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Relative Abundance of Snakes in Kansas

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ABSTRACT

Forty-four samples of the Kansas ophifauna from localities well distributed over the state total 33,117 snakes of 34 species. *Diadophis punctatus* proved to be by far the most prevalent species. Others that are both widespread and numerous are *Coluber constrictor, Thamnophis sirtalis, Pituophis catenifer* and *Nerodia sipedon. Thamnophis radix, Elaphe emoryi, Agkistrodon contortrix, Lampropeltis triangulum, Nerodia rhombifera,* and *Heterodon nasicus* also are well represented in the state. However, a group of diminutive species of secretive and/or fossorial habits, including (besides *Diadophis punctatus*) *Carphophis amoenus, Sonora semiannulata, Storeria dekayi, Tantilla gracilis, T. nigriceps* and *Tropidoclonion lineatum,* all predators on invertebrates, were found to attain much higher densities (scores or even hundreds per hectare) than the larger kinds that prey on vertebrates.

INTRODUCTION

Studies of Kansas snakes began with A. E. Mozley's "List of Kansas snakes in the museum of the Kansas State University" in 1878. Other landmark studies of the state's ophifauna as a whole were those of Craigin (1881), Branson (1904), Taylor (1929), Smith (1950, 1956) and Collins (1982). Meanwhile, more than a dozen authors have published surveys of the snakes in geographic subdivisions of the state such as counties, and a considerably larger group have contributed field notes or local ecological studies of individual species within the state. Through the efforts of all these investigators, 39 species of snakes have been recorded, and their ranges within the state are now known in some detail. However, new records frequently extend known ranges, and for some species ranges are shrinking, as local populations disappear through alteration or loss of habitat.

LOCATIONS

Figure 1 shows sources of samples, areas of major studies (circles with dots), and counties targeted on Kansas Herpetological Society (KHS) field trips (dots). Faunal divisions within the state are:

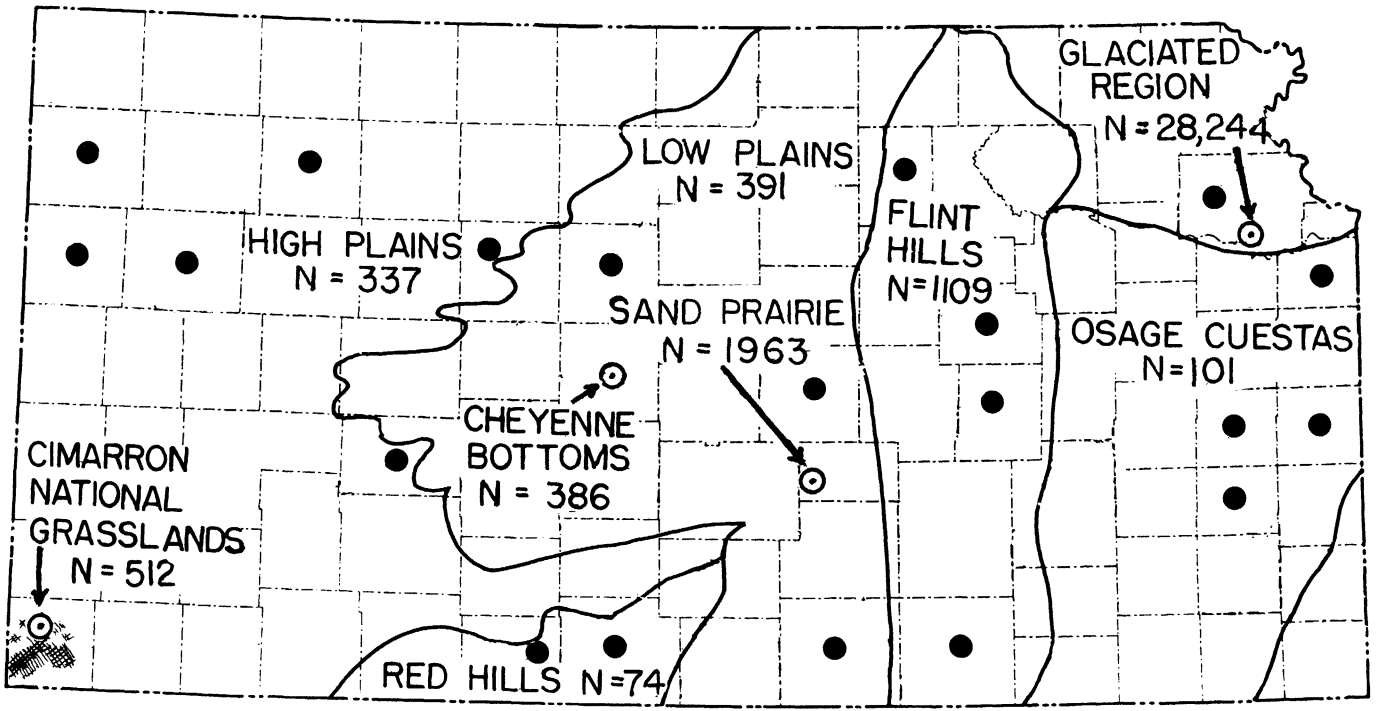

Fig. 1. Map of Kansas showing nine regional subdivisions and numbers of snakes in each sample.

1) *The Glaciated region.* This area includes eight counties and parts of several others in the northeastern corner of the state north of the Kaw River. This relatively cool and humid region supports eastern deciduous forest and edge habitat, with tallgrass prairie relicts. Loess and glacial till deposits are prominent. The snake sample, from the northeasternmost section of Douglas County and adjacent sections of Jefferson and Leavenworth counties, is by far the largest (more than six times larger than all other samples combined, representing 44 years of fieldwork by the author, with 28,244 snakes of 17 species.

2) *Osage Cuestas.* This area of eastern Kansas south of the Kansas River and about 115 kilometers from east to west, is like the glaciated region just to the north of it, climatically and topographically. It supports eastern deciduous forest and tallgrass prairie relicts, with much pastureland, and cultivated land mainly in river valleys. Seven KHS samples represent Allen, Anderson, Douglas, Johnson and Linn counties with a total of 101 snakes of 16 species.

3) *Flint Hills.* These rocky, rolling hills extend across eastern Kansas in a band 65 to 80 kilometers wide from east to west. Tree growth is scanty, mostly limited to sheltered ravines. Land use is mostly for grazing, with little cultivation. Tallgrass and mid-grass prairie predominates, with spring burning a common management practice. Six KHS field trips represent Chase, Cowley, Morris and Pottawatomie counties, with a total of 940 snakes of 17 species and my own records from trapping at the Lalouette Ranch, Marion County, provide an additional 169 records of six species.

4) *Low Plains.* These constitute a large, diverse and irregular area in the middle of the state west of the Flint Hills. Elevation ranges from 320 to 670 meters and annual rainfall averages from 510 to 810 mm. The land is flat or rolling, much of it under cultivation, some pastured. Trees are scarce and natural vegetation consists largely of prairie shortgrasses and mid-grasses. Eight KHS field trips represent McPherson, Russell, and Sumner counties, with a total of 391 snakes of 16 species.

5) *Cheyenne Bottoms.* This area is within the Low Plains Physiographic Province, but is distinctive in having extensive marshland, with artificial dikes, open water and dense stands of rushes (*Juncus*) and cattail (*Typha*). It is surrounded by flat land, mostly cultivated but with some shortgrass pasture. In a 1986 survey Irwin and Collins (1987) obtained 386 snakes of 11 species. In an earlier study Berglund (1967) stated that *Thamnophis radix* was the most abundant species of snake and that he had seen hundreds during the course of the summer. He also reported that *Nerodia rhombifera* was seen by the hundreds and was the most abundant kind of watersnake. He recorded one species (*Tropidoclonion lineatum*) not found in the Irwin and Collins survey.

6) *Sand Prairie Reservation* (Bethel College). This area also is within

the Low Plains as described above, but it has a distinctive habitat. It is adjacent to the Arkansas River and is essentially treeless, with low well-stabilized sand dunes interspersed with small ponds, some intermittent. Some of the land was privately owned and pastured at the time of sampling, which extended over the years 1959 to 1962, with live-trapping carried on for me by Dr. Dwight R. Platt and students working under his direction. A total of 1963 snakes of 15 species was obtained.

7) *Red Hills.* These consist of a highly eroded plateau of gypsum formations, along the southern border of the state in its western half. Land use is mainly for grazing and the human population is sparse. Arborescent vegetation consists largely of cedar (*Juniperus*), mostly on slopes and in ravines. Otherwise vegetation is dominated by shortgrass and sagebrush. Six KHS field trips representing Barber, Kiowa and Comanche counties yielded 74 snakes of 19 species.

8) *Northern High Plains.* This large area in the northwestern part of the state ranges from 620 to 1240 meters in elevation, with annual rainfall 385 to 585 mm. It is virtually treeless except for groves of cottonwood (*Populus deltoides*) along streams. Shortgrass (*Bouteloua gracilis* and *Buchloe dactyloides*) or sagebrush (*Artemisia tridentata*) is often the dominant vegetation. Much of the land is cultivated and some is pastured. Six KHS samples represent Hodgeman, Sheridan, Sherman, Wallace, Ellis and Logan counties, with 249 snakes of 12 species. In 1959, live-trapping carried on for me at Cedar Bluff Reservoir, Trego County, yielded 88 snakes of nine species, three of which were different from those of the KHS sample.

9) *Southern High Plains.* The Cimarron National Grassland in the southwestern corner of Kansas (Morton County) represents this region with a sample assembled by R. L. Ball (1992) over the years 1985 to 1991, with 512 snakes of 12 species. Sampling was by random search and road cruising. In climate and physiography the area is similar to the Northern High Plains, but it averages somewhat warmer temperatures and has additional species of snakes. Land use is mainly grazing, but much of the land was formerly cultivated.

Results and Discussion

Table 1 shows numbers of snakes of each species obtained in each regional sample, and compares samples and species. Disparity in sizes of samples among the nine regional divisions of the state renders them difficult to compare. The sample sizes were influenced by abundance of the snakes, by sampling effort, by method of sampling used, by terrain, by weather, and by timing with respect to daily and seasonal cycles. For all samples combined, *Diadophis punctatus* made up 56.46%, *Agkistrodon contortrix* 11.90%, *Coluber constrictor* 8.55%, *Thamnophis sirtalis* 7.85%, *Elaphe obsoleta* 1.94%,

Table 1. Numbers of snakes obtained, grouped according to species and regional sample.*

	Index of abundance overall	Mean percentage of combined samples	Cheyenne Bottoms	Cimarron Grasslands	Flint Hills	Glaciated region	High Plains	Low Plains	Osage Cuestas	Red Hills	Sand Prairie
Agkistrodon contortrix	20	2.90			14 3 (1.26%)	3925 9 (13.90%)			11 8 (10.90%)		
Arizona elegans	11	1.30		57 8 (11.13%)							26 3 (1.32%)
Carphophis amoenus	16	1.97			10 2 (0.90%)	289 5 (1.02%)			16 9 (15.84%)		
Coluber constrictor	49	7.39	7 4 (1.81%)	27 4 (5.27%)	45 6 (4.06%)	2340 7 (8.28%)	57 9 (16.91%)	2 1 (0.50%)	5 5 (4.95%)	5 5 (6.76%)	352 8 (17.93%)
Crotalus horridus	7	0.74			3 (0.27%)	97 (0.34%)			6 7 (5.94%)		
Crotalus viridis	6	0.85		29 6 (5.66%)			2 1 (0.59%)			1 + (1.35%)	
Diadophis punctatus	56	30.31			753 10 (67.90%)	17,469 10 (61.8%)	102 10 (30.26%)	266 10 (68.03%)	37 10 (36.63%)	6 6 (8.10%)	
Elaphe emoryi	22	1.96			60 8 (5.41%)	102 + (0.36%)	28 6 (8.31%)	14 8 (3.58%)			
Elaphe obsoleta	14	0.84			4 1 (0.36%)	621 6 (2.20%)		4 4 (1.01%)	4 (3.96%)		
Heterodon nasicus	18	4.02		97 9 (18.95%)			1 (0.29%)			3 2 (4.05%)	253 7 (12.88%)
Heterodon platirhinos	7	0.84					4 2 (1.18%)				126 5 (6.42%)
Hypsiglena torquata	+	0.15								1 + (1.35%)	
Lampropeltis calligaster	8	0.68	1 1 (0.26%)		1 + (0.09%)	216 3 (0.76%)		2 + (0.51%)	1 + (0.79%)	1 + (1.35%)	46 4 (2.39%)

Table 1. Continued.

	Index of abundance overall	Mean percentage of combined samples	Cheyenne Bottoms	Cimarron Grasslands	Flint Hills	Glaciated region	High Plains	Low Plains	Osage Cuestas	Red Hills	Sand Prairie
Lampropeltis getula	10	2.25	5 3 (1.29%)	5 1 (0.98%)	6 1 (13.54%)	2 +	1 (0.29%)	3 2 (0.76%)	2 3 (1.98%)	1 + (1.35%)	1 (0.05%)
Lampropeltis triangulum	20	1.78		5 1 (0.98%)	33 5 (2.93%)	124 + (0.44%)	26 5 (7.72%)	8 6 (2.04%)	2 3 (1.98%)		
Masticophis flagellum	15	1.13		36 7 (7.03%)	3 + (0.27%)		4 7 (1.18%)	2 1 (0.51%)		1 + (1.35%)	
Nerodia erythrogaster	10	1.72								11 9 (14.86%)	11 1 (0.56%)
Nerodia rhombifera	19	6.32	218 10 (56.47%)								9 + (0.45%)
Nerodia sipedon	24	1.63	9 5 (2.00%)		7 10 (0.13%)	240 4 (0.85%)	2 4 (0.59%)	2 + (0.51%)	3 3 (2.97%)	5 5 (6.76%)	16 2 (0.82%)
Opheodrys aestivus	+	0.12							1 + (1.08%)		
Pituophis catenifer	36	7.81	3 2 (0.77%)	188 10 (36.71%)	4 + (0.36%)	131 1 (0.46%)	13 3 (3.85%)	4 4 (1.02%)	1 + (1.08%)	14 10 (18.93%)	135 6 (6.8%)
Regina grahami	10	2.72	82 9 (21.24%)							2 1 (2.70%)	3 (0.60%)
Rhinocheilus lecontei	5	0.61		28 5 (5.47%)							
Sistrurus catenatus	9	1.21	26 8 (6.73%)					1 + (0.25%)	1 + (0.99%)	2 1 (2.70%)	4 + (0.20%)
Sonora semiannulata	17	2.75						60 9 (15.35%)		7 8 (9.45%)	
Storeria dekayi	2	0.26				186 2 (0.66%)	1 + (0.29%)			1 + (1.35%)	

Table 1. Continued.

	Index of abundance overall	Mean percentage of combined samples	Cheyenne Bottoms	Cimarron Grasslands	Flint Hills	Glaciated region	High Plains	Low Plains	Osage Cuestas	Red Hills	Sand Prairie
Tantilla gracilis	16	1.44			83 9 (7.48%)	2 +		2 1 (0.51%)	5 6 (4.95%)		
Tantilla nigriceps	15	1.80		6 + (1.17%)			30 7 (8.90%)	7 5 (1.79%)		4 3 (5.40%)	
Thamnophis marcianus	2	0.35		16 2 (3.13%)							
Thamnophis proximus	2	0.54			2 + (0.18%)				2 1 (1.98%)	2 1 (2.70%)	
Thamnophis radix	23	4.11	25 7 (6.48%)	18 3 (3.51%)			25 4 (7.42%)	1 + (0.25%)			380 9 (19.36%)
Thamnophis sirtalis	41	6.50	10 6 (2.51%)		58 7 (5.23%)	2497 8 (8.84%)		1 + (0.26%)	3 3 (2.97%)	6 7 (8.10%)	600 10 (30.57%)
Tropidoclonion lineatum	20	2.13			23 4 (2.07%)	2 +	41 8 (12.17%)	14 8 (3.58%)		1 + (1.35%)	1 +
Virginia valeriae	+	0.11				1 +			1 + (1.08%)		

* Figures represent number of snakes, rank within regional sample, and percentage of regional sample (in parentheses).

Pituophis catenifer 1.49%, *Heterodon nasicus* 1.07%, *Thamnophis radix* 1.04%, with each of the other 26 species comprising less than one percent. However, these ratios are biased in favor of the Glaciated Region, since its sample was much larger than all others combined.

A better comparison was obtained by calculating the percentage of each species in each regional sample and summing these percentages to show relative abundance overall. For example, *Nerodia rhombifera* was represented by 218 individuals constituting 56.47% in the Cheyenne Bottoms sample and nine constituting 0.45% in the Sand Prairie sample, but did not occur in the other seven regional samples; its mean percentage overall was 6.32 [(56.47 + 0.45) ÷ 9)]. Comparison of the means for different species again demonstrates the prevalence of *Diadophis punctatus* (30.31%) followed by *Pituophis catenifer* (7.81%), *Coluber constrictor* (7.39%), *Nerodia rhombifera* (6.32%), *Thamnophis sirtalis* (6.50%), *Thamnophis radix* (4.11%) and *Heterodon nasicus* (4.02%) while five other species fall between two and three percent, nine species between one and two percent, and 12 species are each less than one percent (Table 1).

In another comparison, species were assigned a rank within sample (RWS) according to their order of abundance. The most numerous species within the sample was designated as number 10, the second most abundant as number nine, down to the tenth as number one. Those below the tenth were generally less than one percent of their respective samples and were assigned a + indicating occurrence, but no number. For each species the RWS scores of all samples were summed to obtain an Index of Abundance (IA). As shown, *Diadophis punctatus* scored the highest IA (56), occurring in six of the nine regional samples and ranking first in five of them. *Coluber constrictor* scored second highest (IA 49) and was present in all nine samples. Because of its speed and alertness, this species was probably the one most likely to avoid capture during the sampling; approximately half of those I have found beneath artificial shelters have escaped. Hence even the high score of 49 may underrate the species' abundance. Perhaps for this reason, it was not the most numerous species in any sample, but scored second in the High Plains sample and third in the Sand Prairie sample. *Thamnophis sirtalis* was third overall (IA 41) and was present in all samples except the Northern High Plains and the Cimarron Grasslands. It ranked first for Sand Prairie and third for the Glaciated Region. *Pituophis catenifer* scored fourth (IA 36). It was present in all nine samples and was the most numerous species in the Cimarron National Grassland. *Nerodia sipedon* ranked fifth (IA 24) occurring in eight samples. It was followed by *Thamnophis radix* (23), *Elaphe emoryi* (22), *Lampropeltis triangulum, Agkistrodon contortrix* and *Tropidoclonion lineatum* (each 20), *Heterodon nasicus* (18), *Sonora semiannulata* (17), *Carphophis amoenus* (16) and *Tantilla gracilis* (16), with 16 other species scoring from one to 15 and three species scoring only + (Table 1).

The ecological impacts of snakes on associated species depends in part on their population densities, but information concerning actual numbers is scanty. The numbers obtained in population samples are affected by population density but also depend upon the method of sampling, and the habits of the species concerned. The relative abundance of species in a sample is subject to a variety of biases, and no doubt every sample used in this study was biased to some degree. Questions generated by the study are: How well do the combined samples reflect the relative abundance of the 39 species of Kansas snakes? What can be inferred about the actual population densities of the various species?

In the largest sample, that from the Glaciated Region, with 28,244 snakes, the most numerous species, *Diadophis punctatus,* had 17,469 records, more than 4.5 times as many as the second most abundant, *Agkistrodon contortrix,* with 3925 records. While these figures suggest that *Diadophis* is by far the more numerous, differences in habits and sampling techniques obscure the true ratios. Censuses based on individual marking and recapture ratios on specific areas are available for several species (Table 2). In the table, densities of *Lampropeltis calligaster, L. triangulum, Nerodia sipedon, Pituophis catenifer,* and *Storeria dekayi* are inferred from their ratios to the more abundant species of similar habits that were censused by Petersen Index (Fitch, 1960, 1963*a,* 1963*b,* 1965, 1970, 1982; Platt, 1969; Clark, 1970). The specific areas censused differ in size and location, depending on the species, but in each instance figures were obtained from favorable or near-optimum habitat. According to these figures *Diadophis punctatus,* with a density averaging 1266 per hectare, is 171 times as numerous as *Agkistrodon contortrix.* For *Carphophis amoenus* also, a remarkably high density, with 334 per hectare is indicated. A third diminutive species, *Storeria dekayi,* though rarely seen and not considered abundant, is indicated to have a density (12.7 per hectare) several times as high as those of the common kinds of larger snakes.

Some of the species of diminutive snakes are highly fossorial and others are secretive, living in moist habitats with dense vegetation where they are likely to be overlooked. However, census figures suggest that small, secretive-fossorial species are often much more numerous than larger snakes. As predators on invertebrates, including earthworms, mollusks and insect larvae, they have abundant food sources with biomass probably much exceeding that of the rodents, birds, lizards, frogs and fish eaten by the larger kinds of Kansas snakes. Small, secretive snakes of Kansas that have never been censused by capture–recapture ratios include *Sonora semiannulata, Tantilla gracilis, T. nigriceps* and *Tropidoclonion lineatum,* but each of these dominates in at least one sample and probably each attains high population density under ideal habitat conditions. In general it seems that diminutive, fossorial-secretive species tend to attain high densities, with scores or even

Table 2. Population densities of Kansas snakes as indicated by individual marking and capture-recapture records.

Species	Number of censuses	Mean density per ha	Locality	Authority
Diadophis punctatus	7	1266	KU reservation, Douglas Co.	Fitch, 1970
Carphophis amoenus	2	334	Nelson Envir. Study area, Jefferson Co.	Clark, 1970
Storeria dekayi	—	12.7	KU reservation	Fitch, 1982
Agkistrodon contortrix	2	7.4	KU reservation	Fitch, 1960
Coluber constrictor	37	4.7	KU reservation	Fitch, 1963*b*
Heterodon nasicus	4	4.4	Sand Prairie Res., Harvey Co.	Platt, 1969
Thamnophis sirtalis	6	3.7	KU reservation	Fitch, 1965
Heterodon platirhinos	4	1.3	Sand Prairie Res.	Platt, 1969
Elaphe obsoleta	1	0.90	KU reservation	Fitch, 1963*a*
Lampropeltis triangulum	—	0.24	KU reservation	Fitch, 1982
Lampropeltis calligaster	—	0.14	KU reservation	Fitch, 1982
Nerodia sipedon	—	0.13	KU reservation	Fitch, 1982
Pituophis catenifer	—	0.13	KU reservation	Fitch, 1982

hundreds per hectare at some times and places. A few of the common larger snakes including *Agkistrodon contortrix, Coluber constrictor, Heterodon nasicus* and *Thamnophis sirtalis* are often present in densities of one to 10 per hectare, while most others, *Arizona elegans, Elaphe* sp., *Masticophis flagellum, Lampropeltis* sp., *Pituophis catenifer,* are usually present in densities of less than one per hectare. Some snakes with aquatic tendencies, *Nerodia* sp., *Thamnophis* sp., *Regina grahami,* may attain high densities in marshes and along shore lines, but such concentrations are highly localized.

Conclusions

Several species of snakes that are wide-ranging (mostly transcontinental in distribution) and adaptable in climatic tolerance, habitat and food habits are the most prominent kinds within Kansas: *Coluber constrictor, Pituophis catenifer, Thamnophis sirtalis, Nerodia sipedon,* and especially *Diadophis punctatus.* Species of somewhat less ecological significance, but which were well represented in at least one regional sample, include *Agkistrodon contortrix, Carphophis amoenus, Nerodia erythrogaster, N. rhombifera, Sistrurus catenatus, Sonora semiannulata, Tantilla gracilis, T. nigriceps, Thamnophis radix, Elaphe emoryi* and *Tropidoclonion lineatum* and *Lampropeltis calligaster.* Other species that are restricted regionally and were not numerous in any sample include *Elaphe obsoleta, Heterodon platirhinos, Lampropeltis triangulum, Masticophis flagellum,* and *Thamnophis proximus. Arizona elegans, Crotalus horridus, C. viridis, Lampropeltis getulus, Rhinochelus leconteі, Storeria dekayi* and *Thamnophis marcianus* were represented by relatively few individuals when represented at all. Other species that seem to be genuinely rare and localized are *Hypsiglena torquata* and *Opheodrys aestivus,* each represented by just one record in the survey, and *Virginia valeriae* represented by two. Three species of snakes known to occur in Kansas were not found in the present survey, and these are all diminutive, fossorial and/or secretive kinds: *Leptotyphlops dulcis* has been found only on the state's southern edge in its western half; *Storeria occipitomaculata* is known only from a few isolated localities along the state's eastern edge, but is common in deciduous forests farther east. *Virginia striatula* occurs in Kansas only in the southeastern corner, along with other species of animals that represent an Ozarkian fauna. This area was not sampled in the present survey.

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