INTERACTIONS BETWEEN THE PRAIRIE GARTER SNAKE *(Thamnophis radix)* AND THE COMMON GARTER SNAKE *(T. sirtalis)* IN KILLDEER PLAINS, WYANDOT COUNTY, OHIO

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This paper is a progress report on a two-year study begun in March 1978 on the status of the prairie garter snake or eastern plains garter snake, *Thamnophis radix*, in Wyandot County, Ohio. This species is listed as endangered in Ohio (Ohio Div. Wildl., 1976) because of its very restricted distribution and unique association with relict wet prairie. Our eventual goals are an evaluation of the present distribution, habitat associations, and management practices affecting *T. radix*. This report is an evaluation of the potential for interspecific competition between *T. radix* and its close relative, *T. sirtalis*, the common garter snake, at the Killdeer Plains Wildlife Area.

Thamnophis sirtalis has the widest distribution of any reptile in North America, while *T. radix* is principally found in the Great Plains (Conant, 1975; see our Fig. 1). Considerable overlap exists in the ranges of the two species, a phenomenon common in garter snakes. *Thamnophis radix* is notable due to the presence of disjunct populations in relict prairie outliers in Ohio, Missouri, Indiana, and Arkansas (Fig. 1). This species is a good example among vertebrates for the Prairie Peninsula concept of Transeau (1935; Smith, 1957). This garter snake was first reported in Ohio in 1945, based upon specimens from Wyandot and Marion Counties (Conant, Thomas, and Rausch, 1945) and in 1958 it was reported in Crawford County (Adler, 1958). These localities are in or close to an area that "was once the most extensive single wet prairie area in Ohio" (Conant et al., 1945:63; see our Fig. 2).

Both species live in open, moist habitats although *T. sirtalis* is common in a wider variety of habitats than *T. radix* (Conant, 1951). The two species are similar in size, general habits, and food preferences (Conant, 1951), and both were recorded from Killdeer Plains in the original description (Conant et al., 1945). Our preliminary study at Killdeer Plains in 1977 revealed both species to be syntopic or commonly occurring together in the same local area (Rivas, 1964). The general similarity of the species and their syntopy indicate possible competition for resources. Such competition was not an issue in earlier studies of *T. radix*. In Illinois only 1.8 percent of the garter snakes collected were *T. sirtalis* and none were located a second time (Seibert and Hagen, 1947); in Colorado only one specimen of *T. elegans* was reported in a two-year study of *T. radix* (Bauerle, 1972). In Minnesota at the prairie forest ecotone, *T. radix* occurred only in the prairie, while *T. sirtalis* was rare there but common in forested areas (Jordan, 1967). Hart (1975) compared niche attributes of *T. sirtalis* and *T. radix* in allopatry and sympatry in Manitoba. *Thamnophis sirtalis* had a lower average field body temperature than *T. radix*, and Hart considered this parameter, as well as habitat type, to be factors contributing to "niche discrimination" between the two species. Unfortunately, he did not clearly define his use of the term sympatry (versus syntopy); hence the exact nature of ecological interactions of the two species in Manitoba remains unclear.

The present nature of the ecological interactions of *T. radix* and *T. sirtalis* must be understood and evaluated before further management decisions can be made. This study evaluates (1) the degree to which the two species show niche overlap, (2) the present population dynamics of the two species, and (3) the estimated resource limits relative to snake densities.

STUDY AREA

Killdeer Plains Wildlife Area, Wyandot County, is a 3448.8 ha (8622 acres) area administered by the Ohio Department of Natural Resources. The principal species for which the area is managed is the Canada goose *(Branta canadensis)*, however, other species of wildlife are maintained in the area for sportsmen and nonconsumptive wildlife use. Approximately 40 percent of the area is in open grassland, 25 percent in crops, and the remaining area about equally divided between woodlands and water surface of ponds, marshes, and a reservoir.

Within Killdeer Plains Wildlife Area four sites were initially surveyed for garter snakes in the spring. At two of these sites only *Thamnophis sirtalis* was located but in such low frequencies as to be unproductive for our study. At two other sites both species were present and one of these, an area of grassland of approximately 20 ha adjacent to the wildlife area headquarters and pond number six, Prairie Slough Pond (Fig. 3), was chosen for an intensive study in 1978. The area is still being surveyed to locate sites where each species occurs by itself for future comparisons. All areas where garter snakes have been located are similar in that they border upon ponds with riparian vegetation, are low-lying grasslands with poorly drained soils with high (60-70 percent) clay content (Steiger, 1978, personal communication), and include prairie plants, such as big bluestem, blazing-star, and prairie-dock. All sites surveyed are bordered by drainage ditches and were once, but no longer, subjected to tile drainage.

In the spring the low-lying grasslands are inundated by water, often 10 cm (2.54 inches) above the substrate surface. By midsummer the water table has receded up to several meters below the surface and the soil is dry, cracked, and very hard.

Other species of snakes known from Killdeer Plains include the massasauga rattlesnake *(Sistrurus catenatus)*, the common water snake *(Natrix sipedon)*, the brown snake *(Storeria dekayi)*, and the smooth green snake *(Opheodrys vernalis)*. None of these species are as commonly seen as the garter snakes, and all are quite different from the garter snakes in general habits, food consumed, or body size.

FIELD METHODS

Field observations and hand capture of snakes were performed once each week from March through July 1978. A mark-recapture technique for successive sampling (Schumacher and Eschmayer, 1943) was used in conjunction with a ventral scale marking technique (Brown and Parker, 1976). Upon capture, the snakes were marked and the following information recorded:

1. Cloacal and ambient temperatures. Ambient temperature was taken at and 1.5 m (5 ft) above the substrate surface where the snake was collected. A Schulteiss quick-registering thermometer was used for temperature readings, and only body temperatures obtained within 5-10 sec were recorded.
2. Snout to vent and total body lengths.

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3. Sex and reproductive condition (if female).
4. Food by forcing regurgitations of recently swallowed meals.
5. Scale and color pattern to identify possible hybrids.
6. Time of day.
7. General habitat associations.
8. Description of behavior before capture.
9. Two compass headings from the point of capture were taken to standard points on the periphery of the study sites to evaluate movement upon recapture.

Most snakes were caught while basking or mating. As the summer progressed it became more difficult to catch the snakes as they rapidly fled through very tall vegetation.

MATERIALS AND METHODS FOR STUDY OF EVAPORATIVE WATER LOSS

Specimens of *Thamnophis radix* and *T. sirtalis*, collected in early June, were kept at 22° C with a 12-hr photoperiod centered at 1300 hr (EST). Water was provided freely and no feeding occurred prior to testing. Tests were run for periods between 1.5 and 2.5 hr during the time between 0800 and 2100 hr. Five specimens of each species were tested and most tests were repeated once but never in the same day. The desiccation system used was similar to those described by Claussen (1969), Elick and Sealander (1972), and Gans et al. (1968). The snakes and postchamber tubes of drierite were weighed on a Mettler PN1210 open pan balance accurate to 0.01 gm before and after each run.

NICHE OVERLAP

General Habitat

The close association of *Thamnophis radix* with wet prairie led Conant et al. (1945) to consider it restricted to the Killdeer or Sandusky Plains area of Ohio, even though the area has been greatly altered by agriculture. In contrast, *T. sirtalis* is common in various habitats in Ohio and populations occur throughout Ohio in open, as well as forested areas (Conant, 1951).

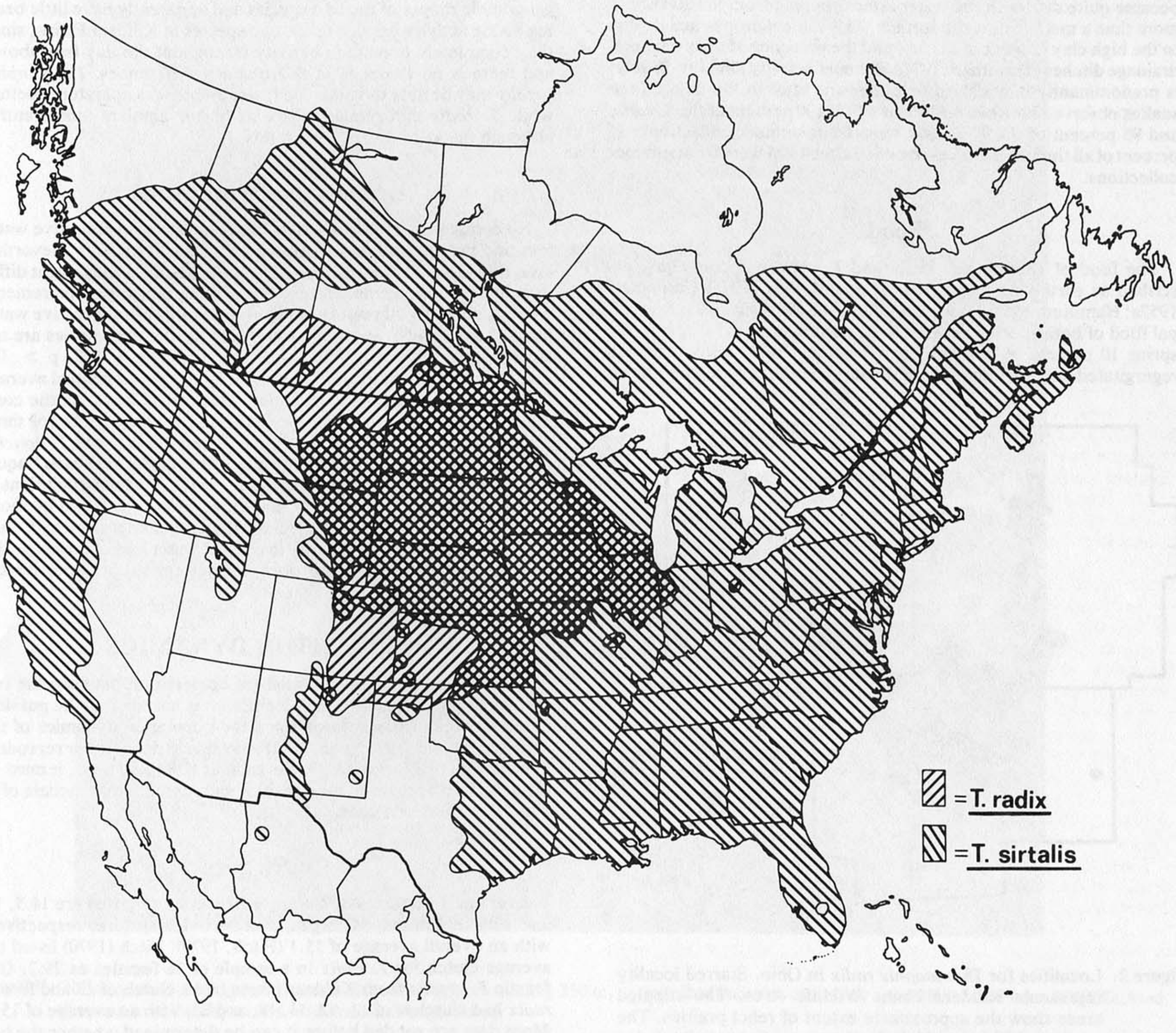

Figure 1. Geographic ranges of *Thamnophis radix* and *T. sirtalis* in North America. (After Conant, 1975).

Hibernation and Copulation

In 1978 both species were first found emergent from hibernation in the first week of April. When approached both species commonly sought refuge down the holes of crayfish *(Falicambarus fodiens)* which probably serve as sites of hibernation (Carpenter, 1952b; Neil, 1951). Both species could be collected in the same fields and were observed in copulating groups within 20 m of one another. No mixed pairs were observed copulating and no hybrids were identified by color or scale count. Premating isolation may be accomplished by species specific pheromonal cues which may explain the apparent lack of hybrids (Ford, 1978).

Activity and Movements

No significant difference ($X^2 = 5.898$, df = 10, $p > .05$; Snedecor and Cochran, 1967) was noted in the daily activity patterns of the two species for the entire study period (Table 1). Daily activity in the spring (31 March-20 May) is principally restricted to midday when temperatures are at their highest; between 1 and 3 PM, 88 percent and 86 percent of the *Thamnophis radix* and *T. sirtalis*, respectively, were caught or observed. Spring activity occurs principally in the low-lying grasslands in which the snakes emerged from hibernation while summer activity centers in drainage ditches and the riparian vegetation surrounding ponds. Toward the end of May, the hibernation sites became quite dry, with the water table dropping from the surface to more than a meter below the surface. This radical drop is mainly due to the high clay content of the soil and the presence of the peripheral drainage ditches (Trautman, 1977). Summer activity (26 May-18 July) is predominantly bimodal, both earlier and later in the day. Of the snakes observed between 8 AM and 1 PM, 100 percent of the *T. radix* and 96 percent of the *T. sirtalis* were from summer collections; 75 percent of all the garter snakes obtained after 4 PM were from summer collections.

Food

The food of *Thamnophis radix* and *T. sirtalis* is commonly described as earthworms and frogs (Conant, 1951, 1975; Carpenter, 1952a; Hamilton, 1951; Foquette, 1954). At Killdeer Plains the principal food of both species appears to be earthworms and frogs. In the spring 10 percent of *T. sirtalis* and 7 percent of *T. radix* collected regurgitated only earthworms. In the summer the only regurgitations were frogs (young *Rana pipiens*, snout-vent length 30-50 mm). In the laboratory both species readily take earthworms and frogs. Hart (1975) reported the major food regurgitated to be frogs (especially *R. pipiens*) with no significant differences between the species.

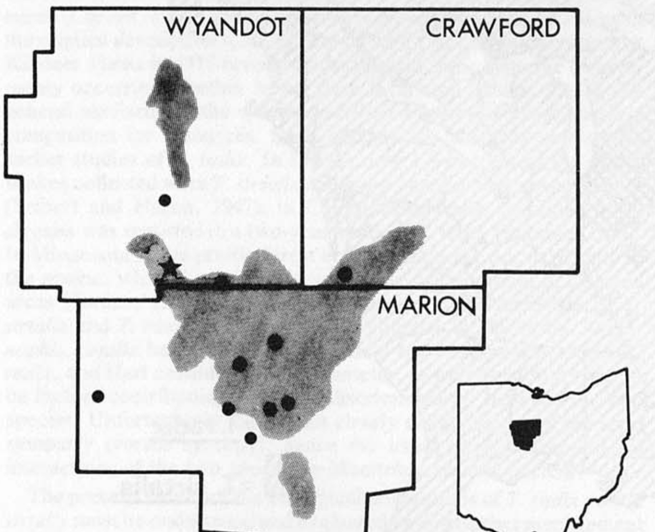

Figure 2. Localities for *Thamnophis radix* in Ohio. Starred locality represents Killdeer Plains Wildlife Area. The stippled areas show the approximate extent of relict prairies. The portion of Ohio in which the three counties are situated is indicated in the smaller map at lower right. (Modified after Conant et al., 1945, and Adler, 1958.)

Thermobiology

All snakes collected in the field had their body temperatures recorded immediately by placing the bulb of a Schulteiss quick-registering thermometer into the cloaca. Subsequent substrate surface temperatures where the snakes were collected were recorded. Sixty-five specimens of *Thamnophis radix* and thirty-six of *T. sirtalis* were collected. The average field body temperature values (averages followed by 95 percent confidence interval limits) of 65 for *T. radix* (27.9° C ± .91) and 36 for *T. sirtalis* (26.1° C ± 1.45) closely overlap (Fig. 4). Hart (1975) found approximately a two-degree difference in the body temperatures of these species in Manitoba. He attributed the lower average body temperature of *T. sirtalis* to its lower albedo and concomitant higher warming rate. Hart stressed this temperature difference in his evaluation of the potential for interspecific competition. However, such a small difference should not be too quickly asserted as a critical factor in explaining differences in the distributions of these two species. At present field body temperature comparisons point more to the similarities of these two species. Such small differences may not be biologically significant in much of the geographic ranges of the two species and apparently have little bearing on the activity periods of the two species at Killdeer Plains, since they completely overlap in activity throughout the day (see above) and there is no evidence of microhabitat differences. *Thamnophis sirtalis* may be able to withstand lower ambient temperatures better, while *T. radix* can remain active at higher ambient temperatures although our data do not reflect this.

Evaporative Water Loss

No complete correlation exists between rate of evaporative water loss and habitat preferences (Elick and Selander, 1972). Nevertheless, the possibility that *Thamnophis radix* and *T. sirtalis* might differ in habitat requirements because of differing moisture requirements was evaluated by laboratory study of their rates of evaporative water loss. The rates of evaporative water loss for the two species are not significantly different (Wilcoxon rank test, $T_1 = 125$, $p > .05$; Snedecor and Cochran, 1967; see our Fig. 5). The combined average for both species was 3.70 mg/gm/hr. This rate is less than the combined average obtained by Cohen (1975) of 6.12 mg/gm/hr for three species of garter snake (*T. cyrtopsis, T. marcianus*, and *T. couchi*) from the southwest. Cohen categorized these garter snakes as "aquatic." These results and our observations of the habitat associations of *T. radix* and *T. sirtalis* indicate that they are less restricted by moisture considerations than the species of garter snake studied by Cohen (1975). Moreover, the similarity in rates of water loss of these species indicate that moisture alone does not determine the more limited distribution of *T. radix* in Ohio.

POPULATION DYNAMICS

Our concern with the potential for competition between the two species of garter snakes at Killdeer Plains is based upon the possible consequences of competition upon the population dynamics of the endangered prairie garter snake. If a decline in densities or reproductive success of *Thamnophis radix* exist at Killdeer Plains, it must be evaluated with regard to the densities and reproductive success of *T. sirtalis* at Killdeer Plains.

Clutch Size

Average clutch sizes of *Thamnophis sirtalis* reported are 14.5, 18, and 12.9 in Kansas, Michigan, and New Hampshire, respectively with an overall average of 15.1 (Fitch, 1970). Fitch (1970) listed the average clutch for *T. radix* in a sample of 16 females as 29.2. One female *T. sirtalis* from Killdeer Plains had a clutch of 15 and five *T. radix* had clutches of 11, 12, 13, 18, and 25, with an average of 15.8. More data are needed before it can be determined whether the two species differ in fecundity at Killdeer Plains. Fitch (1970) has shown that the percentage of gravid *T. sirtalis* in the two-year age class is 42

Figure 3. Oblique aerial photograph from an altitude of approximately 350 m, or area that includes our study site at Killdeer Plains Wildlife Area, showing area headquarters and Prairie Slough Pond.

Table 1. Daily activity data by hourly intervals for *Thamnophis radix* and *T. sirtalis* at study site in Killdeer Plains, 31 March through 18 July 1978.

Hour of Day	Number of Snakes Observed *T. radix*	*T. sirtalis*
8-9 a.m.	4	3
9-10	9	8
10-11	7	5
11-12	4	5
12-1 p.m.	5	4
1-2	11	6
2-3	16	19
3-4	1	4
4-5	6	3
5-6	1	1
6-7	1	0
Totals	65	58

percent and increases to 100 percent by the six-year age class. *Thamnophis sirtalis* in Kansas and data on *T. melanogaster* (Tyning, 1977) indicate that clutch size increases with body size. Hence, age specific fecundities should be evaluated at Killdeer Plains in the future. Garter snakes held in the laboratory gave birth to young in the first two weeks of August, but newborns were rarely observed in the field.

Size-Age Classes and Mortality

The ranges in body lengths of *Thamnophis radix* and *T. sirtalis* captured are 400-750 mm and 350-700 mm, respectively. In both species maximum male body length is smaller than for females, as has been reported in earlier studies (Carpenter, 1952a, b; Fitch, 1965). Size-age classes are not easily separable at this time and the sex ratios of both species approach one to one, although more data are required before certainty.

Turner (1977:218-221) reviewed the literature on mortality in snakes and discussed the inconsistencies in prenatal data and the shortcomings of survival estimates. Most workers (Turner, 1977) agree that the majority of mortality is prenatal or within the first months of life, including hibernation. No estimates of mortality were made in this study.

Seibert (1950) estimated a mortality rate of 20 percent for *T. radix* in Illinois, however, Seibert and Hagan (1947:19) stated that "no safe approximation of this figure [mortality rate] can be derived" from their data. At Killdeer Plains few garter snakes are seen dead on the road, but approximately 5 percent of the snakes observed had been chopped up in mowing operations employed to improve the grazing area for Canada geese.

Population Density

Density estimates for the two species at our study site (Fig. 3) are based on data collected from 31 March to 18 July 1978. Sixty-six individuals of *Thamnophis radix* and thirty-one of *T. sirtalis* were marked during this time and the recapture rates were 11 percent and 29 percent, respectively. The absolute population estimates and their 95 percent confidence limits are 219.6 ± 64.6 and 58 ± 21.2 for *T. radix* and *T. sirtalis*, respectively. To compare these values with earlier studies, the population estimates were transformed to densities per hectare (Turner, 1977). Only the area in which snakes were collected has been used in this estimate. Our total study site was approximately 20 ha, but snakes were only collected in 4.3 ha of this area. Using only this collected area, we estimate 51 and 14 individuals/ha for *T. radix* and *T. sirtalis*, respectively.

Earlier density estimates for *T. sirtalis* are similar: 11 snakes/ha in Kansas (Fitch, 1965) and 24 snakes/ha in Michigan (Carpenter, 1952a). However, earlier density estimates for *T. radix* are much higher than the present estimate of 51 individuals/ha: 320 individuals/ha in Colorado (Bauerle, 1972) and 845 individuals/ha in a landfill near Chicago (Seibert, 1950). The lack of confidence limits for these estimates and the various techniques used for estimation make comparisons difficult.

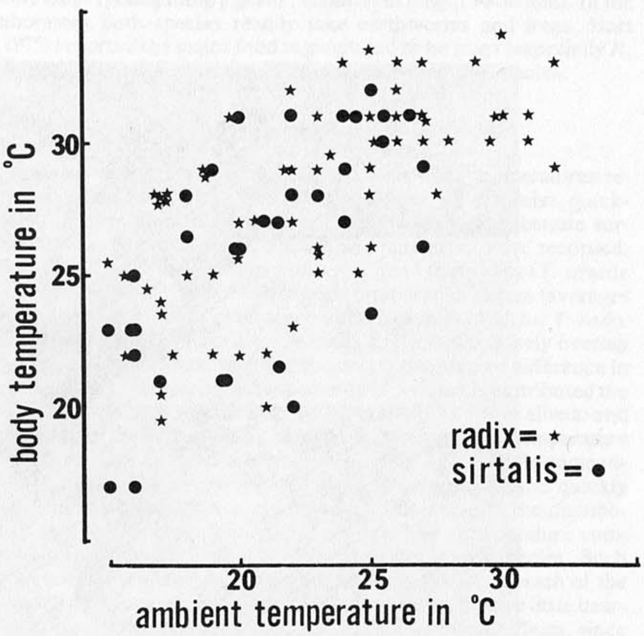

Figure 4. Relation of cloacal body temperatures to ambient substrate surface temperatures of specimens of *Thamnophis radix* and *T. sirtalis* recorded at study site in Killdeer Plains.

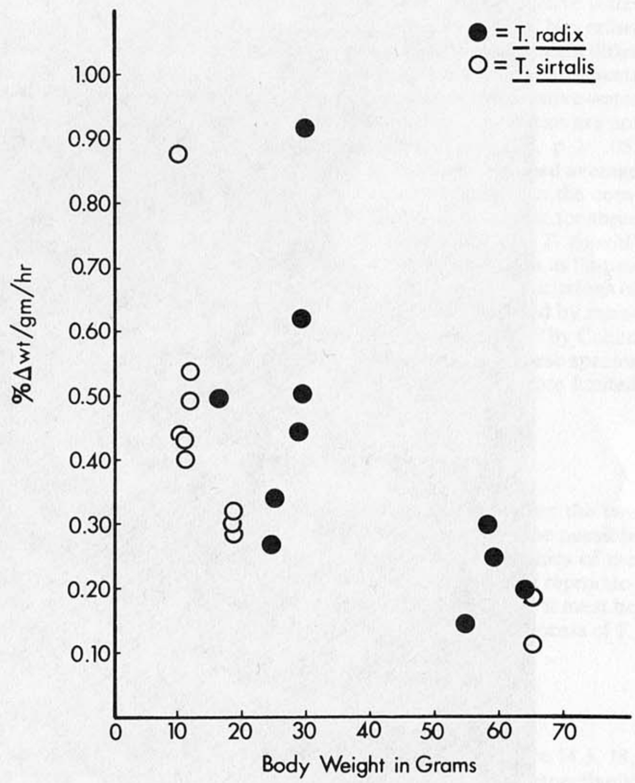

Figure 5. Relation of percent weight loss/mg/hr to body weights of *Thamnophis radix* and *T. sirtalis*.

RESOURCE LIMITS

Predator and Prey Biomass

Frog (*Rana pipiens*, young of the year) and earthworm population biomass values were obtained for comparison to a biomass estimate of the garter snakes/ha. Transects of pond periphery and riparian vegetation gave an average value of 104 frogs/ha; at an average weight of 10 gm/frog this gives 1.04 kgm of frogs/ha. Earthworm biomass estimates were unsuccessfully attempted using the formaldehyde method (Edwards and Lofty, 1977). We have, therefore, taken the average biomass value of earthworms/ha from 17 earlier studies of "arable land, pastures and orchards" summarized by Edwards and Lofty (1977: Table 5) as 883 kgm/ha (over 3 million worms/ha). However, the high clay content of the soils and the radical seasonal changes in soil moisture at Killdeer Plains indicate that earthworm densities here may be lower than average. Therefore, we conservatively assume the earthworm biomass at Killdeer to be one-half the average value or 441.5 kgm/ha.

Bauerle (1972) gave the average weight of *Thamnophis radix* as 39 gm. Using this value to estimate the total biomass for both species at Killdeer Plains (65 snakes/ha) gives 2.6 kgm/ha of garter snakes. The total biomass of principal prey, frogs and worms, is 451.9 kgm/ha. By this method the predator-prey ratio by biomass would be 1 to 167. Schoener (1977) stressed the low energetic requirements of reptiles in general, and he mentioned estimates of minimal energetic requirements for snakes of 1.25-3 times the body weight per year. Bauerle (1972) came to the same conclusion in his study in Colorado; however, a number of mathematical errors appear to have been made in his energetic analysis. Given the low predator-prey ratio estimate for Killdeer Plains and the relatively low energetic requirements of snakes in general, it seems unlikely that prey are a limiting resource for the present population of garter snakes at Killdeer Plains.

Habitat

Because *Thamnophis sirtalis* occurs throughout Ohio, the available habitat at Killdeer Plains is not at issue for this species. *Thamnophis radix* is restricted to this relict prairie region; hence, the available habitat for this species is central to an understanding of its future status. Because both species are at reasonably high population levels, for snakes, we assume that habitat is not at present a limiting resource with regard to relative densities at Killdeer Plains. The density estimates of 320 snakes/ha (Bauerle, 1972) and 845 snakes/ha (Seibert, 1950; Turner, 1977) for *T. radix* in Colorado and Illinois indicate that much higher relative densities could be reached at Killdeer Plains.

The planting of crops at Killdeer Plains is considered advantageous to a variety of wildlife as well as to local farmers. On the basis of the present year's crop rotations at Killdeer Plains, approximately 25 percent of the area is being farmed. Fortunately, the Ohio Department of Natural Resources has required that agriculturally modified areas be widely dispersed throughout the area; hence, no major barriers are impeding the movements and spread of populations of the prairie garter snake within Killdeer Plains. Approximately 40 percent of the area is classified as open grassland, but the actual habitat available to garter snakes fluctuates seasonally primarily as a function of water content in soils, which in turn affects the distribution of the main prey types.

One factor that further reduces available habitat at Killdeer Plains is the mowing of open grassland to improve the grazing area for Canada geese. While such mowing appears to have only a limited mortality effect, it does leave grassland unsuitable to the snakes since such areas dry out very quickly. The combined effects of mowing and progressive drying of the soils with the onset of summer results in the concentration of garter snakes near ponds and drainage ditches.

SUMMARY

Our preliminary data indicate the *Thamnophis radix* and *T. sirtalis* show extensive niche overlap at Killdeer Plains with regard to habitat use, hibernation sites, time of copulation, activity and movements, food, thermobiology, and moisture requirements. The data available on population dynamics indicate that the two species differ considerably in densities with 51 individuals/ha for *T. radix* and 14/ha for *T. sirtalis;* however, the resource base on which they depend appears to be ample for their support. Moreover, the total population density of garter snakes estimated for our study area is much lower, 65 snakes/ha, than the density estimates for *T. radix* at other localities, 320 and 845 snakes/ha, indicating that even higher densities might be supportable at Killdeer Plains. The lower estimate for *T. radix* at Killdeer Plains may partially be due to the generally marginal quality of habitat for disjunct or peripheral populations or the effects of general habitat deterioration of the wet prairies in Ohio (Trautman, 1977).

In the general context of competition, this study reveals that, while competition cannot and probably never will be ruled out, the present resource base appears capable of supporting the present density of garter snakes even though the two species show extensive niche overlap.

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LITERATURE CITED

Adler, K.K. 1958. Third contribution to the herpetology of Ohio. J. Ohio Herp. Soc. 1:20.

Bauerle, B. 1972. Biological productivity of snakes of the Pawnee Site, 1970-1971. U.S. Internatl. Biol. Program, Grassland Biome Tech. Rep. No. 207, Univ. Northern Colo., Greeley, Colo. 72 p.

Brown, W.S., and W.S. Parker, 1976. A ventral scale clipping system for permanently marking snakes. J. Herp. 10:247-249.

Carpenter, C.C. 1952a. Comparative ecology of the common garter snake (*Thamnophis s. sirtalis*), the ribbon snake (*Thamnophis s. sauritus*), and Butler's garter snake (*Thamnophis butleri*) in mixed populations. Ecol. Monogr. 22:235-258.

__________. 1952b. Growth and maturity of the three species of *Thamnophis* in Michigan. Copeia 1952:237-243.

Claussen, D.I. 1969. Studies of water loss and rehydration in anurans. Physiol. Zool. 42:1-14.

Cohen, A.C. 1975. Some factors affecting water economy in snakes. Comp. Biochem. Physiol. 51A:361-368.

Conant, R.C. 1951. The reptiles of Ohio. Second edition, revised. Univ. Notre Dame Press, Notre Dame, Indiana. 284 p.

__________. 1975. A field guide to reptiles and amphibians of eastern and central North America. Second edition. Houghton Mifflin Co., Boston, Mass. 429 p.

Conant, R.C., E.S. Thomas, and R.L. Rausch. 1945. The plains garter snake, *Thamnophis radix*, in Ohio. Copeia 1945:61-68.

Edwards, C.A., and J.R. Lofty. 1977. Biology of earthworms. Chapman and Hall, London, Engl. 333 p.

Elick, G.E., and J.A. Selander. 1972. Comparative water loss in relation to habitat selection in small colubrid snakes. Amer. Midl. Nat. 88:429-439.

Fitch, H.S. 1965. An ecological study of the garter snake, *Thamnophis sirtalis*. Univ. Kans. Publ. 15:493-564.

__________. 1970. Reproductive cycles of lizards and snakes. Univ. Kans. Misc. Publ. 52. 247 p.

Ford, N.B. 1978. Evidence for species specificity of pheromone trails in two sympatric garter snakes, *Thamnophis*. Herp. Rev. 9:10.

Fouquette, M.J., Jr. 1954. Food competition among four sympatric species of garter snakes, genus *Thamnophis*. Texas J. Sci. 6:172-188.

Gans, C., T. Krakauer, and C.V. Paganelli. 1968. Water loss in snakes: Interspecific and intraspecific variability. Comp. Biochem. Physiol. 27:747-761.

Gans, C., and D.W. Tinkle, eds. 1977. Biology of the Reptilia. Vol. 7. Academic Press, N.Y., N.Y. 720 p.

Hamilton, W.J., Jr. 1951. The food and feeding behavior of the garter snake in New York state. Amer. Midl. Nat. 46:385-390.

Hart, D.R. 1975. A quantitative niche comparison of the western plains garter snake *(Thamnophis radix haydeni)* and the red-sided garter snake *(Thamnophis sirtalis parietalis)* in allopatric and sympatric regions of Manitoba's interlake district. M.S. Thesis, Univ. Manitoba, Winnepeg.

Jordan, O.R. 1967. The occurrence of *Thamnophis sirtalis* and *T. radix* in the prairie-forest ecotone west of Itasca State Park. Minn. Herpetologica 23:303-308.

Neil, W.T. 1951. Notes on the role of crawfishes in the ecology of reptiles, amphibians, and fishes. Ecology 32:764-766.

Ohio Division of Wildlife. 1976. Endangered wild animals in Ohio. Ohio Dept. Nat. Resources. Publ. 316.

Rivas, L.R. 1964. A reinterpretation of the concepts "sympatric" and "allopatric" with proposal of the additional terms "syntopic" and "allotopic." Syst. Zool. 13:42-43.

Schoener, T.W. 1977. Competition and the niche, p. 35-136. *In* C. Gans and D.W. Tinkle, eds.

Schumacher, F.X., and R.W. Eschmeyer. 1943. The estimate of fish population in lakes or ponds. J. Tenn. Acad. Sci. 18:228-249.

Seibert, H.C. 1950. Population density of snakes in an area near Chicago. Copeia 1950:229-230.

Seibert, H.C., and C.W. Hagen, Jr. 1947. Studies on a population of snakes in Illinois. Copeia 1947:6-22.

Smith, P.W. 1957. An analysis of post-Wisconsin biogeography of the Prairie Peninsula region based on distributional phenomena among terrestrial vertebrate populations. Ecology 38:205-218.

Snedecor, G.W., and W.G. Cochran. 1967. Statistical methods. Sixth edition. The Iowa State Univ. Press, Ames, Iowa. 593 p.

Transeau, E.N. 1935. The Prairie Peninsula. Ecology 16:423-437.

Trautman, M.B. 1977. The Ohio country from 1750 to 1977—a naturalist's view. Ohio Biol. Surv. Biol. Notes. No. 10. 25 p.

Turner, F.B. 1977. The dynamics of populations of squamates, crocodilians and rhynchocephalians, p. 157-264. *In* C. Gans and D.W. Tinkle, eds.

Tyning, T.F. 1977. Clutch size and size of young in the Mexican garter snake, *Thamnophis melanogaster*. Herp. Rev. 8:118.

SIGNIFICANCE OF NATIVE PRAIRIE TO GREATER PRAIRIE CHICKEN *(TYMPANUCHUS CUPIDO PINNATUS)* SURVIVAL IN MISSOURI

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The greater prairie chicken *(Tympanuchus cupido pinnatus)*, a product of the primeval tallgrass prairie ecosystem, reached its fullest potential in the dawn of settlement which had modified the land of grass with islands of grain crops. Until then, the prairie chicken had been dependent for some diversity in its habitat and for grain on Indian tribes who tilled crops. Today, only splintered remnants of the native tallgrass prairie remain in a land of grain lightly populated with prairie chickens. The new caretakers of the land since settlement have been both the giver and taker, creating optimum habitat then destroying it.

The vital role of grassland in prairie chicken ecology has been documented state by state. Hamerstrom et al. (1957:84, 87) concluded that "total grassland appears to be a rough index to habitat quality in that the densest populations are shown to be those areas which are 55-60 percent grassland . . . To save the prairie chicken, grasslands must be preserved and managed for them. There are no substitutes." Certainly, the native tallgrass prairie has filled the role as primary grassland habitat for the prairie chicken in the pre- and postsettlement eras, but the destruction of native prairie continues. Can the prairie chicken survive?

HISTORY OF PRAIRIE CHICKEN SURVIVAL

Originally about ten states in the eastern range of the prairie chicken supported substantial populations of prairie chickens for hunting year-round (Christisen, 1969). Much of this area became the heart of the cornbelt. Millions of acres of native grass prairies are now gone, sunk beneath a sea of corn and soybeans! Bread basket monoculture does not produce prairie chickens because the birds do not live by grain alone.

Iowa, Indiana, Ohio, Kentucky, and Arkansas no longer have prairie chicken populations. Only five states have enough breeding stock to maintain at least a flock or more of chickens as museum species. Survival of the birds in Michigan's alien habitat is on a precarious year-to-year basis. More birds exist in Illinois, but suitable, domestic-crop habitat offers a narrow survival base. Wisconsin probably has a chance of keeping a small population in newly created habitat converted from marshes. Minnesota and Missouri have remnants of the original native tallgrass prairie habitat, good residual populations of prairie chickens, and bright hopes for maintenance of the species.

The western habitat represents both ends of the habitat spectrum—the good and the bad, the original and the new land. Baker (1953:10) surmised that originally" the greater prairie chicken did not occur further west than the middle of Kansas and that the bird did not occur in impressively large numbers." Changes in land-use occurred and the prairie chicken extended its range in the Dakotas, Nebraska, and Kansas and into Colorado in the wake of pioneer agriculture as native eastern prairies were converted to corn and small grain. One author (Anonymous, 1953:8) observed:

> When the proportion of grassland [in North Dakota] was about 20 to 80, the pinnate [prairie chicken] moved in and began to increase . . . As the proportion of grain to grass . . . tipped over the other way . . . the pinnate could find plenty of food but no nesting cover . . . or escape cover. He was literally plowed out of house and home.

Mohler (1944:8) stated that "the breeding and nesting habits of this species require extensive grassland and the disappearance of the native prairie through cultivation was responsible for the eviction of the prairie chicken from eastern Nebraska many years ago." According to Baker (1953:12), "The disappearance of the greater prairie chicken from eastern Kansas is attributable to the reduction of native grasslands by plowing . . . where the greater prairie chicken now occurs in eastern Kansas, grasslands always have been at least as extensive as at present."

The drier climate of the mid- and shortgrass country has deficiencies too, in both food and cover. The extensive range lands are virtually without grain, and the dry land farming and irrigated areas have little grass. The new land is only a substitute for a range diminished and marginal for prairie chickens.

Only four states have prairie chicken hunting seasons. In South Dakota and Nebraska, they coincide with the sharp-tailed grouse seasons as a pragmatic accommodation for hunters. In Kansas and Oklahoma, which rank first and second in total bird harvest and have larger acreages of native tallgrass prairie, they are featured seasons.