

A FIELD STUDY OF THE PRAIRIE KINGSSNAKE (*LAMPROPELTIS CALLIGASTER*)

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ABSTRACT

Lampropeltis calligaster was studied at the University of Kansas Natural History Reservation, 1948 to 1978, and in western Harvey County, south-central Kansas, 1959-1963. At both localities *L. calligaster* was found along with fifteen other snake species, and compared with others was intermediate in both size and abundance. It occupies a variety of grassland habitats. Males differ from females in relatively longer tails (15.2% S-V vs. 13.5%) and larger size (870 vs. 823mm S-V; 216 vs. 176.5gms). Scale-clipped individuals that were recaptured had made movements up to 485m (males) and 350m (females) in fairly well graduated series, implying ranges of these diameters, with areas of about 22 and nine ha., respectively. *Microtus ochrogaster* was estimated to make up approximately 48% by volume of 66 recorded food items. Eight other species of small mammals, seven of reptiles and the eggs of bobwhite quail made up the remainder of the food. Neither insects nor amphibians were found as primary food items. For 25 egg clutches, including 11 obtained in this study and 14 from published literature, average was $10.10 \pm .98$ (6-17); egg-laying extends over a little more than a month and average date is 3 July. Many adult females are non-breeders. Most young hatch in late August or September. Growth is highly variable. Typical year-old young have nearly doubled in length, from 272 to 536mm S-V. A gain of 23mm per month is typical in the second year. Maturity is attained in the second or third year. Because of differences in size, habitat, food preference and hunting technique, *L. calligaster* seemingly does not compete with many of the snake species that are its community associates on the two study areas. Certain species share some of the same food resources, but in every instance there are important differences.

The prairie kingsnake (*Lampropeltis calligaster*) is a secretive species that is relatively uncommon throughout most of its range, hence thorough studies of its natural history and ecology have not been made, and most information that has accumulated concerning it in the literature is of an anecdotal nature. In a thirty-year field study of snake populations of the University of Kansas Natural History Reservation, these kingsnakes were obtained in such small numbers that they were never a major objective. However, the accumulated records yield a substantial sample that permits insight into various aspects of the species' ecology. Consequently

this report was undertaken to set forth new findings pertaining to the natural history of *L. calligaster*, and to compare its ecological role with those of other snake species that are its community associates. Trans. Kansas Acad. Sci., Vol. 81:4, 1978

METHODS AND MATERIALS

Most of the prairie kingsnakes examined were captured alive on the University of Kansas Natural History Reservation, Douglas County, Kansas, or the adjacent Rockefeller Experimental Tract in Jefferson County. Others were retrieved, either dead or alive, from county roads nearby or from miscellaneous collecting sites in the two counties mentioned and still others were obtained from a study area in Harvey County, south-central Kansas, 1959-1962. All snakes obtained were measured and weighed. Those that were dead were dissected for examination of stomach contents or gonads. Those that were alive were individually marked by clipping of subcaudals according to the Blanchard and Finsler (1933) system. Also, to minimize the chances for erroneous identifications (arising from occasional uncertainty as to which scales at the tail base should be used to begin a count) minor peculiarities in pattern were noted for each individual. These usually pertained to the anterior dorsal blotches—whether unusually extended, truncated, or slanted on one side or the other.

Most of the snakes were captured in wire funnel traps (Fitch, 1951) but some were caught by hand when found beneath concealing objects or wandering in the open. By the end of the 1978 season a total of 255 captures had been recorded (of which 47 were recaptures) from northeastern Kansas, and 64 from Harvey County, of which nine were recaptures. The annual catch varied from none in 1948 and 1970 to 32 in 1961. Best catches were made from 1957 through 1966, and 1976 through 1978 when several dozen funnel traps were maintained through most of the snakes' season of activity. In most other years only one to four captures were made.

HABITAT

L. calligaster occurs in various types of grassland, in open woodland and in woodland edge. Many of those captured on the Reservation were in upland and bottomland areas that had been brome grass (*Bromus inermis*) pastures until 1948, and subsequently were protected from grazing. The resulting invasion of arborescent woody vegetation, with habitat change from short-grass cover to tall-grass and extensive thickets, eliminated many species (e.g. *Terrapene ornata*, *Cnemidophorus sexlineatus*, *Eumeces obsoletus*) but *L. calligaster* did not undergo any striking change in numbers. On the Rockefeller Tract the snakes were found in virgin tall-grass prairie, and on regenerated prairie in mowed, grazed and untreated areas. On the Harvey County study area the

snakes were found in rolling sand prairie dominated by big bluestem (*Andropogon gerardi*).

Sexual differences The sexes are similar in appearance externally. Tails average relatively longer in males, but with broad overlap. Tail length as a percentage of snout-vent length averaged $15.2 \pm .161$ in males ($N=42$) and $13.5 \pm .173$ in females ($N=34$). All snakes used in this comparison were adults exceeding 700mm in snout-vent length. In 31 young measured soon after hatching in the laboratory, or captured either before their first hibernation or soon after spring emergence, the sexual difference in tail ratio was less. These young ranged from 234 to 328mm snout-vent. In 20 males the tail-to-snout-vent ratio averaged 14.75 ± 1.96 percent, and in 11 females averaged $13.4 \pm .144$ percent.

In adult male *L. calligaster* snout-vent lengths averaged 870 ± 16.25 mm (700-1185; $N=59$) and in adult females 823 ± 11.60 mm (651-1070; $N=49$). For the same two series weights averaged 216.0 ± 14.30 grams (105-570) and 176.5 ± 17.10 grams (83-310). Hence males are on the average substantially larger.

In colubrids the size relationships of the sexes vary widely. Females are larger than males in many kinds; larger size in the male is probably closely correlated with active competition and combat. Moehn (1967) described the "combat dance" of competing male *L. calligaster*. The fighting, which involved vicious biting, as well as coiling and jerking to throw the opponent, continued intermittently over a period of days after the snakes were captured and caged together.

Spatial relationships Two adult *L. calligaster* were equipped with small radio transmitters and their day-to-day movements were checked (Fitch and Shirer 1971:123). An adult male made successive daily movements of 11, 18.5, 7, 15 and 4.5m, and an adult female moved 12, 22, 21, 0, 0, 4.5, 29, 12, 0, 0.6, 0, 0, 0, 0.5, 0, 20, 3, 0, 0, and 0.8m. The transmitters were embedded in silicone rubber and the egg-shaped package was placed in the snake's stomach. Several individuals of *Coluber constrictor* and *Thamnophis sirtalis* that were so equipped were found to be considerably less vagile than other marked (scale-clipped) snakes of the same species that had empty stomachs. It was concluded that objects in the stomach, especially those large enough to cause some distension, cause a marked reduction in activity.

Because of this constraint, the radio-equipped kingsnakes did not yield data suitable for home-range analysis but the day-to-day trailing clarified some aspects of their behavior. When located by the radio signal they were invariably out of sight under cover, in shallow burrows of small mammals (*Microtus ochrogaster*, *Scalopus aquaticus*) or merely beneath mats of dead vegetation in open, grassy places.

Twenty-five marked kingsnakes were recaptured after intervals of from nine days to 46 months; one was recaptured five times, one three times, and six were recaptured twice. Obviously the records are not adequate to map the home-range of any individual, but they do show

general trends. For 35 distances between successive capture points, average was 232m (18.3 to 764).

If a snake stayed within a circular area moving about at random, average distance between successive capture points would be equivalent to the area's radius, and the accumulated records would tend to form a graded series from zero up to the full diameter. Recaptures after intervals too short for the snake to move across its area would bias the data in the direction of shorter movements. An elliptical shape in the area used would also bias the figures resulting in the recording of more short movements than long ones; migratory or exploratory movements beyond the area normally used would cause bias toward long movements.

In studies of other species, male snakes have generally been found to be more vagile than females (Fitch 1960b, 1963, 1965; Clark 1970; Platt, 1969), hence data for the sexes need to be considered separately.

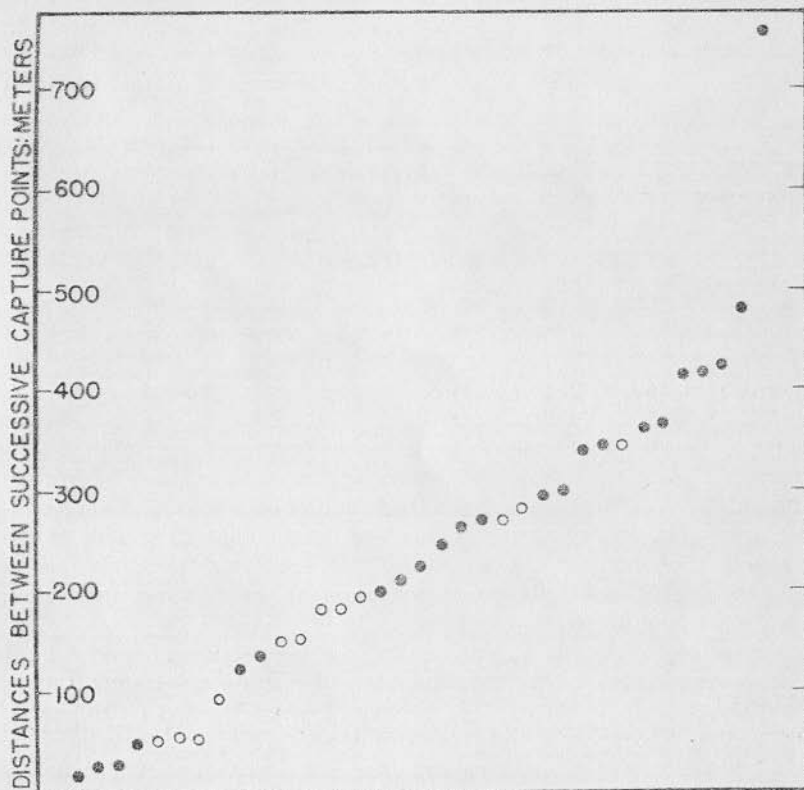


Figure 1. Movements of marked prairie kingsnakes, as indicated by straight-line distances between successive capture sites; dots show records of males, open circles show records of females, the entire series arranged in sequence from shortest to longest.

In Figure 1 movement records of *L. calligaster* are arranged in sequence from shortest to longest. Records of males are the more numerous, and ten of the 11 longer distances are movements of males whereas the shorter distances are more evenly divided between the sexes; one record is exceptional in being much longer than any of the others. If the one exceptionally long movement is excluded, the remaining 23 records of males tend to form a graduated series (18 to 482m) averaging 265m, whereas records of females (52 to 348) average 169m. The data suggest that males may range over areas 2.46 times as large as those of females, and that if the movements recorded can be taken as representative of the radii of circular home-ranges, these areas may be nearly nine ha in females and 22 ha in males.

With greater elapsed time, distances between capture points tend to be larger. Five male movements in intervals of a month or less averaged 75% of 18 movements occurring in longer intervals. For females the five movements in a month or less averaged 96% of the seven in longer intervals.

Several species of snakes on the Reservation, including *Elaphe obsoleta*, *Coluber constrictor*, *Pituophis melanoleucus*, *Diadophis punctatus*, *Thamnophis sirtalis*, *Nerodia sipedon*, *Agkistrodon contortrix* and *Crotalus horridus*, all make semi-annual migrations to hilltop limestone outcrops which serve as their hibernacula in fall and back to home ranges in other habitats in spring.

Some *L. calligaster* likewise shift from their grassland summer ranges to rock ledge hibernacula in woodland; of 26 October records, eleven were at wooded rock ledges. The remaining 15 records were from typical summer grassland habitats, and I suspect that many of the snakes remain in these situations to hibernate, probably using burrows of rodents, moles and other mammals.

Food habits A total of 66 food items were identified; 23 were palated from stomachs of the snakes captured on the Reservation or nearby, 31 were from the scats of snakes trapped on the same area, and twelve were from scats or stomachs of snakes trapped on the Harvey County study area. Identifications were as follows: 30 *Microtus ochrogaster*, 5 *Scalopus aquaticus*, 5 *Cnemidophorus sexlineatus*, 4 *Blarina brevicauda*, 3 *Peromyscus leucopus*, 2 each of *Microtus pinetorum*, *Cryptotis parva*, *Coluber constrictor*, *Ophisaurus attenuatus*, *Eumeces fasciatus*, *Colinus virginianus* (eggs) and one each of *Sylvilagus floridanus* (small young), *Sigmodon hispidus*, *Mus musculus*, *Synaptomys cooperi*, *Crotalus horridus* (neonate), *Diadophis punctatus* and *Eumeces obsoletus*. On the basis of weight, *Microtus ochrogaster* was calculated to be 48%, *Scalopus aquaticus* 24.0% and, in decreasing order, all less than 3.2% were, *Microtus pinetorum*, *Ophisaurus attenuatus*, *Sigmodon hispidus*, *Sylvilagus floridanus*, *Peromyscus leucopus*, *Cnemidophorus sexlineatus*, *Blarina brevicauda*, *Synaptomys cooperi*, *Eumeces obsoletus*, *Coluber constrictor* and *Crotalus horridus*. The remaining four species each made up less than

1%. Trends were similar in the samples from stomachs and those from scats, and between the Harvey County and Douglas-Jefferson counties' sample. *L. calligaster* is revealed as being primarily a mammal-eater, with snakes and lizards making up relatively small percentages of the food.

One adult *L. calligaster* ate a racer that was confined with it; another ate a worm snake (*Carphophis amoenus*) and a juvenile milk snake (*Lampropeltis triangulum*). Another constricted and ate several *Eumeces obsoletus* in rapid succession. Remains of a neonate rattlesnake (*Crotalus horridus*) were found in a scat of a large adult male captured at a woodland limestone outcrop on 17 October 1958. Carpenter and Gillingham (1975) found that *L. calligaster* as well as *L. getulus* (but not *L. triangulum*) would cause a peculiar defense response, "bridging," in crotalids, including various species of *Crotalus*, *Sistrurus catenatus*, *Agkistrodon piscivorus*, and *A. contortrix*.

Insect fragments were found in several of the scats, but were assumed to have come from the digestive tracts of small vertebrates eaten by the snakes, rather than being primary items. However Klimstra (1959), who examined 140 digestive tracts of *L. calligaster* from southern Iowa, recorded many insects including fifty-one orthopterans, six beetles, four hymenopterans, two homopterans and one lepidopteran. He also recorded thirty-three anura of seven species but no amphibian prey was found in my study. Otherwise the trend of Klimstra's data was fairly similar to that of my own. In order of decreasing numbers he found: 97 *Peromyscus* sp., 70 *Microtus ochrogaster*, 39 *Mus musculus*, 32 *Microtus pinetorum*, 23 *Scalopus aquaticus*, 20 *Synaptomys cooperi*, 12 *Sylvilagus floridanus*, 12 *Rana pipiens*, nine *Blarina brevicauda*, eight *Hyla crucifer*, five *Sceloporus undulatus*, and smaller numbers of five kinds of amphibians, four each of reptiles and mammals, and several unidentified birds. Mammals made up 68.6% of the volume in Klimstra's sample, amphibians 11.2%, reptiles 6.8%, birds 6.8% and insects 6.4%.

Reproduction A clutch of 13 eggs in an adherent mass were plowed up from a depth of about 75mm in a field 2km north of the Reservation on the Harold Brune farm, on 25 June 1978. After incubation in the laboratory, all hatched 18-19 August. In ten other clutches laid by confined females, or palpated in those captured and released, or found in road kills, average was 8.7 eggs (7-14). Females ranged from 651 to 983mm S-V. These combined with literature records (Anderson, 1942, 1965; Blanchard, 1921; Cagle 1942; Carpenter, 1958; Clarke, 1954; Dietrich 1960; Shoop, 1957; Minton 1944; Smith, 1961) provided information regarding 25 clutches. For the entire group eggs average $10.10 \pm .98$ (6-17) and females range from 651 to 1085mm. Dates of egg-laying (N=14) range from 19 June to 22 July and average 3 July. Table 1 brings out the great difference in length and weight of eggs within and between clutches; in some newly laid clutches eggs average more than twice the average weight of other clutches.

In a series of 31 young (including 19 hatched in the laboratory) in late August, September and early October, snout-vent lengths varied from 234 to 308mm and weights from 6.0 to 12.2 grams. A first-year juvenile captured on 13 August 1963, when it was presumably almost a year old, had snout-vent length of 328mm and weight of 140 grams—only a little larger than some recently hatched young in autumn. On the basis of these figures, it might be expected that second- and third-year young would overlap widely in size.

Females that are gravid with oviducal eggs or large yolked follicles are easily recognized as reproductive; those that have recently laid tend to be thin and slightly wrinkled and can often be recognized as parturient. Many of the adult females examined in June and early July did not fit either category suggesting that they were not reproductive. Possibly females produce only in alternate years, or perhaps their production from year to year is variable and controlled by weather, food supply, and/or other environmental factors.

A clutch of seven eggs laid on 19 June 1959 by a female confined at the Reservation, hatched in 67 to 68 days. A clutch of ten laid by a Harvey County female and kept by Dwight Platt at Newton, Kansas, hatched after 62 to 63 days. These incubation periods are notably longer than the 45 to 49 days reported by Shoop (1957) for two clutches from near Carbondale, Jackson County, Illinois, but are shorter than the 73 to 75 days reported by Anderson (1965) for a clutch laid by a female from DeKalb County, Missouri.

Table 1. Sizes and Weights of Eggs In Clutches Laid In Captivity

♀ S-V	Egg Measurements			No. in Clutch	Source
	Length (mm)	Width (mm)	Weight (grams)		
860	44.1 (48.5-41.0)	19.3 (20.0-18.5)	11.6 (12.4-10.9)	9	Clarke, 1954
870	37.9 (43-34)	21 (22-19)	—	11	Shoop, 1957
783	40.0 (46-38)	18 (19-17)	—	8	Shoop, 1957
983	36.2 (41-34)	19.75 (22.5-18)	9.23 (10.8-8.5)	10	Harvey County
651	28.6 (31-27)	16.2 (18.5-14)	4.73 (5.7-3.5)	8	Harvey County
715	43.4 (47.9-36.8)	19.6 (20.5-18.1)	10.0 (11.3-9.4)	7	Reservation

Growth One brood of 13 young from a clutch hatched 18-19 August averaged 267mm (234-303), and another of six young hatched 25-27 August averaged 256mm (234-268). Seven other recently hatched young captured in late summer averaged 287 (264-308). For the entire group of 26 hatchlings snout-vent lengths averaged 272mm \pm 3.60, and weight averaged 7.96 \pm .212 grams (6.0-12.2). All young hatch within a period of a few weeks in late August and September, and they form a size group that is ordinarily easily distinguished from older young.

At this same time of year other immature snakes that were too large to be hatchlings, and were believed to be one year old, were of the following lengths: 417, 466, 509, 524, 534, 546, 567, 573, 578, 590 and 596mm. This group averaged 536mm, approximately twice the length of

Table 2. Growth in *Lampropeltis calligaster* Under Natural Conditions

		Rate of gain per month (mm)	Months of growth between captures		Date	S-V length	Probable age, months
No. 1	♂	65	3	original capture	10-16-65	546	13.5
				recapture	7-30-66	740	22.5
No. 2	♂	46	1.5	original capture	8-3-78	455	11
				recapture	9-16-78	524	12.5
No. 3	♂	38	5.5	original capture	7-12-60	538	10.5
				recapture	6-28-61	748	22
No. 4	♀	25.6	6	original capture	5-85-76	456	20
				recapture	5-10-77	609	32
No. 5	♂	23.8	22	original capture	10-22-58	495	13.7
				recapture	8-06-62	1018	59
No. 6	♀	21.6	15.5	original capture	8-05-58	534	11
				recapture	5-16-61	870	44.5
No. 7	♀	16.2	6	original capture	5-22-60	672	33
				recapture	5-24-61	769	45
No. 8	♂	16	20.5	original capture	6-29-59	708	34
				recapture	9-15-62	1035	72.5
No. 3A	♂	17	5	1st recapture	6-28-61	748	22
				2nd recapture	5-29-62	833	33
No. 9	♂	4.5	8	original capture	4-16-70	635	31.5
				recapture	6-13-71	670	45.5

hatchlings. Since about half the year is passed in hibernation, these young 246mm longer than at hatching, must have averaged gains of approximately 41 mm per month of active life. Besides the hatchlings and year-old snakes, a group of seven adolescents at the same time of year and presumed to be two-year-olds, had the following lengths: 635, 638, 654, 668, 686, and 713, average 676mm. A gain of 140mm in the second year, amounting to 23mm per month of active life is indicated.

Nine of the snakes that were marked by scale-clipping were recaptured after making substantial growth, as shown in Table 2. In this table No. 3 and 3A are the same snake, showing growth during two consecutive periods. The growth records of these nine marked snakes show that: 1) individuals were unpredictable and highly variable in their growth rates. 2) in general, growth in the marked snakes was compatible with the patterns described in the preceding paragraph, on the basis of size groups. The entire group made a total length gain of 2029mm in a combined total of 91.5 months of growth, an average gain of approximately 22.1mm per snake per month for individuals mostly in their second and third years. No. 3A and No. 8, though already of adult size, made substantial growth in the intervals indicated. In this table individuals are arranged in order from fast to slow growth rate. Most grew much more slowly than No. 1 but much faster than No. 9.

Sexual maturity is probably attained in the third year in most individuals, which breed at an age of thirty-two months after emerging from their second hibernation, and become parents as three-year-olds. The best criterion for sexual maturity in the male was the presence of motile

sperm in the cloaca. The smallest male in which sperm was found was 640mm, and males larger than 700mm generally had sperm. In females a prominent thickening of the cloacal wall producing a palpable lump at the end of the body (Fitch 1960) is a sign of approaching sexual maturity; such thickening usually was lacking in females of less than 700mm S-V. However, one female that was only 651mm in length produced a clutch of unusually small eggs (Table 1).

Numbers Snake-trapping was carried on most extensively in 1961. In that year ten *L. calligaster* were caught on the Rockefeller Experimental Tract in a continuous block of approximately 32 ha of grassland, and 13 were caught on the Reservation on four separate grassland areas of about 32 ha, combined. A minimum density of one snake to 2.6 ha (.384 per ha) is suggested but probably there were many kingsnakes present that escaped capture. In the thirty-year period, 1948 through 1977, 166 *L. calligaster* were captured on the Reservation and Rockefeller Tract vs a total combined catch of 1414 *Coluber constrictor*. From capture/recapture ratios, the population density of the racer was calculated as 4.72 per ha. The ratio of one kingsnake captured to 8.5 racers suggests a density of about .55 kingsnake per ha, but this estimate does not allow for its more secretive behavior, with greater likelihood of evading persons and traps. The racer's relatively rapid and frequent movements would increase its chances of being trapped. Hence the true ratio of kingsnakes to racers, and the true density of kingsnakes, may be substantially higher than my figures indicate.

Discussion On the Douglas-Jefferson counties study area of northeastern Kansas *L. calligaster* is one of 16 snake species, but was found to differ ecologically from all other, probably to the extent that competition is slight. Among the 16 species *L. calligaster* is eighth in order of abundance, averaging less than .01% of the numbers of *Diadophis punctatus*, which is the most abundant. It is fifth in size among local species, averaging about one-fourth of the bulk of the largest (*Pituophis melanoleucus*) but 80 times the bulk of the smallest (*Tantilla gracilis*). Several of the smaller species are earthworm-, slug-, or insect-eaters and do not overlap *Lampropeltis* in their feeding. *Nerodia* and *Thamnophis*, also, are much different in the trend of their feeding, taking chiefly amphibians and fish, but *Thamnophis* does overlap *Lampropeltis* in preying on voles and mice. Several of the species are characteristic deciduous forest inhabitants, and do not overlap much the prairie habitat of *L. calligaster*. Greatest similarity in food habits is with *Pituophis melanoleucus*, but the latter does not prey regularly on snakes and lizards as does *L. calligaster*, and it takes, on the average, much larger prey including rabbits and gopher- and rat-sized rodents that are too large to be taken by the smaller species.

On the Harvey County study area also, there are 16 species of snakes, only six of which are the same as those on the Reservation. *L. calligaster* is seventh in order of abundance, and eighth in size. Most of

the species do not overlap *L. calligaster* in their feeding; *Elaphe guttata* and *Arizona elegans* are believed to have the greatest overlap, but few records of their food on this area have been obtained.

On both areas *Microtus ochrogaster*, as an abundant primary consumer, is an important food source for snakes. In biomass it is the most important food not only for *L. calligaster* but for *Agkistrodon contortrix*, *Coluber constrictor*, and is also a major item in the diets of *Crotalus horridus*, *Elaphe obsoleta*, *E. guttata*, *Pituophis melanoleucus*, *Thamnophis sirtalis*, *Heterodon nasicus*, *Sistrurus catenatus*, and probably *Arizona elegans*. Besides *L. calligaster* the species at the Reservation are: *Agkistrodon contortrix*, *Carphophis amoenus*, *Coluber constrictor**, *Crotalus horridus*, *Diadophis punctatus*, *Elaphe guttata**, *E. obsoleta*, *Lampropeltis getulus*, *L. triangulum*, *Nerodia sipedon**, *Pituophis melanoleucus**, *Storeria dekayi*, *Tantilla gracilis*, *Thamnophis sirtalis*, and *Virginia valeriae*. The Harvey County assemblage included those in the foregoing list marked with an asterisk, and also: *Arizona elegans*, *Heterodon nasicus*, *H. platyrhinos*, *Nerodia erythropaster*, *n. rhombifera*, *Regina grahami*, *Sistrurus catenatus*, *Thamnophis radix*, and *Tropidoclonion lineatum*.

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