to exposure to the elements, particularly in the extreme temperatures and when snowstorms prevent range fed cattle from getting feed when they need it. In feedlots, cattle are exposed, unprotected, to the sun and have relatively impoverished environments and may be crowded.

251. Standing in muck exposes hooves to hoof rot and infection by pathogenic organisms in the dung.

252. Feedlot cattle are fed a variety of antibiotics at subtherapeutic levels throughout the growth period to reduce liver condemnations due to abscesses, control bacterial pneumonia associated with shipping fever complex, prevent and control coccidiosis, and improve feed efficiency and rate of gain. The need for these compensating treatments indicates that the environment of feedlot cattle is not conducive to good welfare.

253. Double-muscled quality is economically desirable due to meat yield. Cows bred to or artificially inseminated with semen from double-muscled bulls produce large calves and are subject to dystocia (difficult births) which are life-threatening without human assistance, generally require caesarian births, and if calves are naturally delivered, the large size of the fetus results in a difficult passage through the birth canal and the pelvic opening which is often narrow. As a result the calves suffer from anoxia, have low vigor and take longer to find the teat and gain nourishment. This delay can create welfare issues for the calves.

SWINE

General

254. From the beginning of its history the pig was a forest dwelling animal and was distributed widely in the Old World. The European breeds of domestic pig were derived from *Sus scrofa,* the local wild boar. Far Eastern breeds were derived from another wild pig, *Sus vittatus*, a smaller animal with shorter legs and higher reproductive ability. Modern breeds of pig *Sus scrofa vittatus* evolved from different crossings between these two types.

255. Studies of Wild boar, feral pigs, and domestic pigs kept in semi-natural "parks" are the main sources for understanding the natural behavior of pigs. Although the domestic pig

[42] On April 25, 2001, three days after this GEIS report was initially submitted, the report of the Scientific Committee on Animal Health and Animal Welfare, Health & Consumer Protection Directorate-General, *The Welfare of Cattle kept for Beef Production*, was adopted in the European Commission. The reader is referred to: http://europa.eu.int/comm/dg24/health/sc/scah/out54_en.pdf

has retained many behavioral characteristics of the Wild boar, some of these such as the threshold for anti-predator responses have changed. Hence, with respect to behavioral needs of modern domestic pigs, an observation in only Wild boar can be at most suggestive, whereas observations from Wild boar as well as feral pigs and domestic pigs under semi-natural conditions are more likely to reflect a fundamental evolutionary adaptation that is still present in modern, domestic pigs.

256. Although domestication and selection have altered basic aspects of pigs' physiology and anatomy, studies have shown that no major changes in behavioral systems have occurred during domestication. Instead, as with the other agricultural animals, behavioral differences between the different genetic lines of pigs are of a quantitative nature.

257. Pigs are gregarious in nature and form stable, linear-approaching hierarchies within groups. Individual recognition is largely based on smell, while vision becomes relatively unimportant once the basic social order in the group has been established.

258. Dominance relationships between each two individuals form the basis for the hierarchy of the group as a whole, as in other agricultural species. At least in pigs these dominance relationships are based on an avoidance order in which, by turning her head aside, a submissive sow signals her intention to a dominant sow that she is not challenging her when they meet. For the signal to be effective, the submissive sow needs to be at a sufficient distance from the dominant sow; in a confinement situation this appears to be at least two meters.

259. Home ranges of Wild boar and feral pigs range in size from 100 hectares to over 2,500 hectares, with size seeming to depend on food availability. Daily activity pattern of Wild boar and feral pigs is highly variable, becoming more nocturnal in areas where they are heavily hunted.

260. Domestic pigs in experimental pig parks were most active in the morning and late afternoon to early evening with resting periods in mid-day and during the night. Pigs foraged in selected areas during periods of activity and rested on one of several commonly used resting sites during the resting periods. Sometimes these resting sites were bedded by the pigs with grass, twigs, and other bedding material.

261. Pigs are omnivorous and readily adapt their diets to prevailing environmental conditions. Even when fed full rations of commercial feed, the pig park pigs were noted to spend 6-8 hours searching for food post-feeding. Post-feeding activities included foraging with rooting, grazing, and browsing.

262. Pigs are curious and highly intelligent and resourceful. Exploration forms a substantial part of the time budget of free-ranging domestic pigs, even at an early age.

263. Maternal behaviors of pigs are similar among wild boar, feral pigs, and domestic pigs in semi-natural environments, with prefarrowing behaviors (restlessness, isolation from the rest of the herd) beginning about 24-48 hours before farrowing. Onset of nestbuilding precedes farrowing by about 16-20 hours. The nest is generally finished and the sow lies still in the finished nest by two to four hours before birth begins.

264. Specific features of farrowing sites in the pig parks included that they were far from the main flock, were protected horizontally toards at least one side by slopes or large stones, and were protected vertically by branches.

265. During the prefarrowing and farrowing period, a series of hormones is released in the periparturient sow that strongly influence her to isolate herself from the group of sows, seek the best possible nest site, root in the ground to form a depression, go out and seek and collect nesting materials and return with them to the nest site to build the nest, and when it is finished, to lie down and give birth.

266. These behaviors differ only by degree among sows, reflecting the sow's capability and experience. What the nest site will look like will also depend on exogenous factors such as available materials and the sow's assessment of the quality of the nest site.

267. Prolactin peaks during nestbuilding and then starts to fall off. Shortly before prolactin peaks, oxytocin starts to rise. Spontaneous uterine contractions occur only when oxytocin concentrations are elevated. Uterine contractions increase in frequency about four hours before parturition. Sows stop nestbuilding, as a result of the rise in oxytocin, and settle into the nest. Oxytocin affects the duration of parturition and probably the vitality of the piglets (prolonged parturition leads to anoxia and weakness at birth).

268. The text and reference describe the hormonal changes in more detail. The implication is that hormonal changes generate innate nestbuilding behavior and "regulate" the farrowing process, affecting the vitality of the piglets and the health of the sow, and for that reason nestbuilding should be taken into account when designing animal housing conditions.

269. In the wild, finding a secure nest site away from the group avoided accidental injury to piglets by other members of the group and allowed piglets to bond to the mother, contributing to the survival of the litter, the group as a whole, and the species. More piglets were observed to die when farrowings were not well isolated from the rest of the group.

270. Domesticated sows under free-range conditions remain in the nest and its close surroundings with their piglets for around 10 days, during which time a teat order is formed (each piglet finds a teat and sticks to it throughout the nursing period) and the unused teats, if any, dry up. Particularly in the early stages of lactation, the sows lie down while piglets suckle. Suckling is characterized by distinct phases, including pre-massage of the udder (40-60 seconds), milk ejection (20 seconds), and after-massage (30 seconds to 10 minutes). Each behavior has a role in milk production.

271. A 20-second milk letdown makes it crucial for piglets to be at their teat when letdown begins or they will lose their chance to feed and it will not be possible to make it up. Each missed nursing leaves the piglet weaker and too many lead to starvation.

272. Studying the sow-piglet communications prior to and during nursing has yielded knowledge useful for the design of farrowing and lactation facilities, including illumating the need for quiet ventilation systems in the barns so that piglets can (1) detect their own mother's voice among all the other sows in the room when she calls them to nurse and (2) recognize the different grunting sounds the mother makes during lactation, particularly as letdown time gets close. During lactation, the sow grunts rhythmically with an increasing grunt rate, reaching a peak about 20 seconds before milk ejection.

273. It has been observed that the sow and piglets "coordinate" their behavior when the sow returns to the nest. The sow grunts to alert them to her presence and the piglets group on one side of the nest.

274. Among the domestic pigs in the pig parks, weaning began the first week of life but was not finished until the pigs were at a weaning age of 13-22 weeks (avg. 17). Weaning was characterized by a gradual decrease in suckling frequency, a gradual changeove between sow-initiated to piglet-initiated sucklings, increased pre-massage time and shortened post-massage time and an increased frequency of sucklings with the sow standing, interpreted as the sow's inferring an increased cost of maintaining lactation.

275. During the time in the nest, piglets form strong associations with littermates that persist after natural weaning. After rejoining the larger group of sows and pigs, these bonds with littermates remain stronger than the bonds that form between them and other pigs in the larger group.

276. During the ten to fourteen days spent at the nest site, pigs gradually start to leave the nest with their mothers to forage. When the pigs are ten to fourteen days of age, the mother guides them to the larger group of sows and piglets and they abandon the nest. Piglets become gradually socialized into the larger group with a high level of social activity, including play fighting, but with little overt aggression. Play fighting apparently teaches piglets how to manage aggression when they become adults.

277. Knowledge from behavioral studies, combined with practical experience, are very important for making alternative pig housing systems that incorporate more of the important welfare parameters for the pig work successfully. Compared to free-range animals, animals in confinement, even when it is extensive confinement, affect each other more intensely. When humans do not accordingly increase space allowance or enrich living spaces appropriately, the result can be reduced ability of animals to avoid aggression, which can lead to injury, and which, in some cases influenced the industry to adopt even more restrictive management practices such as individual housing.

278. The text provides some elements of a successful group housing system for pregnant sows based on the experience of Swedish producers who have operated deep-bedded group housing systems for the breeding herd for the past 25 years.

279. Unlike sows in nature, on pasture, or in enriched indoor environments, sows in crates get no functional feedback from trying to root and make a nest. Stress hormone levels in crated sows begin rising the day before farrowing, whereas in sows that are free to move around and make a nest in response to the rise in prolactin, relatively even levels of stress hormone are shown until they rise when the stress of farrowing itself begins.

280. The frustration from unrelieved stress can lead to much digging and pawing at the floor and sides of the crate by the sow and eventually to stereotyped behavior, implying her welfare is poor. Stress around farrowing increases the sow's susceptibility to mastitis, metritis, agalactia (MMA). Prolonged parturition leads to anoxia and weakness at birth.

Welfare Problems of Pigs: The Breeding Herd

281. An aim of artificial selection in pig breeding has been to increase growth rate and the proportion of valuable cuts in the carcass, which, in turn, has led to longer and leaner pigs that are more susceptible to leg weakness and resulting lameness problems as pigs grow. It is especially a problem for sow and boar welfare as they generally outlast market hogs in the production system.

282. Animal welfare scientists have found an antagonism between growth performance and sow survival. Breeding for leanness has also been implicated in "thin sow syndrome" in which young female pigs do not eat enough to maintain their body weight and may not experience estrus.

283. Housing also affects welfare. Studies have measured bone and muscle strength in slaughtered sows from gestation crates and loose housing systems and have found that osteoporosis and muscle weakness result from lifetime housing in crates. Muscle weakness and bone thinning are implicated in downer sow syndromes that create much suffering in the animal, even when it is treated kindly.

284. Observers in the swine industry are becoming concerned about the growing downer sow syndrome, estimated to be 10% to 20% of sows on farms going severely lame or being killed on the farm.

As a downed sow is a nuisance on the farm, as illustrated by undercover video shot by a PETA employee on an intensive farrowing operation, she also is vulnerable to abuse by employees.

Besides osteoporosis from continuous immobilization in crates, on-farm sow mortalities have been attributed to inadequate diet, inadequate immunity levels, poor air quality, poor transport, poor floor surface, poorly trained workers, genetically selected low backfat, and employee reward programs based on piglets produced per sow.

285. On many intensive breeding farms, boars are also housed in crates until they are needed. Individual crating of boars used to be a common practice in Europe but is outlawed today. A new European Union directive for welfare of pigs has been proposed that requires sows to be housed in groups and have materials for rooting.

286. The nature of pigs is to forage and explore their environments for a large portion of each day. Housing in crates frustrates these motivations and creates a conflict in the animal in that it cannot use its basic repertoire of tools and resources – its behaviors – to adapt to its environment. Instead, a series of internal adaptations takes place, including neuroendocrine responses, which are sometimes manifest in abnormal behaviors such as stereotypies and redirected behaviors.

287. It has been hypothesized that stereotypies "reflect a cutoff of higher nervous function." Stereotypies are generally believed to result from stress in the animal's situation with which it has not been able to cope. Stereotypies may be mistaken as normal behavior by individuals who have only seen disturbed animals – e.g., zoo keepers may think of repetitive route-tracing by caged cats and bears as normal, laboratory staff may perceive twirling around drinkers by rodents as normal, and farmers may perceive repetitive bar-biting by stall housed sows as normal.

288. As early as 1969, research had been conducted showing a reduction in abnormal behaviors and improved health and well-being of loose housed sows when straw was provided, as compared to sows that were housed in crates during pregnancy without straw.

Welfare of the Farrowing Sow

289. Sows farrowing outdoors will construct nests prior to farrowing and remain relatively still in them during farrowing and up to a week afterward. In commercial pasture swine production, portable huts serve as shelters and the sow uses available straw and hay to make nests.

290. When sows were confined indoors as pig farms grew larger, they were placed in small pens to farrow, and in the most intensive systems where liquid manure handling was used, were not given bedding. Confined sows unable to perform nesting behaviors are more restless than free-range sows and change position often. Position changes are believed to be primary causes of piglet mortality from crushing.

291. Farrowing crates were introduced into piglet production to restrict the movements of the sow. They kept the sow facing in one direction and made her continuously available to the piglets for nursing. Crushing continued so crates were equipped with bars that would control the sow's getting up and lying down movements more closely, but had the effect that the sow could not lie down as she would naturally, i.e., she now could not control her lying down movements.

292. Although farrowing crates reduce piglet mortality, they do not eliminate it. USDA figures showed an increase of 8.3% in piglet crushing between 1990 and 1995 when the percentage of US pig producing firms using farrowing crates was rising relative to those still using pens.

293. The existence of pressure sores and abrasions from the floor and crate equipment causes sows to get up and lie down more often and prevent her from resting comfortably on the hard floor. Analgesics reduce this getting up and lying down behavior, indicating that the sores are painful to the sows.

294. In intensive systems, sows are kept in constant, often accelerated production, which becomes a problem for sows genetically selected for leanness because they have few body stores to fall back on.

295. Of the high sow mortality on intensive US pig farms, about 50% occurs in the first three weeks after sows have farrowed and about 27% is in sows that have not farrowed, as sows are bred at earlier and earlier ages.

296. Between 1990 and 1995, the addition of antibiotics to the feed of pigs in the US breeding herd increased by 6.1% (to 45.5%) in sows and by 27.5% (up to 38.4%) in boars. Subtherapeutic antibiotic use in the breeding herd helps deal with problems in the production system by increasing conception rates, pigs born per litter, and piglet birth weights, and by reducing incidence of mastitis in sows. Their purpose in boar feed was not described.

Welfare of Piglets

297. Concern sometimes arise that pregnant sows housed loose in groups will lose some of their embryos due to fighting and for that reason should be confined to crates during pregnancy. The window of critical days for the pig embryo to fasten itself to the uterine wall is between approximately the 10^{th} and the 28^{th} day following conception.

The experience of producers who have used loose housing systems for many years is that as long as sows are grouped one or two days following mating and have had a chance to establish a stable social structure (fights to establish dominance relationships and a group structure may last up to one and one half days), and as long as sow environments are functionally enriched with straw and appropriate space allowance, housing sows in groups has not created embryo endangerment problems.

298. Welfare problems of neonatal piglets include getting sufficient nutrients and colostrum within the first few days after birth.

299. A key factor in getting sufficient nourishment appears to be clear and undisturbed communications between the mother and her piglets during the first days when her grunting calls them to the udder and synchronizes their suckling behavior. Piglets exposed to the common and routine noise of a ventilation fan while nursing received less milk from the udder than did piglets from litters that were not exposed to fan noise while nursing. Special ventilation units have been developed for group lactation systems in Sweden to ensure a high-volume air exchange at low air speeds and low decibel level.

300. Undernourished pigs or pigs that have not had sufficient colostrum are vulnerable to chilling and crushing.

301. Not all of the sow's teats are similarly productive and piglets on poorly-producing teats will not thrive. There are recommended techniques for cross-fostering, for example regarding how much time can elapse after a sow farrows before she will reject an addition to her litter.

302. In a farrowing crate the sow is always available to the piglets for nursing, so weaning will be abrupt. In loose housing or outdoor production, where sows can get away from the piglets, weaning takes place more gradually and pigs are encouraged earlier to eat solid feed and chew and swallow straw, which helps prepare their guts for when the sow will wean them entirely.

303. Farmers operating loose housing and outdoor farrowing systems have expressed their belief that five to six week weaning helps prepare the pigs by getting them used to solid feed and by helping them build immunity to the microorganisms in the environment before the sow is moved away.

304. While there are clear advantages to the sow to be unrestricted during farrowing and lactation, in some cases, when the farrowing environment is inappropriate, there may be a tradeoff between sow welfare and piglet mortality compared to the case in farrowing crates. This need not be the case in all systems. In an Iowa State University study of piglet mortality by crushing in five types of outdoor farrowing huts, the piglet saving performance of the four "best" huts was better than the industry norm for farrowing crates of 10%. The best huts had larger floor spaces for the sow and angled walls so pigs could get off to the side of the sow. Having the doorway to the hut toward the corner of the front wall rather than directly in the center also seemed to influence how the sow entered and lay in the hut, giving more space to the pigs.

Welfare of Piglets: Tooth Clipping

305. Piglets are born with eight sharp "needle teeth" they use to compete with each other at the udder. In the US, pig producers usually clip these off with hand held pincers to prevent damage to the pigs and the udder. Teeth clipping can reduce a piglets ability to compete with littermates, expose the pulp cavity allowing for pulpitis and gingivitis, damage the gums, cause the teeth to splinter, and cause a permanent toothache. Teeth and gum problems occur less frequently when needle teeth are ground or filed and this is how the national veterinary service in Sweden advises Swedish farmers to handle needle teeth. The new European directive on pig welfare also proposes that grinding or filing needle teeth rather than clipping should be required.

Welfare of Piglets: Tail Docking and Castration

306. Tail-biting is sporadic in occurrence but when it occurs can lead to cannibalism, which is not only a welfare problem, but a significant management, health, and economic problem in

the industry. The behavior is primarily seen in growing pigs grouped in pens and did not become significant until the confinement pig industry became established after World War II.

307. It is thought that tail-biting can take hold because the afflicted pig may not at first be aware a penmate is chewing its tail. The tip and brush portion of the tail are apparently not sensitive enough to alert the victim.

308. Tail-biting can become severe once blood is drawn, with penmates attacking the tail and back and chewing it down and then attacking other parts of the pig. The afflicted pig may become depressed and react only slightly to being bitten. Mortality may result eventually, but not until after the afflicted pig has suffered immensely.

309. When the brush and tip of the tail are docked at birth, the incidence of other pigs trying to manipulate penmates' tails does not drop off but penmates notice it and do not tolerate it.

310. Tail docking is usually successful in stopping cannibalism resulting from tail-biting, therefore improving pig welfare when there is potential for tail-biting.

311. Research has found that there is a high incidence of traumatic neuromas iin docked pigs tails, indicating that tail docking may continue to cause significant pain to the pig for much of its life.

312. This gives rise to interest in more welfare-friendly solutions for tail-biting. Oral activity is greater in the pig than any other farm species. The pig learns about its environment by chewing and rooting. Under extensive husbandry systems, pigs engage in considerable mouthing activities such as picking up and carrying sticks and chewing up bedding. Tail biting is less seen in clean, dry, hygienic environments where pigs are provided with straw or other functionally relevant materials to manipulate than in barren environments.

Animals that have the opportunity to root in earth almost never show tail biting behavior. Tail-docking in Sweden, for example, is not permissible by law. Provision of small amounts of straw to grow-finish pigs and consistent husbandry have been preventive of tail-biting.

313. Piglets vocalize loudly when castrated and call at a higher frequency especially during severing of the spermatic cord. The January 2001 European Union proposed directive for the welfare of pigs requires that castration not entail ripping or tearing of the spermatic cord and that it should be done before the piglets are 7 days of age or otherwise performed by a veterinarian with proper anaesthesia.

Welfare of Piglets: Weaning

314. Piglets are born without protective immunity. In general, maternal antibodies are delivered through the colostrum approximately for the first two weeks of life. This is followed by a period of about one week when the piglet is unprotected from microorganisms in the environment. At the beginning of its third week of life, its immune system starts to develop antibodies in response to exposure to microorganisms in the environment, but this process is gradual. If weaned at three weeks, it has not had the chance to develop immunity, and is particularly vulnerable. Segregated early weaning techniques are used to wean pigs at five to 15 days of age before the maternal antibodies run out. The pigs are then transferred to a biosecure nursery that may be hundreds of miles from the parent farm. When they are 60 pounds they are moved to a grow finish unit.

315. Weaning is stressful for pigs at any age but at five to 15 days of age they may not have developed enough to have learned to eat solid feed and have not had the chance to develop their own natural immunity. Stress results both from loss of the mother and from the abrupt change in diet. Addition of antibiotic feed additives to the water suppresses scours and other enteric illnesses in early-weaned piglets.

316. Segregated early-weaned pigs are called high health pigs. In SEW nurseries there can be high morbidity and mortality rates, however. Health problems include "post-weaning multi-systemic wasting syndrome." Piglet mortality can range from five to 15%.

317. When pigs are weaned at less than five weeks of age, physiological changes detrimental to cellular immune reactivity have been shown to occur. Piglets' adaptive mechanisms are also considerably taxed by early weaning at six days of age.

318. Nurseries in industrialized farming operations are comparatively barren environments. Air quality in the vicinity of the pigs is frequently poor because they live on perforated floors above storage pits in which their manure collects. Belly-nosing and redirected behaviors due to deprivation of stimuli may be exhibited, indicating that the pigs' environment is not optimal from the standpoint of pig welfare.

319. At 60 pounds, early-weaned pigs are moved from the nurseries to grow finish barns, which are equipped with barren pens on slatted floors over manure storage. In general, both early-weaned pigs and pigs in grow-finish systems continue to require antibiotics in the feed and water to control disease and promote growth through the grow-finish period.

320. Concentration and intensification in the pig and other livestock industries has resulted in a changed disease panorama. With confinement, new animal diseases have emerged, especially enteric and respiratory diseases, which are costly in terms of productivity losses and treatment and are difficult to treat.

321. Poor health is by definition poor welfare.

322. SEW and multi-site procedures do not appear to have an advantage over conventional systems when it comes to reducing prevalence of salmonella in swine. In 1994, death losses from salmonellosis in weaned pigs sometimes exceeded 20% and American Cyanamid estimated that production costs of salmonella in pigs totaled $100,000,000 in the major hog producing states.

323. Morbidity rates for pigs in finishing facilities can be from 30% to 70% in some herds from porcine respiratory disease complex. Problems include onset of acute pneumonia in 16 to 20 week old SEW pigs. A high proportion of finishing hogs goes to market with lung lesions and popular dermatitis.

324. Economies of space gained by crowding and immobilizing pigs are among the most significant economies contributing to the industrialization of livestock farming as long as ways exist to compensate for the stresses, such as continuous, low-level administration of antibiotic feed additives. Economies of space and labor allowing more output per unit of investment can make up for losses of individuals.

325. It has been possible to avoid breeding herd mortality and piglet illnesses by providing hygienic and behaviorally appropriate environments and weaning piglets after they have

had time to develop healthy natural immune systems. This principle of natural immunity and "host defense" was explained in Chapter 10. Management in systems that depend on prevention without prophylactic administration of antibiotics must be very good.

ENVIRONMENTAL ENRICHMENT FOR PIGS

326. Newberry has defined environmental enrichment as "an improvement in the biological functioning of captive animals resulting from modifications to their environment." The key to animal well-being in loose-housing systems that provide ample straw to pigs, is that the enrichment attempts have functional significance to the animals and are similar to substrates they would encounter and use in nature to root through, manipulate, and use to make nests.

327. Straw is a functionally rich material for farm animals. Hens will work hard to get straw in experimental situations. For pigs, straw has been shown in numerous studies to be an appealing natural material for manipulation and occupation. Consuming it gives bulk to the diet. Straw around farrowing provides a natural substrate for nest building. Providing straw to gilts is beneficial for their welfare before farrowing while they are motivated to build nests. Straw must be hygienic. Wet or moldy straw leads to illness and has been known to cause stillbirths.

328. Provision of a handful of straw per pig per day to finishing pigs living on slats provided an occupation for about one and one half hours a day for every pig. Conflict behaviors indicating reduced well-being had a frequency three times as great in the barren situation without straw compared to that with straw. In another study, a handful of straw per pig added to a pen each day reduced cannibalism to one-sixth of its previous frequency.

329. A number of studies have showed lower antibody levels and greater disease susceptibility of tethered sows in pens without straw compared to free-going sows in pens with straw and that for sows and piglets there is a direct correlation between disease susceptibility, restraint, and the absence of straw. Growing pigs housed with straw bedding spent more time exploring the substrate while pigs housed in a barren environment spent increased time exploring pen walls and other pigs.

330. Straw was found to be important to pigs for resting, feeding, and rooting behaviors ound that providing straw as bedding to growing pigs resulted in higher levels of manipulation of the substrate. Straw enriched the environment, stimulating exploratory and foraging behavior and resulting in significantly altered time budgets. Pigs with straw spent less time manipulating substrates other than straw such as walls, dung, or penmates compared with pigs that had no straw. Pigs in the pens with straw were cleaner than pigs in the pens on fully-slatted and solid floors without straw.

331. In one study comparing three hundred and twenty pigs reared from birth to slaughter (at 21 weeks) in intensive housing with slatted floors and minimum recommended space allowances with enriched environments with extra space and an area with peat for rooting and straw in a rack, pigs in the enriched environment spent more time (a quarter of their time, total) in exploratory behavior and less time inactive or engaged in aggressive behaviors toward penmates than pigs in the slatted floor housing. Pigs in the barren environments persistently nosed and chewed penmates. Growth rates were higher for pigs in the enriched environments and they had heavier carcass weights than pigs from the non-enriched environment. Pigs from enriched environments also had more backfat at slaughter than the pigs in the non-enriched environment and pork from pigs reared in enriched environments showed lower cooking losses and shear force value than pork from pigs reared in barren environments.

332. Increasingly, there are markets for pigs raised in enriched environments, with consumers' attraction to the products lying in the quality of the meat from pigs in those environments and the assurance of knowing that how the pigs were raised meets their expectations. An important part of the attraction of these alternative meats, based on results from taste panels, appears to be improved flavor and texture in meat from pigs that have an increased level of backfat and have been free to exercise.

333. It is reasonable to conclude that a future emphasis on pig welfare will require changes in the industry and will precipitate them as well, but will not signal its demise.

POLITICAL ECONOMY OF ANIMAL WELFARE

334. Farm animal welfare is a public good. Optimal amounts of farm animal welfare are not provided by the market. Animal welfare represents a cost that is not internalized by the producer. The costs to animals are reduced vigor and mental well-being, possibly long-term deterioration leading to eventual pre-slaughter death. The cost to people is the loss of benefits from more humane and ethical animal production. These lost benefits are intangible: e.g., a good conscience from being able to purchase animal products that have been produced by methods consistent with their values. They are also tangible: e.g., reduced adverse impacts of animal production on human health and the environment resulting from healthier animals and positive contributions to the environment and human health by safer production practices.

335. How best to provide farm animal welfare in a public good context is an important question for policymaking both in Minnesota and the US; however, as animal welfare has always been perceived as an extra cost, a full estimation of potential private and social costs and benefits of farm animal welfare legislation in the US is not currently available for use in policymaking.

336. With the current costly foot and mouth outbreak, it is perceived in Europe that Europe in part is experiencing the consequences of individual countries' failure to enforce community directives on animal welfare, particularly animal transport. With this perception is emerging a new resolve for reform of Common Agriculture Policy to reward socially responsible agricultural production, including animal welfare and environmental protection. The European resolve presents an opportunity for cooperation or conflict with US and Minnesota prospective trading partners. As Europe perceives potential reforms as necessary for preservation of its agriculture, its position is likely to be firm. The choice lies with us as to whether there will be cooperation or conflict.

ANIMAL WELFARE REGULATIONS: US AND ELSEWHERE

337. Legislation and regulation based on up-to-date scientific knowledge about the biological and behavioral needs of farm animals are the most reliable available and potential mitigation measures for improving the welfare of animals raised for food or food production, *if strictly and equitably enforced*, because they are capable of providing a high level of welfare to farm animals and they ensure a level playing field for all producers.

338. There is very little legislation protecting farm animals in the United States and what laws there are carry weak penalties. Whereas pet animals are well represented by the state's humane organizations, Minnesota's farm animals have few organized defenders.

339. In all but a handful of agricultural states, farm animals have been legislated out of the state anticruelty acts that originally protected all animals. Agribusiness-initiated legislation exempting farm animals from state anticruelty acts sometimes has been supported by pet animal organizations who see the move as an acceptable tradeoff for getting stronger penalties for cruelty to pets.

340. There is no scientific evidence that farm animals suffer any less than pet or companion animals do from cruelty or neglect nor is there evidence that, morally speaking, it is defensible that they should be less protected under the law than pet or companion animals.

341. As the welfare of an animal includes aspects of animal well-being that are not necessary for it to produce an output and yield a profit, leaving responsibility for animal welfare up to the producer is not a viable way of ensuring the welfare of farm animals. The large number of downed, pregnant, and injured animals that are marketed for slaughter, demonstrate that many producers' interests in their animals are limited to their usefulness and ability to generate a profit for the producer and not what is best for the animal.

342. No state agency is mandated to oversee or ensure the welfare of individual animals on Minnesota farms. This is an important gap in animal protection that should be filled. While Minn. Stat. 343.01, et seq., as of now covers all animals in Minnesota, the statute provides weak penalties for violations against farm animals, no matter how severe the violation. In the 2001 legislative session, farm animals' status has been weakened further relative to companion animals by a new bill that increases the penalty for cruelty to pet animals but leaves farm animal cruelty a misdemeanor.

343. The Minnesota Board of Animal Health is charged with "protecting the health of Minnesota domestic animals." However, the majority of their inspections (98% of 2,000 inspections annually) deal with the detection and eradication of infectious diseases of farm animals to prevent their spread. While this contributes to reducing welfare problems resulting from epizootic illnesses, it does not cover the impacts on animals of what was defined in earlier chapters as resulting from deficiencies in the production environment or in management, for example, injuries, lameness, infertility, cruelty in handling, and behavioral deprivation.

344. The availability of successful alternative models of production is critical to abandonment or reform of existing models. However, the institutional framework must be "hospitable" to adoption of new methods. Hence, the existence of alternative production systems providing more biologically and behaviorally appropriate management and environments can be included among available and potentially available mitigation measures for addressing negative impacts of animal agriculture on animal health and well-being. The existence of technology choices provides the opportunity for reform. However, the framework of laws and policies still must reflect society's preferences for animal farming more in tune with animals' natural capabilities and needs.

345. In Minnesota, opportunities for investigation of alternatives have opened up with the legislative mandate to investigate alternative swine production systems. Research is starting at the University of Minnesota West Central Research and Outreach Center, where research into alternative dairy production systems known as intensive rotational grazing was initiated some years ago.

346. In general, with respect to the formulation of laws based on respect for animals, the US lags behind Western Europe and Scandinavia. However, EU directives are not

consistently or strongly enforced, meaning that many countries in Western Europe have not benefited from the good animal health situation that prevails in countries such as Sweden, where the society has been united behind regulations and both rules and enforcement have been comparatively strong.

347. Without strong and equitable enforcement, laws are not effective.

348. Animal welfare laws also serve as animal health rules. In Sweden, animal welfare laws are perceived by farmers and society as ways of ensuring naturally healthy animal production. Swedish animal health programs reflect a preventive approach to animal health so that catastrophes can be avoided insofar as possible by paying for prevention up front. The alternative is to risk catastrophe and when it occurs, still pay the costs, both monetary and in terms of human and animal suffering and losses such as valuable breeds. Recent events in Europe related to foot and mouth disease and bovine spongiform encephalopathy have renewed European commitment to effective laws and agricultural technologies that are supportive of animal welfare. The Europeans are likely to stand firm on these demands at the World Trade Organization.

349. Opportunities exist for conflict or cooperation between the US and the EU with respect to animal agriculture policies, particularly with respect to Europe's commitment to animal welfare. A common understanding of the basic scientific principles underpinning ethical concerns about the welfare of farm animals would be useful to negotiations.

II. Overall Conclusion and Recommendation

The picture of the prevailing model of highly-intensive animal agriculture that emerges from serious perusal is that the animal agriculture industry is placing tremendous pressures on farmed animals in ways that are adverse to their welfare and that humans also feel these consequences. By focusing only on increasing the productive performance of animals at the expense of vigor (physical energy or strength, the capacity for natural growth and survival) and mental wellness we seem to be engaging in a very delicate and increasingly precarious balancing act between mass production and potential catastrophe for the animal industry and society.

The typical animal production science that is performed in agricultural universities needs to be transformed into an animal welfare science whose goal is to optimize the health and well-being of agricultural animals. Human life must be sustained on the well-being of individual animals rather than on the depletion of their natural capabilities and the redirection of their systems and resources to growth and prolificacy alone. This is necessary, not only for the animals' sakes, but also to ensure food safety and security into the future.

The welfare of farm animals needs to be made the responsibility of the producer from birth to slaughter. However, ways must be found to enable the producer to exercise that responsibility effectively. For example, the producer should have the power to demand from genetics suppliers animals that are genetically sound and vigorous and not merely prolific and fast growing and the price paid to producers for their animals and animal products should make it possible for them to produce them in conformance with societal values.

The current situation in US animal agriculture may not change until the public is finally motivated overwhelmingly to choose quality (of both product and production method) over price. It

is important that cost-benefit studies of impacts associated with animal welfare regulations or product standards also include in their calculations the high private and social costs in the present and into the future of maintaining the highly intensive status quo in animal agriculture so that the full range of implications of their choices will be more transparent to producers and the public at large.

Stronger legislation is necessary to protect Minnesota's farm animals, but it should include recommendations for contributing to the welfare of the animal, not simply preventing cruel acts against it, and it should be accompanied by funding for research and transition periods to make adoption of more welfare-encompassing methods viable for producers.

Particularly as the public increasingly demands the phase-out or elimination of gestation stalls, crates and tethers in the US and in other developed countries, it will be critically important for Minnesota producers and University research faculty to be knowledgeable in animal welfare science and its applicability to alternative housing systems, to be a step ahead, so to speak, because change appears inevitable. The State Department of Agriculture could do much to foster such research and guide future technology development and transfer opportunities. The newly-established alternative swine systems program at the University of Minnesota provides opportunities for research and cooperation with Minnesota swine farmers and animal welfare centers at other universities in the US and abroad. Similar opportunities could be explored for other livestock species, as well.

A further reason for raising the level of research and policy work in relation to farm animal welfare relates to the role of trade in Minnesota's future. This year, the EU is committed to bringing farm animal welfare to the World Trade Organization (WTO), strengthened in its commitment by the devastating social, animal welfare, and economic effects of this spring's foot and mouth disease epidemic

However, issues such as farm animal welfare and multifunctionality of agriculture, which are of substantive importance to Europeans, are usually looked upon in the US as potential excuses for creating trade distortions. Scientific and ethical discussions in the European Union have led to a policy that explicitly imputes sentience to farm animals. In the US, there is no written policy about farm animals. However, in practice, in the US, farm animals are handled primarily as basic commodities and factors of production without regard for their sentience.

The European Community, through its Scientific Veterinary and Animal Welfare Committees and the Council of Europe Standing Committee on Farm Animal Welfare, has benefited from decades of sound and apolitical scientific and technical input into policymaking on farm animal welfare. In the US a comparable level and caliber of input have been missing and, consequently, policymakers may have had little opportunity to form an appreciation of animal welfare's scientific and economic aspects (and the ethical issues they raise) or of the basic conceptual framework within which the Europeans are operating with respect to farm animal welfare.

For cooperative work on an issue over which parties have disagreement to be fruitful, the parties must share at least a common awareness of the basic principles underlying the issue (be on the same page). Awareness, in turn, may lead to appreciation of the other's viewpoint and to the resolution of otherwise potentially irreconcilable conflicts. A basic scientific conceptualization and economic discussion of farm animal welfare are presented in this report.

III. Some suggested measures for legislation and research

The following recommendations are meant to be suggestive only and do not exhaust the possibilities.

Affirm and legislate where practicable:

1 Farm animals are sentient beings and caretakers and animal production systems shall take into account their basic biological and behavioral needs in construction, operation and management.

2. Farm animals shall be accorded
   a) freedom from fear
   b) freedom from hunger, thirst, and malnutrition
   c) freedom from pain, injury and disease
   d) freedom to express normal patterns of1behavior
   e) freedom from discomfort
   from birth through slaughter.

3. Every animal shall be accorded a painless and distress-free death
   a) When it is clear that an injury or disease is beyond healing, each afflicted animal shall be mercifully and expeditiously euthanized
   b) Slaughter facilities shall be designed and managed so as to permit and ensure effective stunning prior to killing, effective killing before further handling, e.g., before dismemberment and skinning
   c) No injured animal shall be transported from the farm of origin until it has healed and transport can be undertaken with minimal pain, distress, or discomfort to the animal
   d) If transport without pain, distress, or discomfort cannot be ensured, the animal shall be euthanized at the place of origin
   e) There shall be no transport to slaughter or disposal of pregnant animals, downed animals, or animals in an otherwise weakened state. If the animal will not get well, it shall be euthanized (given a gentle death) where it is.

4. Farm animals are entitled to and shall be accorded the freedom
   a) to perform natural physical movement as needed for health and vigor (e.g., flap their wings, walk, turn around, lie down with ease and in full lateral recumbency)
   b) to associate with other animals, where appropriate of their own kind and under conditions which do not encourage aggression
   c) hygienic, spacious, and bedded facilities for comfort activities such as rest, sleep, and body care (e.g., no animal shall have to lie on bare concrete, wet and dung covered floors; animals shall have soft lying areas, space for self-maintenance such as grooming)
   d) provision of food suitable for its species (e.g., not feeding animal remains to ruminants or herbivores) and fresh water to maintain full health
   e) opportunity and materials for exploration and play
   f) satisfaction of minimal spatial and territorial requirements including a visual field and personal space, to minimize aggression in group situations

5. Base farm program payments on adoption of environmentally beneficial and animal-welfare compatible production goals and criteria and on detectable improvements in this regard in farmers' production methods and systems

6. Require farm animal transport vehicles to be insulated and equipped with climate monitoring devices in the cabs to ensure that animals are not stressed by cold or extreme heat; establish space requirements in transport vehicles based on animal species, sex, and age; establish driver training and special licensing programs that reflect drivers' ability to handle transport vehicles with minimum discomfort to the animals being transported. Prohibit transport of injured, ill, pregnant, or crippled animals.

7. Using Codes of Practice and legislation in other countries as a model (for example, Canada, the UK, Sweden, Switzerland, and Australia), establish codes of practice for Minnesota animal agriculture that reflect scientific knowledge and public concerns regarding the health and well-being of agricultural animals.

8. Begin a herd health program based on healthy animal immune systems, including vaccination, rather than the total exclusion of pathogens from the animal, to render Minnesota agricultural animals less vulnerable to externally introduced diseases and reduce herd health vulnerability and dependence on strict biosecurity measures. This should include a phase-out of the use of antibiotics at non-therapeutic or subtherapeutic levels in all farmed animal feeds whether substitute measures are already available or not because only necessity is likely to spur invention

9. Require farmer and farmworker certification programs to build individual professionalism and self-respect in the industry and ensure that people responsible for animal care understand basic principles of animal biology and behavior that underlie animals' responses to their environment and human handlers

10. Create a mechanism to fund a center or department at the University of Minnesota devoted to research and technology development and testing in respect to welfare-appropriate breeding, housing, and management of farm animals according to species-specific characteristics and needs. Fund the center and its faculty from appropriate disciplines of ethology, veterinary health, biology, and ethics by a producer tax on each battery cage and gestation crate sold in the state

11. Institute mandatory phaseouts over periods of 1-10 years, depending on level of capital investment required for phaseout, of gestation crates, individual stall housing of boars, battery cages for laying hens, with simultaneous, full-scale investigation into and development of behaviorally appropriate and economical alternative methods. For example, certification programs that do not require capital infusions could be initiated in one to two years while phaseout of crates and cages could be gradual with a requirement that immediately no new construction can include crates and cages

12. Hire individual to gather information regarding and compile examples of codes of practice for welfare-appropriate animal production as enacted by legislative and industry bodies in other countries with an eye to recommending adoption of similar codes of practice in Minnesota

13. Appoint task force to come up with recommended codes of practice based on scientific findings and on codes of practice assembled in 12

14. Train extension livestock specialists and other personnel that meet the public or are responsible for animal care at research stations in the basics of welfare-compatible production

systems for dairy, pig, poultry, and beef production; hire more livestock specialists with training in behavior of farm animals. Sensitivity training should be part of the training programs to promote respect and openness with regard to public concerns

15. Establish division at MN Department of Agriculture to oversee and fund research and farmer-initiated innovations in systems that promote the welfare of farm animals

16. Create division within Minnesota Board of Animal Health that provides oversight and enforces regulations regarding the health and well-being of individual animals on farms. Fund it with a sales tax on specialized animal confinement equipment such as crates and cages

17. Require producers to have one or more people at their facilities trained and certified as animal welfare officers. A small farmer might have just one person (and that person might even be the farmer or a member of the family), while large producers might need more people in different parts of the operation.

18. Provide up-to-date scientific information to inform producers who currently favor continued genetic or artificial selection on production traits such as yield, growth rate, and prolificacy, of the long-term costs of selection limited to production traits. Encourage producers to demand traits necessary for health and well-being, e.g., fertility, bone and muscle strength, walking ability, and vigor.

View publication stats