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Ecological Observations on the Six-Lined Racerunner (*Cnemidophorus sexlineatus*) in Northwestern Illinois

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ABSTRACT

Six-lined racerunners, *Cnemidophorus sexlineatus*, in northwestern Illinois were studied in June of 1997 and 1998. The sand prairie habitats of these lizards in Illinois are relatively small and isolated. I report preliminary information on population size, density, structure, and food habits that provides a base for future research on Illinois populations of *C. sexlineatus*. Low recapture rates suggested that the population size was relatively large. The future of this population depends on availability of sand prairie habitat, which may be threatened by its fragmented status and recent increase in human activities.

INTRODUCTION

The six-lined racerunner, *Cnemidophorus sexlineatus*, is widespread throughout central and eastern United States (Conant and Collins, 1991). Information on population density, home range size, feeding habits, and other aspects of this lizard's ecology has been gathered primarily from southern and western populations (Fitch, 1958; Carpenter, 1959; Hardy; 1962; Bellis, 1964; Clark, 1976). Little is known about the ecology of *C. sexlineatus* in the northern portion of its range.

Illinois populations of *C. sexlineatus* are mainly confined to dry hill prairies and sand prairies adjacent to the Mississippi, Ohio, and Illinois Rivers (Smith, 1961). Fragmentation of suitable habitat has increasingly isolated these populations. In June of 1997 and 1998, I gathered data from two nearby localities inhabited by *C. sexlineatus* in Whiteside and Carroll Counties, Illinois (Warner, 1998). Herein, I present observations on population size, density, structure, and food habits. I report information gathered in 1997 (Warner, 1998) and in 1998. In addition, I discuss the significance of my findings in relation to previous reports on other populations.

STUDY AREAS

Field work was conducted at two study sites separated by approximately 500 m of pine plantation. The southernmost site is located at the Thomson-Fulton Sand Prairie in Whiteside County, Illinois. This sand prairie is bordered on the south and east by agricultural development, on the north by a pine plantation, and on the west by the Mississippi River. The Thomson-Fulton Sand Prairie is governed by the Illinois Natural Heritage Commission and covers about 0.40 km^2. The second site just north of the pine plantation is in Carroll County, Illinois. It is also bordered by the Mississippi River to the west and by agricultural development and human habitation to the north and east. This site is a segment of the Upper Mississippi River National Wildlife and Fish Refuge and covers about 0.12 km^2. Both sites are characterized by sandy soils and grass/shrub vegetation. Dominant plants include *Stypa* sp., *Opuntia humifusa*, patches of *Rhus aromatica*, *Tradescantia virginiana*, and *Tephrosia virginiana*. Various tree species (*Quercus* sp., *Prunus* sp., *Rhus* sp., and *Juniperus* sp.) are scattered throughout both sites. Mohlenbrock (1986) provides a list of grass species of the sand prairie. Vegetative cover varies greatly as some areas are densely covered, whereas other areas are nearly devoid of vegetation (large sand blowouts). Smith (1961) and Warner (1998) provide photographs of sand prairie habitat in Whiteside County.

MATERIALS AND METHODS

Field work was conducted every morning from 1 June through 2 July 1997 and 27 May through 2 July 1998 except for rainy or highly overcast days when *Cnemidophorus sexlineatus* was not active. Drift fences with pit fall traps were placed only in areas where lizards were observed. Drift fences were constructed of aluminum flashing (about 30 cm high), and buckets (19 liter) were buried at approximately 5 m intervals from each end of a fence. Fences were checked twice daily, once in the morning and once in the evening (except on rainy or overcast days). At the Thomson-Fulton Sand Prairie, lizards were captured only by hand until 21 June 1997 when drift fences were installed. Four drift fences (two straight and two three-winged arrays covering a total distance of approximately 130 m) were installed along the western half of the prairie. In 1998, eight drift fences (three straight and five three-winged arrays covering a total distance of approximately 225 m) were installed on both eastern and western halves of the Thomson-Fulton Sand Prairie. Three straight fences (total distance = 55 m) were installed at the northern site on 16 June, 1998.

After capture, snout-vent length (SVL) and tail length were measured to the nearest mm and mass was taken with a Pesola® spring scale to the nearest g. Other features were also recorded (i.e. broken tail or reproductive status). Adults were sexed by examining secondary sexual characteristics (Smith, 1961). Lizards were marked with unique toe clip combinations for individual identification (Waichman, 1992). Toe clipping apparently does not affect the sprint performance of *C. sexlineatus* (Dodd, 1993). Toes that were removed were retained in liquid nitrogen for future genetic studies. Lizards were released at their location of capture.

Population size was estimated using mark-recapture data only from the Thomson-Fulton Sand Prairie because no lizards were recaptured at the northern site in 1997. Recapture rate was low in 1997 and 1998, therefore, traditional population size estimators (Lincoln-Peterson, Jolly-Seber) were not used. Instead, I used a Bayesian method that is designed for cases with low recapture rates (Gazey and Staley, 1986). This procedure estimates probabilities for all possible population sizes (for more details about this technique, see Gazey and Staley [1986]).

Population density was estimated only for the Thomson-Fulton Sand Prairie. Density was estimated using data collected during visual encounter surveys (VES) conducted on 28 and 29 June, 1997. Surveys were conducted from 0900 to 1100 when racerunner activity was high. Visual encounter survey transects were spaced at 10 m intervals with five people covering 50 m. Visual encounter surveys covered 0.30 km^2 of the Thomson-Fulton Sand Prairie. Lizard sightings were recorded and their perpendicular distance from the transect line was estimated to the nearest meter. Density estimation was calculated as D = n/2La, where n = number of lizards sighted, L = length of the transect, and a = greatest distance that a lizard was sighted from the transect (Krebs, 1989). Visual encounter surveys were not conducted at the northern study site nor were they conducted at either site in 1998.

To investigate distribution of lizards throughout the prairie in relation to vegetation, I measured vegetative cover around each drift fence and evaluated the relationship between vegetative cover and capture success. A 1 x 1 m quadrat, divided into 100 10 x 10 cm squares, was used to measure vegetative cover. The quadrat was raised above the ground on 30.5 cm stilts. The 10 x 10 cm squares were visually subdivided into 400 5 x 5 cm squares to increase resolution. The number of squares filled with vegetation was divided by 400 to give a percentage of vegetative cover in a particular area. Four vegetation samples were taken around the straight drift fence arrays and six samples were taken around the three winged arrays. Each quadrat was located 1 m from the ends and middle of each array. These locations represented the vegetative density that lizards would pass through to get to the drift fence.

To obtain information on feeding habits, I collected fecal samples produced by lizards after capture. Samples were frozen and later analyzed in the laboratory.

RESULTS

Lizards with a SVL of 50 mm or greater were defined as adults and those less than 50 mm were juveniles. A total of 42 lizards was captured, marked, and released in 1997. Of these, 14% (n=6) were juveniles, 52% (n=22) were adult male, and 34% (n=14) were adult female. Four of the 14 females were gravid (29%). All gravid females were captured from mid June to the end of June (between 13 and 29 June). In 1998, a total of 80 lizards was captured. Of these, 14% (n=11) were juveniles, 49% (n=39) were adult male, and 37% (n=30) were adult female. Fifteen females were gravid (50%) and captured as early as 27 May and as late as 24 June. The male to female sex ratio was 1.57:1.00 in 1997 and 1.30:1.00 in 1998 and did not differ significantly from 1:1 in either year (χ^2_{1997}=1.78, P=0.18; χ^2_{1998}=1.17, P=0.37). The overall sex ratio (both years combined) did not differ significantly from 1:1 (χ^2=2.75, P=0.10).

Male and female racerunners did not differ significantly in mass or SVL (Table 1). I did not include the mass of gravid females in these calculations because their mass was significantly greater than that of nongravid females (t=3.97, P=0.001). Mass and SVL of juveniles and adults did not differ significantly between years. The frequency of juvenile capture (14% in 1997 and 1998) was much less than the frequency of adult capture (86% in 1997 and 1998). It was also clear from daily observations that adult abundance was much greater than that of the juveniles during June of both years. Juvenile SVL's ranged from 32 mm to 47 mm, whereas adult SVL ranged from 51 mm to 72 mm (Figure 1).

Recapture frequency was low during both years even when combining the data from the two study sites. During 1997, 14.2% (6 of 42) of all lizards marked and released were recaptured. However, an additional 12% (5) that were marked in 1997 (all adults) were recaptured for the first time in 1998, giving a recapture frequency of 26% when combining all recaptures of the animals marked in 1997. Of the 80 individuals captured in 1998, only four were recaptured (5%). Combining both field seasons, 11 of the 14 recaptures (78.6%) were male, and 3 (21.4%) were female. No juvenile was recaptured either year.

I used capture-recapture data only from the Thomson-Fulton Sand Prairie study site to estimate population size. Most of the sampling efforts were concentrated on the west half of the prairie in 1997; 36 captures and 6 recaptures were used in the population estimate. The Bayesian method indicated that the most probable population size was approximately 90 individuals. In 1998, I used the same method with 59 captures and 2 recaptures. The most probable estimate was 191 lizards. In a third analysis, I used the same method, but included the 1997 and 1998 captures (36 and 59 lizards, respectively), plus the individuals that were marked in 1997 but were recaptured in 1998 (4 lizards). For both years combined the most probable population estimate was approximately 200 lizards (Figure 2).

Population density estimate from visual encounter surveys at the Thomson-Fulton Sand Prairie was 333 lizards/km^2 in 1997. The total population size for the entire Thomson-Fulton Sand Prairie (0.40 km^2) was thus estimated at 133 lizards. Visual encounter surveys were not conducted in 1998.

Capture rate per drift fence was not related to the vegetative cover around the drift fences (second order regression, r^2=0.31, df=10, P=0.23). However, lizards were not seen in areas with extremely high and low amounts of vegetation cover. No lizards were caught or observed in sand blowouts. Lizard capture rate was greatest in drift fences assembled in areas with an intermediate amount of vegetation cover (51.3% cover) and lowest at fences assembled in low vegetation cover (21.3% cover) (Table 2).

Twenty five adult fecal samples were analyzed. Of the samples, 52% contained Orthoptera, 24% contained Hymenoptera, 20% contained Coleoptera, 4% contained Diptera, and 20% contained unidentified arthropod parts.

DISCUSSION

The patterns of recruitment documented for southern and western populations of *C. sexlineatus* may provide an explanation for the relatively high abundance of adult lizards during my June observations (Fitch, 1958; Carpenter, 1959; Hardy, 1962; Etheridge et al., 1983; Mushinsky, 1985; Paulissen, 1988). Eggs of southern and western populations hatch between July and September and hatchlings remain active until late October or early November, whereas adults go into hibernation in mid-September. Hatchlings grow until hibernation and emerge from hibernation a month earlier than adults. Hatchlings reach near adult size in June or July. Assuming a similar pattern of recruitment at my study site, mostly adults and few juveniles would be expected to be seen during June. Another possible explanation is that overwinter survivorship could be low, therefore juveniles would be in low abundance during June compared to hatchling abundance prior to winter.

Two age classes were identified based on SVL. Small lizards (SVL<50 mm) were most likely juveniles in their first year and large lizards (SVL>50 mm) included adults of various ages. Female body size at maturity in Illinois is similar to that of western populations. Studies of western populations (Kansas, Oklahoma, and Texas) report females reaching maturity at a minimum size of 54 mm (Fitch, 1958; Carpenter, 1960; Hoddenbach, 1966). In this study, the smallest gravid female captured was 58 mm. However, Bellis (1964) suggests that it is possible that females do not lay eggs until they reach 71 mm at his South Carolina population.

Racerunners in this population have a similar body size to those in Florida. In this study, mean body size for adult males was 61 mm and adult females was 62 mm. The largest individual captured had a SVL of 72 mm. In addition, Smith (1961) points out that racerunners rarely exceed 70 mm in Illinois, except for a population at the southern tip of the state. In a Florida population, adult body size rarely exceeds 65 mm (Mushinsky, 1985). Racerunners in Kansas (Fitch, 1958), Oklahoma (Carpenter, 1959, 1960), and Texas (Clark, 1976) exceed 80 mm in SVL. My findings and Mushinsky's (1985) findings suggest that adult racerunners in northern Illinois and Florida do not reach the body lengths of racerunners from western populations.

Sex ratios (males:females) did not statistically differ from 1:1 in either year. Sex ratios in this study were similar to that in a South Carolina population (1.44:1.00) (Bellis, 1964). These ratios may be male biased because males tend to be more active and are more likely to be captured (Carpenter, 1959; Bellis, 1964).

The population estimate for the two years combined seemed to be the most reasonable. The most probable population estimate using the 1997 data (90 lizards) was not likely to be accurate because I captured over 90 different lizards and still had low recapture rates over the two year study. The population estimate using the 1998 data showed a broad distribution of possible population sizes and the most probable estimate (191 lizards) is not very different from the analysis with the two years combined. For the two years combined, the population estimate had a narrow distribution of possible population sizes and the most probable estimate was 200 lizards (figure 2). Overall, a total of 122 individual captures with only 14 recaptured over the two year study indicated that this population is relatively large.

These population estimates would be biased if individuals became trap shy after their initial capture or if individuals were not equally available for capture because of differential dispersal. However, all lizards that were recaptured in pit fall traps were initially captured in pit fall traps suggesting that lizards did not become trap shy. Moreover, the population consisted mostly of resident adults that would be unlikely to disperse into surrounding non-sand prairie habitat.

Data from the visual encounter survey in 1997 indicated that the number of lizards (133) estimated for the entire Thomson-Fulton Sand Prairie is within the range of possible population sizes from the Bayesian estimates.

Variation in vegetative cover can influence local abundances of lizards. Lizards in this study were never observed or caught in open sandy blowouts, possibly because of the lack of retreat sites. In addition, lizards were never observed in areas where vegetation was extremely dense (i.e. close to 100% cover). Areas with intermediate amounts of vegetative cover resulted in higher capture frequency, which presumably reflects local abundances of lizards, however, this relationship was not statistically significant.

Little is known of the diet of *C. sexlineatus* in Illinois (Smith, 1961). My findings are consistent with those of other studies. Orthoptera parts were most frequently found. Orthopterans have been shown to be a major part of the adult diet (Paulissen, 1987a, 1987b). In Oklahoma, Orthoptera was most frequently found in diets of adults (Paulissen, 1987a). Similar observations were made in populations in Georgia (Hamilton and Pollack, 1961) and Kansas (Fitch, 1958).

Information in this report provides a preliminary base for future research on Illinois populations. One concern is that this population may experience inbreeding and be more likely to become extinct compared to populations in large unfragmented habitat. Habitat conservation is important in maintaining stable populations. For example, prescribed burns scheduled for the sand prairie may be beneficial for *C. sexlineatus*. Research in Florida indicates that periodic fires open up habitat for *C. sexlineatus* and result in increased density (Mushinsky, 1985). In addition, selective cutting and bulldozing may cause expansions of *C. sexlineatus* populations (Walker, 1964). A public bicycle path was recently constructed through the middle of the northern site and its impact on *C. sexlineatus* is unknown.

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Figure 1. Size distributions of *Cnemidophorus sexlineatus* captured in 1997 and 1998. Juvenile SVL ranged from 32 to 47 mm and adult SVL ranged from 51 to 72 mm.

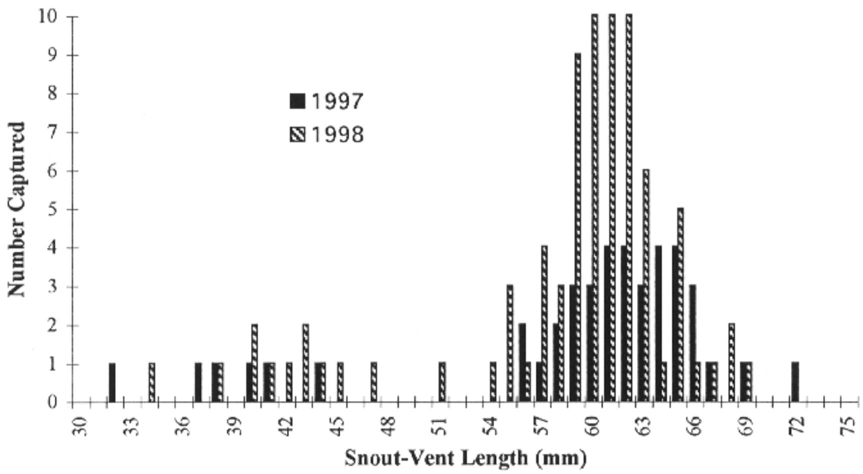

Figure 2. Estimates of the *Cnemidophorus sexlineatus* population size at the Thomson-Fulton Sand Prairie (0.40 km^2) for 1997, 1998, and combined years. Data from 1997 included 36 captures and 6 recaptures. Data from 1998 included 59 captures and 2 recaptures. Data from the two years combined included 95 captures and 6 recaptures, which included lizards marked in 1997 but recaptured in 1998. The Bayesian population estimate is a probability density function, therefore the sum of the probabilities for all possible population sizes equals one. The probability that the population size is within the range under the curve is one.

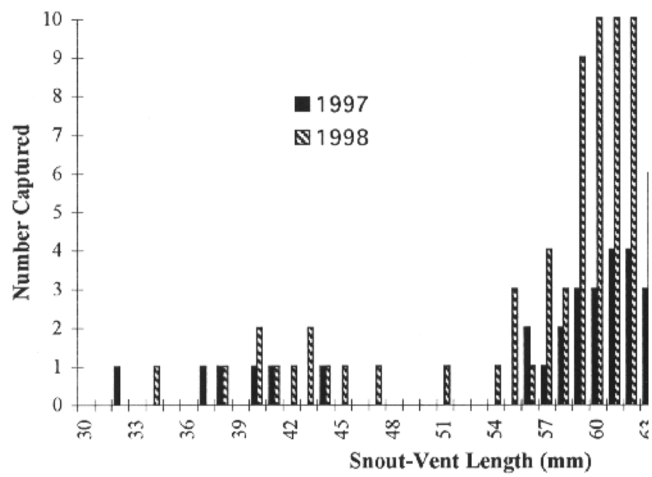

Table 1. Summary of size data (mean ± standard deviation, range) for combined years.

	n	SVL (mm)	Mass (g)
Male	61	60.9 ± 3.3, 51-68	6.9 ± 1.1, 5-10
Female	44	61.9 ± 3.7, 56-72	7.4 ± 1.6, 4-10
Juvenile	17	40.5 ± 3.9, 32-47	2.9 ± 1.1, 1-6
Total	122	58.4 ± 6.6, 32-72	6.6 ± 1.9, 1-10

Table 2. Lizard capture rate for drift fences assembled in areas with low, intermediate, and high vegetative cover. Drift fences were not assembled in areas with 0% or 100% vegetation cover because lizards were never observed or caught in areas with those vegetation densities. The relationship between capture rate per drift fence and vegetative cover around drift fences was not statistically significant (second order regression, r^2=0.31, df=10, P=0.23).

Vegetative cover (%) (mean ± standard deviation)	Number of lizards captured	Capture rate (lizards/day)
Low (21.3 ± 9.2)	6	0.13
Intermediate (51.3 ± 28.5)	18	0.43
High (76.0 ± 20.8)	16	0.33