TIMBER RATTLESNAKE *CROTALUS HORRIDUS* FIELD SURVEY ON SOUTHEASTERN MINNESOTA STATE LANDS (1990-1991)

submitted to

Minnesota Department of Natural Resources
Nongame Wildlife Program

date submitted

July 1992

submitted by

Dr. Daniel E. Keyler
Principal Investigator
Division of Toxicology, Department of Medicine,
Hennepin County Medical Center
701 Park, Minneapolis, Minnesota 55415

Dr. Barney L. Oldfield
Co-Investigator
Hiawatha Valley Veterinary Clinic
P.O. Box 273, Goodhue, Minnesota 55027

TABLE OF CONTENTS

ABSTRACT

Minnesota represents the northernmost range for the Timber Rattlesnake (*Crotalus horridus*) in the Midwest. Although the species was reported along the upper Mississippi river valley as early as 1680 there is virtually no recent documentation of Timber Rattlesnake distribution, population density, or the biology of the species in Minnesota.

The current distribution of *Crotalus horridus* was studied on state lands in Houston, Goodhue, Fillmore, Winona, and Wabasha Counties of southeastern Minnesota. Field surveys were conducted during the months of April through October in the years of 1990 and 1991.

A total of 101 specimens of *Crotalus horridus* were observed in the field at 16 of 33 survey sites with 48 snakes processed for biological information and 43 marked for identification. The majority of the specimens (n=86) were found in Winona County. Most specimens were observed in bluff prairie habitat (often in close proximity to hiking trails and observation points) with the exception of 2 snakes at a quarry site, 3 captured on paved roads, and 1 caught on a paved biking trail.

May 4 was the date of earliest snake sitings with the latest observations having been made on September 7. Temperatures were taken in the field of habitat environment and specimens yielding a mean substrate temperature of 26.7 ± 3.3 C (n=52), mean air temperature of 24.8 ± 3.5 C (n=52), and mean body temperature of 27.7 ± 3.4 C (n=49). The largest specimen measured 135 cm from the tip of its snout to the base of its rattle and had a body mass of 1.76 kg. Sex ratio was approximately 1:1.

It is hoped that the collective data in this report will contribute to the biological information on the species in the state of Minnesota and provide for rational land use patterns on state lands which will insure the protection and preservation of the Timber Rattlesnake.

INTRODUCTION

Minnesota is the most northwestern geographical range of the Timber Rattlesnake (*Crotalus horridus*), a species which can attain considerable size compared to most other species of rattlesnakes. Thus, Minnesota is unique in lying on one of the northernmost latitudes supporting a population of large-bodied rattlesnakes. Historically, the Timber Rattlesnake's presence has been documented in only six counties of southeastern Minnesota (Goodhue, Wabasha, Olmstead, Winona, Fillmore, and Houston) (Breckenridge, 1944; Klauber 1982). Even though rumors as to their existence elsewhere in the state are numerous, no confirmation or material proof has ever been provided.

In the six southeastern Minnesota counties where the Timber Rattlesnake does exist there is a paucity of information in regard to its distribution and population status. Historical records and scattered reports from State Parks are not abundant and the only sources as to numbers of Timber Rattlesnakes (which may also indirectly reflect distribution) in the southeastern part of the state are local bounty records. For instance, in Houston County the trend in bounties paid in given years is as follows: 1939 - #2059 bounties paid, 1941 - #5957, 1967 - #3787, 1970 - #4955, 1972 - #1894, 1977 - #480, 1980 -#819, and in 1987 only 191 bounties were paid in all counties combined. This trend suggests a decline in Timber Rattlesnake populations within this particular county. However, bounties were commonly paid for the fetuses removed from gravid females as well as the mother herself. With gravid females capable of containing 8-12 young these reported numbers are difficult to accurately interpret.

This limited amount of information suggested that the need for an updated study was evident and necessary. Minnesota's State Parks and lands represent areas protected from extensive development and may be a last safe stronghold for the Timber Rattlesnake in the state. To insure the preservation of the species and provide for appropriate land use patterns on State lands the current study was undertaken to determine the present-day distribution and population status of *Crotalus horridus* in southeastern Minnesota's State lands. Preliminary data on the biology of the species in this northern cline were also collected.

MATERIALS AND METHODS

Survey Areas and Sites

USGS quadrangle topographical maps (7.5 minute series) and State Park and Trail maps were evaluated for potential Timber Rattlesnake habitat. Survey sites were determined by locating areas with knolls at elevations of approximately 200 - 350 meters and with southeastern to southwestern exposures. Along the State Trail site, areas of investigation were based on siting reports. Land owners adjacent to state lands were also interviewed for information concerning local populations and historical sitings. All sites were surveyed by foot with the slopes being traversed from the top downward or the bottom upward depending on the accessibility. Fieldman hours spent at a given site, the date, and number of *Crotalus horridus* were recorded. Fieldman hours were calculated as : no. persons in the field x no. of hours in the field = no. fieldman hours. All fieldman hours represent actual time in the field surveying for snakes. Specific localities and sites were documented.

Processing

Snakes were captured when possible using FurMont snake hooks and Whitco tongs (Furhman Diversified, Inc., LaPorte, Texas). If a snake was in a position making capture difficult or likely to cause possible injury no attempt to procure the animal was made. When a specimen was captured it was processed and biological data were recorded. The first measurement taken was the body temperature using a Miller and Weber (MIller and Weber, Inc., Queens, New York) cloacal thermometer. This measurement was the first taken so that the body temperature would most accurately reflect the snake's temperature just prior to capture. Body temperature rapidly changes as a result of handling and direct sun exposure which may occur during capture. FurMont snake sexing probes were used for sex determination. When newborns were collected in the field no attempt to sex the specimen was made due to the possibility of injury. Gravid females were obvious when found and no sex confirmation was necessary. Palpation was performed on gravid females to determine the vitellogenic stage. Specimen length was taken from tip of snout to the base of the rattle using a metric tape measure. Live measurements were made to the nearest centimeter with all values rounded downward to the nearest centimeter to avoid exaggeration. Snakes were placed in a rip-stop nylon bag and weighed with a 0 - 200 g or 0 - 2000g range spring scale (Sargent-Welch, Skokie, Illinois) previously tared for bag weight and weighed to the nearest gram. Rattles were counted beginning with the button as zero and all free segments thereafter numbered consecutively. Snakes were marked for identification, upon possible recapture, on their rattles by using a permanent marker to make a vertical line up the central grove from the basal segment, on each side of the mark-line, a letter was placed beginning with the first letter of the alphabet and each consecutive specimen at a given site lettered consecutively (i.e. A/A. B/B etc...). Specimen color morphology was recorded as well as the presence of specific markings (i.e. post-ocular stripes and mid-dorsal stripes). All specimens were released at the site of capture. The survey site of capture was recorcded and photographs taken to document unusual markings and color morphology. All specimens were handled in accordance with those published in the , Guidelines for Use of Live Amphibians and Reptiles in Field Research, 1987.

Habitat Documentation

When a site was surveyed a brief description of the habitat was documented with descriptions of the vegetation, presence of rock cover, elevation, extent and direction of exposure, degree of slope, and soil substrate type. Since most surveys were made in the spring and fall habitat descriptions are representative of den and hibernacula or areas adjacent to these known as transient habitat.

Along with the brief habitat description certain climatologic measurements were recorded whenever a specimen was captured or observed. The air temperature and substrate temperature where the snake was laying were measured using a Miller and Weber surface thermometer.

RESULTS

Collective Review (Southeastern Minnesota State Lands):

Distribution, Habitat and Numbers:

Beginning May 4, 1990 through September 7, 1991 (Appendix II) field surveys were made of 33 sites representing nine localities on southeastern Minnesota State Lands (Appendix I). The common habitat features for the localities studied are that of oak forest around the sites, presence of bluff prairies with steep slopes with south or southwestern exposures, rock formations with ledges or fissures, and scattered cedars and birch on the slopes (Table II, Appendix III). Most sites possessed these characteristics with the exceptions of an old stone quarry at Beaver Creek Valley State Park, a paved bike path on the Root River Trail, and paved roads in Whitewater State Park.

A total of 41 field days representing 299.5 fieldman hours yielded 101 observations of *Crotalus horridus* (this number includes six recaptured snakes) at 16 sites in seven of the nine localities studied (Tables I, II, Appendix IV). Four specimens were documented as a result of State Park Staff captures in Whitewater State Park, Whitewater Management Area, and Beaver Creek Valley State Park. The locality with the greatest number of observations was O.L. Kipp State Park, where 85 specimens (6 of which were recaptures) were found, while the 16 other rattlesnakes were observed in Beaver Creek Valley, Whitewater (all Park Staff Captures on roads), Whitewater Management Area (Park Staff capture), Root River Trail, and north of Frontenac State Park. There were no confirmations at John A. Latsch State Park, Forestville State Park or in Frontenac State Park (Table I, Appendix IV). The average number of fieldman hours for each *Crotalus horridus* specimen observed was only 2.2 fldmn/hrs for O.L. Kipp, but was 25.0 fldmn/hrs for the Root River Trail (Tables I). These numbers may be of value in determining the expected frequency of observation of snakes in the field, which may be reflective of population numbers at a given locality. Further study will be needed to determine the validity of this hypothesis. Field surveys also provided information as to the presence of other herpetological species in several localities, including the Five-lined Skinks, Six-lined Racerunner, Blue Racer, and others (Appendix II, Table V).

Biological Information:

Of the 101 specimens observed in the field 54 were captured (43 marked on the rattle) and biological data recorded (Appendix II, V). The first Timber Rattlesnake observations were made on May 4, 1990 and the last for 1990 were made on September 3. In 1991 the earliest and latest observations were made on May 13 and September 7, 1991, respectively. Most of the marked Timber Rattlesnakes were from the O.L. Kipp locality (n=37). Four snakes were marked in Beaver Creek Valley, one on the Root River Trail, and one in Whitewater. A total of 27 males, 25 females (3 gravid and 4 with follicles) were observed in the field, resulting in sex ratio of 27:25 (1.08) or approximately 1. Of the 12 newborns observed in the field, which were representative of four litters from O.L. Kipp, only two snakes were processed for size data and the sex was not determined. The average size of adult males was a body mass (BM) of 974 g, length (SBR = snout to base of rattle) = 110 cm; adult females BM = 586 g, SBR = 90 cm; and newborn BM = 32 g, SBR = 34 cm (Table III, Appendix V). The largest male had a BM of 1.76 kg, SBR of 135 cm and was observed and processed on site at the Reno Management Unit while the largest female was observed and processed on site at Beaver Creek Valley and had a BM of 1.07 kg, SBR of 104 cm, and was not gravid (Appendix V, Table III). When the body mass, body length, and body mass to body length ratios are viewed graphically it appears that the study population (both males and females) is normally distributed. Even when these same parameters are illustrated for each sex, a normal distribution is suggested (Figures I, II, III).

The markings and color morphology of specimens showed that approximately 80% of the biological data specimens exhibited post ocular stripes and mid-dorsal stripes (Appendix V slides). Two specimens from O.L. Kipp were of an unusual color morph as they were aneurythristic (lacking yellow and yellow dependent colors) giving them a slate gray appearance. Their eye color outside the iris was also slate gray. This color morph does not appear like the black morph of the

Appalachians (Brown, 1992). These were both adults and both sexes were represented with the female possessing follicles. Thus, the potential for more specimens of this color morph is evident (slide 26).

Rattles of the study snakes ranged from 1 to 11 segments with an average of 6 ± 2 segments (actual calculated value is 5.85 ± 2.17). The largest rattle was 11 complete segments; however, other specimens were observed to have 10 rattle segments but were incomplete suggesting these rattles were originally greater in their number of segments. Incomplete rattles were not an uncommon finding as over 60% of the snakes had rattles which had been broken off by some means (Appendix V).

Temperature data (Table VI) reveal that the Timber Rattlesnakes' body temperature is warmer than the air and substrate temperatures in its immediate environment. The mean body was 27.7 C°, while the mean ambient air and substrate temperatures were 24.8 C° and 26.7 C°, respectively. Furthermore, mean body temperatures of females was 28.6 C° while that of males was 26.9 C°. Even body temperatures of non-gravid females were similar to gravid females and values of both these groups were greater than that for males (Table VI). These data are representative of temperatures documented from May through September in both 1990 and 1991.

RESULTS BY LOCALITY

Beaver Creek Valley

A total of 36 fieldman-hours were spent surveying six sites in this locality with 7 Timber Rattlesnakes observed. BEA 2 and BEA 5 were the two sites where all but one specimen were found (Appendix I, IV, Table I). BEA 2 (Appendix I, III) is an old stone quarry, immediately adjacent to a hiking trail, two large male specimens were found on different occasions. Repeated efforts were made at this site but no females or other snakes were seen. This site may be representative of a remnant population as the two males appeared to be older snakes as they were of considerable size and had incomplete rattles of 10 and 11 segments (Appendix V). It is surprising that there are not more sitings due to the close proximity of the hiking trail; however, this may not be a heavily used trail. BEA 5 (Appendix I, III) is the hill just west of Schechs Mill and is actually outside the State Park. This site has multiple bluff prairies with good cover and may have a stable population as four adult rattlesnakes were found (1, a female with follicles) with only two surveys having been made. Snakes from this site could quite easily move into the State Park during the summer months. Numerous Five-lined Skinks were also observed at these sites and the Six-lined Racerunner observed at BEA 5 (Appendix II, Table V). A single specimen was captured by Park Staff in a prairie area adjacent to a stream, BEA 6 (Appendix I, II).

Forestville

One site was surveyed in this Park and no specimens were found (Tables I, II). The Park Manager stated that one or two sitings were reported annually, but accurate identification may not always have been confirmed. A historic den site has been reported, but there have been no sitings in years.

Frontenac

This Park reports the presence of Timber Rattlesnakes historically, but no confirmed sitings have been reported for years. We surveyed one site within the Park, FRO 2 (Appendix I, III) and found no evidence of rattlesnakes. FRO 1 (Appendix I, III) is also known as Rattlesnake Bluff and is adjacent to the Park. This area is extremely difficult to hunt as it is very steep with multiple drop-offs; however, it did yield three specimens (Appendix II, IV). This would be appropriate habitat for protection and possible purchase if an opportunity affords itself.

O.L. Kipp

A total of 12 sites (Appendix I) were surveyed over 185.5 fieldman hours in this Park with 85 Timber Rattlesnakes (includes six recaptured snakes) observed at eight sites collectively. This Park has the best contiguous expanse of habitat and the greatest number of specimens of all

localities surveyed on State Lands (Table I, Appendix I, II). Sites KIP 2 (Hill of Many Timbers) and KIP 8 (Queen's Bluff) are where 31 and 36 specimens were observed respectively and as such represent the most heavily populated sites surveyed. The numbers above include three recaptures at each site. The fieldman hours/snake at KIP 8 was 0.83 (Appendix IV), thus we observed or processed a Timber Rattlesnake approximately every 50 minutes we were in the field at this site. It is possible that this high frequency was due to surveys which happened to be made at the time of peak emergence or ingress. KIP 2 and KIP 8 were also the only sites where newborns were observed. One litter of four was seen coiled with their mother under a small rock ledge at KIP 2. This site was also the only site where courting behavior was observed (specimens KK & LL, Appendix V). Site KIP 2 yielded a fieldman hours/snake ratio of 2.9 or in other words we observed/processed a snake about every three hours we were in the field. This may be a more realistic value as it is representative of surveys made throughout the Timber Rattlesnakes active season. The unique aneurythristic color morph was observed in two snakes at KIP 2 (specimens DD & PP, Appendix V) with both a male and a female (with follicles) observed. The sex ratio of males to females in O.L. Kipp was 23.21 (0.91) or approximately 1, and may be representative of a stable population. An important finding in this Park is that a number of sites are in close proximity to hiking trails (Map) and the possibility of a human/snake encounter is quite possible. In fact there are several confirmed and documented sightings each year. This Park is truly the best stronghold for the Timber Rattlesnake on the State Lands surveyed, and it will be important to keep this Park a "Natural State Park". Further development of this locality will have a definitive negative impact on the survival of this species on Minnesota's State Lands.

John A. Latsch

This Park has very little Timber Rattlesnake habitat, and there have been no reported sightings for years. Therefore, only a single survey was made of this locality with no snakes having been observed (Appendix I, III, IV).

Reno Management Unit

A single survey was made at a single site in this locality (Appendix I, II, III). Two specimens were observed and processed, resulting in confirmation of the largest Timber Rattlesnake ever documented in the State of Minnesota (Table III, Appendix V). This locality has a vast area surrounding it which could potentially harbor a considerable number of rattlesnakes. Further study and surveys may confirm this suspicion.

Root River Trail

Only a single specimen of *Crotalus horridus* was observed at this locality (Appendix I, II, III) even though 25 fieldman hours were spent surveying for snakes in what appeared to be favorable habitat (Table I). The second largest specimen of the study was observed at this locality and we believed it to be very old (Appendix V). There were numerous reported sightings from bicyclists along the trail and it is difficult to know if this is reflective of a greater number of snakes in the area or a result of high traffic use on the trail resulting in increased sightings of a few snakes. Most sightings are reported around the trail bridges; however, there is suitable habitat adjacent to the trail from which the snakes must move down. It should be noted that many sightings are probably not Timber Rattlesnakes as Fox Snakes were found right on the trail during our surveys. One reported sighting described a 7 ft. rattlesnake climbing a post to a blue bird house and eating the baby birds. Obviously, this type of report does not serve to confirm a Timber Rattlesnake sighting. This area may indeed be the refuge for many rattlesnakes, but it is difficult to survey as much of the land immediately adjacent to the trail is private.

Whitewater

Two snakes were observed and captured by Park Staff on Park roads (Appendix I, II) at this locality. These were the only specimens to be documented during the current study. Surveys were made into many areas of the Park in search of rattlesnake habitat (Appendix III), but little was found. Most areas, which may have once been favorable habitat, are now grown over and covered

by the forest canopy. This Park proved to be very difficult to survey and even with considerable effort only a few Garter Snakes and a Milksnake were found (Table V). It may be that, in fact, there are not many Timber Rattlesnakes in the Park.

Whitewater Management Area

A single specimen came from this locality with no information as to exactly where in the area the snake was collected for it was captured by Park Staff after local individuals had moved the snake. As this is a lowland/wetland habitat it is likely the snake had moved down from an adjacent bluff prairie area.

DISCUSSION

The results of this study do confirm the presence of the Timber Rattlesnake on Minnesota State Lands; in particular these State Lands are designated as State Parks, State Trails, State Forests, and Scientific and Natural Areas. As such, these lands represent an extremely important refuge for the remaining populations of this Minnesota Special Concern Species. Private lands are increasingly being sold for development, and no legal protection for the Timber Rattlesnake is afforded in these areas. Consequently, snakes encountered on these lands are often killed. Even State Lands in Minnesota are under pressure to increase recreational use. The Timber Rattlesnake is a species that doesn't move on when its habitat is in jeopardy, or adapt to major changes, it just slowly disappears. This has happened in several New England states and resulted in the species being totally protected in several other states (information obtained at the Timber Rattlesnake Symposium, Massachusetts Audobon Society, Smith College, Northampton, Massachusetts, December 7, 1991). Minnesota is fortunate to still have this species present on lands where protective measures can be implemented. Of the state lands surveyed during the course of this study, one locality, O.L. Kipp State Park in Winona County supports a substantial Timber Rattlesnake population. It is the only locality where newborn litters and courting behavior of adult snakes were observed. The multiple, south to southwestern facing bluff prairies with contiguous ridges and valleys, limited recreational development and use of this park and its adjacent Scientific and Natural Area are collectively favorable features which contribute to the sustaining of the Timber Rattlesnake. Interviews with landowners peripheral to the park confirm the snakes come from the park to their land, not the inverse. This makes it increasingly important to acquire these adjacent lands when possible to permit further protection of snakes while migrating from one site to another. This is important because Timber Rattlesnakes have been reported to travel as far as 2.5 miles from their den site (Brown, 1992). Thus, they become more vulnerable to human predation when they cross private land tracts, as several landowners admitted to killing rattlesnakes. This concept of increasing land acquisitions would also be beneficial at Beaver Creek Valley, Frontenac, and the Root River Trail.

Although 101 Timber Rattlesnakes were observed during 1990 and 1991 on study localities this number should not imply there are "rattlesnakes everywhere". This number of specimens was observed only with intense field efforts over a two year period. Recent observations in Western Wisconsin, just across the Mississippi River from several of the study localities, have suggested a decline in Timber Rattlesnake numbers compared to historical records (Oldfield and Keyler, 1989). It has also been reported that dens in Pennsylvania with 45 rattlesnakes, or fewer, are not viable (Martin, 1990). Thus, Minnesota populations may be on the brink of their demise. In comparison a well known Timber Rattlesnake researcher in Virginia has reported observing over 300 specimens a year in the Shenandoah National Park (Martin, 1979). It could be argued that habitat is more favorable for the species in Virginia; however, if this is the case it is all the more reason to preserve and protect Minnesota's remaining habitat.

The biology of the Timber Rattlesnake is complex and is gradually being delineated in the northeast (Brown, 1991). The findings in this study are quite preliminary and much more field work and monitoring will be necessary to further understand the biological processes of the species in its northwestern range. The findings of Brown may however serve as somewhat of a parallel representative to Minnesota, for his data are derived from specimens studied in a similar northern latitude. Brown's findings are those of long natural lifespan (25 years), low reproductive rate (females reproduce at 3 and 4 year intervals), age of first female reproduction may be 9-10 years, litter size of only 6-9 young, infrequent reproductive attempts, high mortality in juveniles and low mortality in adults (Brown, 1992). With the severe Minnesota winter climate it appears that snakes are in hibernation for seven months (November-April) as our earliest and latest observations are May and September, respectively. Thus, with a long hibernation time and the extremes in temperature which may potentially range from +95 F^{o} to -60 F^{o}, newborn and juvenile mortality may be significant.

Furthermore, the loss of an adult specimen via human predation or vehicular accident may have impact on the reproductive status of a given population.

The sizes of Minnesota Timber Rattlesnakes are comparable to those reported in northeastern New York (Brown, 1992) suggesting average values may be consistent for the species at a given northern latitude. The present study also demonstrated sexual dimorphism as males were larger than females (Table III). One interesting observation was that of body temperature differences between males and females (Table IV). This difference does not appear to be skewed due to the inclusion of gravid females or females with follicles which are commonly reported to prefer warmer temperatures. Although the numbers of snakes for this evaluation are small (n=27 males, n=25 females) it does reflect a possible tendency of females, in general, preferring warmer temperatures. It is difficult to determine what this finding may mean or if the observation will remain the same through time and further monitoring will be important.

Minnesota's Timber Rattlesnakes represent an important wilderness species like the Timber Wolf. Like the wolf it has persevered decades of predation and only recently (1989) did the legislature remove the bounty system on rattlesnakes in Minnesota. The Timber Wolf is now a protected species, and in the not too distant future without protection, the Timber Rattlesnake may become extinct in the State of Minnesota. It would be wise to make efforts to protect this species and its habitat now, before the remaining Timber Rattlesnakes are non-viable remnant populations.

MANAGEMENT RECOMMENDATIONS/CONSIDERATIONS

The management of public lands that are home to the Timber Rattlesnake (*Crotalus horridus*); and protection of the Timber Rattlesnake presents several unique problems not associated with harmless reptile species. First, the actual and perceived dangers associated with a rattlesnake encounter while hiking, biking, picnicking or camping are a genuine management concern. Secondly, this species lacks adaptability, is slow to mature and has a low reproductive rate. Keeping these concerns of Timber Rattlesnake biology in mind, and relating it to the information gained during our field research work on Minnesota Public Land, the following recommendations are provided for consideration.

Habitat Management

The best habitat management practices favoring Timber Rattlesnakes is that which favors minimal development and minimal human impact. Any development of the bluff prairies and rock outcrops (hiking trails, mountain bike access, observation decks) would have a serious negative impact on Timber Rattlesnake populations and their movement. In fact, it may be advisable to close or reroute a section of trail that has a relatively high number of sightings or is known to be in proximity to denning areas. Development (camp grounds, recreational areas, recreational vehicle access, trail systems) of surrounding forests and prairie areas adjacent to dens will certainly increase Timber Rattlesnake encounters with the public, and potentially result in decreased populations over the long term. Plans for future development within State Parks (especially O.L. Kipp State Park) should be carefully assessed as to impact on Timber Rattlesnake populations prior to implementation.

There are two special State Park cases concerning habitat management for the Timber Rattlesnake. The first concerns the lack of suitable habitat and apparent depressed numbers of snakes within Whitewater State Park. Timber Rattlesnakes may benefit and populations may improve if some of the knolls and adjacent areas near the south and southwest facing rock outcrops were opened up by clearing trees and vegetation to increase basking site availability. Years of fire control is the primary reason that much of this bluff area is now covered with trees and heavy vegetation. Aerial photographs from the past indicate that these areas were much less forested.

The other special case involves bluff prairie maintenance at O.L. Kipp State Park. These bluff prairies are essential Timber Rattlesnake habitat, and as such represent an extremely important stronghold for *Crotalus horridus* in an environment providing legal protection. Every effort to maintain these important prairies should be made. Sumac (*Rhus sps.*) appears to be the natural invader that demands the most attention. Cutting and burning are methods of sumac control currently employed. Manual cutting is labor intensive, but it has minimal impact on other vegetation and animal life on the prairie. Burning bluff prairies is also used to control Sumac as well as replenish the soil with nutrients. Once burning has been established as an important method of bluff prairie maintenance, concerns of timing and frequency of controlled burns and their resultant effect on Timber Rattlesnakes may be significant. A program to monitor Timber Rattlesnake populations on prairies after burns should be part of long term management for this species at O.L. Kipp State Park.

Snake Management

Since Timber Rattlesnakes are secretive and generally timid when encountered, very little snake management is needed. On occasion a Timber Rattlesnake will be found in or near a campground, recreational area, or alongside a road. It may be necessary to move the snake to a less trafficked area. Park personnel should be capable of using a snake hook or lawn rake to carefully place the snake in a large trash can until it can be released in a more remote part of the park. Even a brief exposure in direct sun can kill a snake trapped in a trash can, so care must be taken to keep it in the shade until the release can be made.

People and Timber Rattlesnakes

Often the most difficult management problems in state lands is dealing with man and his activities, and it becomes even more complicated when dealing with a venomous reptile. Many State Park visitors will never encounter this species, but the few that do may put themselves at risk of being bitten. Unwitting visitors may injure, kill or attempt to collect this species.

Although, Timber Rattlesnake bite in Minnesota is extremely rare, the consequences of such a bite cannot be understated. State Park managers should maintain a snakebite protocol at strategic locations. Primarily the protocol should include information for keeping the patient calm and providing for rapid evacuation to a hospital that is prepared to treat snakebite. The Minnesota Regional Poison Center (1-800-222-1222) should be called if there is any question concerning the handling of the patient. The two medical centers in southeastern Minnesota that routinely stock antivenom are Winona Community Hospital in Winona and St. Mary's Hospital in Rochester. First aid treatment on site that may be of value is a venom first aid kit called, "The Extractor" (Sawyer Products, Box 188, Safety Harbor, Florida 34695). Keeping one of these kits with instructions for proper use is recommended.

There is increased potential of snakebite for those park personnel cutting Sumac on the prairies. They should be advised of this prior to each season and given instructions in the event that a mishap should occur. It is recommended that snake proof boots or leggings should be provided for D.N.R. employees required to work on bluff prairies from May through September (the activity season of the Timber Rattlesnake.)

Since rattlesnakes are frequently misunderstood, public education is an important component of conversation. Minnesota D.N.R. trail maps for Beaver Creek Valley State Park, Forrestville State Park, O.L. Kipp State Park, Whitewater State Park, and Root River State Trail indicate the presence of the Timber Rattlesnake in a low key, conservational tone. Also, Timber Rattlesnake warning signs being displayed at trail heads and information centers within these public lands provide an important component of visitor education. Naturalist programs provide meaningful information to interested State Park visitors at Whitewater State Park. Periodic programs at other State Parks by qualified individuals would be beneficial.

During the period of this study, evidence that snake hunters disrupted habitat and killed or collected Timber Rattlesnakes on Queen's Bluff (a Scientific and Natural Area) was discovered (slide 8). In most cases, snake hunters will be intent on collecting or killing this reptile, and they are usually obvious when hunting with snake sticks and bags. Park personnel should be instructed to promptly report any suspicious snake hunting activity. Local Conservation Officers should investigate illicit Timber Rattlesnake hunting activity in State Parks and S.N.A.s and enforce legal protection for this species as provided by law.

TABLE I:

SURVEY LOCALITIES, FIELDMAN HOURS AND NUMBERS OF *CROTALUS HORRIDUS*

Locality	Fieldman hours	No. *C. horridus*	hrs/snake
Beaver Creek Valley	36	7	5.1
Forestville	2	0	-
Frontenac	12	3*	4.0
O.L. Kipp	185.5	85	2.2
John A. Latsch	4	0	-
Reno Management Unit	9	2	4.5
Root River Trail	25	1	25.0
Whitewater	26	2^	-
Whitewater Management Area	-	1^	-

*North of State Park - private land
^Park staff capture

TABLE II

COMMON HABITAT FEATURES OF SURVEY LOCALITIES IN SOUTHEASTERN MINNESOTA

Locality	Bluff Prairie	Exposure	Slope°	Rock Type	Slope Plant Species	Predominant Forest
Beaver Creek Valley	+ -	S-SW	35-50°	Limestone	Sumac Wild Grape	Oak/hardwood
Forestville	+	S	35-50°	Limestone	-	Oak/hardwood
Frontenac	-	S-SE	40-50°	Limestone	Sumac	Oak/hardwood
O.L. Kipp	+	S-SE-SW	40-50°	Limestone/ Sandstone	Sumac Wild Grape Bittersweet Blue Stem Grass	Oak/hardwood
John A. Latsch	+	SE-E	40-50°	Limestone	Sumac	Oak/hardwood
Reno Mngmnt Unit	+	S-SW	40-50°	Sandstone	Sumac Wild Grape	Oak/hardwood
Root River Trail	+ -	S-SW	40-50°	Limestone	Sumac	Oak/Cedar
Whitewater	+	S-SE-SW	40-50°	Limestone/ Dolomite	-	Oak/hardwood
Whitewater Mngmnt Area	-	-	- -		-	Wetland

TABLE III

SIZE RELATIONSHIPS OF SURVEY STUDY
CROTALUS HORRIDUS SPECIMENS

SEX	BM (g)	SBR (cm)
Male (n = 25)*	974 ± 374	110 ± 13
Female (n = 22)*	586 ± 250	90 ± 12
Male (largest)	1760	135
Female (largest)	1075	104
Newborn (n = 2)	32	34

*Values represent sample means ± standard deviations

BM = body mass (grams)
SBR = snout to base of rattle length (centimeters)

TABLE IV

TEMPERATURE RELATIONSHIPS COMPARED WITH SEX AND GRAVID/FOLLICULAR STATE OF SPECIMENS*

		AT (°C)	BT (°C)	SST (°C)
M	(n=27)	24.0 ± 3.6	26.9 ± 3.8	26.2 ± 3.5
F tot	(n=25)	25.4 ± 3.3	28.6 ± 2.9	27.3 ± 3.0
F grav or fol	(n=7)	24.8 ± 3.9	28.8 ± 3.5	27.8 ± 3.0
F nongrav	(n=18)	25.6 ± 3.2	28.4 ± 2.8	27.1 ± 3.1
M + F	(n=52)	24.8 ± 3.5	27.7 ± 3.4	26.7 ± 3.3
Range		18.0 - 33.0	20.4 - 33.2	21.0 - 36.0

M = MALE
F = FEMALE
grav = gravid, nongrav = nongravid
fol = follicles
tot = total (all females)
AT = air temperature
BT = body temperature
SST = substrate temperature

*Determined from data gathered on dates ranging from May 6 through September 3, 1990, and May 13 throught September 7, 1991.

TABLE V:

OTHER HERPETOLOGICAL SPECIES OBSERVED ON SOUTHEASTERN MINNESOTA STATE LANDS*

Locality	Species
Beaver Creek Valley	Six-lined Racerunners (*Cnemidophorus sexlineatus*) Five-lined Skinks (*Eumeces fasciatus*) Ringneck Snakes (*Diadophis punctatus*) Common Garter Snakes (*Thamnophis sirtalis*) Milksnakes (*Lampropeltis triangulum*) Gray Treefrog (*Hyla versicolor*) American Toad (*Bufo americanus*) Woodfrog (*Rana sylvatica*) Painted Turtle ((*Chrysemys picta*)
Frontenac	Fox Snake (*Elaphe vulpina*)
O.L. Kipp	Bullsnakes (*Pituophis catenifer*) Racers (*Coluber constrictor*) Milksnakes (*Lampropeltis triangulum*) Common Garter Snakes (*Thamnophis sirtalis*) Six-lined Racerunners (*Cnemidophorus sexlineatus*) Green Frog (*Rana clamitans*) Gray Treefrog (*Hyla versicolor*) American Toad (*Bufo americanus*) NorthernLeopard Frog (*Rana pipiens*)
Root River Trail	Milksnake (*Lampropeltis triangulum*) Fox Snakes (*Elaphe vulpina*) Ringnecked Snakes (*Diadophis punctatus*) Redbelly Snakes (*Storeria occipitomaculata*) Common Garter Snakes (*Thamnophis sirtalis*) Gray Treefrogs (*Hyla versicolor*)
Whitewater	Milksnake (*Lampropeltis triangulum*) Common Garter Snakes (*Thamnophis sirtalis*)

FIGURE 1: BODY MASS DISTRIBUTIONS OF CROTALUS HORRIDUS, STUDY POPULATION IN SOUTHEASTERN MINNESOTA

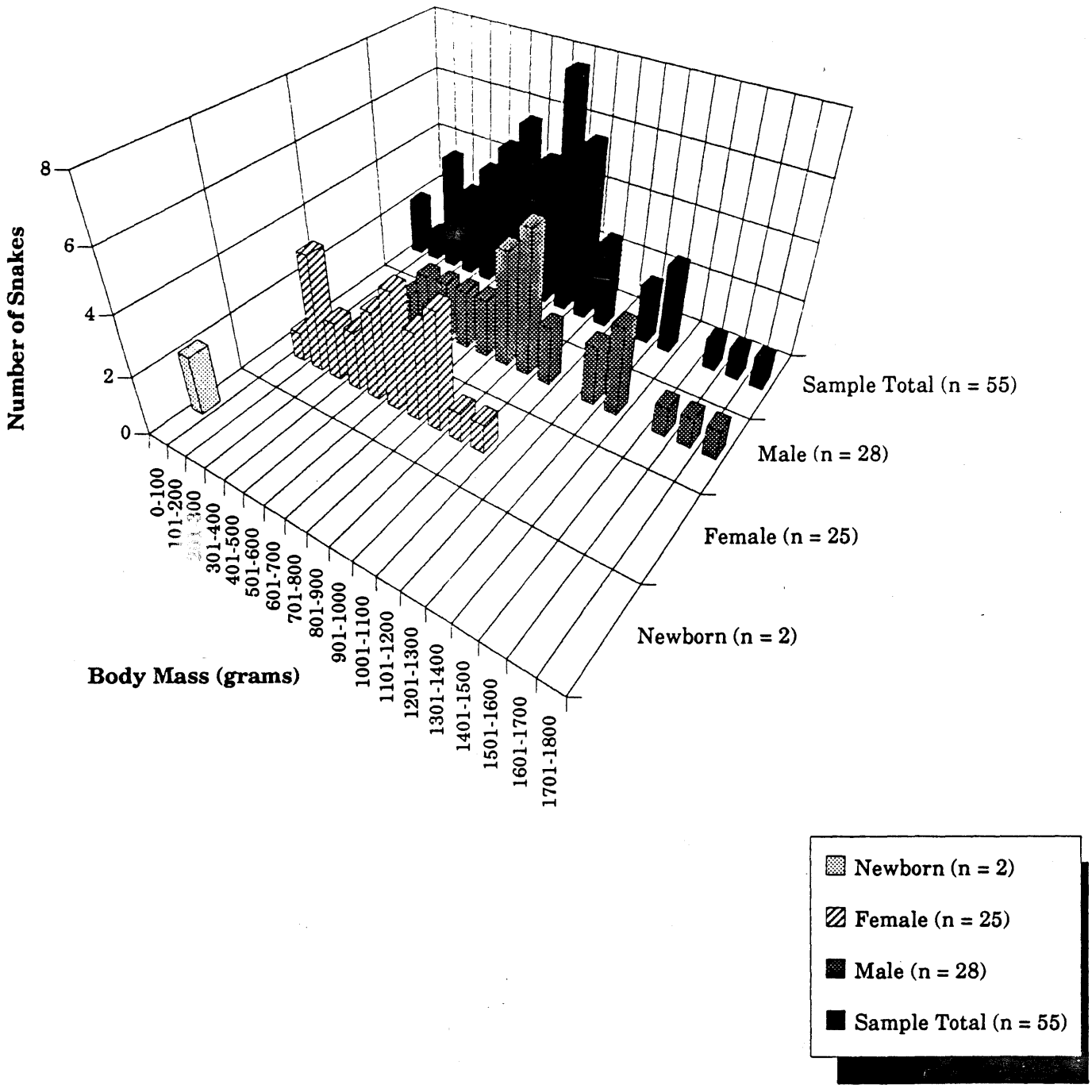


FIGURE 2: BODY LENGTH DISTRIBUTIONS OF CROTALUS HORRIDUS, STUDY POPULATION IN SOUTHEASTERN MINNESOTA

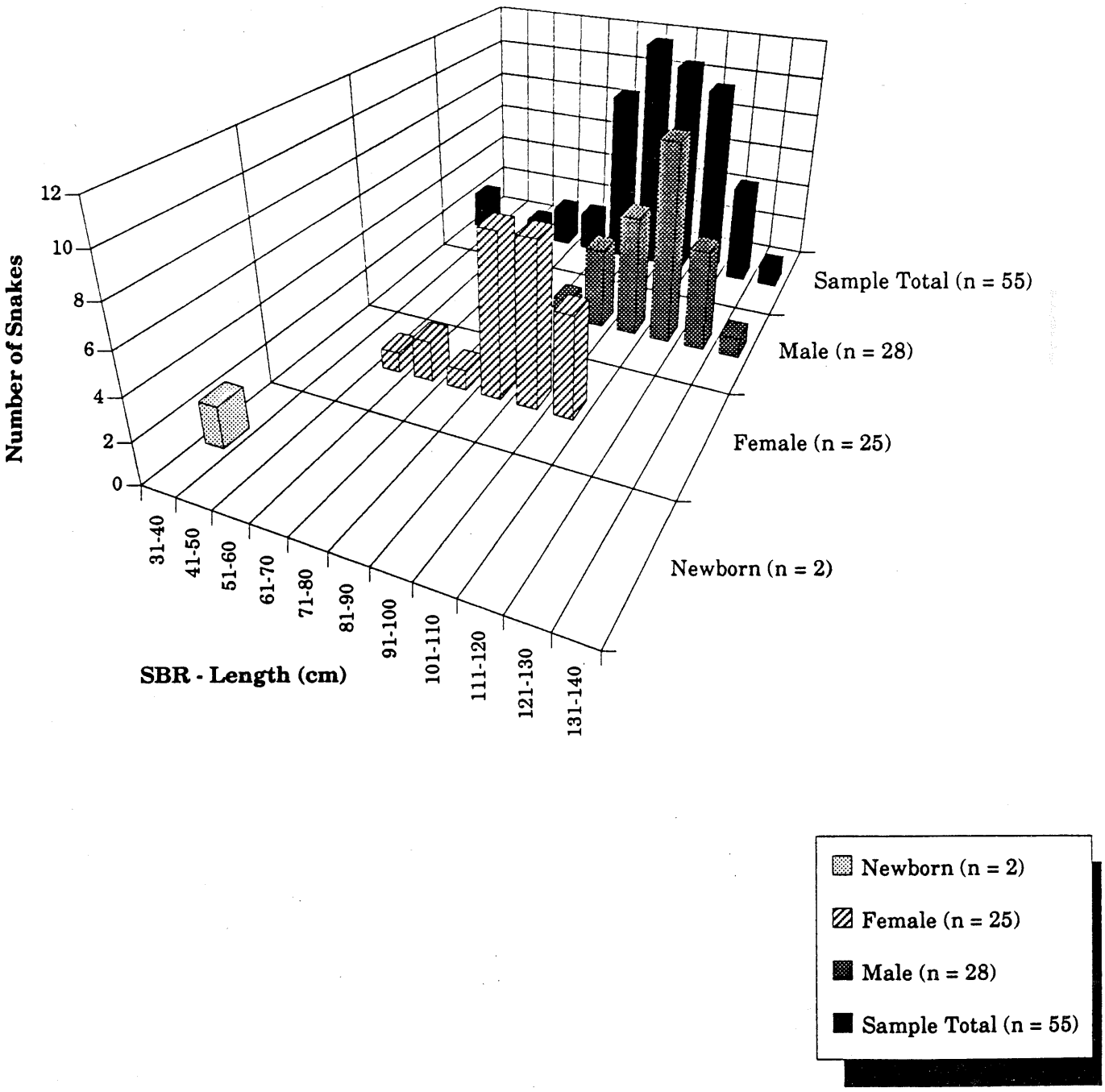
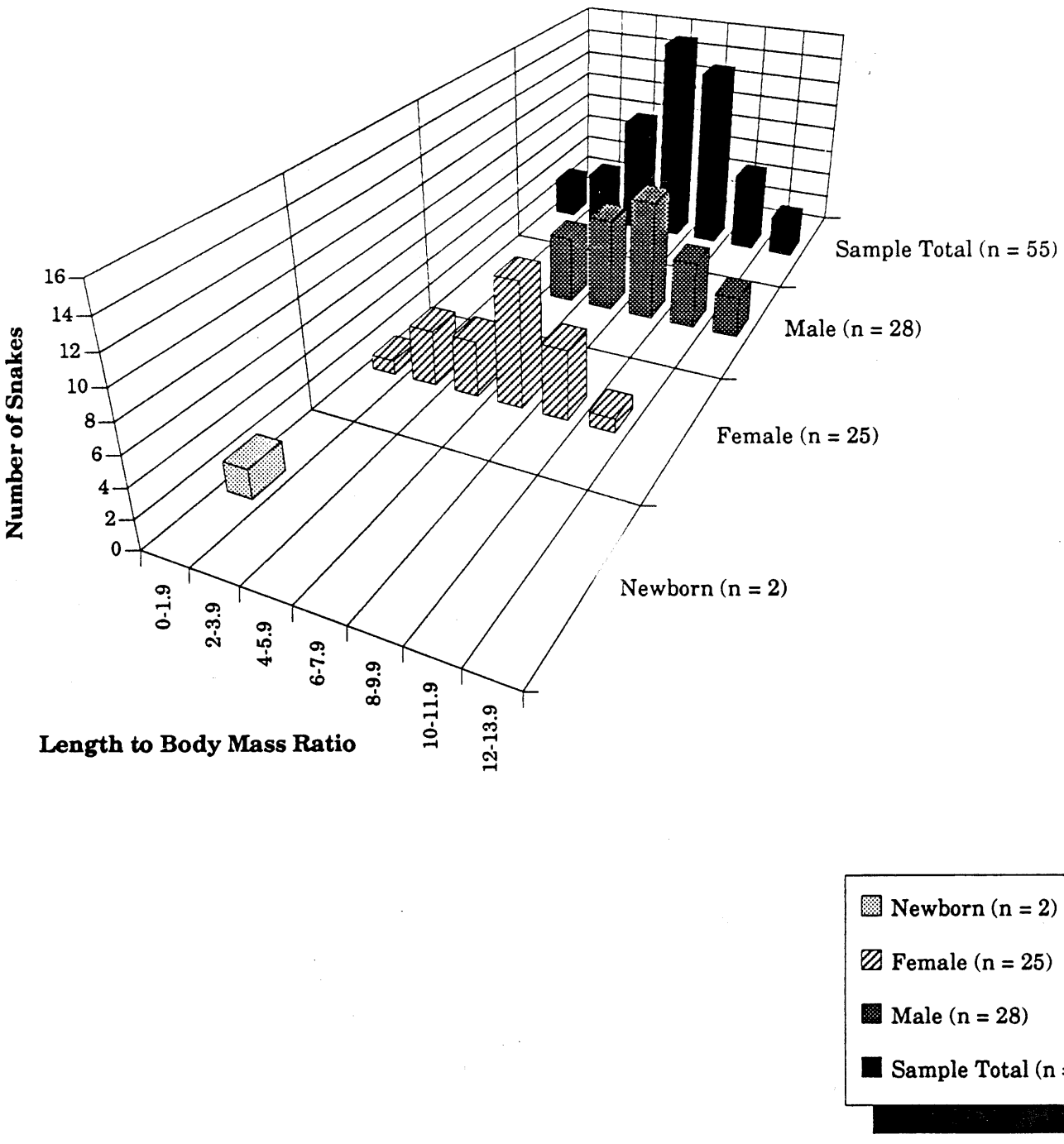


FIGURE 3: BODY LENGTH TO BODY MASS RATIO OF CROTALUS HORRIDUS, STUDY POPULATION IN SOUTHEASTERN MINNESOTA



REFERENCES

1) Breckenridge, W.J. 1944. Timber, or banded, rattlesnake, Crotalus horridus (Linnaeus). Pages 153-159 In W.J. Breckenridge. Reptiles and amphibians of Minnesota. 3rd printing. Univ. Minnesota Press, Minneapolis.

2) Brown, W.S. 1991. Female reproductive ecology in a northern population of the timber rattlesnake, Crotalus horridus. Herpetologica 47:101-115.

3) Brown, W.S. 1992. Biology, Status, and Management of the Timber Rattlesnake (*Crotalus horridus*): A Guide for Conservation. Herpetological Circulars (published by Society for the Study of Amphibians and Reptiles [SSAR]), in press.

4) Guidelines for Use of Live Amphibians and Reptiles in Field Research. American Society of Ichthyologists (ASIH), Herpetologists League (HL), and Society for the Study of Amphibians and Reptiles (SSAR), 1987.

5) Klauber, Laurence M. Rattlesnakes - Their Habits, Life Histories, and Influence on Mankind. Abridged Edition. University of California Press. Berkely, Los Angeles, and London, 1982.

6) Martin W.H. Life History of the Timber Rattlesnake, *Crotalus horridus*. Investigator's Annual Report, United States Department of Interior, National Park Service, Natural Sciences Research - Shenandoah National Park, 1986.

7) Martin, W.H. 1990. Status survey of the timber rattlesnake in Pennsylvania, in Brown, W.S. 1992. Biology, Status, and Management of the Timber Rattlesnake (*Crotalus horridus*): A Guide for Conservation. Herpetological Circulars (published by Society for the Study of Amphibians and Reptiles [SSAR]), in press. p.20.

8) Martin, W.H. 1992. Phenology of the timber rattlesnake (Crotalus horridus) in an unglaciated section of the Appalachian Mountains. In J.A. Campbell and E.D. Brodie, Jr., Eds. Biology of the pitvipers. Selva Press, Tyler, TX, in press.

9) Oldfield, B.L. and D.E. Keyler. 1989. Survey of timber rattlesnake (Crotalus horridus) distribution along the Mississippi River in western Wisconsin. Wisconsin Acad. Sci. Arts Lett. 77:27-34.

APPENDIX I: TIMBER RATTLESNAKE SURVEY SITES IN SOUTHEASTERN MINNESOTA

Site		Locality	County	Township	Range	Section	Elevation (meters)
BEA	1	Beaver	Houston	102 N	6W	17NW1/4	320-335
	2*	Creek		102 N	6W	17NW1/4	329-335
	3	Valley		102 N	6W	17SE1/4	311-335
	4	State		102 N	6W	17NE1/4	305-335
	5*	Park		102 N	6W	5SW1/4	268-305
	6*			102 N	6W	8NW1/4	238-305
FOR	1	Forestville State Park	Fillmore	102 N	12W	13SW1/4	335-372
FRO	1*	Frontenac	Goodhue	112 N	13W	6NE1/4	299-335
	2	State Park		112 N	13W	2	244-328
KIP	1*	O.L. Kipp	Winona	106 N	5W	35SW1/4	317-372
	2*	State		105 N	5W	2NE1/4	305-372
	3	Park		105 N	5W	36SW1/4	335-366
	4*			106 N	5W	35NE1/4	299-366
	5*			105 N	5W	2NE1/4	305-366
	6			106 N	5W	35SW1/4	323-366
	7			106 N	5W	27NW1/4	320-366
	8*			106 N	5W	27NE1/4 & 26NW1/4	274-366
	9*			106 N	5W	36SW1/4	320-366
	10			106 N	5W	35SW1/4	305-366
	11*			106 N	5W	35SE1/4	305-335
	12*			106 N	5W	34NE1/4	387
LAT	1	John A. Latsch State Park	Winona	108 N	8W	75W1/4	305-366
REN	1*	Reno Management Unit	Houston	102 N	4W	26SE1/4	290-335
RRT	1*	Root River Trail	Fillmore	103 N	10W	23NW1/4	262
WHI	1	Whitewater	Winona	107 N	10W	20NW1/4	274-320
	2	State		107 N	10W	29NE1/4	274-335
	3	Park		107 N	10W	29NW1/4	305-335
	4			107 N	10W	29SW1/4	305-335
	5			107 N	10W	29NE1/4	274-366
	6			106 N	10W	20SE1/4	244-320
	7			106 N	10W	20SE1/4	244-320
	8*			107 N	10W	20NE1/4	241
WMA	1*	Whitewater Management Area	Winona	108 N	9W	7SW1/4	351

**Crotalus horridus* confirmed at these sites.

APPENDIX II: CHRONOLOGY OF FIELD SURVEYS BY SITE (1990-1991)

Site	Date	# hrs	# Persons	# *C. horridus*	Other spp
BEA 1	5/6/90	2	1	0	0
BEA 2	5/6/90	1	1	1	0
BEA 3	5/6/90	1	1	0	Five-lined Skinks
BEA 2	5/7/90	1	1	0	0
BEA 1	5/7/90	1	1	0	0
BEA 3	5/7/90	1	1	0	Five-lined Skinks
BEA 4	5/7/90	1	1	0	0
BEA 2	5/22/90	2	1	0	0
BEA 2	8/26/90	2	2	1	Five-lined Skinks, Garter Snakes, Painted Turtle, Gray Treefrog
BEA 5	8/26/90	1.5	2	1	Six-lined Racerunner, American Toad
BEA 3	9/10/90	1	2	0	Five-lined Skinks, Garter Snakes, American Toad
BEA 2	9/10/90	1	2	0	0
BEA 1	9/10/90	1	2	0	Woodfrog
BEA 1	5/15/91	1	1	0	Ringneck Snakes
BEA 1	5/22/91	1	1	0	0
BEA 5	5/24/91	3	3	3	Five-lined Skinks, Milksnake, Ringneck Snakes, Six-lined Racerunners
BEA 1	6/16/91	1	2	0	0
BEA 6	7/7/91	caught by park staff		1	-
TOTALS		field-man hrs=36		*C. horridus*=7	
FOR 1	5/16/90	2	1	0	0
*Park staff say they hear of 1-2 sitings a year					
TOTALS		fldman hrs=2	0	0	
FRO 1	5/4/90	3	2	2	0
FRO 1	5/24/90	2	1	1	0
FRO 2	8/7/90	2	2	0	Fox Snake
TOTALS		fldman hrs=12		*C. horridus*=3	
KIP 1	5/12/90	1	2	0	0
KIP 2	5/12/90	1	2	0	0
KIP 2	5/13/90	5.5	2	7	Bullsnake, Six-lined Racerunners
KIP 3	5/13/90	1	2	0	0
KIP 1	5/13/90	1	2	4	Six-lined Racerunners
KIP 2	5/22/90	3.5	1	1	Six-lined Racerunners, Milksnake, Garter Snake
KIP 5	5/22/90	3	1	1	Milksnake, Garter Snake, Six-lined Racerunners
KIP 2	6/13/90	3	2	1	Six-lined Racerunners
KIP 2	6/14/90	3	2	2	Bullsnake
KIP 2	8/25/90	3	2	1	Bullsnake
KIP 2	9/3/90	3.5	2	8	Bullsnake, Racer, Six-lined Racerunners
KIP 1	9/3/90	2	2	1	Green Frog, Gray Treefrog, American Toad
KIP 2	9/9/90	3	2	0	Six-lined Racerunner, American Toad
KIP 1	9/9/90	2	2	0	0
KIP 6	9/10/90	2	2	0	Milksnake, Northern Leopard Frog
KIP 2	5/13/91	3	1	3 (1RC)	0
KIP 6	5/14/91	3	1	0	0
KIP 1	5/14/91	2	1	2	Milksnake
KIP 2	5/15/91	3	1	1	0
KIP 7	5/16/91	2	2	0	0
KIP 2	5/16/91	1	1	0	0
KIP 2	5/17/91	1	3	0	0
KIP 2	5/19/91	4.5	2	4 (2RC)	Milksnake

KIP 8	5/20/91	4	2	17	Milksnakes, Garter Snake
KIP 1	5/20/91	2	1	3	Six-lined Racerunner
KIP 2	5/22/91	4	1	0	Bullsnake, Racer
KIP 8	5/23/91	4	1	3 (2RC)	Milksnakes
KIP 1	5/25/91	3	3	0	Bullsnake
KIP 2	5/26/91	1	2	1	0
KIP 4	5/26/91	1	2	0	Racer
KIP 9	5/26/91	2	2	2	Garter Snake
KIP 8	5/27/91	3	1	2	0
KIP 2	6/15/91	2	2	0	Bullsnake
KIP 4	6/15/91	2	1	1	0
KIP 8	6/15/91	3	2	3 (1RC)	0
KIP 2	6/16/91	2	2	0	0
KIP 2	8/11/91	2	2	0	Bullsnake
KIP 12	8/11/91	2	2	1	0
KIP 4	8/12/91	2	1	1	0
KIP 2	8/31/91	4	1	1	Six-lined Racerunners
KIP 10	9/7/91	3	1	0	0
KIP 11	9/7/91	1	3	2	0
KIP 2	9/7/91	2	3	1	0
KIP 8	9/7/91	3	3	11	0
TOTALS		fldman hrs=185.5		*C. horridus*=85	
LAT 1	9/27/91	2	2	0	0
TOTALS		fldman hrs=4		*C. horridus*=0	
REN 1	8/17/91	3	3	2	0
TOTALS		fldman hrs=9		*C. horridus*=2	
RRT	5/16/90	3	1	0	0
RRT	6/17/90	4	2	0	Milksnake, Fox Snakes, Garter Snake
RRT	8/25/90	4	2	0	Garter Snakes, Redbelly Snake, American Toads, Gray Treefrogs
RRT	5/24/91	2	3	1	Milksnake, Ringneck Snakes, Garter Snakes
TOTALS		fldman hrs=25		*C. horridus*=1	
WHI 1	5/4/90	2	2	0	Garter Snake
WHI 2	6/16/90	1	2	0	Milksnake
WHI 3	6/16/90	1	2	0	Garter Snakes
WHI 4	6/16/90	1	2	0	0
WHI 5	6/16/90	1	2	0	Garter Snakes
WHI 6	6/17/90	2	2	0	0
WHI 7	6/17/90	2	2	0	0
WHI 7	5/25/91	2	3	0	0
WHI 8	7/12/91	caught by park staff		1	-
WHI 8	7/14/91	caught by park staff		1	-
TOTALS		fldman hrs-26		*C. horridus*=2	
WMA 1	6/25/90	caught by park staff		1	-
TOTALS				*C. horridus*=1	
GRAND TOTALS		33 sites	299.5 fldman hrs	101 *C. horridus* (6 recaptures)	
		16 sites *C. horridus* observed			

Locality	Site	Exposure	Slope(º)	Habitat
BEAVER CREEK VALLEY	BEA 1	S	40-50º	Small bluff prairie with little amount of rock, surrounded by oaks
Mixed hardwood forested slopes, (oaks, maple, walnut & basswood) rugged valleys with streams.	BEA 2	S	35-45º	Limestone quarry, ledge fissures covered with wild grape vines - no soil cover - midway between valley floor and plateau above. Surrounded by oaks.
	BEA 3	S, SW	35-45º	Small bluff prairie with almost no rock surrounded by oak and birch
	BEA 4	S, SW	35-45º	Bluff prairie similar to BEA 3
	BEA 5	S	40-50º	Pockets of bluff prairies with scattered fallen sandstone rock covered with wild grape, birch and cedar interspersed. Very sandy soil.
	BEA 6	N, S, E, W	0	Valley floor - grass prairie (with brush piles) adjacent to stream
FORESTVILLE	FOR 1	S	35-45º	Bluff prairie, limestone talus with cedar surrounded by oaks.
Hardwood forest of oaks, ironwood, green ash, basswood black walnut, elm & bitternut hickory Steep valley walls of limestone, sandstone & shale with streams in the valley floor.				
FRONTENAC	FRO 1	S	40-50º	Limestone ledges with fissures above large rock outcrops. Loose leaf litter floor with scattered areas open to light with oak forest (Area is outside of park).
Mixed hardwood forest of oaks, maple basswood, and birch. Limestone is predominant. Adjacent to Mississippi River. Prairie restoration areas.	FRO 2	SE	40-50º	Limestone walls with fissures. Fairly forested over with only intermittent light.

O.L. KIPP

Mixed hardwood forest of oaks, maple, shagbark hickory, green ash, black walnut, aspen, and birch. Half-domed steeply divided bluff prairies (some with cedar and oak savana on top). Large amounts of lime- and sandstone.

KIP 1	SE, S, SW	40-50°	Bluff prairie with small amounts of limestone bolder scattered in in the grass covered with wild grape. Sumac interspersed. Sandstone bolder formations at base of prairie (some sand pit areas) with birch, juniper, and cedar.
KIP 2	SE, W, SW	40-50°	Bluff prairie with large limestone bolders scattered throughout. Sumac, birch, cedar, and juniper on slope with wild grape and bittersweet vines on rock. Sandstone formations at base of slope (some sandpits) with aspen and oak border.
KIP 3	E, SE	40-50°	Large limestone wall with fissures. Edges bordered by oak forest. No bluff prairie.
KIP 4	S	40-50°	Bluff prairie with limestone ledges at top, scattered rock outcrops with sandstone at bottom. Surrounded by oak forest.
KIP 5	SW	40-50°	Horizontal sandstone ledges interspersed with bluff prairie. Scattered small rock with oak forest around it.
KIP 6	SW, S	40-50°	Horizontal sandstone ledges below small bluff prairie with sumac and scattered rock. Surrounded by oak forest.
KIP 7	SW, W	40-50°	Large expanse of bluff prairie with scattered limestone rock.
KIP 8	SW, W	40-50°	Large expanse of bluff prairie with tall blue stem grass. Limestone talus and skree covered with wild grape, mixed with sumac. Some birch scattered on the slope. Oak and cedar on top of slope with oak forest at the base. Strong sun exposure and very steep.
KIP 9	S, SW	40-50°	Bluff prairie with small to medium size limestone outcrops. Small bolder field with heavy sumac. Surrounded by oak forest.
KIP 10	SW	40-50°	Sandstone ledges with small bluff prairie. Some birch and wild grape with adjacent oak forest.
KIP 11	SE	40-50°	Sandstone ledges with small bluff prairie. Wild grape, birch, with oak forest surrounding.

JOHN A. LATSCH Mixed hardwood forest with limestone bluff.	LAT 1	E, SE	40-50°	Limestone bluff with adjacent prairie, oak forest surrounding.
RENO MANAGEMENT UNIT Mixed hardwood forest of oak hickory, basswood, maple, and walnut. Sandstone.	REN 1	S, SW	40-50°	Bluff prairie with sandstone ledges and outcrops. Oak savana at base with birch at top.
ROOT RIVER TRAIL Asphalt recreation trail in river bottom. Cottonwood, maple, with cedar adjacent to trail.	RRT 1	S, SW	40-50°	Hillside with limestone bluff, scattered talus and substantial cedar forest with small grassy areas.
WHITEWATER Area of rugged valleys with dolomite bluffs, slopes, cedars and areas of oak savana.	WHI 1	S	40-50°	Steep dolomite cliff with large rock slide down its face. Cedars on the plateau and stream below its oak base.
	WHI 2	E, SE	35-45°	Limestone band which wraps around a leaf littered plateau with cedars, birch, and oak forest. Many fallen trees at edges of plateau. Stream on valley floor below.
	WHI 3	E, SE	40-50°	Small bluff prairie with only a couple of bolders at its edge allowing for sun exposure. Area surrounded by heavy oak forest.
	WHI 4	E, SE	30-40°	Large dolomite rock formations with only slight exposure to sun and heavy oak forest cover. Stream on valley floor below.
	WHI 5	W, SW	40-50°+	Band of bluff prairie with some accessible exposed rock. Very steep and surrounded oak forest with some cedar at edges.
	WHI 6	S	40-50°	Large limestone rock peninsula with cedar and oaks. Fairly exposed and heavy recreation use.
	WHI 7	E	40-50°	Large limestone rock formations with fairly dense oak forest canopy and little snake cover.
	WHI 8	-	0	State Park road between and below SE and W, NW facing cliffs.
WHITEWATER MANAGEMENT AREA		-	-	Site of capture of the single specimen from this area is unknown, but the general area is lowland/wetland.

APPENDIX IV

FIELDMAN HOURS/SITE - FIELDMAN HOURS/SNAKE

Site		Fieldman hrs.	# *Crotalus horridus*	Fldmn hrs/snake
BEA	1	9	0	-
	2	10	2	5
	3	4	0	-
	4	1	0	-
	5	12	4	3
	6	-	1	PSC
Total		36	7	5.1
FOR	1	2	0	-
FRO	1	8	3	2.67
	2	4	0	-
Total		12	3	4.00
KIP	1	25	10	2.5
	2	92.5	31 (3RC)	2.9
	3	2	0	-
	4	8	2	4.0
	5	3	1	3
	6	7	0	-
	7	4	0	-
	8	30	36 (3RC)	.83
	9	4	2	2
	10	3	0	-
	11	3	2	1.5
	12	4	1	4
Total		185.5	85	2.2
LAT	1	4	0	-
REN	1	9	2	4.5
RRT	1	25	1	25
WHI	1	4	0	-
	2	2	0	-
	3	2	0	-
	4	2	0	-
	5	2	0	-
	6	4	0	-
	7	10	0	-
	8	-	2	PSC
Total		26	2	-
WMA	1	-	1	PSC
TOTALS		299.5	101	

SAMPLE MEAN ≈3.0 fieldman hours/rattlesnake
PSC=Park Staff Capture
RC=Recapture

APPENDIX V: BIOLOGICAL DATA OF *CROTALUS HORRIDUS* FROM SOUTHEASTERN MINNESOTA

DATE	SITE	F (sex)	M	SBR (cm)	BM (g)	Rat (#seg)	MDS	POS	ID
5/6/90	BEA-2		M	122	1090	10i	+	-	AA
5/13	KIP-2		M	97	570	7	+	+	AA
5/13	KIP-2		M	120	1210	7i	+	+	BB
5/13	KIP-2		M	102	630	3i	+	+	CC
5/13	KIP-2		M	97	540	5i	ANEUR		DD
5/13	KIP-2	F		94	460	6i	+	+	EE
5/13	KIP-4	F		89	380	6	+	+	FF
5/24	FRO-1	F		56	100	3	+	+	-
6/13	KIP-2		M	76	310	6	+	+	GG
6/14	KIP-2		M	122	1310	9i	-	-	HH
6/14	KIP-2		M	112	980	10i	-	-	II
8/25	KIP-2	F		76	290	6	+	+	HH
8/26	BEA-2		M	122	1580	11	+	-	BB
9/3	KIP-2	F*		89	590	6	+	+	JJ
9/3	KIP-2		M	112	810	7	+	+	KK
9/3	KIP-2	F*		89	660	4	+	+	LL
9/3/90	KIP-2	NB		33	25	1	-	+	-
5/13/91	KIP-2		M	120	1390	7i	RC		BB
5/13	KIP-2	F*		89	560	6	+	+	MM
5/13	KIP-2	F		92	425	9	+	+	NN
5/14	KIP-4		M	92	470	6	+	+	OO
5/15	KIP-2		M	117	1270	1i	-	-	PP
5/19	KIP-2		M	100	640	6	RC		DD
5/19	KIP-2	F^		92	675	6	+	+	OO
5/19	KIP-2	F		94	625	3i	RC		EE
5/19	KIP-2	F^		99	810	6i	ANEUR		PP
5/20	KIP-8	F		104	850	4i	+	+	11
5/20	KIP-8		M	114	1000	6i	+	+	22
5/20	KIP-8		M	104	890	-	-	+	33
5/20	KIP-8	F		102	775	7i	+	+	44
5/20	KIP-8	F^		92	710	5i	+	+	55
5/20	KIP-8		M	107	825	5i	+	+	66
5/20	KIP-8		M	102	790	7i	+	+	77
5/20	KIP-1	F		89	590	6i	+	+	QQ
5/20	KIP-1	F		96	810	7i	+	+	RR
5/23	KIP-8	F		104	850	4i	RC		11
5/23	KIP-8		M	115	1070	4i	-	-	88
5/23	KIP-8		M	114	1000	6i	RC		22
5/24	RRT-1		M	127	1700	7i	-	-	SM
5/24	BEA-5	F^		104	970	8i	+	+	SM
5/24	BEA-5	F		104	1075	7i	+	+	SM
5/26	KIP-2		M	112	940	8i	+	+	SS
5/26	KIP-9	F		69	260	5i	+	+	TT
5/26	KIP-9	F		89	610	4i	+	+	UU
5/27	KIP-8		M	122	1390	6i	+	+	99
6/15	KIP-4		M	107	890	9i	+	-	SM red
6/15	KIP-8	F		85	360	6	+	+	1010
6/15	KIP-8	F		92	710	5i	RC		55
7/11	WHI-8		M	89	490	6	+	+	SM
8/12	KIP-4		M	107	780	5i	-	-	AA red
8/17	REN-1	F		66	210	2	+	+	-
8/17	REN-1		M	135	1760	8i	+	+	-
9/7	KIP-8		M	114	940	6i	+	+	1111
9/7	KIP-8	NB		36	40	1	+	+	-
9/7/91	KIP-8	F		84	290	5	+	+	-
n = 55 (includes 6RC)							39	38	43 marked
Ranges				33-135	25-1760	1-11			

Sex ratio 25:22:2

F = female, M = male, NB = newborn, SBR = snout to base of rattle, BM = body mass, Rat = rattle segments, RC = recapture, ANEUR = aneurythristic color morph, i = incomplete rattle, SM = verticle stripe mark on rattle, MDS = mid-dorsal stripe, POB = post ocular stripe, ID = identification marking.

* = gravid, ^= follicles present

APPENDIX VI: TEMPERATURES OF *CROTALUS HORRIDUS* SPECIMENS, WITH AIR AND SUBSTRATE TEMPERATURES AT SITE OF OBSERVATION

Site	Date	Sex	AT (ºC)	BT (ºC)	SST (ºC)
BEA-2	5/6/90	M	24.0	24.8	28.0
KIP-2	5/13	M	18.0	24.0	24.0
KIP-2	5/13	M	22.0	24.8	28.0
KIP-2	5/13	M	22.0	30.2	28.0
KIP-2	5/13	M	22.0	31.6	28.0
KIP-2	5/13	F	23.0	29.8	27.6
KIP-4	5/13	F	23.0	23.8	29.2
FRO-1	5/24	F	26.0	33.2	36.0
KIP-2	6/13	M	28.0	20.4	28.0
KIP-2	6/14	M	27.0	31.4	32.0
KIP-2	6/14	M	28.0	29.4	29.0
KIP-2	8/25	F	30.0	31.0	29.0
BEA-2	8/26	M	24.0	25.0	-
KIP-2	9/3	F*	21.0	22.0	23.0
KIP-2	9/3	M	21.0	23.0	23.0
KIP-2	9/3	F*	27.0	28.0	28.0
KIP-2	9/3/90	NB	27.0	-	28.0
KIP-2	5/13/91	M	32.0	29.2	26.0
KIP-2	5/13	F*	32.0	32.0	28.0
KIP-2	5/13	F	32.0	32.0	28.0
KIP-4	5/14	M	32.0	31.0	32.0
KIP-2	5/15	M	22.0	25.0	28.0
KIP-2	5/19	M	20.4	27.4	-
KIP-2	5/19	F^	20.4	28.2	-
KIP-2	5/19	F	-	27.6	-
KIP-2	5/19	F^	25.0	31.0	-
KIP-8	5/20	F	20.0	24.0	26.0
KIP-8	5/20	M	20.0	24.0	26.0
KIP-8	5/20	M	20.0	20.5	26.0
KIP-8	5/20	F	24.0	31.6	29.0
KIP-8	5/20	F^	24.0	32.0	29.0
KIP-8	5/20	M	24.0	29.0	-
KIP-8	5/20	M	24.0	31.4	32.0
KIP-1	5/20	F	28.0	26.0	24.0
KIP-1	5/20	F	28.0	26.0	24.0
KIP-8	5/23	F	22.0	26.8	27.4
KIP-8	5/23	M	22.0	21.8	21.0
KIP-8	5/23	M	22.0	-	21.0
RRT-1	5/24	M	21.2	21.0	21.0
BEA-5	5/24	F^	24.4	28.6	31.0
BEA-5	5/24	F	23.0	27.0	23.6
KIP-2	5/26	M	23.0	30.5	22.0
KIP-9	5/26	F	28.0	30.8	27.0
KIP-9	5/26	F	25.4	30.5	24.0
KIP-8	5/27	M	26.0	21.6	21.0
KIP-4	6/15	M	23.0	27.5	27.6
KIP-8	6/15	F	25.0	28.8	28.8
KIP-8	6/15	F	25.0	29.0	26.0
KIP-4	8/12	M	26.5	29.6	27.0
REN-1	8/17	F	24.0	27.5	-
REN-1	8/17	M	24.0	32.0	-
KIP-8	9/7	NB	29.0	28.0	24.0
KIP-8	9/7	F	29.0	26.0	24.0
KIP-8	9/7/91	M	29.0	23.2	24.0
n=54		27M:25F:2NB			
Mean			24.8	27.7	26.7
± SD			3.5	3.4	3.3
Range			(18.0-33.0)	(20.4-33.2)	(21.0-36.0)

F=female AT=air temperature
M=male BT=body temperature
NB=newborn SST=substate temperature
*=gravid, ^=follicles present

SLIDE KEY

TIMBER RATTLESNAKE SURVEY

1	**Bluff Prairie Habitat - Queen's Bluff** **O. L. Kipp State Park**	6/91
2	**Bluff Prairie Habitat** **O. L. Kipp State Park**	5/90
3	**Bluff Prairie Habitat** **O. L. Kipp State Park**	8/90
4	**Bluff Prairie Habitat** **O. L. Kipp State Park**	8/90
5	**Limestone Quarry Habitat** **Beaver Creek Valley State Park**	5/90
6	**Bluff Prairie Habitat** **with 2 *Crotalus horridus*** **O. L. Kipp State Park**	6/91
7	**Bluff Prairie Habitat** **with a male *Crotalus horridus*** **O. L. Kipp State Park**	5/91
8	**Bluff Prairie Habitat - Queen's Bluff** **showing vandalism due to snake hunters** **O. L. Kipp State Park**	5/91
9	**Field Procedures - Queen's Bluff** **O. L. Kipp State Park**	5/91
10	**Field Procedures - Queen's Bluff** **searching with a mirror** **O. L. Kipp State Park**	5/91
11	**Field Procedures - Queen's Bluff** **weighing a Timber Rattlesnake** **O. L. Kipp State Park**	5/91

12	Field Procedures marking the rattle Root River State Trail	5/91
13	Field Procedures taking cloacal temperature Root River State Trail	5/91
14	Field Procedures a marked rattle O. L. Kipp State Park	6/91
15	Timber Rattlesnake - male O. L. Kipp State Park	5/90
16	Timber Rattlesnake - female O. L. Kipp State Park	5/90
17	Timber Rattlesnake - male Root River State Trail	5/91
18	Timber Rattlesnake - male Beaver Creek Valley State Park	5/90
19	Timber Rattlesnake - female O. L. Kipp State Park	6/91
20	Timber Rattlesnake - female Rattlesnake Bluff near Frontennac State Park	5/90
21	Timber Rattlesnake - male Beaver Creek Valley State Park	5/90
22	Timber Rattlesnake - male Beaver Creek Valley State Park	8/90
23	Timber Rattlesnake - male Beaver Creek Valley State Park	5/90