

# Natural History of the Black Rat Snake (*Elaphe o. obsoleta*) in Kansas

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Over a 15-year period, 359 black rat snakes were captured, mostly on a 750-acre area; because many were recaptured after marking, records totaled 516. The average emergence date was 16 April and 27 October was the average date for the end of the season's activity. Calculated home ranges averaged 29 acres for males and 23 acres for females. Males are more inclined to wander, but in both sexes the tendency to remain within a familiar range is strong.

Hatchlings appear in late summer or early autumn and range in snout-vent length from 290 to 368 millimeters; typical one-year-olds range from 500 to 650 millimeters. Sexual maturity is attained in the fourth year usually at a snout-vent length of a little less than 900 millimeters in males (which usually mature somewhat earlier) and a little more than 900 millimeters in females. Monthly gains in the growing season average 36 millimeters in the young of each sex. In the third or fourth year there is abrupt slowing, most marked in the females. Large adult males gain on the average a little more than three millimeters per month in the growing season. On the basis of observed growth rates more than one-fourth of the rat snakes recorded were eight years old or older, and some may have been more than 20 years old.

The rat snake depends primarily on small birds and mammals for food, but takes an occasional frog, lizard, or snake. Birds are preyed upon chiefly in the nesting season; few adults are eaten. The red-tailed hawk is an important natural enemy; 577 instances of predation on rat snakes were recorded for this kind of hawk, but for other predators few records were obtained.

FROM July 1948, through May 1963, a field study of the black rat snake was carried on at the University of Kansas Natural History Reservation, the northeasternmost section of land in Douglas County, Kansas, and (after 1956) on the adjacent Rockefeller Experimental Tract of 160 acres. The combined area is typical of ecotonal regions between the more eastern deciduous forests, represented here chiefly by oaks, hickories, and elms, and the more western prairies, represented here by bluestems and other native tallgrasses, and by various introduced pasture grasses.

The black rat snake is the largest of the 15 species of snakes occurring on the area, and is moderately common; hence, it is obviously important in the local ecology. Study of the black rat snake was carried on concurrently with study of various other species of snakes on the area, some of them much more numerous than the rat snake. The field study of snakes was supported by three successive grants from the National Science Foundation (G-3413, G-6158, G-16104). Many persons assisted the writer in

various phases of the work. Those who helped with the study of the black rat snake include most of the same persons whose contributions have already been acknowledged in the writer's two earlier papers on snakes on the Reservation (1960:92; 1963: in press).

The capture of live snakes and their individual marking, by scale-clipping, and release, provided the main basis for the study, and over the 15-year period involved, 359 black rat snakes were recorded a total of 516 times. The total includes records of 41 young from clutches of eggs hatched in confinement, and also includes records of 41 rat snakes from outside the actual study area, mostly individuals found DOR on nearby county roads. In most instances the scales clipped for permanent marking of the snakes were the ventrals on the posterior part of the body, but in some of the snakes subcaudals were clipped. Regeneration of clipped scales is more rapid and complete in the black rat snake than in any of the other species of snakes studied. In some instances the faint scars remaining after

periods of years were not readily distinguished from the scars remaining from natural injuries. There is some possibility that the clipped scales regenerated so completely that individuals were unrecognizable (Conant, 1948:1). In retrospect it would have been desirable to duplicate the marks on each snake by clipping the appropriate scales for any given formula on both subcaudals and ventrals, or at both anterior and posterior ends of the ventral series. This probably would have eliminated the chances for any uncertainty. However, the formulas were readily recognized in most of the marked snakes, even after periods as long as eight years.

Black rat snakes were obtained by three different methods. Many were found in the course of routine field work, and were caught by hand. Others were found when the scolding of birds, excited in the presence of their natural enemy, drew the attention of field workers to it. Still others were caught in wire funnel traps of a type already described in previous publications (Fitch, 1951:77). This last method produced the largest number of records. However, the traps were made and set primarily for snakes of smaller kinds, and were not highly effective for the capture of large adult rat snakes. Many of the best records of the latter were obtained when birds drew attention of the observer to the snake. The rat snakes that were being heckled by birds usually were climbing, and sometimes were high in trees, hence, capture was by no means assured even when the snake was located. A 17-foot pole with a wire hook at the end was kept on hand for such contingencies but often it did not suffice to reach the climbing rat snakes.

#### HABITAT

Like many of its community associates in eastern Kansas, the black rat snake is a species typical of deciduous forests, and occurs throughout much of the Deciduous Forest Biome of eastern North America. In Kansas its range extends only as far westward as deciduous forests are found. Of several other species of amphibians and reptiles that share its habitat preferences and much of its geographic range, namely *Bufo americanus*, *Hyla crucifer*, *H. versicolor*, *Eumeces fasciatus*, *Lygosoma laterale*, *Storeria dekayi*, *S. occipitamaculata*, *Carphophis amoenus*, *Aghistrodon contortrix*, and *Crotalus horri-*

*dus*, none extends quite so far westward in Kansas as does *Elaphe obsoleta*. The ranges of all these species in Kansas have been mapped in detail by Smith (1956). Although all require mesic habitats, the rat snake is perhaps slightly more tolerant of xeric conditions than any of the others. Also, it is the most vagile of these species, and probably has extended its range slightly to the westward in the past hundred years, keeping pace with successional changes that have occurred since settlement of the land by human beings. Since prairie fires have been brought under control, woodland vegetation has spread rapidly on nonagricultural areas, especially along stream courses, and trees have been extensively planted on farms, about towns, and in shelterbelts. The rat snake would be able to invade such newly suitable areas as fast as they became available, providing it had access to them, from adjoining or nearby areas.

On the Reservation the black rat snake is present in all habitats, including mesic and xeric woodlands, woodland edges, and brushy fields. The distribution of its records seems to be determined more by the location of traps and the places where field work was concentrated than by differences in habitat. Many rat snakes were captured in tallgrass prairie, but no point on the study area was more than 500 feet from woodland.

#### SEASONAL SCHEDULE

On the Reservation black rat snakes usually emerge from hibernation in April, but may not appear until early May; retirement usually occurs in late October, but may be delayed until early November. There is much variation from year to year according to the trends of the weather; also in any one year there is much difference between individuals in the timing of these events. Earliest records of rat snakes over a 14-year period are: 12 April 1950; 15 April 1951; 26 April 1952; 8 April 1953; 8 April 1954; 18 April 1955; 2 May 1956; 24 April 1957; 17 April 1958; 2 April 1959; 12 April 1960; 4 April 1961; 5 May 1962; 18 April 1963. Latest seasonal records are: 22 October 1949; 31 October 1950; 2 November 1951; 16 October 1952; 23 October 1953; 25 October 1954; 28 October 1955; 9 November 1956; 30 October 1957; 2 November 1958; 10 November 1959; 26 October 1960; 21 October 1961; 11 November 1962. The

species was not sufficiently common to be recorded daily, even in the season of its activity, and it might well have been missed for a week or more at the beginning or end of its season in some years.

For the 15 years of the study combined, the monthly catches of rat snakes were as follows: 28 in April, 88 in May, 104 in June, 59 in July, 30 in August, 51 in September, 99 in October, 5 in November. Although man-hours in the field and numbers of traps operating both varied in the course of the study, the numbers recorded from April through August probably reflect fairly accurately the relative extent of activity in each of those months. As in other kinds of snakes, activity reaches a peak early in the season, and wanes thereafter. The improved catches in September and October resulted from the fact that the snakes preparing to hibernate concentrated their activities along the hilltop limestone outcrops at that season and were hence more readily trapped than at other times.

#### MOVEMENTS

Like most other snakes of the Reservation, black rat snakes, so far as known, always return in autumn to the hilltop limestone outcrops where numerous deep crevices and fissures provide them with adequate shelter for hibernation. In spring, they tend to disperse from such situations, and some of them, at least, occupy regular home ranges that are disjunct from the outcrops where they hibernate. Perhaps some of the snakes, of all ages, are wanderers; at any rate the majority was caught only once, whereas other individuals in the same areas were recaptured repeatedly. Wandering tendencies are more strongly developed in the males, as indicated by the following figures:

- Of 217 individuals caught only once, 65.0 per cent were males.
- Of 49 individuals caught twice, 59.1 per cent were males.
- Of 9 individuals caught three times, 44.4 per cent were males.
- Of 9 individuals caught four or more times, 44.4 per cent were males.

For each of 15 individuals, successive captures were made at a presumed hibernating site at a hilltop rock outcrop in spring or autumn and at a spot removed from the outcrop in summer, providing information regarding the extent of the seasonal shift.

The average distance was 1,260 feet—1,321 feet for eight males and 1,187 feet for seven females. Each of 12 rat snakes was found at the rock outcrops on two occasions, usually in different years, and the trend of the figures seems to indicate no constancy to any one hibernaculum. For six males the average distance between successive rock ledge locations for the same snake was 1,745 feet, whereas for six females the corresponding figure was 713 feet.

In 81 instances recaptured rat snakes were recorded at successive capture points away from hibernation sites. Except in the cases of occasional wandering individuals, the distances between successive capture points could be expected to reflect rather accurately the sizes of the home ranges. The average distance was 663 feet. The distances are rather evenly distributed from zero up to 1,380 feet, but with three much longer movements—3,200, 2,240, and 2,240 feet (Fig. 1). These three long movements probably represent shifts in range, or wandering. Some of the shortest movements may be unrepresentative also, because of the short time elapsed between captures, or for other reasons. To eliminate unrepresentative movements, the upper and lower 10 per cent were removed. Average distance for the remaining 33 movements of males was 636 feet, and for the remaining 32 movements of females was 576 feet. The median distance was 610 feet for males and 500 feet for females.

The home range is visualized as an area covered rather uniformly by the snake wandering in random fashion within it, this area tending toward circular shape but usually somewhat elliptical. Any two random capture points will be separated on the average by half of the area's diameter. An approximation of the home range can be calculated from the formula  $\pi r^2$ . On this basis the average range of the male was calculated to be about 29 acres, and the average range of the female about 24 acres. In this context the hibernaculum is not considered to be a part of the home range proper, because it is disjunct from the area where most activities are carried on. A case might be made for considering the hibernaculum and the travel route to and from it as extensions of the home range, if it could be shown that the same routes and the same hibernacula are used regularly.

An important consideration is whether

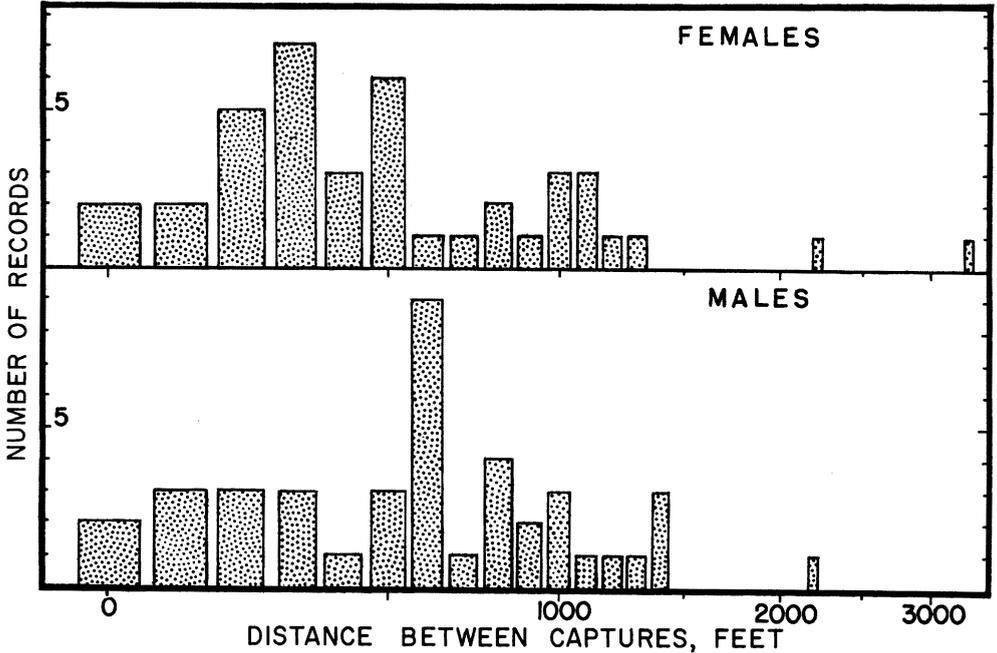


Fig. 1. Distances between successive summer captures of marked individuals of the black rat snake. Home ranges up to 1,400 feet in greatest diameter are indicated, and longer movements are few.

the population in any given area consists essentially of resident individuals settled in regular home ranges or whether it includes a high percentage of wanderers. At first sight the latter conclusion might seem the more plausible in view of the high proportion of rat snakes that were each captured only once. However, the area encompassed by lines of live traps was a mile and a half long and a mile wide, sufficiently large to show fairly extensive wandering. Yet only three of 81 movements exceeded the distances to be expected in individuals remaining within home ranges of 30 acres or less.

In a ten-acre area (372-foot radius) around the writer's residence, chances of recapturing any rat snakes present were undoubtedly much better than elsewhere, because the writer's activities and those of his family and collaborators were relatively concentrated in this vicinity, comprising only about 2 per cent of the total study area. On the ten-acre area, 18 per cent of the captures pertained to rat snakes caught only once, while on the remainder of the study area 65 per cent of the captures were of snakes recorded only once. Of 18 snakes caught only once on the ten acres, 72 per cent were

immature, but of 16 caught two or more times, only 50 per cent were immature. Possibly young are inclined to wander somewhat more than adults, but young that were recaptured had not moved farther than adults; the low rate of returns on young seems to be due primarily to their relatively short life expectancy. Having attained adult size, the snakes are less subject to predation or accidental death, and the chances are good for their continued survival over further periods of years. Even on the ten-acre area where chances of recapture were best, intervals between captures averaged 14 months for the 16 rat snakes that were recaptured. Obviously the methods of capture used were so inefficient that the majority of rat snakes present on the study area as a whole were missed, and for those captured once the chances of recapture were poor.

Black rat snakes that are active move slowly and travel by roundabout routes. Many days, or perhaps even weeks, normally would be required for the snake to cover its entire home range. It was rarely possible to keep an individual under observation for more than a few minutes. However, for

individuals that were traveling near the Reservation headquarters, the intermittent scolding of birds sometimes served to mark the progress from hour to hour and even from day to day. After several days such a snake often was still within a few hundred feet of the place where it was first noted, although of course it had actually traveled a much greater distance, moving up and down trees, zigzagging, and looping back over the route already covered.

#### REPRODUCTION

On 18 April 1960, 26 May 1955, and 28 May 1949, pairs of adults were found together. On 15 May 1963 a male black rat snake of 1,317 millimeters snout-vent length and a female of 1,075 millimeters were found within a few feet of each other at a farmhouse near the Reservation and both were killed. The female had semen with active sperm in her cloaca—evidence of recent copulation. On 9 May 1953 Dr. Ruggero Tomaselli saw one large adult following closely behind another in what was probably courtship. As in most other North American reptiles spring is the main breeding season, but mating may occur at other times of year. Adult males have mature sperm at all seasons, and on 14 October 1959 a female was found to have abundant sperm in her cloaca.

Females generally produce their first clutches of eggs late in the fourth year, when they are more than 870 millimeters but less than 1,030 millimeters in snout-vent length. The clutches of such individuals contain fewer eggs than the clutches of large adults; on 13 July 1956 an 890-millimeter female laid six eggs; on 3 July 1961, a 983-millimeter female palpated was found to contain seven eggs ready to be laid; on 11 July 1959, a 960-millimeter female laid eight eggs, and on 1 June 1955, a 1,028-millimeter female found DOR contained nine large eggs.

In contrast, a 1,170-millimeter female palpated on 20 June 1960, contained 11 eggs, and on 27 June 1952, an unusually large female (not measured) was found in the process of egg laying, with 27 eggs already laid and the 28th about to be laid. The site was a decaying elm stump about 18 inches in diameter. One side of the stump had rotted away to ground level, exposing the cavity inside. The snake was found lying beside the stump in a peculiarly kinked po-

sition, with her head and the rear end of her body inside the cavity. Investigation revealed the eggs in the crumbling and slightly damp decayed wood at the base of the cavity. Some of the eggs were barely covered, others were as much as three inches beneath the surface. Several were wedged in the cavity left by a decaying root and were extricated from it with difficulty. Most were separated but some were adherent in pairs or clusters. This clutch of eggs was kept and hatched on 24 and 25 August. A clutch of ten eggs hatched on 28 August 1952. Another clutch, incubated in the laboratory, hatched 10 and 11 September 1956. In 1951 a group of hatchlings, obviously newly emerged, was found at the rotten base of an oak snag in the second week of October. In this instance late hatching probably was correlated with the trend of unusually cool and wet weather in the summer of 1951.

Wright and Wright (1957:233) compiled records from the literature of 23 clutches in which the number of eggs ranged from 6 to 44 and averaged 14.5 but only one clutch had more than 24 eggs.

#### GROWTH

In 31 hatchlings from eggs incubated in the laboratory, snout-vent length ranged from 290 to 368 millimeters, with no evident difference between the sexes. In June, July, and early August there are individuals within this size range, but these presumably are from the previous year's brood and are retarded because they were unusually small at hatching, or because they have failed to grow at the normal rate, as a result of injuries or diseases, or poor success in finding food. However, typical one-year-olds are from 500 to 650 millimeters in snout-vent length. They overlap two-year-olds in size and only the first-year snakes can be definitely allocated as to age, except for those individuals marked early in life. In Table 1 the records of individuals marked and recaptured after periods of two to six years, and still not fully grown at the time of first captures, are shown.

Gains are most rapid in the hatchlings but rapid growth continues, usually through the fourth year at least. Subsequently there is progressive and sometimes abrupt slowing, but even large adults make some gains over periods of years, and growth perhaps never ceases entirely, as long as the snake remains in good condition.

TABLE 1. SELECTED RECORDS OF BLACK RAT SNAKES MARKED AND RECAPTURED AFTER INTERVALS OF GROWTH

Sex	Original Record				Recapture Record			
	Date	Snout-Vent Length in Millimeters	Weight in Grams	Probable Age in Months	Date	Snout-Vent Length in Millimeters	Weight in Grams	Probable Age in Months
♀	25 Sept. 1952	364	14.0	1	30 June 1956	1,028	213	45
♂	15 Oct. 1959	372	14.7	1½	28 Sept. 1962	922	142	37
♀	27 Sept. 1953	571	43.8	13	23 Sept. 1955	952	180	37
					8 Aug. 1958	1,127	282	71
♀	20 Oct. 1953	625	48	14	23 July 1959	1,144	327	85
♂	10 Aug. 1954	733	83	23	5 June 1957	1,075	430	56
♀	19 Oct. 1956	757	134	26	12 Sept. 1958	960	215	48
					26 June 1959	1,020	260	58
♀	12 April 1950	846	146	31	27 Sept. 1951	1,100	460	49
♂	29 May 1951	822	128	33	6 June 1957	1,208	459	105
					26 Sept. 1959	1,300	515	132
♂	6 July 1959	870	145	34	29 May 1961	1,077	315	57
♂	27 May 1960	825	118	33	29 May 1962	1,098	—	57
♀	31 May 1954	1,028	284	56	20 May 1960	1,228	475	128

Table 2 compares growth in rat snakes of different size groups, and the slowing trend is well shown. Averages are shown separately for the sexes where sufficient numbers were available. Too few records of growth are available to show differences in growth rate between males and females; indications are that there is little difference for the first three years, but that with attainment of maturity, growth slows sooner and more rapidly in females. The largest male examined had a snout-vent length of 1,530 millimeters. Excluding recapture records, eight other males but no females exceeded 1,400 millimeters. Seventeen males and two females were between 1,300 and 1,400 millimeters. In Table 2 hibernation periods are not included in the summation of months and the estimation of gain per

month. Although hibernation is of variable length in individuals, and in the same individual from year to year, growth was estimated on the basis of a five-month growing season—May through September. There is some activity in April, October, and even early November, but also much time is spent in dormancy during these months, and on the average the season of activity for each snake is somewhat less than half the year.

#### SURVIVAL AND LONGEVITY

At the rate of growth calculated for juveniles and young adults, a male black rat snake would attain a snout-vent length of 1,200 millimeters some time in his eighth year. Disregarding the records of recaptures and of those snakes hatched in confinement, 226 males were recorded of which 61, or 27

TABLE 2. AVERAGE GAIN PER MONTH IN MARKED AND RECAPTURED BLACK RAT SNAKES OF DIFFERENT SIZE GROUPS

Size Range in Millimeters	Number and Sex	Combined Gain in Millimeters	Combined Months	Average Gain in Millimeters per Month per Snake
up to 900	7 males 1 female	2,326	65	35.8
up to 1,100	1 male 4 females	2,002	63½	31.8
800 to 1,200	7 males	1,613	79	20.4
800 to 1,200	6 females	718	55	13.0
1,140 to 1,350	6 males	442	77½	5.7
1,373 to 1,448	4 males	141	44½	3.2

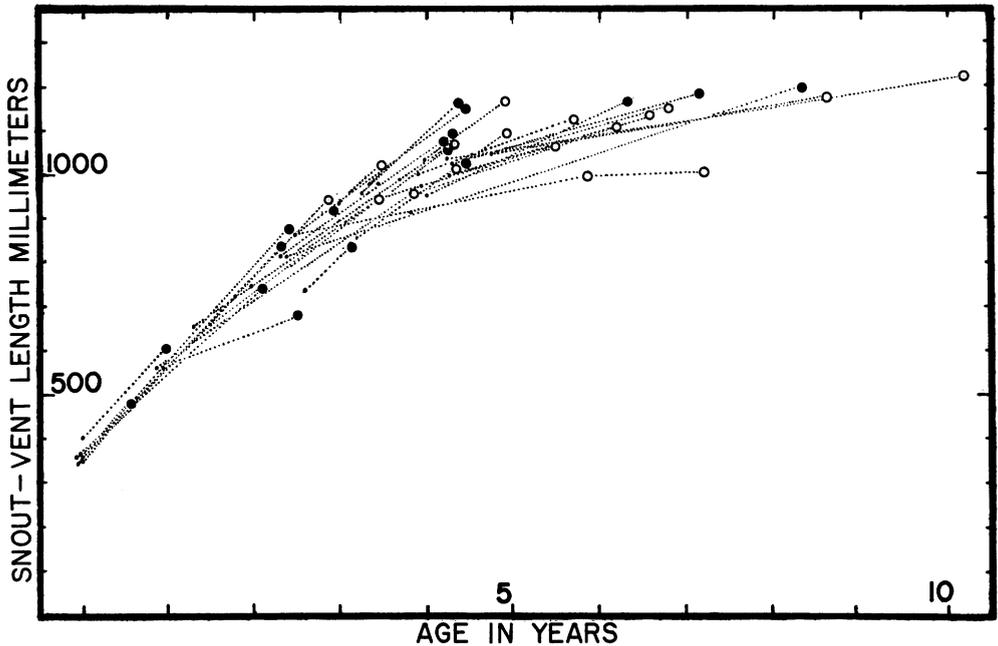


Fig. 2. Growth curve of black rat snake as indicated by individuals marked and recaptured. Lines connect records of the same individuals, represented by a dot for the original capture and a circle (solid for males, open for females) for each subsequent capture. Age estimate was made on the basis of size at first capture.

per cent, had attained a length of 1,220 millimeters or more and hence were probably eight years old or more, belonging to many annual age groups. If an eight-year-old, 1,220-millimeter rat snake continued to grow with an annual increment of 20 millimeters per year, he would reach the size of the largest snake recorded in my study at an age of 24 years. Each supposed year class up to 24, except that of 23-year-olds, was represented by from one to six individuals among the males actually recorded.

Some individuals, for periods of months at least, greatly exceed the average or typical (Fig. 2) rate of growth, and the largest male may have been much younger than 24 years. Nevertheless, it seems plausible that the largest rat snakes captured were near, or more than, 20 years of age. Several individuals marked and recaptured yielded data bearing on the question of longevity. A female of 1,270 millimeters and 545 grams (age perhaps 10 to 13 years) when marked on 16 September 1952, was recaptured on 25 September 1957 and had grown to 1,465 millimeters and 1,270 grams. A male of 1,245 millimeters marked on 31 August 1953, was recaptured in May 1955, and May 1958.

At this last capture he had grown to 1,328 millimeters and 560 grams. A male marked on 16 July 1950 was 1,373 millimeters in length and weighed 609 grams. His age was probably between 12 and 16 years. He was recaptured on 19 July 1954, 7 July 1956, and 25 April 1958. On this last date he measured 1,448 millimeters and weighed 674 grams.

#### NUMBERS

In the present study records were too few and too diffuse to be well adapted for use in a census. Field work in 1958 was more extensive and intensive than in any other year; in 1958, 45 rat snakes were captured. Of this number 38 were on a rectangular 250-acre area, including the northwestern part of the Reservation and the southern two-thirds of the Rockefeller Tract, where field work was most concentrated. Doubtless many of the snakes had home ranges that were partly outside the 250-acre study area and merely overlapped it. For census purposes it is customary to add a peripheral strip the width of half the home range, and if this is done the area to be considered is increased to 450 acres.

Of the 38 rat snakes, 34 were caught only once in 1958; three were each caught twice (17 April and 30 May, 30 June and 15 July, 8 August and 13 August); and one was caught three times (11 May, 1 June, 8 June). The low ratio of recaptures makes it obvious that many rat snakes on the area were missed, and several that were marked on the area before 1958 were not recorded that year but were caught again in subsequent years.

In order to estimate the population by the capture-recapture ratio (or Lincoln Index) it is necessary to have two successive comparable sampling periods. If the 1958 summer's data are divided so that the first sampling period includes dates through 29 June, and the second sampling period includes dates from 30 June onward, there are, for the first sampling period, 16 snakes, and for the second, 23 snakes of which none were recaptured from the earlier period. Because of the lack of recaptures, no census is possible. However, if the first sampling period is extended through 30 June, there are 18 snakes from the first period and 21 from the second, with 1 recapture. The 21 to 1 ratio in the second period indicates a population of 378 snakes in the first period. If the first sampling period is extended to include 1 July, the ratio is slightly changed, as follows: first period, 19 snakes; second period, 20 snakes with 1 recapture, indicating a population of 380. On each date that rat snakes were caught the ratio changed. For the 74 possible census trials from 17 April to 12 August, the population figure obtained ranged from 9 to 380 and averaged 166. If this average figure is accepted, a population density of approximately 0.37 rat snake per acre is indicated for the 450 acres involved.

As in all other samples of rat snakes collected, the 1958 sample was strongly biased in the distribution of its age groups, as follows: first-year individuals, 4; second-year, 3; third-year, 7; fourth-year, 8; fifth-year, 6; sixth-year and older, 10. These ages were estimated on the basis of size. Actually, the first-year snakes must comprise by far the most abundant age class, the second-year class must be the next most abundant, followed by the third-year class. The young must be much more secretive than the adults, or at least much less conspicuous; a higher proportion of them are overlooked.

Since the adult female rat snake produces

an annual brood with an average clutch of 14.5 eggs, the first-year young must greatly outnumber the adults, especially in fall, after hatching occurs. Even if 50 per cent of the eggs are eliminated before hatching, and if the young snakes are subject to 50 per cent reduction annually until they reach maturity, a population of 100 adult females might represent some 1,268 young (725 hatchlings, 362 second-year young, 181 third-year young). If some such ratio obtains, then the 38 rat snakes caught on the restricted study area in 1958 and the 166 calculated to be present from their ratios would represent a total population of 770 (1.71 per acre) at the time of the annual maximum, or 380 (0.84 per acre) at the time of the annual low point. A much larger and more concentrated sample would be necessary for a reliable census; however, the information at hand indicates a population density of the order of magnitude of one rat snake per acre.

#### NATURAL ENEMIES, DISEASE, AND PARASITISM

The large and relatively slow-moving rat snake is exposed to injury and death from various predators and even from potential prey. The prey is killed by constriction, but rodents, especially, may use their long, sharp incisors with telling effect in attempts to defend themselves before they are overcome. The following were some of the injuries noted in the rat snakes captured (in large adults in most instances): "scar on right side three-fifths of distance from head to end of body"; "terminal inch of tail almost broken off"; "back broken seven inches anterior to end of body, wound healed externally"; "back broken three inches anterior to end of body, injury healed externally but rear of body and tail paralyzed, tail dry and rigid, looped through itself in a knot"; "base of tail infected and swollen"; "right eye missing"; "left eye missing, scar on right side of back"; "tail broken and healed."

In an eight-year study of the red-tailed hawk (*Buteo jamaicensis*) the writer and his collaborators collected pellets from 49 nests at localities well scattered through the eastern one-third of Kansas. Of 1,131 pellets, 577 (51.0 per cent) contained remains of black rat snakes; only the prairie vole with 647 occurrences was more frequent. The rat snake must have made up an even greater proportion of the food than indicated by its 24.4 per cent frequency, as it

was one of the larger kinds of prey represented in the hawk's food. It was estimated, on the basis of relative weights, that approximately 46 per cent of the actual bulk of food consisted of this kind of snake. At this rate a pair of hawks on their territory of perhaps half a square mile would destroy a large number of rat snakes, and would be one of the important factors in the ecology of the snakes. Remains of the rat snake in pellets consisted chiefly of scales, which were easily distinguished microscopically from those of other snakes and lizards. Remains of other snakes, including those of garter snake, copperhead, racer, and bull snake, were relatively scarce even though most of these species are much more abundant than the rat snake in the region where the collections were made. The rat snake seems much more vulnerable to predation by hawks, which perhaps are alert to the disturbance caused by birds scolding rat snakes when the latter are climbing. Judging from the sizes of scales in the pellets, a high proportion of the rat snakes eaten were juveniles, but some were large adults, as indicated by the large scales found in occasional pellets, or by the remnants of spinal columns found in several nests.

Among 71 prey items collected in June and July 1954, from a broad-winged hawk (*Buteo platypterus*) nest, there was one juvenile black rat snake. Among 512 prey items of the copperhead and 1,008 of the blue racer there were one and four juvenal rat snakes, respectively. Of the many horned owl pellets collected on the Reservation, mostly from the colder part of the year, only one pellet (collected on 22 April 1953) had scales and bones of a rat snake.

Like other kinds of snakes on the Reservation, rat snakes are subject to skin infections that cause blisterlike swellings, especially in early spring, or in unusually wet periods of summer. Snakes that have them often appear sickly or emaciated and probably mortality sometimes results. Black rat snakes are especially subject to parasitism by chiggers. Loomis (1956) in his study of the chigger mites of Kansas found seven species on these snakes—a greater number than found on any of the other 47 species of reptiles examined. In early summer black rat snakes on the Reservation sometimes carry hundreds of chiggers (mostly *Trombicula alfreddugèsi*) which form a reddish encrustation over the skin between the scales.

TABLE 3. MONTHLY PERCENTAGES OF VARIOUS CATEGORIES OF PREY IN THE FOOD OF THE BLACK RAT SNAKE ON THE STUDY AREA

Month	Number of Items	Monthly Percentage of Each Kind of Prey			
		Bird	Mammal	Reptile	Frog
May <sup>1</sup>	35	20	74	3	3
June	26	42	42	—	15
July	11	35	55	9	—
August	5	20	80	—	—
September	5	—	100	—	—
October <sup>2</sup>	15	—	87	7	7

<sup>1</sup> Including three records from late April.

<sup>2</sup> Including two records from early November.

However, the chiggers seem to have little effect on the snakes. In May and June a few of the rat snakes that were examined on the Reservation had lung flukes in their mouths.

#### FOOD HABITS

Forty-seven food items were taken from snakes found eating or were removed from the stomachs or gullets of snakes; 53 items were identified from scats, the latter either found in traps with the snakes or obtained from them before the snakes were released. The items were as follows: 22 prairie voles (*Microtus ochrogaster*); 16 white-footed mice (15 *Peromyscus leucopus* and 1 *P. maniculatus*); 8 pine voles (*Microtus pennsylvanicus*); 8 frogs (none identified to species because remains were in scats and were fragmentary); 6 cottontails (*Sylvilagus floridanus*); 6 bird eggs of kinds not definitely identifiable from the crumbled shell fragments found in scats; 5 "mammals" (voles, mice, and shrews not fully identifiable); 5 nestling and fledgling blue jays (*Cyanocitta cristata*); 3 unidentified nestling birds; 3 mourning dove (*Zenaidura macroura*) eggs; 2 harvest mice (*Reithrodontomys megalotis*); 2 cotton rats (*Sigmodon hispidus*); 2 wood rats (*Neotoma floridana*); 2 shrews (1 *Blarina brevicauda*, the other either this species or *Cryptotis parva*); 2 bluebird (*Sialia sialis*) eggs; 2 five-lined skinks (*Eumeces fasciatus*); 1 jumping mouse (*Zapus hudsonius*); 1 house mouse (*Mus musculus*); 1 nestling phoebe (*Sayornis phoebe*); 1 rat snake (*Elaphe obsoleta*).

The food consists essentially of mammals (66 per cent of items) and birds (23 per cent) with amphibians and reptiles making up 8 per cent and 3 per cent respectively. Table 3 shows the distribution by months

of the various groups of prey. Birds are best represented in June, the month when the nesting season is at its peak.

Invertebrates, including a snail, several small beetles, a caterpillar, and various unidentified insect fragments, were found in 5 scats, and in each instance were accepted as tentative evidence of predation on a frog. In two scats there were meager but recognizable remains of frog, and one of these contained insect remains also. Two occurrences of invertebrates in scats were not associated with other animals; the remaining occurrences were associated with mouse, bird, and egg. Prevalence of frog-eating habits in the rat snake was indicated by the presence of lung flukes in the gullets or mouths of some of those examined. Flukes of this group (Reniferinae) require a snail and a frog as hosts during different stages of their development.

The rat snake obtains much of its food by searching out nests containing eggs, or still helpless young of birds or mammals. A high percentage of the birds' nests observed by the writer on the Reservation have been robbed by predators. In most instances the identity of the predator could not be determined, but black rat snakes have been found in the act of robbing birds' nests in four instances—more than recorded for any other kind of predator.

Despite its stealthy gliding movements, a rat snake in a tree is often detected by a bird whose cries of alarm soon attract other birds of several species. Within a few minutes a group of a dozen or more birds often will assemble to harass the rat snake, but if the latter remains motionless, the group will rapidly dissolve. However, from time to time a bird returns to observe the snake and scold it briefly, and if the snake is found in motion, the excited scolding evoked soon causes a group of birds to re-

assemble. Such aggregations on the Reservation have included red-bellied woodpeckers (*Centurus carolinus*), downy woodpeckers (*Dendrocopos pubescens*), tufted titmice (*Parus bicolor*), black-capped chickadees (*Parus atricapillus*), field sparrows (*Spizella pusilla*), cardinals (*Richmondia cardinalis*), summer tanagers (*Piranga rubra*), myrtle warblers (*Dendroica coronata*), and blue jays (*Cyanocitta cristata*). The last are the only ones that have been seen to attack a snake. The observed attack occurred while the snake was actually robbing the jay's nest. Mr. George C. Boone caught a rat snake that had just robbed the nest of a red-bellied woodpecker, and the snake had a fresh wound on its back that probably had been inflicted by one of the parent birds. Normally, scolding birds stay several feet away from the snake and their heckling has no noticeable effect on it, but may draw the attention of a larger predator to the snake.

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