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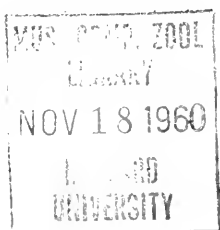
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1960



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MUSEUM OF NATURAL HISTORY

Volume 11, No. 1, pp. 1-9, 4 figs.

July 14, 1958

Systematic Status of the Colubrid Snake,
Leptodeira discolor Günther

BY

WILLIAM E. DUELLMAN

UNIVERSITY OF KANSAS

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UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

Editors: E. Raymond Hall, Chairman, Henry S. Fitch,
Robert W. Wilson

Volume 11, No. 1, pp 1-9, 4 figs.

Published July 14, 1958

UNIVERSITY OF KANSAS
Lawrence, Kansas

PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1958



27-6708

Systematic Status of the Colubrid Snake, *Leptodeira discolor* Günther

BY

WILLIAM E. DUELLMAN

At the time of completing my study of the genus *Leptodeira* (1958) I had seen no specimens of *Leptodeira discolor*, a species described by Günther in 1860 and subsequently referred to the genus *Hypsiglena* by Cope (1887), Boulenger (1894), and Mocquard (1908), and to the genus *Pseudoleptodeira* by Taylor (1938). Günther's description was based on two syntypes (British Museum of Natural History numbers 1946.1.23.67 and 68) collected in Oaxaca, México, by Auguste Sallé. Information concerning the scutellation and coloration of the syntypes was provided by J. C. Battersby; in my revisionary study (*op. cit.*) this information was included in a short discussion of the species, which was referred to *incerta sedis* until specimens could be examined and the relationships of the species determined.

Through the courtesy of John M. Legler of the Museum of Natural History, University of Kansas, I have been able to study a specimen of *Leptodeira discolor* obtained six miles southeast of Tamazulápam, Oaxaca, México, by J. R. Alcorn on June 22, 1955. Superficial examination of the external characters of this snake shows a striking resemblance to *Leptodeira*. The specimen has a vertical pupil, divided anal, 21 scale rows, and two apical pits. The enlarged posterior maxillary teeth are without a trace of a groove. Examination of the hemipenis revealed that the organ was bifurcate and had a forked sulcus; these penial characteristics are diagnostic of the subfamily Xenodontinae and not the subfamily Colubrinae that includes the genera *Hypsiglena* and *Leptodeira*.

Examination of all available xenodontine genera indicates that this snake belongs to a heretofore unnamed genus. In recognition of the mental torment customarily suffered by workers attempting to ascertain the relationships of the many genera of colubrid snakes, I propose the generic name

Tantalophis, new genus

Leptodeira (in part), Günther, Proc. Zool. Soc. London, pp. 317-318, 1860; Garman, Bull. Essex Inst., vol. 16, p. 23, January 9, 1884; Dunn, Proc. Nat. Acad. Sci., vol. 22, pp. 697-698, December, 1936; Duellman, Bull. Amer. Mus. Nat. Hist., vol. 114 (1), pp. 95-96, February 24, 1958.

Hypsiglena (in part), Cope, Bull. U. S. Nat. Mus., no. 32, p. 78, 1887; Günther, Biologia Centrali-Americana, Reptilia, pp. 137-138, pl. 49, fig. A,

October, 1894; Boulenger, Catalogue Snakes British Museum, vol. 2, p. 211, September 23, 1894; Mocquard, in Duméril and Bocourt, Mission Scientifique Mexique l'Amérique Centrale, vol. 3, p. 871, 1908; Amaral, Mem. Inst. Butantan, vol. 4, p. 183, May, 1930.

Pseudoleptodeira (in part) Taylor, Univ. Kansas Sci. Bull., vol. 25, no. 15, p. 343, June 1, 1938.

Type Species.—*Leptodeira discolor* Günther, Proc. Zool. Soc. London, pp. 317-318, 1860.

Diagnosis.—A xenodontine colubrid snake having a bifurcate hemipenis with a forked sulcus spermaticus, many longitudinal folds on basal portion, and small spines and calyces on distal part; 12 or 13 maxillary teeth followed by short diastema and two somewhat enlarged maxillary teeth lacking grooves; small parotid gland; normal colubrid skull; no hypapophyses on posterior vertebrae; elliptical pupils; two apical pits; smooth scales; normal colubrid head shields; divided anal; paired caudals.

The generic name comes from the Greek *Τάνταλος*, a mythological character symbolic of eternal torment, and from the Greek *ὄφις* for snake.

Tantalophis discolor (Günther) New comb.

The synonymy for the species is indicated in the account of the genus. The description below of the species is based on an adult male from 6 miles southeast of Tamazulápam, Oaxaca, México (University of Kansas Museum of Natural History No. 40143).

Scutellation.—Head shields normal; upper labials 7-7 (third and fourth entering orbit); lower labials 9-9 (1-4 in contact with anterior chin-shield, 4 and 5 in contact with posterior chin-shield); preoculars 1-1 and not in contact with frontal; postoculars 2-2; temporals 1-2-3, 1-2-3; nasals divided by a distinct groove below nostril and faint groove above; portion of rostral visible from above, one-third length of internasals; internasals pentagonal and one-half as long as prefrontals; parietal suture approximately as long as frontal; ventrals 178; anal divided; caudals 80. Scales in 21 rows at midbody and showing the following reduction:

$$21 \frac{2+3 \ (130)}{2+3 \ (130)} \quad 19 \frac{8+9 \ (162)}{8+9 \ (152)} \quad 17 \ (178)$$

Coloration.—Dorsal ground-color light brown and extending onto edges of ventrals; transverse body blotches numbering 50, each $1\frac{1}{2}$ to 3 scales long and separated by light interspaces $1\frac{1}{2}$ to 2 scales long; blotches brownish black and extending onto second scale row; lateral intercalary spots forming dark smudges on rows 1 and 2. Top of head black, flecked with tan; nape cream, followed by dark band six scales long; dark nape stripe from posterior edges of parietals to first dark body band. Venter cream-tan; throat and labials cream; posterior margins of all upper labials and of lower labials 1-3 black-edged (Figure 1).

Size and Proportions.—Head and body 312 mm. long; tail 118 mm., amounting to 37.8 per cent of length of head and body.

Variation.—Data on the syntypes of *Leptodeira discolor* furnished by J. C. Battersby give some indication of the variation in the species. Both are males, and they have 175 and 180 ventrals, 88 and 89 caudals, 1 preocular, 2 postoculars, 1-2-3 temporals, 7 and 8 upper labials, 9 lower labials. They have

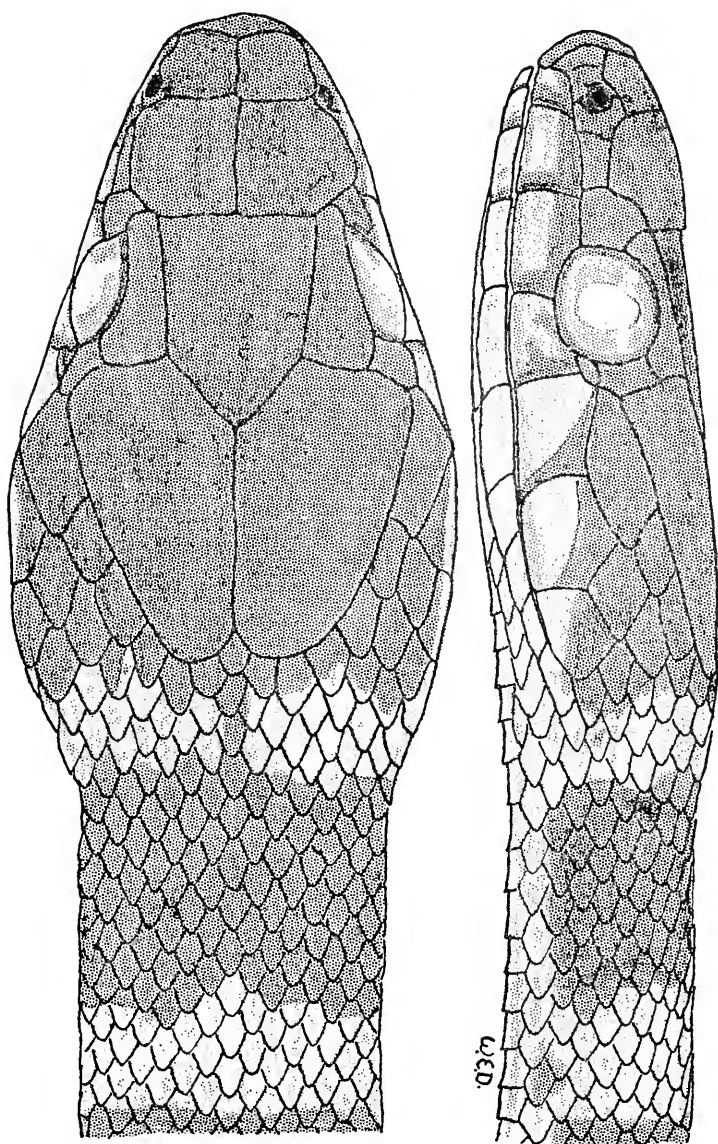


FIG. 1. Dorsal and lateral views of the head of *Tantalophis discolor* (Günther).
(KU No. 40143). $\times 7$.

body lengths of 365 and 402 mm., total lengths of 509 and 555 mm., tail/body ratios of 38.0 and 39.4. They have 51 and 54 dark blotches on the body.

Skull.—The skull is typically colubrid and shows no modifications. The quadrate has both a median and a lateral depression, forming a strong lateral flange on the anterior edge; the columellar process is elliptical, and the supra-columellar crest is robust. The posteroinferior vomerine process extends directly posteriorly and then angles sharply posterodorsally, enclosing an elliptical vomerine fenestra. The lateral processes of the premaxillary are slightly pointed; the median spine is relatively thin and high. The pterygoids bear 23 and 21 teeth that decrease in size posteriorly; the transpalatine articulating process of the pterygoid is rounded, not robust; the lateral crest is high and moderately robust; the depression in the ventral surface of the pterygoid is moderate. There are 12 and 13 maxillary teeth that increase in size posteriorly; these are followed by a short diastema and two larger, solid teeth. The prediastemal teeth are slightly curved and slender. The maxillary is laterally compressed; the posterior knob is not robust; there is one foramen in the lateral face of the bone (Figure 2). The 10 palatine teeth are almost uniform in size; the dentary bears 19 teeth that decrease in size posteriorly.



FIG. 2. Lateral view of the left maxillary of *Tantalophis discolor* (Günther). (KU No. 40143). $\times 17$.

A thin and otherwise small parotid gland or "venom sac" extends posteriorly from beneath the eye to about the angle of the jaw; a minute duct connects with the anteromedian surface and extends to the fleshy part of the mouth at the posterior end of the maxillary (Figure 3).

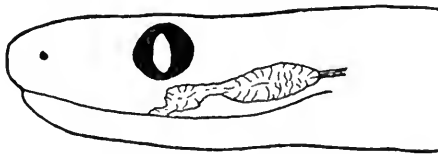


FIG. 3. Lateral view of the head of *Tantalophis discolor* (Günther), showing the position and relative size of the parotid gland. (KU No. 40143). $\times 3$.

Hemipenis.—In *situ* the hemipenis extends to the posterior edge of the thirteenth caudal. The unforked part of the organ is bedecked with numerous heavy longitudinal folds alternating with thinner folds. The basal parts of the two heads are covered with moderate sized spines, those closest to the base and the sulcus being the smallest. The distal parts of the heads are covered

with calyces. The sulcus bifurcates on the unforked part of the organ at a point about two-thirds of the distance from the base to the division of the organ. The sulcus is a deep groove between heavy folds proximally and is a shallower furrow distally (Figure 4).

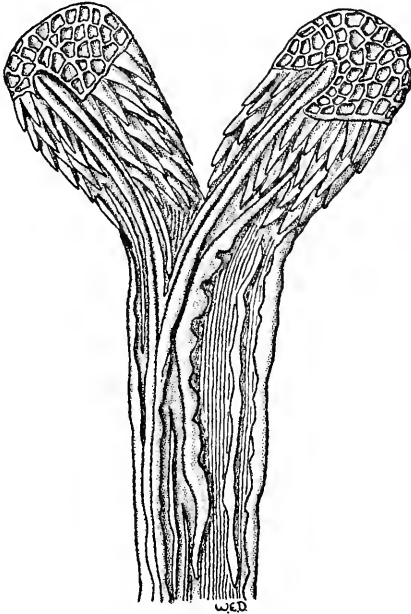


FIG. 4. Hemipenis of *Tantalophis discolor* (Günther). The organ was cut on the ventral surface and opened. (KU No. 40143). $\times 4$.

Relationships.—Using Dunn's (1928) arrangement of the American colubrid snakes as a guide permits the taxonomist to group *Tantalophis* with several genera, some of which occur in South America and others in the West Indies. Although the significance of such generic characters as scale pits and nature of the hemipenis is not clear, these characters must, of necessity, be utilized in attempting to ascertain the relationships of *Tantalophis* to other colubrid snakes. Assuming that the primary divisions of the American colubrids into subfamilies based on the nature of the sulcus spermaticus and the presence or absence of hypapophyses on the posterior vertebrae have some reality, *Tantalophis* must be placed in the subfamily Xenodontinae comprising genera chiefly South American in their distribution, but with several genera in Middle America and a few in North America and the West Indies.

In order to limit the number of genera to be compared with *Tantalophis*, only those xenodontines having apical pits and bifurcate hemipenis are considered. These include *Cyclagras*, *Drepanoides*, *Hypsirhynchus*, *Ialtris*, *Leimadophis*, *Pseudablables*, *Siphlophis*, *Tachymenis*, *Tomodon*, and *Trypanurgos*. Aside from differences in scutellation, *Leimadophis*, *Siphlophis*, and *Trypanurgos* have the heads of the hemipenes terminating in a disc, and *Ialtris* has a plicate hemipenis. *Tomodon* has basal spines on the hemipenis. The hemipenes of the other genera have proximal folds, distal spines, and distal calyces, not greatly unlike the condition found in *Tantalophis*. Of these, *Cyclagras*, *Hypsirhynchus*, and *Pseudablables* have round pupils and certain differences in scutellation. *Drepanoides* and *Tachymenis* have elliptical pupils like those of *Tantalophis*, but *Tachymenis* has only one apical pit, and *Drepanoides* has one apical pit or none. In the above characters no especially close relationship between *Tantalophis* and any one of these genera is apparent.

If the characteristics usually employed in distinguishing and relating genera are ignored and other more subjective criteria are used, the relationships of *Tantalophis* still remain obscure. Of the xenodontine genera *Tantalophis* approaches *Leimadophis* in general physiognomy; perhaps it represents an early divergent stock of *Leimadophis* that has undergone radical changes in the hemipenis and other characters. On the other hand, if the nature of the hemipenis is of no importance in defining supergeneric groups of colubrid snakes, *Tantalophis* may have its relationships with *Leptodeira* and *Hypsiglena*. Although herpetologists have been working intensively on American colubrids for many decades, the relationships of the majority of the groups are not well understood. Until the hemipenes and skulls of all of the forms have been studied and compared, and the evolutionary significance has been determined for the characters of the hemipenes, dentition, and apical pits, our knowledge of the relationships of these snakes will be incomplete.

Remarks.—The individual on which this paper is based is the only specimen of the species with definite locality data. It is from a locality six miles southeast of Tamazulápam in northwestern Oaxaca. This town lies at an elevation of about 6500 feet in the upper reaches of the Balsas Basin, an arid interior valley that expands in its upper end to form a broad basin of rolling and dissected terrain ranging from about 4000 to 6800 feet in elevation. The countryside around Tamazulápam is arid and supports plants of the genera *Prosopis*, *Acacia*, *Ipomoea*, and *Cassia*, and also columnar cacti. Oaks and pines grow on the limestone hills rising above the

rolling valley. *Tantalophis* may be endemic to the Balsas Basin, as are many other species of reptiles. However, if the snake has its relatives to the south in lower Central America and South America, such a distribution seems unlikely, even for an apparent relict.

Acknowledgments.—For permission to study and report on this specimen I am indebted to Dr. E. Raymond Hall and Mr. John M. Legler. I am grateful to Dr. Laurence C. Stuart for many helpful suggestions and to Dr. Norman E. Hartweg for placing at my disposal the facilities of the Museum of Zoology at the University of Michigan.

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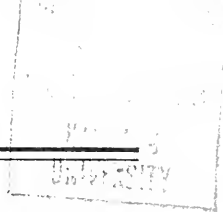
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Transmitted March 11, 1958. Contribution No. 11 from the Department of Biology, Wayne State University, Detroit 2, Michigan.

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MUSEUM OF NATURAL HISTORY

Volume 11, No. 2, pp. 11-62, 9 figs. in text, 9 tables

September 19, 1958

Natural History
of the Six-lined Racerunner
(*Cnemidophorus sexlineatus*)

BY

HENRY S. FITCH

UNIVERSITY OF KANSAS

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—1958

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- Index. Pp. 651-681.
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- Vol. 5. 1. Preliminary survey of a Paleocene faunule from the Angels Peak area, New Mexico. By Robert W. Wilson. Pp. 1-11, 1 figure in text. February 24, 1951.
2. Two new moles (Genus *Scalopus*) from Mexico and Texas. By Rollin H. Baker. Pp. 17-24. February 28, 1951.
3. Two new pocket gophers from Wyoming and Colorado. By E. Raymond Hall and H. Gordon Montague. Pp. 25-32. February 28, 1951.
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5. Comments on the taxonomy and geographic distribution of some North American rabbits. By E. Raymond Hall and Keith R. Kelson. Pp. 49-58. October 1, 1951.
6. Two new subspecies of *Thomomys bottae* from New Mexico and Colorado. By Keith R. Kelson. Pp. 59-71, 1 figure in text. October 1, 1951.
7. A new subspecies of *Microtus montanus* from Montana and comments on *Microtus canicaudus* Miller. By E. Raymond Hall and Keith R. Kelson. Pp. 73-79. October 1, 1951.
8. A new pocket gopher (Genus *Thomomys*) from eastern Colorado. By E. Raymond Hall. Pp. 81-85. October 1, 1951.
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- *10. A synopsis of the North American Lagomorpha. By E. Raymond Hall. Pp. 119-202, 68 figures in text. December 15, 1951.
11. A new pocket mouse (Genus *Perognathus*) from Kansas. By E. Lendell Cockrum. Pp. 203-206. December 15, 1951.
12. Mammals from Tamaulipas, Mexico. By Rollin H. Baker. Pp. 207-218. December 15, 1951.
13. A new pocket gopher (Genus *Thomomys*) from Wyoming and Colorado. By E. Raymond Hall. Pp. 219-222. December 15, 1951.
14. A new name for the Mexican red bat. By E. Raymond Hall. Pp. 223-226. December 15, 1951.
15. Taxonomic notes on Mexican bats of the Genus *Rhogeössa*. By E. Raymond Hall. Pp. 227-232. April 10, 1952.
16. Comments on the taxonomy and geographic distribution of some North American woodrats (Genus *Neotoma*). By Keith R. Kelson. Pp. 233-242. April 10, 1952.
17. The subspecies of the Mexican red-bellied squirrel, *Sciurus aureogaster*. By Keith R. Kelson. Pp. 243-250, 1 figure in text. April 10, 1952.
18. Geographic range of *Peromyscus melanophrys*, with description of new subspecies. By Rollin H. Baker. Pp. 251-258, 1 figure in text. May 10, 1952.

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UNIVERSITY OF KANSAS PUBLICATIONS
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Volume 11, No. 2, pp. 11-62, 9 figs. in text, 9 tables

September 19, 1958

Natural History
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UNIVERSITY OF KANSAS

Lawrence, Kansas

PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS

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27-3118

Natural History
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HENRY S. FITCH

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INTRODUCTION

Opportunity to investigate the interrelationships of many common species of the same ecological community was afforded the writer in 1948 with the creation of the University of Kansas Natural History Reservation. On this area six miles north northeast of the University of Kansas campus at Lawrence, the species of vertebrate animals have been investigated in an order somewhat proportional to their abundance and conspicuousness. Since the Reservation has been protected as a natural area, ecological succession has proceeded; species of native plants and animals that were scarce or restricted in distribution on the area have, in some instances, greatly increased. Concurrently, certain other species that had thrived under the habitat conditions created by cultivation or heavy grazing have decreased or disappeared. Among the latter species adversely affected by the successional changes, is the six-lined racerunner.

Belonging to a genus the species of which are primarily inhabitants of deserts or other arid regions, this racerunner has in the course of its evolution, penetrated far to the north and east of most of its congeners, into a region which, under original conditions was chiefly deciduous forest. It exists partly in disjunct populations, selecting mainly habitats of xerose aspect such as sand dunes, beaches, and the edges of cultivated fields. On the Reservation, deeply incised gullies in fallow fields, heavily grazed pastures, and exposed soil and rock of a limestone quarry created favorable habitat, and racerunners were numerous in localized colonies. Under protection, after 1948, herbaceous vegetation grew luxuriantly in the former pastures, and progressively encroached onto the barren areas of soil and rock on the eroded gully banks and at the quarry. In the course of this change, the racerunner's habitat shrank and its numbers were correspondingly reduced. Because of variation in the annual weather cycle, there were occasional reversals of the general trend; drought delayed the course of succession and permitted the racerunner to regain some of its losses, in numbers and in area occupied. However, in the summer of 1957, rainfall was above average, and racerunners on the area were further reduced, to the point where few were recorded, and no significant additions were made to the data already accumulated. With the conviction that the species is disappearing from the area, and that future field work there can be more profitably devoted to animals of other kinds, I have undertaken the preparation of this report, despite the

fact that much still remains to be discovered concerning the ecology of the six-lined racerunner.

My study is based upon the records of 230 individual racerunners caught, or seen and recognized in the field, a total of 581 times. I have collected and observed racerunners in many other places in Kansas. Also I have examined a series of 226 racerunners (mostly from Kansas) in the University of Kansas Natural History Museum for certain supplementary items of information.

Credit is due to my son, John H. Fitch, and my daughter, Alice V. Fitch, for assistance with field work, particularly in the capture of live racerunners, which required the combined efforts of two or more persons for best results in maneuvering the lizards into traps.

METHODS

In the course of routine field work, racerunners were observed from time to time. Some were caught when they were discovered inactive beneath rocks. Others were caught in traps that were set primarily for animals of other kinds, pitfalls made of gallon cans sunk in the ground at strategic locations, and especially cylindrical wire funnel traps (Fitch, 1951). In 1952 and later years attention was concentrated on a colony living along an old diversion ditch near the headquarters of the Reservation. Many funnel traps with several screen drift fences were installed to intercept those racerunners that used the bare soil of the ditch banks as travelways. The traps were checked several times daily at the season when the lizards were most active, and occasionally a lizard that was moving near a trap was chased toward and into it.

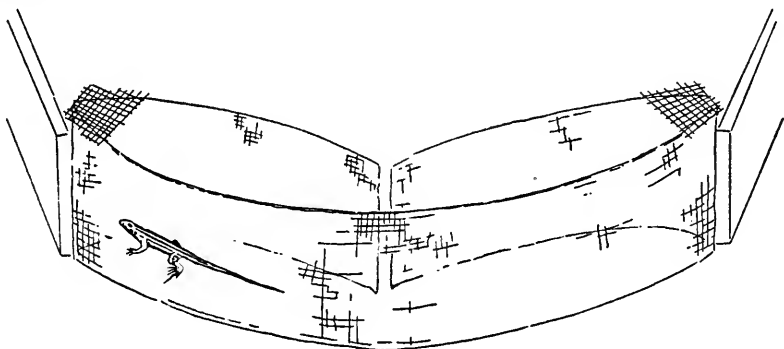


FIG. 1. Diagram of "corral trap," used for capture of racerunners, viewed from above and behind. The enclosure is open on top, except for a small piece of wire mesh at each of the two ends to prevent the lizard from climbing out.

Later, portable "corral traps" were devised, each consisting of a piece of hardware cloth wire of $\frac{1}{4}$ inch mesh, about one foot wide and six feet long, set up on one edge and bent into a bilobed enclosure. The two lobes were compressed to narrow, angular shape, and in the apex of the V between them,

the ends of the strip almost met, leaving a narrow entrance (Fig. 1). This device was used with the assistance of a second person; when a racerunner was sighted, one person kept it under observation while another set up the trap, usually at a distance of 30 to 50 feet. The edge of the wire was worked into the loose soil, so that the lizard could not easily escape by passing beneath, and an eight-inch square of hardware cloth was set horizontally over the end of each lobe to hinder the lizard from climbing or jumping out. A board several feet long and six or eight inches wide was set up on edge, projecting from each wing of the trap as a "drift fence." Both persons then maneuvered to the side of the racerunner opposite the enclosure, and advanced cautiously, directing the animal's movements with slender poles, and steering it toward the enclosure without alarming it unduly by sudden movements. When the racerunner had progressed to a point between the two converging boards, it could usually be driven into the enclosure by a direct approach.

Even after the quarry's entry into the enclosure, a capture was by no means assured. Within a few seconds the racerunner's attempts to escape would become frantic. It could burrow under the wire with a few rapid strokes of its forefeet, and could make an exit even more speedily by climbing or jumping the barrier. Almost perfect timing was required to drive the lizard into one corner and seize it as it climbed the wire. Many of those driven into the enclosures escaped; nevertheless the method was rather effective, and served in the capture of a large proportion of the racerunners that were recorded. In collecting various species of desert lizards, I have used the same device with notable success. Important advantages of the "corral trap" method were that the individual racerunner's normal activities were only briefly interrupted and it was not exposed to unfavorable weather, predators, or to lack of food. Significant records of body temperature were obtained from the lizards driven into corral traps while those caught in other traps usually had been confined so long that their temperatures were altered beyond their control.

Smaller numbers of racerunners were caught by hand. Most of these were hatchlings; they permitted closer approach than did the adults, and had less endurance. After a hatchling had been chased several times in succession from one shelter to another it seemed to tire and become less inclined to run but was more inclined to hide. It might permit approach to within a few feet while skulking behind a clump of grass. Sometimes I was able to seize such a lizard, by waiting until it momentarily closed the eye that was directed toward me. Chances of catching a racerunner in this way were best when the air temperature was relatively low; the animal then was reluctant to run, and was slower than usual in its movements. Several had much lower temperatures than that which racerunners usually maintain.

In the field I usually carried a quick-reading Schultheis thermometer and at each capture of a racerunner, in a corral trap or by hand, I recorded body temperature by inserting the bulb into the cloaca for approximately 15 seconds, meanwhile holding the lizard through several thicknesses of cloth, to prevent conduction of heat from my hand.

Racerunners were permanently marked for individual recognition by clipping off two toes (always on different feet) near their bases and deriving a formula from them. The clipped toes healed rapidly and seemed to inconvenience the racerunners little or not at all. Probably those individuals marked were somewhat handicapped by loss of two of their ten toes, but speed and

agility were not noticeably affected, and it seems that the mutilation involved in marking was not often a decisive factor in the survival of the individual. Racerunners were marked also with black ink in the early stages of the study, and later with bright colored enamel paint. Loss of these colors served as an indication that a lizard had molted; also the color served to render the individual recognizable, as each had paint on a different part, such as the left side of the base of the tail, the right thigh, or the nape. The colors were conspicuous for a day or more but dulled rapidly as a result of adhering of soil, and wearing off of the paint. After a week a mark was usually so obscure that it could not be recognized with certainty unless the lizard was in hand.

The sight records obtained from such individuals served to supplement much more numerous records based on actual captures, with regard to movements and molt. Ordinarily each racerunner captured was transferred to a small cloth bag and brought back to the laboratory, where it was measured, weighed, marked with paint, and toe-clipped (if it happened to be an individual not marked previously). Those caught at the diversion ditch near the Reservation headquarters were ordinarily returned the same day but those from more remote study areas were of necessity most often kept a day or two in the laboratory. The racerunners caught in 1949 were mostly released without being brought back to the laboratory. They were weighed with spring scales accurate to within two grams, but only those weights obtained by means of a laboratory balance accurate to 0.1 gm. were actually used in preparing the following account.

RELATIONSHIPS

The six-lined racerunner is a member of the large family Teiidae, which includes about 37 genera and 200 species (Darlington, 1957:216). All the genera occur in South America, and only two (*Cnemidophorus* and its near relative *Ameiva*) range much farther north. The South American tegu is a giant of the family (three feet long), and its genus, *Tupinambis*, is known from the Oligocene and Pliocene of Argentina. *Cnemidophorus* is the only teiid genus occurring north of the Neotropical region, and is known from the Pliocene of North America. In its modern distribution the genus centers in desert regions of the Mexican Plateau and the southwestern United States. Of approximately 20 species in this genus, the six-lined racerunner is the most northern in its over-all range although a widespread, desert living, western species, *C. tigris*, attains a latitude in central Oregon approximately the same as that reached by *C. sexlineatus* in Minnesota and Wisconsin. Of five natural species-groups within the genus, recognized in the most recent revision (Burt, 1931), the *sexlineatus* group is one of the most advanced, characterized by peculiarities in the arrangement of the cephalic shields, and by the stripes on back and sides; it ranges throughout Guatemala, most of Mexico, and the central and southern United States, except the far West. *C. sacki*, with many subspecies, occupying most of Mexico and much of the southwestern United States, is the central species of this group, and may most closely resemble the ancestral type from which the others have been derived. *C. sacki* differs from *sexlineatus* in larger size, more sluggish behavior, and spotted pattern, with partial loss of stripes. *C. sacki octolineatus* of Arizona, New Mexico, and adjacent regions shows no differences between the sexes in coloration or bodily

proportions whereas in *C. sacki gularis* of Texas there is striking difference between the sexes. The male of *gularis* has an orange throat and deep blue on the belly in contrast to the cream color of the ventral surface of the female. *C. s. gularis* seems to be the nearest relative of *C. sexlineatus* and the ranges of the two overlap in approximately the eastern half of Texas and much of Oklahoma.

HABITAT

The habitat of the six-lined racerunner has been amply described by earlier writers. Burt (1931:91-92) quoted the statements of nearly all those authors whose publications preceded his own. Of eleven authors, quoted by Burt who described the habitat in ten different states representative of the entire range, eight mentioned sandy situations which seemed to be the chief feature that habitats had in common, although the racerunner is not invariably confined to places where there is sand. Three of the authors alluded to high or hilly habitat, two described the habitat as dry, two mentioned plowed fields, and two mentioned rocky hills. One statement contrasting with the general trend of all the others was that of Strecker (1915:24) describing the species as ". . . partial to wooded bottom lands" in the southwestern part of its range near Waco, Texas, although he also described the species as common in cutover pine woods (which presumably were sandy uplands) in the more eastern part of the state.

The following briefly quoted statements, from more recent authors, describe the habitat in 13 states, representative of the entire geographic range. Coastal Virginia: ". . . along sandy roads and in borders of fields . . .", Richmond and Goin (1938:308). Eastern North Carolina: ". . . beach drift . . . on coastal banks . . . isolated sandy areas", Robertson and Tyson (1950:136). South Carolina: ". . . open and grassy portions of the dry pinewoods . . .", Malnate (1944:729). Florida: ". . . not entirely restricted to xeric situations . . . plowed up in deep damp muck . . . wet sand under logs on lake beaches", Carr (1940:74). Indiana: ". . . dry, almost arid, habitat . . . sand dune country . . . crests of the Bald Knobs . . .", Minton (1944:449). Mammoth Cave region of Kentucky: ". . . paths and in old fields where there are clearings", Hibbard (1936:280). Western Tennessee: ". . . in both uplands and river bottoms, usually near forests or thickets . . . sandy and gravelly regions . . .", Parker (1948:25). Mississippi: "dry, sandy or gravelly soil . . . corn and cotton fields . . ." Cook (1943:13). Southeastern Minnesota and adjacent Wisconsin at the northernmost stations of occurrence: "dry hillsides . . . cinder fills along railroad . . . steep gravel sides of a ravine with red cedar and sandburs . . . sand beach of the river at the foot of a steep sand and gravel bluff", Breckenridge (1943:95). Nebraska: ". . . dry, sandy places . . .", Hudson (1942:40). Southeastern Missouri: ". . . dry, open woods and glades . . .", Boyer and Heinze (1934:192). Southeastern Oklahoma: ". . . weeds along the roads, in open fields, along the fence rows, and along the edges, and in open glades of the forest." Trowbridge (1937:294). Lake Texoma area in Oklahoma and northern Texas: ". . . well drained areas . . . free of timber . . . especially sand dunes", Bonn and McCarley (1953:469).

Burt (1931:92) described the habitat in Kansas as including rocky hillsides,

fields cultivated for corn and wheat, upland meadows, sandy riverbanks, chalk cliffs, railroad embankments, road beds, sand dunes, rock outcroppings, and wooded hillsides. Burt indicated that in Kansas the racerunner occupies a greater variety of habitats than does any other kind of lizard, and speculated that a high moisture content of the soil surface was the chief limiting factor as the species was rare in places where the soil was loamy. Twenty-five years later, Smith (1956:206) made the following statement regarding the habitat in Kansas: "The habitat is in relatively dry areas, where sandy or other loose soil, short grass, and other kinds of low vegetation occur. The chief requirement seems to be a certain degree of dryness. The land may be flat or hilly, and the soil coarse or fine." Near Fort Leavenworth, in the northeastern corner of Kansas, Brumwell (1951:204) found the racerunner to be the most abundant lizard, living in woodland, especially about rotted logs and rock ledges.

My own observations indicate somewhat different habitat preferences in different parts of the state. In the Chautauqua Hills area representing approximately the westernmost extent of the original deciduous forests, and located about $\frac{3}{4}$ of the distance east across the state from the western boundary, and in the southern one-third, the species is especially abundant. Here the rocky woodlands support mostly scrubby oaks, especially post oak and black-jack oak, and underbrush is sparse. Farther east and north, in more mesic types of woodlands, with more continuous leaf canopy, and more underbrush shading the ground, the racerunner is confined to open situations. The racerunner does not thrive in a typical prairie habitat, either of tall-grass type or of short-grass. Where it occurs in prairies, it requires patches of open ground such as are produced by excessive grazing or trampling (especially about salt-licks or watering places of livestock) or such as occur naturally, along eroded gully banks and stream edges, or on slopes and hilltops where soil is shallow and rocky, and vegetation is sparse.

In northeastern Kansas I have found the racerunner to be most abundant in sandy situations, and also fairly numerous about heavily grazed rocky pastures. Often it is found in cultivated fields but usually near their edges. The species is abundant in sandy lowland areas near the Kansas River. In the great flood of July, 1951, when the river's floodplain was entirely inundated, the population of racerunners was mostly destroyed, and they did not recover their former numbers for several years, despite the favorable habitat conditions created by extensive sandy deposits. In May, 1957, I found racerunners abundant along the south bank of the Kansas River a few miles west of Lawrence, in Douglas County. Here groves of young cottonwoods and thickets of willow had sprung up since the flood, creating an abundance of shelter. About the razed remains of an old building destroyed in the flood, the lizards were especially numerous, and when disturbed, they sought shelter beneath the piled debris of boards and shingles. The sand there was riddled with their burrows. Often several racerunners were in sight at the same moment.

On the Reservation in 1948, racerunners were localized, and occupied only a small part of the square mile. None was seen in most of the cultivated fields. They were mostly in rocky and brushy parts of the heavily grazed pastures, and occasionally appeared on roads and gully banks. Some were present in a much eroded upland field, which had been fallow for several years.

CYCLES OF ACTIVITY AND TEMPERATURE RELATIONSHIPS

Daily and seasonal activity

Various observers have noted that racerunners are not uniformly active throughout the day, but have periods of relatively concentrated activity in the open and spend a greater part of the time in retirement. Taylor (1935:211) wrote that in Arkansas near Devall Bluff, in July, racerunners emerged daily about 11 A. M. to begin feeding, and disappeared into their burrows about 3 P. M. Oliver (1955:133) wrote that in Florida in April the racerunner becomes active about 9:45 A. M. and remains more or less active until about 4 P. M., but that late in summer when midday temperatures are higher, it is abroad only in early morning and late afternoon.

Milstead (1957:111) studying four other species of *Cnemidophorus* (*perplexus*, *sacki*, *tessellatus*, and *tigris*) in western Texas, found that in summer the daily activity began between 7:00 and 9:00 A. M., continued until from 11:00 A. M. to 1:00 P. M., and was resumed near 5:00 P. M. He concluded that soil temperature was more critical than air temperature; the lizards were active at soil temperatures of between 29° and 50° C.

By means of laboratory experimentation, Barden (1942) determined that under normal conditions of light and temperature, racerunners attained a peak of activity between 10 and 11 A. M. When kept in complete darkness (at 85°F) or in constant artificial light, the lizards tended to retain the same cycle but this could be altered by reversed illumination. Technique in this study involved suspending the racerunners' cage from a sensitive brass spring, so that movements of the cage were recorded on a kymograph.

In my own experience on the Reservation, the daily schedule of racerunners is somewhat variable according to the individual, the season, and especially the temperature. On some warm summer days most of the population is active by 8 A. M., and by noon most have returned to their burrows. In mid-afternoon, the hottest part of the day, activity was usually at low ebb, and the few individuals that remained active above ground kept to shaded spots and travelled little. At temperatures higher than 90° F, when the sun was shining brightly, the soil surface was probably too hot to permit the lizards to forage comfortably; they were usually seen at somewhat lower air temperatures. On cloudy days the racerunners did not emerge at the usual time, but might remain in their burrows all day, or might emerge, hours later than usual, whenever the sun was shining. For 25 individuals that I caught by hand, time of capture was rather evenly distributed from 8 A. M. to 3 P. M.

Opportunity and effort to obtain records of racerunners varied considerably during the course of the study. Nevertheless, the monthly totals in Table 1 show well defined trends of increasing and decreasing activity in the course of the growing season. Only a few records were obtained in April, but activity rapidly increased in May to a peak in June, then abruptly fell off in July, August and September, with only an occasional record in October (Fig. 2).

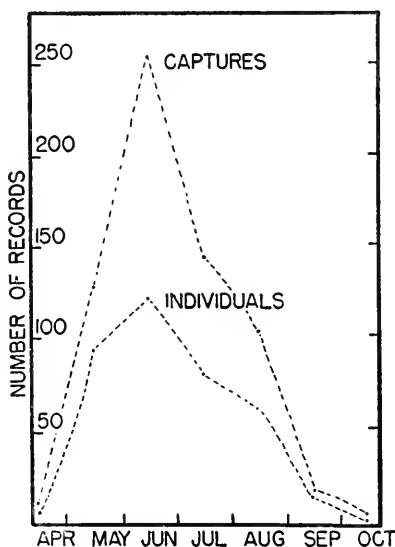


FIG. 2. Seasonal incidence of records for racerunners on the University of Kansas Natural History Reservation. Combined data for nine consecutive years are represented. Activity begins in late spring, reaches a peak in June, and then declines rapidly.

Effect of Temperature

Bogert (1949) originally called attention to the fact that lizards, in the course of their normal activities usually maintain high and fairly uniform body temperatures, the preferred level being characteristic of the species, with differences between genera and families. Of various lizards studied by Bogert, the racerunner was found to maintain temperatures higher than those of any other kind. Bogert found that in *Cnemidophorus sexlineatus* of Florida, the optimum body temperature and temperature range were both similar to those of *C. tigris* living on the Arizona desert under much different habitat conditions. Both species were found to have preferred body temperatures several degrees higher than the species

of *Sceloporus* (*S. woodi* and *S. magister*, respectively) that shared their habitats.

Of the one hundred body temperatures that I recorded (Fig. 3), three-fourths were in the five-degree range, 38° to 42°. Racerunners will tolerate a range some 5° below the optimum before they seek shelter, but will tolerate only about 2° above it. Milstead (*op. cit.*:112) found that in four other species of *Cnemidophorus* in Texas, body temperature in the normal range of activity varied between 36° and 40°.

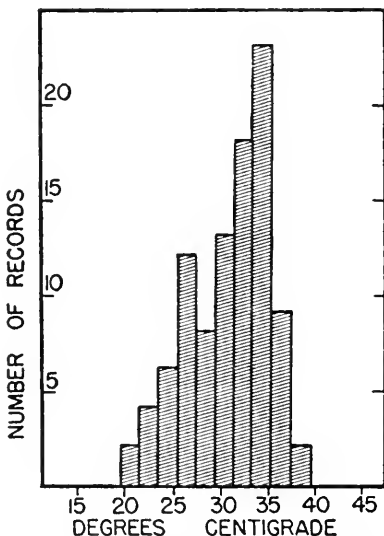


FIG. 3. Air temperatures at which records of active racerunners were obtained. The records are distributed over a 20-degree range, but are concentrated between 33° and 35°C.

The lowest air temperature at which I found a racerunner in the open was 20.4°; the lizard, chased into a trap, was found to have a body temperature of 37.1° C. At the same time another found already in a trap but basking in the sunshine, had a body temperature of 35.3°. Early in the afternoon of June 1, 1956, at an air temperature of 21.5°, three racerunners, caught while they were active, had body temperatures of 37.0°, 38.6°, and 39.6° C. On May 26, 1956, an adult female, which had just sought shelter under a board after the sun had disappeared behind a cloud, was found to have a temperature of 36.4° when the air was 29.0° C. On June 1,

1955, when the sky was overcast (air 25.0°, soil surface 28.2° C) only one racerunner could be found active along the diversion ditch where many usually could be seen at times favorable for their activity. The lone racerunner was noticeably slower than usual in its

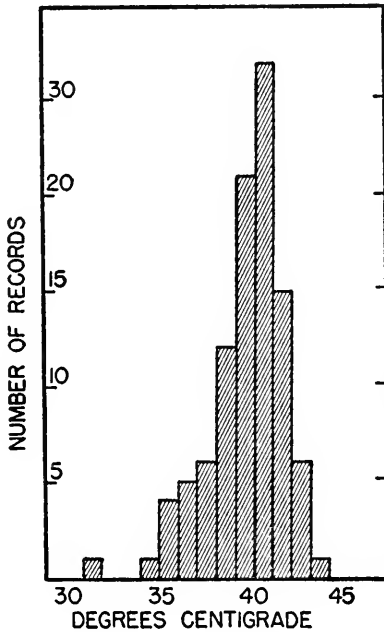


FIG. 4. Body temperatures of active racerunners; the range is narrow and the preferred level is high, between 40° and 41°C.

movements because of low temperature; nevertheless it easily avoided capture by hand. On June 5, 1954, a recently caught adult male was weighed and measured in the laboratory at a body temperature of 26.5°C. He was able to run and dodge with some agility when released on a table top, but was so much slower than normally active racerunners that he was easily recaptured. As I reached for him, he turned and snapped at my fingers. On May 4, 1955, an adult caught the day before and kept overnight in the laboratory was found to have a body temperature of 19.5° when handled. It was stiff and slow, although it struggled vigorously. When released on a table, it could not rise up on its legs to run, but progressed with a sprawling gait and was easily recaptured. On September 23, 1952, a juvenile was weighed and measured in the labora-

tory at a temperature of 14°. When released on a table, it tried to run, dragging itself with stiff, heavy movements, and after it had progressed a few inches and bumped into the wall, it subsided into quiescence.

In 1955 racerunners became active in a warm period of late April and early May. Nevertheless, in the second week of May, with the return of somewhat lower temperatures, none was seen; even temperatures in the low seventies (F) were too cold for the lizards to emerge, despite bright sunshine.

Hibernation

Feeding and reproductive activity are concentrated in late spring and early summer. After July, activity wanes and the adult racerunners spend more time in their burrows and are seen with decreasing frequency; they are rarely seen in September even though summer weather may still prevail. Whether such racerunners emerge regularly each day, even for brief periods of activity, seems doubtful. They probably burrow to depths where temperatures are fairly stable, and far below those that they require for full activity, then lapse into a semitorpid state, which passes into true dormancy with the onset of winter. Because the racerunner's lower limits of temperature for various activities such as locomotion, feeding, and mating, are all relatively high, the species emerges relatively late in spring. On the Reservation it was consistently the last species of common reptile to appear each spring. Cook (1943:13) wrote that in southern Mississippi racerunners seldom emerge from hibernation before the first of April, whereas in the northeastern part of the state they usually are not in evidence until mid-April. In northern Florida the racerunner's hibernation begins in October and ends in March or April (Oliver, 1955:118). Neill (1948:109) stated that in Richmond County, Georgia, the racerunner remains active late in the autumn, but is the last species of reptile to emerge in summer. Neill described hibernation burrows, which usually end beneath a large rock. The lizards found in these hibernation dens were sometimes single and sometimes in twos and threes. The hibernating racerunners were able only to writhe and gape when uncovered. Carr (1940:74) discussing habits of the species in Florida, wrote: "They hibernate under six or eight inches of sandy soil; two specimens have been found in gopher [turtle] holes." In Indiana, Minton (1944:449) found that racerunners seldom emerge before mid-May and retire to hibernation

in early September. Burt (1933:191) recorded finding three racerunners (two adults and one juvenile) with a collared lizard (*Crotaphytus collaris*), all hibernating together under a deeply embedded large rock, in Cowley County, Kansas, on March 6, 1933. These lizards were completely dormant and immobile.

No hibernating racerunners were found in my study, but in each of several years specimens were found in spring under deeply embedded rocks before any were found in the open. Such racerunners were in distinct nest cavities and often were in contact with the lower side of the rock, and were warm to the touch as a result of absorbed heat. The cavities occupied had no evident tunnels leading either to the outside or to possible hibernation sites at deeper levels, but it seemed most probable that the lizards had not yet emerged, having merely worked their way up from a lower level, compacting the soil as they progressed, until attaining contact with the comfortable warmth of the rock's lower surface.

Over a seven-year period, May 1 was the average date for earliest record of a racerunner in the open (Table 1), and the average

TABLE 1.—YEAR BY YEAR RECORD OF EVENTS IN THE ANNUAL CYCLE OF THE SIX-LINED RACERUNNER ON THE UNIVERSITY OF KANSAS NATURAL HISTORY RESERVATION.

YEAR	Earliest records		First recorded hatchling	Last recorded adult	Last recorded hatchling
	Under shelter	In open			
1949	.....	.....	August 13	September 19	.....
1950	April 14	April 26	September 3	September 1	October 10
1951	.....	May 2	September 13	.....	.....
1952	.....	April 29	August 13	September 16	September 21
1953	May 3	May 8	August 9	September 21	.....
1954	April 24	May 6	August 4	September 18	October 3
1955	April 18	April 21	.....	.....	.....
1956	.....	April 21	August 9	.....	.....
1957	May 10	.....	.....	.....	.....

deviation from this date was a little less than six days. For five different years of late season records for adults, September 15 was the average date, with an average deviation of five days. At the latitude of the Reservation the length of the growing season for the racerunner is thus about $4\frac{1}{2}$ months, but for an individual it probably averages somewhat shorter. Approximately two-thirds of the entire year is spent in hibernation.

MOVEMENTS

The only published statement known to me concerning home range in the six-lined racerunner is that of Oliver (1955:112), evidently based on his original observations in Florida: ". . . does not appear to maintain a definite territory, but wanders over a fairly large home range of 200 to 300 feet in diameter, perhaps more." In a much quoted statement concerning speed of the racerunner, Hoyt (1941:180) related an instance of one that ran on the road in front of a truck, gaining and then maintaining a speed of 18 miles per hour, for a period of a little more than a minute. It must have travelled for approximately $\frac{1}{3}$ mile in the same direction during the observation, but there is no reason for believing that this movement was entirely within the normal home range. The speed attained by this individual is possibly the maximum actually recorded for any reptile, although a few desert inhabiting lizards are generally supposed to be even swifter.

In the course of my study, 85 of the racerunners that were marked were subsequently recorded at different locations, affording information on their movements; 50 were recaptured only in the same season, 31 others after the lapse of one hibernation, four in three different seasons, and one in four different seasons. In some instances span of individual records was longer than these figures indicate, since a marked racerunner might be missed for an entire growing season, or even two, and then recaptured subsequently.

Because of the nature of the terrain on the Reservation, the racerunners recorded by me usually did not move freely in all directions, but tended to have their movements channeled linearly along rock outcrops or the barren banks of gullies or ditches. The shape of the home range was hence long and narrow, and the size may have been considerably different from that in locations where favorable habitat features were more generally distributed.

As a typical example of the movements recorded for the marked racerunners, a male first recorded on the ditch banks on May 20, 1955, still well below average adult size, was recorded two more times in the following month and on 23 additional occasions in late May, June and early July of 1956. All the 26 records were along the ditch; 16 including the first and last were at the same central location. Frequency of capture at this particular spot perhaps resulted not so much from the racerunner's preference as from the fact that a screen drift fence extended diagonally across the ditch

bottom, with funnel traps facing in either direction, which were fairly effective in intercepting travel. With respect to this central location, the other ten in the order they were recorded, were: 280 feet east, 30 feet west, 70 feet east, 305 feet east, 240 feet west, 40 feet east, 70 feet west, and 260 feet east. On several occasions within a few minutes after being released from a trap, this racerunner was seen in one of the more remote parts of the home range; hence it was obvious that the entire area was covered frequently. The ditch extended in both directions beyond the lizard's known range, and this individual probably would have been either trapped or observed at more remote locations if it had ranged consistently in those directions. The 545 foot stretch of ditch along which it was recorded probably was almost the full length of the home range, and the width of the area with bare soil or sparse vegetation used by the racerunners along this ditch averaged approximately 25 feet; hence the computed home range was 13,625 square feet, or .31 acre.

No other racerunners were caught so many times or at so many different locations as this one. Only a few were recorded along such a long segment of the ditch. Presumably in most instances the data are inadequate to show the full extent of the home ranges of the individuals involved. The racerunners that frequented the ditch probably had home ranges that were limited to this area, because nearby areas were, in general, not suitable habitat.

If recorded locations for an individual were distributed at random along the length of the elongate home range, any two records would be separated, on the average, by a distance equivalent to approximately 35 per cent of the area's full length. Even though individual racerunners were able to cover their whole ranges within a few minutes, and were not dependent on home bases, they tended to concentrate their activities at certain places where conditions were especially favorable for feeding, basking, or other essential functions. Traps were not randomly distributed either, and a disproportionately large number of captures were made at a few especially strategic locations. For 188 recorded movements of male racerunners between successive captures (or sight records), distance averaged 125 feet. The comparable figure for 102 movements of females was 171.3 feet. These figures exclude several exceptionally long movements between the hilltop quarry and the ditch at the base of the hill, which seem to represent shifts from one home range to another. Home range lengths along the ditch of 343 feet

for males and 440 feet for females are indicated, with actual areas of approximately .20 acre and .25 acre.

Home ranges of these sizes seem remarkably small for an animal that moves so rapidly and frequently as the racerunner. Milstead (1957:116-117) measured a home range of .53 acre for a marked individual of the desert living *Cnemidophorus tigris* for which 17 recoveries were recorded. Excluding one outlying point of recovery, this lizard's recorded locations all fell within an area of .26 acre. Milstead concluded that the home range may be divided into an area of greater activity and a contiguous area of lesser activity. My records of the six-lined racerunner also show a definite tendency to cluster in one part of the home range for most individuals.

In general, the conditions of my study were not well adapted for showing the longer movements made by racerunners, including exploration, possible migration, and shift from one home range to another. However, in the drought years of 1953, 1954, and 1955, when habitat conditions became more favorable for racerunners than in the several preceding years, the lizards appeared abruptly in places where they had not been seen before—in places in 1950 and 1951 where vegetation had been too dense for them. This prompt exploitation of newly available habitat demonstrated the potential vagility of the species. Six of the marked racerunners (three of each sex) were recorded to make fairly long movements that must have involved shifts in range; in every instance the shift was between the quarry and the ditch. For males distances in feet were: 700, 600 (and back again in the same season), and 1170. For females distances in feet were: 750, 750 (and back again in the same season), and 900.

The slope between the quarry and the ditch is woodland with brushy tangles. Little sunlight reaches the ground, and the habitat is unfavorable for racerunners. However, on a few occasions the lizards were seen on a trail that led from the ditch to the quarry.

BURROWS

The six-lined racerunner is well equipped for digging, having well developed and powerful forelegs with long, powerful claws, and spends much time underground in its burrows, even at the season of greatest activity. The burrows have several important functions. They provide nocturnal shelters (as these lizards are strictly diurnal and heliophilic), and are insulated retreats that are

used at any time when the lizard is inactive because of unfavorable weather conditions. For example, the burrow's shelter is sought at times when air and soil temperatures are so high that the racerunner cannot readily hold down its body temperature to the preferred level of around 40°C, since temperatures only slightly higher would be lethal. Also, in times of emergency when the lizard is hard-pressed by a pursuer despite its fleet and elusive running, a burrow constitutes the final refuge.

Where burrows of other small animals, such as mice, voles, or moles are abundant, the racerunner utilizes them and needs to do less digging than in places where such ready-made shelters are lacking. Where there are flat rocks, the racerunner digs beneath them and at the end of a short tunnel it excavates a disk-shaped cavity, just large enough to squeeze into when the long tail is curled up. Where rocks and burrows of mammals are absent, the racerunner does much digging. Burt (1928:43) stated that the burrows are used repeatedly. Boyer and Heinze (1934:192) described the burrows as forming a network of runways in dry open woods in southeastern Missouri in places where racerunners were abundant. Blanchard (1922:6) describing the habits of the racerunner in sandy areas of western Tennessee, stated: "The burrow is short and has two openings, and when the lizard is inside, one of these openings is partially filled with sand thrown out from within." Cook (1943:13) stated that in Mississippi the racerunner makes free use of mole runs in old abandoned fields. Edgren (1955:141) described the short, shallow tubular burrows that are used in the sand dune region of northern Illinois to escape unfavorably high surface temperatures. Taylor (1935) described the burrows of racerunners where the species was abundant in a cotton field near Devall Bluff, Arkansas; from two to four tunnels would meet in a somewhat enlarged cavity usually eight to ten cm. below the surface (maximum depth 14 cm.). Pearson and Nelson (1952:188) examined 40 burrows of the oldfield mouse (*Peromyscus polionotus*) in Marion County, Florida, and found that at least one-third had recent tracks of racerunners leading into the entrances. The lizards were found to have excavated lateral tunnels of their own, which led nearly to the surface and thus could serve as emergency exits.

At the old diversion ditch where my own observations were most concentrated the racerunners while foraging kept mostly to the nearly barren soil of the ditch bottom and banks, but when alarmed, they would retreat to nearby sheltering vegetation. Burrows and

surface runways of the prairie vole (*Microtus ochrogaster*) were numerous in the grass beyond the bank, and racerunners that were chased often took refuge in them. Also, they often escaped into burrows that were in the more barren areas. Some of these were old burrows of indeterminate origin, but most were probably made originally by the mole (*Scalopus aquaticus*). The mole does not leave open surface entrances; its tunnels become accessible when the layer of soil roofing them collapses, or when the lizards dig into them. In its foraging the mole excavates and soon deserts extensive tunnel systems, which then become available to the racerunner and many other small animals. Being a voracious predator, the mole would almost certainly kill and eat any racerunners it encountered in passing through its runways or digging new tunnels. Other small digging insectivores (*Blarina brevicauda*), mice (*Peromyscus* and *Reithrodontomys*) and even voles (*Microtus*) might sometimes prey on racerunners found in this manner at times when they were too sluggish to escape quickly.

Besides the old burrows of moles and other small mammals, there were many burrows on the ditch bank that were obviously excavated by the racerunners themselves. These burrows were of diameters only slightly greater than the lizards, and were concentrated in bare soil in what seemed to be the hottest and driest situations that could be found. They were on the sunny north bank of the ditch, and none was ever noted on the south bank, which was shaded throughout most of the day. Often burrows were noted to be plugged from within with finely pulverized soil. At times when I attempted to dig out such burrows, the lizard inside usually burst through the surface crust a few inches away and escaped. Ordinarily most of the burrows were not plugged and those dug out usually were unoccupied. Probably a racerunner frequently digs new burrows, and its attachment to any one burrow probably is temporary.

A hole is defended by the occupant against trespassers. On September 9, 1953, in a brief cloudy period, I saw a juvenile enter a burrow beneath a flat rock, and almost instantly it darted out again chased by another of about the same size. Within a few seconds the pursuer returned and re-entered its burrow.

In the summer of 1957 several racerunners were kept in a circular enclosure ten feet in diameter, with an 18-inch wall of sheet metal, buried in the ground for several inches. The lizards excavated many burrows in a sand pile at the center, and a few among rocks near the wall. Each individual seemed to have its own burrow.

FOOD HABITS

Burt (1928:58-61) summarized early published literature (Holbrook, 1882; Cope, 1866; Hartman, 1906; Ruthven, 1907; Ditmars, 1915; Taylor, 1916) concerning the racerunner's food, along with his own observations on captives offered a variety of foods, and his analysis of contents of 15 stomachs of specimens from Kansas. Ditmar's statement that "Adults are not adverse to feasting on eggs of small birds that nest on the ground" was rightly questioned by Burt, as the smallest eggs of ground nesting birds are much larger than items normally eaten by the racerunner. Other early authors referred to the racerunner's insectivorous habits, and its swiftness in securing such agile prey as flies, tiger beetles, cockroaches, spiders, and grasshoppers. Burt listed many types of insects obtained with a sweep net and offered to captive racerunners, that were eaten with relish. Insects that were rejected included ladybird beetles, large butterflies, and ground beetles (unless their elytra were removed). The 15 stomachs that Burt examined contained: grasshoppers and crickets (*Melanoplus*, *Nomotettix*, gryllid, tettigoniid) 41.5%; spiders (salticids, lycosids, etc.) 24.5%; lepidopterans (9 adult moths, 2 pupae and 12 caterpillars) 19.9%; snails (*Polygyra*, pupillids) 7.0%; beetles (*Sitonia hispidulus*, *Agonoderis obliquus*, *Arma*, *Baris*) 2.5%; ants and wasps (*Ponera*, *Crematogaster*, *Formica*, *Chalcis*, *Sigalphus*) 1.9%; flies (tachinids) .5%.

Boyer and Heinze (1934:192) mentioned a racerunner that disgorged a cutworm, and Breckenridge (1943:96) mentioned one that contained a medium-sized grasshopper. Force examined stomachs of 29 specimens from Okmulgee County, Oklahoma. Eleven had no food. In the remaining 18, food was found in the following percentages: locustids 52, arachnids 15, myrmicids and formicids 16, elaterids 3.5, unidentified larvae 9, mayfly and mosquito larvae each 1. Hudson (1942:40) recorded that five from Nebraska had eaten spiders, grasshoppers, beetles and their larvae, and bugs.

Racerunners that were foraging moved about jerkily, probing with the long snout beneath objects and into holes and crevices, as if guided partly by olfactory sense. Stebbins (1948:199) in his study of nasal structure in lizards, examined specimens of another *Cnemidophorus* species ("*tesselatus*" = *tigris*), and finding the nasal chamber completely lined with olfactory epithelium, concluded that, on a structural basis, members of this genus would appear to have a keen sense of smell. That these lizards depend

more on scent and less on sight than do some others in finding their prey is evidenced by the taking of such immobile prey as pupae. Foraging racerunners dig frequently with the forefeet, and some of the prey at least is found beneath the surface. As compared with some others, these lizards are dainty feeders, which spend a long time killing, and worrying their prey, and sometimes reducing it to small morsels, instead of gulping down relatively large objects.

On May 20, 1955, an adult male that had been under observation about ten minutes as he foraged along a ditch bank, was seen to find a 1½-inch larva of a sphingid moth. Immediately he attacked it, biting it, shaking it, and tossing it about. However, the victim was too bulky for this lizard to subdue or swallow. After struggling with it for approximately two minutes, he left it, still alive though perhaps seriously injured.

BREEDING

Sexual behavior in various kinds of lizards kept under laboratory conditions, was studied by Noble and Bradley (1931). The species observed included *Cnemidophorus sexlineatus*, and another teiid, *Ameiva chrysolema*. Both were similar in their courtship and mating, illustrating the authors' findings that each family of lizards has a characteristic behavioral pattern that varies somewhat in different genera and species, but to a lesser degree than families differ from each other.

The report by Noble and Bradley is an important contribution and has done much to promote a better understanding of the behavior of lizards. Nevertheless, it is my impression that their results were influenced to a large degree by the conditions of captivity, such as crowding and relatively low temperature, and that these results have been interpreted too literally as applying under natural conditions.

Noble and Bradley stated that the male racerunner commences sexual activity by rubbing his pelvic region on the ground in lateral movements, and he may continue this rubbing as he runs in a circuitous course the shape of a figure eight. Thus stimulated he may pursue any other racerunner that comes within sight, and overtaking it he may poke or nip its neck with his pointed snout. The male has well-developed femoral pores, and having attained a dorsal position straddling the mate, he employs leg rubbing as further stimulation, also continuing the pelvic rubbing on the female's back. He thrusts his tail beneath that of the female to attain

cloacal contact, and as copulation begins, he shifts to a flank grip, with his body arched in a lateral flexure over the posterior part of the female's back. A few seconds after coitus has begun, the male begins forward thrusts of the pelvis, about two per second. In the instances observed by Noble and Bradley, copulation in *Cnemidophorus* lasted from five to fifteen minutes, considerably longer than in *Ameiva*. In 15 instances of attempted matings, eight of the courted lizards were males and seven were females. Therefore Noble and Bradley concluded that racerunners do not recognize sex in other individuals, except by behavioral responses. Fighting also was observed, and in this phase of behavior the racerunner differed from *Ameiva*, in which the males do not fight and the sexes are similarly colored. An aggressive male of *Cnemidophorus* would rise high on his legs, thus showing off the bright colors of his sides and would rush at others to bite them with a more vigorous and direct approach than that used in courting, and without the preliminary pelvic rubbing and neck poking.

The laboratory temperatures in the study by Noble and Bradley averaged 82.2°F, which is now known to be below the normal activity range of the six-lined racerunner. Significantly, the authors noted that courtship and fighting occurred most often just after treatment with artificial ultra-violet illumination, when presumably, the lizards had temporarily raised their body temperatures. From the text and photographs it is my impression that most of the lizards in the crowded cages were lying in a semi-torpor, too sluggish either to escape or to make the normal responses ordinarily evoked by the approach of another individual. Under these conditions, the aggressor lacking the usual cues, might easily mistake the sex of the individual approached. Also, in lizards as a group, a more powerful male may express his dominance by homosexual mating with a weaker individual, who is unable to escape or defend himself effectively. In the cages, containing many individuals of each sex, olfactory cues must have been much confused, and like other reptiles, the racerunner probably does not readily shift its attention from one type of response to another. The long time required for completion of copulation probably was a result of the unfavorably low temperature, as field observations have not borne out the laboratory findings in this regard.

In adult six-lined racerunners the striking differences in coloration and proportions probably serve as the basis for social releasers, eliciting courtship, fighting, and other types of behavior. The fe-

male retains the juvenal pattern little altered except that the bright blue of the hatchling's tail fades to brown, and the vivid longitudinal light stripes of the hatchling become dull, less sharply set off from the ground color. In the adult male however, the stripes fade more completely and those on the sides may almost disappear; meanwhile the dorsum and sides become increasingly suffused with greenish coloration, shading into blue-green on the flanks. The male's head is broader and more robust than that of the female, and even when the female's body is not distended with eggs, it is of more plump appearance than that of the male.

The conspicuous sexual dichromatism of the six-lined racerunner is not shared by most other members of the genus and family, nor is it associated with elaborate behavioral displays such as are common in lizards of some other families. Sexual relations seem to be promiscuous with a minimum of courtship behavior. Association between members of a pair was of brief duration in the instances that I observed.

Copulation was observed on several occasions. On May 30, 1953, at 8:40 A. M. at the west end of the quarry, my attention was attracted by rustling in dry leaves, to two racerunners struggling on the ground. The male had grasped the female near the base of her tail on one side, but the two were facing in opposite directions. The female was thrashing and twisting in vigorous attempts to escape. After about 20 seconds the male suddenly shifted to a dorsal neck grip. For the next three minutes he rode the female, as she carried him about in short jerks alternating with brief pauses, moving in circles a few inches in diameter. From time to time the male's hindquarters made waggling movements, and several times he shifted his grip slightly. This phase was terminated when the male suddenly shifted his grip about two inches posteriorly, to the female's flank, and arched his body about her hindquarters, commencing copulation, which lasted about $1\frac{1}{4}$ minutes. Afterward, the male released the female, and as she darted away, he followed her for a few inches, with his tail arched and his vent pressed against the ground.

On June 7, 1956, a pair was found copulating on bare soil of the dry ditch bottom. At the disturbance of my approach, they broke apart, and the female ran, with the male in pursuit. The female hid in concealing vegetation of the ditch bank. A half-grown juvenile, basking nearby, was startled by the sudden movements and darted aside; instantly the male's attention was transferred to it, and he

chased it for 50 feet along the bank. On June 24, 1956, an adult male was seen chasing a much smaller, but perhaps sexually mature, female along the ditch bank. Several times the larger lizard caught the smaller by the side, and turned it on its side or back. The smaller lizard was quiescent most of the time that it was held down, but when the male attempted to shift his grip, it broke loose and darted away.

On July 1, 1956, an adult male and female were placed in a cage with a small female (63 mm. snout-vent length) which had laid eggs the day before. The eggs had been removed from the cage. The young female had been kept there for several days, and had become familiar with her surroundings. Almost immediately she darted at the larger female and bit her. In the next few minutes she repeated the attack many times, approaching the larger lizard with menacing demeanor—standing high off the ground, with snout depressed and body tilted toward her adversary. The larger female, being in strange surroundings, merely attempted to escape without retaliating. Toward the adult male the young female's attitude was strikingly different; she avoided his proximity, but with no display of hostility.

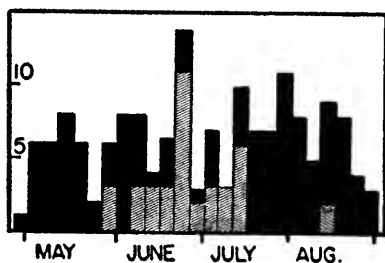


FIG. 5. Records of adult female racerunners grouped in five-day intervals; those known to be gravid are shown in lined columns, and those not gravid are shown in solid black.

Breeding begins a few weeks after emergence from hibernation, and extends through much of the growing season. For a week or more before laying, the enlarging ovarian eggs, and those in the oviducts after ovulation has occurred, so noticeably distend the body of the female that her gravid condition is obvious. Over an eight-year period such gravid females were recorded in May on the 27th, 28th, and 30th; in June on the 8th (2), 10th, 11th (2), 13th, 16th, 20th (2), 21st (2), 22nd (1), 23rd (3), 24th, 25th (4) and

28th (2); in July on the 1st (3), 6th, 9th (2), 11th (4) and 13th (2); and in August on the 12th (2). The concentration of records near the end of the third week in June and again in the second week of July suggest that two main broods are represented. Probably the same females in some instances, contribute to both, with an intervening interval of two to three weeks between successive clutches. In 1955 and especially in 1949 the trend of records was somewhat advanced as compared with other years. Individuals were not recaptured with sufficient regularity to permit tracing the history of their breeding, in most instances. One large adult female recorded as gravid on July 1, 3, 5, 7, and 9, was again recorded as gravid with what was probably a second clutch, on July 19. Another large female was recorded as gravid on June 23 and 25, 1954, and again on July 6. In view of the racerunner's short growing season in the latitude of northern Kansas, it is remarkable that females mature sexually and produce eggs while still in their first year. Records of three such individuals, gravid when less than eleven months old, are recorded in Table 2.

TABLE 2.—LENGTHS AND WEIGHTS OF FIRST-YEAR FEMALES NEARLY READY TO LAY THEIR FIRST CLUTCHES OF EGGS, IN LATE JUNE.

DATE	Snout-vent length in mm.	Weight in grams
June 28, 1954.....	62	.....
June 23, 1955.....	63	6.4
June 21, 1956.....	62	5.4

Still another female, 63 mm. in snout-vent length when captured in the last week of June, 1956, laid two eggs while in confinement on June 30. These two eggs were of normal size and constituted the entire clutch. As in other reptiles, size of clutch tends to be proportional to size of the female. The measurements of the 24 museum specimens found to be gravid are not entirely comparable, because of shrinkage of several per cent after preservation. Of these 24 gravid females, half were considered to be fully adult (lengths 85, 85, 76, 71, 70, 70, 69, 69, 68, 68, 67, 67) and the remaining half were considered to be first-year individuals (lengths, in mm. 65, 64, 64, 63, 62, 61, 61, 61, 60, 60, 58, 54). For the group of larger individuals, judged to be fully adult, clutches averaged 4.4 eggs, while for the smaller lizards judged to be in their first year, clutches averaged only 2.0 eggs (1 to 3, see Fig. 6).

The eggs and nesting habits of the six-lined racerunner are well known, especially through the careful studies of Brown (1956) in Piedmont North Carolina. By digging in old sawdust piles left from transitory sawmill operations, Brown was able to find nests in quantity. The sawdust piles were preferred over more natural nesting sites in sandy soil, and had unusual concentrations of nests. For 55 such nests found in sawdust, mean depth was 5.6 inches, varying from three to eleven inches and usually the nest was situated in a

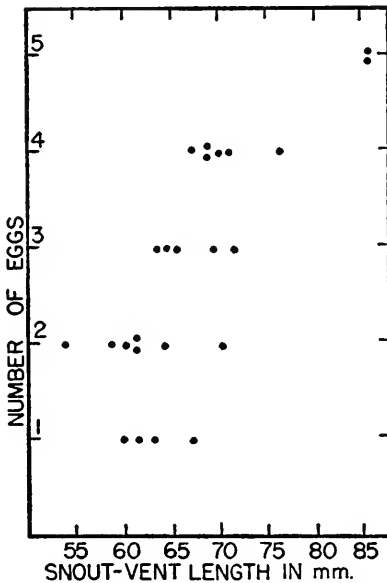


FIG. 6. Number of eggs per clutch (determined from gravid museum specimens) correlated with sizes of females. First-year females (usually less than 65 mm. in snout-vent length) produce smaller clutches than do fully mature females.

moist zone. A typical nest cavity was closed off, with a low domed ceiling, and had a volume of twice or even three times that of the enclosed eggs. Daytime temperatures at the depths where the eggs were situated were always near 90°F, while surface temperatures were much higher, and deep within the piles temperatures approached or exceeded 100°F. Number of eggs within a clutch was most typically three (29 instances), but might be two (18 instances), four (15 instances), one (3 instances), or five (twice). By gradual absorption of moisture an average egg enlarged from

16.2 x 9.3 mm. and .78 grams at laying to 18.4 x 13.0 mm. and 1.76 grams at hatching. The average hatchling had a snout-vent length of 32 mm., tail 61 mm., and weight .84 gram, with no significant differences in size or proportions between males and females.

Hatching dates in the clutches studied by Brown ranged from late June to early September, with concentrations near mid-July and in early August. Post-laying incubation of approximately 60 days was indicated. Although Brown assumed that an individual female produces only one clutch per season, the distribution of hatching dates seems to suggest that two or more clutches are produced. It is evident that the breeding season begins at least a month earlier in the region of Brown's study than it does in north-eastern Kansas. Also, it is of longer duration and less concentrated.

Milstead (1957:120) studying four other species of *Cnemidophorus* (*sacki*, *perplexus*, *tessellatus*, and *tigris*) in western Texas, reached a rather surprising conclusion regarding the production of eggs: "The size of mature eggs in the oviducts implies that it would be a physical impossibility for more than two eggs to mature simultaneously." He found one to four eggs in most of the gravid females examined, but was of the opinion that where the larger number was present they represented more than one clutch.

Of five clutches that I recorded on the Reservation, one had six eggs, one had four, two had three, and one had two, an average of 3.6, contrasting with the average of only 2.9 found by Brown in a much larger series of clutches, but in the 24 gravid museum specimens that I examined, mostly from Kansas and Arkansas, the average clutch was only 2.6. Five was the maximum number found in a clutch by Brown, who cited records from the literature (Boyer and Heinze, 1934; Cook, 1943; Minton, 1944) of six eggs per clutch, and mentioned the possibility of larger average clutch size in other parts of the range. It seems that one of the two records by Cook of six eggs in a nest pertained to a composite clutch, since three of the eggs were on the point of hatching while the other three had small embryos. For 13 clutches reported in the literature, from Indiana (Minton, 1944), Kansas (Marr, 1944), Mississippi (Cook, 1940), Missouri (Boyer and Heinze, 1934), Nebraska (Hudson, 1942) and Oklahoma (Force, 1930) the average was 4.5, even higher than in my own sample from the Reservation. It seems that size of clutch is subject to geographic variation, but the chief variable may be composition, by age, of the population of females contributing to any sample of clutches. Age composition of course varies according to the time and place. For the total of 112 clutches

recorded in my study or reported in the literature, there were 339 eggs, an average of 3.03 per clutch.

GROWTH

Earliest appearances of hatchling racerunners were in the first week of August, but in most years they did not appear until the second week of August. Each year within a few days after the first appearance, young all about the same size, had become abundant. By September, young of noticeably different sizes were in evidence; some near the minimum size were from late broods, and others from early broods were partly grown. The smallest young were 32 to 35 mm. in snout-vent length and weighed approximately one gram. Most rapid growth occurs in the interval between hatching and the time of retirement into hibernation. From the size of the largest hatchlings caught in September, it is evident that the most successful young average an increment of approximately half a millimeter per day onto the snout-vent length. By the time of hibernation, after approximately six weeks of growth, they are about midway in snout-vent length between newly emerged hatchlings and average-sized adults. These half-grown young weigh a little less than half as much as small adults. Sizes of selected individuals of these half-grown young are shown in Table 3.

TABLE 3.—SIZES OF MOST ADVANCED HATCHLINGS IN EARLY AUTUMN OF THREE DIFFERENT YEARS, ILLUSTRATING THAT, IN SOME, NEARLY HALF THE GROWTH FROM HATCHING (SNOUT-VENT LENGTH 32 TO 35 MM.) TO MATURITY (72 MM.) IS MADE WITHIN A FEW WEEKS IN LATE SUMMER BEFORE THE FIRST HIBERNATION.

YEAR	Snout-vent length in mm.	Date of record	Most probable date of hatching
1952.....	53	September 16	August 13
1953.....	52	September 9	August 9
1954.....	53	September 18	August 4

These three young had each increased approximately 20 mm. in snout-vent length, assuming they were of average hatching size at the start, and that their emergence corresponded approximately with my earliest records of hatchlings in the same years. Some young from broods hatched late in the season make relatively little growth before they are forced to hibernate.

Emerging, usually in May, after their first hibernation, the young resume their rapid growth, but the rate gradually decreases as they

approach minimum adult size. By the end of the summer all are adults. The five individuals whose histories are set forth in Table 4, show the variation in size and the trends in growth in these first year young after emergence from hibernation.

TABLE 4.—GROWTH IN YOUNG RACERUNNERS AFTER HIBERNATION.

INDIVIDUAL AND SEX	Dates of capture	Snout-vent length in mm.	Tail length in mm.	Weight in grams
No. 1, female...	May 9, 1956	39½	65	1.3
	May 21, 1956	44	74	1.8
	June 26, 1956	55	101	3.1
	August 9, 1956	68	130	7.0
No. 2, female...	May 21, 1956	42	81½	1.6
	July 3, 1956	55	113	3.4
	August 14, 1956	69	138	8.1
No. 3, male...	May 31, 1956	48	80	2.3
	June 20, 1956	50½	91	2.9
	August 2, 1956	70	133	.....
No. 4, female...	June 1, 1956	46	85	2.2
	July 9, 1956	61	113	4.3
No. 5, male...	June 29, 1956	62	46 (recently broken)	3.9
	August 12, 1956	71	57 (+60 regenerated)	8.8

TABLE 5.—GROWTH IN INDIVIDUAL RACERUNNERS APPROACHING ADOLESCENT SIZE. IN THIS GROUP AVERAGE GAIN PER DAY WAS ALMOST ½ MM. FOR INTERVALS THAT AVERAGED ALMOST A MONTH.

SEX	Increase in snout-vent length from beginning to end of interval ¹	Growth interval in days	SEX	Increase in snout-vent length from beginning to end of interval ¹	Growth interval in days
♂	52 to 58	23	♀	49 to 61	31
♂	53 to 58	17	♂	49 to 59	20
♂	53 to 59	35	♀	46 to 61	38
♂	56 to 58	29	♀	50 to 56	13
♀	50 to 56	44			

1. Total gain 77½ mm. Total clasped time 250 days. Average increment per day 0.31 mm.

Slower growth in larger young is illustrated by a group of 26 that averaged 55.2 mm. in snout-vent length at the beginning and 68.1 mm. at the end of growth intervals that averaged 34 days, as shown in Table 6.

TABLE 6.—GROWTH IN 26 RACERUNNERS OF ADOLESCENT SIZE. ON THE AVERAGE, THESE GREW LESS THAN $\frac{1}{4}$ MM. PER DAY.

SEX	Increase in snout-vent length from beginning to end of interval ¹	Growth interval in days	SEX	Increase in snout-vent length from beginning to end of interval ¹	Growth interval in days
♂	51 to 70	64	♂	57 to 61	14
♂	58 to 64	38	♂	58½ to 70	49
♀	61 to 61½	22	?	62 to 68	20
♂	59 to 63	29	♂	65 to 69	12
♂	60 to 65	20	♂	62 to 66	14
♂	56 to 68	69	♂	64 to 68	20
♂	54 to 67	68	♂	65 to 70	21
♀	55 to 68	44	♂	64 to 67	27
♂	58 to 63	23	♂	58 to 71	48
♀	55 to 69	42	♀	63 to 71	41
♂	56 to 61	41	♂	62 to 64	19
♂	50½ to 70	53	♂	64 to 70	23
♀	59 to 62	11	♂	62 to 71	44

1. Total gain 199½ mm. Total elapsed time 876 days. Average increment per day 0.226 mm.

In these large young, approaching adult size, the growth rate had slowed to less than half the daily length increment of hatchlings. Eight even larger young increased in snout-vent length from 66.6 to 73.1 mm. in intervals that averaged 35 days, thus having an average increment of .18 mm. per day as small adults.

Twenty-seven young adults recorded in May and June, all known to be second year individuals because they had been caught and marked in early stages of growth, averaged $72.8 \pm .51$ mm. in snout-vent length, and ranged from 77 mm. to 68 mm. Eleven marked adults that were recaptured when they were known to be late in their third years (having hibernated in three winters) averaged $75.6 \pm .78$ mm., indicating a growth rate of 2.8 mm. beyond the average size of second year individuals. Five fourth-year adults averaged 78.9 mm. (77½ to 81); four fifth-year adults averaged 81.5 mm. (79 to 84), and the only known sixth-year individual had a snout-vent length of 83 mm. The largest racerunner recorded had a snout-vent length of 84 mm., and it was one of those known to

be in its fifth year. In each series males and females averaged approximately the same size, and the small differences were not statistically significant.

As growth proceeds, there are changes in proportion and these are somewhat different in the sexes. Relative size of the head as a ratio of total length, and the shape of the head are among the more important changes, and there are smaller changes in the proportions of torso and limbs. No attempt was made to analyze these changes, but length of the tail was one of the items regularly recorded in each lizard handled, and, in those racerunners having intact tails, the relative length of tail varied according to age and sex, being longer in adults than in young, and longer in mature males than in mature females.

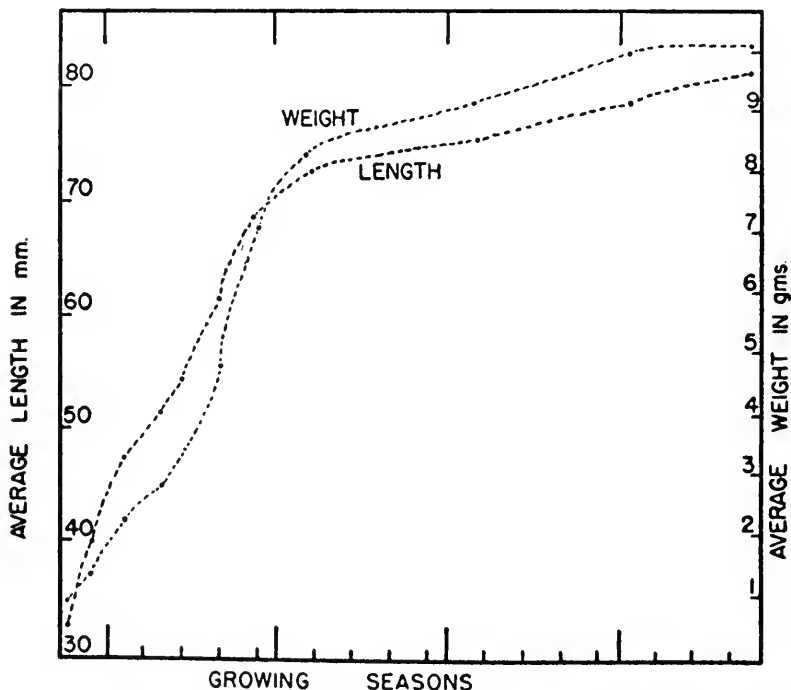


FIG. 7 Correlation of average length and average weight with age in six-lined racerunners through four growing seasons. Each growing season is divided into 4½ months. Growth is most rapid during the first year, but continues, at a decreasing rate, for several years, perhaps throughout the individual's lifetime.

PROPORTIONS OF THE TAIL AND IT'S REGENERATION

The racerunner's tail is flagelliform, and in adults is approximately twice the combined length of the head and body. In closely related species, *Cnemidophorus perplexus* and *C. inornatus*, the tail is relatively even longer, and it may be nearly three times the snout-vent length. In the racerunner, as in the majority of other lizards, the tail is fragile, breaking easily if it is struck or pinched. If grasped by the tail, the racerunner promptly snaps off the appendage in order to escape. The detached tail performs jerky squirming movements for several minutes, a circumstance obviously advantageous to the lizard in allowing it to escape while the attention of a predator is distracted. However, in the racerunner the detached tail is less lively and conspicuous than in other common lizards including skinks, anguids, and iguanids. Also, the tail is less fragile than in some of these kinds.

Brown (1956:38) found that in hatchling racerunners in North Carolina, snout-vent length averaged 32 mm., and tail length averaged 61 mm., or 190 per cent of the former measurement. In all the hatchlings examined in the course of my field study, relative length of tail was considerably less. To test the possibility that this character is subject to geographic variation, I measured series of museum specimens, including five hatchlings from Louisiana, Arkansas and Oklahoma, in which tails averaged 199 per cent of the snout-vent length, and 13 hatchlings from Kansas the tails of which averaged 166 per cent of the snout-vent length. Comparable differences may exist in adults, although the material available to me is not well adapted to demonstrate them. In 12 adults (more than 61 mm.) from Arkansas, tails averaged 211.5 per cent of snout-vent lengths whereas in 18 adults from Kansas tails averaged 197.6 per cent of the snout-vent length.

Relative length of tail increases as the racerunner grows. For 12 small young 30 to 40 mm. in snout-vent length, the tail averaged 167 per cent of the snout-vent length. This increased to an average of 199 per cent in males of more than 70 mm. in snout-vent length (Fig. 8). In males that are partly grown and those that are adult, tails consistently average somewhat longer than in females of comparable size, but there is overlapping. These figures are based on live racerunners measured in the course of my field study; the figures in the preceding paragraph apply to preserved museum

specimens that cannot be measured so accurately, as they cannot be relaxed, and are subject to some shrinkage and distortion.

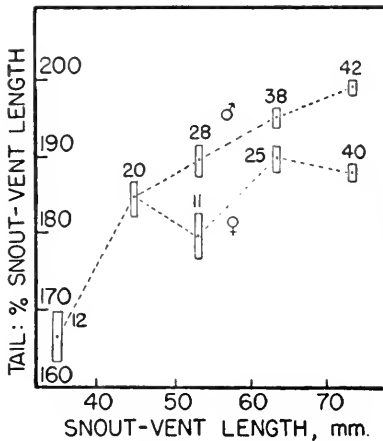


FIG. 8. Relative tail-length in live racerunners of different sizes. Tails are shortest in hatchlings, and increase in relative length until in large adult males they are nearly twice the combined length of head and body. Rectangles indicate standard errors of the means; figures indicate size of each sample.

These factors may reduce by several per cent the snout-vent measurement, thus resulting in a high figure for relative tail length.

Many adult racerunners retain the tail intact, whereas others have had their tails broken or regenerated one or more times.

TABLE 7.—PERCENTAGES OF RACERUNNERS RETAINING INTACT TAILS IN VARIOUS SIZE GROUPS, FROM HATCHLINGS TO LARGE ADULTS.

	Size group, snout-vent length in mm.					
	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79	80 to 84
Number in sample....	14	20	39	55	84	8
Percentage retaining tails intact.....	100.0	95.0	92.2	87.1	77.3	50.0

Probably the incidence of broken tails varies according to the time and place, under the influence of such factors as numbers and kinds of natural enemies present, and the population density of the racerunners themselves, influencing to some degree the amount of intraspecific competition and actual fighting. Table 7 shows the decreasing percentage retaining intact tails as greater size and age is attained, but even in the largest and oldest group, half retain their original tails. Differences between the sexes are not evident in this connection.

In individuals having regenerated tails, length of the regenerated part varied greatly in proportion to the original part and the body length (Fig. 9). Records of marked individuals have shown that most rapid growth of the regenerating tail takes place within a few weeks after a break. Presumably, therefore, the majority of

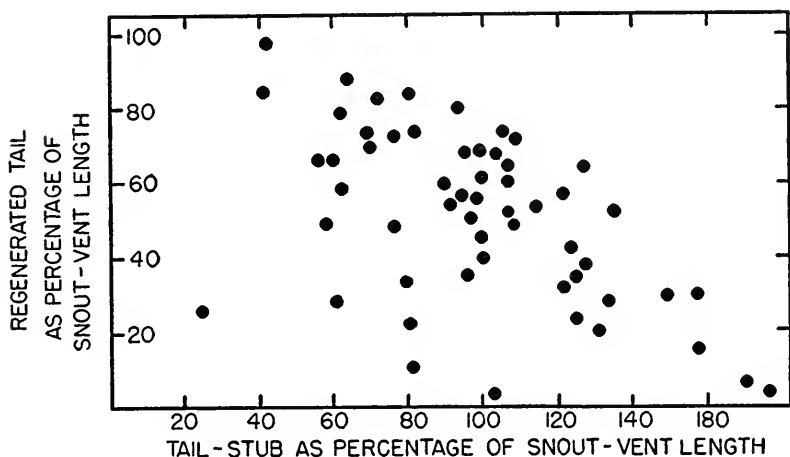


FIG. 9. Relative lengths of original and regrown parts of the tail in individual racerunners that have lost and regenerated varying lengths of their tails.

regenerated tails recorded were not still in process of active growth. Size and age of the lizard at the time a break occurs, and the abundance of food in the early weeks of regeneration are among the factors which might have important effects on the amount of regeneration.

Individual histories of several of the racerunners that yielded most significant records concerning regeneration of their tails are set forth in Table 8.

TABLE 8.—RATE AND AMOUNT OF REGENERATION IN RACERUNNERS HAVING BROKEN TAILS.

INDIVIDUAL	Dates of capture	Snout-vent length	Tail length
No. 1, young male.....	May 24	54	35 (+ 68 broken off)
	June 19	60	40 (+ 2 regenerated)
	June 28	60	41 (+ 8 regenerated)
	July 25	67	50 (+ 48 regenerated)
	July 31	67	50 (+ 49 regenerated)
No. 2, young male.....	June 29	62	46 (broken stub)
	August 12	71	57 (+ 60 regenerated)
No. 3, small adult male....	June 15	71½	87 (broken in capture)
	July 1	73	87 (+ 11 regenerated)
	July 28	74	91 (+ 13 regenerated)
	April 26	74	91 (+ 25 regenerated)
No. 4, adult male.....	June 17	76	92 (broken in capture)
	July 15	76	95 (+ 6½ regenerated)
	July 28	77	96 (+ 22 regenerated)
	August 14	77	96 (+ 28 regenerated)
No. 5, large adult male....	June 28	80	96 (+ 4 regenerated)
	July 7	80	96 (+ 23 regenerated)
	May 22	80	96 (+ 35 regenerated)
No. 6, small adult female...	June 23	63	76 (+ 19 regenerated)
	May 20	74	77 (+ 45 regenerated)
	July 11	74	77 (+ 45 regenerated)
	June 5	74	77 (+ 51 regenerated)
No. 7, small adult female...	June 2	71	68 (recently broken stub)
	June 24	71	70 (+ 16 regenerated)
	August 8	77	75 (+ 39 regenerated)

MOLT

The racerunner, like other lizards, undergoes periodic molt in which the outer layer of epithelium loosens and breaks off in small translucent flakes. The molt begins on the head and progresses posteriorly. Several days sometimes elapse from the beginning to the completion of the process. The distal part of the tail usually retains its layer of old skin after shedding has been completed on the head, body, and limbs.

To determine how often shedding occurred, I marked the skins of most of the racerunners that were examined. In 1949 and 1950 indelible black ink was used, but it was unsatisfactory, becoming obscured within a few days. In subsequent years I applied enamel paint of a bright color (usually red or yellow) contrasting with the color of the skin, to an area perhaps half an inch square, on one leg, one side of the tail base, the flank, nape, or some other conspicuous location to serve the dual purpose of individual recognition in the field, and of indicating when the racerunner shed its skin. This paint was not wholly satisfactory either, as the color was soon dulled by bleaching and by adhering soil, and the paint tended to peel or flake off.

Occasionally lizards were in process of shedding at the time of capture or at least retained old skin on the distal part of the tail indicating recent shedding. Others, from their glossy "new" appearance, were known to have just completed shedding. However, for most, the time of shedding was unknown. No individual was recorded twice in consecutive sheddings. The paint merely served to show whether the lizard had, or had not molted since the preceding capture when paint was applied. Lizards marked with paint were recaptured while still retaining the color after the following intervals of days: 28, 26, 22, 18, 17, 15, 14, 14, 13, 13 and 11, in addition to many shorter intervals of less than a week. Others that were recaptured after the following intervals of days had elapsed had lost their paint: 62, 62, 50, 45, 42, 40, 36, 35, 27, 20, 20, 17, 16, 13, and 13. No racerunner recaptured after a hibernation period retained paint from the previous season. Some of those marked with paint probably were almost ready to shed, and hence lost the color within a few days after their release, whereas others perhaps had shed a short time before they were painted. The fact that none was recaptured retaining paint after more than 28 days suggests that this is near the maximum interval elapsing between molts in the season when the lizards are active. Some may molt at considerably shorter intervals. As in other kinds of lizards, growing young probably shed their skins more frequently than do adults. Some of the racerunners found to have lost paint between captures may have shed twice in the intervening time.

One of the best records was that of a female recorded seven times in the summer of 1956, from May 9, soon after emergence from hibernation, when she was only a little larger than the size at hatch-

ing, to August 13 when she was of small adult size. Her records follow.

May 9	Marked with red paint.
May 21	In process of completing molt; paint renewed.
June 1	Paint retained.
June 26	Paint gone; renewed.
August 8	Paint gone; renewed.
August 9	Paint gone; renewed.
August 13	Paint retained.

For this rapidly growing young racerunner, four molts are indicated in the three-month period covered by the records, and a fifth molt might reasonably be expected before retirement into hibernation.

A young male more than half grown when first captured on May 1, 1956, was recorded seven times within an interval of a little less than two months, as listed below.

May 12	Marked with red paint.
May 28	Paint gone; renewed.
May 30	Paint retained.
June 10	Paint retained.
June 25	Paint retained.
June 26	Paint gone; renewed.
July 3	Paint retained.

This racerunner is known to have shed twice within the first half of its season of activity—a period of a little less than two months. The two molts are known to have been separated by an interval of at least 29 days, and probably somewhat more. That no additional molts occurred within this period is amply demonstrated by the captures on May 30, June 10, and June 25, when this lizard retained its paint.

PREDATION AND PARASITISM

Escape reactions

The racerunner depends primarily on speed to escape from its enemies. No actual observations on the pursuit and capture of one by a predator are known to me. The escape behavior evoked by the presence of persons may differ from the responses to some natural enemies. Racerunners found in the field nearly always demonstrated alertness and timidity. Ordinarily they detected a human intruder before he was aware of the lizard's presence; the lizard might be noted merely as a flash of motion as it darted away to shelter. Only on rare occasions, when a racerunner was preoccupied with catching prey, fighting, or mating activities was it ob-

served unaware at close range. Racerunners seemed able to detect the approach of a person from a distance of at least 50 feet, or perhaps considerably farther. At such mild alarm, the lizard might cease its previous activity, sometimes crouching against the ground on the spot where it happened to be and sometimes darting to nearby shelter such as a clump of grass. The racerunner might permit approach to within a few yards. Lying flattened against the ground, it was inconspicuous. I have never seen a racerunner in the open until it moved. The crouching racerunner might wait until a person had approached within a few yards before darting away. A racerunner approached by a person often seemed confident of its ability to escape, and was uneasy rather than alarmed. It might resume or continue its foraging, while obviously attentive to the intruder, holding its head cocked toward him, and moving furtively, skulking through screening vegetation, or dashing across small bare areas between such coverts. Where the racerunner's habitat was in a narrow band, along a road, or bank of a ditch or gully, one might run ahead of a person for as much as 100 yards, maintaining a minimum distance of several yards with occasional spurts alternating with the usual jerky, half-running and half-walking gait. Behavior varied somewhat according to individual temperament, age, sex, and season, the temperature, and the actions of the person. If sudden movements were avoided by the observer, the racerunner seemed to become accustomed to his presence, and might even approach to within three or four feet of a person standing still. In such instances, however, it was obvious that the lizard was still alert and suspicious.

A sudden attempt to overtake or seize a nearby racerunner was rarely successful, and only resulted in the almost instantaneous disappearance of the lizard. Running full speed it would move so rapidly that it became a blur and characteristically it darted in an erratic course from one clump of vegetation to another, with frequent changes in direction. It might enter a burrow, or might stop beneath screening vegetation, but in either case it could not be readily relocated. If, upon resumption of activity, it was again approached, it was much more wary than before, maintaining a greater distance between itself and the person following, and panicking more easily.

On May 15, 1952, one seen on the road near the Reservation headquarters ran along the wheel track for about 30 feet, then turned off abruptly and ran several yards through brome grass more than a foot high. The grass was not thick, and stalking the lizard, I was

able to observe its tactics. It would crouch motionless until I came within perhaps five feet, then would spring up and dash away, spinning around and changing direction after a few feet or sometimes only a few inches. After several such short, erratic dashes, it would stop abruptly and then was difficult to see. Soon it eluded me.

Racerunners that were chased into burrows usually emerged again promptly. They seemed to have no central home base upon which they depended for shelter, but each directed its movements with respect to a succession of escape coverts as it foraged. Usually a racerunner is able to attain shelter in a dash of only two or three seconds, whenever the need arises. In crossing open areas where there is no cover, the racerunner usually travels in long, rapid dashes.

Edgren (1955:141) described how, in sandy areas in Illinois, racerunners that had burrowed in the sand would "explode" through the surface, at any disturbance, and would dash away to sheltering vegetation. The burrows in which the lizards rested were shallow, nearly straight, parallel to the surface, and about $1\frac{1}{2}$ times the length of the lizard which rested inside. In western Tennessee, Blanchard (1922:6) recorded these racerunners as using short burrows dug in the sand. When a racerunner was inside, it partially filled one of the burrow openings, with sand thrown out from within. The lizards spent the night in such burrows, and could be easily caught in early morning before they had become active. To escape they would rush into grass or brush.

Burt and Hoyle (1934:202) recorded that a six-lined racerunner chased into a stream in Beckham County, Oklahoma, escaped by swimming 12 feet to the opposite bank. Dillon and Baldauf (1945:174) recorded one which after it was alarmed, scurried through dry leaves to the edge of a stream, where it jumped two feet into the water, and took shelter beneath a submerged rock near the farther bank. Stille (1947:143) in catching racerunners in the sand dunes of northern Indiana, found that they would often escape by running into the water of small ponds and marshes and hiding on the bottom, especially when they were chased downhill toward the water.

Burt (1933:192) described the defensive behavior of racerunners that were found in shallow pits beneath flat rocks along prairie ledges in Kansas, on cool days in spring. The lizards, not fully active, and unable to escape by running, would back into crevices, facing outward, with jaws gaping threateningly.

Natural enemies

In confinement, various predators have been recorded to eat racerunners, but the significance of such records is doubtful. Burt (1933:191) wrote that a captive box turtle (*Terrapene ornata*) ate one that was placed in the turtle's cage. It is well known that these turtles avidly accept animal food including small vertebrates, and in many areas both the turtles and racerunners are abundant. A turtle would be unable to catch a racerunner that was fully active, but the box turtle can carry on normal activities at temperatures many degrees lower than those required by the racerunner (Fitch, 1956:439). Therefore, the turtle might be able to dig out and devour racerunners that had taken shelter beneath flat rocks or in shallow burrows in loose sand. Hurter (1911:130) recorded that a captive collared lizard (*Crotaphytus collaris*) ate a racerunner, and Pritchett (1903:284) noted another instance. The collared lizard is notorious for eating small lizards, and may be an important predator on racerunners in certain areas where the ranges and habitats of the two overlap. Klauber (1956:610) quoted Loewen (1947:53) concerning a captive massasauga (*Sistrurus catenatus*) that ate two racerunners, as part of a varied diet that included several kinds of small birds and mammals and even pieces of meat.

Wright and Funkhouser (1915:130) recorded racerunners from the stomachs of two racers (*Coluber constrictor*) from the Okefinokee Swamp in Georgia. Marr (1944:484) recorded a racer (*C. flagellum*) from Trego County, Kansas, that had remains of at least two racerunners in its stomach. I found a racerunner in the stomach of a halfgrown yellow-bellied racer (*Coluber constrictor*) caught in an upland field area of the Reservation on June 15, 1955, and a juvenal yellow-bellied racer was found to have eaten a hatching racerunner on September 13, 1955. The racers *C. constrictor* and *C. flagellum* both prefer habitats similar to that of the racerunner, and are swift-moving diurnal predators that are notorious lizard eaters. Burt (1935:331) collected a halfgrown prairie king snake (*Lampropeltis calligaster*) near Lamont, Kansas, which disgorged an adult racerunner. In a study of the food habits of snakes at Fort Benning, Georgia, Hamilton and Pollack (1955 and 1956) found the racerunner to be a common prey, eaten by no less than nine species. Of those snakes that contained food, the following numbers had eaten racerunners: Coachwhip (*Masticophis flagellum*) 23 (of 45); black snake (*Coluber constrictor*), 5 (of 57); corn

snake (*Elaphe guttata*), 5 (of 32); timber rattlesnake (*Crotalus horridus*), 3 (of 26); pine snake (*Pituophis melanoleucus*), 1 (of 5); grey rat snake (*Elaphe obsoleta*), 1 (of 13); king snake (*Lampropeltis getulus*), 1 (of 13); hog-nosed snake (*Heterodon platyrhinos*), 1 (of 33); pigmy rattlesnake (*Sistrurus miliarius*), 1 (of 12).

In the contents of 104 armadillo stomachs collected in west-central Louisiana in 1947 and 1948 (Fitch, 1949) I found one racerunner, and several clutches of lizard eggs, some of which may have been those of racerunners. On June 24, 1950, at a hilltop rock outcrop (Rat Ledge) on the Reservation, remains of a marked adult female were found where she had been killed and partly eaten by a predator. The head and tail and one hind leg had been eaten. The racerunner had been dug out from beneath a rock, and there was much digging about other rocks in the vicinity. The predator in this instance was probably a spotted skunk (*Spilogale putorius*), judging from the sign, found frequently in this vicinity. Striped skunks (*Mephitis mephitis*) and raccoons (*Procyon lotor*) also are probable predators on the racerunner, and on the Reservation both species have from time to time molested reptiles and invertebrates caught in funnel traps. On May 27, 1955, a dead juvenal racerunner partly eaten by an unknown mammalian predator, was found on an exposed gully bank. On several occasions harvest mice (*Reithrodontomys megalotis*) caught in funnel traps with racerunners, killed and partly devoured them. In these instances the harvest mice were impelled to attack by close confinement, and by hunger in the absence of other food, but free-living individuals of these and other mice may occasionally prey upon racerunners that are inactive in their burrows because of low temperatures.

In an exhaustive study of the food habits of the coyote in Nebraska, Fichter, Schildman and Sather (1955:23) found that reptiles made up a negligible percentage of the diet over the state as a whole, but that in the vicinity of the Nebraska National Forest (in a sandhill area a little north and west from the center of the state), lizards were eaten frequently. Analysis of 1740 scats revealed lizard remains in the following percentage frequencies according to season: winter 4.3; spring 9.3; summer 15.9; fall 2.5. Although the lizards were not identified as to kind, some probably were racerunners. Other lizards known to occur in the same area include only the earless lizard (*Holbrookia maculata*), the scaly lizard (*Sceloporus undulatus*), and the skink (*Eumeces multivirgatus*). It is significant that in this sample, lizards were well repre-

sented not only in spring and summer but in fall and winter when the population is dormant. This fact suggests that the coyote obtains them by digging them out of the sand, and they could be effectively hunted by this method on cool cloudy days, or at night, in the summer. In the contents of 1190 coyote stomachs from Kansas, Gier (1957:12) found lizard remains (*Sceloporus*) only twice. In 118 scats of coyotes collected on the Reservation over a period of years, there were no lizard remains, but most of these scats represented the colder half of the year (Fitch and Packard, 1955).

On June 13, 1957, the entire tail of an adult female racerunner was found in a broad-winged hawk's nest, beside the young hawks. The remainder of the lizard probably had been eaten by the hawks. There seemed to be no chance that the lizard had merely shed its tail and escaped, because the tail included the root, proximally beyond the point where fracture can occur. In 1954 more than 100 prey items were recorded in another broad-winged hawk's nest, and they included no racerunners, although other lizards (*Eumeces fasciatus*, *E. obsoletus*, *Ophisaurus attenuatus*) were well represented. The sparrow hawk (*Falco sparverius*), Cooper's hawk (*Accipiter cooperi*) and marsh hawk (*Circus cyaneus*) prey extensively on lizards of kinds that inhabit open situations, and might be important as enemies of the racerunner where they share its habitat, but no specific instances of such predation are known to me.

Parasites

Few racerunners were dissected in the course of my study, and no internal parasites were recorded although there are, probably, many kinds that infest this lizard. Harwood (1932:65) found the rectums of two of four racerunners from Huntsville, Texas, to be heavily parasitized with the oxyurid nematode, *Pharyngodon warneri*. Of ectoparasites, chiggers are by far the most conspicuous. Almost all racerunners are infested with chiggers throughout the greater part of the growing season. In early summer most infestations are extremely heavy. Chiggers attach in tight clusters, and may occupy almost all areas of exposed skin between the scales. On the ventral surface the scales are relatively large and the spaces between them constitute especially favorable sites for attachments, as do the axilla, the groin, anal region, ear opening, and eyelid. The masses of chiggers attached to these areas of exposed skin contrast with the greenish color of the scales giving the lizard the appearance of having reddish markings. Many hundreds, or even thousands, may be attached to the same racerunner simultaneously.

Loomis (1956: 1386) examined 96 racerunners from eastern Kansas (including many of the same individuals on which my own field study is based) for chiggers. All were infested, with the exceptions of 13 of the 14 collected in May, and one each in June, July, August and October. In the course of the season, average number of chiggers per host on the infested racerunners changed as follows: May, 10; June, 653; July, 288; August, 115; September, 14; October, 1. The trend in these numbers closely paralleled the numbers of unattached larval chiggers, sampled by placing polished black plastic squares on the ground for one minute and then counting the chiggers running over them. These larvae are hatched in great numbers with the advent of warm, humid weather in late May, and their numbers continue to increase with the increments of successive broods in June when weather conditions are most nearly ideal. With increasingly dry weather and lower humidity characteristic of late summer, chiggers wane in abundance.

Although some 46 species of chiggers occur in Kansas, all those found on racerunners were the common pest species, *Trombicula alfreddugèsi*, which is the kind that commonly infests man. Dozens of species of vertebrates including most of the mammals, birds and reptiles that are common in eastern Kansas, are known hosts. Thus this parasite is unspecific and not dependent on any one kind of host. Nevertheless certain host species, including the cottontail (*Sylvilagus floridanus*), the box turtle (*Terrapene ornata*), the black rat snake (*Elaphe obsoleta*) and the racerunner, are especially favored, and carry disproportionately large infestations. Although it is relatively small, the racerunner perhaps carries more chiggers per square inch of body surface than does any other kind of host. Therefore, in localities where it is abundant, the racerunner may be an important factor in maintaining high populations of chiggers.

POPULATIONS

Most complete data are available for the small colony of racerunners that inhabited the diversion ditch near the Reservation headquarters. This ditch extended for approximately 1000 feet, from the outlet of a pond to a gully. At most times, in all seasons, the ditch was dry or had only a slight trickle. Unusually heavy summer rains occasionally caused the pond to overflow, and for a period of hours the ditch might carry a large volume of water, even a three or four foot depth with the result that many of the racerunners were drowned or washed away. In the summer of 1951, unusually heavy precipitation flooded the ditch repeatedly, and

few racerunners survived. In 1952 and 1953, drought conditions prevailed, with the result that racerunners thrived along the ditch, and increased in numbers there by both reproduction and immigration. In 1954 there was heavier rainfall but it was not sufficiently concentrated at any one time to flood the ditch. The summer of 1955 was, on the whole, dry, but on July 5 a rain of 3.15 inches flooded the ditch; thereafter for the remainder of the summer, few racerunners were in evidence. In 1956 they regained their numbers, but in 1957 torrential flooding in June brought the colony to its lowest ebb since 1951.

For several years this largest remaining colony on the Reservation has thus existed on a somewhat precarious basis, subject to drastic reduction by floods and yet largely dependent on the seral habitat created by the scouring of the ditch bottom and banks in such floods. The effective width of the barren or partly barren ditch bottom and banks combined was estimated to average approximately 25 feet; hence, for the 1000-foot stretch of ditch the total area was approximately 25,000 square feet, or .57 acre. For the years 1953 to 1956 numbers of racerunners (exclusive of hatchlings) recorded were as shown in Table 9. The known population density represented by this colony in the four different years were: 65 per acre in 1953, 40 per acre in 1954, 49 per acre in 1955, and 72 per acre in 1956.

The relative numbers of the different age groups fluctuated rather widely from year to year, as might be expected from the vicissitudes to which this population was exposed, but with sharp reduction from year to year, usually amounting to somewhere near half in each age class, as shown by the following percentages for the four annual samples combined.

57.0 per cent	were first-year individuals
25.4 per cent	were second-year individuals
10.0 per cent	were third-year individuals
5.4 per cent	were fourth-year individuals
1.5 per cent	were fifth-year individuals
.7 per cent	were sixth-year individuals

It should be made clear that the percentages listed above apply essentially to a population of sexually mature racerunners. By "first-year individuals" is meant those hatched in the preceding August or September, and recorded any time, from May to October, in the entire growing season following their first hibernation. A few caught in May and early June were not much larger than newly hatched young, but most were recorded later in the season and were

more than half grown; many had already attained adult size or were approaching it. Obviously a sample obtained in spring soon after emergence from hibernation would have different composition with a much higher percentage of first year individuals, still small, after only a few weeks of active life.

Insufficient data are available to compute accurately the productivity of the population. Most females if not all, participate in the annual breeding season; the yearlings making up fully half the total may each produce one clutch of one or two eggs, while the older females, perhaps comprising somewhat less than half, probably produce two clutches, usually of three or more eggs apiece. A population of 100 racerunners might be expected to produce perhaps 200 eggs per season. Even if the eggs are subject to heavy losses during their incubation, the population might be doubled by the annual hatch of young.

TABLE 9.—COMPOSITION, BY AGE GROUPS, OF A SMALL POPULATION OF RACERUNNERS IN SEVERAL DIFFERENT YEARS.

AGE GROUP	Year				Combined sample
	1953	1954	1955	1956	
First year.....	20	10	22	22	74
Second year.....	8	8	5	12	33
Third year.....	4	4	1	4	13
Fourth year.....	3	1	.....	3	7
Fifth year.....	2	.....	.....	.....	2
Sixth year.....	1	.....	.....	.....	1
Total.....	38	23	28	41	130

SUMMARY

The six-lined racerunner, a small teiid lizard, is the northernmost representative of its genus and family, and occurs throughout much of southeastern North America, but usually in a xeric type of habitat that most closely resembles the desert regions inhabited by other species of the genus *Cnemidophorus*. Over a nine year period at the University of Kansas Natural History Reservation 230 racerunners were recorded a total of 581 times. Racerunners became scarcer on this area after it was no longer grazed or cultivated; herbaceous vegetation closed in and reduced areas of bare soil and rock.

Belonging to a group that is largely tropical, the racerunner prefers a body temperature higher than that of most North American reptiles (near 40°), and spends a relatively large part of the annual cycle (half to more than two-thirds) in hibernation. Activity is greatest in early summer. The racerunner is strictly diurnal. It retreats into a burrow for the night, and also resorts to the burrow by day at times when conditions above ground are not favorable. In hot weather this lizard is most active in the morning, and spends the hotter part of the day in its burrow. In late afternoon the racerunner may again emerge from its burrow for a second period of activity. The racerunner digs well and makes its own burrows, but uses also those of various other small vertebrates. The burrows are utilized to escape enemies, and to avoid high or low surface temperatures. Air temperature of approximately 34°C seems to be preferred with a range of at least 19° to 39°, but soil surface temperatures are probably even more critical. Activity is almost entirely limited to times when the sun is shining, permitting maintenance of a high and fairly constant body temperature by insolation.

Although racerunners cover ground rapidly in the course of normal activities, each individual tends to keep to a small area. Home ranges of .20 of an acre for males and .25 of an acre for females are indicated, but occasionally the lizard may explore well beyond the limits of its normal range, and may even shift to a new location hundreds of yards away.

Racerunners shed their skins at intervals of about four weeks or a little less. For young in their first growing season, four or five molts probably are most typical. Adults shed somewhat less frequently.

Racerunners do not maintain territories, and many of both sexes share the same area; home ranges overlap broadly. Males fight and have bright colors that are prominently displayed before such encounters. In the breeding season promiscuity prevails. Egg-laying takes place in June, July and early August, thus extending over a large part of the racerunner's season of activity. Some individuals, at least, produce two (or perhaps even more) clutches of eggs in the course of the summer, and young produced one summer breed the next summer when less than a year old, at which age they have attained less than half the weight of fully matured adults. Numbers of eggs regularly vary from one to six, depending in part on the size of the female. First year females usually have

only one or two eggs, occasionally three. For 97 clutches reported in the literature or recorded in my study, the average was approximately 3.1 eggs per clutch. In the southern part of the range the breeding season is longer, and there is some indication that clutches average slightly smaller.

Typically the eggs are buried in sandy soil, at a depth of only a few inches. Incubation time in the neighborhood of two months is indicated. Hatchlings first appear in early August, but because of the extended breeding season, some are near half-grown, that is to say intermediate in length between hatching size and adult size, by the time of retirement into hibernation. Others then are still near the minimum size. Hatchlings resemble adults in miniature, but the light stripes of hatchlings are more vividly outlined against the dark ground color which lacks the greenish suffusion of the adult and the tail of the hatchling is bright blue. Also body proportions are somewhat different; the head of a hatchling is relatively large with blunt muzzle, and the tail is relatively short. By the time a racerunner has emerged from its second hibernation, late in its second year of life, it is of typical adult size (average 72.8 mm. snout-vent length in May and June). For successive years of age (and with successively smaller samples) growth to $75.6 \pm .78$ mm., 78.9 mm., 81.5 mm., and 83 mm. was recorded.

To escape enemies racerunners depend primarily on speed, and upon seeking shelter in dense vegetation or in their burrows. The most important natural enemies are snakes, notably the racers, *Coluber constrictor* and *C. flagellum*. Hawks (only *Buteo platypterus* definitely recorded), skunks, coyotes, armadillos, and even box turtles are known to eat six-lined racerunners.

Little is known of the diseases or internal parasites that affect the racerunner, although nematode worms (*Pharyngodon warneri*) have been found in the gut. By far the most important external parasite is the common pest chigger, *Eutrombicula alfreddugèsi*. Especially in early summer, a single racerunner may carry hundreds of these parasitic mites, and the racerunner seems to be one of the favorite hosts, although this particular chigger attaches to a great many kinds of vertebrates. Locally, where it is abundant, the racerunner may be important in maintaining the numbers of chiggers.

The racerunner is active and persistent in seeking out its prey, which consists mostly of small insects, but also includes spiders and snails. Most food items are relatively small in proportion to the size of the racerunner. Sense of smell aids the racerunner in

obtaining food; prey is often found beneath the soil surface. Prey does not have to be moving to attract the attention of the racerunner as is the case with many other kinds of lizards.

In a partly isolated colony occupying a .57 acre area (a 1000-foot long dry ditch), population density (exclusive of hatchlings) varied between 40 per acre and 72 per acre. Sex ratio was approximately 1 : 1, and the population comprised seven successive annual age groups (including hatchlings). Loss, through natural mortality factors, of roughly half the individuals in each age group in the course of a year is indicated.

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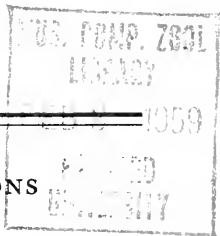
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December 12, 1958

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and Seasonal Movements of Vertebrates
of the Natural History Reservation

BY

HENRY S. FITCH

UNIVERSITY OF KANSAS

LAWRENCE

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Volume 11, No. 3, pp. 63-326, 6 pls., 24 figs., 3 tables

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Home Ranges, Territories,
and Seasonal Movements of Vertebrates
of the Natural History Reservation

BY

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UNIVERSITY OF KANSAS

LAWRENCE

1958

UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

Editors: E. Raymond Hall, Chairman, Henry S. Fitch,
Robert W. Wilson

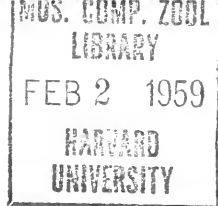
Volume 11, No. 3, pp. 63-326, 6 pls., 24 figs. in text, 3 tables
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UNIVERSITY OF KANSAS
Lawrence, Kansas

PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1958



27-3117



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INTRODUCTION

In July, 1948, ecological investigations were initiated on the newly created University of Kansas Natural History Reservation, a 590-acre division of the original "Robinson Farm." Although all phases of ecology have been given some attention, greatest effort has been devoted to autecological studies of the more abundant kinds of vertebrates.

Invariably in such studies a major amount of time and effort is expended in an investigation of spatial relationships. In order to understand the ecology of a species it is necessary to recognize individuals and to trace individual histories. It is necessary to ascertain how the typical individual animal is limited in time and space in order to understand the population dynamics of the species. As stated by Dice (1952: 231) most individual animals do not wander about at random, but the great majority spend their lives in closely limited areas, each confining his movements to a small part of the

habitats that are fully suited to his existence, and over which he is potentially free to roam.

From a practical standpoint it is important to understand the daily and seasonal movements of an individual, and the spatial requirements of a breeding population for those species that have major economic bearing. Such information serves as a basis for control measures for those kinds that are harmful, and as a basis for encouragement through positive management for those kinds that are beneficial.

In the course of routine field work, information concerning movements has been obtained for most of the species of vertebrates recorded from the Reservation. However, the quantity and quality of the information obtained varies greatly from species to species. Ideally the information obtained for each species would have answered the following questions: What is the size of a typical home range and how much does it vary in size and shape? Is the home range permanent; if not, how much and how often does the animal alter it? How is the home range affected by weather, food supply, and population density? What are the essential habitat features that a home range must include? How do home ranges differ between male and female, between adult and young, or between any other special groups within the species? Is the home range in whole or in part defended as a territory? If so, what classes of individuals (according to size, age, or sex) are active in such defense, and what classes of individuals (or what other species of animals) are objects of territorial hostility? Does the male share his territory with a mate or with a family group? Is the territory a phenomenon of the breeding season, or is it maintained throughout the year?

For none of the species studied was the information obtained sufficiently extensive to answer all these questions completely. For the rarer and more elusive species, the data obtained are scanty. Nevertheless, for many of the more abundant species, the essential items of information have been obtained.

Birds as a group have been studied in the past much more extensively than the other groups of vertebrates, with regard to spatial relationships. In general birds are more easily studied, because they can be more readily observed. On the Reservation, observing birds was unusually difficult because of the dense sheltering vegetation, and the shyness of most species. Attempts to trace movements of individuals were often unsatisfactory. Because of the

large number of species present, the time available to devote to any one species was limited. The mammals, and especially the reptiles and amphibians, have been studied less, heretofore, and I made concentrated efforts to secure information concerning those kinds that were abundant and available.

In the course of my field study, spanning more than nine years, emphasis has shifted from time to time. Short lines of live-traps for small mammals were first operated in 1948, and these operations were much expanded in the spring of 1950. Live-trapping of reptiles and amphibians was begun, on a small scale, in the summer of 1949, and was gradually expanded. Observations on birds were most concentrated in the years 1952 through 1955. Many of my data concerning spatial relations of the narrow-mouthed toad, five-lined skink, Great Plains skink, collared lizard, opossum, coyote, prairie vole, eastern woodrat, and summer tanager have already been published. The manuscript resulting from the present study was completed in essentially its present form in 1956, but significant items of data obtained since then have been incorporated. The species accounts of amphibians and reptiles were written first, on the basis of data on hand on July 1, 1955. Although more data were collected subsequently for most species, the new figures were incorporated into the account only in those instances where they seemed to alter substantially the trends previously revealed.

A faculty grant for the years 1956-1957, and 1957-1958 has aided substantially in the completion of this project. Many persons have contributed to the work in various ways. Richard E. Freiburg (1951), Edwin P. Martin (1956), Robert L. Packard (1956) and Dennis G. Rainey (1956) have published separate reports concerning several species of vertebrates studied by them on the Reservation, and I have drawn freely upon their findings. Other persons who have contributed data or have assisted me with field work include: Maurice F. Baker, William N. Berg, Alice V. Fitch, John H. Fitch, Richard W. Fredrickson, Richard D. Harder, the late Robert M. Hedrick, Donald W. Janes, Richard B. Loomis, John Poole, Louis M. Sandidge, and my wife, Virginia R. Fitch who also typed much of the manuscript. Mr. Robert M. Hedrick, Mrs. Connie Wynkoop, and Mrs. Lorna Cordonnier completed the illustrations. Dr. E. Raymond Hall, Director of the University of Kansas Museum of Natural History, has provided valuable counsel and suggestions at various stages of the work, and has made available the services of the Museum staff artists.

To supplement my original findings a large amount of published literature has been examined, and the findings of other authors are often cited in the species accounts for purposes of contrast or comparison. However, because of the large number of species involved, a thorough survey of the literature for all was not feasible. For the birds, especially, many pertinent published papers probably have been overlooked.

METHODS OF STUDY

To facilitate ecological studies the University of Kansas Natural History Reservation has been subdivided into 80 separate areas, having as their boundaries, creeks, ravines, wire fences, rock walls, roads, trails, and, in some instances, imaginary lines. Each subdivision has within it numerous specific landmarks. Most of these are trees, but boulders, fence posts, logs and other objects, even metal stakes especially placed for the purpose, have also been utilized. Each record of an individual animal was located with reference to some such named landmark. Distances sometimes were actually measured with a steel tape, but normally they were estimated to the nearest ten-foot interval. In studies of small mammals, traps were usually laid out in grids (50-foot, 30-foot and 20-foot intervals were used) with each position measured from a definite landmark. Many of the landmarks were discernible on an aerial photograph made on the scale of one inch to a hundred feet. A map on the same scale, with two-foot contour intervals, was also available.

Various methods were used, depending on the species, in determining the area covered by an individual animal. For a small minority of kinds it was possible to keep an individual under continuous observation as it moved about, carrying on its normal activities. The male dickcissel is perhaps the best example. As he moves about his territory, with frequent shifts, usually perching on the topmost twigs of the largest shrubs or saplings, he soon reveals the approximate extent of his territory. An individual may be recognized on successive occasions, even though he is not distinctively marked, by his habit of returning regularly to the same favorite perches.

The same method also applied well to the field sparrow, but was more difficult because this species more often stayed in concealing cover, because the sexes could not be readily recognized, and because the species was so abundant that confusion might often arise concerning the identity of an individual that was momentarily out of sight, or that encountered another.

Most other kinds of birds were less readily kept under observation, because they were more wary or more secretive in their behavior. For many kinds, including the wood thrush, the Kentucky warbler, and the several species of vireos, the song of the male provided the chief basis for tracing movements since the birds themselves were glimpsed only occasionally. However, under favorable conditions, the frequent and regular bursts of song by the bird as it moved about slowly in its foraging, served to keep the observer informed as to its course. Little was learned concerning the movements of the females in these particular species, but in each instance it is known that the members of a pair are the joint occupants of a territory.

In many of the other species of birds that were studied, a combination of sight and sound was used in keeping the individuals under observation and tracing their movements. In some instances distinctive artificial marking of individuals was an important aid. Besides the regular metal bands, provided by the U. S. Fish and Wildlife Service, colored celluloid bands, or dyed feathers crimped onto the tail, or colored nylon ribbons, were used for sight identification. In practice positive sight identification of individuals was made only rarely, even with the aid of these various devices. The nylon ribbons were most effective. Each was looped around the tarsometatarsus and sewn snugly in place with a free end of approximately half an inch projecting out behind, like the jess on a falcon. This colored ribbon, presenting several times as much surface as an ordinary leg band, could be distinguished at a greater distance. Most sight records from colored ribbons were obtained for red-bellied woodpeckers, downy woodpeckers, and field sparrows.

The same types of ribbons, attached to the ears of cottontails (Janes, MS), often served for sight records of these animals. Colored collars and ear disks on gray squirrels and fox squirrels served the same purpose (Packard, 1956: 9). For the six-lined racerunner, paints of various colors, carefully applied on different parts of the body surface, served effectively to render individuals distinguishable in the field for short periods. Through bleaching and wear these colors rapidly dulled and after a few days they were no longer distinguishable. The addition of bright colors, unnatural to the species involved in the attachment of ribbons, bands, feathers, or paint, may of course, have rendered the animals more susceptible to certain predators, and also may have affected their social status adversely, reducing their chances of survival. Actually, no evidence of such adverse effects was noticed, and it seems safe to assume that the over-all ecology, and especially the movements, were not altered to any important degree, in most species at least.

For most kinds of mammals, reptiles, and amphibians, and some kinds of birds, individual identification could be made with certainty only by recapturing and handling the animal. Many kinds are too wild, secretive, or nocturnal to observe in the field. For birds, trapping was carried on principally in winter. Procedure was not uniform, because of variation in the number of traps and time available. Ordinarily 30 or more traps were set at fairly uniform intervals in a line extending from the Reservation headquarters for a quarter mile or more in one direction, then looping back to the starting point. From time to time the trap line was altered by moving one leg of it beyond the other, and in the course of an entire winter the whole trap line was rotated through 360 degrees about the central point of the headquarters. In the course of a season, therefore, traps were well distributed over an area as large as 125 acres. For individuals ranging entirely within the area encompassed by the trap lines the pattern of records obtained might show the extent of home range (or territory) fairly well.

Most of the mammals recorded were caught in live-traps set in a grid pattern or in parallel lines; the interval between traps was varied from time to time and place to place, from ten to 120 feet. Mammals were marked by a combination of ear-clipping and toe-clipping, or by toe-clipping alone (Fitch, 1952: 32-33), in those species having small and inconspicuous ears. In the

latter (*Microtus ochrogaster* and *M. pinetorum*) one toe was clipped on each of four feet (excluding the minute "thumbs") and a total of 400 combinations were possible without duplication. In others only two toes were clipped in combination with a distinctive ear mark. Because of the short life span of small mammals in general, the animal marked with any one formula had died long before there was need to use the same combination again. For some of the most abundant species the same series were used repeatedly.

Toe-clipping was used also in the marking of frogs, toads and lizards. These animals were secured by a variety of techniques. Many were caught by hand. Others were taken in strategically placed funnel traps or pitfalls. The captures in funnel traps and pitfalls were less randomly distributed than the records obtained otherwise, as they were mainly along rock ledges or other natural obstacles that might affect the movements of the animals. For the glass lizard the marking technique consisted of removing three scales from the edge of the lateral fold, from which a formula was derived. The nick from the most anterior excision served as a base mark from which the positions of the other two nicks could be recorded according to the number of scales between.

Snakes were marked by excising subcaudals in different combinations, counting backward from the base of the tail. Only the proximal portion of the tail was used, up to subcaudal number 20. When all possible combinations were exhausted, they were used again in combination with ventral scutes clipped on either right or left sides. Snakes were obtained by various methods. Some were found by chance in the course of routine field work, some were discovered by raising sheltering objects such as rocks and boards beneath which they had taken cover, and some were located by attention to the calls of birds, mammals or frogs caught or pursued by the snakes or by the calls of blue jays and certain other birds that harassed the snakes. Even more snakes were caught in funnel traps. Success with these traps was greatest in September, October, and sometimes early November, along the hilltop rock outcrops where many snakes congregated to hibernate. So far as known, there were no major "dens" on the area. A snake having gained a rock outcrop might travel along it a longer or shorter distance, and might retreat into any deep crevice favorable for hibernation, perhaps solitarily or perhaps in company with several others of of its own species and other species. Attempts to trap snakes in these same situations in spring, after their emergence from hibernation, were notably unsuccessful. At this time of year there was rapid dispersal into other habitats. In summer, funnel traps were set along specially constructed screen drift fences, in grassland, thickets, and at woodland edge.

From this account it is evident that in the course of the study significant movements of animals were actually observed only on rare occasions. For the most part movements had to be reconstructed from the fragments of information obtained by occasional captures, in live-traps or otherwise. Obviously, in most instances the animal did not move directly from one recorded point to another, but usually covered a much greater distance, coming to the second point by a roundabout route. When two or more such locations were recorded for an individual within a short time, the assumption seemed justified that they were probably within a home range (or territory) and partly defined its extent. However, when much time had elapsed between two consecutive records, there was no assurance that the animal had not shifted more or less permanently. Ex-

tensive comparison of long-term and short-term records was necessary to establish the probability of shifts in range.

In general, any point where an animal is recorded within its home range or territory is located at random with reference to any other point of record, but there are many exceptions. If records are based on live-trapping, trap habit may become an important factor altering the behavior of the individual, and may cause it to return regularly to one or a few traps while neglecting to visit other parts of its home range. An animal that has a regular home base relied upon for shelter and escape, such as the home burrow of a vole, the stick house of a woodrat, or the home blackberry patch of a cottontail, naturally tends to stay within easy reach of this shelter, and in outlying portions of its range, activities become increasingly diffuse. For a parent bird, the nest or young similarly provide a focal point of attraction, and activity tends to be much more concentrated near the nest than it is in remote parts of the territory.

Other animals actually tend to move about more or less at random over their territories or home ranges. Tracks of a foraging opossum, for instance, show that the animal wanders circuitously in what seems to be an aimless course. Opossums live-trapped show little or no tendency to return to any one trap regularly. A male wood thrush, singing as he forages, seems to cover his territory rather uniformly. In many other kinds of birds, the male uses a series of territorial perches for singing, and these are usually well distributed over the area to which his activities are confined.

The term "minimum home range" has been widely used in studies of small mammals, in recognition of the fact that the area disclosed by investigation nearly always is somewhat smaller than the total area utilized, because data

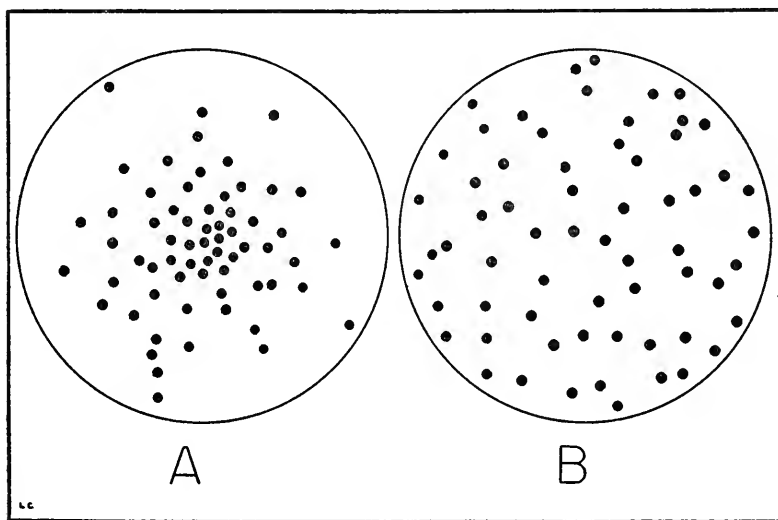


FIG. 1. Hypothetical home ranges of the same size, showing patterns of records for: (A) an animal that has a central home base and uses the various parts of its range in inverse proportion to their distance from the home base; and (B) an animal that wanders at random over its area.

are incomplete in varying degrees. Thus a minimum home range could be plotted on the basis of only three records, providing that all three were at separate locations, and that these locations did not fall in a straight line. However the triangular area encompassed by the three locations would almost certainly amount to only a small part of the total range. A fourth record of the same individual might fall within the original triangle, or it might fall outside, increasing the minimum home range and altering it to quadrangular form. Obviously many more records would be needed before the minimum home range disclosed would be expanded to an approximation of the entire home range occupied by the individual. Odum and Kuenzler (1955) have presented a scholarly discussion of this problem, showing that the rate of increase is, on the average, reduced with each additional record, until it becomes insignificantly small. For practical purposes Odum and Kuenzler advocated accepting as complete a minimum home range in which the increase for each additional record is below the one per cent level. Their procedure was to connect outlying points with lines and measure the enclosed area after each series of ten records. When such a series of ten added less than ten per cent to the previously plotted range, they considered addition of further records superfluous. As demonstrated by Odum and Kuenzler, the number of records required to achieve this one per cent level varied widely according to the species and also varied within the species, according to the stage of the nesting cycle and other factors. In a pair of chipping sparrows that were feeding nestlings, the one per cent level was obtained by means of only 20 observations. Earlier, in the nest-building stage, 55 records of the same pair of birds were necessary to achieve the one per cent level, and the area covered was nearly three times as large as it was in the nestling stage.

Using a wood pewee as an example, Odum and Kuenzler (*op. cit.*: 131) show the increasing size of minimum home range (actually a territory in this instance) with the addition of successive tens of records. The one per cent level was attained after the fourth series of ten records. The polygon outlining the bird's known range at this stage had nine marginal points (each represented by a single record). The other records, inside the polygon, tended to be clustered at a few favored locations. In this respect the pewee's pattern of records resembles those of various other animals, including the small mammals that are taken in live-traps exclusively.

The wood pewee and chipping sparrow studied by Odum and Kuenzler, are, of course, almost ideal subjects for such observation. For such active and vocal small birds that are not especially wary of humans many location records can be obtained in a short period of observing. In studies of small mammals, thousands of trap nights may not yield a comparable set of records for any one individual. In only a few instances was I able to obtain records of individual movements as complete as the set shown for the pewee by Odum and Kuenzler. Because most animals tend to return frequently to favored spots, the number of marginal locations, rather than the total number of records, or even the total number of points, is the best indication of reliability in the minimum home range plotted. While a home range plotted on the basis of only three or four points is almost sure to be much smaller than the true home range, one plotted from six points may outline the range fairly accurately, especially if the points are well spaced along the margin. Home ranges based on seven

or more marginal points are considered to be sufficiently representative of the area covered by the animal.

As numbers of marginal points increase with more complete records, the range plotted generally tended toward a circular or elliptical shape. If only marginal points are connected, there are no concavities in the outline of the polygon representing the home range. Concavities in the outline of the home range polygon are permissible when uninhabitable areas extend within it. For example water may extend into the home range of a terrestrial animal, or forest may extend into the home range of an animal closely limited to grassland. The irregular borderline between forest and grassland resulted in many home ranges of irregular shape among those that were plotted, both for species characteristic of forest and those typical of prairie habitat.

Because a large number of records are necessary to plot the home range of any individual with reasonable completeness, according to this method, relatively few of the animals recorded are usable. In my study, an alternative method of determining size of home range was used, which permitted inclusion of individuals even when only two records were available. This method was based on the theory that any two locations where an individual was recorded in its range, were situated at random with respect to each other. Distances between successive points of record were averaged for all individuals of a species, or according to sex, age group or season. The average figure obtained in each instance was considered representative of a home range radius. The home range is visualized as tending toward a circular shape, and random points within it will be separated by, on the average, half the diameter of the area. In an animal the range or territory of which has one or more focal points, where activity tends to be concentrated, the distances between randomly selected points will average less than the home range radius reflecting the extent to which activity is concentrated within one part of the total area.

From the average distance between successive locations recorded, the area covered was computed from the formula πr^2 or the area of a circle. Obviously this method is subject to various sources of error; the home range nearly always deviates from a circular shape, and usually some parts of its are used more than others. The advantages of this method are (1) that it makes possible a calculation of approximate size of home range on the basis of a relatively small amount of data, (2) that it provides a check on size of area plotted as a minimum home range from actual points of capture.

Still another method of computing area covered, is applicable specifically to territorial birds. This method involves measuring the distances between males that are singing simultaneously and answering each other, in situations where the habitat is continuous. Under such conditions the territories presumably have a common boundary. The distance between two singing males may be considered representative of the distance from one territorial center to another, the equivalent of a territory's diameter. A possible source of error in this method is that males happening to be in adjacent parts of their territories may be stimulated to competitive singing in defense of their boundaries, but it seems doubtful that this was an important factor in any of my records. In most instances when distances were recorded, singing was general and the males tended to be rather uniformly spaced. The method provided an important means of checking the figures obtained from the two methods previously discussed.

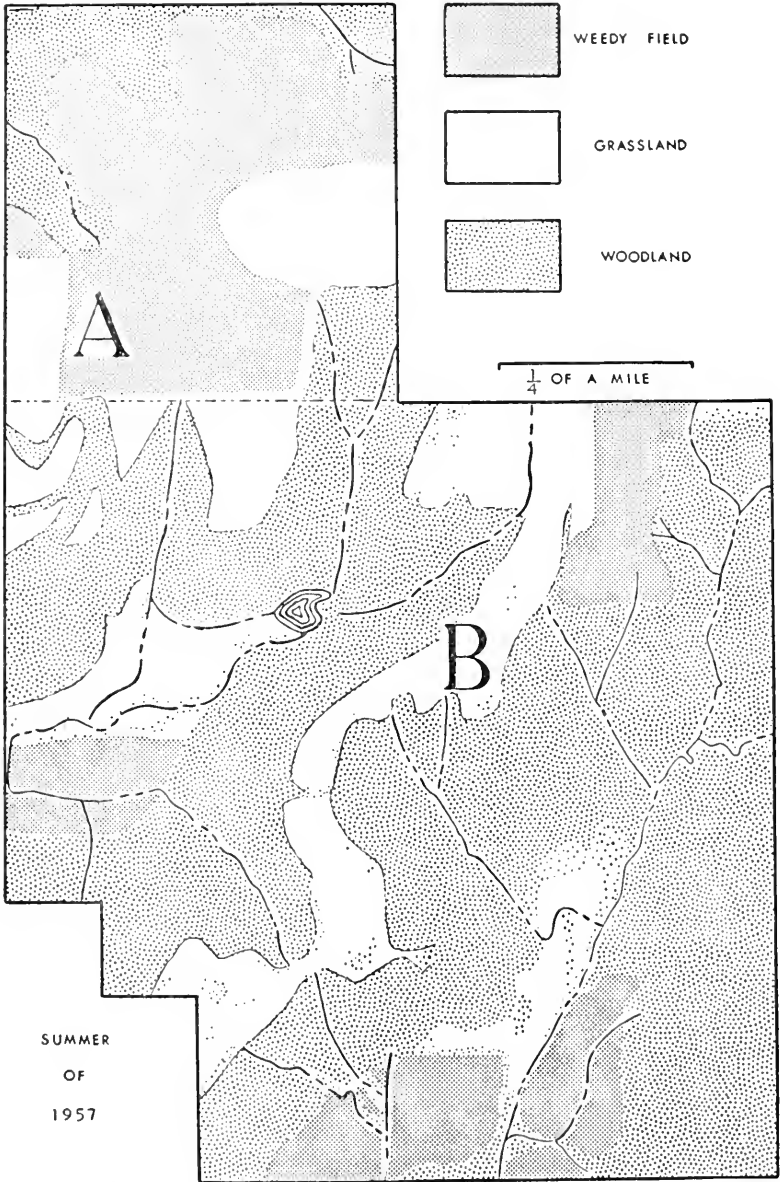


FIG. 2. Map showing areas where field work was done: (A) the 160-acre Rockefeller Experimental Tract, and (B) the 590-acre University of Kansas Natural History Reservation, showing distribution of weedy fields, grassland and woodland. The grassland includes prairie, both original and reestablished, dominated by bluestems and other tall grasses. Former pastures are mostly dominated by awnless brome.

In the following species accounts, binomials are used for the kinds of animals discussed. Subspecific identities can be determined from the appropriate reference among the following: Smith, 1956 (reptiles and amphibians); Tordoff, 1956 (birds); and Hall, 1956 (mammals).

This publication is intended to serve, incidentally, as a list of the vertebrates recorded from the Reservation. Therefore, all species known from the area are listed, although for certain kinds so little information has been obtained that their inclusion would not be justified otherwise. The present list revises and extends one published earlier (Fitch, 1952:23-29). The king snake (*Lampropeltis getulus*) was included in the earlier list on the strength of an individual found on the county road approximately half a mile south of the Reservation. However, the habitat there was somewhat different and the species still has not been definitely recorded from the Reservation. It is therefore deleted from the present list. Besides the species added to the original list, or deleted from it, certain other species have been found to have somewhat different status from that originally attributed to them. Domestic animals are not included in the following lists and species accounts. It is the policy to exclude them from the Reservation; nevertheless, domestic birds and mammals play some part in the ecology of the area. A colony of the domestic pigeon (*Columba livia*) has persisted into 1958 in the old barn on the Rockefeller Tract, but their effect on the ecology of the area seems slight, except as they may compete for nest sites with other species that seek an edificarian habitat. Their foraging is carried on chiefly in cultivated areas remote from the nest sites. Cats (*Felis domesticus*) and dogs (*Canis familiaris*) from nearby farms cannot be entirely excluded from the area, and prey upon various kinds of native vertebrates. Livestock, including cattle (*Bos taurus*), horses (*Equus caballus*), pigs (*Sus scrofa*) and sheep (*Ovis aries*) played an important part in the trends of succession on the area before it was protected from them. They still stray onto the Reservation from time to time, and obviously their presence on adjoining farms affects the native fauna.

POPULATION DENSITIES

Over the period of my study every species of vertebrate on the Reservation has undergone great changes in numbers. For most species no precise figures for the entire area have been obtained, even for any one time. The population changes have been actually measured in relatively few instances.

In most instances the figures listed below represent preliminary estimates. For convenience in this discussion, I have divided the species of vertebrates of the Reservation into five main groups as regards their occurrence. These groupings are entirely arbitrary. They overlap each other, and many species constitute borderline cases between two or more groups. Group 1 includes species recorded from the Reservation only once or on but few occasions, and ordinarily not present there. These kinds are of negligible importance in the ecology of the area. Group 2 also consists of species

that ordinarily do not occur on the Reservation, although they appear there as wanderers or stragglers with some regularity. On the whole, this group too is ecologically unimportant, although in some instances, as when a great blue heron stops at the pond for a period of days and eats large numbers of frogs, the fauna may be appreciably affected. Group 3 consists of species that reside on the area (either year round or at one time of year) but are represented there by few individuals. In general these species also are unimportant ecologically because of their small numbers and biomass, but the larger carnivores and raptors may exert important effects on the ecosystem even though only a few are present. Group 4 consists of species which are usually not present on the area, but which make brief seasonal visitations usually in substantial numbers. Species of this group are obviously of greater importance in the ecology of the area than those of the three groups previously mentioned. Group 5 includes those species which regularly inhabit the area (either year round or for part of the year) in substantial numbers. They are the species which have greatest influence on the ecology of the area. It is for the Group 5 species, primarily, that I have attempted to obtain census figures.

In the following lists, the 12 species of birds marked with asterisks in Group 1 and Group 2 are those that have been seen flying over the Reservation but are not known to have stopped there. The census figures listed for Group 5 have been obtained by various methods. The only attempt to obtain complete counts of individuals for the entire Reservation was limited to the birds, and was made in the week January 29 to February 4, 1954. Numbers of some kinds of birds were unusually low at the time of this census, and the counts obtained may be regarded as minimum figures in most instances. For various kinds of reptiles and mammals the census figures cited are mostly based upon relatively small study areas. In some instances these sample areas are typical of major habitat divisions on the Reservation, and the figures obtained may be projected to show an approximation of the numbers on the entire area. In other instances (collared lizard, six-lined racerunner, Plains harvest mouse) the small sample areas where high concentrations were found were almost the only places where the species occurred locally. For many of the more secretive species, direct counts were impracticable, and the figures cited are based on the ratios of new to marked individuals recorded at various stages in the course of field work, with due regard for population turnover through mortality, reproduction, and individual shifts.

GROUP 1. (species seldom present)

Black Bullhead	Wilson Snipe	Yellow-throated Vireo
Green Sunfish	Upland Plover	Solitary Vireo
Tiger Salamander	Spotted Sandpiper	Black and White Warbler
Eastern Box Turtle	Solitary Sandpiper	Nashville Warbler
Painted Turtle	Lesser Yellow-legs	Black-throated Green Warbler
Franklin's Ground Squirrel	Franklin Gull *	Blackburnian Warbler
Woodchuck	Barn Owl	Blackpoll Warbler
Gray Fox	Saw-whet Owl	Oven-bird
Pied-billed Grebe	Yellow-bellied Sapsucker	Northern Water-thrush
White Pelican *	Scissor-tailed Flycatcher	Louisiana Water-thrush
Black-crowned Night Heron	Yellow-bellied Flycatcher	Canada Warbler
American Bittern	Olive-sided Flycatcher	American Redstart
Pintail	Bank Swallow	Yellow-headed Blackbird *
Goshawk	White-breasted Nuthatch	Orchard Oriole
Rough-legged Hawk	Red-breasted Nuthatch	Scarlet Tanager
Bald Eagle *	Winter Wren	Painted Bunting
Prairie Falcon *	Short-billed Marsh Wren	Grasshopper Sparrow
Sandhill Crane	Olive-backed Thrush	White-crowned Sparrow
Virginia Rail	Gray-checked Thrush	Fox Sparrow
Sora	Veery	Swamp Sparrow
American Woodcock		

GROUP 2. (species occasionally present)

Fathead Minnow	Ring-necked Duck	Rough-winged Swallow *
Great Blue Heron	Lesser Scaup	Cliff Swallow *
Green Heron	Sharp-shinned Hawk	Purple Martin *
Canada Goose *	Marsh Hawk	Mockingbird
White-fronted Goose *	Sparrow Hawk	Hermit Thrush
Snow Goose *	Coot	Cedar Waxwing
Blue Goose *	Killdeer	Orange-crowned Warbler
Mallard	Black-billed Cuckoo	Baltimore Oriole
Green-winged Teal	Nighthawk	Vesper Sparrow
Blue-winged Teal	Belted Kingfisher	Chipping Sparrow
Shoveller	Alder Flycatcher	
Wood Duck	Least Flycatcher	

GROUP 3. (species with few individuals)

Snapping Turtle	Long-tailed Weasel	Long-eared Owl
Prairie Skink	Red Fox	Chuck-will's-widow
Common Water Snake	Muskrat	Chimney Swift
Smooth Earth Snake	Turkey Vulture	Ruby-throated Hummingbird
Prairie King Snake	Cooper Hawk	Wood Thrush
Milk Snake	Red-tailed Hawk	Loggerhead Shrike
Slender Flat-headed Snake	Red-shouldered Hawk	Long-tailed Chat
Timber Rattlesnake	Broad-winged Hawk	Red-winged Blackbird
Plains Pocket Gopher	Screech Owl	Blue Grosbeak
White-tailed Deer	Horned Owl	Lark Sparrow
Coyote	Barred Owl	

GROUP 4. (common species absent for most of annual cycle)

Plains Spadefoot Toad	Warbling Vireo	Bronzed Grackle
Eastern Kingbird	Tennessee Warbler	Rose-breasted Grosbeak
House Wren	Yellow Warbler	Purple Finch
Catbird	Myrtle Warbler	Pine Siskin
Robin	Yellow-throat	Leconte Sparrow
Golden-crowned Kinglet	Wilson Warbler	Clay-colored Sparrow
Ruby-crowned Kinglet	Western Meadowlark	White-throated Sparrow
Starling	Rusty Blackbird	Lincoln Sparrow

GROUP 5. (species of major importance)

American Toad: In both 1955 and 1956, 25 males were caught and marked in the chorus at the pond. From the ratios of marked individuals to others, it was evident that many more were present which were not recorded. The breeding aggregation at the pond represented only a part of the population on the Reservation. Normally the population probably fluctuates from a low point of somewhat more than 100 to a maximum of many thousands or even tens of thousands (including recently metamorphosed young).

Woodhouse's Toad: The number has fluctuated from none to perhaps several hundred young.

Cricket Frog: Several hundred adults usually are present at the pond and the small creek. At times this number may expand to many thousand.

Gray Treefrog: In early summer, breeding aggregations of more than 100 adults normally are present at the pond.

Chorus Frog: Breeding aggregations at the pond have varied from as few as ten to more than 100. In the breeding season the numbers may increase to many thousands.

Great Plains Narrow-mouthed Toad: This toad is one of the most numerous species; its breeding populations normally amount to several hundred and increase to many thousands, perhaps tens of thousands, in summer after a successful reproductive season.

Bullfrog: Numbers of adults and well grown young have fluctuated from none to probably more than a thousand.

Leopard Frog: Numbers have fluctuated from few or none to probably several thousand.

Western Box Turtle: Population density of this species is estimated as one to 13 acres, on the basis of numbers found each year in the northwestern quarter-section of the Reservation, and the ratio of new to recaptured individuals.

Collard Lizard: Over the six-year period that the colony on the Reservation survived there were on the average, 3.6 adults in the area occupied at the quarry, a little larger than half an acre.

Slender Glass Lizard: The population normally amounts to several per acre in the more favorable grassland areas.

Six-lined Racerunner: Over a four-year period population density averaged 56 per acre on a half-acre area of favorable habitat, the ditch in the headquarters area.

Ground Skink: The population density on the Reservation is low. Only a few are seen each season and it seems probable that there is only one to several acres of woodland.

Five-lined Skink: Population density was calculated as $\dot{\circ}$ 67 per acre in an unusually favorable woodland area of $2\frac{1}{4}$ acres where this species was most intensively studied.

Great Plains Skink: Population density was calculated as 16 or 17 per acre on a four-acre area of rocky upper slope where these skinks were intensively studied.

Brown Snake: Density is probably only one to several acres over most wooded areas of the Reservation.

Common Garter Snake: Over the nine-year period of my study numbers caught annually averaged 23 (11 to 35) and relatively few marked snakes were recaptured. A population of one to many acres is indicated.

Ring-necked Snake: In 1950, 47 were collected on a study area of a little more than four acres. Populations exceeding ten per acre probably occur over extensive areas of the Reservation.

Worm Snake: In 1951, 51 worm snakes were collected on a study area of 2½ acres, and the ratio of recaptures indicated that this was only a part of the population. Such high concentrations, exceeding 20 per acre, are limited to relatively small areas of favorable habitat.

Yellow-bellied Racer: In 1957, 36 were collected in a grassland area of 25 acres, and these represented the majority of the population present. Populations of from one to two per acre for grassland habitats are indicated.

Black Rat Snake: The population density for the Reservation is calculated as perhaps one adult to ten acres.

Bull Snake: The number resident on the Reservation is normally fewer than ten.

Copperhead: A population of one to several acres is indicated.

Opossum: Population densities of from one in 20 acres to one in 40 acres are indicated.

Short-tailed Shrew: There may be several short-tailed shrews per acre in certain areas of favorable habitat in woodland or edge.

Little Short-tailed Shrew: Probably this shrew averages much less than one per acre in the grassland portions of the Reservation where it occurs.

Mole: No basis is known for estimating numbers; from the abundance of sign populations exceeding one per acre might be expected, at least for the wooded parts of the area.

Red Bat: Probably there is one bat to several acres.

Cottontail: In September, 1955, Janes (MS) recorded 33 cottontails on a 21-acre area of woodland.

Fox Squirrel and *Gray Squirrel:* Packard (1956: 17) found a population of 1.18 squirrels per acre in the better type of woodland; more than two-thirds of this total consisted of fox squirrels.

Plains Harvest Mouse: In December, 1957, on a partly barren formerly pastured 7.1-acre plot of the Rockefeller Tract, 65 plains harvest mice were caught, indicating a population density of 9.2 per acre, almost the same as for deer mice on the same plot.

Western Harvest Mouse: In late winter of 1951, on a hilltop grassland plot of 1.6 acres, dominated by brome grass, an exceptionally high population with a total of 80 adults was recorded but doubtless some were wanderers and others lived mostly outside the plot, having home ranges which merely overlapped it slightly. Populations as high as 50 per acre are rarely attained, but densities between one per acre and ten per acre are normal for most grassland areas of the Reservation.

Deer Mouse: In December, 1957, 66 were caught on a partly barren formerly pastured 7.1-acre plot on the Rockefeller Tract, indicating a population density of 9.3 per acre. On most areas where the deer mouse occurs, it is in lower population densities.

White-footed Mouse: In early spring of 1951, 16 adult white-footed mice were caught in a woodland study area of 12½ acres. Ordinarily the numbers probably exceed one per acre in edge or woodland habitat.

Hispid Cotton Rat: In November, 1957, 28 cotton rats were caught in a prairie plot of 3.1 acres on the Rockefeller Tract. The population of nine per acre represented is regarded as moderately high, but at certain times and places under favorable conditions it is much exceeded.

Eastern Woodrat: From a high population of several per acre in most wooded areas in 1948, this rat decreased to a low point of perhaps one per hundred acres in 1954.

Prairie Vole: Martin (1956: 378) found populations of from 25 to 140 per acre in the grassland areas where his studies were made.

Pine Vole: The population of the entire Reservation is estimated as consistently less than 100 adults, concentrated in a few highly localized colonies.

Norway Rat: For the entire Reservation the population of adults probably has never exceeded ten.

House Mouse: Population densities of several to many per acre are at times attained on limited areas, but ordinarily numbers are much lower.

Jumping Mouse: This species is poorly known on the area. It is doubtful whether population density exceeds one per acre except for brief periods in unusually favorable habitats.

Raccoon: Several family groups live on the area. Populations as high as one to 50 acres probably have been attained.

Spotted Skunk: Winter populations somewhat exceeding one to 50 acres are usual.

Striped Skunk: This species is slightly less numerous than the spotted skunk. In winter there is somewhat less than one striped skunk to 100 acres.

Bob-white: In the 1954 winter census 25 were recorded, but usually numbers are somewhat higher.

Mourning Dove: Probably at least 20 pairs breed on the Reservation.

Yellow-billed Cuckoo: The breeding population probably exceeds 20 pairs.

Whip-poor-will: A breeding population of perhaps ten pairs is present in summer.

Yellow-shafted Flicker: In the 1954 winter census seven were recorded, but often the population is much higher.

Red-bellied Woodpecker: In the 1954 winter census 21 were recorded, probably a typical number for that time of year.

Red-headed Woodpecker: The resident colony usually includes between 10 and 20 individuals.

Hairy Woodpecker: In the 1954 winter census 13 were recorded; probably this population is fairly stable.

Downy Woodpecker: In the 1954 winter census, 42 were recorded.

Crested Flycatcher: The normal breeding population is estimated as somewhat more than ten pairs.

Phoebe: The breeding population of the Reservation is usually from three to seven pairs.

Eastern Wood Pewee: Perhaps as many as 20 pairs nest on the area; no definite figures are available.

Horned Lark: In 1957 six pairs nested on a 72-acre area of formerly cultivated fields on the Rockefeller Tract.

Barn Swallow: Two pairs nested at the old barn on the Rockefeller Tract in 1957. In earlier years many more had nested there.

Blue Jay: In the 1954 winter census 12 were recorded but usually more are present.

Crow: In the 1954 winter census ten were recorded but this is probably near the minimum figure. In winter there are, at times, hundreds on the area, and in summer the breeding population may approach one to ten acres.

Black-capped Chickadee: In the 1954 winter census 214 were recorded, perhaps a typical figure for that time of year.

Tufted Titmouse: In the 1954 winter census 40 were recorded.

Brown Creeper: In the 1954 winter census two were recorded but usually a larger number winter on the Reservation.

Carolina Wren: In the 1954 winter census, nine were recorded, probably a typical number for that time of year.

Brown Thrasher: Probably there are never more than five pairs present in summer and sometimes none.

Eastern Bluebird: In winter, flocks of as many as 20 bluebirds use the Reservation regularly. In summer there are probably never more than five pairs on the area.

Blue-gray Gnatcatcher: It seems probable that more than 20 pairs live on the area, although no census figures are available.

Bell Vireo: With successional changes the number of breeding pairs has gradually increased since 1952, to perhaps as many as ten pairs.

Red-eyed Vireo: A 1955 census figure of one pair per 2.1 acres on a wooded north slope may apply for the better woodland habitats throughout much of the Reservation.

White-eyed Vireo: Usually the breeding population has varied from one to six pairs.

Kentucky Warbler: Probably not more than five pairs nest on the Reservation.

English Sparrow: A colony of more than 20 pairs bred in vicinity of the buildings on the Rockefeller Tract in 1957, but none has successfully nested on the Reservation.

Eastern Meadowlark: Approximately six pairs nested on the Rockefeller Tract in 1957. To my knowledge no more than one pair annually has ever nested on the Reservation.

Cowbird: The breeding population is estimated as the equivalent of at least 20 pairs. The majority of all passerine nests found on the area have been parasitized by cowbirds.

Summer Tanager: At least six pairs breed on the Reservation annually.

Cardinal: In the 1954 winter census 40 were recorded, but usually the winter population is somewhat higher. The breeding population also probably exceeds this number normally.

Indigo Bunting: Perhaps as many as 30 breeding pairs are present in summer.

Dickcissel: In recent years the breeding population has amounted to approximately ten pairs.

Eastern Goldfinch: In the 1954 winter census nine were recorded.

Red-eyed Towhee: The breeding population is estimated at ten pairs or a little less. The wintering population also normally approximates this number, but none was recorded in the 1954 census.

Junco: In the 1954 winter census 41 were recorded, but usually there are more.

Tree Sparrow: In the 1954 winter census 17 were recorded. Numbers are variable and sometimes greatly exceed this figure.

Field Sparrow: This is the commonest breeding bird; 58 pairs were recorded on a 300-acre area in 1950.

Harris Sparrow: The numbers of these sparrows wintering on the area are highly variable depending on the food supply. In the winter of 1956-57 a flock of more than 100 lived on the Rockefeller Tract and the adjacent part of the Reservation, feeding largely on waste grain from a sorghum crop.

Song Sparrow: In the 1954 winter census 18 were recorded, but probably the winter population is usually somewhat larger.

HABITATS

The habitats of the University of Kansas Natural History Reservation have been described in some detail by Fitch (1952, 1954), Fitch and McGregor (1956), Leonard and Goble (1952), and Packard (1956). These include not only descriptions of the Reservation as a whole, but detailed descriptions of small areas. The present brief discussion is intended merely to supplement these earlier descriptions, and to show the chief successional changes that took place from 1948 to 1957, while the study was in progress.

Fields in bottomland, cultivated until 1949, include Ditch Field and Coon Field in the small valley of the west-central part of the Reservation, and Oat Field, Square Field, Corn Field, Woods Field and Weed Field in the southern part. The pioneer vegetation of secondary succession in all these fields at first consisted chiefly of sunflower (*Helianthus annuus*) and giant ragweed (*Ambrosia trifida*), in a rank growth, with stems as much as two inches in diameter and plants as high as ten feet. After several seasons the sunflower had almost completely disappeared and the giant ragweed had become much stunted, and was absent from parts of the field. Many other weeds, including thistle (*Cirsium sp.*), horseweed (*Erigeron canadensis*), goldenrod (*Solidago sp.*), goose-foot (*Chenopodium sp.*), wild lettuce (*Lactuca scariola*), nightshade (*Solanum sp.*), spurge (*Euphorbia sp.*), velvetleaf (*Abutilon theophrasti*), smartweed (*Polygonum sp.*), aster (*Aster sp.*), Joe-Pye weed (*Eupatorium altissimum*), and false boneset (*Kuhnia eupatoroides*) dominated certain parts of the fields. Annual grasses, especially foxtail, became increasingly prominent, and dominated extensive patches. Saplings, especially those of American elm (*Ulmus americanus*), also became increasingly prominent until by 1957 the edges of the fields bordering woodland had become dense thickets, with trees up to twelve feet high.

Throughout the woodland, in general, the trend was toward larger size in the second growth trees, and shading out of the understory layer including not only saplings of the climax species, but species such as red haw (*Crataegus mollis*), crab apple (*Pyrus ioensis*), redbud (*Cercis canadensis*), dogwood (*Cornus drummondii*) and wild plum (*Prunus americana*). Later, in 1953 and 1954, there was extensive mortality in trees of all sizes, particularly American elm and black oak (*Quercus velutina*), as a result of drought and disease. Large gaps in the leaf canopy opened up permitting the establishment of various weedy herbs, notably wild lettuce. The dead trees are in process of disinte-

gration, producing an abundance of rotting logs and hollow snags, such as has not existed before since the area first came under control of white immigrants.

While most of the woodland areas were fenced and were protected from livestock throughout the nineteen forties, the wooded hillsides of "Horse Woods," "Skink Woods," and "Rat Woods," were connecting strips between pastures and were exposed to grazing and browsing until 1949. At that time the three areas had little underbrush or herbaceous vegetation, and were relatively open as compared with adjoining parts of the woodland over the fence. By 1957 the reverse was true; the formerly browsed woodlands had dense thickets of elms, hackberries, and other young trees, up to six feet high, while in the adjoining areas the underbrush had grown taller and sparser.

Former pastures on the area, including a long flat hilltop from Angle Field on the southwest to Gate Field on the northeast, Top Field, Quarry Field, Tree Field and Point Field, also on hilltops, and Picnic Field, House Field, Dike Field, Gully Field and Cow Field in the two small valleys, have changed even more than the woodlands. Formerly these fields had only a few trees, which were of medium to large size, and the awnless brome grass (*Bromus inermis*) and bluegrass (*Poa pratensis*) which provided the chief forage were mixed with many weedy forbs, notably nightshades, spurge, vervains (*Verbena* sp.), milkweeds (*Asclepias* sp.), lespedeza (*Lespedeza striata*), germander (*Teucrium canadense*), and ironweed (*Vernonia baldwini*). In succeeding years since grazing was discontinued, the brome has made up an ever-increasing proportion of the herbaceous vegetation and all the weedy species have become

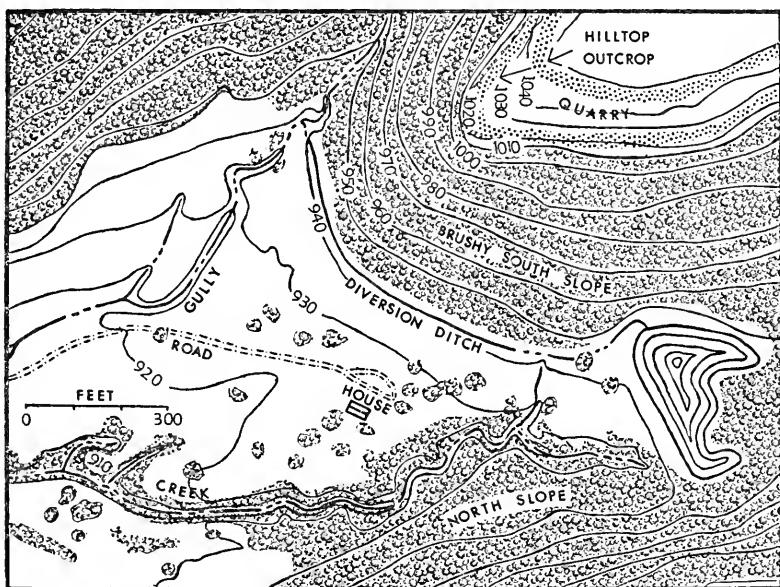


FIG. 3. Map of an area in the northwestern quarter of the Reservation, where field work was most concentrated, showing ten-foot contour intervals, distribution of woodland (tree pattern) and grassland and buildings, diversion ditch, hilltop outcrop of rock ledges (stippled), and other details. The maps in Figs. 4 to 10 and 16 to 24 include parts of this same area.

scarce. At the same time young trees have sprung up in profusion. These saplings are unevenly distributed, as in some parts of the fields, especially near the edges they form dense thickets, while in other areas, farther removed from seed sources, they are relatively sparse.

An area in the northwest corner of the Reservation was long maintained as bluestem prairie but by 1957, after approximately 20 years of protection from fire and mowing, encroachment of woody vegetation, including dogwood, sumac (*Rhus glabra*), blackberry (*Rubus argutus*), and saplings of various trees, had crowded out so much of the grassland vegetation that on the hill slope the area had assumed the aspect of a thicket. On the adjacent hilltop, encroachment proceeded much more slowly, and was temporarily halted in April, 1956, when a fire spread from neighboring land and burned over this small hilltop prairie patch. The fire killed most of the woody vegetation, including hundreds of young boxelders (*Acer negundo*). In 1956 and 1957, big bluestem (*Andropogon gerardi*) made up the bulk of the vegetation in this prairie plot. Other kinds of prairie vegetation including many kinds of legumes, and composites that were abundant on an adjacent plot to the north (on the Rockefeller Tract) were scarce or absent on the prairie of the Reservation.

An upland area under cultivation in the nineteen thirties, and so heavily eroded that most topsoil was lost, included Road Field and High Field which were sown to seeds of native grasses in May, 1949. By 1957 the perennial grasses were well established and dominated the area causing it to have, superficially, the aspect of a prairie, but only a few of the grasses and forbs typical of prairie were present on this area. Deep gullies cut by torrential rains when the area was cultivated, have become largely revegetated but there are still barren patches on the steep banks. The stand of perennial grasses is not continuous but there are intervening weedy patches, with goldenrod and aster dominating. Dry Field and Slope Field constituting the eastern part of this upland field area were not sown to native grasses, and revegetation has proceeded slowly. Erosion continues, with vegetation sparse, and many small areas of bare soil intervening. Goldenrods, aster, lespedeza and three-awn grass (*Aristida oligantha*) are the most prominent plants.

Aquatic and riparian habitats are not well represented on the Reservation. The pond near the headquarters was variable in extent, depending on weather trends, but never covered more than an acre. Originally constructed in 1936, this pond had been nearly filled with silt fifteen years later. It was deepened along the side adjacent to the dam and an outlet pipe was installed in 1953-1954. Although water has been present continuously since then, the level has fluctuated widely. Aquatic vegetation consists chiefly of pondweed (*Potamogeton sp.*), naiad (*Najas guadalupensis*), wapato (*Sagittaria latifolia*), and cattail (*Typha sp.*). The willow grove that has overgrown the silted portion of the pond has a dense understory vegetation with various hydrophytic plants. Some of the willow trees have grown to a trunk diameter of six inches, and many of them have died and fallen, creating a tangle of dead trunks amid the thick weedy vegetation.

The intermittent creeks that flow through the two small valleys have cut deep and narrow gullies. Their bottoms are gravelly. Hydrosereal vegetation is scarce. At the upper ends of the small valleys the creeks emerge from steep rocky ravines on the wooded hillsides. After heavy rains these rocky stream beds are filled with torrents of muddy water, but ordinarily they are dry.

Vegetation adjacent to these channels differs little from that found elsewhere in the woodland, except that sycamore trees tend to be concentrated there.

In the spring of 1957, the Rockefeller Tract, a quarter-section adjoining the western half of the Reservation on the north (Fig. 2) was acquired by the University of Kansas as an adjunct to the Reservation itself. Unlike the Reservation, the Rockefeller Tract is not maintained rigidly as a natural area. Rather, it is manipulated in various ways with the object of restoring and maintaining a tall-grass prairie vegetation on the portions that are not woodland. Several species of vertebrates ordinarily absent or rare on the Reservation were common on the Rockefeller Tract and were studied there in 1957. This 160-acre area had an eight-acre virgin prairie (mowed annually for hay) in the southwest corner, and had blocks of woodland in the remaining three corners, but most of it was under cultivation. An 18-acre block in the east-central portion was overgrazed pasture, dominated by bluegrass but with many weedy annuals. A small artificial pond in this pasture had often been dry, but held water throughout 1957. The northwestern and northeastern parts were north slopes of oak-hickory woodland somewhat different from any on the Reservation, with a high proportion of red oak (*Quercus rubra*) and with linden (*Tilia americana*) and certain other species not found on the Reservation. The southwest corner consisted of a ravine and hilltop, with a few large elms and other trees, and with thickets of underbrush, especially blackberry, dogwood and young honey locusts. The cultivated parts of the Rockefeller Tract had been used for growing of milo, oats, wheat, barley and alfalfa for many years. Soil had become considerably impoverished through erosion and long continued cultivation. On the edge of the cultivated land the level is one to two feet lower than that on the adjoining prairie as a result of loss of topsoil through sheet erosion.

In April, 1957, the pasture and formerly cultivated portions of the Rockefeller Tract were disked as preparation for a seedbed, and were sown to seeds of native grasses, chiefly little bluestem (*Andropogon scoparius*), with smaller proportions of big bluestem (*Andropogon gerardi*), Indian grass (*Sorghastrum nutans*), switch grass (*Panicum virgatum*), and with some forbs characteristic of tall-grass prairie. By July, 1957, weedy vegetation, chiefly sunflower, ragweed (*Ambrosia artemisiifolia*), and dogbane (*Apocynum cannabinum*), had sprung up, shading the slow-growing perennial grasses. To reduce competition from these weedy species, the area was mowed. By late summer, annual grasses, notably foxtail (*Setaria* sp.), and crabgrass (*Digitaria sanguinalis*) made up a major portion of the vegetation.

As a result of the more open terrain and different vegetation, the Rockefeller Tract in 1957 provided favorable habitat for the sparrow hawk, kingbird, barn swallow, horned lark, loggerhead shrike, lark sparrow, English sparrow, chip-sparrow, and a few other kinds of vertebrates that likewise rarely or never visited the Reservation. Dickcissels, meadowlarks, and redwings were also common in the open areas. Field sparrows, indigo buntings, and cardinals were common along woodland edges. Birds of the woodland were not known to differ from those of the Reservation. In the pasture of the Rockefeller Tract the Plains harvest mouse was common. Otherwise mammals of this tract were not known to differ from those of the Reservation. Woodhouse's toad, common on the Rockefeller Tract, was the only species of cold-blooded vertebrate well represented on this tract but not regularly present on the Reservation.

ACCOUNTS OF SPECIES

*Fishes****Pimephales promelas* Rafinesque**

Fathead Minnow

Status.—Irregular resident and wanderer on area whenever water supply is adequate.

Habitat.—Lakes, ponds, and slow flowing streams; on Reservation limited to small creek draining eastern part of area. At maximum occurs for approximately half a mile along course of this creek, living chiefly in small pools having clay and gravel bottoms. Creek channel is within gully 15 feet or more in depth.

Movements.—From 1948 through July 1952 these minnows, and probably other kinds also, were abundant along the creek's course. Subsequently, drying progressed in the late summer of 1952, until no water remained along the creek's channel and all fish had perished. Throughout the next four years the creek was dry almost continually and no fish were present on the Reservation. On July 29, 1957, several small adults and many young of various sizes were found to be present. Frequent heavy rains in May and June, culminating in a downpour of more than six inches near the end of June had restored the flow of water, creating favorable habitat conditions and had made possible upstream migration to the area.

These small minnows tend to be nomadic, and heavy summer rains stimulate them to migrate upstream into small tributaries and spawn. In the small pools where specimens of minnows were collected, it was noticed that each fish had certain niches or crevices beneath submerged rocks in which it sought shelter when too greatly disturbed.

Among many kinds of small fish which might conceivably reach the Reservation by migrating upstream from the Kansas River to the heads of the small tributaries, the fathead minnow is the only one known to have been present in 1957. In future cycles of wet weather perhaps other kinds of fish will reappear on the area. Nevertheless, it is certain that in the past one hundred years, habitat conditions for fishes in general have undergone progressive deterioration on the area. Before major portions of the drainage systems were subjected to cultivation, and to heavy grazing by livestock, run-off was much less rapid. The two small streams were then much different in character, meandering, with many pools and

sloughs, through their partly wooded valleys. The molluscan fauna, represented by numerous unfossilized shells in the deposited silt of the creeks, included several pond-living or semi-aquatic species which have either disappeared from the area altogether, or are now confined to the one small pond (Fitch and Lokke, 1956: 444). Severe erosion has occurred. Much topsoil has been washed away, especially in upland fields, and the creeks have incised their channels to form gullies that are as much as 20 feet deep, in places. With each heavy rain there is further gully-cutting, but the rate has been reduced. Protection of most of the watershed from grazing and cultivation probably has been instrumental in checking erosion. The water supply has become uncertain and fluctuating, often turbid and with occasional flash floods. The fathead minnow seems better adapted to survive under such unfavorable conditions than does any other species of fish.

Ictalurus melas (Rafinesque)

Black Bullhead

Status.—Occasional and temporary resident, at least formerly; none present in recent years.

Habitat.—Ponds, lakes, dams and sloughs, or slow-flowing streams.

Movements.—In 1951 and 1952, schools of young were seen in the small creek in the eastern part of the Reservation. In 1954 after exceptionally heavy rains in June, a small group was in the creek at the west boundary of the Reservation. All these were young less than an inch long which had moved upstream in schools, after heavy rains.

Lepomis cyanellus Rafinesque

Green Sunfish

Status.—Reaches area as an occasional wanderer, when water supply is sufficient.

Habitat.—Streams with slow moving water, or ponds and lakes.

Movements.—In late June, 1954, several days after heavy rains, three were collected in a pool at the west edge of the Reservation. From the behavior of these sunfish it appeared that they were preparing to breed. The heavy rains, following prolonged drought, had seemed to initiate a breeding cycle, and had caused the fish to run far upstream into this small tributary.

*Amphibians**Ambystoma tigrinum* Green

Tiger Salamander

Status.—Occasional wanderer; only two found in nine years of field work.

Habitat.—Both individuals recorded were in funnel traps in woodland along hilltop rock ledges, when the surface of the soil was still damp after rain. One was caught on October 24, 1951, the other on October 7, 1955.

Movements.—There is no evidence that the tiger salamander breeds on the Reservation. Both individuals recorded were immature and of approximately the same size, 140 mm. total length. They probably had travelled considerable distances after metamorphosis. The nearest known breeding place was a slough in the Kansas River Valley, approximately two miles farther south.

Scaphiopus bombifrons Cope

Plains Spadefoot

Status.—Few records have been obtained from the Reservation, and it is unlikely that this secretive toad is regularly present even in small numbers. Its voice has never been heard in the choruses of breeding salientians at the pond.

Habitat.—Breeding choruses of spadefoot toads have been heard at several places within a two-mile radius south and west of the Reservation. From the location of these choruses it seems that the spadefoots occur chiefly in the Kansas River flood plain and the fairly level land near its margins, although one small pond, on the tip of a spur of hilltop projecting out into the valley, was used. Burrows of small mammals are probably an essential feature of the habitat. Pocket gophers (*Geomys bursarius*) were abundant near the places where spadefoot choruses were heard.

Movements.—None was recorded on the Reservation until May 8, 1955, when an adult female was caught in a funnel trap in a ditch bottom near the headquarters approximately 3000 feet from the nearest pond where choruses had been heard, and a mile from places where other choruses had been heard to the south and west. On July 13, 1956, after a heavy rain, two recently metamorphosed young were found at points 1900 feet and 3000 feet from the hilltop pond near the south boundary of the Reservation, where a chorus

had been heard some nine weeks earlier. In the summer of 1957, ten spadefoots, including both adults and young, were caught in funnel traps in the western half of the Reservation.

***Bufo terrestris* Bonaterre**

Common American Toad

Status.—Abundant resident.

Habitat.—Rocky situations in open woodland, or near woodland edge, perhaps provide optimum habitat. The shelter provided by flat rocks, with damp, loose soil underneath, is an important factor. This toad is not narrowly limited in its habitat requirements, and probably uses the entire area, but it is seldom found in open fields with high dense vegetation. It breeds in the pond and, when sufficient water is available, in the two small intermittent creeks, in marshy situations where the current is normally sluggish.

Movements.—In the breeding pond each trilling male shifts position frequently with no attachment to a specific location. Usually not more than a dozen males were calling at any one time, and they tended to be concentrated within an area perhaps 30 or 40 feet in diameter, but with a few well separated from the main aggregation. However, from night to night the location of the main aggregation shifted. An individual was often seen to swim for a distance of several yards to take up a new position, and occasionally a marked individual recaptured after a short interval was found to have crossed the pond from one shoreline to another. Males that were members of breeding choruses were recaptured after intervals of 53 days, 31 days, 24 days, 23 days and several shorter periods. It is uncertain whether these males had left and returned in the intervals.

Occasionally toads were found in their daytime retreats, in hollows beneath flat rocks excavated partly by their own efforts. Tenure of such shelters was found to be brief. For six immature toads whose shelters were checked from time to time, known occupancy averaged only 9.5 days. The longest known tenure was one of 26 days. Recorded shifts (in feet) from one shelter to another were: 150, 100, 65, 50, 30, 25. All the toads involved in these records were immature individuals several weeks or several months old.

Size of home range was suggested by successive captures of seven individuals all living in the headquarters area. The total of twelve movements averaged 47 feet, indicating a home range of approximately .16 acres. This figure is almost certainly too low for a typical

home range because the resident toads were most likely to be recaptured when they were moving over the sidewalks or lawn adjacent to the buildings, and were least likely to be noticed when they moved farther away. The longest movement recorded was one of 150 feet, in two days.

The newly metamorphosed young, like those of other salientians, disperse rapidly and wander widely in wet weather. On May 30, 1955, swarms of young were noticed at the edge of the water, many still having tail stubs. Two days later the young were no longer confined to the water's edge but were abundant on damp ground near the pond. One had travelled 400 feet from water, but most were still much nearer the pond. On June 8 one was found on a wooded hilltop 700 feet from the pond and at an elevation 100 feet higher, and by the following week the young had dispersed to every habitable situation.

Travel is undertaken at times when the humidity is high and the soil is damp. The young toads soon become familiar with their surroundings and each settles within a small area. Marked young have been recaptured, after periods of days or weeks or even months, near the original location. One marked on August 9, 1951, when it was 39½ mm. in length, was recaptured 150 feet away on April 30, 1952.

Breeding choruses were heard at several farm ponds within a half-mile radius of the single breeding pond on the Reservation. Ponds and intermittent creeks are well distributed over the general area; consequently individuals need not travel more than half a mile to spawn. One male caught and marked as a well grown young (51 mm.) on a wooded slope on May 7, 1953, was recaptured in a breeding chorus at the pond some 1900 feet away, a little more than a year later. A female marked when she was about half-grown was recaptured 150 feet away, in the pond, as a breeding adult nearly 22 months later.

Bufo woodhousei Girard

Woodhouse's Toad

Status.—Scarce and irregular resident.

Habitat.—This toad is much more numerous on adjoining closely grazed pasture and cultivated fields than it is on the Reservation, where it has been found only in grossly disturbed situations, along the road, on or near the lawn, and at the pond. It would seem that the woodland, and the dense herbaceous vegetation present in grassland, render conditions unfavorable for it over most of the Reservation.

Movements.—Most records of this species on the area were obtained in 1955, 1956, and 1957. On July 4, 1956, for most of the day, two were calling at the pond where none had been heard before, although several other ponds within a mile of the Reservation were used regularly for breeding. In 1955 an adult female was seen on September 19, 21, and 23, and on October 10, within a 50-foot radius about the house. Another large adult female was recorded near the house on September 24, 1955, and again on August 21, 1956. Six young were found near the house, in late August and September 1955, and in July, August and September, 1956.

Acris gryllus Le Conte

Cricket Frog

Status.—Resident, and at times perhaps the most abundant of all species of vertebrate animals on the Reservation, although its numbers vary greatly in response to weather conditions, and time of year.

Habitat.—Water, either stagnant or running, is the chief requirement.

The cricket frog is present about the pond and along the two small creeks and their tributary gullies, wherever moisture is normally to be found. Shallow water, either stagnant or with sluggish current, along muddy banks supporting thick grass, provides the most favorable type of habitat. The proportion of the area habitable at any one time depends upon the humidity and moisture supply; at times when moisture conditions are favorable there is dispersal throughout the woodlands and parts of the open areas. In time of drought the population dwindles, and becomes restricted to the remaining limited area with a water supply.

Movements.—Cricket frogs tend to stay in damp places but may wander extensively along creek beds and pond edges in dry weather, and almost anywhere in wet weather. Available evidence, from direct observation on individuals, and from recapture of marked frogs, seems to show that there is but little tendency to remain within a familiar area.

In the spring of 1955 I made effort to mark those in a small area—a strip about 70 feet long along the pond edge at the northwest corner. At each successive visit most of the frogs taken were new, unmarked individuals, indicating a high rate of population turnover. The numbers of new and recaptured individuals taken on various dates were as follows:

- April 22 2 males and 5 females marked.
June 12 8 males and 5 females marked; no recaptures from April 22.
June 13 5 males and 5 females caught, all new except 1 male from June 12.
June 16 2 males and 6 females caught; 1 male and 2 females from June 12.
June 20 3 males and 3 females caught; 1 male and 2 females from June 12,
and 1 male from June 13.
June 21 1 male and 1 female caught, the female from June 20.
July 2 3 males and 8 females caught, including 1 male and 1 female from
June 12 and 2 females from June 20.

The pond's circumference amounted to some 1100 feet and most of the frogs disappearing from the strip under observation probably remained somewhere along its borders. However, one adult female marked on April 11 was recaptured on May 29, 500 feet west of the pond on damp soil in a ditch bottom.

On many occasions, in rain or mist, cricket frogs have been seen travelling far from permanent water, in tall grass of fields, in undergrowth of wooded slopes, or crossing roads. Each heavy rain seems to trigger a mass migration from the normal habitat of marsh, streamside, or pond. The migrating frogs seem to wander at random until, presumably, they perish from lack of moisture as dry weather again sets in. Only a small percentage would be likely to find suitable conditions permitting them to survive. In the summer of 1951 the frequent heavy rains permitted extensive wandering. At an old quarry 600 feet from the pond and approximately 100 feet higher, a depression in the limestone, several inches deep and three feet in diameter nearly always contained water and several cricket frogs usually could be found in the vicinity.

The frequent dispersal and decimation of the population relieves overcrowding in the streamside or marshland habitat. Also, it ensures that any area of suitable habitat will be found and occupied. The frogs are able to travel far and rapidly, as they easily cover two or three feet at a leap. Hence, they are able to seek out remote and isolated areas of habitat at the times when they are wandering.

The larval and postlarval development is rapid, and the crop of young cricket frogs produced one year seemingly attains sexual maturity in time to participate in the next breeding season. The reproductive potential is therefore high, with normally an adequate surplus to repopulate all available habitats.

Hyla versicolor Le Conte

Gray Treefrog

Status.—Common resident.

Habitat.—For breeding evidently requires semi-permanent stagnant pools with mud bottoms and weedy vegetation; some occur in this type of situation throughout summer, but most adults disperse from breeding pool to woodland early in summer. Occurs throughout woodland preferring situations where trees are large and where there are low shrubs; least favorable woodland is open type on dry south slopes, consisting mainly of honey locust and osage orange. Occasionally found in woodland edge situations.

Movements.—Of 113 treefrogs marked in the course of eight seasons of field work, only five were ever recaptured. Most of the frogs marked were adults in breeding aggregations at the pond. One male marked at the edge of the pond on May 2, 1955, was recaptured 30 feet away on June 1. Each of two others recaptured after shorter intervals had moved approximately 30 feet.

An adult female was found in a niche in the vertical rock face at the old rock quarry on July 14, 1950. On August 18 she was recaptured 90 feet farther along the rock exposure. On August 26 she was recaptured a second time at an intermediate location. Another adult female found on the outside wall of the house on October 5, 1952, was recaptured there on October 18. The records of these two frogs suggest that an individual tends to settle in a limited area, for periods of weeks, at least. The adults are not commonly seen except at the breeding ponds, and information concerning their movements is difficult to obtain.

Newly metamorphosed treefrogs, unlike chorus frogs, toads, and narrow-mouthed toads, do not disperse rapidly from the breeding pond. By the time the treefrogs have metamorphosed, in middle or late summer, annual vegetation such as smartweed, giant ragweed and cattail, has grown tall and rank, providing shade and maintaining high humidity near the wet ground. The young treefrogs live on these broadleaved plants. In several different years they remained abundant near the pond up until the time when cold weather arrived.

Pseudacris nigrita Le Conte

Chorus Frog

Status.—Abundant resident, but with great variation in population level from year to year; wide fluctuations in numbers are affected by varying success of breeding season.

Habitat.—Grassland seems to be preferred, but some have been noted in woodland or at the edge of woodland. This frog is so secretive in its habits that it is rarely seen, and its abundance would scarcely be suspected, were it not for the attention attracted by breeding choruses. Impressions regarding habitat preferences have been gained chiefly by observations on the dispersal of the newly metamorphosed young, and the situations where calling adults have been heard, away from water, just before onset of the breeding season. Such bits of information indicate a wide choice of habitats. The frogs seem to be largely subterranean in their habits. Most of those found were under rocks. Probably burrows of the prairie vole, and other small mammals, are important in the chorus frog's ecology.

Movements.—Chorus frogs are active above ground mainly while rain is falling, or afterward while soil and vegetation are still wet. The records are fairly uniformly distributed throughout the year except for December and January. Excluding those frogs that were found in or beside water, 38 of the 44 records for adults were in grassland or open weedy situations, and only six were in woodland. Similarly, 29 of the 36 records for young were in grassland and other open situations. Chorus frogs found in woodland were generally in the more open parts. Most of the frogs found at water were either breeding adults or newly metamorphosed young. A seeming exception was an adult male found at the edge of the pond with swarms of cricket frogs on October 20, 1955.

Chorus frogs found at times other than in rainy weather, or under extremely humid atmospheric conditions were in well protected situations, typically under flat rocks. Whether the frogs carry on all their activities underground for long periods or emerge regularly to forage by night, is uncertain. On the average, they breed well before other local salientians in spring, sometimes even in February, but rain is a necessity for migration to the breeding ponds. In 1956, when no spring rains occurred, breeding was much delayed at the pond on the Reservation, although the supply of water was adequate. Throughout April and early May, 1956, whenever there were warm days with high humidity, one was heard

PLATE 1



FIG. 1. Eastern end of "House Field" in the headquarters area of the Reservation, August 4, 1951. The foreground vegetation consists of awnless brome grass, interspersed with various weeds, notably vervains, ironweed, milkweeds, and ragweeds. The prairie vole, cotton rat, western harvest mouse, glass lizard, and yellow-bellied racer were abundant in the area shown. When this picture was taken, herbaceous vegetation was especially luxuriant as a result of abundant summer rain. The area shown is included in all the maps, figs. 2 to 24.



FIG. 2. Another view of the eastern end of House Field with dam and willow grove in background, August 4, 1951. Brush and young trees encroaching into the field have created a typical "edge" habitat favorable to the cottontail, pine vole, cardinal, indigo bunting, and field sparrow.

PLATE 2



FIG. 1. Site of old limestone quarry on southward projecting spur of hilltop, October 13, 1949. Limestone strata are prominently exposed with cracks and fissures, providing shelter for many kinds of small vertebrates. Level rocky area in foreground has a sparse vegetation of lespedeza and ragweed. The open, rocky area was especially favorable habitat for various reptiles including the box turtle, collared lizard, racerunner, Great Plains skink, slender-flat-headed snake, red milk snake, prairie king snake. The narrow-mouthed toad, striped skunk, woodrat, white-footed mouse, bob-white, and broad-winged hawk also frequented this place.



FIG. 2. Diversion ditch at edge of woodland near Reservation headquarters, June 21, 1949. The bare soil of the banks and rocky bottom provided favorable habitat for the six-lined racerunner. This ditch was a travelway for coyotes, foxes, opossums, various kinds of snakes, and in wet weather, amphibians including the spadefoot toad, American toad, cricket frog, bullfrog, leopard frog, and narrow-mouthed toad.

PLATE 3



FIG. 1. Woodland of a rocky upper slope, dominated by chestnut oak, July 22, 1950. Many kinds of vertebrates prefer this habitat type. Some species that attained their maximum numbers here were the narrow-mouthed toad, American toad, worm snake, copperhead, short-tailed shrew, mole, gray squirrel, and white-footed mouse.



FIG. 2. Hilltop rock ledge in woodland dominated by American elm, November 7, 1951. The ledge provided shelter for many kinds of animals, notably the opossum, short-tailed shrew, woodrat, and cottontail. In autumn various species of snakes including the timber rattlesnake, copperhead, yellow-bellied racer, black rat snake, king snake, garter snake and water snake repair to such places to find shelter for hibernation.

PLATE 4



FIG. 1. Eroded hilltop field at end of 6th growing season after sowing native grass seeds in April, 1949. Side-oats grama to left of gully, and switch grass to right. Deep gully choked with vegetation and erosion almost stopped. U. S. Soil Conservation Service photo, November 9, 1954.



FIG. 2. Another part of same field (shown in Fig. 1) without native grasses, eroded from cultivation in the 1930s. U. S. Soil Conservation Service photo, November 9, 1954.

PLATE 5



FIG. 1. Pond 200 yards east-northeast of Reservation headquarters on November 1, 1951. Cattails, and other hydrophytic vegetation surround the open water. American toads, narrow-mouthed toads, treefrogs, chorus frogs, cricket frogs, leopard frogs and bullfrogs bred in abundance here. Water snakes and snapping turtles preyed upon them. Redwinged black-birds nested in the marsh.



FIG. 2. Upland prairie in northwestern part of Reservation, October 13, 1951. Foreground was part of a farm (later purchased as the Rockefeller Tract) and was subjected to annual mowing and occasional burning. A rich flora of characteristic prairie plants remains. In background, on Reservation, is prairie area not subjected to burning or mowing for many years, dominated by big bluestem, but having fewer associated species than the mowed area. Trees in background are along rock ledge at top of brushy slope. Photo by Robert Rose.

PLATE 6



Intermittent creek in deep gully in southeastern part of Reservation, November 7, 1949. The aquatic fauna here was meager, but fathead minnows were often present in the creek. American toads, cricket frogs, chorus frogs, and leopard frogs bred in the pools. Coyotes, opossums, raccoons, and skunks regularly hunted along this gully, and used it as a travelway.

calling, in a three-inch iron culvert beneath the sidewalk at the Reservation headquarters. It was not known to have emerged.

Rate of dispersal of the newly metamorphosed young was observed in 1951. On the night of June 6 there was a heavy rain and on the following morning there were swarms of young at the quarry, having migrated 200 yards overnight up a wooded slope from the pond at 100 feet lower elevation. Similar rapid dispersal of young has been noted on other occasions. Otherwise little is known concerning movements from day to day and over longer periods, because none of those marked was ever recaptured.

Gastrophryne olivacea (Hallowell)

Great Plains Narrow-mouthed Toad

Status.—Common resident.

Habitat.—Perhaps this species occurs throughout the entire area, but it prefers rocky situations in grassland or open woods, and is abundant along hilltop rock ledges, especially where there is open woodland. Less frequently these toads have been seen or trapped in open fields of the valleys or hilltops. They are secretive in habits and nocturnal in movements and finding them is difficult where there are no flat rocks to turn. In such situations they probably depend upon burrows of other animals for shelter. Breeding occurs at the pond and at a rain pool a few hundred feet from the south boundary of the Reservation. Several times, in summer, after periods of unusually heavy precipitation, when water had collected in small weedy depressions in hilltop fields, these toads were heard calling in them.

Movements.—Freiburg (1951: 384) published findings concerning movements of marked narrow-mouthed toads on the Reservation. More recently Fitch (1955) analyzed the findings concerning movements that have resulted from the capture and marking of 1215 individuals over a six-year period. Only eight percent of the toads marked were ever recaptured. The mean distance for movement for all individuals recaptured was 72 feet. The secretive habits of the toads render them difficult to study. Those that moved farthest from the places where they were marked were least likely to be recaptured, since most of the work was concentrated on small study areas.

Certain individuals were found in the same niche under a flat rock over periods of days or even weeks, but these individuals were exceptional. Of the relatively few that were recaptured, most were

not found at the same place on successive occasions. An individual seems to have no definite permanent home base, but the habits are sedentary. The toads ordinarily do not venture away from their protected shelters except when the soil and vegetation are wet, during or soon after heavy rains.

Of the 59 individuals recaptured after one or more hibernations, 47 were adults, many of which had made one or more round-trip migrations to the breeding ponds. Most of these toads were recaptured in the general vicinity of earlier captures, indicating a homing tendency. Of the toads that were recaptured at greatest distances (hundreds of feet) from the point of release, several were at the breeding pond or *en route* to it in heavy rains. One adult female was caught in the same funnel trap in both 1954 and 1955 while making the trip between the home range and the breeding pond, suggesting a tendency to follow a definite route on successive trips to water.

The concept of home range does not apply well to animals having habits like those of the narrow-mouthed toad, which does not range regularly over a definite area, but occupies in succession a series of subterranean niches in the same general vicinity. When weather conditions are favorable the toad migrates to a nearby niche and does not necessarily ever return to the one it has left. The niche occupied provides protection from enemies, and from extremes of the hostile outside environment; also it provides a regular food supply (chiefly ants of the genus *Crematogaster*).

Narrow-mouthed toads that were recaptured even after intervals of weeks, months, or years, were most often less than 50 feet from the site of original capture. For greater distances, up to 400 feet, there was gradual decrease in the numbers of individuals. Several individuals recaptured at distances in the neighborhood of 400 feet from an original location were later recorded to have moved back near the original site. Therefore it seems that some "home ranges" may have a maximum diameter as great as 400 feet although certainly the usual diameter is much less.

Rana catesbeiana Shaw

Bullfrog

Status.—Resident, with a large population at the pond.

Habitat.—The pond, normally having a surface area of about one-half acre, and adjoining marshy areas of somewhat greater extent, provide the habitat to which this frog is normally limited on the Reservation. Although this small area is normally such favor-

able habitat that it supports hundreds of adult and partly grown bullfrogs, the population often has been decimated by drying in late summer.

Movements.—When drying is in progress, dispersal of frogs occurs mainly at night, or at other times when humidity is high. At such times the frogs are frequently seen in high grass, often along the creek bed and sometimes hundreds of feet from it, in the bottomland valleys. They have seldom been found on wooded hill-sides. Their dispersal is less random than that of leopard frogs, and they tend to keep to low ground where the chances of finding water are better.

Bullfrogs were abundant at the pond in 1952, but in mid-July the pond dried and all were eliminated either by death from desiccation or migration down the creek bed $\frac{1}{4}$ mile or more to places where water remained. On the afternoon of July 10 when humidity was high, a large adult was found in high grass more than 100 yards from the pond. It did not attempt to escape when disturbed, but stood high off the ground and inflated its body to assume a threatening posture.

The pond held water in late spring and early summer of 1953. On May 18 a bullfrog was calling there. It must have travelled at least half a mile—farther if it followed the creek bed. Others reached the pond in the next few weeks but the population remained low and was again eliminated when the pond dried in late summer. In 1954 the pond did not dry, and by early 1955 several adults had become established.

In late May and early June, 1952, 24 bullfrogs were marked with colored tags. A total of 14 recaptures and sight records were recorded; in five instances no measurable movement had occurred; two had moved approximately 10 feet, 3 approximately 20 feet, 2 approximately 30 feet, and one approximately 40 feet. Each individual kept to its own small area within the pond. However, over periods of weeks there was a reshuffling of individuals. Home ranges, if they existed at all, were ephemeral.

Rana pipiens Schreber

Leopard Frog

Status.—Resident, with high population at pond, and occurring throughout entire area, population density and extent of area occupied varying greatly according to season and weather conditions.

Habitat.—Largely dependent on stagnant or sluggish water, at pond and to lesser extent, along two small creeks.

In moisture laden vegetation, when humidity is high, after rain or heavy dew, the population may disperse to every habitat of the Reservation. The frogs, especially the partly grown juveniles, are commonly found in woodland throughout the summer.

Movements.—Leopard frogs commence breeding in early spring, and by early summer the tadpoles are completing their metamorphosis. In dry weather large numbers accumulate in the moist areas along margins of creeks and ponds, but during and just after heavy rains there is a mass dispersal, with relatively few remaining behind. The breeding season may continue from early March until mid-summer or even later, and successive waves of migrants emanate from the breeding ponds throughout the summer. Presumably most of them perish without finding a suitable water supply. However, if drought conditions are not severe, they may survive for days or weeks, staying in protected shelters under rocks, logs, or boards, when humidity is low, and moving about at night. Adults as well as young participate in the mass migrations from the breeding ponds. Travel is fairly rapid on the overland migrations. On rainy nights the frogs have been seen in the glare of automobile headlights hopping across roads. Within a few hours after heavy rains, frogs have been caught in funnel traps on slopes and hilltops hundreds of yards from the pond, where probably the trip was begun.

No evidence of home range nor tendency to keep within a familiar area has been found in the leopard frog. Of several dozen marked and released at different times, none has been recaptured.

Reptiles

Chelydra serpentina Linnaeus

Snapping Turtle

Status.—Moderately common as a resident or transient.

Habitat.—Confined to pond and two small streams on area, so far as has been observed.

Movements.—Over a seven year period 18 snapping turtles have been captured and marked on the Reservation but none has ever been recaptured. Twelve of those marked were hatchlings; the remaining six were large adults. Several other large ones were seen that were not caught. The evidence thus far obtained suggests that these turtles wander more or less indefinitely following up and down the small intermittent creeks according to the water supply.

Terrapene carolina Linnaeus

Eastern Box Turtle

Status.—This species is tentatively classed as an occasional transient or resident, on the basis of one record. The Reservation is slightly outside the known range, which extends from the east into nearby Wyandotte and Franklin counties, Kansas. However, there is an old (and somewhat doubtful) record for Manhattan, Riley County (Smith, 1956: 137).

Habitat.—Deciduous forest and edge.

Movements.—The only record is of a large adult found by Donna Fitz Roy on May 29, 1958, 250 feet south-southwest of the Reservation headquarters. It is almost certain that this individual had recently come to the area; otherwise it would have been seen as frequently as the other box turtles having ranges in this vicinity.

Terrapene ornata Agassiz

Western Box Turtle

Status.—Resident on area, but in sparse population as compared with numbers in more favorable habitat elsewhere.

Habitat.—Probably this terrestrial turtle occurs throughout the area but it has not been found in the fallow fields that have rank growths of weeds so tall as giant ragweed and sunflower. Grazed pastureland provides the most favorable habitat, woodland next, open fields with undisturbed prairie vegetation or with brome grass and weed mixture are less preferred, and the rank weed habitat of recently fallowed fields seems to be least favorable.

Movements.—Because box turtles were scarce on the Reservation, the information obtained concerning their movements was meager. However, in the closely related *Terrapene c. carolina*, movements have been studied more thoroughly than in any other kind of animal (Stickel, 1950). Probably *T. ornata* is similar to *T. carolina* in the extent and pattern of its movements. Stickel found that in *T. carolina* the average range of adult males was 330 feet and that of adult females, 370 feet; the difference was not statistically significant. Home ranges are maintained from year to year, but overlap widely with no indication of territoriality. Within the area of its home range a turtle seems to wander in an aimless manner, making numerous turns, criss-crossings and detours. However, there seems to be a tendency to return to certain places and to travel repeatedly over certain relatively short preferred routes; "One turtle walked

over a single short stretch of path seven times in eight days, traveling over diverse areas between times." (Stickel, *op. cit.*: 367).

Fourteen box turtles marked on the Reservation were recaptured from one to nine times. Seven were adult females, six were adult males and one was a juvenile of undetermined sex. The time span involved was within a single season for three; two seasons for four; three seasons for two; and four, six, and seven seasons for the other three. In 30 instances distances between successive sites of capture averaged 325 feet. One exceptionally long movement of 1830 feet was made by a female in a 53-day interval. This movement probably represented wandering well outside the usual range, and there-

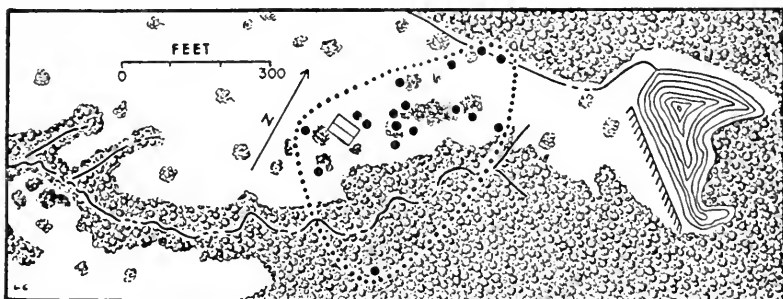


FIG. 4. Range of an adult female box turtle recorded 17 times from June 17, 1954, to July 31, 1957.

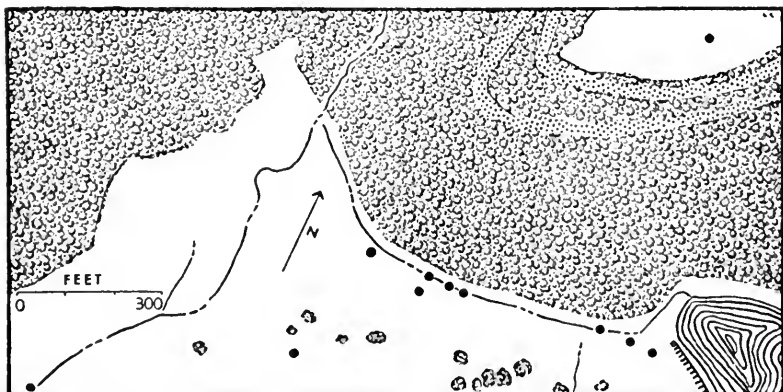


FIG. 5. Range of an adult female box turtle recorded 11 times from July 11, 1949, to May 25, 1957. The area of activity for this individual probably is much larger than for the one shown in Fig. 4; in the interval of nearly eight years the one concerned in Fig. 5 altered her home range extensively.

fore is best eliminated from the figures used to estimate size of home range. For the remaining 29 movements, the average was 274, and there was but little difference between the sexes (average for seven males, 282 feet; for 22 females, 270 feet).

Assuming random movement over the home range (although Stickle's findings suggest that the movements are not entirely random), and assuming that captures recorded were within the regular home range of the individual involved (except for that of the individual that had moved 1830 feet), the radius of the home range, in the neighborhood of 274 feet, indicates that an area of approximately 5.4 acres is covered.

One turtle was brought to the Reservation headquarters and released approximately half a mile from its original location. Nearly a year later it was found only 210 feet from the point of release. This single observation suggests that homing tendencies are either totally lacking or weak in the box turtle.

On several occasions box turtles were equipped with trailers, a spool of thread rotating on a spindle and unwinding as the turtle travelled. Such turtles usually travelled several hundred feet in the course of a day. Several individuals equipped with such trailers were kept under observation for periods of a week or more by John M. Legler, who also has made much more extensive studies of the box turtle's natural history and ecology in grazed pasture habitat west of Lawrence.

Chrysemys picta Schneider

Painted Turtle

Status.—Recorded just once in fall of 1951, at pond.

Habitat.—The one individual seen was basking in the sunshine on a floating board in the pond. The species is known to occur in lakes, large ponds, and sluggish streams where the water supply is sufficiently extensive and permanent to provide shelter and to support an aquatic fauna upon which the turtle depends for food.

Movements.—No definite records of movements have been obtained, but the abrupt appearance of the single adult individual at the pond, perhaps $1\frac{1}{2}$ miles from the nearest suitable habitat, indicates that it must have made an overland journey of this distance; or it might have followed up the creek from a larger stream, which would have involved an even longer trip.

Crotaphytus collaris Say

Collared Lizard

Status.—Permanently resident, 1949 to 1956, but with few individuals, and limited to small area, at quarry.

Habitat.—Requires open, sunny situations, with loose rocks; habitat represented on Reservation only at old rock quarry.

Movements.—Suitable habitat on the Reservation over the period of study was limited to an area at an old rock quarry approximately 400 feet long and 100 feet wide. The colony under observation was small; 56 individuals, in all, were recorded over a seven-year period, but these represented several successive generations. Although there was territorial pressure, the colony showed no tendency to expand into adjacent habitats. They filled the quarry area to the extent of its carrying capacity, and so far as known, those that were eliminated were taken by predators without having left the area. At times when the population was crowded, as a result of successful reproduction, incidence of mortality was notably increased because of intraspecific friction. Recently hatched young, partly grown young that are attaining sexual maturity, and adult males that are dominated by others are especially susceptible to elimination.

Hatchling collared lizards, escaping from the nest burrow in broods of two to a dozen or more, tend to disperse immediately and wander for at least a day or two, to distances up to a hundred feet, or perhaps more; consequently they are not concentrated where they would compete with each other or where several at once would be captured by a predator. Hatchlings recently emerged have been noted to run in a random and aimless manner when attempting to escape. Others, still less than a week old, have been noted at each alarm to run to a regular place of shelter, a burrow or crevice providing security. Such young obviously had already become familiar with their immediate surroundings, and in their day to day activities they tend to stay in home ranges only a few yards across, consisting of one or several look-out rocks for perching and basking, and as escape shelter. Over periods of days or weeks, nevertheless, the juvenile may gradually shift its activities to a place many rods removed from its original home range. Also, the size of its home range is gradually increased.

From the time they are about a quarter-grown in bulk (75 to 80 mm. in snout-vent length), males are territorial. On September 30,

1953, when no adult males were present, the eight young males all approximately seven weeks old, were almost uniformly spaced along the 400-foot stretch of ledge at the quarry. Pursuit and fighting resulted immediately when any one of the young males was chased into the area dominated by another.

Ordinarily no more than two adult males were present at the quarry, and they divided the 400-foot stretch of ledge between them. A break in the outcrop near its middle separated the two territories, each of which was dominated by a succession of different males.

Territories tended to be linearly arranged along the 400-foot stretch of the quarry, as the lizards usually stayed close to the rock outcrop. They perched and travelled mainly along the bare rock at the top of the ledge and the shallow layer of bare soil adjacent to it. As a result of quarrying operations some years before, there was an exposed vertical rock face four to six feet high below the ledge, and a taluslike accumulation of sloping rock and soil with weeds and saplings which the lizards also used. The width of the outcrop and the rocky area below it averaged about twenty feet, and the lizards' activities ordinarily were confined chiefly to this width. Occasionally they ventured out on the adjacent flat, almost barren, limestone area. Grasshoppers, which constituted the lizards' main food supply, were abundant on this flat, but shelter was lacking, and at any alarm the lizards would rush back to the ledge.

Because of such occasional use of areas outside the usual sphere of activity, the extent of home ranges or territories cannot be stated with precision. One female that was recorded more than 100 times over a six year period was always within an area of approximately 300 feet x 40 feet. She was known to have shifted her headquarters several times, and the area covered in any daily or weekly period would have amounted to only a small part of the total area of 12,000 square feet covered in her lifetime. Individuals differ notably in the extent of their ranges. A female from the same brood as the one mentioned above, early became established at the opposite end of the quarry area. She was remarkably sedentary in her habits, and it is estimated that she spent at least half of her time within an area of only a square yard. Nearly always she was seen within a few yards of the same crevice, into which she quickly retired at any alarm. But to lay her eggs, she moved along the ledge some 150 feet from her home base. The adult and nearly adult females present at the quarry at any one time usually arranged themselves in territories that were mutually exclusive, or nearly so. The females

are much less aggressive than the males, but occasionally pursuit and attack of one individual by another has been observed. Individuals of the opposite sex, so far as observed, were never objects of territorial hostility. Males and females were often associated in pairs even at times when there was no breeding activity. The males have territories that average several times as large as those of females. In August, 1950, the four adult females present occupied stretches of ledge from west to east, 100 feet, 70 feet, 60 feet and 25 feet long. At times when only one adult male was present, he would range along the entire 400-foot length of ledge. The adult males were generally tolerant of partly grown males and, even though the latter were sexually mature, did not pursue or attack them. The small males were wary of the adults and did not challenge their dominance.

Ophisaurus attenuatus Baird

Slender Glass Lizard

Status.—Common resident.

Habitat.—This species occurs in grassland portions of the area; also in woodland edge situations and in open woodland or parkland with a herbaceous ground cover. It was seen only a few times in 1948 and 1949, when the pasture areas were grazed. The lack of adequate cover under these conditions was unfavorable, and probably the lizard was able to persist only because of the cover provided by marginal situations, along edges of fenced woodlands and edges of thorn thickets where herbaceous vegetation was at least partly protected from livestock. In later years glass lizards have been seen more frequently, and a high proportion of those seen were young, suggesting successful reproduction and steady increase with amelioration of habitat conditions after grazing was discontinued and by 1957 they had become moderately abundant.

Movements.—Over a seven-year period a total of 108 glass lizards have been captured, marked and released, and 31 have been recaptured from one to eight times. For most, the records extended over periods of months. Eighteen were caught in only one year, six over two years, three were caught over a four-year period, and four over three years.

These lizards are secretive and seem to travel but little, relying to a large extent on dense cover and concealing coloration to escape notice of both prey and predators. Most time is spent underground, or at least beneath the surface mat of dead vegetation. Many glass

lizards, including all of those that were recaptured, were known to live in the field within 300 yards of the Reservation headquarters where my field work was concentrated. Yet seeing a glass lizard in this area was a rare occurrence. Even when conditions of temperature and humidity seemed near optimum for them to be in the open, the area might be traversed several times by a person without his seeing one.

Glass lizards were usually found in tall grass and were remarkably elusive. One that was startled would dart away with rapid lateral undulations of its body, usually permitting no more than a glimpse of it. In this initial spurt the lizard rarely traversed more than ten feet but it was always difficult to relocate, as its dark brown color blended well with the background of old dead vegetation of the surface mat. Relying on concealment the lizard might permit close approach before moving again. Or it might move away slowly and stealthily with none of the commotion of its initial spurt. Occasionally in stalking a glass lizard in high grass I have "flushed" it four or five times in succession before finally catching or losing it. Working alone I have most often failed to make a capture, but when accompanied by one or more other persons, I have often been able to direct their movements in such a way that the glass lizard was driven toward me, came within easy reach, and was secured with a sudden grab. This maneuvering involved in flushing, stalking and capture of a glass lizard was generally within an area not more than 20 feet in diameter. If not caught within a minute or two, the glass lizard invariably found shelter and disappeared. In some instances it may have merely wriggled beneath the surface mat of dead vegetation. In other instances, however, glass lizards were seen to escape into burrow entrances of the prairie vole. The extensive underground runway systems of the voles may provide the retreats where the glass lizards spend the greater part of their time when they are not active on the surface.

In 36 instances the intervals between successive captures ranged from 280 feet to 10 feet, and averaged 88 feet, indicating home ranges in the neighborhood of .55 acres. The records are not sufficiently numerous to show conclusively the differences between the sexes, and between young and adults, but they do suggest that such differences exist. For adult males (20) the average was 98 feet, for immature males (11) 90 feet, and for adult females (5) 43 feet. Those that hibernated one or more times between captures are not included in these figures. For 15 such intervals the average

movement was 282 feet (850 to 20), indicating that there is some tendency to shift the home ranges over long periods. However, only one individual had moved more than 500 feet.

Cnemidophorus sexlineatus Linnaeus

Six-lined Racerunner

Status.—Locally abundant on several small areas of Reservation until 1956; much reduced in numbers since then.

Habitat.—Patches of barren soil seem to be the essential habitat requirement; therefore the species has been confined to relatively small areas on the Reservation. Habitat deterioration has progressed as luxuriant vegetation encroached on sites that formerly had a sparse vegetation or were largely barren. The quarry formerly supported the largest number. A hilltop field formerly cultivated, and heavily eroded, with topsoil washed away and subsoil dissected by a system of gullies, supported a moderate population in 1948. At that time the area was partly barren with sparse vegetation of bindweed, three-awn grass, and lespedeza. In the following years as grass and weedy vegetation encroached, bare areas were increasingly restricted to the bottoms and steep sides of the gullies, and the lizards became correspondingly scarcer. By late 1952 few remained but in the following four years of drought they partially regained their numbers. A diversion ditch carrying water from the pond about 1000 feet along the base of a hillside, between woods and an open field, was usually dry except after heavy rains when the pond overflowed. In 1952 the dry channel of this ditch was occupied by a colony of these lizards, which found the bare soil of the ditch bottom and banks a favorable habitat, and thrived there for the next five years.

Movements.—The racerunner is far more active than any other species of reptile on the area. Individuals move about almost constantly when they are active, and are capable of great speed. In its normal foraging this lizard moves over areas of bare soil with a brisk, jerky gait that seems to be half running and half walking. Individuals foraging in this way have often been followed for as much as 200 feet in the same general direction.

The racerunner shows a strong tendency to stay in a familiar area. Many of those marked were recaptured frequently, up to as many as 25 times, and successive captures were nearly always in the same general area. On the Reservation the individual areas of the lizards tended to be long and narrow, probably because barren ground occurred in strips along the hilltop ledges, gully banks,

ditch and road. In a more typical habitat of sand dune or open field, a home range probably would be more nearly circular or oval. For the entire group a total of 290 movements between successive captures were recorded and the average movement was 141 feet, but with notable disparity between the sexes, and between young and adults. For 102 movements of females the distance was greatest,

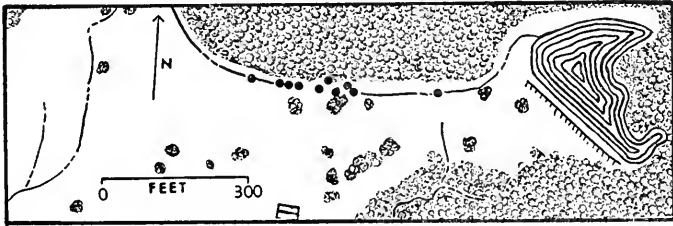


FIG. 6. Records of an adult male six-lined racerunner captured 17 times from June 19, 1952, to July 13, 1953. The records for this individual and most others on the Reservation tend to be linearly arranged where there are strips of barren soil—along banks and bottom of a diversion ditch in this instance. Such disturbed situations provide the final refugia as revegetation proceeds on the Reservation.

171.3 feet; for 188 movements of males average was 125 feet, and 42 movements of young averaged 99 feet.

The young were of both sexes and various sizes, from hatchlings to subadults. Observations on hatchlings indicate that at first they stay within an area of only a few yards, and that as a lizard grows, becoming fleet of foot and more familiar with its surroundings, the sphere of activity gradually enlarges to the size of the adult's home range.

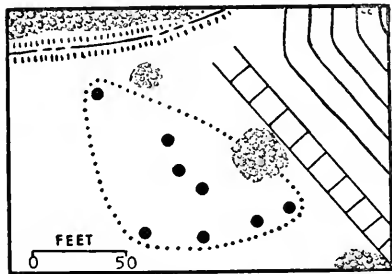


FIG. 7. Records of an adult female glass lizard captured eight times in the period May 30, 1956, to August 27, 1957. The area covered was approximately 125 feet in greatest diameter. For male glass lizards ranges recorded were often somewhat larger.

The partly barren area of the ditch banks and bottom, providing favorable foraging grounds for racerunners, averaged approximately 25 feet in width. If the lizard wandered at random along the length of the territory, it is calculated that any two records of an individual would, on the average, be separated by a distance

35 per cent of the range's full length. On this basis the figures already cited would represent home ranges of .25 acre for all race-

runners, .28 acre for adult females, .20 acre for adult males, and .16 acre for young.

Frequently, both on the Reservation and elsewhere, racerunners have been seen in locations familiar to me, where none had been observed previously. Obviously, at times they leave the areas habitually frequented and make movements of an exploratory nature. Exceptionally long movements recorded for the marked individuals recaptured in the course of my field work were 1100, 700, and 600 feet (and back again) for adult males; 900, 750, and 750 feet (and back again) for adult females, and 650 feet for a young male. The previously mentioned hilltop quarry, and the ditch in the field near the headquarters of the Reservation were separated by a wooded slope 600 feet across at its narrowest. The woods were thick, with tangled undergrowth, and seemed entirely untenable as habitat for the racerunners. Nevertheless, several that were first caught and marked at the quarry were later recaptured along the ditch bank. Also, on several occasions, lizards that were not individually identified, were seen in the woods. Most of these were on a man-made trail where ground vegetation was sparse and trampled, making running easier for them. Probably this trail served as an avenue of travel and permitted the racerunners to cross the wooded slope more easily than they could have otherwise.

Having large feet and powerful claws, racerunners are efficient burrowers, and excavate underground retreats into which they retire at night and in periods of inclement weather. On many occasions racerunners have been found in small nest cavities beneath flat rocks. Such cavities do not constitute permanent home bases, as an individual has rarely been found more than once in any one nest cavity.

The temporary nest cavities seem to be defended. On several occasions lizards, even young less than one-third grown, have been seen to dart out of burrows in pursuit of others that had started to enter, and chase the intruder for several yards. Chasing has been noted frequently, but it is usually sexual pursuit or masculine hostility not involving the defense of a definite territory. Individuals overlap extensively in their ranges. In favorable habitat a given situation may be used by several or many individuals of both sexes.

Lygosoma laterale (Say)

Ground Skink

Status.—Uncommon resident.

Habitat.—Woodland and woodland edge are preferred; the records of this species on the Reservation are perhaps too few to define its habitat requirements with precision, but seem to indicate that it occurs in all types of woodland, and ordinarily does not invade open fields beyond the shade of adjacent woodland. It is usually found in ground litter of fallen leaves and has been found most often in situations dominated by oak or hickory. One was at a board pile in the edge of a field of brome grass a few feet from the edge of hickory woods. Several were taken at a rock pile near the pond, adjacent to woodland. Several were found in grass in a parklike situation beneath large elms near the headquarters. One was found in bluestem prairie about 40 feet from trees and brush near its border.

Movements.—No records of movements were obtained; of a dozen individuals marked and released none has been recaptured.

Eumeces fasciatus Linnaeus

Five-lined Skink

Status.—Resident throughout the wooded parts of the Reservation.

Habitat.—Occurs in all types of woodland but in varying abundance; most numerous in hilltop ledge situations in open woods, and least numerous on heavily wooded north slopes where thick canopy permits little penetration of sunlight to forest floor. Flat rocks for shelter are an important requirement and where they are scarce or absent skinks are correspondingly scarce.

Movements.—In a recent publication (Fitch, 1954:99-115) I have discussed in some detail the data concerning movements of five-lined skinks accumulated over a four-year period. Several hundred skinks were marked and released, mostly on study areas of only a few acres. A total of 323 marked skinks were recaptured, many after one or more hibernation periods. None was captured frequently. Seven captures were the maximum recorded for any individual, and

these were spread over a period of nearly four years. In almost every instance of recapture of a marked skink, the actual distance of travel and the time, frequency and motivation were unknown. Although the records were inadequate to show the home range of any one individual, they were sufficiently numerous to show the trends according to sex, age, and lapse of time. Five-lined skinks are secretive, living where there is abundant shelter in the form of leaf litter, decaying wood and rocks. They stay under cover most of the time, and when travelling, they move furtively, always keeping near cover. The home range usually centers about a decaying log or comparable shelter, and the size and shape of the range is altered accordingly. Home ranges averaging approximately 90 feet in greatest diameter are indicated both for adult males and young. These skinks seem to have no regular home base, but use any convenient shelter within the area when they are inactive, or escaping from enemies. The adult females, however, have regular nest burrows in which they usually stay, except for occasional brief emergencies to find food, from the time they become pregnant in early May until after the eggs hatch in July or August. On their brief forays for food these nesting females usually venture only a few yards from their burrows. Although they occasionally leave the nest burrow and eggs to forage, they then range much less widely than at other times. Several male skinks that were recaptured repeatedly were shown to have moved back and forth within areas 200 to 275 feet in greatest diameters, which constituted their home ranges. Others were limited to much smaller areas. A rock pile of approximately 70 x 30 feet harbored many skinks of both sexes and various sizes because food and shelter were abundant there. The rock pile was bordered on three sides by areas unsuitable as habitat, and on the fourth side the habitat also was much less favorable than in the rock pile itself. The rock pile or parts of it constituted the entire home range for all the skinks present there. These skinks are not territorial but males are hostile and fight on sight in the breeding season.

Eumeces obsoletus Baird and Girard

Great Plains Skink

Status.—Confined to relatively small parts of area where its habitat is present; there moderately common.

Habitat.—This large skink typically lives in open grassy situations with large flat rocks. Hundreds of captures have been recorded, mostly within four small areas totalling only a few acres

in extent. Perhaps not much more than one percent of the area is regularly occupied, and the habitable area steadily diminished as ecological succession proceeded with woody vegetation steadily encroaching. Under original conditions, with the area mostly prairie, the hilltop rock ledges several miles long, must have supported a large population of these skinks. By 1955 they dwindled to four separate relict colonies, one at the quarry, and the other three along stretches of rock ledge and adjacent woodland that were grazed by livestock until 1949 (the remainder of the rock ledge and woodland was fenced and protected from livestock beginning in the 1930's).

Movements.—"The usual concept of a home range does not apply well to the Great Plains skink despite its tendency to remain within a small area. One skink may spend many days in its small burrow system under the same rock, or else if it does emerge at all it makes only short trips and then returns. But such shelters and burrow systems are temporary, generally occupied for only a few days, or, at the most, a few weeks. Then the skink moves on to another site, often only a few yards away. Later as it shifts to still other successive locations, it ordinarily does not move farther in the same direction, but tends to keep within a small area, probably using the same travel routes and depending on the same landmarks. The 'home range' encompassing the area to which normal movements are confined, is, however, ill-defined, because it is covered infrequently and has no definite boundaries, and its size, shape and position are ephemeral." (Fitch, 1955: 69.)

Great Plains skinks were much less numerous than five-lined skinks on the Reservation, but, for individuals, records of recapture were more frequent. Over a four-year period 634 captures were recorded for 208 individuals. In general, individuals tended to stay within areas more than 50 feet but less than 150 feet in greatest diameter. Males are more vagile than females and adults are more vagile than young. For twelve adult males each recorded in at least four locations, the average distance between most remote points of capture was 125 feet; for six adult females and seven juveniles comparable figures were 75 feet and 60 feet respectively. All these were selected individuals that moved back and forth without making long shifts. For 226 recorded movements of marked individuals, between successive captures, mean distances were as follows: adult males (80), 70 feet; adult females (51), 31 feet; young (95), 39 feet. The higher figure for adult males is influenced by the

fact that they are more inclined to shift. Eliminating the few movements of more than 200 feet, which are obviously shifts in most instances, average movements are: adult males, 51 feet; adult females, 19 feet; young, 30 feet. On this basis it is estimated that home ranges are .2 acre or less in adult males and of even smaller size in the females and young. Not included in these figures are the 45 movements in the intervals that included one or more hibernation periods, 121 feet for 16 adult males, 119 feet for 10 adult females, and 81 feet for 19 young. These figures suggest that the lapse in day to day routine and the seasonal change in habitat associated with hibernation often induce individuals to shift to new home ranges. These skinks often do shift away from an original home range to a new area more or less remote from it. Over periods of months or years many of the skinks on the study areas turned up at locations hundreds of feet from the areas encompassed by a series of early capture records. After such a long movement a skink never returned to an original home range. The longest record of movement was one of 500 feet (830 feet if the skink kept to the usual rock ledge habitat) in an individual whose records extended over 47½ months.

On many occasions skinks seemed to appear abruptly on study areas that had long been under intensive observation. After an original capture some such individuals were often recorded regularly over periods of weeks or months, indicating that they had settled in the new location after immigrating from a more or less remote location.

Unlike most other kinds of reptiles occurring on the Reservation, Great Plains skinks dig well in soil that is loose and moist, and they spend most of their time in the burrows that they have excavated. The burrows may be several inches or several feet in length and usually they are under rocks. A skink may stay in such a burrow for periods of days, then may emerge, wander briefly, and begin a new burrow a few yards away. In the breeding season, May and June, adults are often found in pairs in their burrows under large, flat rocks. Such burrow systems may be thought of as temporary small breeding territories because they are never occupied by more than the pair of adults, and the male will viciously attack intruding males.

Although these skinks seemed to be disappearing from the Reservation by 1955, they made surprising gains in numbers in 1956 and 1957, and even appeared in several areas where they had not been recorded previously.

Eumeces septentrionalis Baird

Prairie Skink

Status.—Only three recorded on Reservation, perhaps survivors of relict colony.

Habitat.—All three skinks were found on lower slopes of hillsides having southern exposures, in grassy places sparsely wooded with osage orange, honey locust, dogwood and haw, grazed by livestock until 1949. As compared with most other places in northeastern Kansas where the species has been collected, these sites differed in having encroaching woody vegetation, and more rank herbaceous cover. Discontinuance of grazing is resulting in the elimination of this skink's habitat.

Movements.—In the summer of 1953 one was caught twice, at stations 100 feet apart in funnel traps set in a ditch between woodland and grassland. Breckenridge's (1943) study of marked individuals of a local colony of these skinks suggests that the species is at least as sedentary in habits as is *E. fasciatus* or *E. obsoletus*.

Natrix sipedon Linnaeus

Common Water Snake

Status.—Uncommon, and probably irregular, resident, its number influenced by uncertain water supply.

Habitat.—Mainly in vicinity of permanent water supply, either stagnant or running; in spring and autumn has been found along hilltop rock ledges far from water, and evidently seeks such situations to hibernate.

Movements.—Of 23 water snakes marked and released, four have been recaptured. A large adult female caught twice in 1949 was recaptured in 1952 and 1953. All captures were at the pond or near it, with the exception of the second 1949 record, which was some 450 feet farther west along a diversion ditch. Of two young females recaptured, one was taken in early September and again the following May in the same rock pile near the pond. The other was recaptured after a three-month interval less than 100 feet from the original location, beside the pond. A juvenile was recorded three times within a 15-foot radius, at the Reservation headquarters in September 1953. The records of these several marked individuals that were recaptured demonstrate that individuals may live for periods of months or years where there is a limited and isolated water supply. The other records suggest that individuals occasionally wander long

distances to find such habitat. Stickel and Cope (1947:129) recorded one recaptured at a distance of 380 feet after a lapse of two years.

Storeria dekayi Holbrook

Brown Snake

Status.—Uncommon resident; actually may be more numerous than some of larger snakes that are considered moderately common, but is seldom seen because of small size, secretive habits, inconspicuous dull coloration, and preference for situations with dense ground cover.

Habitat.—Woodland in damp, well-shaded situations where leaf canopy is dense; also in wet situations near stagnant or running water.

Brown snakes are most commonly found in late March or April, under flat rocks, often associated with ring-necked snakes and worm snakes.

Movements.—No information has been obtained; none of several brown snakes marked and released has been recaptured.

Thamnophis sirtalis Linnaeus

Common Garter Snake

Status.—Common resident.

Habitat.—Damp situations wherever its prey, earthworms and amphibians, are available. The pond and the two small creeks provide the most preferred habitat, but this garter snake also ranges far and wide through moist fields and woodlands. Garter snakes have been caught in greatest numbers in October, in funnel traps set along hilltop rock ledges, which are preferred hibernation sites. The ledges chosen are those in warm and dry situations, with south-facing exposures.

Movements.—A total of 150 garter snakes had been marked and released on the area and 22 had been recaptured by the end of 1956. Twelve of these records were of snakes recaptured after one or more hibernation periods. In eleven instances the distances between successive capture locations averaged 688 feet (777 feet for seven males and 532 feet for four females) indicating home range areas in the neighborhood of 34 acres (or 43 acres in males and 20 acres in females, if the differences between the sexes in this small sample are representative). Movements to or from hilltop rock ledges, where hibernation dens usually are located, were not

included in the computation of average movement between captures. In most instances travel to or from the hibernation den must have taken the snake well beyond the limits of the usual range. The longest movement recorded was one of 2300 feet, in a female first caught as a juvenile at a hilltop ledge on October 25, 1950. An adult male recorded at a hilltop ledge twice in November was recaptured 1040 feet from there in a bottomland meadow the following May. No garter snake was recaptured in the same denning area after an intervening summer, although in several instances a snake was recorded more than once in a denning area in the same autumn, or in autumn and again in spring. From the trend of the records, it seems that garter snakes have some attachment to definite areas, but tend to range more widely than most other snakes, and, over periods of months or years may wander into new areas. Of 97 records on the area, 49 were at hilltop ledges, 30 were in the vicinity of water including several at a rock pile near the pond which was also used for hibernation, 13 were in grassland and five were in woodland. Double or multiple catches were made in funnel traps much more often than might have been expected from chance. The catch might consist of three males (once), two males and a female (twice), two males (twice), two females (twice), male and female (five times). Most of these catches were made along hibernation ledges, and it seems probable that trailing by scent of one snake by another was responsible for the double or multiple captures. This idea is borne out by the fact that when a garter snake was removed from a trap on one day, a second was often caught on the day following.

Carpenter (1952:250) studying a population of this species in Michigan found the average "activity range" to be about 600 feet in length and 150 feet in width, thus having an area of 2.07 acres.

Haldea valeriae (Baird and Girard)

Smooth Earth Snake

Status.—Rare and seldom seen (only two records) because of secretive habits, but probably resident on Reservation in small relict population.

Habitat.—This small, burrowing snake lives chiefly in deciduous forest. Here, in the northwestern corner of its range, it seems to prefer open woodland with rocks and brush but not a continuous leaf canopy. The species is known from only five localities in Kansas (Smith, 1956:287), these clustered in or near Douglas County, where the Reservation is situated.

Diadophis punctatus Linnaeus

Eastern Ring-necked Snake

Status.—Abundant resident; at times this snake probably outnumbered, in individuals, all other kinds of vertebrates on the Reservation.

Habitat.—Optimum habitat seems to be in open woodland with abundant flat rocks. Ring-necked snakes do not often bask in direct sunlight, but regulate their body temperatures by maintaining contact with the undersides of rocks warmed by sunshine. They are largely subterranean in habits. They are relatively scarce in woodland with a continuous leaf canopy shading the ground. In meadow habitat, where rocks are absent, the snakes are difficult to find, but have been seen on many occasions crawling through the grass or crossing roads. On several occasions they have been found in underground tunnels of the prairie vole. Several have been found in the humus and litter beneath the stick houses of woodrats.

Movements.—The ring-necked snake is probably the most abundant reptile of the Reservation, but because of its secretive tendencies, attempts to study it were remarkably unproductive. A total of 333 have been marked and released, mostly in 1950 and 1951, but only 11 recaptures for ten individuals have been recorded. Most of the individuals marked were in small areas of favorable habitat where intensive field studies were in progress, which should have greatly increased the chances of recoveries. However, of the ten individuals recaptured, seven were taken after intervals of less than a month, and perhaps had not had time to wander far from the original location. An eighth was a juvenile caught and marked shortly before going into hibernation (October 2) and recaptured the following spring at the same place soon after emergence (April 26). Of these eight, two had moved 60 feet, one 30 feet, and the remaining five had made no measurable movement. An adult male caught and marked on April 26, 1950, was recaptured 90 feet away on May 1, 1951. An adult male marked on April 27, 1951, was recaptured 350 feet away on May 22, 1954.

These small snakes may not have regular home ranges as they seem to wander widely. Each year in April and May, ring-necked snakes were found in large numbers in certain rocky places that were evidently optimum habitat at that time of year or served as hibernation sites. Most of the individuals marked were those found in such places, which had an almost complete turnover of the

population from year to year. Evidence of wandering was obtained frequently. The grassy field where the Reservation headquarters are situated was much less favorable habitat than the rocky slope where the snakes were more often found. However, on many occasions, when temperature and humidity were favorable, the snakes were seen crossing the road or crawling through high grass. Strips of tarpaper were placed on the ground in many places in the field. When weather was moderately cool and soil was moist, ring-necked snakes usually could be found under these strips, but none of these was ever recaptured.

Carphophis amoenus Say

Worm Snake

Status.—Common resident.

Habitat.—This snake occurs throughout the wooded portions of the Reservation and along woodland edges. Most individuals have been found in open rocky woods. Nearly all were uncovered in loose soil beneath large flat rocks. These snakes have been found chiefly in the rock-strewn portions of the woodland, but perhaps are not actually concentrated in such situations to the extent that my records would suggest, since it would be far more difficult to find them in the absence of rock cover. Isolated large rocks in woodland often have worm snakes hiding under them. Loose damp soil is a necessity. The snakes are found mainly in April and May, and are little in evidence later in the season, when evidently they retreat deep underground. In periods of rainy weather when the soil is unusually damp, they may be found occasionally in the types of situations frequented in spring, while in periods of dry weather, they cannot be found at all.

Movements.—Worm snakes usually stay beneath the surface of the soil. They are more specialized for fossorial life than any other species of reptile occurring in the area. The head is small and flattened, with snout spade-like, lower jaw counter-sunk, eyes minute, and cephalic plates reduced. The neck is especially thick and muscular, adapted for driving the head through soft soil. I have never found a worm snake travelling above ground in the open. Such travel is indicated by occasional individuals caught in pitfalls or funnel traps, but probably they emerge only under cover of darkness.

Of 137 worm snakes marked and released, nine have been recaptured. One was recaptured four times, another twice and the others

only once each. Seven were recaptured only in the same season they were marked; the other two were recaptured in the following season after lapses of 12 months and 10½ months. A large adult female had moved 410 feet between May 19 and June 7, 1951, but all other individuals were much more sedentary. An adult male had moved 50 feet between May 30, 1949, and April 14, 1950. An adult female had also moved 50 feet between April 30 and May 25, 1951, but on May 29, May 31, and September 14, she was found within five feet of the second location. An adult male had moved 20 feet in 38 days. Each of the other individuals either was recaptured under the same rock where the snake was captured originally or had moved no more than five feet. Span of records between first and last captures for these individuals were: 352, 5 (with three captures), 5, 4, and 2 days.

The trends of these meager data seem to suggest that worm snakes have no home range in the usual sense, but tend to stay for long periods in the soil at the same place, moving mainly in vertical planes in response to changes in temperature and moisture. Occasionally individuals may make relatively long shifts, perhaps wandering at random, and then may settle in new locations. There is no evidence that the snakes ever return from such wanderings.

Coluber constrictor Linnaeus

Yellow-bellied Racer

Status.—Common resident.

Habitat.—Occurs throughout the entire area with seasonal shifts.

In summer it ranges over grassy fields, especially those of the two small valleys, also in bluestem prairie, along woodland edge thickets, and in open woodland where some herbaceous ground cover is present. In fall most of the population or all of it resorts to hill-top ledges for hibernation, after moving across wooded areas to reach these sites, in some instances.

Movements.—By July 15, 1955, a total of 337 yellow-bellied racers had been marked and released on the Reservation and 74 had been recaptured, mostly after substantial intervals. Forty-two were recaptured after lapse of a year or more. Four was the maximum number of captures for any one individual.

In the area of the Reservation, yellow-bellied racers spend most of the active season in prairie, pasture, or hay field habitat or occasionally can be found in glades of open woodland. However,

in autumn there is a general shift to hilltop rock outcrops, where clefts and fissures provide dens for hibernation. After moving to the rock outcrops the population is much more concentrated than it is on the summer range. As a result, most of the individuals recaptured (48 of the 74 total) were taken only along hilltop rock outcrops. These were classed as follows: 8 adult males, 11 adult females, 17 yearling males, 7 yearling females, 4 hatchling males, and one hatchling female. Although these groups are too small for statistical comparison, the trends do not appear to be significantly different. Excluding several that shifted from one hilltop ledge to another distant one, the mean movement for 48 was 210 feet, ranging from 0 to 875. For the 26 recaptured after intervals of a year or more, the mean distance was 174 feet. Individuals may return year after year to the same part of the hilltop rock outcrop. After 55 months a large female was found 300 feet from the original site of capture. Another was found at 390 feet after 43 months.

Eleven individuals were caught both at a hilltop rock outcrop, where presumably they had come to hibernate, and in a bottom-land valley where presumably they spent the summer, providing some idea of the distance of travel to and from the hibernation ledges. Distances ranged from 500 to 1360 feet and averaged 770. The tendency seems to be for the racers to seek the nearest suitable stretch of ledge rather than to make an unnecessarily long trip to one that is farther away. Hilltop fields near or adjacent to the ledges where snakes hibernated also provided suitable habitat. Two individuals were caught both at a ledge and in a hilltop field, and they had moved distances of 230 feet and 1350 feet.

Twenty-three individuals were recorded and then recaptured away from outcrops in the areas where, presumably, they live during the summer. One of these was caught as a hatchling and recaptured 19 months later at a distance of 1500 feet. This long movement probably represents one or several shifts rather than normal use of a home range. Another hatchling male had moved 470 feet in 18 months. The remaining 21 movements were all of adults. For 13 records of males the average was 567 feet, indicating an average home range of 23 acres, and for nine records of females the average was 367, indicating home ranges of 9.7 acres.

Eight of the individuals captured at hilltop ledges had made relatively long movements, probably having shifted permanently away from the original site of capture. These movements were:

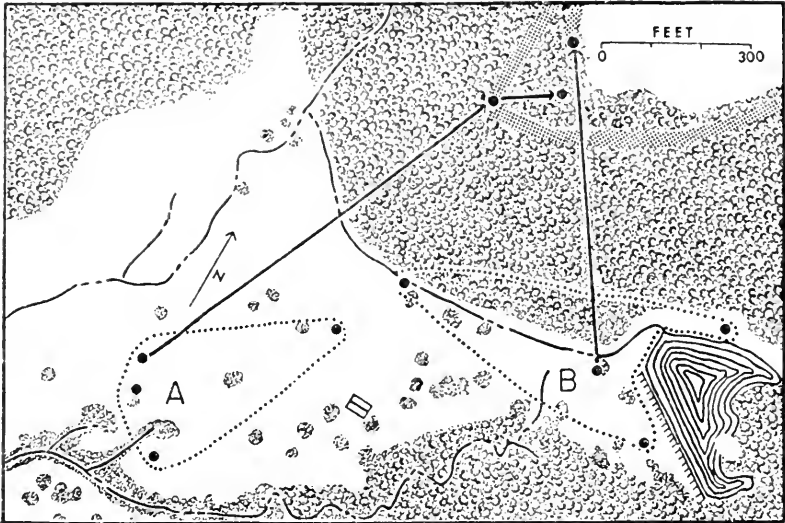


FIG. 8. (A) Capture locations of an adult male yellow-bellied racer (6 records, October 21, 1953, to July 15, 1957); and (B) capture locations of an adult female. In each instance summer records were in a grassy bottomland field, but fall records were at hilltop rock ledges where the snakes came to hibernate after moving 138 to 200 yards up a wooded slope.

3150 feet in six months, hatchling female; 3000 feet in two months, yearling female; 2950 feet in 31 months, adult female; 2900 feet in three months, yearling male; 2700 feet in two months, subadult female; 2430 feet in two months, adult female; 2250 feet in twelve months, yearling female; 1250 feet in six months, yearling male. Because field work was mostly limited to a square mile area, and was concentrated to a large extent on relatively small parts of it, the chances of recapturing individuals that made long movements were poor. The number of long movements actually recorded therefore seems high. Possibly much longer movements may be made occasionally. Much more information is needed concerning the vagility of the species. With the information available at present it can be said that individuals have a strong tendency to stay within the same home range, and to traverse an area that may be several times the diameter of the home range to return to the same hibernation shelter each autumn, but that some, of both sexes and various ages, may shift permanently for half a mile or more beyond the original range of activities.

Elaphe obsoleta Say

Black Rat Snake

Status.—Moderately common resident, evidently utilizing all parts of area.

Habitat.—This snake is characteristic of deciduous forests; on the Reservation it has been found most often along hilltop rock ledges. It is notorious as a climber and raider of birds' nests. It often has been found along woodland edge and even in open fields. The open field situations are utilized chiefly in summer, when there is high grass.

Movements.—Of 159 black rat snakes marked and released on the Reservation 22 were recaptured. Many of those marked were small young which probably had a short life expectancy and, in some instances, perhaps had not yet established themselves in definite areas. Some adults were caught in outlying areas that were seldom visited in the course of routine field work, and the opportunities for recapturing them were limited. For the adults captured within the area where field work was concentrated, the incidence of recaptures was relatively high. Span of records, in months, for the 22 individuals were: 49, 48, 48, 44, 42, 32, 25, 24, 22, 21, 20, 20, 17, 15, 12, 12, 12, 10, 8, 1, 1, 1, and 0. From the trend of these records it is evident that adults and well grown young remain in familiar areas for periods of years, or perhaps for life. Greatest distances recorded as covered by black rat snakes were: 2200 feet (adult male in 44 months), 1680 feet (adult male in 49 months), 1650 feet (adult male in 21 months), 1600 feet (hatchling in 32 months), 1560 feet (adult male in 42 months), 1450 feet (half-grown male in 24 months), 1200 feet (adult male in 24 months), 1100 feet (hatchling male in 22 months). Thirteen others had moved distances of less than 1000 feet.

Several of those that made long movements were recaptured later, back nearer the original capture point, suggesting that they were still within a home range. For example, an adult male first recorded on October 5, 1949, was recaptured 1900 feet away on June 12, 1950. On April 21, 1953, he was captured a third time 2200 feet from the second location but only 300 feet from the first location. Another adult male was caught on July 16, 1950, September 19, 1950, October 3, 1950, May 15, 1951, June 12, 1952, June 17, 1954,

and July 19, 1954. The second and third captures were at approximately the same place on a hilltop ledge more than 1000 feet from the other six capture points, which were all within a hundred-foot radius near the Reservation headquarters. Another adult male caught on June 6, 1950, June 2, 1952, April 27, 1953, May 9, 1954, June 6, 1954, and July 27, 1954, was found at four places in the headquarters field, over a distance of 1380 feet, and shifted back and forth between this field and a hilltop ledge three different times, covering distances of 850 to 1350 feet in doing so.



FIG. 9. Capture locations of an adult female black rat snake recorded eight times in a six-year period.

For the total of 38 movements between successive captures, the average distance was 817 feet. Stickel and Cope (1947: 129) recorded ten movements of black rat snakes, ranging from 130 feet to 1760 feet and averaging 767, on the Patuxent Research Refuge in Maryland. Marked disparity between the sexes in vagility was evident in the trend of my records. For the 29 movements of males the average was 897 feet, indicating a home range of 57.6 acres, while for nine movements of females the average distance was 559 feet, indicating a home range of 17.9 acres.

Pituophis catenifer Blainville

Bullsnake

Status.—A few individuals are permanent residents on the Reservation, but others from adjacent cultivated land resort to the area to find hibernation shelters along hilltop rock ledges.

Habitat.—Bullsnakes live primarily in grassland but also in open woodland. Fields of alfalfa and other hay crops in nearby farmlands provide a habitat more favorable than any to be found on the Reservation itself, perhaps because of the abundance in them of pocket gophers, which constitute the chief food of the bullsnake. On the Reservation bullsnakes have been found from time to time in brome grass fields and also have been found in summer in open rocky woods on south-facing slopes. The majority of those seen were individuals caught in funnel traps along hibernation ledges in October.

Movements.—Eighteen bullsnakes have been marked and released on the area. Of the 23 captures 17 were made in late September or October, or in early spring, along rock ledges where presumably the snakes had come to hibernate. One large female was caught on September 22, 1951, crossing a county road at the edge of an alfalfa field. Nine days later she was caught 2700 feet away at a hilltop rock ledge on the Reservation. Another adult female was caught at sites along the ledge 310 feet apart on October 17, 1950, and September 1, 1953.

Some of the records suggest that these snakes trail each other by scent to the hibernation dens. On "Sugarloaf," a hilltop overlooking an expanse of cultivated fields to the west, three large adults were caught within a few days in the autumn of 1950. In October of 1949, 1950 and 1951, an adult female was found along a 200-foot stretch of ledge where evidently she returned each year to hibernate. She was found 420 feet farther along the same ledge in June, indicating that her summer range also extended into this same area.

Imler (1945:273) recaptured 12 marked bullsnakes in Nebraska and found that 11 had moved distances less than 300 yards, while the twelfth had moved 1½ miles. Fitch (1949:556) working with the subspecies *catenifer* in California, recorded movements of less than 1000 feet in 25 of the 28 snakes recaptured.

Lampropeltis calligaster Harlan

Prairie King Snake

Status.—Scarce, but seems to be regular resident on Reservation.

Habitat.—Open grassy situations with flat rocks seem to be preferred. Several have been trapped in fall along old rock walls, and rock ledges in thick woods of oak, hickory and elm. Several have been found in brushy pastures of brome and bluegrass.

Movements.—Over a seven-year period, 16 have been marked

and released on the Reservation, but none has ever been recaptured. The secretive and partly subterranean habits would account, in part, for this lack of success, but it also seems probable that the snakes wander widely.

Stickel and Cope (1947:129) recorded two recaptures of this species (subspecies *rhombo maculata*); one was recaptured at the same place after one day; the other had moved 600 feet in six weeks.

Lampropeltis doliata Linnaeus

Milk Snake

Status.—Rare, probably with small permanent population tending to be localized in few small areas that satisfy habitat requirements.

Habitat.—Grassy, rock-strewn areas, usually in open woodland or at woodland edge.

Movements.—Over an eight-year period ten milk snakes have been marked and released, and two have been recaptured. A small juvenile marked and released on June 16, 1951, was found again after 31 days, beneath the same piece of rusty sheet metal where it was originally discovered. A half-grown individual marked and released on May 26, 1955, was recaptured 12½ months later at a distance of 1320 feet from the original location, and had grown to small adult size.

Tantilla gracilis Baird and Girard

Slender Flat-headed Snake

Status.—Rare and seldom seen (only three records) because of secretive habits, but probably resident in small relict populations.

Habitat.—The three found on the Reservation and a few found at other places in northeastern Kansas were all on sparsely wooded, rocky hilltop edges of southward exposure. Of those found on the Reservation, one was at the old quarry, the other two were found in 1950 and 1956 at almost the same spot of "Rat Ledge."

Agkistrodon contortrix Linnaeus

Copperhead

Status.—Common resident.

Habitat.—Living chiefly in woodland, the copperhead is one of the species most characteristic of the deciduous forest climax. It ranges throughout all parts of the woodland, but with some change in preference according to weather and season. Rocky upper slopes

near hilltop ledges in woods of chestnut, oak, hickory and elm perhaps provide the optimum habitat, and provide hibernation sites where there is some concentration in fall.

Shelter is provided by crevices in the ledge, and by loose flat rocks. The rocks selected for hiding places are often massive slabs several inches thick and several feet wide. In summer the snakes undergo some dispersal from these ledges throughout the woodland, woodland edge, creekside and roadside thickets, grassy fields, both in the bottom lands and on hilltops, and even to hay fields adjacent to the Reservation.

Movements.—Copperheads are sluggish by nature and seem to obtain their prey by ambush rather than by active search. Their movements are therefore usually short and leisurely, and are governed to a large extent by changes in temperature and humidity during the daily cycle. The fact that activity is largely nocturnal makes observation difficult.

A total of 94 individuals caught and marked on the area have been recaptured, after intervals of from a few days to five years. Two (both adult females) were released at distances from their capture points and they had made unusually long movements 2870 feet and 600 feet when recaptured after intervals of four months and six months. The remaining 92 individuals averaged a distance of 455 feet between capture points. The significance of this average figure is lessened by the fact that trends differed notably between the sexes and in different age groups. For 31 adult males the average of 717 feet is approximately twice that in the 25 females—358 feet. Probably difference in vagility between the sexes is even greater than these figures suggest, because of the 11 males that had moved less than 100 feet nine were recaptured after relatively short intervals of about a month, or less. Restlessness and frequent activity caused these males to be recaptured in traps or found in the open before they had moved far from the sites of original captures. However, of the six females that had moved less than 100 feet only three were captured in intervals of less than a month; others were recaptured after intervals of 45 months, 21 months, 20 months, 11 months, one month, and one month. For 36 other copperheads that were marked as young of various sizes, and recaptured, average distance was 298 feet. Thus it seems that adults of either sex are somewhat more vagile than the young. Among the juveniles, females had moved somewhat farther on the average than had males.

Difference in vagility between the sexes in adults is best demon-

strated by eliminating from consideration all those individuals recaptured after less than six months. For the 15 males distances ranged from 205 to 3040 feet and averaged 1323; for the 15 females distances ranged from 0 to 1950 feet and averaged 292.

Of the 25 adult females two had made outstandingly long movements: 1950 feet and 1350 feet. These probably represent shifts from one home range to another, and therefore should not be included in a computation of home range size. The remaining 23 movements are rather evenly distributed from zero up to 500 feet (with one of 655 feet), and they average 246 feet. Most probable home range diameter is, then, approximately 500 feet, representing an area of roughly 6.5 acres.

Sedentary nature of the adult females is demonstrated also by the frequency with which individuals were recaptured as compared with males and young. Of the individuals captured three times, seven were adult (or subadult) females, one was an adult male, two were immature females, and one was an immature male. Of individuals caught four times, two were adult females and one was a half-grown male. The only individual caught five times was an adult female. She was caught on June 27, 1951, July 17, 1951, August 3, 1951, August 6, 1953, and September 26, 1953, all within a one hundred-foot diameter.

The nature of long-time movements in adult males remains somewhat obscure. Of the 31 recaptured, 8 made movements of 1000 feet or more as follows: 3040 feet in 12 months, 2750 feet in 12 months, 2250 feet in 32 months, 2250 feet in 26 months, 2250 feet in 11 months, 1300 feet in 12 months, 1120 feet in 8 months, and 1000 feet in 19 months. On the other hand prolonged occupancy of a relatively small area is suggested by the following records: 700 feet in 57 months, 650 feet in 21 months, 300 feet in 17 months, 270 feet in 39 months, 210 feet in 20 months, 205 feet in 37 months, 90 feet in 6 months, 60 feet in 6 months.

Available observations suggest that newborn copperheads are remarkably sedentary and that they extend their spheres of activity slowly over periods of weeks, as they gradually become familiar with their surroundings. On September 17, 1948, in a deep crevice of a limestone outcrop I found shed skins of several young copperheads entwined in the same mass of sticks, dry leaves, and cobwebs. Obviously these were snakes of the same litter, which had all shed about the same time, before they dispersed. According to my own findings and those of Gloyd (1934:600) young born in captivity

most often do not shed their skins for a number of days after birth. On September 24, 1950, a litter of young copperheads born in captivity was released at the spot where the female was originally found. On the afternoon of September 26 all seven were found again at the same place. The day was cloudy and humid, about 72° F., and all the young were in tight circular resting coils in the open. Four were within a ten-inch radius just where they had been dumped from the sack 48 hours earlier, under a skunkbush (*Rhus trilobata*). Some two hours later, when the temperature was falling rapidly, the spot was checked again. One snake had disappeared and another had begun to move toward shelter of the rock cleft. On September 28 four of the litter were again found at the same place, but a little more scattered, all within a ten-foot space. On September 30 five of the litter were found at the same place, and four were found again on the following day. Two were found there again on October 3 after a minimum night temperature of approximately 40° F.

Gloyd (1934:592) on three occasions found associations of gravid females, and found other reports in the literature. He speculated that the gravid females tend to assemble in places where conditions provide favorable shelter. On August 3, 1950, I turned a flat rock two feet in diameter and two to three inches thick and found two gravid females. They were coiled in a nestlike depression which had the damp earth of its sides packed and smooth as if the snakes had been there for a long time. While I was catching these two a third gravid female was heard gliding through the grass toward the rock, and it also was captured.

I found a second aggregation on August 9, 1950, about 400 feet from where the first group was found, under a large flat rock that was exposed to sunshine for several hours during the middle of the day. Four gravid females were lying in resting coils in contact with each other. When uncovered, they began to move about restlessly but seemed reluctant to leave the depression. While I was catching three, the fourth escaped into thick brush nearby. On the following day the fourth female was found within a few feet of the rock where the group had been, in a resting coil on the sticks of an old woodrat house beneath a bush and partly in the sunshine.

On the Reservation copperheads are too scarce to be seen frequently, and rarely is more than one found in a day, even though intensive search is made, and many rocks suitable for shelter are turned. Shelter is abundant, and similar conditions of temperature

and humidity can be found under hundreds of different rocks within a small area. Therefore it seems that the aggregations of females found are not due to chance meetings at sites where physical conditions are favorable but that the females have a definite affinity for each other causing them to seek others and remain associated with them, in suitable shelters, for extended periods.

Crotalus horridus Linnaeus

Timber Rattlesnake

Status.—Rare resident.

Habitat.—This rattlesnake prefers deciduous forest, especially along hilltop rock outcrops in thick woods. Individuals range widely and may temporarily invade other habitats. One was found in brome grass at the edge of a field a few yards from edge of the woods, near the pond. One was killed in a hayfield adjoining the Reservation. The few records on the Reservation are well scattered.

Movements.—On September 25, 1950, an adult female was caught at a hilltop rock ledge. On October 4 she was caught only 40 feet from the first location. In the period September 30 to October 17, seven newborn young were caught within 50 feet of the female's second location. One young was caught at the same place on September 30 and October 7; two others each moved approximately 10 feet between October 7 and October 13, and another moved approximately 10 feet between October 13 and October 17. These young were obviously litter mates. For each only a "prebutton" was recorded in the nine captures made up to October 13. On the night of October 15 one underwent its first molt while confined in a sack, and the one recaptured on October 17 also had molted. In mid-October, an estimated three weeks after their birth, these young had scarcely begun to disperse and they were probably still near their birth place when they hibernated.

A half-grown female was caught on October 14 and October 26, 1952, at the same place on a hilltop rock outcrop. These several recaptures near the original location, after short intervals show little regarding extent of home range, but emphasize the sluggish nature of rattlesnakes, which ordinarily hunt by awaiting the approach of their prey in strategic locations. After approximately 3½ years an adult female was recaptured on the same ledge 280 feet from the original location. This is the only instance of a rattlesnake recaptured near the same place after a long interval, and it seems

clear that these snakes wander widely. A large adult male marked in the autumn of 1948 was reported killed in a hay field more than half a mile away in the early summer of 1950. It was recognized by the wire marker attached to one rattle. On June 2, 1953, a large adult male was marked in a hilltop woods, and on October 16, 1954, it was recaptured at a ledge 2100 feet away. Another large male was marked in November, 1950, and almost five years later its recently cast skin was found 2940 feet from the original location. The fact that these individuals made movements among the longest for any snakes of the hundreds recaptured over a nine-year period, and that none of the 26 other rattlesnakes marked was ever recaptured after intervals of more than a few days, indicate that timber rattlesnakes travel extensively. The wandering tendency probably has been an important factor in reducing the population of rattlesnakes locally and throughout much of the range. According to written and verbal testimony of longtime residents in Douglas County, rattlesnakes were abundant on the area that is now the Reservation in the late eighteen hundreds, and even up into the nineteen twenties. Under modern conditions, with heavy motor traffic on county roads, each rattlesnake in its wanderings is liable sooner or later to be run over and killed. Copperheads, being less vagile, tend to stay on the rough wooded slopes where habitat conditions are most favorable and therefore remain common locally, holding their own against encroaching civilization even within the city limits of Kansas City and other urban communities.

Mammals

***Didelphis marsupialis* Linnaeus**

Opossum

Status.—Common resident.

Habitat.—Primarily woodland, woodland edge, and along margins of pond and creeks; also, to lesser extent, utilizes open fields.

Movements.—Home range and movements of the opossum on the Reservation have already been discussed in a recent publication (Fitch and Sandidge, 1953). To summarize the findings of this study: Individual opossums have home ranges of irregular size and shape over which the animal roams more or less at random in the course of its nocturnal prowling. Home ranges tend to be circular or oval, with an average radius somewhere in the neighborhood of 800 feet. There is no territoriality and several or many individuals may use the same area simultaneously. Two or perhaps

more may even use the same den. The animal may shift frequently from one den to another. Home range boundaries are fluid, and the ranges are constantly altered, partly in opportunistic exploitation of new food sources that become available, and also perhaps as a result of innate wandering tendency. The tendency to wander and shift the range is much more apparent in the male, and normally results in complete replacement of the individuals on any small area within a year. After attaining independent status, young males are especially likely to shift to new areas, while young females are likely to remain on or near the area occupied by the mother. In actual size of range no difference is discernible between males and females or between old adults and yearlings.

Blarina brevicauda (Say)

Short-tailed Shrew

Status.—One of commoner small mammals of Reservation.

Habitat.—This shrew occupies most of the area, occurring in a variety of habitat subdivisions. Woodland is its main habitat. It has been taken most often in wire funnel-traps set for reptiles along hilltop rock ledges. Often it has been taken in rainy weather in mouse traps set in brome grass fields, especially near woodland edge. Also it has been taken at the quarry rock ledge, the rock pile near the pond, and in brush along fence rows at field edges.

Movements.—Although shrews are fairly common on the Reservation, the information regarding their movements remains meager because of the lack of a satisfactory method of catching them alive in good condition. All captures were made in traps set for rodents, reptiles or amphibians. Because the shrews were always caught in relatively small numbers, it was not practical to run trap lines for them specifically. The shrews, being much more delicate than the other animals trapped, were subject to heavy mortality while in the traps, and their numbers would have been decimated on the study areas but for the fact that they entered the traps so seldom. The box traps set for small mammals were normally tended at 24 hour intervals, but shrews caught usually exhausted the food supply and starved within this time. Pitfalls and funnel traps set for amphibians and reptiles were checked less frequently since these animals were not harmed by going unfed for periods of days. The shrews caught by chance in traps of these types usually died before they were found.

When grids of one hundred or more mouse traps were maintained, capture of one or more short-tailed shrews could be expected on days when there was heavy rainfall. Such captures were made both by day and by night. Occasional captures were made on days following a heavy rain, when the ground was still soaked, but in most instances the shrew was caught while rain was still falling. Similarly, in the pitfalls and funnel traps, which were unbaited except with insects and other small animals that happened to wander into them, captures of shrews were almost invariably made in heavy rains. During dry weather the same trap lines might be maintained for weeks, or even months, without a single capture of a short-tailed shrew. The implication is that, ordinarily, these shrews venture forth on the soil surface only in wet weather, and spend the remainder of their time under shelter in burrows and runways. When there is snow on the ground, they are perhaps more inclined to wander than at other times. On several occasions their tracks have been noticed in snow on the frozen surface of the pond, extending for 100 feet or more away from cover, in a meandering course.

Although shrews dig burrows and make runways of their own, the tunnels and runways of voles seem to play an important part in their ecology. On various occasions the tracks of the shrews or the animals themselves have been seen entering burrows of voles.

Whether shrews are to any extent territorial has not been determined, but they are quarrelsome and pugnacious. On various occasions their high, trilling squeaks have been heard in dense vegetation, but usually the sound ceased abruptly when attempt was made to locate the source. On November 3, 1951, a shrew was heard squeaking in a thicket, and then was glimpsed thrashing and darting about among dead leaves on the ground, but its supposed antagonist was not seen. After a few seconds the shrew darted into a burrow entrance which appeared to be that of a pine vole.

Although the shrew is known to be an important predator on voles, it may not be able to cope with an adult pine vole. On April 18, 1951, while checking a trap line, I heard the shrill squeaking of a shrew and traced it to a live-trap some 50 feet away. The shrew was in the trap huddled against the door. A large pine vole was also in the trap, and it was standing menacingly, with its head held high, at the entrance to the nest box. From time to time the vole would dart forward and strike the shrew a sharp body blow, forcing it back, and eliciting the protesting squeaks.

Only 14 of the short-tailed shrews marked were recaptured. Two were each caught five times, two others were each caught four times, one was caught three times and the remaining nine were each recaptured just once. Records of these are summarized below: 570 feet in 18 days, 2 captures (adult female); 490 feet in 215 days, 2 captures; 340 feet in 97 days, 4 captures (twice near the same place in December, 100 yards away in February, and had moved back to near the original location in March); 180 feet in 18 days, 4 captures (first and second capture sites were 150 feet apart, the third was the same as the second, and the fourth was back near the starting point); 95 feet in 8 months (first four captures within a 40-foot space and a 17-day period). The other nine shrews had moved distances of 75 feet, 60 feet, 60 feet, 32 feet, 30 feet, 22 feet, 20 feet, 0 feet, and 0 feet in periods of from one day to three months. From the trend of these few records it appears that shrews temporarily at least may carry on their activities in small areas of not much more than 100 feet across, but that they may also shift their activities for distances of hundreds of feet and return.

The two longest movements probably represent shifts beyond the limits of a home range. The remaining 12 movements probably are all within home ranges, as indicated by return movements of 300 feet and 150 feet. These 12 movements average 110 feet, indicating home ranges of .87 acres. Manville (1949:65) recorded 38 movements of short-tailed shrews, which averaged 91.5 feet (30 to 315). He found no significant difference between the sexes in the 13 males and 15 females that he was able to sex with certainty. Burt (1940:50) concluded, on the basis of movements made by twelve shrews that he had marked and recaptured in Michigan that a normal home range is probably about 50 yards in diameter and covers about .4 acre.

Cryptotis parva (Say)

Little Short-tailed Shrew

Status.—Common resident.

Habitat.—This species inhabits grassland and open woods. Most of the little short-tailed shrews recorded have been taken in pitfalls as they are small enough to squeeze out of most of the live-traps used, and are little attracted by bait. Most habitats have not been thoroughly sampled for these shrews and pitfalls are limited to a small part of the area. The shrews have been caught most often along the dry, exposed ledge at the quarry, and many have been caught at the ledge at "Skink Woods," in open grassy woodland.

Others have been found in various parts of the woodland. Several were caught in mouse traps in open fields.

Movements.—Little short-tailed shrews seem to be somewhat less common than *Blarina* on the Reservation. At any rate they are caught in traps set for small mammals much less frequently. Because of their minute size they are sometimes able to enter and leave such traps without tripping them, and are also able to squeeze through small openings to escape. The majority of those caught in pitfalls were found dead, and those that were marked and released were never recaptured.

Captures of *Cryptotis* in pitfalls, like those of *Blarina*, were almost invariably made in heavy rains. At other times the shrews seem to stay beneath ground litter. One shrew caught in a mouse trap had killed and eaten a harvest mouse larger than itself, which was in the trap with it.

On several occasions two adults of the little short-tailed shrew, male and female, were caught together in the same pitfall trap. In these instances it seemed probable that the pair had been travelling together when they were caught, although this could not be definitely determined.

Scalopus aquaticus (Linnaeus)

Eastern Mole

Status.—Common resident.

Habitat.—Most typically, woodland, but also present in parklands, pasture, prairie, and fallow fields.

Movements.—No suitable live-trap was available for the capture of moles; therefore nothing was learned concerning the movements of individuals. Moles were rarely seen, and the only basis for judging their activity was provided by the mounds and ridges of earth thrown up by them. Activity was noted to differ greatly from time to time and from place to place. During times of drought, as during most of 1953, and for shorter periods in other years, mole workings were seldom seen. However, after heavy rains had softened the soil, there was always a surge of activity and evidence of burrowing was conspicuous. For example, on February 15, 1954, there was a rain of 1.35 inches, and within three days many new mounds and ridges had appeared. Groups of such workings were concentrated, each in a small area, and each presumably originating from a different mole. Within a 20-foot radius of a large elm in the headquarters area, the ground was criss-crossed with a network of mole ridges.

Branches extended out in several directions and one was traced for more than 100 feet.

After prolonged drought, moles were noticeably less common than at other times. Difficulty in digging through the hard dry soil presumably restricted their movements and limited their food supply.

In the spring of 1957 after soaking rains, new mole ridges were noted to be numerous along the edges of formerly cultivated fields on the Rockefeller Tract. Several runways that were followed extended out into the fields for 200 feet or more in meandering courses, as if the moles were finding some kind of subterranean insect prey. No deep burrows or mounds were noted in the fields, and obviously the moles were not living in the fields, but entered them temporarily from adjacent woodland. Brumwell (1951:208) mentioned similar exploratory tunneling in recently deposited sandbars along the Missouri River, with digging concentrated about patches of smartweed, sedge, grass, or willows where insect prey was abundant.

Lasiurus borealis (Muller)

Red Bat

Status.—Common resident in summer; evidently migrates to more southern regions in winter.

Habitat.—Primarily woodland; often noticed flying at dusk near woodland edge or through parklike open stands of large elms, or near pond.

Movements.—Red bats often were observed at dusk flying over a regular beat. Most often the bat was 30 to 50 feet above ground and kept to a fairly straight course, in the open but in the vicinity of trees. For example, on July 27, 1951, at twilight, one was coursing back and forth over an open stretch about 100 feet long, between large elms just east of the headquarters area. On other occasions, the beat covered was somewhat longer and less regular.

On August 18, 1949, a red bat was found hanging on a bush three feet from the ground, at a hilltop rock ledge in thick woods.

Sylvilagus floridanus (J. A. Allen)

Eastern Cottontail

Status.—Abundant resident.

Habitat.—The cottontail uses every part of the Reservation. It is seen frequently in both grassland and woodland. Actually it is concentrated along the line of contact or transition from woodland to grassland, in "edge" habitat. Blackberry thickets provide the

most preferred type of refuge, and the rabbits are especially numerous where such thickets are well developed. Other types of shelter that are used are: thorny clumps of gooseberry; rock crevices along ledges; deserted and partly collapsed old houses of woodrats; dead brush from crowns of fallen trees; grass clumps in open fields; among dead leaves in woodland. Under cover of darkness the rabbits forage out from these shelters and may visit relatively exposed situations. In summer, when fields are covered with high grass, rabbits are much less closely limited to situations with woody vegetation for protection, and may shift their headquarters out into the fields.

Movements.—From September 1954 to March 1956 Donald W. Janes carried on a program of live-trapping and marking cottontails on part of the Reservation. A total of 89 were caught and marked; 54 were recorded repeatedly and yielded data permitting computation of home range areas. These cottontails were equipped with colored markers attached to their ears, serving for sight identification, and many were trailed from the stain left in the snow after the feet had been soaked in liquid dye of a bright color. The data were hence far more complete than they would have been if based on live-trapping alone. Janes computed the average home range as 8.34 acres (2.42 to 12.62). For males the average was 8.92 acres, and for females 7.76. Janes found that when records of an individual were sufficiently numerous to form a pattern with nine marginal points, the area encompassed was fairly representative of the entire home range, and was ordinarily increased little or none by additional records. Computation of the home range area from distances between successive (random) points of capture, assumed to represent a home range diameter, yielded a figure of 8.40 acres, approximately the same as the 8.34 acres obtained from actual measurements. In several cottontails Janes noted increase of the home range area in summer five to fifteen per cent beyond the size of the area covered in winter.

Young cottontails that are old enough to forage increase their ranges gradually. For one female Janes recorded the following: age three weeks (July 1954), range approximately .25 acre; age 11 weeks, range 1.5 acres; age 23 weeks, range 8 acres; age 75 weeks, range 11 acres.

In Michigan Haugen (1942:366) found that adult females occupied an average home range of 14.0 acres during the winter, and that the size increased to 22.5 acres during the breeding season. He found that adult males wandered much more extensively.

Spermophilus franklinii (Sabine)

Franklin's Ground Squirrel

Status.—Rare wanderer.

Habitat.—Situations with tall grass or other rank herbaceous vegetation are preferred.

Movements.—On June 27, 1958, Robert L. Packard saw one on the Rockefeller Tract east of the buildings in a field having low grass and weedy vegetation. It escaped into woodland and could not be found again on subsequent days, when search was made.

Marmota monax (Linnaeus)

Woodchuck

Status.—Uncommon transient.

Habitat.—Woodchucks have been observed at well-scattered points, both in woodland and in grassland. In foraging, the species prefers situations with lush grass, at edges of fields near thickets of woodland edge or fence rows. It has not been seen in eroded field areas having scant weedy vegetation.

Movements.—Over the nine-year period covered by my work on the Reservation woodchucks were noted approximately a dozen times. However, no two records were in the same place, and none was associated with a burrow. In each instance the animal was a wanderer. No permanently occupied burrows were known nearer than a mile to the Reservation. The woodchucks noted on the area were all adults and were mostly in brushy and wooded situations. One found on April 18, 1951, was in a small elm tree 20 feet above the ground. It remained "frozen" motionless as persons walked beneath it and tossed sticks at it. On June 13, 1951, one was seen three times at about the same place on the road between an alfalfa field and a brushy hillside.

Sciurus carolinensis Gmelin

Gray Squirrel

Status.—Moderately common resident.

Habitat.—Dense woodland of mesic aspect, typically oak-hickory, where trees are large and have a thick leaf canopy.

Movements.—Packard (1956: 29) presented figures showing the average movements of the squirrels marked by him and recaptured, both on the Reservation and on the Dillon Farm some eleven miles south, classified according to sex and age groups.

Packard kindly made available his original records for the Reservation. For 26 intervals between successive captures in gray squirrels on the Reservation the average distance was 513 feet. However, it is questionable whether all movements recorded were within the home range of the animals. Of four movements of more than 1000 feet recorded (1350, 1250, 1110, 1110), each of three was made in a single day, supporting the supposition that it was within the individual's normal range. For ten movements of males the average of 626 feet was higher than the average of 472 feet for the 15 movements of females.

Packard (*op. cit.*:117) found a population of nine gray squirrels and 15 fox squirrels on a 27.1-acre tract of woodland where his study was concentrated. No interspecific strife was observed. Obviously the gray squirrel does not maintain large individual territories, although the nest and its surroundings are defended against other individuals.

Sciurus niger Linnaeus

Fox Squirrel

Status.—Abundant resident throughout wooded portions of area.

Habitat.—Woodlands of all types are utilized, most notably where there are large trees of oak and hickory, and especially walnut. These squirrels sometimes live in parklike situations where trees are well scattered. Even isolated lone trees that are productive of food are visited regularly. Some such trees may be 100 yards or more from the edge of woodland. Extensive treeless areas are avoided.

Movements.—Packard (*op. cit.*:28) presented figures concerning the average movements of fox squirrels and gray squirrels trapped by him on the Reservation. These figures are well adapted to show differences between the species, and within a species according to age and sex. However, they give little idea of the normal movements of an individual, because different kinds of movements are combined. Packard has kindly permitted me to examine and rearrange his original data. Fifty-five movements are rather evenly distributed for distances up to 1000 feet. Ten longer movements (1600 and 1600 feet for adult males; 3400, 2175, 1550 and 1050 feet for adult females; 2850, 2175, 2050 and 1450 feet for young males) seem to represent shifts of range, in most instances at least, and they are therefore excluded from computations of home range. For the 55 movements of less than 1000 feet, the average is 436 feet,

representing a home range 13.7 acres in area. This figure may be representative for the species in a woodland habitat. Significant differences in the average movement were evident according to age and sex, as follows: 22 adult males, 450 feet (14.5 acres); 14 adult females, 364 feet (9.5 acres); 11 young males, 500 feet (18.0 acres); 8 young females, 439 feet (13.7 acres).

Geomys bursarius (Shaw)

Plains Pocket Gopher

Status.—Occasional on the Reservation; abundant on adjacent cultivated land.

Habitat.—Locally this gopher is found mainly in hay fields, especially those that are used for growing alfalfa. The population of an extensive agricultural area of the Kansas River flood plain was largely eliminated in the flood of July, 1951, and the area has been re-occupied gradually. Gently sloping land along the edges of the valley, like the farm lands adjoining the Reservation on the west and south, provided retreat where a population was able to survive the flood. Individual gophers have shifted onto the Reservation from time to time. Their workings have been found in bottomland of each of the two small valleys, in brome grass fields.

Movements.—When field work was begun on the Reservation in 1948, the whole area was searched thoroughly for sign of gopher, but none was found. Subsequently, on several occasions gopher mounds appeared in situations remote from any known colonies, and the individual (or individuals) involved were known to have remained in the same small area for periods of months. Isolated individuals, such as those that appeared on the Reservation, offered unusual opportunity for determining the extent of a burrow system and the changes that occurred in it with time. Ordinarily, where gophers occur the burrow systems of individuals overlap and intercommunicate so extensively that the limits of any one system cannot readily be determined.

On the Reservation gopher mounds were found first in September, 1948. Several were noticed on a gentle slope in the pasture a short distance north of the headquarters area. On October 12, a week after a heavy rain, there were many more mounds at this place; 22 fresh ones were counted, all within a space of 40 feet. On October 25 there were many new mounds within the same area. The

most remote were 50 feet apart, with freshly deposited mounds at each edge and at several intermediate locations. By this time the loose earth of the mounds covered a substantial portion of the area encompassed by the burrow system. By November 2, a linear series of mounds extended out from the former limits of the system, up the gentle slope some 50 feet to a ditch bank. For the next 17 months this burrow system was continuously occupied, and new mounds were thrown up from time to time, all either within the limits of the area occupied in September and October, 1948, or within a few yards of its edges. This burrow system was in a former pasture dominated by brome grass, 1450 feet from the nearest boundary of the reservation and hundreds of yards farther from any area that was permanently occupied by gophers. In early October, 1949, a second group of mounds was noticed in the same field 950 feet farther east southeast. The extent of this burrow system was checked from time to time and in the next three months it was steadily extended north northwest 160 feet up a gentle slope to the edge of woodland. From the trend of the lines of mounds, it was evident that several times in the course of extending its burrows up the slope, the gopher had divided its efforts between two more or less parallel or diverging branches.

In the summer of 1953 a group of large mounds was noticed beneath a locust grove in the large pasture in the southeastern part of the Reservation. This burrow system may have been present for a long time before it was noticed. On December 21, 1953, most of the mounds were within a span of 40 feet, but several fresh mounds were more than 100 feet from the main group. Soil was deep and rich at this place, and the mounds were exceptionally large; some were estimated to contain as much as 100 pounds of earth. Throughout the winter, the burrow system was almost co-extensive with a grove of locusts and osage orange, about two dozen trees in all, covering an area approximately 150 by 100 feet. For most of the next winter the burrow system was limited to the same area, but by April 1 a linear series of 35 new mounds extended the system for 100 yards east southeast, in an almost straight line. This temporary extension of the burrow system was probably soon abandoned, but activity continued in the burrow at least into the spring of 1958, indicating more than 4½ years of continuous occupancy.

In each instance when a gopher appeared on the Reservation,

the animal probably had wandered on the surface for hundreds of yards, from an established colony. An immature male, probably a wanderer, was found dead on the road near the Reservation headquarters. It appeared to have been attacked by a predator.

Reithrodontomys montanus (Baird)

Plains Harvest Mouse

Status.—Uncommon resident.

Habitat.—This mouse is confined to grassland, especially where the grass is short. The habitat requirements are more restrictive than those of the western harvest mouse, which is common and widely distributed on the area. One Plains harvest mouse was caught at the headquarters, where grass had been cut several times annually. Others were caught in the large hilltop field where prairie grasses had been restored, but their records were concentrated at a few trap stations where grass was short. In the spring of 1957 a colony was discovered in the blue-grass pasture on the Rockefeller Tract. A few weeks later, when this pasture, no longer grazed, had become overgrown with high weeds, none could be caught in live-traps.

Movements.—Twenty-five of the Plains harvest mice recorded were recaptured only at the site of the original record. One of these was recaptured four times; three, three times; five, twice; the others only once each. Twenty-nine movements were recorded, and averaged 83 feet, a figure remarkably close to that obtained for the western harvest mouse, with more than twenty times as many records. Therefore, I conclude that in this species also, the home range averages approximately half an acre.

Most captures were made on the Rockefeller Tract in November and December 1957, especially in the more barren parts of the pasture, where vegetation was chiefly lespedeza and three-awn grass. Because of minute size and delicate touch, these mice were often able to enter the traps without springing them, and after traps had been set for periods of days, individuals or pairs might take over as residences the nest boxes attached to some of the traps. The harvest mice released from live-traps were easily followed in their open habitat, but attempts to trail them to a hole or nest were invariably unsuccessful. The mouse followed wandered slowly and furtively in an irregular course, often stopping to crouch in a depression attempting to conceal itself, but never entering a burrow.

Reithrodontomys megalotis (Baird)

Western Harvest Mouse

Status.—Abundant resident.

Habitat.—Grassland of various types.

Especially high concentrations were present along the weedy margins of the pond where there were dense mats of rice cutgrass (*Leersia oryzoides*) mixed with other grasses and forbs; and in tall-grass prairie. In the latter there were more harvest mice in mixed stands and those of switch grass, Indian grass and side-oats grama than there were in stands of little bluestem or big bluestem. In fallow fields, patches of foxtail grass supported colonies. When the Reservation was first established, in 1948, the pastured areas, consisting of brome grass with a mixture of many weedy species, were closely grazed, and did not provide suitable habitat for harvest mice. In subsequent years, after discontinuance of grazing, the rank vegetation provided a favorable habitat, and by late 1949 all these formerly pastured areas were well populated with harvest mice. The mice continued to thrive in 1950 and 1951, but subsequently as various kinds of herbaceous plants were crowded out, and succession progressed toward a pure stand of brome, the numbers of harvest mice dwindled to a low level.

Movements.—Harvest mice were trapped in large numbers in several habitats, and a large amount of data was obtained concerning their movements from day to day and over longer periods. In the months of June, July, August and September harvest mice were trapped in much smaller numbers than at other times of year. They seemed to be less attracted to bait in summer, probably because of the abundance of preferred natural foods. The June-to-September period therefore constitutes a gap in the records of many individuals that were marked and recaptured over periods of months.

Harvest mice that were released from traps most often hid in dense ground vegetation, but sometimes they moved off in unhurried fashion, seemingly unconcerned by the presence of an observer. Occasionally such a mouse was followed for 100 feet or more, but none was ever followed to its nest. Such mice progressed through tall grass by alternately walking and making long bounds, gripping the stems in all four feet, and more often climbing than walking on the ground surface.

One harvest mouse was trapped 16 times, and many others were caught five times or more, permitting some idea of the extent of

their normal movements. For one the span of records covered 20 months, and for a dozen others the records covered a year or more. No movements of hundreds of yards, from one study area to another, were recorded. It seemed that each individual was restricted to a limited area and there was but little tendency to wander. For individuals that were caught many times there was a disproportionately large number of captures at one or two stations and other captures were more scattered at several other sites. Outlying stations were most often represented by just one capture each.

For 106 harvest mice each caught at four or more locations, the "minimum home ranges" (areas encompassed by the capture sites) averaged .29 acres. For the 30 that were each captured at four locations, the average area was .16 acres; for 26 each captured at five locations the average area was .29 acres, and for those captured at seven locations, .24 acres. For 18 each caught at more than seven locations, the average area was .53 acres. Corroborative evidence of home ranges approximately half an acre in extent was obtained from many other individuals recaptured too few times to permit plotting their separate ranges. For 327 intervals between successive captures in males, the distance averaged 85 feet, indicating home ranges of approximately .52 acres. For 261 intervals between successive captures in females, the distance averaged 84 feet, indicating that there is no significant difference between the sexes. In each instance those movements of more than 300 feet (5.5 per cent in males and 5.1 per cent in females) were arbitrarily eliminated from the computation, as such long movements were considered to represent shifts in home range or wandering beyond the usual boundaries. The relatively few movements recorded in summer did not differ in their trend from the year-around movements, and it seems that the same home range may have been maintained throughout the year.

The extent of movement does not seem to differ much in males and females. For 37 females each caught at four or more locations the "minimum home ranges" plotted averaged .26 acres, while for 67 males the comparable figure was .29.

On many occasions nests of harvest mice have been found, mostly on the surface of the soil in dense vegetation. Some were partly underground in shallow depressions or in cracks of eroded banks. Others were fixed in plant stems above the ground surface, and one was three feet above ground in a dense osage orange thicket. The harvest mice found in such nests were mostly litters of young, but pairs of adults also have been found occupying nests.

The nest found above ground in the osage orange was occupied by five harvest mice that seemed to be of adult size but may have all belonged to the same litter. On many other occasions, in walking through grass, I have flushed harvest mice without being able to find a nest. Individuals may spend a good deal of time away from their nests resting or feeding in sheltered places. Each individual probably has a nest to which it returns regularly. Those kept in captivity always made nests of cotton, shredded grass, or any other available material.

Live-trapping records seem to indicate complete lack of territoriality in harvest mice. The home ranges plotted show extensive overlap with several or many adults of both sexes using the same area. Frequently more than one harvest mouse was caught in a trap. Most often the mice caught together consisted of pairs, adult male and female. In many instances the females of such pairs were not in breeding condition. Therefore it seems that the members of a pair live together more or less permanently in the same nest and forage together. Not all multiple captures involved a pair; some consisted of a female and her well-grown young, and other captures were of two adults of the same sex, either male or female. On many occasions mixed groups of adults have been caged together without any fighting, and they were generally tolerant of other individuals.

Peromyscus maniculatus (Wagner)

Deer Mouse

Status.—Moderately common resident in more open situations.

Habitat.—Grassland, especially where grass cover is low and sparse because of heavy grazing, or erosion, or poor soil, or combinations of these factors and others.

As compared with the white-footed mouse this species occurs in much lower populations on the area. Habitat separation between the two species is almost complete; overlapping occurs only in grossly disturbed situations where vegetation is in an early seral stage: margin of the pond, talus at base of rock quarry, and along cut banks of gullies. Most captures of deer mice were made in a field which had been stripped of sod, eroded and covered with a thin stand of lespedeza and poverty grass, which was gradually being replaced by brome grass. None was ever caught in the woods.

Movements.—Deer mice were persistent repeaters where live-traps were available to them. One was caught 43 times, and eleven

were caught 12 times or more. Those individuals caught frequently were usually taken time after time at one or two stations, and were caught much less frequently at outlying stations. The female caught 43 times was taken 12 times in 6 different months at the most favored station, and 5 times in 3 different months at a second station 75 feet from the first. She was taken 4 times at another station and 3 times at each of two others and twice at one station. At each of the remaining fourteen stations she was caught only once.

One individual was caught seven times in succession at the same station, and was not caught elsewhere, although the station was within a 50-foot trap grid. Another individual was caught eight times in succession at the same place, but subsequently it made shifts of 50, 100, 50 and 70 feet. Of the individuals recaptured, 52 had too few records to show extent of home ranges. For these, however, 149 recaptures do show something of the average trend of movements. In 43.3 per cent of the recaptures the animal was at the same station as at its preceding capture; in 18.8 per cent the animal had moved from 10 to 50 feet; in 20.1 per cent it had moved from 51 to 100 feet; in 12.4 per cent it had moved from 101 to 200 feet, and in 5.4 per cent it had moved more than 200 feet. The longest movement recorded was 525 feet, and other notably long movements were: 500, 350, 310, 300, and 275 feet.

"Minimum home ranges" were plotted, by drawing a line around all capture stations (except those involving obvious shifts) for 18 individuals. The average area was .74 acres, but with a wide range, from 2.24 to .27 acres. The two with only four capture stations had the smallest areas, .27 and .28 acres; the eight with six or seven stations each had areas from .34 to .50 acres (average .39), and those with 8 or more stations ranged from .53 to 2.24 acres, averaging .96. Only the one individual covered more than an acre. If this one notably large area is excluded, the average for the seven others caught eight or more times is .78 acres. Corroborative evidence concerning size of home range is provided by a total of 84 intervals between successive points of capture. These intervals (excluding two that were exceptionally long and were thought to represent shifts in range) averaged 107 feet, representing areas of .8 acres. The ranges of males are, on the average, larger than those of females; for 43 movements of males the average was 120 feet, indicating a home range of one acre, while for 41 movements of females the average was 92 feet indicating a home range of .6 acres.

On many occasions deer mice released from live-traps were trailed to hiding places which may or may not have been their

regular home bases. Several times individuals trapped near the edge of a road ran rapidly along the open area of the wheel track for distances up to 200 feet, turning off sharply into thick grass in a manner suggesting that they were following routes familiar to them and frequently travelled. Released individuals, unless startled by sudden movements of the observer, usually moved slowly and cautiously slinking through dense vegetation, and occasionally crossing open areas with a series of brisk bounds.

Deer mice were caught at all seasons, but records tended to be concentrated in cold weather, November through March. Presumably preferred natural foods available in quantity during the warmer months caused the mice to be less tempted than by trap bait. Seasonal change in food supply and cover may result in small scale shifts in range. One adult female, caught four times within a 75-foot radius in February and March, was caught in May at a station 1000 feet from her original range. This was by far the longest movement recorded. In several other instances much shorter movements were recorded to stations that seemed to be outside the main home range of the animal involved.

Blair (1942:29) estimated that home ranges of adult male prairie deer mice in Michigan average .77 acre and those of adult females .63 acre. He found that the woodland deer mouse (subspecies *gracilis*) in northern Michigan has a home range considerably larger than that of the prairie subspecies. He calculated average home ranges of $2.31 \pm .27$ acre for adult males and $1.39 \pm .16$ acre for adult females. Manville (1949: 14) reported home ranges for *P. m. gracilis* in northern Michigan, of .11 acre to .31 acre in adult males and .12 acre to .25 acre in adult females. Manville's calculations were based on a grid of live-traps spaced at ten yard intervals, and he considered each trap to cover effectively and to represent the 100-square yard area nearest it. Trap stations where an animal was not recorded were not considered to be within the home range and their areas were not included even though they were surrounded by other capture sites. Blair's calculations included such areas and therefore the home ranges indicated were larger. Nevertheless, the possibility was mentioned by Blair, and by Dice and Howard (1951:6) that the method used would result in too small an estimate of home-range area, because each individual tends to be trapped each night before he has travelled from his homesite to the outer limits of his range. Dice and Howard presented many instances of deer mice that, in the course of their normal activities, moved distances considerably greater than would be expected if

their movements were confined to a 2.29 acre area (the maximum home range area recorded by Blair). Dice and Howard found that dispersal occurs in many young deer mice when litters are nearing maturity, with a mean dispersal distance of 188 feet for females and 339 feet for males.

Peromyscus leucopus (Rafinesque)

White-footed Mouse

Status.—Abundant resident throughout woodlands and woodland edge situations of the Reservation.

Habitat.—Though present in all types of woodland this mouse occurs in varying populations depending on availability of shelter, and on the food, especially at critical seasons. Relatively few have been taken in deep woods having a thick canopy. In open woods having a ground layer of grass and other herbaceous vegetation, the mouse tends to be more numerous and probably attains highest populations in woodland edge habitat, and in parkland situations. Coralberry bushes, bearing abundant crops of berries, where they are not too heavily shaded, provide one of the main food sources. Some favorite types of shelter used as nesting sites are: holes and crevices in hilltop rock ledges; spaces beneath loose flat rocks; hollows of dead logs, stumps and snags; stick heaps of deserted woodrat houses and low squirrel houses; and root tangles of overhanging banks. This mouse usually does not venture more than a few yards out into open fields, but has been trapped, hundreds of feet from woodland, along brushy fence rows, and in patches of sumac (*Rhus glabra*).

Movements.—White-footed mice were caught in almost every kind of trap line that was maintained on the Reservation. In autumn they were often caught in wire funnel traps set for snakes along hilltop rock ledges. The traps set for reptiles were not checked daily and the incidence of mortality was high among the mice trapped. Traps set in trees and bushes, for birds, at times when ground was snow-covered, caught white-footed mice consistently if left overnight. Lines of mouse traps baited with grain, caught white-footed mice in a variety of habitat situations, but these mice were rarely taken in open fields more than a few yards from the edges.

In extremely cold weather these mice rarely were caught. Sudden warming after such cold spells may induce the mice to emerge and forage in daylight, providing unusually favorable opportunity for observing them. On the afternoon of January 3, 1952, after two

days and nights of temperatures mostly below 15° F., weather had warmed to slightly more than 40° F., the sun was shining and the two-foot snow was melting. Several sets of recent tracks of the mice were noted. Each set followed a meandering and aimless course. One set was followed to a distance of more than 100 feet from the starting place, the mouse having travelled several times as far in actual distance. Another set led to a clump of coralberry bushes where the mouse itself was found, feeding on the seeds two feet above the surface of the snow, which was littered with the discarded hulls of the berries. The mouse dropped onto the snow when I approached, but after moving only a few inches, it resumed its search for food, burrowing in the snow to reach a honey locust pod on which it began to feed. In snow, trails are often short and direct, leading from one shelter to another, sometimes only a few yards apart. After snow has been on the ground for several days, such a route may become worn to a well-beaten trail with numerous sets of tracks superimposed. White-footed mice released from live-traps often returned to shelter by an indirect but convenient and presumably familiar route. For example, one followed beneath one edge of a log, turned sharply to run up an inclined stick, through a bush along horizontal branches, and then passed into the side of a rotten stump. On December 23, 1953, I noticed tracks of a mouse in snow on a wooded slope. The mouse had made many trips of approximately 100 feet up and down the slope, tending to follow the same route, but often deviating from it for part of the distance, so that there was one main trail with several parallel to it, frequently merging and separating.

Each mouse maintains a home base, a shelter where it is insulated from extremes of weather and relatively safe from predators. Dry leaves, straw and fur may be brought to the nest cavity. Unless there are dependent young, material is scanty in the summer, but may be abundant in cold weather. The mouse may use several such shelters, alternating between them. In late July, 1951, mice of this species were found in unusually large numbers beneath large flat rocks on wooded slopes. Excessive rainfall in the preceding month probably had saturated many of the nests in burrows, rotten logs and stumps, rendering them untenable. On many occasions, females with young have been found in nests under flat rocks. Pairs of adults have been found together in nests at all times of year, and have often been caught together in traps of various types.

Territoriality seems to be only weakly developed; several or many

white-footed mice inhabit the same area. A trap set beside a deserted woodrat house caught five adult mice simultaneously. Probably all were occupants of the rat house.

Of the white-footed mice live-trapped and marked, 249 were recaptured one or more times providing information concerning movements. Each of 16 mice was caught a dozen times or more, over periods of up to 15 months. The longest distances recorded were, in feet: 1760, 850, 660, 620, 600, 580, 520, 480, 440, 420, 380, 330, 330, 330, 330, 320, 320, 305, 300. These few relatively long movements involved only 2.1 per cent of the total. Even after periods of months any individual mouse was usually caught within the same small area. Numbers of records representing various distances were as follows: 0-20 feet, 449; 21-40 feet, 139; 41-60 feet, 77; 61-80 feet, 46; 81-100 feet, 46; 101-120 feet, 24; 121-140 feet, 26; 141-160 feet, 17; 161-180 feet, 12; 181-200 feet, 12; 201-220 feet, 7; 221-240 feet, 5; 241-260 feet, 6; 261-280 feet, 5; 281-300 feet, 3.

Twenty individuals each caught at six or more different places provided information concerning size of home range. Minimum home ranges were plotted by drawing lines on a map between capture points and measuring with a planimeter the enclosed area. The areas ranged in size from .03 up to .36 acre (average .16 acre). Better information concerning the usual extent of home range is available from the 637 intervals between successive points of capture. These intervals averaged 74.4 feet, indicating home ranges of approximately .4 acre (.35 for 341 movements of males and .42 for 295 movements of females).

Burt (1940: 26) found an average "minimum home range" of .27 acre for 58 adult males and .21 acre for 65 adult females. In my study a large adult male was caught at six places linearly arranged within a 425-foot stretch along the edge of a gully in an open field. The gully was fringed with trees and bushes, and presumably the mouse kept to the gully and the adjacent thicket, within a space only a few yards wide. On one occasion when the mouse was released it was followed for more than 100 feet. It stopped once beneath a flat rock where quantities of discarded seed hulls showed that the shelter had been frequently used for feeding, and finally took refuge in a deep vertical crack where soil of the cut bank was sloughing away. Social wasps (*Polistes* sp.) were wintering in large numbers in this and other cracks of the gully bank, and quantities of their discarded remains showed that small predators, probably *Peromyscus*, fed upon them frequently. In an adult

female captured at nine different places the records were also linearly arranged and they encompassed a distance of approximately 320 feet. Other home ranges plotted tended toward triangular, circular, or oval shapes. The data suggest that males and females differ little or none in extent of area covered; that the individual tends to stay in the same home range throughout the year but makes minor seasonal adjustments according to changing availability of food and shelter. Records were obtained in greater numbers in cold weather when bait seemed more attractive.

Sigmodon hispidus Say and Ord

Hispid Cotton Rat

Status.—Common resident at times, but subject to such drastic population reductions that at other times it virtually disappears from the Reservation. Probably in each instance small breeding stock has remained, although for periods of months none was noted.

Habitat.—Grassland, in situations with rank weedy vegetation, as at edge of pond, and near brushy margins of fields.

Movements.—Cotton rats are diurnal, but are rarely seen because of their tendency to keep to situations where dense grass and other vegetation provide cover. Because of their timidity and rapid movements, they were usually only glimpsed as they darted through the grass. Information concerning their movements was obtained almost entirely from individuals marked and retrapped. In the course of their feeding and trampling, cotton rats make runways through the grass that are less well defined than the runways of the prairie vole. In the course of their normal movements, cotton rats seem to be much less closely confined to runways than are voles. A cotton rat released from a live-trap, or flushed, dashes through the grass in an almost straight course, with long bounds, often crashing into grass stems and other obstacles. After it is lost to view its course may be followed for many yards by the sound and the waving grass stems, as it runs without seeking out a runway, making much more rapid progress than a vole would make in its runway.

In cotton rats trap habit was often strongly developed. Each of several individuals was caught several times in the same trap without visiting any of several nearby traps. Some individuals were caught repeatedly at traps that were well separated, but were caught only occasionally or not at all in traps that were more or less intermediate in position.

Most records of cotton rats on the Reservation were obtained in

the summer and autumn of 1951, and in the following winter and early spring of 1952. By the end of April, 1952, few remained.

Many of those recorded were originally caught as partly grown young. After its initial capture a cotton rat might be recaptured almost daily, when the trap line was operated, over periods of weeks. The maximum number of captures recorded for any individual was 46. Many of the rats were caught in only one, two or three locations; each of 42 others was caught four or more times (average 11.7). In each of these instances the records were scattered and seemed to indicate the general size and position of the home range in each instance. These records show that the home range is small, and that its size varies widely. One adult male had ranged over an area of 2.03 acres (8 captures in 23 days) and another had ranged over 1.16 acres (20 captures in 43 days). An adult female had ranged over 1.11 acres (with 46 captures in 295 days).

TABLE 1.—AVERAGE SIZES OF MINIMUM HOME RANGES IN COTTON RATS, SHOWING INCREASING SIZE WITH NUMBER OF MARGINAL POINTS IN MINIMUM HOME RANGE.

Number of marginal points.....	3	4	5	6	7
Average minimum home range.....	.14	.16	.29	.72	.72
Number in sample.....	10	20	10	6	4

Minimum home ranges of 50 cotton rats were plotted. A trend toward larger areas in those with more numerous records was evident, as shown in Table 1. Hayne (1949:14) questioned whether the apparent levelling off in size of minimum home range, with further captures, after a rapid increase with the first few captures, can be assumed to show accurately the size of the actual home range. He suggested that the tendency toward such levelling off might be due to the mechanics of trapping instead. His suggestion is particularly apropos for such small mammals as the cotton rat which quickly acquire a trap habit and an addiction for the bait. An individual's preoccupation with the traps and bait available nearest its "home base" or "activity center" might on most occasions prevent it from reaching the outlying parts of its home range where it could be caught in other traps. Disregarding this unmeasurable factor, the following average distances between successive captures and

home ranges were indicated for the different categories of cotton rats that I trapped.

Adult and nearly adult males (129)	95 feet (.65 acre)
Adult and nearly adult females (67)	79 feet (.45 acre)
Young males (77)	62 feet (.26 acre)
Young females (73)	55 feet (.22 acre)

Neotoma floridana (Ord)

Eastern Woodrat

Status.—Woodrats occur in varying abundance, chiefly in woodland areas. From a peak population of several per acre in favorable tracts of woodland in 1947, woodrats dwindled to only a few individuals on the entire 590-acre Reservation in 1953 and 1954. Extremes of weather in the winters of 1947-1948 and 1948-1949 were probably responsible in part for this drastic reduction. By 1958 numbers had increased to a level somewhat intermediate between the high point of 1947 and the low point of 1953.

Habitat.—Primarily woodland, but extending also into various marginal situations. Since 1949 the reduced surviving population has been confined mainly to hilltop rock outcrops in woodland edge. Those outcrops with south exposures are favored. Most houses are built where a loose boulder, a deep crevice, or a tree or large shrub along the outcrop provides support and additional protection. Projecting spurs of the hilltop where the outcropping ledge of exposed limestone is especially prominent and several feet thick were used more than parts of the hilltop where the outcropping was less prominent. Osage orange trees were often used as house sites, the house being built either at the base (especially in those where the trunk forked at the ground level or near it) or in crotches a few feet off the ground. Other favorite situations included hollow trees and logs, blackberry thickets, exposed tree roots along cut-banks of gullies, among dense, interlaced branches of tops of fallen trees, in brush and weed thickets along fence rows and at the edge of woodland. As the population dwindled, such sites were gradually deserted, until the rats were almost confined to hilltop rock ledges.

Movements.—Each woodrat is normally the possessor of one or more stick houses, shelters within which its nests are located. Such a home base is the focal point for the rat's activities. The rat may maintain two or several such shelters at well separated points, especially if it is a dominant individual, or if the population is low

and effective competition is lacking. When an individual controls several houses, it alternates between them, using each in succession for periods of days or weeks. In sorties from the house, the rat ordinarily keeps to beaten trails, and its activity is most concentrated within a 30-foot radius. Most foraging for food is less than 75 feet in any direction from the house. Because the woodrat usually chooses a residence where there is dense low woody vegetation and feeds upon such abundant materials as the foliage and bark, the food supply within its small range is adequate. The home range cannot be effectively measured as a two-dimensional area because of the rat's climbing tendencies. Much of the food is obtained in trees and bushes, and travelways are often above the ground level, typically along logs and horizontal or gently inclined branches. Over periods of months, rats often shift into new areas, deserting their former houses and home ranges permanently. Although various factors may motivate such shifts, search for a mate is probably the most common cause. Males wander farther and more frequently than females, and large old males are more inclined to shift than are younger individuals. The longest shift recorded was 1080 feet for an adult male; 650 feet was the maximum recorded for a female.

Woodrats are intolerant of each other, and ordinarily when an individual occupies a stick house, others are excluded. Pairs are associated only during a brief period when the female is in oestrus. Ordinarily an intruder is quickly routed when it ventures into an occupied house. The house itself may be thought of as constituting a small territory. The area about the house, in the rat's usual foraging range, is likewise defended. However there is no evidence that territorial boundaries are sharply defined. Intruders may often venture within the territory undetected since each rat spends a major portion of its time in the nest.

Along an osage orange hedge row which offered favorable habitat conditions, a series of twelve occupied woodrat houses were linearly arranged at almost regular intervals averaging approximately 60 feet (minimum 42 feet), but with three longer gaps which probably represented unoccupied potential nest sites (Fitch and Rainey, 1956: 522).

Microtus ochrogaster (Wagner)

Prairie Vole

Status.—Abundant resident in grassland.

Habitat.—Mainly fields dominated by brome.

In this habitat type the voles thrive best where the grass is rank and lush; they tend to be correspondingly scarce where grass is short

and sparse. Consequently they are less numerous in hilltop fields where soil is shallower and drier than in the bottomland fields. In time of drought in the bottomland fields they tended to retreat to marginal situations, such as edge of the road, and disturbed soil of ditch banks where the vegetation was most luxuriant. Coralberry thickets at the edges of fields provided favorable habitat. In some instances weedy fallow fields were occupied, after several successive crops of weeds had produced a protective cover of horizontal stems. Voles were found in such old-field situations where there was scarcely any grass but they were more numerous where there were patches of foxtail grass forming a ground mat. In almost pure stands of big bluestem and other perennial tall grasses the voles were relatively scarce.

Movements.—The prairie vole, like other members of its genus, makes runways through or beneath herbaceous vegetation on the soil surface, and excavates subterranean tunnels. The activities of an individual are largely within these surface and underground runway systems. The pattern of surface runways especially is in a state of constant change as older trails are abandoned and new ones are established. Those runways leading to the most used burrow entrances are well worn and are much more permanent than the runways in outlying areas. The voles are somewhat social in habits, and ordinarily a small group or colony inhabits each system of burrows and runways. Such a group may include several adults of both sexes, as well as young of various sizes. Well situated burrow systems may be occupied over long periods of years by successive generations, although individual occupancy is only a few months at most. Unless the population is unusually low, each colony is in contact with others, the anastomosing surface runways merging in such a way that no boundaries can be identified. The normal range of an individual may include two burrow systems, and the vole may alternate frequently from one to the other. Over periods of weeks or months a vole may gradually alter its range, withdrawing from one portion and extending its activities in another until it occupies a range entirely separate from that in which it lived originally. More rarely, an individual venturing farther than usual may become disoriented, losing contact with its home range, and after a period of wandering may settle in a new location. In a few instances, such shifts, involving distances of hundreds of feet, were recorded in marked voles.

For the prairie vole more data have been obtained concerning movements than for all other kinds of mammals combined. The

excessive bulk of these data have presented a serious obstacle to their analysis. Thorough analysis has therefore been postponed. It may be expected that a detailed study of the available records will show the extent of differences between the sexes, and differences arising because of season, vegetation type, and age of individual in the normal range, and the frequency of shifts. Even without such analysis, the trends are evident.

The female vole usually leaves her young in the nest when she emerges to forage, but occasionally, on short expeditions, she may drag the entire litter behind her, each young clinging to a teat. When the young are approximately nine days old, their eyes open and thenceforth they become more active, emerging from the nest burrow either on their own or following the female, and gradually extending their areas of surface activity, from a radius of only a few inches at first, as they become familiar with their surroundings. The young may remain after they have grown to adults, continuing to use the same burrow system and surface runways which the female parent occupied. However, there is some tendency for dispersal in those that have attained the age of independence. Over periods of years many prairie voles have been caught in funnel

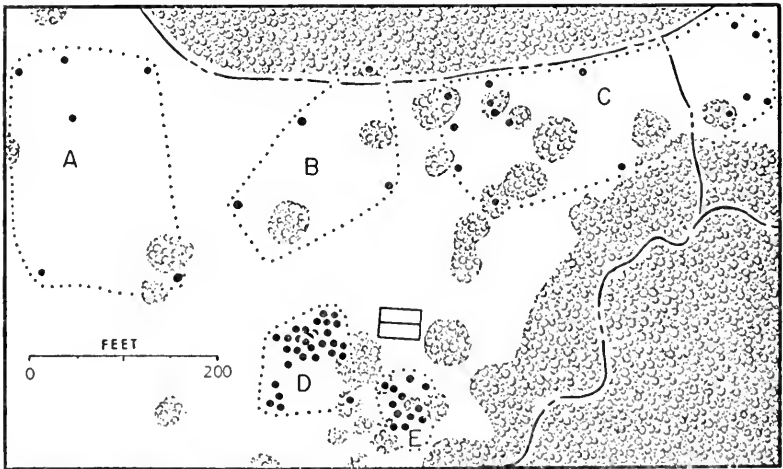


FIG. 10. Typical home ranges of several small mammals: (A) adult male western harvest mouse recorded seven times from November 16, 1950, to August 12, 1951; (B) adult female western harvest mouse recorded five times from April 21, 1953, to September 10, 1953; (C) male hispid cotton rat recorded 20 times from July 24, 1951, to September 5, 1951, both as a juvenile and as an adult; (D) adult female prairie vole captured 52 times from August 3, 1954, to June 30, 1955; (E) adult male pine vole captured 65 times from March 7, 1951, to March 20, 1952. Note small sizes of ranges in the voles.

traps placed for snakes in a woodland habitat where the voles ordinarily do not occur. Nearly all the voles so trapped were within the weight range 20 to 30 grams, a little more than half-grown, and they included a disproportionately high ratio of males.

As a result of extensive live-trapping on the Reservation, Martin (1956:381) found that in both males and females the mean size of home range was .09 acre. He found that over periods of months the total area encompassed by a vole's movements expanded, to a maximum of .26 acre in nine months.

Microtus pinetorum (Le Conte)

Pine Vole

Status.—Common resident, localized in small colonies where habitat conditions are favorable, and subject to drastic fluctuations in population density.

Habitat.—Chiefly parklike areas of woodland edge, where ground is usually shaded and has dense, low herbaceous vegetation. In the bottomland field where the house was located, a strip several hundred yards long and 50 to 150 feet wide, at the edge of woodland, was occupied by the voles. This was in an area shaded by large elms. There was a ground mat of muhly grass and bluegrass, with patches of coralberry, and with giant ragweed and various other coarse weeds. These voles have been taken also along hill-top edges at scattered locations. They have never been taken either in deep woods or in open fields more than a few yards from trees.

Movements.—Each pine vole ordinarily stays within an established system of runways and burrows. Territoriality seems to be entirely lacking. A small group including several adults of both sexes and young of various sizes usually occupies each burrow system. Presumably such social groups live together in the same nest chamber. Often two or even three adults are caught simultaneously in the same live-trap. Frequently such associations involve two males or two females. There is complete lack of hostility between such voles, both while they are in the traps, and when they are kept in cages.

The runway systems of these voles are situated mainly along the line of contact between woodland and pasture. The majority of records obtained in the present study were within the 1000-foot strip of woodland edge in the small valley where the Reservation headquarters are located.

Runways pass through and beneath the ground litter of dead vegetation, usually a mixture of old leaves and remains of herbaceous vegetation. Runways in current use are so well roofed over that their presence may be unsuspected. Runways may pass to greater depths by imperceptible stages, and the runway system may include extensive tunnels three to four inches beneath the surface, or occasionally deeper. Usually the tunnels pass through mats of roots, making excavation difficult, either for a predator or for an investigator. Abandoned burrows of moles (*Scalopus aquaticus*) are often taken over by the voles and incorporated in a runway system.

In general, both the underground tunnels and the runways in surface litter consist of one main axis and numerous lateral branches, most of which have blind ends. Occasionally, however, the secondary runways loop back to join the main tunnel, or anastomose in a complex pattern. The runway system has no well defined limits. Whereas the main runway in the vicinity of the nest is heavily used and well worn, outlying ends of the main runway and numerous branches may be faintly defined, with but little evidence of use.

Presumably the home range of each pine vole is more or less co-extensive with the runway system it occupies. It travels mainly on well established runways, but some of those used earlier may be abandoned, and replaced by other extensions elsewhere as season and food sources undergo changes. Short exploratory trips away from the runway systems are made frequently, and the route taken on such a trip may be retraced until it is incorporated in the runway system.

Seventy per cent of the recapture records were within 30 feet of the vole's last capture site. It seems that most of an individual vole's foraging is confined to a 30-foot radius, and within this small area is confined to the established runway system or its immediate vicinity.

Pine voles were more difficult to catch than were most of the other small mammals occurring on the Reservation. Over a seven-year period approximately a half dozen individuals have been caught in wire funnel traps set for reptiles along hilltop rock outcrops. In these situations no signs of activity of the voles were noted and the voles caught were all more than half-grown but less than full adult size. I suspect that they were recently independent young dispersing from the parents' runway systems and invading unoccupied situations. Other voles live-trapped and marked and

released while they were still less than half-grown have been known to stay in the same location and use the same runway system until adult size was attained and afterward. Dispersal may involve only a small percentage of the young, or may occur only under unusual conditions.

Although the majority of recorded movements were short, marked pine voles occasionally were retrapped hundreds of feet from an earlier location. In every instance these individuals were trapped in well established runway systems. In a large proportion of such instances the same vole was soon retrapped back at its original location. Just why and how such relatively long movements are occasionally made is not altogether clear. It does seem evident that the vole remembers its route and returns by it. Runway systems that are a hundred feet or more apart and appear to be well separated may be connected by little used outlying runways facilitating visiting between them. There is little or no difference between the sexes in vagility. Of the 62 males and 69 females for which movements were recorded, nine males and ten females had made relatively long movements of 200 feet or more. Several of them shifted repeatedly, some as many as six times. Even though individuals may from time to time visit and explore a neighboring runway system, the latter does not constitute a part of the regular home range as it is not used regularly. Ordinarily, shifts in home range are gradual, and usually they involve use of a succession of nest burrows within an area familiar to the animal.

TABLE 2.—RECORDED MOVEMENTS OF PINE VOLES, GROUPED ACCORDING TO DISTANCE.

Distances between recorded capture sites in feet	Percentage of total movements	Distances between recorded capture sites in feet	Percentage of total movements
0 to 5	35.5	96 to 105	1.3
6 to 15	23.5	106 to 115	.3
16 to 25	11.9	116 to 125	.7
26 to 35	7.3	126 to 135	.6
36 to 45	6.2	136 to 145	.3
46 to 55	3.2	146 to 155	.5
56 to 65	2.4	156 to 165	0
66 to 75	2.2	166 to 175	.1
76 to 85	1.3	176 to 185	0
86 to 95	.5	186 to 195	.4
		200 or more	1.5

Burt (1940:51) stated that the normal home range of the species (subspecies *scalapsoides*) is about one-fourth of an acre. This figure was based on recapture records of 17 individuals which indicated an average range-diameter of 38 yards.

Ondatra zibethicus (Linnaeus)

Muskrat

Status.—A permanent population is lacking because of insufficient aquatic habitat. Nomadic individuals stray over the area from time to time and some of these have established themselves at the pond and resided there for periods of months when conditions remained favorable.

Habitat.—Marshland is required; the shallow pond with marshy margins, and with stands of *Typha latifolia* and *Typha angustifolia*, provides favorable habitat when the water supply is sufficient, but on such a limited scale that only a few individuals can be supported.

Movements.—The small amount of information gathered concerning muskrats on the Reservation serves to illustrate: 1. long movements by immigrants, and 2. repeated occupancy of a small and isolated area of favorable habitat by such wanderers.

The pond, when filled to capacity, covers approximately an acre. On the upstream side a silt flat slopes off gradually to the pond bottom, and supports a dense stand of cattails that provide food for muskrats. In the spring of 1948 an old, deserted muskrat house was noticed in the pond, and evidently there was at least brief occupancy in 1949 and again in 1950. In the spring of 1951 trails and cuttings were noticed, but there were no houses and the animals must have been living in bank burrows. High water may have driven these rats from their burrows and exposed them to predation. In any case no more sign was seen until November, when two adults were present. Occupancy, perhaps by these same two, continued through June 1952. At this time the pond was rapidly drying and the water was so shallow over most of it that the rats were unable to submerge completely in swimming. In late June the stand of cattails showed heavy use by the rats, but with lowering of the water level this food source had become inaccessible to the rats unless they exposed themselves crossing the open mud flats to reach it. The rats had, in part at least, turned to a variety of herbaceous vegetation growing on the pond dike nearer their burrows. On July 5 the fresh half-eaten carcass of an adult female was found on the dike a few yards from the burrows. Judging from the man-

ner in which the carcass had been attacked, a red-tailed hawk was the most probable predator. On July 9, at 4:00 P. M. another adult was foraging for green vegetation on the dike near the spot where the female had been killed. It was unselective, gathering Japanese chess (*Bromus japonicus*), prickly lettuce, thistle, and giant ragweed, and carrying them back to the burrow. It made half a dozen trips while I watched, coming within a few feet each time without seeming to notice my presence. On July 14 remains, probably of this same individual, were found on the dike. The remains consisted of scraps of entrails and fragments of skin, and a scat nearby implicated a fox or coyote as the predator.

On March 25, muskrat remains were found beside the small creek in the east part of the Reservation. The carcass had been partly skinned out and the bones picked, in a manner suggesting the red-tailed hawk as the predator.

The muskrats that appear on the Reservation from time to time are wanderers that reach the area from the Kansas River Valley. The nearest known colony, in an old slough cut off by a shift of the river channel, was a little more than two miles air line from the places where the animals were found on the Reservation. In most instances, wanderers probably follow up stream courses.

Rattus norvegicus (Berkenhout)

Norway Rat

Status.—Irregular resident, reaching the area from nearby farms.

Habitat.—Most typically the Norway rat lives in urban situations and about barns, corncribs and occasionally along creeks adjacent to grain fields. A quantity of corn ruined in the 1951 flood was dumped on the edge of the Reservation, and several months later rats were found to be living in the vicinity. They may have been transported there with the loads of corn, or may have been attracted there from a nearby farm. They were living in rock clefts that had been occupied by woodrats until a short time before. Also, several Norway rats were trapped about the laboratory building approximately 900 feet from the corn pile and probably twice as far from any other colony. In this situation they were subsisting largely on natural foods, perhaps supplemented by occasional access to the grain used as bait.

Movements.—The Norway rats that lived beneath the laboratory building at the Reservation headquarters restricted most of their activities to a radius of a few yards. There were several burrow

entrances beside the foundations of the building, and there were trails leading from these burrows into nearby clumps of high weeds and dense patches of foxtail grass (*Setaria viridis*). The rats seemed to be living on this vegetation and on waste grain. The animals of this colony may have originated from those at the pile of waste corn 900 feet north on the hilltop, or they may have made their way up a small creek from cornfields adjoining the Reservation to the west; in the latter case they must have travelled at least half a mile.

Mus musculus Linnaeus

House Mouse

Status.—Common resident in vicinity of buildings, and other favorable situations.

Habitat.—Most numerous and persistently present in buildings.

Elsewhere the house mouse prefers disturbed situations with rank weedy growth, as on silty soil at pond margin, and among roadside weeds. It may occur in brome fields in the same habitat occupied by the prairie vole, harvest mouse, and cotton rat. It has been taken also in wooded hilltop rock ledge situations where the white-footed mouse is the most common small rodent.

Movements.—House mice were not trapped with any degree of regularity. In certain locations they were caught frequently over periods of days and weeks. In view of the low incidence of captures, the frequency of double captures was especially high, suggesting that these mice often live and travel in family groups. Because of their agility, house mice often escaped as the investigator opened the live-trap to remove them.

Occasionally in unusually cold weather of winter, house mice were found dead in a variety of situations. It seemed they had died of exposure, while searching for food in open situations away from shelter. With the advent of cold weather each autumn, house mice became increasingly troublesome in a small building at the Reservation headquarters. Often a dozen or more adults have been trapped within a few days, after the population of nearby areas had converged on this building to find shelter from the cold. On one occasion an adult male live-trapped in the building was carried in a box 860 feet west on the road and released. On the following day it was re-trapped in the building, demonstrating homing ability.

Twenty-five of the house mice live-trapped, marked, and released were subsequently recaptured a total of 36 times. Movements ranged up to 300 feet. Two-thirds of the total were within the range

20 feet to 100 feet. Movements, 33 in all, averaged 73.6 feet. Several of the mice were marked and recaptured on a quarter-acre area that was intensively live-trapped with a grid of traps at 20-foot intervals. All the movements recorded on this trap grid were relatively short, and they lower the average. Exclusive of the movements recorded on this quarter-acre grid, only eleven movements were recorded and these averaged 143.6 feet indicating a home range of 1.48 acres. The minimum home range of an adult male plotted from five successive captures was measured as .44 acre.

Zapus hudsonius (Zimmermann)

Meadow Jumping Mouse

Status.—Moderately common resident.

Habitat.—Mainly high grass, such as in bluestem prairie or brome, especially near woodland edge, where coralberry and various weedy plants occur; also in woodland, at least along its edges.

Jumping mice have been caught in open woods of honey locust and elm on south facing slopes, where a ground layer of muhly grass and low brush was present.

Movements.—In the course of live-trapping for small mammals, jumping mice proved to be particularly elusive—so much so that scarcely any information on movements was obtained from recapture of marked individuals. Most captures in mouse traps have been made in late April and early May, soon after emergence from hibernation. At other times the mice seem not to be interested in bait. However, more than a dozen have been caught in unbaited wire funnel traps set for reptiles along hilltop rock outcrops in October. Traps set in the same situations at other times of year have not caught jumping mice; therefore it seems that some of these mice move to the outcrops from adjacent grassland to find places favorable for hibernation. A young male jumping mouse trapped on April 24, 1952, had perhaps recently emerged from hibernation. He was re-trapped 100 feet farther south on April 29, and again 50 feet farther in the same direction on April 30. This is the only individual that has been re-trapped.

Blair (1940:244) on the basis of live-trapping in southern Michigan, arrived at a figure of $.89 \pm .11$ acre as the average home range of a male jumping mouse, and $.92 \pm .11$ acre as the home range of a female. Manville (1949:69) recorded an adult female on suc-

cessive days in live-traps set 180 feet apart. Quimby (1951:87) recorded an average home range of .38 acre (.19 to .57) for four females, and .43 acre (.14 to 1.10) for five males, near Itasca, Minnesota. Corresponding figures for a larger series obtained near Centerville, Minnesota, were $1.57 \pm .22$ of an acre for 17 females and $2.70 \pm .50$ of an acre for nine males. Quimby attributed the much higher figures at Centerville to the more open habitat there, with more scattered food and cover. He concluded that the range of an individual jumping mouse is relatively unstable.

Canis latrans Say

Coyote

Status.—Frequent transient and irregular resident.

In the summer and fall of 1948 a pair of coyotes probably denned on the area and made it their headquarters, and from time to time others may have lived on the area temporarily. However, it is believed that most often the coyotes on the Reservation were merely crossing the area.

Habitat.—The entire area of the Reservation is used by coyotes. In daytime they tend to keep to brush and thick woods, and have been flushed from such situations on a few occasions. While travelling or hunting at night they seem to prefer grassland.

Movements.—Several travelways were present on the Reservation. One followed the middle of the long narrow hilltop field, leading from the northeastern part of the Reservation almost to the southwest corner of the section. A similar path crossed the large bottomland field in the southeastern part of the area. When the intermittent creek in the eastern part of the area was dry, the bottom of the ravine, walled by steep banks on either side, was used as a travelway. The coyotes that left sign on the Reservation mostly came from rough, wooded areas in the sections to the north in Jefferson County, and were travelling to or from the edge of the Kansas River Valley. Of 118 scats collected on the Reservation and analyzed, several contained remains of animals—such as sheep, pig, domestic chicken, and jack rabbit—that must have been found elsewhere, demonstrating the wide range of the individual coyote. Several times coyote tracks in fresh snow were followed a mile or more, and led beyond the boundaries of the Reservation, bearing out the supposition that the individual animals range widely.

Packs of hounds sometimes crossed the Reservation, baying in pursuit of quarry, which was assumed to be a coyote in most in-

stances, although raccoons, deer, and other animals were sometimes chased. The route followed by the pursued animal could be traced by the baying of the dogs. On one such occasion the owners were intercepted as they were attempting to retrieve the dogs, and they claimed that the chase had begun more than three miles northeast.

In 1948, when the newly created Reservation was still used for pasturing livestock, tracks and scats of coyotes were noticed in much greater numbers than at any time subsequently. Scats collected in 1948 contained a high proportion of carrion from the carcasses of cattle, whereas in later years when livestock were no longer present on the area, rabbits and cotton rats made up most of the food (Fitch and Packard, 1955).

Young and Jackson (1951:59) state that the runway used by a group of coyotes may be no more than ten miles in length, and that it may be used throughout the life span of the individual. Assuming such a route to be circular, and bounding the edge of the home range, the range would have a radius of approximately 1.59 miles, and would cover 7.85 square miles.

Vulpes fulva (Desmarest)

Red Fox

Status.—Irregular resident; sign seen less frequently than that of coyote.

Habitat.—In the winter of 1951-1952 one lived in the northwestern part of the Reservation, having a den in a cleft of the rock ledge on a southwest slope in oak woodland. Its hunting was done mainly in the vicinity of the pond, and in the field near the house.

Movements.—The fox mentioned above was tracked to its den, in a rock cleft along the hilltop outcrop, when snow was on the ground. Subsequently in the winter and spring the den was checked frequently, and it always showed evidence of recent use. Whenever the ground was snow-covered, tracks were seen in great abundance about the upper end of the small valley where the pond was situated, approximately 700 feet southeast from the den. The fox regularly ranged at least 500 feet farther in this direction, and at least 2000 feet south from the den site. Although it probably covered at least half a square mile, its hunting tended to be concentrated in a much smaller area. On March 5, 1952, following the tracks in the snow, I found where the fox had approached a cottontail crouching in a clump of big bluestem. The cottontail, flushing from the clump, had dodged once, avoiding the fox's rush,

and had escaped to the nearby brushy slope, with the fox in pursuit.

In the winters of 1954-55 and 1957-58 fox tracks were again abundant in the same area, and the rock cleft den showed signs of occupancy.

Urocyon cinereoargenteus (Schreber)

Gray Fox

Status.—Uncommon resident or transient.

Habitat.—Woodland or brushy areas.

Movements.—On April 7, 1958, Phillip Ogilvie saw one in the northwestern acre of the Rockefeller Tract. On September 7, 1958, one (possibly the same) was seen to cross a county road headed east onto the Reservation 100 yards north of the entrance gate.

Procyon lotor (Linnaeus)

Raccoon

Status.—Common resident.

Habitat.—The raccoon is primarily a woodland inhabitant and it is notorious for its habit of foraging along edges of streams or ponds. On the Reservation this tendency was well defined, and sign was most frequently noticed at the pond, and along the creek flowing through the eastern part of the area. However tracks and other sign, and experience in trapping raccoons suggested that these animals range throughout all parts of the area, including grassland, woodland, hilltops, and stream courses.

Movements.—Raccoons range over relatively large areas as compared with the smaller mammals on the Reservation. Few individuals were live-trapped and the meager data available do not show the extent of home range. Raccoons probably use every part of the Reservation but change their activities according to seasonal shifts in food sources. Wide expanses of open fields are generally avoided.

In 1948 corn was cultivated on several bottomland fields of the Reservation. Tracks and dropping of raccoons were conspicuous along the margins of these fields adjacent to woodland. It was evident that the animals were utilizing waste corn as a food supply.

The two small creeks on the Reservation were favorite routes of travel for raccoons, whose tracks could be found in wet streamside soil at all seasons. In autumn each year the pond on the Reservation either went dry entirely, or underwent partial drying, leaving mud flats uncovered. Leopard frogs, cricket frogs, and bullfrogs were then partly exposed to predation by raccoons, and the pond

became a focal point for raccoon activity. In late September, 1948, the pond had dried completely and there were deep cracks in the mud. These cracks and the dense stands of cattails provided refuge for swarms of young leopard frogs and cricket frogs, and raccoon tracks were especially numerous. In April, 1954, frogs and toads had begun breeding when there was scarcely more than a puddle of water in the bed of the pond. The water was in the center of an area of open mud with no protective vegetation. Amphibians therefore had no adequate escape shelter. Under these conditions the raccoons made heavy inroads on the breeding populations of American toads and chorus frogs. A large sycamore with a hollow at the base was used for a den in 1953 and perhaps in other years. Sign of raccoon was especially concentrated at the pond in autumn at the time of drying, when swarms of newly metamorphosed frogs and toads were leaving the water, and in spring when breeding aggregations were present.

Sign of raccoon also was often noticed along hilltop rock outcrops. Deep crevices in the rock provided the best den sites, as large hollow trees were scarce on the area. On May 7, 1952, hounds were heard baying, coming from the west probably off the Reservation. Quarry was chased in an almost straight course approximately $1/3$ mile to a hilltop rock crevice where it escaped. An hour later, investigating, I found that the dogs had done much digging but had not been able to reach the raccoon except to tear a few tufts of hair from its partly exposed rump. The raccoon was an immature one.

The raccoon's tendency to shift to any readily available food source was demonstrated on many occasions when these animals formed the habit of following trap lines and systematically raiding them, eating either the bait, the trapped animals, or both. Because of these activities raccoons became a major pest to persons attempting to study populations of small mammals or reptiles. They would follow along the lines of mouse traps, arranged in a grid with a 50-foot interval, and would overturn each trap and eat the grain beneath it. On a few occasions sign indicated that the voles or other small mammals in the traps likewise were eaten. The raccoons showed dexterity in removing the covers of the metal nest boxes attached to the wire live-traps. The nest boxes were constructed with the metal sprung so that these covers snapped into place, and ordinarily the operator removed them with pliers. Once raiding had begun on a trap line, it usually continued with increasing severity until trapping had to be abandoned. In April, 1954, after such raids had forced abandonment of mouse trapping near

the Reservation headquarters, the family of raccoons raided the bait supply kept on the porch of a building, and they learned to unlatch and remove the heavy metal top of a large garbage can in which grain was stored. The raccoons also frequently raided wire funnel traps set along hilltop outcrops, breaking open the traps and eating the insects, reptiles or mammals caught in them.

For most of the year, at least, raccoons seem to travel in family groups. On September 19, 1955, at 1:00 A. M. after a brief shower, a group of four or more young raccoons moving along a nearby dry creek bed, attracted my attention by their peculiar low trilling calls. These calls served to keep members of the group informed of the others' whereabouts as they moved along in the same direction strung out over a distance of 100 feet or more. When the group had travelled approximately 100 yards down the creek channel, they came to a road where I was standing. One, coming within a few feet, suddenly took alarm at my presence and climbed a tree, where it stayed for five minutes, frequently answering the calls of other members of the group. Two others appeared, one keeping close behind the other. They were attracted by the calls of the treed individual, and almost brushed against me, then shied away upon noticing my presence.

Stuewer (1943:226) stated that the normal feeding range includes distances up to one mile from the home base but that raccoons will travel even farther, if necessary, to obtain a preferred food. Whitney and Underwood (1952:118) state that a hungry raccoon may travel several miles, in a meandering course, in one night, and they cite an instance of a female and her three young that travelled $2\frac{1}{2}$ miles to a cornfield for their nightly foraging. Summarizing 459 records, for 87 animals, Stuewer found the average range to be 503 acres for adult males (maximum 2012 acres), 268 acres for adult females and juvenile males, and 111 acres for juvenile females.

***Mustela frenata* Lichtenstein**

Long-tailed Weasel

Status.—Scarce and seldom seen; it is not known whether a permanent populations is present.

Habitat.—No definite preference has been noted; probably it ranges over the entire area. One was seen in March hunting in the daytime at the edge of a fallow field overgrown with giant ragweed and sunflower. Two were caught at different times and places but in similar situations in wire funnel traps set for snakes along hilltop

rock ledges in oak-hickory woods. Another was seen in this same type of habitat.

Movements.—No information has been obtained. The fact that no weasel or sign has been seen more than once in any one place seems to suggest that these secretive small predators wander extensively.

Spilogale putorius (Linnaeus)

Spotted Skunk

Status.—Common resident.

Habitat.—Records of the spotted skunk on the Reservation are so well scattered in both woodland and grassland situations, that no definite preference for any habitat subdivision is detectable.

Movements.—In 1950 during the colder months a line of 50 or more live-traps were kept in operation and were moved from time to time. These traps were set primarily for opossums, but spotted skunks were caught frequently. In the course of a year 18 individuals were caught within an area of approximately half a square mile. All of these were marked by toe-clipping and released, but the data from recaptures are so scanty that little can be learned from them concerning movements. Only two marked skunks were recaptured. One of these was caught at the same place on January 3, January 15, and March 27. An adult female was trapped and marked on October 16, 1950; she was recaptured on March 8, 1951, at a point 900 feet southeast, and on April 4, 1951, she was caught approximately 3300 feet south of the original location. These records, together with the fact that most individuals marked were not recaptured at all, indicate that an individual skunk ranges over an area considerably larger than the area live-trapped.

Crabb (1948:232) in southeastern Iowa found that in winter a spotted skunk has a home range of about .25 square mile with two or three separate dens. He found that in spring the range was similar to that of late winter for the females, but the male's range was greatly expanded, to an area of two to four square miles.

Mephitis mephitis (Schreber)

Striped Skunk

Status.—Common resident.

Habitat.—This skunk prefers grassland, especially in woodland edge situations, for hunting its prey. The captures recorded (mostly in wire live-traps set for opossums) were nearly all in grassland within a few yards of woodland edge, or near margins of streams or

the pond. So far as has been observed dens are usually situated in rock clefts along hilltop ledges in woodland.

Movements.—Eleven striped skunks were live-trapped in a six-months period and within an area of approximately one-third of a square mile. Only two of the eleven were recaptured. One of these was caught at the same place on March 30 and April 4, but was caught at a second location 750 feet away on April 8. Another skunk, caught within a few yards of a currently used den on November 26, 1949, was recaptured 1700 feet away on April 12, 1950. Most captures of skunks were made along edges of fields of brome grass, formerly pastured. Several captures were made along the channel of a small creek draining the eastern half of the Reservation. Skunks released from live-traps did not, like most other animals, make for the nearest shelter, but struck out with seeming fixity of purpose and slight deviation from a straight line course, on relatively long treks, with the home burrow as the obvious objective. Several times attempt was made to follow such skunks, but usually they eluded pursuit by scrambling through thickets or tangles. One such individual, caught at the head of a small valley, travelled 700 feet uphill in its homeward dash to shelter in a fissure at the hilltop rock outcrop.

Dama virginiana (Boddaert)

White-tailed Deer

Status.—Irregular resident.

Habitat.—Chiefly woodland, especially where there is an understory of dense brush; on many occasions seen crossing open fields, or feeding along their edges.

Movements.—Twelve occurrences of deer were recorded from August 18, 1949, to May 25, 1951. All these records probably pertained to the same two individuals, which were usually seen together, a doe and her yearling fawn. However, none was seen from October, 1949, to August, 1950. From May, 1951, to March, 1956, no deer or sign of them were recorded on the Reservation, but subsequently in 1956 and 1957 at least one individual was present on the area and was recorded frequently.

The records of 1949 through 1951 were well distributed over an area of a little more than a quarter of a square mile, rhomboidal in shape and including a narrow hilltop field, the wooded slopes on either side of it, and the meadows at the heads of two small valleys approximately half a mile apart. The area seemed to provide favor-

able habitat conditions. It included approximately two miles of woodland edge thickets, and the meadow portions were being invaded by many kinds of woody vegetation. The area was just over $\frac{2}{3}$ mile in greatest diameter from the southwestern edge to the northeastern, and $\frac{3}{8}$ mile from the southeastern limit to the northwestern. This entire area was not covered uniformly by the deer. The two northwesternmost records were near the Reservation headquarters. Deer or their sign would have been readily noticed in this vicinity and it seems obvious that the animals rarely ventured so far in this direction. In their normal daily activity the animals must have been limited to a smaller home range, from which they wandered occasionally for a variety of reasons.

The deer seen on August 18, 1949, was in the center of a hilltop field late in the afternoon. It seemed nervous but was little alarmed by the nearness of the observer. It stood watching curiously, from time to time giving a snort, or walking a few steps in one direction or another. A few minutes before this deer was seen, coyotes were heard yapping excitedly a few hundred yards farther east, and this disturbance probably had caused the deer to move into the open. It finally moved off into the woods on the opposite side of the field from that where the coyotes had been heard. On May 9, 1951, near the central part of the Reservation, tracks of a running deer and a running coyote were seen. Probably the coyote had been chasing the deer, but their courses could be followed for only a few yards because of the rocky nature of the soil. In late November, 1950, after the pond had dried, deer tracks were extremely numerous in the muddy bottom. One or more deer were visiting the area frequently to feed upon the succulent vegetation.

In the period of this study the Reservation offered habitat conditions favorable to deer. Dense cover was abundant, with a variety of shrubby and herbaceous vegetation for food, freedom from disturbance by humans and from competition with livestock. The 590-acre area would undoubtedly support a large number of deer. The fact that the species still, in 1957, has not become well established in the area can be attributed almost entirely to domestic dogs. In the course of a year many individual dogs hunt on the area, usually in twos or threes, or sometimes in larger packs. Some have been recognized as residents of nearby farms; others perhaps travel many miles to reach the area. Their quarry includes raccoons, coyotes, opossums, squirrels, and rabbits. Hunting is limited almost entirely to the colder half of the year. In summer, because of the abundance of insect pests, dense thorny vegetation, heat and

humidity, the dogs' hunting activity is much reduced. Were it not for this respite during late pregnancy and the period when small young require care, deer probably would be unable to survive at all in this part of eastern Kansas. As it is, the population is kept sparse and scattered. Deer are still sufficiently uncommon that notice of them by farmers or other individuals are frequently reported in local newspapers. In such accounts there is often mention of chasing by dogs, and such incidents as the chasing of a nearly exhausted deer into a farmyard or into the edge of town are common. If chasing by feral and free-ranging dogs could be partially controlled, a rapid rise in the deer population of eastern Kansas might be expected.

Birds

Podilymbus podiceps (Linnaeus)

Pied-billed Grebe

Status.—Occasional migrant.

Habitat.—Sizable bodies of water are required for existence of a permanent population.

Movements.—On at least one occasion a pied-billed grebe was seen in the pond at the Reservation, and on several other occasions lone individuals have been seen on a small pond several hundred yards south of the Reservation. In each instance the grebe was present on only one day. No specific dates were recorded.

Pelecanus erythrorhynchos Gmelin

White Pelican

Status.—Uncommon migrant.

Habitat.—Large lakes, or bays and inlets of the sea coast.

Movements.—On an afternoon in late May, 1949, pelicans in a large flock were seen flying north, high over the Reservation. On June 11, 1953, at 8:45 A. M., a flock of approximately 25 were seen flying slightly above the level of the tree tops, headed north and a little west.

Ardea herodias Linnaeus

Great Blue Heron

Status.—Occasional visitant, especially in April and May.

Habitat.—Normally limited to vicinity of lakes, ponds and streams.

Movements.—These large herons pass over the Reservation frequently but irregularly, usually without stopping. They have been

seen or heard passing over most often around dusk. Usually such herons were flying high, on what appeared to be long overland trips. From time to time a lone individual or a pair has stopped temporarily at the pond, or at one of the small intermittent creeks on the area, attracted by an abundant food supply of frogs and tadpoles. In most instances the leopard frog or the cricket frog, or the tadpoles and young of the bullfrog seemed to be the chief prey. In some instances a heron has remained for a few hours, but failed to return after completing its foraging for the day. In other instances, what appeared to be the same individual returned day after day to exploit an easily available food source, though leaving each evening for a distant roost.

Specific dates when great blue herons were recorded from the Reservation were the following: 1949: September 19, November 24; 1950: April 9, April 13 (one), July 23 (one); 1951: April 14 (one), September 14; 1952: March 30 (one), May 22 (one), October 18 (one); 1953: May 19 (two); 1954: April 19 (four), May 28 (heard); 1955: June 10 (one), June 11 (one); 1956: April 18 (two), April 26, May 1 (one), May 15 (one), May 30 (one); 1957: April 7 (three), April 30 (one), May 6 (two), October 19 (one), October 26 (one).

According to a survey of nesting colonies in Kansas, made by Andrews and Stephens (1956:295), the nearest rookeries are approximately 45 miles west, near Maple Hill, Wabaunsee County, and 35 and 40 miles southwest, near Scranton and Burlingame, Osage County. Since most of the records obtained on the Reservation fell within the nesting season, the status of the herons involved is doubtful. Some may have been non-breeding adults, either residents of the general area or wanderers. Some may have been nesting apart from the rookeries, at places within a few miles of the Reservation. However, Andrews and Stephens obtained no records of nesting colonies in the two easternmost tiers of Kansas counties, including Douglas County.

Butorides virescens (Linnaeus)

Green Heron

Status.—Common summer visitant.

Habitat.—Normally limited to vicinity of lakes, ponds and streams in or near woodland.

Movements.—These herons have frequently been attracted to the pond on the Reservation, and occasionally have come to the two small intermittent creeks. Frogs constitute the chief food supply attracting them to these places. The cricket frog is the kind

most utilized. On various occasions the herons have been seen strolling about on mud near the pond edge where these small frogs were extraordinarily abundant. Dates when green herons were recorded at the Reservation were as follows: 1950: July 13 and 15; 1951: April 25 and 27, May 2, June 22, August 6; 1952: May 3, 23, 24, 28, and 30; 1953: May 9; 1954: May 6; 1955: April 27 and 28, May 8, July 4 and 19; 1956: April 14, 25, 26, 27, 28, and 30, May 1, 4 and 13; 1957: April 30 and May 3.

In some instances the green herons that came to the pond probably stayed there continuously for several days, or even longer periods. In 1956, especially, a pair was seen regularly during the latter half of April and early May. They seemed to be preparing to nest there, but left suddenly after heavy rains on May 7, 8, and 9.

Several of the green herons that appeared in late summer were juveniles. On July 19, 1955, in late afternoon, one perched on a treetop 200 yards from the pond for more than an hour, calling at intervals of approximately five minutes.

Nycticorax nycticorax (Linnaeus)

Black-crowned Night Heron

Status.—Occasional transient.

Habitat.—Swampland is the preferred habitat. On several occasions migrant night herons have been flushed from the willow grove or the pond edge on the Reservation.

Botaurus lentiginosus (Rackett)

American Bittern

Status.—Occasional transient.

Habitat.—Marshland.

Movements.—Only one record—an individual flushed from the pond on May 9, 1953.

Branta canadensis (Linnaeus)

Canada Goose

Status.—Uncommon migrant.

Habitat.—Marshlands.

Movements.—These geese have been seen only as migrants passing over the area in spring. On April 14, 1951, at 8:30 A. M., a flock of approximately 40 were seen flying low, headed due north. On March 19, 1952, at 8:30 A. M., a flock of eleven were seen flying

north. On April 4, 1955, at 7 A. M., a solitary individual was flying low, headed north.

Anser albifrons (Scopoli)

White-fronted Goose

Status.—Rare migrant.

Habitat.—Marshland.

Movements.—R. W. Fredrickson recorded a small flock over the Reservation on April 14, 1952.

Chen hyperborea (Pallas)

Snow Goose

Status.—Abundant migrant in both spring and autumn.

Habitat.—Marshland; arctic tundra in breeding season.

Movements.—The remarks in the species account of the blue goose apply almost equally well to the snow goose. Relatively few of the flocks seen were composed entirely of either kind, but both snow geese and blue geese were usually in the same flock in varying ratios. Also, a high proportion of individuals in a flock often were intermediates, that were partly white and partly "blue" in their plumage. Complete freedom of interbreeding is indicated.

Chen caerulescens (Linnaeus)

Blue Goose

Status.—Abundant migrant in both spring and autumn.

Habitat.—Marshland; arctic tundra in breeding season.

Movements.—In 1949 flocks were seen frequently between October 22 and November 13. In 1950 the northward migration occurred mainly during the first week of March. In 1951 the fall migration reached its peak on October 14. In 1952 the main spring flight lasted for approximately two weeks in mid-March. In 1953 the main spring migration occurred in the period March 8 to 15, but flocks were seen also on March 18, 19, 23, 25, and 30, and on April 1, 2, 3, 4, 8, and 17. A large flock seen on the latter date was flying south. Southward migration in autumn was first recorded on October 13 and reached a peak about October 24, but flocks were recorded also on October 28 and December 20. In 1954 spring migration was noted on March 7, 8, 10, and 12, reaching a peak between the two latter dates. The fall migration was recorded only on October 7 and 13. In 1955, spring migration was noted chiefly

between March 10 and 31, and fall migration was first noted on October 7. In 1956 spring migration began on February 22, reached a peak on March 19, and was last noted on March 26. In 1957 spring migrants were noted on March 1, 2, 3, 4, 12, 15, and 27, and on April 6, fall migration began the second week of October.

Anas platyrhynchos Linnaeus

Mallard

Status.—Irregular transient over area, occasionally stopping at pond when water supply is adequate.

Habitat.—Marshes, ponds, lakes and slow-moving streams.

Movements.—Mallards have been recorded at the pond on the Reservation on only a few occasions: March 19, 1950 (flock of eight); June 11, 1951 (lone female); October 31, 1951 (pair); November 1, 1951 (group of three); February 26, 1952 (pair); February 28, 1952 (pair); March 30, 1952 (about 35); April 3, 1952 (about 35); November 11, 1955 (lone female). Low water, or complete drying of the pond, in late 1952, 1953, and 1954, discouraged use of the pond in those years by ducks; also probably the population was low as a result of widespread drought. On many occasions, including December 9 and 24, 1951, November 5, 1954, March 3, 1955, February 21, 1956, and January 20 and 24, 1957, flocks of mallards were seen or heard flying over the area, although they did not stop there. Most often such flights were noted after dark.

Anas acuta Linnaeus

Pintail

Status.—Occasional transient.

Habitat.—Ponds, lakes and streams.

Movements.—The first evidence of the occurrence of this species on the Reservation was the strewn feathers of an adult male where it had been eaten by a predator (probably a horned owl) in December, 1948. The remains were found approximately 100 yards from the pond, where the duck probably had stopped. It may have been wounded in the hunting season. On many occasions ducks seen flying over the Reservation were too high to be identified positively. Some may have been pintails. R. W. Fredrickson recorded a small flock of pintails flying over the Reservation on March 5, 1949, and a lone individual on April 6, 1952.

Anas carolinensis Gmelin

Green-winged Teal

Status.—Uncommon visitant in late autumn and early spring.

Habitat.—Marshes, ponds, lakes and slow-moving streams.

Movements.—Flocks were recorded at the pond almost daily from November 7 to 14, 1949, March 3 to 11, 1950, and were also recorded on March 4 and 31, 1955.

Anas discors Linnaeus

Blue-winged Teal

Status.—Common visitant, chiefly in spring and autumn.

Habitat.—Marshes, ponds, lakes, and slow-moving streams.

Movements.—From one to 40 individuals were noted at the pond on the following dates: June 27, 1949; April 12, 13, 15, 20 and 23, 1950; April 13, 15, 16, and 19, and October 29 and 30, and November 22, 1951; April 1, 2, 7, 21, and 23, 1952; April 6, 1953; April 17, 20, and 29, 1955; and April 9 and 30, 1956.

Spatula clypeata (Linnaeus)

Shoveller

Status.—Uncommon visitant.

Habitat.—Marshes, ponds, lakes, and slow-moving streams.

Movements.—Throughout April, 1952, one or more groups of these ducks were seen frequently at the pond, which was then full of water. Often the shovellers were associated with blue-winged teal. The number seen at one time ranged from six to fifteen. In other years none was seen at the Reservation.

Aix sponsa (Linnaeus)

Wood Duck

Status.—Uncommon visitant.

Habitat.—Ponds and slow-moving streams in wooded areas.

Movements.—This duck has been noted on the Reservation on only a few occasions: May 29, 1950 (adult male); April 17, 1951 (adult male); November 3, 1951 (adult male); November 4, 1951 (adult male); and March 20, 1952 (pair). Although the records in 1951 extended over more than six months, it is almost certain that the same individual was involved in all three instances. This

was a crippled and flightless male. On the night of November 3, the pond froze over and when the duck was found on November 4, he was 200 yards farther down the gully, where there was still a trickle of water.

Aythya collaris (Donovan)

Ring-necked Duck

Status.—Uncommon visitant.

Habitat.—Ponds, lakes and streams.

Movements.—Recorded at the pond on the Reservation in 1950 only; on March 11 there were approximately 15, along with a larger number of green-winged teal; on March 20 there were approximately 20; on March 21, seven.

Aythya affinis (Eyton)

Lesser Scaup Duck

Status.—Rare visitant.

Habitat.—Ponds, lakes and streams.

Movements.—On March 15, 1952, a lone female was flushed from the pond, and a flock of approximately ten were seen at a farm pond half a mile south of the Reservation. On the following day they were seen again at the same farm pond, along with a group of shovellers. On March 24 several were seen flying to the pond on the Reservation late in the afternoon.

Cathartes aura (Linnaeus)

Turkey Vulture

Status.—Regular summer visitant.

Habitat.—Regularly patrols all parts of the Reservation, and most other areas in northeastern Kansas that are not subject to too much disturbance by humans.

Movements.—Vultures on their northward migration usually reach the Reservation in the last week of March. For the years 1951 through 1957, arrival dates were the 25th, 19th, 20th, 25th, 28th, 27th and 31st of March. In all but one instance the early records were of lone birds, but in succeeding weeks, vultures were most often seen in small groups. A close-knit social group of four pairs used the Reservation regularly. In their flight maneuvers and search for food the members of this group tended to stay near each other, and usually several or all of them were seen simultaneously. Within the group, pair-associations were nearly always

evident, as the members of each pair stayed closer to each other than to the other vultures belonging to the group. Activity of the entire group centered over "East Woods" and "Wall Woods," an area of rocky hilltops and steep slopes near the eastern boundary of the Reservation. When this part of the area was visited, the vultures were almost invariably seen maneuvering over it, whereas they were seen comparatively seldom over the part of the Reservation near the headquarters, two-thirds of a mile farther west. A large proportion of their time seemed to be spent in an area estimated to be less than 200 acres in extent, but whether this area provided their main food supply, or merely served as a rallying place where members of the group maintained contact and performed maneuvers primarily of social significance, is uncertain. Vultures that probably were members of this same group were often noted approximately $1\frac{1}{2}$ miles farther south at the north edge of the Kansas River Valley, about the same distance north, and, occasionally, over the west boundary of the Reservation, a mile west from the place where they were most frequently seen. Nothing was recorded of their movements east of the Reservation, but a minimum area of perhaps six square miles is estimated as the range of this group.

In the area where the group's activity was concentrated, a nest was discovered in 1952, and the same site was used each year subsequently, through 1956. This nest site was in an elm more than two feet in trunk diameter, and having a large hollow in the trunk ten feet above the ground. When the nest site was discovered, there was evidence that it had been robbed recently. The rough bark of the tree was coated with the vulture's down feathers, where the bird might have struggled with a climbing predator that was either approaching or leaving the nest. In 1954, also, the nest was robbed by a predator before the eggs had hatched. The raccoon was considered the most probable predator.

Accipiter gentilis (Linnaeus)

Goshawk

Status.—Rare and irregular winter visitant.

Habitat.—Typically northern coniferous forests, but because of its migratory habits may appear temporarily in much different habitats, such as deciduous woodlands in eastern Kansas.

Movements.—Recorded on the Reservation on only two occasions. One was on December 29, 1950. At 10:00 A. M. alarm calls of a flicker and squalling of a rabbit were heard on a heavily wooded

north slope near the Reservation headquarters. Two cottontails, alarmed by the sound scurried from the edge of the woods and hid in nearby blackberry thickets. Hurrying toward the sounds, I flushed the goshawk, from beneath an osage orange tree. The hawk was carrying an adult cottontail but soon dropped it. The rabbit struggled to its feet and ran heavily a few yards to an old woodrat house where it found shelter. The hawk boldly perched within 100 feet of me, watching intently. I easily caught the rabbit, which was near collapse, and it died a few minutes later. Dissection disclosed that the jugular vein had been pierced, and there were masses of clotted blood in subcutaneous wounds. The back of the head, right side of the neck, and throat had been badly lacerated. A second goshawk was recorded on the area by Donald W. Janes in the winter of 1955.

Accipiter striatus Vieillot

Sharp-shinned Hawk

Status.—Occasional transient, chiefly in winter.

Habitat.—Chiefly woodland.

Movements.—The few records seem to pertain to wandering individuals, since most are well separated in time and space. None has been noted in summer. Specific dates of the records are: September 19, 1956; September 23, 1952; October 13, 1948; November 3, 1956; November 16, 1951; November 17, 1954; December 1, 1956; December 2, 1956; December 15, 1953; December 16, 1954; December 31, 1955; January 9, 1954; January 18, 1952; January 24, 1953; February 2, 1954; February 4, 1952; February 14, 1954; March 8, 1953; April 15, 1950; April 26, 1956, and May 15, 1952.

Accipiter cooperii (Bonaparte)

Cooper Hawk

Status.—Uncommon summer resident; occasional winter visitant.

Habitat.—Chiefly woodland, and mixed habitat of woodland alternating with open fields.

Movements.—Cooper hawks have been recorded on the Reservation most frequently in spring and early summer, the nesting season, when usually at least one pair resides on the area. Records in winter are sporadic, and seem to pertain to wandering individuals that are passing through.

A nest, in dense oak-hickory woods, on a north slope 100 yards south of the Reservation headquarters was used in 1950, 1951, 1952,

and 1953. In 1954 a new site approximately 100 yards east, on the same slope was occupied. In 1955, 1956, and 1957 the territory was not occupied, but Cooper hawks were seen from time to time in the area.

Each year that the territory was occupied, the hawks appeared abruptly in spring and passed through a period of maneuvering and display before nesting actively began. In 1952 the hawks appeared at about the beginning of March, and were heard cackling frequently in the vicinity of the nest site. In 1953 first appearance was nearly a month earlier. Although the bird that arrived first was seen frequently in the territory in February and March, it did not obtain a mate for several weeks. On April 1, 1953, the pair of hawks were seen in a courtship flight. The wings of the male were raised high over his back at each stroke, and moved in a wide arc, giving the flight a peculiar mechanical quality faintly resembling the flight of a nighthawk. Similar display flights were observed frequently throughout most of April. On March 8, 1954, the first Cooper hawk of the season was seen circling with the same slow rhythmic flapping, over a hilltop field area of 32 acres. Apparently this individual was a female.

Because Cooper hawks were ordinarily shy and secretive, the extent of their territories was difficult to ascertain. In late July and early August, 1951, a hawk was seen to bring young chickens regularly from adjoining farms. The farmyard which probably contributed most of the chickens was just under $\frac{3}{4}$ mile from the nest, while the other farm was approximately .6 mile from the nest. The chickens appeared to be about one-third grown, and were heavy loads for the hawk. Both farmyards were on a flat hilltop approximately 115 feet above the elevation of the nest. The hawk, probably the female in each instance, was favored by the lower elevation of the nest, when burdened with heavy prey on her homeward flight. The area over which the pair of hawks were seen to fly, and which they were known to exploit for prey, consisted of at least half a square mile, but the actual territory was probably larger. In 1950, 1951, and 1952 other Cooper hawks were seen frequently on a wooded slope a little less than half a mile south southeast of the nest near the headquarters. Although a nest was never found in this second area, nesting almost certainly occurred there. In 1952 a nest was found in a ravine .6 mile east of the nest under observation near the headquarters, and approximately .8 mile north northeast of the second supposed nest site.

In 1951 the three young hawks left the nest near the Reservation headquarters in the last week of July. For three weeks subsequently they were heard or seen daily on the slope where the nest was located and within 100 yards of it.

Buteo jamaicensis (Gmelin)

Red-tailed Hawk

Status.—Year-round residents, winter residents, and transients occur on the area.

Habitat.—Red-tailed hawks use the entire area. While most perches and nest sites are in woodland, the hawks hunt their prey chiefly in open land. Parkland and woodland edge situations are especially favorable.

Movements.—Individual hawks could not be recognized with certainty except for relatively short periods when missing remiges or retrices occasionally permitted recognition at close range. Behavioral traits provided more useful but not entirely reliable means of recognizing individuals. In most instances, however, these means of recognition were inadequate to trace the turnover in the resident population. Of the red-tailed hawks seen on the area, most were wanderers that did not stay long.

Most of the section of land within which the Reservation is located was divided between the territories of two pairs of red-tailed hawks (Fig. 11). These two territories were maintained in essentially the same form throughout the period of my observations, from 1948 through 1957, although there was partial replacement of the hawks themselves. The configurations of the territories were largely determined by local physiography. The upland *cuesta* north of the Kansas River Valley has peninsular extensions. One of these extensions, a little more than a mile long but less than 100 yards across at its narrowest, crosses the Reservation diagonally from the northeastern to the southwestern corner, as a mesalike flat hilltop. There is a second peninsular hilltop, more or less parallel to this one but $\frac{3}{4}$ mile farther southeast, and a third about $1\frac{1}{4}$ miles northwest. These parallel hilltops formed territorial boundaries, and the territories consisted mainly of the intervening lowland areas, and slopes. Of the two territories, the more western was by far the larger, comprising approximately 800 acres, but it included much cultivated land that was less productive of prey. The more eastern territory was approximately 535 acres of which less than a fifth was under cultivation. The remainder was mostly woodland, with brush and

grassland of former pastures. The territory of this pair included no human habitations nor roads, and was mainly inside the Reservation on the part least visited by people. The pair of hawks occupying this territory are believed to have been the same throughout the eight-year period of observation. Their behavior differed notably from that of other hawks in their boldness and defiance. In May, 1949, I tried unsuccessfully to climb to their nest and thereafter they showed resentment whenever I entered their territory, regardless of whether or not the intrusion was in the nesting season. Upon seeing me as much as half a mile away both hawks might leave their perches, fly toward me screeching, and circle low overhead. Over the years their hostility subsided somewhat, as their nests were not further molested. In 1950 and 1957, the nests were in trees considered unclimbable, and in other years nests were not found while they were in use. The heart of this pair's territory consisted of thick woods of approximately 34 acres on a west-facing slope. On dozens of occasions, the hawks were seen perched on snags on this hillside.

Hawks of the second pair were much shier and more wary. Their territory included the Reservation headquarters, and the residences of four different farms and several roads. As a result, the hawks often encountered humans and probably had been shot at on many occasions. It is certain that in this pair there was occasional replacement when one was shot and the survivor obtained a new mate to share the territory. Whether there was continual tenure through such a line of survivors over the eight-year period is uncertain, but probable in view of the fact that the territory remained essentially the same. This territory centered on a brushy hillside, which had been wooded until it was cut and bulldozed in the winter of early 1949. Cottontails, rodents and small birds were abundant in the brushland habitat. Hunters, with shotguns or .22 rifles, often visited this hillside. When disturbed by humans, the hawks habitually flushed at distances of hundreds of yards and flew to distant parts of their territory. Sometimes they screamed at the moment of flushing, and sometimes flew silently. Their survival obviously was dependent on wariness and prompt response to the presence of humans. A melanistic individual was co-occupant of the territory from the autumn of 1948 until November 3, 1951, when it was found dead beside the county road at the west edge of the Reservation. On three other occasions buteos recently shot were found along this road. Probably wandering individuals suffered the most casualties. Despite their usual wariness, these hawks when hunting were

several times seen to fly through or past a barnyard, in a surprising display of boldness. Although they were not seen to catch anything in or near the barnyards, their behavior suggested that young poultry might be the object of their forays.

In May and June, 1955, the hawks were seen on various occasions carrying prey (usually a snake) to the nest. In each instance, the hawk was within a quarter mile of the nest when first seen. On June 19, a fledgling left the nest when attempt was made to climb to it. For the next six weeks, the fledglings were heard and seen frequently in the parents' territory. On several occasions they were seen soaring with the adults, but tended to be much more sedentary, and often perched for periods of hours in the same small area, calling to be fed.

Territorial encounters between pairs were relatively few. Even when such encounters occurred, they were usually brief and relatively mild, and might consist of circling and screaming with no actual fighting. This was in striking contrast with my observations on the species at the San Joaquin Experimental Range in the Sierran foothills of central California (Fitch, Swenson, and Tillotson, 1946), where habitat conditions were somewhere near the optimum, with high populations of diurnal rodents, and rabbits, sparse cover, and well distributed perch trees. Under these conditions territories averaged only half a square mile, and territorial pressure was intense. Each pair of hawks spent a substantial part of their time in fights and maneuvers with their neighbors as a result of territorial pressure.

Trautman (1940:212) found that red-tailed hawks, wintering in the vicinity of Buckeye Lake, Ohio (where the species is absent in summer), settled in individual territories of two square miles or less in extent. Having settled in such territories, the hawks ordinarily remained for the winter, unless forced to move by unfavorable weather conditions such as a heavy snow cover. After being forced out of its regular territory by a winter storm, Trautman found, an individual hawk would return as soon as conditions again became favorable.

Before there were buildings on the Reservation, in 1948 and 1949, the small valley that was later the site of the headquarters installation was much used by the hawks. The residence and other buildings were erected in the winter of 1949 and 1950. Thenceforth human activity greatly increased, and the hawks habitually avoided this part of their territory, and used the valley much less than they had before. They rarely came within 100 yards of the buildings,

and perched in the valley within sight of the headquarters only at times when there had been no human activity outside for periods of hours. They were most often seen perched 200 yards or more from the house in early morning. As soon as a person came out of the house, they would flush and leave the vicinity and would not reappear for the remainder of the day.

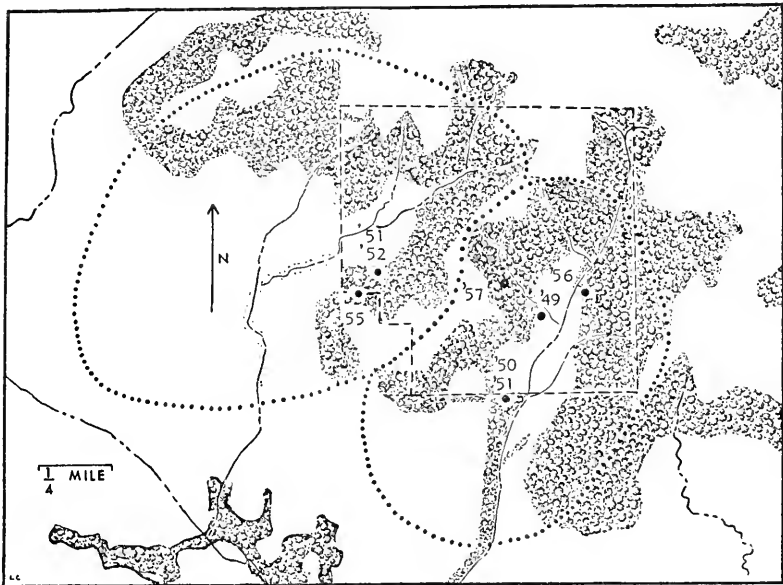


FIG. 11. Approximate extent of two territories of red-tailed hawks as they existed over a period of years. The long, narrow hilltop extending from northeast to southwest across the Reservation was the common boundary. The territory on the northwest was larger, as it contained a high proportion of cultivated land that, for the hawks, was unproductive of food. Dots show locations of nests for the years in which they were found.

Buteo lineatus (Gmelin)

Red-shouldered Hawk

Status.—Uncommon resident of this general area near western limit of breeding range.

Habitat.—Deciduous forest is preferred by this hawk. On the Reservation it was rarely seen in situations where there were mature trees of climax species. Rather it showed preference for such places as the pond and the adjacent willow groves, hilltops with low trees and thorny tangles, and areas of mixed grassland and second growth woodland.

Movements.—Compared with other buteonine hawks on the area, red-shouldered hawks are more secretive. Although I had heard the characteristic call from time to time, I was unfamiliar with it, and failed to recognize the species' presence until June 22, 1953, when a juvenile was flushed at close range at the edge of the pond. Judging from the appearance of this individual, it had not been fledged long, and could not have travelled far from the nest. No more definite evidence of nesting on the area has been obtained. Throughout the latter half of 1953, 1954 (except March and December), 1955 (except January and February), and early 1956, a red-shouldered hawk was seen and heard frequently on the Reservation. Twice in May, 1955, two were seen or heard simultaneously, near together and perhaps paired, but the records pertain mainly to a lone individual that spent most of its time on the Reservation, but occasionally sojourned elsewhere for periods of weeks.

Reason for considering the records to pertain to a single individual is that the hawk was nearly always seen or heard in the same general area, an elliptical territory of 180 acres, approximately twice as long as broad, mostly in the northwestern quarter-section of the Reservation (Fig. 13). Habits of this individual were noted to change over periods of weeks or months. It tended to spend much of its time in a small perching area, but from time to time neglected or altogether deserted one perching area in favor of another that was as much as half a mile away. In March and April, 1955, a red-shouldered hawk was seen at several places along the eastern edge of the Reservation, more than half a mile from the supposed territory. This may have been a second individual, but more probably it was the same. Stewart (1949:26) found red-shouldered hawks in a density of one pair per .8 square mile in the coastal plain of Maryland, in the habitat to which the hawks were confined—wooded stream courses.

The territory of the lone individual on the Reservation overlapped to a large extent the territory of a pair of broad-winged hawks, and also broadly overlapped a red-tailed hawk territory. Although not limited to mutually exclusive territories, these three species of large hawks were somewhat intolerant of each other. On the Reservation interspecific maneuvers, chases or fights involving two species were observed much more frequently than intraspecific encounters. Domination of the red-shouldered hawk by a red-tailed hawk was observed on various occasions. The red-shouldered hawk probably was able to maintain its territory only because it was limited

chiefly to areas little used by red-tailed hawks. In encounters between the red-shouldered hawk and broad-winged hawks, dominance was not clear-cut, nor was any actual fighting observed. The encounters consisted of soaring in overlapping circles with an occasional short swoop toward, but not near to, the opponent.

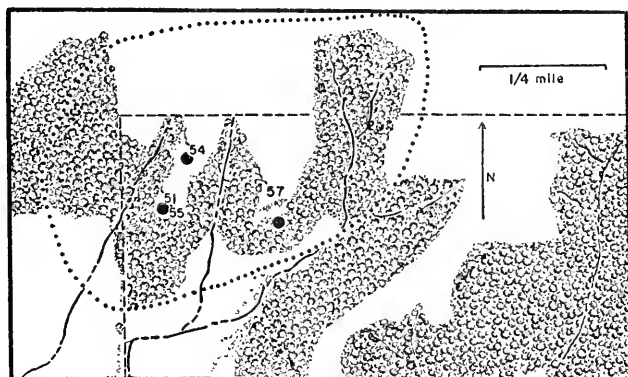


FIG. 12. Approximate extent of the territory of a pair of broad-winged hawks, as it was maintained each summer over a period of years. It was an area of hilltop pasture and rocky, brushy south slope. Dots show approximate locations of nest sites in four different years, but nests were not actually found in 1951 and 1955.

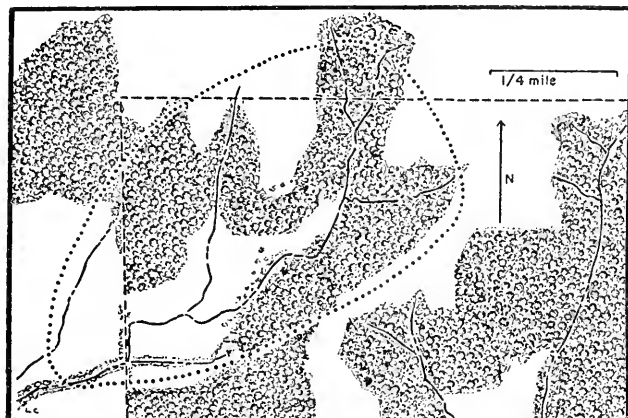


FIG. 13. Approximate extent of territory of a red-shouldered hawk, in the northwestern part of the Reservation and adjacent areas. This territory was shared with red-tailed hawks, and (in summer) broad-winged hawks, but there was constant friction between all three species.

Buteo platypterus (Vieillot)

Broad-winged Hawk

Status.—Moderately common resident in summer, absent from October to late April.

Habitat.—Mixed woodland, and adjacent open areas, especially of rock ledge.

On the Reservation, the abandoned rock quarry was a favorite haunt of these hawks, and on many occasions was the scene of territorial fights. The abundance of reptilian prey of several kinds at this open, rocky place made it attractive to the hawks. The hawks were seen chiefly along the south slopes of the northwest quarter of the Reservation section, where the aspect of the vegetation was xeric.

Movements.—Upon their arrival in spring, broad-winged hawks attract attention by their soaring flight and whistling calls. In autumn before migrating south they spend much less time soaring and are relatively silent; consequently the time of departure is difficult to determine. Arrival dates over an eight-year period, 1950 through 1957, were all in April: the 15th, 18th, 16th, 28th, 20th, 15th, 20th, and 23rd. For these eight years, April 19 was the average date of appearance. After the first appearance the hawks were usually heard and seen many times each day for the remainder of spring. Within the first two weeks they were especially noisy and conspicuous, while they were establishing and maintaining territories against competitors. At this season as many as five have been seen soaring together, with occasional threatening swoops and frequent squealing calls. Activity of broad-winged hawks was mainly limited to the areas of south-facing slopes with xeric second growth woodland, rocky hilltop edges, and upland pasture. Nests were found only in 1954 and in 1957, but probably the hawks nested on the Reservation every year. In 1951 and 1955 they were seen repeatedly, carrying prey items toward the same place, a hilltop edge, with low thorny trees and dense tangled undergrowth, but my many attempts to find the nest were unsuccessful.

For these hawks territorial boundaries were especially difficult to define, since the birds were usually seen circling high over the hillsides. The area over which they were known to forage regularly comprised approximately 250 acres (Fig. 12), but the western

and northern limits, being outside the Reservation, were not well determined. Most satisfactory information was obtained concerning the southern limit of the territory, since it followed the contour of the slope just north of the residence. In early summer the hawks were seen many times each day on this slope, but they only rarely ventured as far south as the residence. The opposite slope to the south supported a more mesic type of forest and obviously was not such favorable habitat. Occasionally, however, a broad-winged hawk was seen to fly out of sight in this direction, in a foray well beyond the limits of the usual territory. Within the territory, a much smaller, elongate area of hilltop edge and upper slope only a few acres in extent included the favorite perches and the places where the hawks most frequently flew.

In 1954, when the nest of these hawks was studied, prey included collared lizards of a marked population at an old quarry nearly a quarter mile east, and several Great Plains skinks, believed to have been caught along a pastureland outcrop $\frac{1}{4}$ to $\frac{1}{2}$ mile northwest, where these lizards were especially numerous.

Buteo lagopus (Pontopiddian)

Rough-legged Hawk

Status.—Rare transient or migrant in winter.

Habitat.—Typically far northern forest, and tundra.

Movements.—Occasionally rough-legged hawks are seen in northeastern Kansas in winter. One was seen on the Reservation on November 2, 1948; one of the dark phase was seen as it was heckled by a pair of red-tailed hawks, over the southeastern part of the Reservation on November 14, 1951.

Haliaeetus leucocephalus (Linnaeus)

Bald Eagle

Status.—Rare transient.

Habitat.—Most typically, forested areas bordering sizable bodies of water.

Movements.—Only one record of a bald eagle on the Reservation has been obtained. On the afternoon of December 9, 1951, my attention was attracted by the screaming of red-tailed hawks overhead; three of these hawks were chasing an adult bald eagle, which was flying northwest. It kept to this course until it was out of sight.

Circus cyaneus (Linnaeus)

Marsh Hawk

Status.—Appears from time to time at all seasons but mainly in winter, when nomadic individuals often wander over Reservation.

Habitat.—The marsh hawk usually frequents open fields of various types. In apparent order of preference, marsh hawks prefer marshland, prairie, bottomland pasture, upland pasture, parkland, and woodland. Although marsh hawks have been seen on many occasions flying over woodland, they were always flying well above the treetops and presumably were crossing from one open field to another. On the Reservation they were seen frequently on all open field areas and especially in the upland field at the north edge, that had a mixture of weeds and native grasses.

Movements.—Marsh hawks were seen on the Reservation each month from September through April, inclusive, but ordinarily they were absent during May, June, July and August. The individuals that used the area in winter were all wanderers that did not maintain regular beats; none was recognized on consecutive days, and there was no regularity in the times or places of their appearance. In 1951 a pair nested on the prairie tract at the north edge of the Reservation. The unusually heavy precipitation probably created conditions favorable for them. On May 8 the male was heard cackling and squealing, and was seen in a display flight over a grassy hilltop approximately 3000 feet south southwest of the spot where the nest was found later. On June 20, when I was walking across the same hilltop, 400 yards from the nest, the male flew toward me, cackling, and swooped with a display of aggressiveness, then withdrew in the direction from which he had come. As I moved farther in that direction, he again flew to meet me, this time accompanied by the female, and both swooped at me. The male was the more aggressive and the female soon retired. Moving back and forth across the field, I was able to detect corresponding increase or decrease in the male's excitement and aggressiveness, and was led to the nest which contained a single downy young. Five days later this young was destroyed by an unknown predator and the adults disappeared from the area. On April 7, 1952, a pair was observed in courtship flight in this same vicinity, but, so far as known, nesting did not occur.

Falco mexicanus Schlegel

Prairie Falcon

Status.—Rare transient.

Habitat.—Typically grassland, in rugged terrain such as that with cliffs and buttes.

Movements.—Only one definite record of a prairie falcon on the Reservation has been obtained. On April 16, 1951, one was seen flying south across the hilltop on the northern part of the Reservation. On October 18, 1951, a medium-sized falcon, not definitely identified, but perhaps of this species, was seen flying rapidly over the southern part of the Reservation, on a southward course.

Falco sparverius Linnaeus

Sparrow Hawk

Status.—Occasional on migration; individuals that live on nearby land wander farther than usual from time to time, encroaching onto Reservation.

Habitat.—Requirements include open ground, with sparse or short vegetation, and high perches from which the hawk may examine surrounding terrain. In 1948, a pair of sparrow hawks having a territory centering in grain fields south of the Reservation were seen frequently in the bottomland pasture of its eastern part, at a time when many cattle were pastured on the area and grass was kept cropped close. In subsequent years, after removal of the livestock and growth of high grass, sparrow hawks no longer included this area in their range.

Movements.—Sparrow hawks have been seen on the area mainly in winter and early spring, when the unfavorable effects of tall grass and other rank herbaceous vegetation are minimized. On February 23, 1955, at a time when the ground was snow covered, a male that normally ranged over cultivated land adjoining the Reservation to the west, was found 200 yards inside the Reservation attempting to attack a song sparrow that was in a trap.

On the afternoon of March 23, 1955, this male or another was found at a bird trap attempting to attack a chickadee. Half an hour later at dusk, a person coming out of the laboratory building flushed a hawk, that was probably the same individual, from an old phoebe nest on the porch. Flying erratically in the semi-darkness the hawk

crashed into the screen of a rear window, and a moment later, having circled the building, it lit beside the door and walked in. Its behavior indicated confusion and unfamiliarity with its surroundings. It was banded and released, and lingered in the vicinity, as in the next four days it was seen twice within a few hundred yards of the headquarters buildings. Cade (1955:11) mentions one territory occupied by a pair in a vacant lot 200 feet by 300 feet. He found that in southern California pairs usually remain together on their territories throughout the winter, though some pairs break up in fall and occupy separate winter territories.

On the Rockefeller Tract in 1957 sparrow hawks were frequently present for periods of days and were recorded April 6 to 9, April 24, May 28, July 17, September 3 to 5, and 24 to 26. Probably those that came from time to time were different individuals. Usually only a single hawk was present, but on July 17 there was a pair, and on September 24 a family group of five with recently fledged young. Invariably activity was concentrated along a line of telephone poles, extending west from the east boundary across the pasture to the buildings near the center of the quarter-section, and along a line of electric wire poles extending north from the south boundary to the buildings along a road with fallow fields on either side. There were 12 poles in all. The hawks usually perched on them (sometimes on the wires stretched between them) and foraged by making flights of usually less than 100 feet from the line to the ground to secure prey. Food was obtained chiefly in this elongated strip .43 mile in length and encompassing perhaps ten acres, but at the maximum a hawk followed over periods of hours and flushed frequently ranged over an area of somewhat more than 80 acres. This was a female present on the area on April 6, 7, 8, and 9.

Colinus virginianus (Linnaeus)

Bob-white

Status.—Common resident.

Habitat.—Although quail range over almost every part of the Reservation, areas in an early stage of secondary succession are preferred. My records of coveys are concentrated at the pond, the old quarry, and the formerly cultivated fields, which had grown up with weed patches adjacent to brush and woodland. Coveys were noted in woodland of various types but were rarely seen where stands of awnless brome grass were dominant in former pastures. In the nesting season when coveys had dispersed, pairs were

often seen in habitats different from those used by the coveys at other times of year. Pairs were often seen along the edges of pastures.

Movements.—In autumn, winter and early spring, there were as many as eight coveys using the area, but the number was variable. Fallow fields of 16.7 acres at the middle of the Reservation on its western edge provided headquarters for one covey, which likewise ranged over adjacent fields, to the west, cultivated for sorghum, corn, and other crops. A second covey ranged over the old quarry on a hilltop edge (where an abundant crop of lespedeza, sweet clover and ragweed furnished an ample food supply), the pond area at the foot of the same hill, the intervening brushy wooded south slope, and field cut by a deep gully. This area was roughly rectangular, approximately 1800 feet long by 1000 feet wide, and its

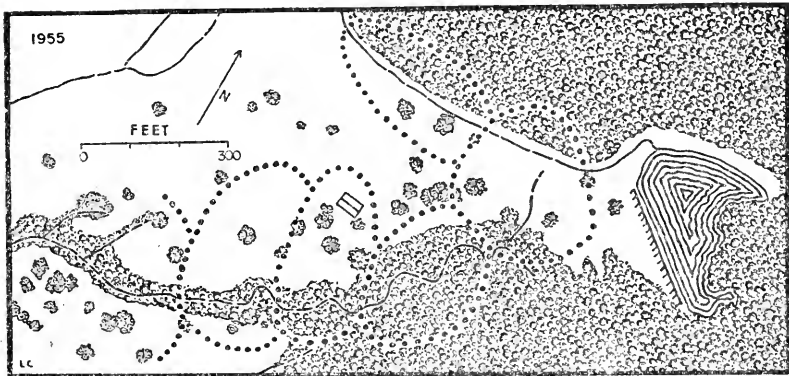


FIG. 14. Approximate extent of territories of five different pairs of bobwhite arranged along woodland and field border, in the late spring and early summer of 1955.

computed area was 40 acres. Two or three other coveys ranged over an area of fallow fields, of 42.8 acres in the northeastern part of the Reservation, and at least two others in another fallow area of 48.5 acres in the southeastern and south-central part. A hilltop field, adjoining the southwestern corner of the Reservation was headquarters of still another covey, which used the area from time to time.

In spring, territorial calling usually has been heard in or near the field where the Reservation headquarters are situated, but in the years when Cooper hawks nested nearby, relatively few quail were heard or seen there. In 1956, when the hawks were not present,

quail were especially in evidence. In May and early June some 13 calling males were recorded along the edges of this field, each in a distinct territory, and presumably accompanied by a mate. The males' habit of answering the calls of neighbors made it possible to establish the approximate position of territorial boundaries. Best data were obtained on the male whose territory included the area around the residence building, as he was seen and heard many times each day, and he was less wary than other individuals, having become conditioned to the presence of humans. On various occasions this male was seen, in early morning or after sunset, foraging with a female. When flushed on such occasions the birds would fly less than 100 feet, and, staying within the territory, would veer back to thickets along a ravine, always alighting close together. On most occasions the male was seen or heard alone, while presumably the female was occupied with laying or incubation. The male spent much time each day in territorial calling, especially in early morning, late afternoon, and in cloudy periods. The oval area within which he stayed was approximately 1.4 acres, but territorial calling and most foraging was mainly confined to the central part of it, an area only about 140 feet in diameter. Four intervals between territorial centers of adjacent calling males averaged 245 feet, indicating territories of approximately 1.1 acres. All the territories tended toward elliptical shape. Two, situated where the transition from woodland to grassland was abrupt, had their long axes along the edge. Three others that were partly in groves in a field adjacent to woodland, had their long axes at right angles to the edge. Some of these bob-white remained in their territories until late August, as they were heard calling from time to time. Nevertheless, territorial calling steadily declined after the end of May, and was not often heard after midsummer.

Grus canadensis (Linnaeus)

Sandhill Crane

Status.—Uncommon migrant.

Habitat.—Northern prairie and tundra in breeding season.

Movements.—On several occasions migrating groups of cranes have been seen near the Reservation, but ordinarily they fly high and do not stop in the vicinity. On the early afternoon of November 13, 1957, a lone crane, which had one leg dangling as if it was

injured, was seen flying west across the northwestern part of the Reservation. A short time later it was seen flying back in the opposite direction. In the following week it was seen daily, making trips back and forth over approximately the same route, which crossed the northern part of the Reservation or the southern part of the Rockefeller Tract. On two occasions it was flushed from the small pond on the Rockefeller Tract. A few days later feathers, bone fragments, and the legs of the crane were found strewn at the pond edge, and along a trail leading off to the south. Probably the crane had been caught and eaten by a coyote.

Rallus limicola Vieillot

Virginia Rail

Status.—Rare transient.

Habitat.—Marshland.

Movements.—One was seen at the pond on May 8, 1955.

Porzana carolina (Linnaeus)

Sora Rail

Status.—Occasional transient.

Habitat.—Marsh.

Movements.—Only one record has been obtained to date; on May 14, 1950, O. M. King and R. W. Fredrickson saw one at the pond on the Reservation. This individual was almost certainly a migrant. At the time, marsh vegetation was abundant at the pond.

Fulica americana Gmelin

American Coot

Status.—Occasional transient.

Habitat.—Lakes, marshes and ponds.

Movements.—In April 1950, remains of a coot were found in a horned owl nest in the southwestern part of the Reservation. This coot had probably been caught at a small hilltop pond that was a little less than 200 yards from the nest. At the larger pond, on the Reservation, coots were recorded on April 22, 1955; May 7, 1951; May 21 to 24, 1953; and October 7, 1955. The pond seemed to provide favorable habitat with ample food and cover at times when coots stopped there, but probably was too small to hold them permanently. Although records are few, their concentration

in late spring suggests that they pertain to individuals dispersed from flocks in search of habitat favorable for nesting.

Charadrius vociferus Linnaeus

Killdeer

Status.—Regular transient, chiefly in early spring and autumn.

Habitat.—Typically in or near wet places with open or partly open expanses of mud, sand or gravel.

In the absence of such habitat on the Reservation, the killdeer has never been known to stop and all 37 recorded dates pertain to birds flying over, singly or in pairs or groups.

Movements.—The records are distributed throughout the year except for the months of December and January, but November 7, 1951, is the latest date in autumn. More than half the records (21) are for March. Earliest records in each of seven years, 1950 through 1956, were the 4th, 26th, 16th, 5th, 1st, 3rd, and 2nd of that month, but in 1957 one was heard on February 9 and in 1958 one was heard on February 26. Probably these numerous early spring records pertain to birds still on their northward migration, or at least still wandering in search of nesting territory. In 1958 precipitation was unusually heavy, and nesting occurred in a partly barren field on the Rockefeller Tract. Young were fledged. In 1951 also, several summer records were obtained (June 22, July 28, August 7, September 13). Most records of killdeers on the Reservation were obtained in rainy weather or soon afterward. Killdeers noted in spring and autumn were usually moving about erratically rather than holding to a direct course on migration. On October 10, 1951, at 10 A.M., five were seen in a group, flying south. On October 18, 1951, a group of 12 circled over a hilltop field.

Philohela minor (Gmelin)

American Woodcock

Status.—Rare migrant.

Habitat.—Wet places in or near deciduous forest.

Movements.—Several were recorded in the late summer of 1948, one on November 4, 1949, and one on August 30, 1951. In the unusually wet summer of 1958, woodcocks, probably a pair, were seen regularly along a 500-foot stretch of woodland edge, in a brushy, damp, upland area. Probably nesting occurred.

Capella gallinago (Linnaeus)

Wilson Snipe

Status.—Occasional migrant.

Habitat.—Wet meadows.

Movements.—On several occasions snipe have been seen on the Reservation, but my only definite record is for October 24, 1951.

Bartramia longicauda (Bechstein)

Upland Plover

Status.—Rare transient.

Habitat.—Prairie, especially of short-grass type, or where heavily grazed.

Movements.—On May 12, 1957, one was flushed from the blue-grass pasture on the Rockefeller Tract. It circled and lit in a newly cultivated field where it remained for more than an hour. When flushed again it flew back into the pasture. On the following day it was gone.

Actitis macularia (Linnaeus)

Spotted Sandpiper

Status.—Occasional transient.

Habitat.—Shorelines of streams.

Movements.—On May 2, 1949, one was seen at the edge of the pond.

Tringa solitaria Wilson

Solitary Sandpiper

Status.—Occasional transient.

Habitat.—Edge of water, in a variety of situations.

Movements.—On April 8, 1953, two were foraging along the edge of the pond, which then contained but little water. On July 14, 1952, one was foraging on mud at the pond edge, late in the afternoon.

Totanus flavipes (Gmelin)

Lesser Yellow-legs

Status.—Occasional transient.

Habitat.—Shorelines.

Movements.—The only definite records are of individuals stopping on northward migration in spring. On May 7, 1953, a group

of six were foraging, wading in shallow water at the edge of the pond in late afternoon. When flushed, they flew northeast. On April 25, 1956, one feeding at the edge of the pond was seen to catch a small frog (probably a cricket frog). When flushed, this bird returned within a few minutes, but after being disturbed a second time, it circled high over the area and left. On April 27, 1956, one that may have been the same was reported at the pond.

Larus pipixcan Wagler

Franklin Gull

Status.—Occasional transient.

Habitat.—Inland marshes and lakes.

Movements.—On May 2, 1951, late in the afternoon, four were seen flying high over the pond headed northeast.

Zenaidura macroura (Linnaeus)

Mourning Dove

Status.—Common summer resident; rarely seen in winter but flocks or lone birds, perhaps from more northern breeding populations, occasionally cross the area or stop on it briefly.

Habitat.—Most of the area is used by mourning doves for nesting, and nests have been found in a variety of situations. Two were on the mat of old dead grass in the bluestem prairie of the northwestern corner. Most others were in trees and shrubs. Parkland situations at the edge of the woods, and open glades with sumac patches on south slopes are favored situations for nesting and foraging. Doves were rarely seen in the denser oak-hickory woods of north slopes. The fallow fields with their abundant crops of weed seeds, provide a potential food source, which was much used in 1948 and 1949. Since 1949 these fields have been little used, because the accumulated dead vegetation makes foraging difficult for the doves.

Movements.—The flocks of mourning doves that are occasionally seen in Douglas County in winter tend to keep to cultivated land, and have rarely been seen on the Reservation. On mild days of early spring, doves appear abruptly and begin territorial calling. These probably are new arrivals that have spent the winter farther south. First recorded dates of territorial calling each year from 1950 through 1957 were: March 17, March 26, March 28, March

12, March 7, April 15, March 6 and March 2. Soon after arrival they begin to nest. Each year doves nested in the vicinity of the headquarters buildings, and on many other parts of the Reservation.

Males moving about and calling from territorial perches have been seen to use stations separated by as much as 700 feet. Others kept under observation for periods of hours, have stayed within an area 100 feet in greatest diameter. In the vicinity of the Reservation headquarters, distances between adjacent calling males in seven instances averaged 689 feet (1300 to 100). If this figure is representative of a territory's diameter, nesting territories averaging approximately eight acres are indicated.

Only rarely were doves seen to come to the ground to forage on the Reservation. On the contrary, those that bred on the area seemed to feed on other areas remote from their territories. Doves that nested near the Reservation headquarters were often seen travelling in strong and direct flight to the west for half a mile or more, to cultivated fields, or were seen returning from such flights, to nests, territorial perches or feeding of young.

A typical instance of territorial defense was recorded on April 20, 1954. A pair engaged in courtship in an elm tree beside the house. After a period of preening, three feet apart on a horizontal limb, they showed increasing awareness of each others' presence. One, presumably the female, postured with tail elevated and wings vibrating. The mate approached, and standing behind, pecked lightly at the other several times, then flew to another tree 50 feet south. The female followed. At this stage proceedings were interrupted when a second male began calling in another elm 100 feet farther south. He soon flew to telephone wires 150 feet west of the pair, and resumed calling. The male of the pair flew and perched on the wire beside him, and several times in succession lunged at him, causing him to fly a short distance. The intruding male moved to a nearby tree, and the female joined her mate on the wire. The pair followed the intruder, perching on the opposite side of the tree. After about ten minutes the unmated male, then the mated male, and finally the female flew to still another tree. Soon all three flushed again, travelling in rapid and erratic flight, the unmated bird closely pursued and harrassed by the mated male, while the female followed farther behind. The pursuit led for several hundred yards over a wooded north slope, and the outcome was not seen.

Nests were found each year from April through September. Few were successful, and most that I saw were destroyed by predators within a few days of their discovery. Often re-nesting, presumably by the same pair of doves, occurred promptly within a few yards of the site where a nest was destroyed. Individuals were not recognized.

Coccyzus americanus (Linnaeus)

Yellow-billed Cuckoo

Status.—Common summer resident.

Habitat.—Cuckoos utilize all types of woodland present on the area, but evidently prefer edge situations, where there are thickets. Nests often are situated in thorny trees or shrubs such as osage orange or honey locust. Territories may include extensive open areas, but these are crossed in rapid direct flight and most of the time cuckoos keep out of sight in dense foliage.

Movements.—Each year cuckoos have been first noted on the Reservation in May; the 15th (1950), 24th (1951), 17th (1952), 21st (1953), 3rd (1955), 12th (1956), and 9th (1957). Within a few days after recording of the earliest arrival, cuckoos are present in abundance and are establishing breeding territories. Nests have been found from May through September, but with a high proportion in the latter half of the summer, suggesting that more than one brood may be the rule. Most of the nests found were destroyed within a few days by predators, and some were blown down in storms. Because cuckoos tend to be silent after late August, and are somewhat secretive at all times, their departure in autumn usually passes unnoticed. On several occasions they have been recorded in the first week of October, but none has been seen later in the season.

Each year throughout the summer cuckoos were present in the headquarters area and were seen and heard daily. Territorial calling of each male tended to be concentrated in one or a few favorite perch trees. In July, 1955, a territory encompassing the grove of elms and other large trees in the headquarters area was approximately 250 feet in diameter and roughly circular.

As cuckoos tended to be secretive, keeping out of sight in dense foliage, their movements could not be readily traced. The spacing of calling males that answered each other provided some indication

of the size of areas occupied. In 17 such instances the interval averaged 615 feet (160 to 1000). On 13 other occasions linear distance covered was measured for individuals that were kept under observation for considerable periods, or that were seen to make relatively long direct flights. These distances averaged 323 feet (140 to 650), with more than half concentrated between 200 and 310 feet. A typical territory of a yellow-billed cuckoo might be approximately six acres.

On August 13, 1956, a cuckoo was watched while it was occupied with nest-building. It flew into a large elm in which one main limb was dead and devoid of foliage. It broke off a twig approximately five inches long, and carrying the twig crosswise in its bill, flew back to the nest tree. It paused, then made its way through thick foliage to the partly built nest situated in a horizontal crotch. As it passed through the thicker part of the tree, its movements were impeded by the transverse stick catching on twigs and leaves. In the next half hour it repeated the procedure time after time with but little variation. It always went to about the same spot on the dead branch, about 60 feet from the nest.

Brumwell (1951:220) at Fort Leavenworth, found the cottonwood-elm association along the Missouri River to be a favored nesting habitat. He observed several adults fly across the river and return with food for the young, making a round trip of approximately a mile.

Coccyzus erythrophthalmus (Wilson)

Black-billed Cuckoo

Status.—Occasional transient and summer resident.

Habitat.—Deciduous forest and edge. The relative rarity of this species on the area suggests that its ecological tolerances are narrower than those of the yellow-billed cuckoo, and perhaps it is limited to habitats providing better cover.

Movements.—On September 6, 1951, one that was flushed in thick woods of elm, locust and osage orange, on a south slope, was carrying a caterpillar in its bill. It uttered rabbit-like squalling sounds and was joined by a mate. After their excitement had subsided somewhat, they gave frog-like rolling notes at intervals of a few seconds. A nest was nearby, about 13 feet above the ground. Others were recorded on the Reservation on May 17 and 22, 1952, and on September 24, 1957.

Tyto alba (Scopoli)

Barn Owl

Status.—Occasional transient.

Habitat.—Typically, grassland with nesting sites such as are provided by caves, hollow trees, old buildings, mine shafts, or niches in gully cutbanks.

Movements.—On December 7, 1949, a pair was flushed from a dense thicket at the edge of an eroded, fallow upland field. After being flushed both owls flew down a ravine and were heckled by small birds. A few minutes later one of the owls flew over, about 100 feet high and it veered, suddenly spiralling downward to the same place from which it originally flushed. On December 1, 1951, one was flushed on a wooded slope 200 yards east of the Reservation headquarters. No other barn owls have been seen on the Reservation but occasionally at night their calls have been heard. On February 7, 1952, at about 9 P. M., one was heard calling and from these calls its flight could be traced along the narrow, flat, grassy hill-top that extends across the Reservation. Those living on nearby farmlands may occasionally wander on the Reservation in the course of their hunting. For the barn owl, habitat conditions on the Reservation have worsened since areas that were formerly grazed or were cultivated fields, have become covered with a dense stand of rank vegetation.

Otus asio (Linnaeus)

Screech Owl

Status.—Probably regular resident, but records were not obtained with sufficient regularity to indicate that area was occupied by permanent population.

Habitat.—Woodland and parkland.

Movements.—Twelve records in eight different months were obtained in 1951, all within a radius of 100 yards, and probably all pertaining to the same pair. Activity seemed to center on a wooded north slope and the ravine along its bottom, south of the Reservation headquarters. On March 17 one of the owls was found sleeping in the hollow trunk of an oak near the center of the area where calling had been heard. On several occasions two owls were heard calling and answering each other. Screech owls were heard also in 1950 (once), 1952 (once), 1954 (twice), 1955

(three times), 1956 (five times), and 1957 (once). All but two of these records were within the area encompassed by the 1951 records.

Bubo virginianus (Gmelin)

Horned Owl

Status.—Abundant (for a large raptor) resident, using nearly all parts of the Reservation.

Habitat.—By day usually seen in dense woods where roosts are located, but at night it is less restricted, ranging far and wide, through woodland, woodland edge, and open fields.

Roosts are usually in large trees such as elms, oaks or honey locusts, especially where thick branches or vine tangles provide concealment.

Movements.—Ordinarily horned owls are territorial. Each territory is occupied by a pair of adults. Territories are occupied throughout the year, and perhaps continuously for long periods of years. Most information concerning territories was obtained in the months of November, December, and January because the owls were especially vocal then. Their hooting would begin a few minutes before sunset and might continue sporadically throughout the night. However, the most concentrated vocalization occurred in a period of perhaps 15 to 20 minutes after sunset. The first owl to hoot would usually be answered, after it had called a few times, by its mate or by a rival on an adjacent territory. Soon still others would begin calling until as many as six pairs could be heard from one vantage point.

In late 1955, approximate centers were located for eight territories, six of which were on the Reservation, while the other two were near the boundary. For 13 instances of territories adjacent to each other, with continuously favorable habitat, the distances intervening between territorial centers ranged from 3070 to 1700 feet (average 2400). In 23 instances of owls answering each other from adjacent rival territories, the intervening distances ranged from 2360 to 686 feet (average 1360).

These figures represent conditions obtaining when the population was high. The number of territories on the Reservation varied somewhat from year to year. No figures are available for 1948 or 1949, but certainly the owls were moderately abundant in those years. In the winter of 1950-51, eight territories were represented

on the Reservation. Three of these were almost or entirely confined to the area, and each of the other five overlapped it extensively. In the winter of 1951-52, there were nine territories represented. In general, they corresponded with the territories of the previous year, but with some shifting of boundaries and centers of activity. The increase in numbers of owls on the area did not represent a higher population density. In 1952-53 only six territories were known to be represented on the area. In correlation with this decrease, the territories were exceptionally large. The best known territory, which was known over the six-year period, reached its greatest extent that winter; it was .6 mile long and .42 mile wide. Baumgartner (1939:280) recorded three or four male horned owls per square mile in favorable habitat south of Lawrence. On a five-square-mile area he recorded an average of two males per square mile.

Low population density of the owls was probably correlated with deficient rainfall and, more directly, with the low population of cottontails. In the summer of 1952 vegetation was relatively sparse because of drought. Having less food and cover than usual, cottontails did not increase normally in the breeding season. Only meager data concerning the numbers and distribution of owls were obtained in the winters of 1953-54 and 1954-55, but there were probably seven or eight territories in those years. In the winter of 1955-56 there were eight territories. Only one of these was entirely within the Reservation, but each of four others had more than half of its extent within the area.

On many occasions the presence of horned owls was revealed to the observer by the clamoring of crows, which heckled and pursued them on sight. Especially in winter, when the population of crows was high, and trees were bare, so that concealment was more difficult, crows spent many hours each day heckling the owls on the Reservation. An owl might be followed and harrassed for an hour or more at a time, and hundreds of crows might congregate. The owl might flush a dozen times or more before ridding itself of the crows. When it flew, excitement increased, as the crows pursued it. Harrassment by crows must be an important factor in the ecology of the horned owl in this region. On February 24, 1953, the course of an owl was recorded for about an hour that it was followed by crows. It flushed six times, with flights of 100 yards to a quarter mile, travelled a linear distance of .9 mile, and was finally left by the crows when it was a little more than .6 mile south of the starting place.

From time to time small accumulations of pellets were found where horned owls had roosted during the day. Such accumulations rarely consisted of more than a dozen pellets, and it was obvious that the owls of each pair changed roosts frequently. Nevertheless certain favored trees were returned to repeatedly and had new accumulations of pellets on many occasions over periods of years. The roosting area is only a small part of the territory, generally 100 yards or less in diameter. The members of a pair have never, in my experience, been flushed from the same tree, but are usually in nearby trees where each may be seen by the other. Upon leaving the roost at dusk an owl may fly to a distant part of its territory, followed by its mate. After dark the owls may move away from the woodland into relatively open situations, perching on fence posts, snags or isolated trees that command a view of the surroundings. Many of the owl kills found have been in fields or pastures, sometimes hundreds of feet from the edge of the woods.

In 1950 a nest was observed from time to time throughout incubation, and subsequent development of the young owls. Both young were banded. The nest was in a honey locust in a hilltop field. After the young had left the nest, they were found perched close together in the edge of the woods about 100 yards from the nest and about 15 feet above the ground. In subsequent weeks these young were seen frequently. At first they stayed within a small area and tended to stay close together. Gradually they shifted in roosting from the southern to the northern part of the territory and even beyond it, and they were no longer found together. Through the spring and early summer these young presumably were still being fed by the adults as their hunger calls were heard often at night, but the adults were never with them when they were flushed in the daytime. Five years later one of these banded young was shot by a farmer at Tonganoxie, some five miles from its parents' territory.

Strix varia Barton

Barred Owl

Status.—Resident; one pair believed to have been in continuous tenure of territory from 1949 through 1957, and others have been present on various parts of Reservation from time to time.

Habitat.—Deciduous forest.

The relatively small portion of the Reservation where a pair of these owls stayed, differed from other woodland areas in more nearly approximating the Oak-Hickory climax, as it had many large, mature trees, with a high proportion of red oak, chestnut oak, black

oak and shagbark hickory. The numerous hollow trees provided nesting sites and perhaps daytime roosts for the owls. This was at the head of a small valley, where two deep ravines joined, near wooded slopes, and a brushy bottomland. In other woodland and field-edge situations where barred owls were seen from time to time, they did not remain for long.

Movements.—The pair of owls that lived near the eastern edge of the Reservation were rarely seen but were heard hooting on numerous occasions, on overcast afternoons or at dusk. My imitation of their calls often caused them to begin hooting. They were almost always heard when the territory was visited after dark.

Most of their hooting was heard within an area estimated to be only 200 yards in diameter. However, these records mostly pertain to daytime or dusk, while the owls were on or near their diurnal roosts, and therefore are not adequately representative of the entire territory. The more dispersed records indicate a territory of approximately a quarter-mile in diameter.

When these owls were caused to hoot, by an imitation of their calls, the response of the first individual was usually followed within a few seconds by that of its mate. The calls of the two individuals came from different points, but within the same general area, evidence that they normally roosted in separate trees. Sometimes the calling was taken up by other barred owls in woods east of the Reservation boundary, at a distance in the neighborhood of half a mile from the resident pair.

More detailed information concerning movements was obtained in the vicinity of the Reservation headquarters, where a barred owl—probably the same individual—occurred over periods of months, alone at first, and later accompanied by a mate. Early records of it were obtained on October 12 and 17, 1950, and on March 5, May 26, and November 13, 1951. This owl may have had a territory farther north and east; if so it only occasionally ranged into the area. However, it was seen more frequently in the autumn and early winter of late 1952. Subsequently, in January, 1953, it seemed to have shifted so that its territory centered near the Reservation headquarters. Thenceforth, throughout 1953, it was recorded many times each month. From mid-May to mid-October it was accompanied by a mate.

In winter, its activity was largely diurnal. On many occasions it was seen hunting, and sometimes was kept under observation for periods of hours. Voles seemed to be the chief food source, and

in winter their activity likewise tended to be limited to the daylight hours. In hunting, the owl did not stay in the woods, but chose trees in meadows or that bordered on them. Flushing distance was usually 150 to 200 feet but sometimes the owl permitted approach to within 60 feet. When not disturbed, the hunting owl usually remained on its perch from a few seconds up to fifteen minutes. While on such a perch, it was alertly scanning its surroundings with almost continual, short, quick movements of its head. From time to time it would fly down into the grass in pursuit of prey, and sometimes would remain as much as a minute. Often it flew up with no evidence of a catch even after it had been on the ground for as much as half a minute. It was seen to fly distances

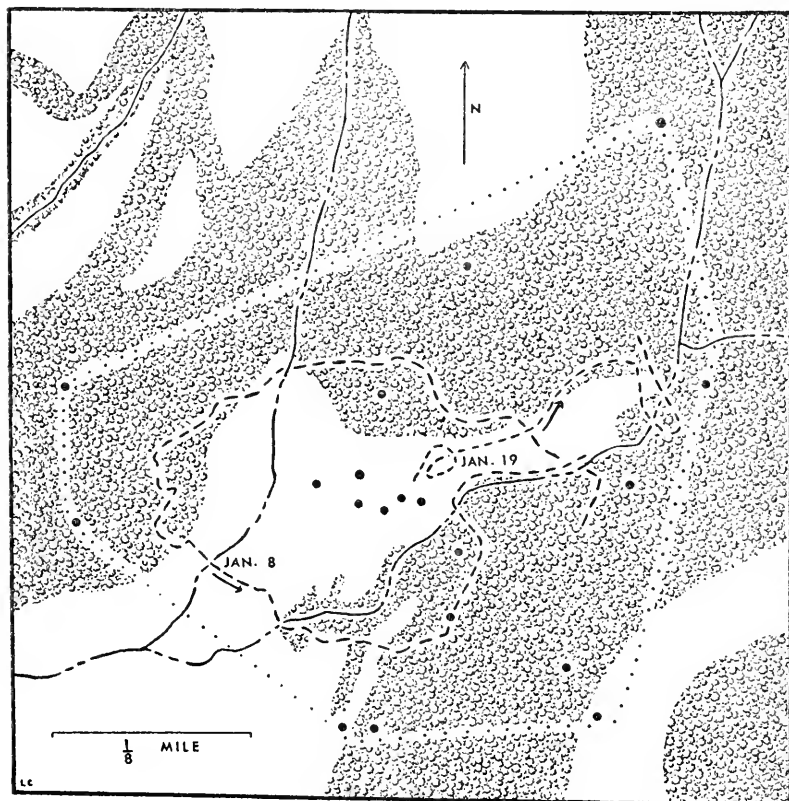


FIG. 15. Northwestern quarter of the Reservation showing territory of a pair of barred owls in 1953. Dots show locations where owls were heard hooting. Broken lines show course of an owl that was followed as it hunted in daylight on January 8 and 19. The circuit shown for January 8 was followed three times in succession, with minor variations.

as much as 100 feet to strike at prey, but usually the flight to the ground was shorter. In moving from one perch to another it sometimes flew only a few feet, rarely as much as 100 yards. The flight seemed remarkably slow. On the different occasions when it was followed, it covered more or less the same area, and returned to many of the same perch trees, although not using them in any definite sequence. The area that it covered was of irregular outline, approximately 1900 feet long and 1200 feet wide. Its diurnal activity in winter was largely between dawn and 10:30 A. M. It was occasionally seen in bright sunlight, but seemed to prefer overcast days. On numerous occasions it was found later in the day, inactive on a roost. It had no special roosting place, but was usually in some large tree with dense foliage, near the central part of the territory.

After this owl obtained a mate, hooting was heard much more frequently. Often the owls began hooting late in the afternoon, answering each other while still on their roosts. They were usually near together, but over periods of weeks their roosting areas shifted until almost every part of the territory had been utilized for this purpose. In fact the area encompassed by their perches was considerably greater than that otherwise known for them; it was bounded by seven marginal points, and was measured as 75 acres. The territory of these owls was separated by at least half a mile from that of their nearest neighbors, the pair already discussed, that occupied an area near the eastern edge of the Reservation. Obviously territorial pressure was not a factor limiting the size of either territory.

Asio otus (Linnaeus)

Long-eared Owl

Status.—Frequent winter resident; occasional in summer.

Habitat.—For roosting this owl prefers dense thickets, and locally most often uses clumps of red cedar which offer better protection than bare deciduous trees. On the Reservation no large cedar trees are present, and the owls have usually been found roosting in thickets of osage orange, honey locust, or chinquapin oak. In their nocturnal foraging, on the Reservation at least, these owls most often seem to hunt over grassland, as analysis of pellets has shown the prey to consist largely of prairie voles, cotton rats, and harvest mice.

Movements.—On October 11, 1950, two were found in a thicket of chinquapin oak at a hilltop edge. They flew about 100 feet and lit in another thicket. On December 7, 1951, one was flushed from a hilltop rock outcrop. On January 8, 1952, a group of three were flushed from an osage orange tree on a wooded south slope. On March 10, 1952, about 200 feet north of this spot, a group of at least a dozen was flushed from within a 20-foot radius in a thicket of chinquapin oak. Ground beneath the thicket was littered with pellets and their fragments, some of which appeared to be many weeks old. Later in the day the owls were located again, mostly together in an osage orange tree about 100 yards south of their regular roost. At my approach they flushed one by one and headed back in the direction of their former roost. White-footed mice and other prey that might have been secured in the forest made up but a small percentage of the items in the pellets that were examined; voles and cotton rats that must have been obtained in open fields, made up the bulk of the diet.

On January 22, 1954, one was flushed from a roost among projecting roots in the cut-bank of a gully. On February 2, 1954, strewn feathers of one were found in the middle of a hilltop field, and it seemed the owl had been attacked and eaten by another predator. On March 23 and 26, 1954, a pair was seen near the same place in a thicket on a brushy south slope.

On a December evening when it was nearly dark, a flock was observed hunting over a hilltop field. They paid little attention to my presence, but were wheeling and circling in a fairly compact group within a few yards of the ground.

On April 19, 1951, a quarter mile southeast of the Reservation, one was found incubating in a nest 20 feet up in a honey locust. The only summer record from the Reservation is of one seen on August 10, 1951.

Aegolius acadicus (Gmelin)

Saw-whet Owl

Status.—Rare transient in winter.

Habitat.—Breeds in northern coniferous forests but moves south in winter and may appear in variety of habitats.

Movements.—Only two have been definitely recorded from the Reservation. In December, 1948, one was seen on a wooded hilltop. It was tame at first, but became more wary and flew farther

at each attempt to stalk it, until it was lost. One perched ten feet above the ground in an osage orange tree on February 11, 1951, at 1 P. M. was in the act of swallowing a white-footed mouse. It permitted approach to within fifteen feet. Twice when it was flushed, it moved only a few yards before settling on another low perch, but it continued to watch my movements alertly.

Caprimulgus carolinensis Gmelin

Chuck-will's-widow

Status.—Irregular summer resident.

Habitat.—Woodland.

On the Reservation activity was concentrated on areas of south slopes with medium to small trees and dense thorny undergrowth, a type of woodland distinctly more xeric than that preferred by the whip-poor-will.

Movements.—The first definite record was obtained on May 11, 1953, when one was heard calling on the slope north of the headquarters. All other records were obtained in 1956 and in 1957, when the species was present throughout the late spring and early summer and was heard almost nightly. One calling on April 27, 1956, was answered regularly by a whip-poor-will in the same general area. In subsequent weeks whip-poor-wills were heard less regularly than they had been in other summers and perhaps were, in part, displaced by the chuck-will's-widows. On May 17 one of the latter began calling at 7:36 P. M., and soon a second began answering nearby. I approached to within 200 feet and heard a peculiar low growling sound, then saw one in close pursuit of the other in an erratic flight through the trees. They settled and resumed calling only about 50 feet apart and a third was calling on a hillside 150 yards away. Another pursuit, accompanied by the same peculiar growling sounds, was noted on June 6, as one chased a rival from one woodland edge to another, across intervening fields, a distance of some 320 yards. The pursuer quickly returned, and both chuck-will's-widows called, answering each other.

A chuck-will's-widow engaged in territorial calling as it shifted from perch to perch, moved, on the average, approximately 430 feet (640 to 240) at each shift. A supposed territory mapped on the basis of 16 stations covered 23.7 acres, but there is some doubt as to whether all the records pertained to the same individual.

An unusually late fall record of a goatsucker that appeared to be of this species was obtained on December 6, 1953, when the bird

was flushed at close range, from the ground or a low branch. It flew about erratically and lit in a large tree but could not be re-located. Temperature was slightly above 50° F. at the time it was seen, but light snow had fallen on the preceding night.

Caprimulgus vociferus Wilson

Whip-poor-will

Status.—Common summer resident, using most parts of Reservation, but chiefly confined to woodland and vicinity of woodland edge.

Habitat.—Woodland, especially that of more mesic types where there are oaks, hickories, and elms.

Whip-poor-wills flushed from their daytime roosts were in dense woods where the leaf litter was thick, and where there was underbrush such as dogwood and gooseberry. Calling males at night were frequently noted in edge or parkland situations.

Movements.—Whip-poor-wills arrived in April each year; from 1950 through 1956, earliest records were the 6th, 24th, 24th, 22nd, 10th, 17th and 20th. Late records include: October 11, 1949; October 1, 1950; September 23, 1951; September 16, 1952; September 8, 1953; September 20, 1954 and September 20, 1955. Throughout May, June and July territorial calling is persistent, beginning at dusk and continuing intermittently until daybreak. This "song," the familiar "whip-poor-will" call, serves to maintain spacing between pairs on adjoining territories. Open spots are chosen for calling. The roofs of the house and laboratory buildings and top of the chimney were especially favored, as were the top of the dike at a dam, and the bare shaly bank of a ditch. In other instances the birds perched on horizontal branches of large dead trees while they were calling. On several occasions when a whip-poor-will was calling, I attempted an imitation. If the whip-poor-will was nearby, this imitation usually caused a strong reaction. The bird might hover erratically, coming within a few yards of me and on one occasion, one lit on the ground only 15 feet away, giving a peculiar purring sound. This same sound has been heard while one individual was chasing another, and immediately afterward. Exceptionally favorable sites for territorial calling may be used by different individuals at different times, neither of the two (or more?) being able to establish absolute control.

In 24 instances the distance between whip-poor-wills that were calling and answering each other, ranged from 1600 feet to 370 feet,

averaging 890. If this distance represents the diameter of a typical territory, the actual size amounts to some 22.6 acres. Territories actually measured insofar as they were known, covered 14.9 acres (18 stations, 4 marginal), 27.5 acres (28 stations, 6 marginal), and 6.9 acres (13 stations, 6 marginal).

On June 10, 1955, a whip-poor-will flushed from leaf litter in oak-hickory woods on a northwest slope feigned injury. On the following day it was flushed again, and the two eggs were found at the spot where it had been sitting. On June 17, the bird was flushed again, and the eggs were approximately twenty feet from the spot where they had been before. On June 21, when the nest was revisited, the parent flushed from a spot ten feet away. The eggs were at the same spot where they had been on June 17, and the parent may have crept away from them before making herself conspicuous. Again she feigned injury, jumping and flopping, moving a foot or two at a time until the sixth leap when she flew several yards, and at the next start she flew out of sight, but soon reappeared, approaching the nest from another direction.

Bent (1940:149) mentions instances of the closely related chuck-will's-widow moving its eggs after disturbance of the nest, and quotes Audubon as stating that the eggs are carried in the mouth. Bent (*op. cit.*:175) also cites instances of female whip-poor-wills flushed from the nest carrying nestlings for short distances grasped between her legs.

Chordeiles minor (Forster)

Nighthawk

Status.—Regular summer visitant; no evidence of nesting on the area has as yet been obtained.

Habitat.—The prey consists of flying insects, and where these are numerous the nighthawk may be present, in any of a variety of terrestrial habitats. The limiting factors are thus not so readily definable in terms of plant associations or physiography as in most other kinds of birds.

Movements.—Earliest records for the Reservation are May 18, 1952, May 22, 1954, and May 15, 1955. Latest records are September 21, 1948, September 20, 1953, September 20, 1954, and September 11, 1955. On September 18, 1954, soon after sunset, a group of more than a dozen, flying erratically on separate courses, passed over the field where the headquarters are located, and gradually moved away to the southwest until they were out of sight. Ap-

proximately a quarter hour later, a similar flight occurred, perhaps of the same individuals. In 1952 nighthawks were often seen foraging over the Reservation in late afternoon, and several times were flushed from woodland in the daytime. In later years, while drought conditions prevailed, they were rarely seen on the area between May and September. Foraging nighthawks that were flying over the area covered ranges much larger than those of other birds of comparable size. Their ranges seemed to be more than half a mile in diameter, and, although some tendency was noticed for an individual to make the same circuit several times in succession, they were not present consistently over periods of days or weeks suggesting that they wandered extensively, or that the areas they were seen to cover comprised only small parts of their total ranges.

Chaetura pelagica (Linnaeus)

Chimney Swift

Status.—Usually present in summer but not known to breed; those that appear from time to time evidently have large foraging ranges that include parts of the Reservation, or possibly all of it.

Habitat.—Aerial maneuvers of the individuals that are seen on the Reservation have little or no relation to the terrain or plant associations beneath. The chimney of the residence was an obvious focal point of activity, though the swifts were never seen to enter or emerge.

Movements.—Over the eight-year period, 1950 through 1957, chimney swifts were first recorded on the Reservation on the following dates: May 20, May 18, May 23, May 24, May 8, May 17, April 28 and April 24. In several years they were noted somewhat earlier within the Lawrence city limits than they were at the Reservation: May 8, 1953, May 5, 1954, and May 1, 1955. Most records for the Reservation are for late April, May, June, and July (latest September 24, 1957). Swifts may have nested in the chimney at the Reservation headquarters. At least, this chimney was the focal point about which their maneuvers centered. Maneuvering was seen chiefly near dusk and on overcast days. On June 24, 1952, two pairs were flying in the headquarters area. Those of each pair kept close together in their rapid flight, but seemed to pay no attention to the other pair. They were flying to distances of hundreds of yards in each direction from the chimney, about which their maneuvers centered. On May 25, 1953, two

seemed to be chasing a third, while a fourth was flying alone. On many other occasions, especially in early June, 1953, and in June, 1955, three were flying together in a group. On June 9, 1953, there were two such groups. On May 8, 1954, the first time that swifts were seen that spring, a pair was moving in rapid flight about the chimney, in circles about 200 feet in diameter, from time to time descending to the chimney in tight spirals, but not entering it. On May 17, 1955, the first swifts noted that season were heard chattering and then a moment later, were heard fluttering inside the chimney.

Archilochus colubris (Linnaeus)

Ruby-throated Hummingbird

Status.—Uncommon summer visitant or transient.

Habitat.—Less limited to specific plant associations and habitat situations than most other species of birds occurring locally. The limiting factor in most instances is an abundance of suitable flowers providing nectar. Hummingbirds shift their foraging areas frequently according to the availability of the food supply at different stages in the season. Germander (*Teucrium canadense*) is a favorite source of nectar. This mint grew in dense patches in some parts of the former pastures for several years after grazing was discontinued. It decreased in abundance and was replaced by grasses.

Movements.—Hummingbirds were generally seen only at times and places where there were abundant supplies of flowers, and may not have nested on the Reservation. Redbud and germander were two of the favorite kinds of blossoms. A hummingbird seen on May 18, 1952, was feeding from dandelion flowers. After 1953, as succession progressed, with germander and other kinds of flowering plants being replaced by grasses, hummingbirds became much scarcer on the Reservation.

Megaceryle alcyon (Linnaeus)

Belted Kingfisher

Status.—Occasional transient.

Habitat.—Vicinity of ponds and streams, requiring vertical cut-banks for excavation of nest burrows.

Movements.—Kingfishers, either lone individuals or pairs, appeared from time to time at the pond on the Reservation. In each instance probably the birds were migrants, which happened to notice the pond in flying over, and stopped there temporarily. Fish

were not present, and amphibians comprised the chief sources of food. Specific dates that kingfishers were seen at the pond were: July 8, 1950; April 7, 1951; May 19, 1951 (pair); February 17, 1952 (may have been one of a pair seen frequently along a slough two miles south of the Reservation); April 16, 23, and 24, 1952; May 28, 1952; April 5, 13, and 29, 1953; March 31, 1955; April 22, 1955; June 21, 1955; April 8, 1956, and May 3 and 4, September 18, and October 4, 1957.

Upon leaving the pond kingfishers sometimes flew in a low direct course as if headed for a predetermined goal. At other times they circled over the area, gradually rising until almost out of sight.

Colaptes auratus (Linnaeus)

Yellow-shafted Flicker

Status.—Common winter resident and migrant.

Habitat.—Woodland, but preferably where alternating with open situations such as grassy pastures.

Every part of the Reservation was utilized by flickers, but with temporary concentration on certain habitats, depending on the season, the weather, and availability of food sources.

Movements.—Flickers have not been recorded on the area from about mid-April to mid-September; generally they are absent in late spring and summer. The area is within the breeding range, and failure of the species to remain through the summer may result from the lack of suitably open situations where flickers might forage on the ground. Because the area is not grazed, or otherwise disturbed, the parts that were formerly open have grown up to thickets of young trees and shrubs, rank weeds, or tall grass.

First recorded appearances of flickers in fall of several different years were: September 28, 1948; September 13, 1951; September 12, 1952; September 19, 1953; September 17, 1954; October 5, 1955; September 21, 1956, and September 18, 1957. In late September and early October numbers on the area were rapidly augmented by new arrivals, and by late October flickers were among the most conspicuous birds of the Reservation. However, unlike most other wintering birds on the Reservation, individual flickers did not seem to become attached to specific areas for more than a few days at a time but were roving about with constant fluctuations in the numbers present.

On October 5, 1953, after one of the first cold nights of the season, many flickers were foraging on the ground near the house in com-

pany with red-bellied woodpeckers and robins, finding grasshoppers and other insects that were immobilized by the cold and were easily obtained in the short vegetation. By 8:30 A. M., this group had dispersed. In autumn, foraging is to a large extent arboreal, and wild fruits such as those of grape and poison ivy are major food sources. In winter relatively few remain, but from time to time there is an influx of migrants. At times when the ground was covered with snow and ice, flickers often concentrated their foraging on the cut-banks of gullies, digging in the loose soil for insects. On warm days after heavy snowfall, weedy fields were favorite places for foraging. There, the snow melted rapidly, being held off the ground by the mat of dead vegetation, and the flickers were able to find areas of exposed soil for digging.

Centurus carolinus (Linnaeus)

Red-bellied Woodpecker

Status.—Common resident; no seasonal shifts are apparent.

Habitat.—Woodland, with perhaps some preference for oak-hickory type.

The main requirement seems to be the presence of large old trees with numerous dead limbs and cavities. It matters little whether the tree happens to be cottonwood, elm, oak, or honey locust. The woodpeckers have been observed to utilize each of these kinds as the headquarters of a family group or an individual. Such groups or individuals are usually well scattered, with intervening woodland, often hundreds of yards in extent, that is little used or entirely unoccupied.

Movements.—Red-bellied woodpeckers were observed to be notably sedentary. Large old trees, including elms, oaks, cottonwoods and honey locusts, were favorite foraging places, and an individual might spend a disproportionately large part of its time in one or several of these trees. At all times of year woodpeckers of this species are somewhat social, and two or more may be observed in the same tree. However, the bond between members of a pair in winter is weak if it exists at all. At that time each individual seems to be largely independent although it may at times associate with another, or even with woodpeckers of different species. In this respect the species differs from the hairy woodpecker, in which a strong bond between members of a pair exists, even at times of year other than the breeding season.

Each year, in warm clear days of early spring, males gave territorial calls from high snags. First records of such territorial calling, for several different years, were: March 24, 1951; March 28, 1952; March 13, 1953; February 1, 1954 (subsequently calling was heard often through February); March 11, 1955; March 30, 1956; February 16, 1957; and February 22, 1958. Often two males on snags hundreds of feet apart would answer each other regularly with the "churring" territorial calls. Also, territorial quarrels were frequent, and were notable for the persistence with which the intruder remained within the territory of his opponent or returned to it. A typical encounter between two males was observed on February 8, 1954, in a large honey locust in the edge of the woods, between the headquarters and the pond. The two males, clinging upright on opposite sides of a vertical branch, would engage in rapid sparring, uttering loud rolling calls every few seconds and also low grinding sounds. One would fly northeast 100 yards or more, chased by the other. In a few seconds the pursuer would return and perch on top of the snag, giving long rolling calls, but soon the second would return and renew the contest. While quarreling, the males drummed from time to time. A female, probably the mate of the defender, was also present in the tree, but she remained aloof and passive. A fourth woodpecker, possibly the mate of the intruder, was calling occasionally near the pond.

On many other occasions similar performances were observed. Probably they involved former co-occupants of a small area of favorable habitat, who became increasingly intolerant of each other and finally excluded each other from their territories as the breeding season approached.

Quarreling red-bellied woodpeckers strutted, bowed, postured and sparred, often moving about from tree to tree; the one that flew was immediately followed by the other. A quarrel might continue intermittently for hours, and might be resumed on successive days.

In their foraging, red-bellied woodpeckers seem to have an affinity for other kinds including hairy and downy, and often are observed in the same tree with one or both of the two last named. The abundant supply of insects probably attracts all three species, but also there seems to be a tendency for such a group to maintain itself in shifts from one tree to another. However, the nesting snags are jealously guarded against other woodpeckers, and against other kinds of birds that use cavities. In autumn the influx of flickers

caused much uneasiness among the red-bellied woodpeckers that lived near the Reservation headquarters. The larger and more aggressive flickers moving in numbers through and near the favorite trees of the red-bellied woodpeckers, caused the latter to scold and to make frequent short, restless movements. The red-bellied woodpeckers seemed to be incompatible with the red-headed woodpeckers, as the former were hardly ever seen or heard in an area at the east edge of the Reservation occupied by a colony of the latter, and from time to time when red-headed woodpeckers temporarily settled in the area near the Reservation headquarters, there was much quarreling. On April 2, 1956, a quarrel between a pair of red-bellied woodpeckers and a male starling was observed in a willow snag having a cavity offering a potential nest site for both species. The starling was the most aggressive. It would dart first at one woodpecker and then at the other, but it did not succeed in driving them from the tree. After ten minutes of continuous quarreling it gave up and flew out of sight headed northwest.

One woodpecker that was color-banded and recorded from time to time over a period of a year, used an area of 20.6 acres measured within the five marginal points. Most of the recorded movements and locations were near the headquarters and the pond, but a single record at a place 900 feet north of the pond greatly increased the total area involved. Certainly the entire 20.6 acre area was not used regularly. In 1955 the nest was in a sycamore snag southwest of the pond. In finding food for the nestlings the adult regularly made trips to places 550 feet southwest, 375 feet north, and 200 feet east of the nest.

In May, 1956, a nest was located in a willow snag beside a gully in a relatively open situation. The adults were often observed flying to and from the nest on foraging expeditions. Because the nest was away from woodland, the foraging expeditions probably were to greater distances than are typical for the species. The adults made expeditions in all directions from the nest, visiting not only the woodland but isolated trees and groves. The main line of flight was north northeast and south southwest, to an extreme distance of 520 feet in the one direction and 820 feet in the other. The area encompassed by all the observed foraging flights was measured as 17.3 acres. This total area, however, included several major portions that were not even crossed by the woodpeckers, and their movements were almost entirely confined to an area of irregular outline measured as nine acres.

A woodpecker that was actively foraging, with frequent shifts from tree to tree, was followed for several hours on December 7, 1953. The hexagonal figure outlining its route was 9.6 acres, and this probably represents the greater part of its home range at that particular time. For one banded, and recorded several times in November and December, 1953, a pentagonal range of twelve acres was recorded. Much of this area consisted of an open field, which was merely crossed by the woodpecker, staying mainly in the woods along its borders on each side. A triangular area of wooded slope within which another was noted repeatedly was 5.4 acres. This probably was only a part of the actual home range.

Occasionally red-bellied woodpeckers were seen making long direct flights, which were almost certainly beyond the limits of the usual home range or territory. On September 15, 1953, one was seen flying high, from a hilltop ("Sugarloaf") in the northwestern part of the Reservation, across an intervening open valley to another hilltop nearly half a mile farther south, a total distance estimated as 2400 feet, although the exact spots where the flight began and ended were not seen. On December 27, 1953, one that was moving about from tree to tree frequently as it foraged was followed over an area 1350 feet across.

Territories between ten and twenty acres in extent are probably most typical of the species on the Reservation and in similar habitat. The same general area is occupied by an individual throughout the year, but with some shifting, occasioned chiefly by the mutual exclusiveness of pairs in the nesting season.

Melanerpes erythrocephalus (Linnaeus)

Red-headed Woodpecker

Status.—Moderately common resident, but localized to small area of woodland along eastern edge of Reservation.

Habitat.—Chiefly forest.

On the Reservation the one colony present from 1952 through 1956 was closely confined to an area of red oak woodland, the part of the area most closely approximating a climax deciduous forest.

Movements.—Red-headed woodpeckers were occasionally seen far from their usual habitat. These were wandering individuals. Some were travelling, but others remained for hours before moving on. It was not determined whether these wanderers had migrated for long distances or were from nearby colonies. They were seen

chiefly in late spring and early autumn, having dispersed just before and just after the nesting season. By months, they were distributed as follows: May—5, June—1, August—2, September—5, October—2. Some of those seen in September and October were in juvenal plumage. From September 10 to 19, 1955, a small group settled in the grove just northeast of the Reservation headquarters. During the time that they stayed most of their activity was confined to several large elms within a hundred-foot radius, entirely within the territory of a pair of red-bellied woodpeckers. There was almost constant quarreling between the two kinds. Scolding and pursuit by the red-bellied woodpeckers may have been the motivation for the red-headed woodpeckers to leave.

In 1956 there was a similar invasion at the same place in the last week of August. On the morning of August 31 at least six were present, and one or more had been heard in the vicinity for several days previously. This group remained until September 6, then disappeared abruptly, but in 1957 another group was present in the same place over the period September 4, 5 and 6.

The colony often observed on the eastern edge of the Reservation covered an area of more than 50 acres including almost level, creek-bottom land with exceptionally large, old trees, and the adjacent slope with oak woodland. More than a dozen of the woodpeckers inhabited this area, but no territoriality was discernible; they seemed to move about more or less at random, over the entire area, usually wandering singly or in small groups, each individual tending to keep within sight or sound of others.

Sphyrapicus varius (Linnaeus)

Yellow-bellied Sapsucker

Status.—Rare transient.

Habitat.—Woodland.

Movements.—On September 30, 1952, at 8 A. M., one in juvenal plumage was working on an elm at the Reservation headquarters. Another, also in immature plumage, was seen in oak woods on the Rockefeller Tract on April 9, 1957.

Dendrocopos villosus (Linnaeus)

Hairy Woodpecker

Status.—Permanent resident, with population of several pairs.

Habitat.—Woodland, especially where there are large mature trees, oaks, hickories, elms and locusts.

It is rarely seen in parts of the woodland where the trees are sparse or scrubby, nor in isolated trees growing in the open. Occasionally seen crossing broad, open fields, in high, direct flight.

Movements.—Hairy woodpeckers were especially noteworthy for the year-round association of pairs in permanent territories. All individuals on the area were shy (a flushing distance of approximately 150 feet was typical) and none was individually marked. Therefore, individual recognition ordinarily was uncertain, but pairs were followed from time to time and were seen in the same places with such regularity that identity could be guessed with some assurance.

On December 10, 1953, a territorial encounter between two males was seen. Soon after one flew into a large elm, another came from the opposite direction and perched nearby. They challenged each other, bowing and scolding. One lunged at the other and when it flushed he followed in close pursuit. The chase led in a circular course, with two complete circuits approximately 200 yards in diameter. Two days later a male which probably was one of those involved in the chase, was followed as he moved about from tree to tree, and the area covered corresponded roughly with that over which the chase extended.

In late 1953 and early 1954, two pairs were often observed separately, and occasionally in contact, in the area about the headquarters. The woodland encompassed by the records of one pair comprised approximately 37 acres. The second pair occupied an adjoining territory consisting of two separate blocks of woodland totalling approximately 22 acres, but with an intervening area of open field that was almost as large. On several occasions these woodpeckers were seen to make high, direct flights from one hillside to another one thousand feet or more away, crossing the open field intervening. In these and shorter flights, the bird that flew first (most often the female in observed instances) called as it launched into flight, and the mate followed within a few seconds. They were never seen to fly close together, but always made their moves to new areas well spaced in tandem fashion. In their foraging they tended to keep in separate trees, often as much as 100 feet apart, but obviously aware of each other's whereabouts through the sound of pecking and the occasional sharp squeaking calls.

Hairy woodpeckers were often noticed foraging in close association with other kinds of woodpeckers, especially the downy and less frequently the red-bellied. Such associations often were maintained when the birds were shifting from one tree to another, suggesting

that actual sociability, rather than mere attraction to a common food supply was involved. However, at other times hairy woodpeckers have been seen to display varying degrees of intolerance (scolding, threat, and actual pursuit) toward both these other species. The reason for such intolerance is not understood. It does not seem to be seasonal, and has been noted at times of year other than the breeding season. Perhaps intolerance involves unfamiliar individuals, while those that are met regularly are accepted as co-occupants of the territory.

A roost in a hollow elm at the gully just south of the Reservation headquarters was used regularly from 1952 to 1957, probably by the same individual. Each evening near sunset this female hairy woodpecker came to trees near the roost, usually making a flight of hundreds of yards, from a remote feeding area. She was remarkably circumspect in approaching the roost, and sometimes spent as much as an hour in the process, maneuvering and calling in the vicinity.

In May, 1955, a nest with young was discovered fifteen feet high in a live honey locust, in thick woods on a north slope. The parents were not observed to forage near this nest, but upon leaving it they usually made flights of hundreds of yards to other hillsides.

Dendrocopos pubescens (Linnaeus)

Downy Woodpecker

Status.—Abundant resident.

Habitat.—Found in all situations where there are trees or large shrubs.

It is numerous in all parts of the woodland, using every species of tree on the area; perhaps even more abundant in parkland where trees are scattered. This small woodpecker does part of its foraging on annual weeds, notably the giant ragweed.

Movements.—In the breeding season each pair keeps to its own small territory, excluding those of other pairs. As these woodpeckers are sedentary in habits, they tend to remain year-round in the same general area. Occasionally there is some displacement. Especially after severe winter storms individuals have been seen foraging in roadside weeds and in other situations removed from their usual woodland habitat. Pairs may continue their association throughout the winter. In February, 1952, a male was color-banded near the Reservation headquarters and was seen frequently in a

period of weeks thereafter, usually associated with a female. All records for this male were within a quadrangular area of 31.5 acres, with most remote locations separated by 2180 feet. Most of the records were concentrated in an oval inner area of only 4.6 acres. Downy woodpeckers were perhaps especially in evidence in 1952 and 1953, when elms were dying off as a result of the combined effects of drought and attack by bark beetles (*Scolytus multi-striatus*). These minute but numerous beetles produced an ample food supply, and the woodpeckers concentrated their attention on heavily infested trees. About the bases of such trees, chips of bark accumulated to depths of several inches. The same tree even though small, might be returned to day after day.

Often in winter, a downy woodpecker or a pair were found in association with mixed flocks of small passerines, usually including black-capped chickadees and tufted titmice, and sometimes including other kinds, such as brown creepers, and golden-crowned kinglets. When such mixed flocks were kept under observation, they were soon noted to undergo at least partial disintegration. The woodpeckers, especially, were liable to be left behind because they moved about less rapidly than the other kinds in foraging.

In a pair that is moving about, each keeps the other informed of its whereabouts by an occasional sharp metallic call. In winter, frequently, a pair has been observed to attack or chase a third individual or a second pair. This does not involve a defense of hard-and-fast territorial boundaries, but is indicative of intolerance for other individuals foraging in the neighborhood of a favored feeding place or of the mate.

Although such hostility is noticeable at all times of year, it is especially prominent in early spring. In mid-April, 1954, a dead snag, having several hollows, at the edge of the woods near the headquarters, was the scene of constant quarreling. Sometimes as many as six downy woodpeckers (presumably those of three different pairs) were in the vicinity simultaneously. Though both sexes participated in the quarrels, males were especially pugnacious. Two would fly from tree trunk to tree trunk, uttering whinneying calls, and perched on opposite sides of a trunk, would thrust at each other with their bills. Territorial drumming was heard as early as the first week of February but chiefly in late March and early April.

Tyrannus tyrannus (Linnaeus)

Eastern Kingbird

Status.—Often present in summer, but not known to breed on the Reservation. Those that appear from time to time are wanderers that have not yet established territories or have left them after the breeding season. Usually they do not remain for more than a few hours in any one place.

Habitat.—Prefers relatively open ground with high perches, for foraging.

On the Reservation, in the absence of grazing, the dense grass or herbaceous ground cover evidently renders habitat conditions unsuitable for this kingbird.

Movements.—In July, August and September, 1948, when field work was begun on the Reservation, kingbirds were seen regularly. Parts of the area were then heavily grazed pastures, and habitat conditions were probably favorable for breeding of the kingbird. With discontinuance of grazing in early 1949, habitat conditions deteriorated for this species because of the high rank growth of herbaceous vegetation. Thenceforth, kingbirds were seen on the area only on migration and, occasionally, as wanderers from adjacent farms where the habitat remained favorable.

Kingbirds have been seen on the Reservation chiefly in May, when they have recently arrived from their northward migration, and perhaps are still moving about in search of territories.

Kingbirds nesting at a farm a quarter mile north of the Reservation boundary were seen on the area near its northern edge on several occasions. In late August of several different years, loose groups of kingbirds were seen moving across the Reservation or nearby areas, perhaps already embarked on their southward migration.

Muscivora forficata (Gmelin)

Scissor-tailed Flycatcher

Status.—Rare transient.

Habitat.—Short-grass prairie or closely grazed pasture with elevated perches such as are provided by scattered trees, fence posts, or telephone wires, comprise suitable habitat for this flycatcher. Presence of woodland and thickets alternating with rank ground vegetation in more open situations renders the Reservation unfa-

avorable for occupancy. This area is on the margin of the species' range, and breeding pairs have been recorded within a few miles.

Movements.—The only definite record for the Reservation is one seen by Donald W. Janes on August 28, 1955, perched on a telephone wire between the headquarters and the west boundary. It was seen twice at the same place. On the second occasion, as a vehicle approached on the road, it flushed and flew out of sight to the west.

Frank W. Fitch, Jr. (1950:153) studying the species in east-central Texas, found that "Territories . . . included the ground within a radius of 35 yards from the base of the nest tree." ". . . an area of complete intolerance to all species immediately surrounds the nest, with gradations of intolerance outside of that, their extent depending on the species involved."

Myiarchus crinitus (Linnaeus)

Crested Flycatcher

Status.—Common summer resident.

Habitat.—Deciduous forest, and edge.

Ordinarily these flycatchers stayed in woodland, showing a distinct preference for large old trees, especially those that were dead or dying and therefore had open crowns.

Movements.—Crested flycatchers first appeared on the Reservation in late April each year; dates were the 27th, 30th, 28th, 20th, 22nd, 26th and 22nd over the period 1951 through 1957. Within a few days after the first one was heard they were present in abundance, and were establishing territories. They were noted chiefly in May and June. As the season advanced, their calling became increasingly restricted to early morning and evening, and finally ceased altogether. Latest seasonal records are August 27, 1952, August 30, 1953, and August 31, 1955.

In early May crested flycatchers were already associated in pairs. Quarrels between pairs, and pursuits have been noted chiefly in May and June. Often two pairs perched in separate trees within 100 feet of each other where their territories adjoined and the males called in seeming defiance, answering each other in turn. Pairs have been seen nest-building in early June. In the nesting season crested flycatchers have often been seen to chase other kinds of birds, including phoebes and cardinals.

In 1955 three adjoining territories were measured, one in the

headquarters area of the Reservation, and one on each side of it. The approximate areas computed were: 7.2 acres, 6.6 acres, and 5.6 acres. All three territories included areas of fields with groves and scattered trees, and edges of woodland bordering the fields on each side. Activity of the flycatchers was mostly confined to the woodland, but in early morning and evening each ventured out into the field and called from the tops of several of the larger trees, in succession. In several instances such a favorite perch tree was used at different times by the birds from each of two territories. Neither seemed able to establish exclusive control, but in each instance the tree was on the borderline of territories that otherwise did not overlap each other.

Engles (1949:287) describes two nests in dead trees where forest had been killed by wind blown sand, on Shackelford Bank, a small island on the North Carolina coast. These nests were, respectively, 274 and 167 "long paces" from the edge of the woodland where the flycatchers did nearly all their foraging. As a result of their unusual situations, the nests were relatively safe from predators, but it was a hard struggle for the flycatchers to fly against the wind back to their nests.

Sayornis phoebe (Latham)

Phoebe

Status.—Common summer resident, several breeding pairs present each year.

Habitat.—The distribution of bridges and buildings providing sheltered nest sites seems to be the chief factor in determining the number of phoebes on the area.

There were perennial nest sites at the Reservation headquarters buildings, at a wooden bridge over a deep gully of the creek in the southeast part of the area, and inside a seven-foot concrete culvert under the county road at the west edge of the Reservation. In their foraging, phoebes seemed to prefer parkland situations, perching in large elms, but also spent much time in nearby fields of brome grass, where they perched in isolated trees or on stakes and weed stalks.

Movements.—Phoebes arrived on the area each year in early spring, and their annual sojourn was of longer duration than that of any other kind of bird that was not a permanent resident. Earliest appearance each year was in March, and for 1950 through 1957 first recorded dates were the 21st, 22nd, 12th, 14th, 12th, 10th, 6th,

and the 13th. In most years the first phoebe noted was in the headquarters area, where nesting occurred annually. Several times such recent arrivals were noted at daybreak or soon afterward, presumably having arrived in the night. The fact that they preceded the main wave of migration, and that they came directly to a nesting territory, suggested that these individuals were survivors that had nested there the year before. However, in 1954, the first phoebe, recorded on March 12, was more than 100 yards from the headquarters area, and it did not come to the buildings. After a few minutes it left, and no others were recorded until March 21.

Buildings were erected at the Reservation headquarters in early 1950, and these provided three perennial nesting sites. One was on a bend of the drain pipe beneath the eaves of the residence at the southwest corner, one was in the garage (or under its eaves) 150 feet east northeast, and the third was on the porch of the laboratory between the other two buildings and approximately 50 feet from the garage. Two pairs always occupied this vicinity; the house and the garage were in different territories. The laboratory nest site was usually used as an alternate by the pair whose territory included the garage, but occasionally it was used by the pair from the house.

The territories occupied were contiguous, and they were similar from year to year. In each, foraging was concentrated in a parklike grove, mainly of large elms, in an area that was roughly circular, and approximately 170 feet in diameter, a little more than half an acre (Fig. 16). Several favorite perches, five to fifteen feet high, were used with such regularity that conspicuous accumulations of excreta and pellets formed beneath them. However, the phoebes often foraged far beyond the limits of the groves where their activities were concentrated. The pair living at the garage often used the open field to the west, perching in the several isolated trees or on weed stalks, as far as a gully that was 600 feet from the nest site. At times, they spent hours daily along the cut-banks of the gully and in adjacent trees and shrubs, and seemed to be preparing to nest there, but no nest was ever found at the gully. In the opposite direction this pair foraged to the pond, approximately 580 feet east from the nest and their territory was about 100 yards wide. Their territory was measured as 7.1 acres, while the pair that nested at the house had a less elongate territory of 3.3 acres.

Throughout the breeding season territorial pursuits and attacks were frequent, owing to the proximity of the two nests. Conflict

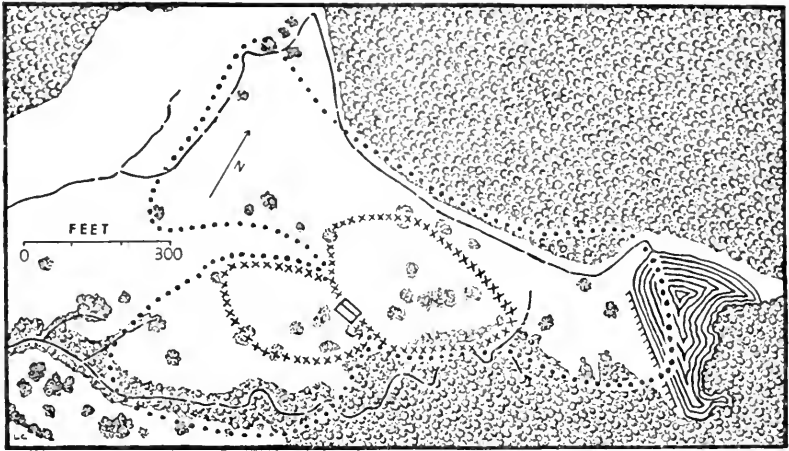


FIG. 16. Territories of two pairs of phoebes; activities of both pairs were concentrated about the Reservation headquarters, as shown by the lines of crosses. Little used outlying portions of the territories are enclosed by the dotted lines.

was especially severe early in the season before territorial boundaries were fully established. The sequence of events in 1953 well illustrates the establishment of territories, and the seasonal cycle. The first phoebe noted was present on the morning of March 14, but no other was seen that day, or on March 15 and 16. At day-break on March 17, two were calling near the old nest at the southwest corner of the house. Later in the morning they were seen near the garage and at other places nearby, perched near together and seemed to be paired. Once there was a spirited pursuit. On March 18 and 19, two phoebes, probably the same, were present in the vicinity. On March 20 at 8 A. M., a third phoebe was present, and the three were involved in a violent quarrel, centering at the old nest on the drain pipe at the corner of the house. The two already paired were trying to drive away the one newly arrived. Most maneuvering was within thirty feet of the nest, and one member of the pair was much more aggressive than the other. Attacks were most severe when the intruder lit on or beside the nest. A defender would fly at it, and would follow close behind as it darted about erratically. Sometimes the pursuer would catch the other, and cling to it persistently, forcing it to the ground where the two might continue to struggle for a few seconds before separating. After escaping, the pursued bird would soon return to approach the nest again. Its persistence suggested that it may have used this

nest site previously. However, by 9:30 A. M. it had withdrawn from the contest for the nest site and was keeping to the vicinity of the garage and laboratory apart from the pair. The latter were staying mostly within thirty feet of the nest site, alternately foraging and courting. The female tended to fly away a short distance each time the male approached. A little later the male flew to the single bird and perched beside it momentarily, twittering as in courtship. Later he repeated this procedure with increasing frequency. In the latter part of the morning he was distributing his time between the two females, spending about two-thirds of it with his original mate and the remainder with the second female. On March 21 wintry weather returned, with high wind and freezing temperatures. On March 22 weather moderated, but the phoebes were preoccupied with foraging, and no courtship or quarreling was noted. Once, all three were seen perched in the same tree. After dark two were flushed from the garage, suggesting that the lone female had acquired a mate, and on the morning of March 23 four phoebes were present, behaving as two pairs on separate territories. There was persistent quarreling and maneuvering in the area between the buildings on this morning, and probably the territorial limits of each pair where their ranges met were established as a result. Later in the day, one (female?) was seen carrying nesting material to the garage, from the ravine 250 feet south of it. On March 25 the nest in the garage was well underway and one of the phoebes made frequent trips to a ditch 190 feet north, carrying back mud for building material. On March 26 a territorial quarrel involving all four phoebes lasted intermittently for more than an hour in the area south of the house. On March 28, a phoebe was observed nest-building at the corner of the house for more than an hour. It was making frequent trips to the ravine 225 feet southeast, and carrying back moss and perhaps mud. On April 3 this nest seemed to be completed. On April 4 the female was accidentally entangled in a net and was found dead. She contained a fully formed egg ready to be laid. The nest in the garage probably received its first egg on this day or the next. The clutch of four was completed on April 8. At dawn this same day a new female had replaced the one accidentally killed and courtship was in progress beside the nest at the corner of the house. Spirited pursuits and fighting were noted later in the day, doubtless resulting from the new female's unfamiliarity with the limits of the territory she had inherited. On April 11 an egg was found broken beneath the

nest in the garage. On April 13 the garage nest had again been disturbed by an unknown marauder; only two eggs remained and the phoebes had deserted. The nest on the house had been raided, torn loose from its foundations, and its lining ripped out. The pair of phoebes that had used this nest were making frequent trips to a puddle 250 feet west and carrying back mud to repair the old nest on the porch of the laboratory.

On April 20 the nest in the garage was empty. On April 21 it was being repaired, partly with spider webs being gathered by the phoebes in a thicket 275 feet south. On April 26 at dusk, a phoebe was flushed from the renovated laboratory nest, which contained a newly laid egg. On April 29 there were four eggs in the garage nest. On April 30 and May 1, the second and third eggs were added to the laboratory nest. The eggs of the garage nest all hatched on May 11 and 12; those of the laboratory nest hatched May 19 and 20. Both broods were fledged. Those of the laboratory nest left June 3 to 6. On June 10 the adults were seen in courtship beside the nest and on the following day one was carrying material to repair the nest. A new clutch of eggs was completed on June 19 and the young that developed from them were fledged on July 18. Thenceforth, phoebes were little in evidence about the headquarters buildings where they had spent the spring and early summer, but throughout August and September the buzzing courtship calls were heard almost every day at dawn at one or more of the old nests. This behavior was last noted on October 18.

If not prematurely disturbed, the young phoebes stay in the nest until well feathered and upon leaving fly strongly to an elevated perch. When one flies from the nest, others may follow close behind it and alight near its perch. Or, if the brood is scattered at first, the hunger calls given by all the young guide them in assembling. Characteristically they perch in a tight cluster in the same bush or tree, and at least one parent stays nearby foraging in the vicinity and feeding them in turn. Whenever one young flies, others are likely to follow. Presumably such an aggregation of fledged young is tended largely by the male parent, and in some instances the female was already incubating a new clutch while the previous brood of fledglings was still dependent. So far as observed, the dependent fledglings remained in the adults' nesting territory but shifted to a part of it remote from the nest itself. For aggregations of young of seven different broods recorded over a period of several years, the distance from the nest tended to lengthen somewhat with elapsed time, as follows: 1 day, 70 feet;

2 days, 200 feet and 260 feet; 3 days, 90 feet and 100 feet; 5 days, 460 feet; 8 days, 120 feet; 11 days, 240 feet; 12 days, 300 feet. Smith (1942:410) recorded similar tendencies in fledglings in Vermont. He observed the young all within a 75-foot radius, 150 to 200 feet from the nest the first day after leaving. At dusk on the third day the young were observed clustered on a branch 300 feet from the nest. By the seventeenth day after leaving, the young were seen with one parent 1300 feet from the nest, but on the eighteenth day, all were back near the nest. Smith noted a gradual reduction in parental attention for the fledglings, which had become partly independent by the seventh or eighth day. After the eighteenth day they were fully independent, and had dispersed.

On one occasion I observed a phoebe 850 feet from its nest, and another was seen 750 feet from its home base, but these distances are unusual. When feeding nestlings, phoebes may stay within 70 feet of the nest.

Latest recorded occurrences in six different years were: October 11, 1951; October 31, 1952; October 18, 1953; September 16, 1954; October 26, 1955; and November 3, 1956. In each year phoebes may have actually remained somewhat later in the season, as they were relatively inconspicuous and silent, and might have been overlooked.

Empidonax flaviventris (Baird and Baird)

Yellow-bellied Flycatcher

Status.—Rare migrant.

Habitat.—Northern coniferous forests in wet places during the breeding season.

Movements.—R. W. Fredrickson recorded one on May 12, 1950.

Empidonax traillii (Audubon)

Alder Flycatcher

Status.—Temporary resident in late spring.

Habitat.—Groves and woodland edges.

Movements.—These small flycatchers have been noticed on the Reservation each year in May. In 1952 and 1956 they were especially conspicuous and seemed to be present in unusually large numbers. The willow grove at the pond was their favorite habitat. They were frequently seen also at various places along the woodland edges of the field in which the headquarters were situated. In 1952 they were seen or heard almost daily from May 20 to June

3. In 1956 they were noted from May 4 to approximately June 4, with the main influx about May 9. In late May several could be found at the willow grove at almost any time, and singing was frequent. Each seemed to move about the grove freely rather than being restricted to any definite part of it, but occasional squabbles and pursuits were seen. Larvae of chrysomelid beetles were abundant on the willow leaves and provided a ready food supply. Several times the flycatchers were seen to depart from their usual method of foraging to hover while picking off these larvae. In 1957 the only record was obtained on May 10.

Empidonax minimus (Baird and Baird)

Least Flycatcher

Status.—Occasional temporary resident in late spring.

Habitat.—On the Reservation seen chiefly at woodland edges having thickets and dead trees.

Movements.—On May 17, 1952, one was seen chasing another, at woodland edge beside the ravine about 100 yards south of the Reservation headquarters. On the following day one foraging near the same place moved from perch to perch in open tree crowns, tending to keep over blackberry thickets. Several were seen on May 17, 1955.

Breckenridge (1956) studied territoriality in this species in Minnesota. He found that territories were usually less than one acre, but size depended partly on height of the trees. He regarded territories as three-dimensional, extending vertically from the top of the shrub stratum to the leaf canopy of the dominant trees.

MacQueen (1950:204) also studied territoriality in this species, at Douglas Lake, Michigan. For 33 territories the size range was from .5 to .03 acre and the average was .18 acre. The territory was found to be defended chiefly by the male.

Contopus virens (Linnaeus)

Eastern Wood Pewee

Status.—Common summer resident in wooded parts of Reservation.

Habitat.—Deciduous forest especially in edge, parkland and other situations where leaf canopy is somewhat discontinuous.

Movements.—Pewees were notably consistent in their arrival

dates; over a six year period earliest records were: May 16, 1952; May 11, 1953; May 17, 1954; May 10, 1955; May 14, 1956; and May 10, 1957. They were seen and heard much less frequently in late summer. The latest record is September 17, 1956. Dead trees or branches seemed to be the favorite locations for territorial calling, but in the course of its normal foraging each bird shifted frequently from perch to perch through the crowns of the trees, in a circuit of its territory.

In defense of territory pewees were especially pugnacious, not only against members of their own species, but against other kinds of birds. They have been seen to chase away mourning doves, bluebirds, phoebes, and field sparrows. On May 22, 1953, one pewee darted at another and caught it in midair. They fell into the grass and after a brief struggle one escaped, closely pursued by the other. A third followed these two.

A pewee that stayed in the headquarters area was observed and followed frequently in August, 1954. On the morning of August 8 its activities were confined to an area measured as .34 acre. On August 12 it covered .57 acre, overlapping only in part the area covered August 8. The woodland edge grove within which it usually stayed totalled 1.1 acres, but occasionally it visited outlying isolated trees in the adjacent field. If these and the intervening area of field were considered part of the territory, its size would be more than two acres.

Notably larger territories were found by Odum and Kuenzler (1955:131), perhaps in more open habitat. They used the wood pewee to illustrate their standardized method of determining size of territory in birds. The individual (male) most thoroughly studied by them was determined to have a territory of 10.8 acres, and fifty observations were necessary, as with each series of ten observations, up to the fifth series, the size of the known range increased by more than ten per cent. At this stage the known territory was a nine-sided polygon. With subsequent observations, the size of the known home range continued to increase, but at a slower rate—below the one per cent level. With the total of 90 records finally accumulated, the territory was still a nine-sided polygon, but with boundaries somewhat extended. Many of the records were in sizable clusters (14, 10, 10, 8, 5), and it was evident that certain parts of the area were intensively used, whereas more extensive intervening portions were used relatively little or not at all.

Nuttallornis borealis (Swainson)

Olive-sided Flycatcher

Status.—Rare migrant.

Habitat.—In breeding season, northern coniferous forest; on Reservation, on migration, woodland and edge.

Movements.—On May 22, 1951, at dusk, two were calling at different places at the edge of the woods near the Reservation headquarters. On October 13, 1951, one was seen by Maurice F. Baker on a telephone wire between the headquarters and the west edge of the Reservation.

Eremophila alpestris (Linnaeus)

Horned Lark

Status.—Common year-round resident in the general area, with numbers augmented in winter by an influx of northern birds; on Reservation, habitat has disappeared as revegetation of formerly barren areas has progressed, and no horned larks have been recorded since 1949.

Habitat.—In eastern Kansas, chiefly cultivated fields; occasionally other open areas that are nearly denuded of vegetation, such as sand or dried silt of stream deposits, and heavily overgrazed pastures.

Movements.—In June, 1949, a male was seen singing as it flew over an eroded fallow field at the north edge of the Reservation, and a cornfield adjacent on the north. Its territory seemed to include parts of both areas. In subsequent years none was seen at this place or elsewhere on the Reservation, because the open type of habitat that horned larks require had disappeared as plant succession progressed.

In the spring of 1957 horned larks were much in evidence on the newly acquired Rockefeller Tract adjoining the Reservation on the north. Fields which in 1956 had crops of milo and wheat, were disked and sown with seeds of native grasses in March, 1957. In early April, seedlings chiefly of annual weeds appeared on this almost barren area, and by late May weeds on some parts of the area had increased in height and density rendering the habitat much less favorable for the larks. A northern block of field comprising slightly more than 36 acres was separated from a southern block of a little less than 36 acres by an alfalfa patch, barnyards

and pasture. Six pairs of horned larks occupied the 72-acre area of fields, with three pairs each on the northern and southern blocks. The distance between the two fields varied from 150 feet to 360 feet and the field's edges formed natural territorial boundaries. However, on many occasions a pair or a male living on one side of the pasture or alfalfa patch flew across and invaded a neighboring territory. Fighting and pursuit were seen frequently. Sometimes a chase lasted for several minutes, one lark flying in the lead, low and rapidly, with frequent sharp turns to avoid the one behind it. Flight song was prominent throughout the nesting season, and especially after territorial encounters. The lark would spiral and tower over the territory in a flight often continuing for five minutes or more, then would swoop abruptly to the ground. It might continue to sing at intervals as it wandered about the territory foraging. Relatively little singing was done from perches. In the nesting season females were seldom seen in flight except when they were flushed. Territories of approximately twelve acres were typical in this habitat.

Riparia riparia (Linnaeus)

Bank Swallow

Status.—Occasional.

Habitat.—For nesting requires cut-banks; otherwise not closely limited in habitat requirements.

Movements.—In May, 1949, a pair was seen patrolling up and down a gully and the adjacent pasture on the Reservation, west of the headquarters area. These swallows may have been nesting or preparing to nest in the bank of the gully, but a few days after they were first seen they disappeared, and none was recorded in subsequent years.

Stelgidopteryx ruficollis (Vieillot)

Rough-winged Swallow

Status.—Occasional in summer.

Habitat.—Usually near bodies of water.

Movements.—Rough-winged swallows have been identified flying over the Reservation on a few occasions in summer. Locations of breeding colonies in surrounding areas are not known. The swallows seen over the area were probably either migrants or individuals that had wandered farther than usual from their normal ranges.

Hirundo rustica Linnaeus

Barn Swallow

Status.—Present in summer; many nest on nearby farms, but none has nested on Reservation.

Habitat.—The chief habitat requirements are: nesting sites of the preferred types, as provided by old farm buildings, and foraging places, chiefly meadows or cultivated fields. Swallows were often seen foraging over the Reservation but it is doubtful whether any individuals had definite home ranges including parts of the Reservation. They were seen over every type of habitat represented. The altitude of flight and the place chosen for foraging probably varied according to the availability of insect prey, as determined by season, temperature, and humidity.

Movements.—Barn swallows usually were not seen on the Reservation until somewhat after their arrival in the general area, in late spring. Earliest dates recorded over a period of years were: May 7, 1952, May 15, 1953, May 18, 1954, May 17, 1955, and April 25, 1956. There were nesting colonies in some years, at least, at farmsites located a quarter-mile north of the Reservation (this latter acquired by the University in 1956 as the Rockefeller Tract), and a half-mile west. These colonies were the sources of most that were seen on the Reservation. On May 15, 1953, when conditions were unusually dry, a pair flew to the Reservation pond and settled on bare ground at the edge of the water, gathering mud for a nest, then flew up a slope, headed for the farmsite some 2800 feet to the north. Ordinarily material for building was collected much nearer to the nest. In the nesting season most activity was within a quarter mile of the colony and was concentrated about a small pond 100 yards from the barn in the area between the pond and barn, and in the adjacent pasture and wheat field. Only an occasional individual crossed to the Reservation a quarter mile south.

On May 30, 1955, a pair came to the buildings on the Reservation and spent several minutes circling the house, hovering under the eaves, and clinging to the walls. These birds soon left, and did not return. Probably they were from a nearby colony and having failed in an attempt at nesting, were in search of a new nest site.

On July 9, 1952, there were many barn swallows on the wires at the west edge of the Reservation and foraging over the fields to the west. These were from the colony at the farmsite half a mile west of the Reservation. The groups on the wires included many fledglings, that were being fed from time to time by the adults.

In 1957 a pair nested in the barn on the Rockefeller Tract. Most of their foraging was confined to an area of about 20 acres, the farmyard, the 14-acre pasture to the east, and a five-acre alfalfa field to the west, although they frequently cut across corners of the cultivated fields adjoining. The pair of swallows perched mainly on a 50-foot stretch of electric wire beside the barn. Latest dates of records were September 12, 1957, and September 27, 1948.

Petrochelidon pyrrhonota (Vieillot)

Cliff Swallow

Status.—Occasional in summer.

Habitat.—Vicinity of water probably is preferred, especially where cliffs or buildings provide nesting sites.

Movements.—No nearby colonies are known and appearances over the Reservation are infrequent. My only specific record is for July 23, 1948. In most instances swallows seen over the Reservation were flying high and were not definitely identified as to species.

Progne subis (Linnaeus)

Purple Martin

Status.—Transient in late spring and summer.

Habitat.—Breeds chiefly about farms and suburban situations.

Movements.—Martins are seen over the Reservation most often in May. Those seen probably are still on migration or are wandering in search of suitable nest sites.

Cyanocitta cristata Linnaeus

Blue Jay

Status.—Common resident.

Habitat.—Hardwood forest.

Locally jays keep mainly to the woodlands of oak, elm and hickory. They are often seen crossing open areas, in high direct flight, but have never been seen to stop on the ground in open fields. They seldom stop in isolated trees in open fields, and spend little time in such situations. In summer they often frequent woodland edge and parkland situations, but in winter, they seem more inclined to stay in thick woods.

Movements.—Numbers of blue jays on the area varied widely from month to month and from year to year. In part this variation

was due to passage, through the area, of migrants from farther north. Jays that breed on the area reside year-round in the vicinity, but are inclined to shift their ranges seasonally according to availability of cover and food. The tendency of the jays to carry on most of their activities as members of social groups, and the existence of more or less permanent bonds between the members of a pair, are factors that control, to a large extent, the movements of individuals.

In spring, the migratory northward movement through the area occurs chiefly in late April, after the resident blue jays have begun nesting. At 9 A. M. on April 29, 1952, 30 or more strung out in a long loose group, were moving northward across the Reservation, passing near the headquarters building. Many of the birds in this group seemed to be associated in pairs. At 4 P. M. on the same day, a smaller group was moving north along a hilltop edge, a quarter mile farther east. At 8:20 A. M. on May 18, 1953, a long loose flock of 22, mostly grouped in pairs, moved north across the Reservation near the west edge. At 11 A. M. on April 24, 1954, a straggling group of 27 was travelling north northeast, flying high over the treetops. On April 26, 1956, between 9:00 and 9:07 A. M., a group of 32 passed the Reservation headquarters headed north. Many seemed to be in pairs. There was a distance of hundreds of yards between the vanguard and those bringing up the rear. They were moving steadily but unhurriedly, in flights mostly less than 100 feet between perches, except where there were open stretches with no perches available. Like other migrating groups this one was relatively silent, but with some low conversational notes between nearby individuals. Each individual maintained contact with the group mainly by sight. Most of the group passed through an elm at the Reservation headquarters where a female was incubating. Although some of the migrating jays passed within a few yards of the nest, neither the female nor her mate, nor any other resident jays in the vicinity paid any attention to the migrating flock.

Transients moving south in autumn are less easily identified, because the residents are restless and noisy at that season, and their numbers are augmented by the annual brood. Southward migration probably occurs mainly in late September and early October—before the advent of cold weather. On September 27, 1954, while approximately a dozen blue jays were foraging in oaks near the pond, 27 more came straggling down the slope from the north and joined them, with much commotion. Obviously these new arrivals, at least, were migrants, as there were not this many jays living in

the vicinity. In 1957 migrating groups were seen on September 27 and October 9.

In the winter of 1953-1954, when the population of jays was low, there were three distinct groups on the Reservation, which kept to separate ranges, one group in the northeastern part, another in the southeastern part, and a third in the western part ranging also onto adjacent farmland farther west. Most observations were made on this latter group, which consisted of approximately eight pairs. The members of each pair usually stayed near together, or at least maintained contact by sight or sound. The whole group also tended to move about as a unit, and each individual maintained contact with the main group by occasional calls and answers, even though at the time the individual might be foraging independently, hundreds of yards from its companions. The precise limits of activity for this group were not determined, but the area encompassed by their usual activity was measured roughly as 3000 feet from north to south and 2000 feet from east to west. It consisted of two wooded hills, with an intervening valley of fields and pasture, 300 yards across. The jays spent most of their time on one or the other of the wooded hills, crossing the intervening valley frequently, and pausing *en route* to perch in high isolated trees or groves. Occasionally they foraged along creekside thickets in this predominantly open area. Jays were often seen to fly $\frac{1}{4}$ to $\frac{3}{8}$ mile from one hillside to another.

With the onset of the breeding season, flocks such as the one described did not disintegrate completely. Although largely preoccupied with its mate and nest, each individual continued to participate to some extent in group activities. Two or more pairs often joined each other in foraging or maneuvers which were for the most part amicable. Each year jays nested in the grove near the Reservation headquarters. On several occasions a jay incubating at this place was seen to fly off its nest to a hilltop 1150 feet west in response to the calls of others on the hilltop, and it joined a group there. The calls to which it responded were not indicative of any unusual disturbance. In the process of nest building, jays were seen to bring sticks the full distance from this same hilltop, but more often twigs were obtained nearer the nest site, sometimes from the same tree where the nest was situated. After a fledgling had left the nest, but was still unable to follow the adults, the latter were seen to bring food regularly from a hillside approximately 400 feet from the young bird's hiding place beneath the nest tree. In

June, 1956, an adult was seen to bring food to a nest in this same tree from a distance of 900 feet.

In the nesting season instances of intolerance observed from time to time, did not seem to involve defense of a well defined territory. However, the nesting jays were intolerant of other pairs courting or lingering in the nest tree or in nearby trees. On May 11, 1955, while incubation was in progress in one nest at the Reservation headquarters, a pair of jays came into a large elm 90 feet from the nest tree, and were met there by the resident pair. The beginning of the encounter was not seen. When noticed, all four jays were moving about through the tree rapidly, uttering low calls. After several minutes of maneuvering, they shifted to the nest tree where the scolding and movements became more animated. A defending jay would dart at an intruder and follow it persistently for several seconds. A variety of squawks, squalls, and scolding sounds were uttered. Finally the intruding pair was put to rout, and with raucous calls they flew off together headed northeast.

In time of stress, in the presence of a natural enemy, nesting jays were completely tolerant of neighboring pairs, and two or more pairs might combine in mobbing it. On June 7, 1955, excited calling drew my attention to a large black rat snake which had climbed to a jay's nest and had begun to eat the young. Within a few seconds the scolding adult jay was joined by its mate, and both set up a frantic clamoring. They closed in, and actually attacked the snake, striking it many times and staying within a foot of it throughout most of the encounter, though leaping back warily at each movement it made. After approximately one minute a second pair of jays arrived. They participated in the heckling, but did not attack, and stayed at a safe distance, several feet away. They left after approximately two minutes, while the snake was still on the nest.

Corvus brachyrhynchos Brehm

Crow

Status.—Common resident; those that breed on Reservation remain in vicinity throughout year, with influx of migrants from farther north in winter.

Habitat.—During annual cycle crows use every available habitat, exploiting any available food source. In general, however, they probably utilize open fields more than woodland, and cultivated fields in preference to pastureland. All nesting sites discovered were in thick woodland.

Movements.—Resident crows generally kept apart from the large flocks of wintering crows, and the two groups were notably different in habits during the part of the year when both were present. In autumn the population of migrant crows moving in for the winter built up gradually over periods of weeks, as numbers were augmented by new arrivals. In several different years flocks of recently arrived wintering birds were first noticed on the following dates: October 17, 1950; October 3, 1951; September 18, 1952; September 14, 1953; October 26, 1957. The wintering crows were especially gregarious. In roosting they congregated in flocks which sometimes had thousands of individuals. Each morning there was partial dispersal of the roosting aggregation, and the flocks of varying sizes scattered over an area as large as ten square miles. As the crows proceeded with their morning foraging, the large flocks disintegrated into progressively smaller units. In late afternoon the crows became increasingly restless, tending to gather at rallying points such as tall trees on hilltops. Usually before sunset these groups began homeward flights toward the roosting area, strung out in long straggling files. Roosting procedure was much influenced by the weather. Rain, snow, and wind interfered with the normal foraging activities, and caused the crows to congregate in the roosting area long before dark, as early as 3 P. M. on midwinter days. Prolonged maneuvers preceded the actual roosting, as hundreds or even thousands of individuals milled about, calling, flying and perching together. These maneuvers were notable for their seeming aimlessness and lack of leadership, often with indecision up to the last moment regarding choice of a roosting site. Often the main group would split, one division moving away hundreds of yards or more to a different roosting area. Movement from one group to the other might begin with a lone individual or a pair, followed by a trickle and then a steady stream and finally a mass movement as those remaining merged with the rival flock. Occasionally there might be simultaneous interchange between two such large groups, with uncertainty as to which would eventually be drained into the other. Actual roosting sometimes occurred soon after sunset but in other instances it was delayed until almost total darkness. Roosts were in dense thickets of osage orange, or less frequently, in thick honey locusts. The crows flew down rapidly from their hovering over the roost or from tall trees nearby, into the thicket.

Many of the wintering crows seemed to be in pairs as they foraged and moved about during the day, sometimes within a group

and sometimes more or less independently. In the evening flight toward the roost, pair-associations were especially noticeable. In maneuvers over the roost or nearby, pairs were even more readily discernible. In a hovering flock individuals would often swoop at others nearby. The one followed would bank sharply downward in a long swoop, and then carried on by its momentum, would rise abruptly to approximately its former elevation, closely followed by the partner, which maintained approximately the same spacing throughout the maneuver. In some instances three individuals seemed to be associated; such groups perhaps included a young of the previous nesting season still remaining with its parents.

Throughout April the numbers of wintering crows dwindled, but usually some stayed on into May. The latest dates when sizable roosting aggregations were seen in several different years were May 4, 1952, May 11, 1953, and May 21, 1956. Crows were known to come for as much as three miles to roost. It is doubtful whether any came from much farther. The wintering flocks varied greatly in numbers from year to year, but it was not determined whether these variations represented widespread trends in population or whether they resulted merely from shifts to other roosting areas. A roosting aggregation estimated to contain at least 2000 crows was first discovered on December 25, 1950, in a dense osage orange grove a quarter mile southeast of the southeast corner of the Reservation. By February 8, 1951, this aggregation was roosting a half-mile farther east. In October, 1951, both these sites were utilized, and smaller groups that split off from the main aggregation roosted at greater distances. The crows seemed reluctant to enter any roost, and were inclined to panic at any alarm. On several occasions when it was nearly dark, after crows had already settled on the roosts, they were heard cawing in excited confusion, and were seen erupting in all directions, flying low and rapidly, and continuing on out of sight. Presumably they then roosted singly or in small groups far from the communal roost, which was subsequently shifted to a new site. On the roosts they were especially subject to predation by a variety of flesh-eaters, notably the horned owl. Evening flights toward the roost were often interrupted when one of these owls hooted, inadvertently drawing attention of the crows to itself. As the owls were most vocal between sunset and dark, this mobbing was an almost daily occurrence. A crow having spied the owl, swooped down toward it cawing excitedly and causing others streaming past to join it. Soon hundreds might congregate to heckle the owl, but they continued on their course within a few minutes.

In spring long before the wintering crows left, the resident crows began nesting. Each pair selected a nest site in thick woodland and spent much of each day in the vicinity. The onset of the breeding season was indicated by the peculiar squalling calls in the woods where courting pairs had settled to nest. Over several years these calls were first heard on March 25, 1953, March 22, 1954, April 18, 1955, March 31, 1956, and April 26, 1957. The nesting crows were non-territorial, and were social in many of their activities. Foraging was carried on chiefly at a distance from the nests, in open land, and several pairs from the same nesting area or from different areas, might mingle freely in their search for food. In several different years, for much of the nesting season, a small patch of alfalfa in a field west of the Reservation was observed to be a favorite feeding ground. Insect prey, perhaps scarabaeid beetles, seemed to be abundantly available at this place, which was approximately $\frac{3}{4}$ mile south of a slope covered with a dense grove of osage orange. Crows that nested in the grove spent much of their time in the alfalfa patch, and made the round trip to it and back many times each day.

Often two or three or four pairs of crows nested in the same part of the woods, within a distance of 100 yards. An individual might guard the entire nesting area, and spread the alarm at any disturbance. In the summer of 1952, in a 200-acre woods in the western and northern part of the Reservation, five distinct nesting areas were noted, with a total of approximately 20 adult crows.

Parus atricapillus Linnaeus

Black-capped Chickadee

Status.—Abundant resident, present on all parts of the area where trees or tall shrubs are present.

Habitat.—Forest.

Much of the activity of this species is in American elms, these being the most abundant trees of the area, but clear-cut preference is not evident, and all available species of trees and large shrubs are used. The population of chickadees tends to concentrate along edges of woodland, especially where the adjacent open land is in an early stage of succession, with coarse weeds such as sunflower and giant ragweed, their seeds providing a food supply. Presumably the presence of tree holes for roosting places is a limiting factor.

Movements.—Chickadees are social at all times of the year, and are nearly always seen with a group, or, in the breeding season, a mate. Mild sunny days in late winter initiate pairing and terri-

torial behavior. Territorial calling was first heard on February 11, 1952, January 26, 1953, and January 29, 1954. By early February, pairs may separate from the flocks and keep to themselves, temporarily, but cold, wet or windy weather causes recombination into groups. On March 20, 1952, a group of six were foraging together in a small ragweed patch, with no indication of pairing or of hostility, except that frequently they gave calls "zr-wick-ick" usually associated with territoriality. In early March trios of chickadees have been observed in prolonged quarrels and maneuvers, as two competed for the same mate, each competitor scolding persistently and striving to keep between the mate and the opponent.

In late March, April, and May, 1953, the establishment of a territory, and part of the nesting cycle were observed in a pair in the vicinity of the headquarters. On the morning of March 26 the pair was observed moving about silently in what was later recognized as their territory. One entered a cavity in a dead snag where bluebirds were nesting, and was instantly routed by them. On March 30, both chickadees were in the top of an elm 150 feet farther north, and were staying within a radius of a few yards. Catkins of the elm provided an abundant food supply. An inclined dead limb approximately two inches in diameter had a decayed spot near its end, and the chickadees were persistently working on this trying to enlarge it into a cavity for nesting. As one pecked at the soft wood, removing small fragments, the other would forage nearby. At frequent intervals the one at work was relieved by its mate, and took a turn at foraging. When another pair flew into a large elm 80 feet away, giving territorial calls, the pair under observation promptly flew toward them and engaged them in a quarrel which consisted chiefly of maneuvering at close quarters in the top of the tree, with much scolding. The commotion attracted a third pair and then a fourth, and for a quarter hour the scolding birds milled about through several nearby trees, including the one where the nest cavity was located. After they dispersed, the pair under observation promptly resumed work on the nest cavity. Later the same day another territorial melee similar to the first one was observed. It seemed that territorial boundaries were as yet ill-defined, and individuals that attracted attention in intermediate areas were harrassed by others until they retreated, or until the quarrel was terminated by mutual withdrawal. If such quarrels were prolonged, they usually attracted

other pairs. Many three-pair and four-pair quarrels have been witnessed in late March and early April.

On the morning of April 2 work was still in progress on the same nest cavity, but several times that day one of the chickadees was seen to fly down to a five-foot log leaning against the side of a building and peer in a cavity near its upper end. This was approximately fifty feet northeast of the nestsite originally chosen. On the morning of April 3 the pair had definitely abandoned the original nest cavity, on which they had made little progress in four days of excavation. They were visiting the new cavity every few seconds. Although it appeared to be of ample size, with an entrance $1\frac{1}{2}$ inches in diameter and a depth of several inches, the chickadees spent most of their time from April 3 through April 9 enlarging the cavity. Carrying of nesting material was first observed on April 13 and last on April 23. The carcass of an opossum approximately 100 feet from the nest was the source of most of the nesting material. Many times the chickadees were seen flying with billfulls of hair from the carcass to the nest. On other occasions they visited a blackberry thicket some 200 feet south of the nest, and brought back tufts of cottontail hair. The total area covered by this pair during nest building and incubation was computed as 2.3 acres, and was a little more than 600 feet in length. Actually the outlying parts of this area were visited rarely and they overlapped broadly the areas of at least two other pairs. Activity was concentrated in two elm trees within a 70-foot diameter, an area of approximately .1 acre. This territory was remarkably small compared with those that Odum (1942: 526) observed and mapped on the Huyck Preserve near Rensselaerville, New York, which ranged from 8.4 to 17.1 acres (average 13.2). Odum found that the size of the territory and the vigor of its defense decreased as the nesting season progressed.

In late May, 1953, a pair of adults with fledged young were observed and followed several times within a half acre area of woodland edge, suggesting that at this stage, with varied and abundant food supply, and while fledglings are still unfamiliar with the terrain, family groups may confine their activities to relatively small areas.

In winter, individuals cover relatively large home ranges, usually associated as members of a flock, and often associated, although more loosely, with other kinds of small birds. In few instances were a sufficient number of records obtained, for any one individual,

to permit outlining a home range with any degree of completeness. One such home range, plotted on the basis of nine capture points, was a pentagon of 19.1 acres. However, the average distance between successive captures for a series of individuals provides the best basis for calculating size of home range in winter. A total of 56 such movements for 21 different individuals averaged 583 feet. A home range with a radius of this length would cover 24.4 acres. Odum (*op. cit.*:529) found larger home ranges in New York, with an average size of 36 acres (21 to 55). For the individuals in my study, successive records were obtained within a few weeks at most and it is unlikely that extensive shifts in range occurred within the period that an individual was trapped. In six other instances consecutive records of individuals were in different winters, and for these, distances averaged 800 feet, indicating that there is generally some reshuffling of ranges after the summer interval.

In winter mixed flocks of small birds often forage together, and three kinds or even four or five kinds are often found in close association. The black-capped chickadee is perhaps the pivotal member of such associations. At least it is usually the most conspicuous species, and being less specialized than some other kinds in its foraging habits, it may function as an intermediate link to hold them together. Wing (1946:511) listed nine species-combinations in such winter aggregations. He stated ". . . it seems to me that the company sticks together day after day." At times aggregations have been followed by me for hundreds of yards, and have been noted to change the rate of travel or to reverse directions abruptly without losing their unity. Nevertheless, it is obvious that the associations are temporary. On many occasions when the travelling groups have been followed, individuals or species have dropped out after a short time. Actually, the associations are ephemeral and change rapidly. The tufted titmouse is the most consistent associate of the chickadee. For both parids, seeds of giant ragweed are a favorite winter food, and mixed groups often forage together where there are ragweed patches near the edge of woodland. Instances of incompatibility between the two species are rare and have been observed only when a titmouse and chickadee were competing for a roosting place, in a cavity of a hollow limb. In mixed groups there are almost always more chickadees than titmice. The chickadees tend to forage more rapidly, and to cover larger areas, and sooner or later they leave the titmice behind. Foraging habits are somewhat similar, but at times the titmice do

much of their foraging on the ground, while chickadees rarely come to the ground. Golden-crowned kinglets appear on the area irregularly, but are frequently in association with chickadees. In such mixed groups, the kinglets tend to move more rapidly and leave the chickadees behind. Downy woodpeckers and brown creepers also frequently forage in association with chickadees, but both kinds move about more slowly than the chickadees and tend to be left behind. Juncos and myrtle warblers at times associate with chickadees but less persistently than the other species mentioned.

Parus bicolor Linnaeus

Tufted Titmouse

Status.—Common resident in woodland.

Habitat.—Forest, with tendency toward preference of oak-hickory-elm type especially in summer; similar to the chickadee in general habitat and in preference for edge situations which provide a food supply of weed seeds, and are frequented in winter especially.

It differs from the chickadee in doing much of its foraging on the ground, and it often forages on exposed soil in sheltered spots such as cut banks of gullies at the edge of the woods. Like the chickadee, this species requires tree holes for roosting and nesting, and in some situations the absence or scarcity of holes may constitute a limiting factor.

Movements.—An individual titmouse ordinarily remains year-round in the same general area, varying its home range according to the seasonal availability of food. Changes in population density and in intolerance according to season, are also important factors controlling the size of an area occupied by an individual.

Territorial calling usually is initiated by unseasonably warm weather in January. For example, on January 4, 1956, a clear day with temperature in the mid-fifties, singing was heard several times. On January 11, 1951, an unusually mild day (74° F.), singing was frequent. Individuals well spaced through the woodland were calling and answering each other at regular intervals. Such early territorial activity was quickly terminated by the return of inclement weather. However, by the end of January or early February, territorial calling was more easily evoked, and might occur on clear mornings even when air temperature was at or near freezing. In February territorial behavior became increasingly prominent.

At times of year other than the breeding season, titmice are

somewhat social in their habits. In summer, family groups of fledged young and their parents, move about together. In autumn, titmice are usually found in associations of two to eight individuals. In most instances these, too, are perhaps family units that have maintained their identity since the nesting season. However, some of the larger groups must include either successive broods reared by the same parents in the course of the season, or composite assemblages from different families. At all times of year there is some intolerance for individuals other than the mate or the social group. Seeds of osage orange made available by fox squirrels tearing apart the "hedge balls" constitute an important part of the diet in winter, especially when the ground is snow-covered. An isolated osage orange tree in a field near the headquarters was a favorite feeding place in February, 1952, because of its heavy crop of fruit. On February 6, a group of three titmice, recognizable by their color bands and often seen together, were followed to the tree. After they had fed there for several minutes, two others came to the tree from another direction. Immediately one of the original group darted at one of the newcomers and chased it rapidly from branch to branch for several seconds, causing it to leave, and it flew to another tree 150 feet south. In the next few minutes it returned time after time to the osage orange tree, but each time it was soon driven off by the hostile member of the original group. When driven away it retreated to a tree 150 feet south, or to one 50 feet north or a third 250 feet west. Several times, flying toward the osage orange tree it was intercepted by the defending titmouse and turned back. The pursuit was accompanied by much scolding and calling by both titmice. Hostility was notably lacking in the other three individuals.

Outright fighting has not been observed, but territorial encounters are frequent in spring. These may involve two individuals of different pairs, or may involve as many as three pairs simultaneously. With loud and persistent scolding, the opponents would hop and flutter from twig to twig, within a few inches of each other, each attempting to block the other's progress into its own territory. Such quarrels might take place frequently at about the same place over periods of days, when some attraction such as a potential nest site or food source happened to be situated near the territorial boundary.

Size of territory is subject to much variation. In late February, March, April, and May, when territorial calling is prominent, indi-

viduals in adjacent territories answer each other regularly. In 24 instances approximate distances between such calling titmice on adjacent territories were recorded. These distances ranged from 190 feet to 900 feet, averaging 484. Assuming this figure represents the average distance between centers of adjacent territories, the average territory would cover 4.2 acres. In April and May, the nesting season, individuals or pairs were often kept under observation for periods up to several hours. For 19 such observations the most distant points reached by individual titmice ranged from 250 to 950 feet apart and averaged 400 feet. Assuming that the latter figure represents the average diameter of a territory, the territory would average 2.9 acres. This is a minimum figure, because an individual watched for a relatively short time could not be expected to cover the full extent of its territory. A typical territory probably is somewhere between the two average figures obtained (4.2 acres and 2.9 acres) or about $3\frac{1}{2}$ acres. One pair observed frequently in June and July, 1952, while they were feeding young, covered an

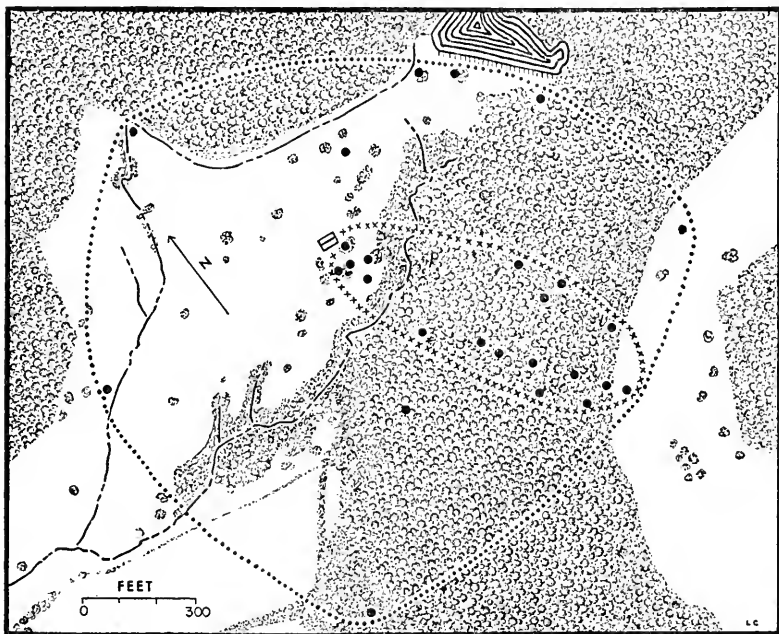


FIG. 17. Winter range of a tufted titmouse, recorded at 26 places from December 21, 1954, to January 20, 1956. A relatively small inner area shown enclosed by crosses, comprised the usual home range, but occasionally the bird wandered farther. All parts of this winter range were used also by many other titmice.

elliptical ten-acre area, approximately 600 feet in length and 220 feet in breadth. The young were banded on June 29, when they were nearly fledged. Although still unable to fly, they had remarkable climbing ability. When released on the ground each would make for the base of a tree, and gripping the rough bark firmly, would walk up the vertical trunk, fluttering to maintain its position. Three days later all the young had left the nest and were in the treetops, all within a 50-foot radius some 200 feet from the nest. Although still unable to fly strongly, the fledglings seemed to be at ease, as they were preening and frequently fluttering from branch to branch. The adults were foraging in different directions, and frequently returning to deliver food.

In winter, individuals and groups range more widely than in spring and summer. Average size of the minimum home ranges measured varied according to numbers of marginal locations, as follows: 4 points (8), 10.4 acres; 5 points (14), 10.5 acres; 6 points (7), 13.9 acres; 7 points (2), 11.3 acres; 8 points (2), 19.7 acres. Fig. 17 shows the known range of the individual for which the largest number of records were obtained. For 16 individuals each live-trapped in seven or more locations, the areas encompassed varied from 43.9 to 3.2 acres but were mostly in the range, 9 to 15 acres and averaged 14.4. These are minimum home ranges in most instances, but several for which the higher figures were recorded may have shifted within the time span of the records. For 34 other titmice that were live-trapped fewer times, a total of 80 movements recorded between consecutive points of capture, averaged 466 feet, indicating home ranges of 15.5 acres.

Sitta carolinensis Latham

White-breasted Nuthatch

Status.—Rare and irregular visitor.

Habitat.—Typically oak woodland.

Movements.—One was recorded on the area in 1949, by R. W. Fredrickson. The only one recorded by me on the area was first seen on November 24, 1955. It was seen and heard frequently in the next three months, and was color-banded in December. Its isolation from others of its species together with the fact that it was banded, made individual recognition easy. It was often observed and followed, and was live-trapped several times. Its known range was a woodland slope of northwest exposure, with mixed growth, chiefly of American elm, chestnut oak, and shagbark

hickory. It showed no definite preference for any one kind of tree, but seemed to forage on any kind that happened to be in the vicinity. On several occasions it was seen in a large elm at the Reservation headquarters. It usually spent many minutes in a tree before moving on to the next. On one occasion it was followed on a circuitous course 740 feet between most remote points, and, on another occasion, 500 feet. The hexagonal area encompassed by the records over the three-months period was measured as 37.1 acres, of which approximately one-sixth was open field, the remainder woodland. The area was approximately 2000 feet long. The nuthatch may not have ranged over all of this simultaneously as only the later records were in the southern half of it. Usually this nuthatch was seen moving about alone, but at other times it was associated with creepers, chickadees, and titmice.

Sitta canadensis Linnaeus

Red-breasted Nuthatch

Status.—Rare and irregular winter visitor.

Habitat.—Coniferous forest.

Movements.—R. W. Fredrickson recorded this nuthatch from the Reservation in 1949 or 1950. On September 11, 1954, one was calling near the headquarters, and on October 8 one was heard 700 feet northeast. On October 22, 1954, two were heard in woodland at a hilltop just west of the Reservation boundary. Probably different individuals were involved in each instance. There are no conifers on the Reservation, and the only evergreen trees present are red cedars (*Juniperus virginiana*) of bush size. Wintering nuthatches therefore usually do not stop on the area, and the fact that several were recorded in the autumn of 1954 suggests an unusually heavy wave of migration then. Another was seen on October 1, 1957.

Certhia familiaris Bonaparte

Brown Creeper

Status.—Moderately common in winter.

Habitat.—Woodlands throughout the entire area; most often seen in denser type of woods but little preference for any particular kind of tree has been noted.

Movements.—Creepers are present on the area each winter. However, because of their inconspicuousness, secretive habits, and small numbers, they are not regularly observed. Early autumn rec-

ords are October 13, 1948; October 23, 1955; and October 14, 1956. Latest spring records are April 9, 1953; April 6, 1954; April 4, 1956.

An individual was often seen frequently over periods of days or weeks in the same tree. Most commonly each individual was solitary but sometimes two were seen together and one might follow the other as they shifted from tree to tree. In early February, 1955, a group of at least four roosted together regularly on the stoop of the laboratory building. In late afternoon, or at any time in the day when particularly inclement weather, such as sleet, snow, or high wind, interfered with normal foraging, the members of this group would suddenly appear on the outer wall of the building, and climbing up the rough siding, would cluster in a compact mass at the top. The well protected spot selected for this aggregation was only a few inches from the corner of the door at the entrance of the building, and persons passing in and out often disturbed the creepers. Probably as a result of this frequent disturbance, the creepers deserted this roost in favor of one in the bole of a hollow elm 140 feet northeast of the building. Somewhat similar observations on roosting were recorded by Stone (1950:391) at Schenectady, New York, on February 27, 1949. He observed two come to roost at 4:15 P. M., climbing stucco siding to the point where a chimney met the overhang of a roof, partly sheltered by an old mud-dauber's nest. The birds roosted snuggled together, with their bills piercing the wood of the roof. According to Stone's informants, the birds had been using this roost for more than a month.

On most occasions the creepers seen on the Reservation were associated with other small insectivorous birds, including black-capped chickadees, tufted titmice, downy woodpeckers, and golden-crowned kinglets. These associations seemed to be extremely loose and fluid. Because of differences in rate of foraging, the birds of one species might soon move out of sight and hearing of the others. Each kind was attracted to the group whenever it saw or heard them.

Individual creepers were often followed for an hour or more in order to determine the extent of the area covered in their daily movements. The creeper was usually soon lost to the observer. Its inconspicuousness, and faintness of its utterances, which were audible only at close range, made it especially difficult to follow. On November 30, 1957, one was followed from the creek near the Reservation headquarters through woodland on a north slope to a hilltop approximately 800 feet from the starting point, and then part way back down the slope.

Troglodytes troglodytes (Linnaeus)

Winter Wren

Status.—Rare winter migrant.

Habitat.—Well sheltered places such as thickets and ravines are required.

Movements.—One was seen on the Reservation in December, 1948, but none has been recorded since then.

Troglodytes aëdon Vieillot

House Wren

Status.—Present each year only briefly after arrival from northward migration in spring, and before departure in autumn, but there are no breeding records from the Reservation.

Habitat.—Mainly woodland edge, especially where there are thickets, gullies with exposed tree roots, or rock ledges, providing an abundance of niches and crannies such as this species requires.

Although numerous singing males in apparently established territories are present in early summer, they soon leave the area. It is not fully evident what habitat deficiencies cause this exodus; scarcity of low cavities of the type required for nest sites is probably one factor but it cannot wholly explain the failure of these wrens to breed on the area.

Movements.—Over a six-year period, 1952 through 1957, wrens have first appeared in April, on the 28th, 23rd, 8th, 15th (approximately), 25th and 10th. Each year in a period of a few days after the first one was noted, numbers increased rapidly, and the song was heard frequently. Singing males seemed to be settling in breeding territories but within about three weeks all were gone, ordinarily. In 1956, an exceptionally late one was heard singing on June 2, but none had been heard previously since May 19. None has been noted on the area in July or August. In September there is an influx of wandering house wrens, perhaps already started on their southward migration. They were first noticed on September 14, 1948, September 8, 1953, September 11, 1954, September 20, 1955, and September 14, 1957. Such individuals may settle for periods of days. From September 15 to 18, 1953, a wren thought to have been the same individual was seen repeatedly in a weedy gully within a distance of approximately 100 feet, and it would turn back when driven to the limits of this small range.

Thryothorus ludovicianus (Latham)

Carolina Wren

Status.—Resident in woodland; because of its specialized requirements, total population amounts to few pairs or family groups. Populations fluctuate noticeably, and, as this locality is near north-western extreme of geographic range, intolerance to cold and food scarcity occasioned by winter storms are perhaps important limiting factors.

Habitat.—Woodland and "edge" where there are streams or gullies with steep, cut banks, and exposed tree roots are preferred. Both spreading of the forest and severe eroding of gullies presumably have improved habitat conditions for this wren.

Movements.—Carolina wrens have been observed in pairs at all times of year. The pair-associations and the territories occupied are probably permanent for as long as both birds survive. These wrens sing more consistently throughout the year than do any other birds on the Reservation. On sunny days, even in midwinter, song may be heard frequently. The territory of a pair may be so remote from those nearest it that ordinarily the neighbors are neither seen nor heard. In most observed instances territories were well separated, but some were adjacent. Such territories were in contact for only a small part of their circumferences, because the two pairs ranged along different stretches of the same gullies and their territories were placed end to end. When numbers were relatively low, territories were usually not adjacent and a pair might take over the former territory of an adjacent pair, in whole or in part. In six instances in which different adjoining males were heard answering each others' songs, distances between them, in feet, were approximately: 1300, 1200, 1100, 900, 800, and 580.

The gully of the intermittent creek near the Reservation headquarters provided the axis for a territory which was occupied through most of the period covered by my observations. Over a six-year period the occupants were often replaced by newcomers as shown by the disappearances of several banded individuals. The total number involved is unknown but probably on the average each pair was replaced at least once annually. Nevertheless this territory tended to maintain its general conformation. At one end a broad dike across the ravine, and the pond behind it, formed a territorial boundary seldom crossed by the wrens. In the other

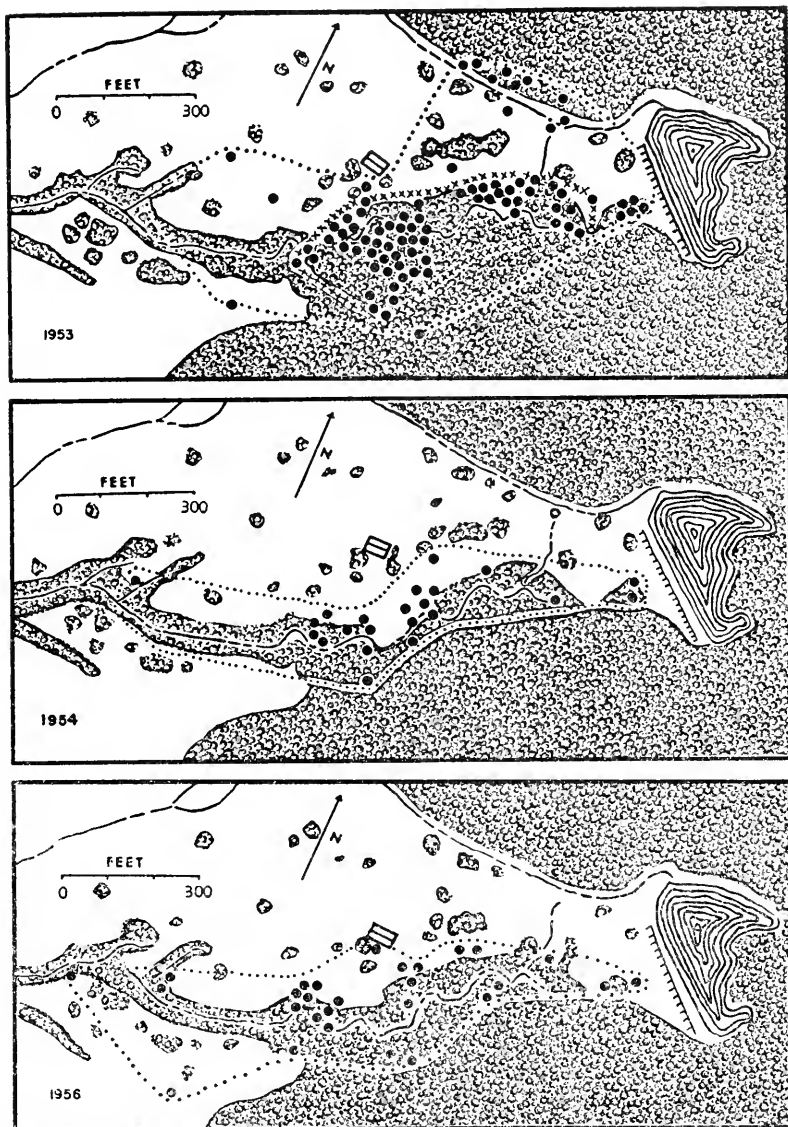


FIG. 18. Territory of a pair of Carolina wrens, as revealed by the male's singing stations, in 1953, 1954, and 1956. Each year the territory extended along a wooded ravine. In 1953, when by far the most complete records were obtained, activity was most concentrated in the relatively small central portion. In 1953 the wrens occasionally crossed the narrow east end of the field to the woodland edge thicket on the north side, while in other years they kept on the south side of the field.

direction, where the gully emerged from woods into almost flat, open fields, and abruptly changed in aspect, with lower less eroded banks, the habitat became less favorable, to the exclusion of the wrens. In 1952, 1953, 1954, and 1956 the length and area of this territory were measured as 1100 feet, 5.8 acres (from 6 points); 1150 feet, 9.2 acres (from 9 points); 1150 feet, 3.9 acres (from 9 points); and 1250 feet, 7.6 acres (from 10 points), respectively. Singing and other activities of the wrens tended to be concentrated in a relatively small central area of blackberry thickets, logs and steep eroded banks with exposed tree roots. The gully along which this territory was situated was in woodland edge. A hillside extension of this same woodland converged to join that of the gully near the pond (Fig. 18). A grassy field lay between. In 1953 the wrens often crossed the narrow end of this field to the edge of the hillside woodland. A distance of about 250 feet was the maximum that they essayed to cross, and even then they were likely to pause *en route* in isolated trees or shrubs. Failure to cross the field where it was wider emphasized the secretive habits of these wrens. Brewer (1955:141) recorded average areas of only .3 acre (.12 to .61) covered by three Carolina wrens in a swamp thicket habitat in southern Illinois.

Chapman (1947) who observed several nesting pairs in La Salle Parish, Louisiana, noted that the feces of the young were dropped by the parents 50 to 100 feet from the nests. Goin and Goin (1954:59) noted that in carrying any but minute objects to the nest, the wrens would climb to an elevated perch to gain altitude before taking off. They cited instances of wrens climbing 14 feet to fly 44 feet, and 16 feet to fly 49 feet.

Wrens were absent from this area from mid-February to late June in 1952; from mid-May until late December in 1954; for many weeks in late winter and again in early summer in 1955. These absences from the area of favorable habitat were correlated with general reductions of the population, which perhaps resulted from the decimating effects of severe winter storms.

Trautman (1940:318) at Buckeye Lake, Ohio, noted that in unusually cold weather Carolina wrens often shifted from their regular territories in partly exposed situations to neighboring woodland.

In late August and early September, 1953, the two adults in the territory near the Reservation headquarters were accompanied by three fledglings. When first observed, on August 19, this group stayed in a thicket area only a few yards in diameter, but within a

few days the group was moving about over the entire territory, still tending to remain near together.

In the winter of 1955-1956 the resident pair roosted huddled together in an old phoebe nest under the eaves of the garage at the Reservation headquarters which was near the center of the territory. The previous summer they had nested successfully in an open can lying in a cardboard carton inside this same building.

Cistothorus platensis (Latham)

Short-billed Marsh Wren

Status.—Rare migrant.

Habitat.—Usually associated with rushes, reeds or tall grass in riparian situations.

Movements.—On April 9, 1957, one was seen at the small pond on the Rockefeller Tract. Cover was limited to a strip of low smartweed approximately 15 feet wide and 100 feet in circumference. Several times the wren permitted my approach to within 15 feet before making a short flight. It was seen several times that day and again on the following morning, but late in the second day it had disappeared.

Mimus polyglottos (Linnaeus)

Mockingbird

Status.—Occasional wanderer, chiefly in spring.

Habitat.—Open situations, with groves or scattered trees are favored. Deficiencies of the Reservation as a habitat probably result from the too dense growth of vegetation—both the herbaceous cover in the more open situations and the trees and shrubs in the woodland.

Movements.—My only definite records are for April 27 and 28, 1956. On many occasions mockingbirds have been seen perched on telephone wires or in roadside thickets adjoining pastures or cultivated fields within half a mile of the Reservation.

On April 10, 1957, one was observed on the Rockefeller Tract. Its behavior suggested that it was still on migration. It had stopped at a fence corner where there was a high mound of earth with weeds and trash providing shelter. Mostly it perched silently, with no attempt at foraging. About 15 minutes after first seeing it, I heard it sing briefly. After about an hour, it became more animated, and from time to time, made short, quick flights of 15 to 20 feet to

the ground nearby to catch insects. After several such sallies, the bird flew to the nearby fence and then struck out north northeast and flew out of sight across open rolling fields.

Dumetella carolinensis (Linnaeus)

Catbird

Status.—Moderately common spring migrant and temporary resident in early summer.

Habitat.—Thickets, blackberry, elderberry, dogwood, and saplings of honey locust and osage orange, mainly at woodland edge.

Movements.—Arrival dates for several different years were: April 30, 1951; May 1, 1952; May 9, 1953; May 6, 1954; April 28, 1955; May 6, 1956; and May 6, 1957. In 1956 several were seen at Lone Star Lake on April 29, more than a week before their appearance on the Reservation. Pairs have often been seen together in the latter half of May, along creekside thickets between the headquarters and the pond, and elsewhere on the Reservation, but none has ever been seen or heard on the area in June. They find habitat conditions unfavorable and move elsewhere. On July 7, 1954, and July 25, 1952, individuals were heard calling in thickets near the headquarters. There are several records for August and even more for September, probably resulting from a dispersal after the nesting season. Late records, probably of individuals already started on migration, are: October 3, 1951; October 4, 1953; and October 1, 1956.

Toxostoma rufum (Linnaeus)

Brown Thrasher

Status.—Occasionally heard and rarely seen in summer; one or more pairs may breed on Reservation, but as yet no nests have been recorded.

Habitat.—On the Reservation thrashers have been heard and seen mainly on a relatively small area of a few acres, a south slope with trees mostly of honey locust and osage orange, the larger ones scattered, but with dense thickets of saplings of these species, and of dogwood, prickly ash, and blackberry patches. For two miles south of the Reservation, the county road is bordered by dense thickets of osage orange, and many pairs of thrashers nest in these thickets.

Movements.—Thrashers arrive on the Reservation each spring, and are seen and heard frequently over a period of days or weeks

thereafter. For several years, first appearances in spring were April 26, 1951; April 18, 1952; April 23, 1953; April 10, 1954; April 20, 1955; May 3, 1956; and April 24, 1957. So far as known, thrashers have not nested on the Reservation. Lack of open areas, with suitably short vegetation adjoining thickets, probably prevents their establishment. In 1951, 1952, and 1953 thrashers were noted only in April. In 1954 thrashers appeared earlier than in other years, and were seen more often than in the other five years combined. They were seen repeatedly in June, August and September.

Turdus migratorius Linnaeus

Robin

Status.—Resident in general area, but of erratic occurrence on Reservation, where evidently occurs only as migrant; in summer rarely seen; those present from time to time do not stay for more than part of day, and they seem to be dispersing juveniles or individuals that are wandering, having failed to establish breeding territory, or having completed breeding cycle.

Habitat.—Robins that stop on the Reservation use nearly all parts of the area, at different times, depending on the season and the local distribution of the food supply. Grape (*Vitis vulpina*) is the one chief food supply that attracts robins to the area at the time of the fall migration. Grapevines are most abundant on the cooler, moister, north slopes, and in these situations robins congregate. In early fall, with the first wave of migration, robins may feed avidly on pokeweed fruits in open fields and edge situations.

Movements.—Robins have been recorded every month of the year, but there is only one record for June. In July, August, and early September they have been seen only occasionally, wandering singly or in small groups. In early autumn there is a sudden influx of migrants. Robins were first noticed in large numbers on October 11, 1948; October 25, 1950; October 13, 1951; September 13, 1952; October 5, 1953; October 5, 1954; October 7, 1955; October 24, 1956; and September 21, 1957. Through much of October, while weather remained warm and leaves were still unshed from deciduous trees, the robins tended to stay in well shaded places in thick woods, and did not wander over the area extensively. At times in late October, November, and December, the species may have exceeded in numbers all other kinds of birds on the Reservation. Numbers were difficult to estimate because of the frequent and erratic movements. Throughout the colder part of the winter robins were seen much

less frequently, and at times, in late December, January, and early February, none was present on the area. In early April robins, usually single or in small groups, and obviously migrating, were seen more frequently than in February or March. On April 11, 1956, a pair was seen near the Reservation headquarters, the male singing frequently in several favored perch trees. Foraging was chiefly on a bare area where the soil had been turned in the installation of a pipe line the previous October. After remaining in the vicinity for two weeks, this pair disappeared.

Hylocichla mustelina (Gmelin)

Wood Thrush

Status.—Moderately common summer resident in woodland.

Habitat.—Wood thrushes on the Reservation forage on leaf litter in low, damp situations where there is a large amount of shrubby or herbaceous undergrowth.

Movements.—Dates of arrival on the Reservation in several different years were: May 5, 1950; April 20, 1951; April 30, 1952; May 5, 1953; April 25, 1954; May 7, 1955; April 26, 1956; and May 9, 1957. In 1953 they were seen and heard in abundance at Miami County State Lake two days before they appeared on the Reservation 50 miles farther north. Singing was heard chiefly in May and early June. Later in the season singing was more subdued, and was largely confined to short periods around dawn and dusk, and just

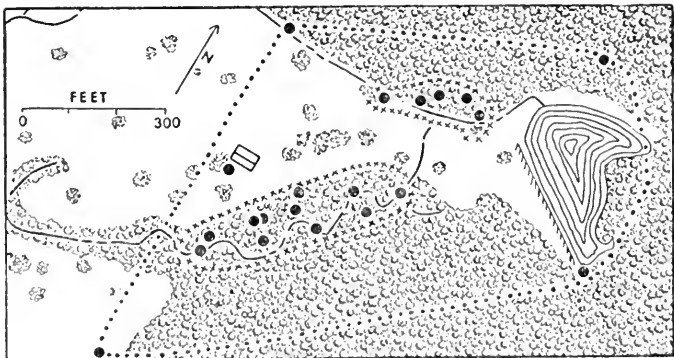


FIG. 19. Territory of a wood thrush, as revealed by singing stations of male (dots) in early summer of 1953. The territory was in woodland edge along a streamside thicket. Occasionally the thrush crossed the narrow east end of the field to the edge of the woodland on the north side of the field. In the absence of adjoining pairs, the thrush sometimes visited outlying stations, as shown here, beyond the usual limits of its territory.

after showers. On May 12, 1952, several wood thrushes were foraging within a 50-foot radius, and it seemed that territoriality was not yet well established. Usually within a few days of first arrival a pair was established along the creek south and east of the Reservation headquarters, to the exclusion of others. In 1953 the pentagonal area within which the singing male ranged was measured as 12.6 acres. Actually only small parts of this area were regularly used. The territory proper, within which the male moved about as he sang, consisted of two separate parts, each several times longer than wide. The combined area was computed as 1.4 acres (1.05 and .35), both along woodland edge, with an intervening field 150 feet across. (Fig. 19.)

Hylocichla guttata (Pallas)

Hermit Thrush

Status.—Uncommon migrant in spring and autumn; occasional in winter.

Habitat.—Woodlands, thickets and edges, with fairly open ground for foraging.

Movements.—In 1954 hermit thrushes arrived on the Reservation around mid-October. Although they were seen on only a few occasions, one or more were heard each morning for almost a month, calling in thickets just south of the Reservation headquarters. On December 25, 1955, one was seen in a thicket of wild plum (*Prunus americana*) at the edge of a field.

Hylocichla ustulata (Nuttall)

Olive-backed Thrush

Status.—Rare migrant.

Habitat.—Boreal forests.

Movements.—R. W. Fredrickson recorded one on May 7, 1949, and several on May 11, 1950.

Hylocichla minima (Lafresnaye)

Gray-cheeked Thrush

Status.—Occasional migrant.

Habitat.—Woodland.

Movements.—On April 11, 1956, two were seen on a brushy east slope in woodland dominated by American elm (*Ulmus americana*). Each time the observer approached, they flushed and moved farther

up the slope, keeping near together, and continuing for more than 100 yards in the same direction, until finally they were lost. The association suggested that these thrushes were already paired. However, Dilger (1956:345) found that in this genus the male arrives first to establish a territory, and reacts to the female's arrival with hostility and pursuit, which lasts for several days, gradually subsiding as the male becomes tolerant of the female and the pair-bond develops.

Hylocichla fuscescens (Stephens)

Veery

Status.—Rare migrant.

Habitat.—Northern deciduous forests.

Movements.—R. W. Fredrickson recorded one on May 15, 1950.

Sialia sialis (Linnaeus)

Eastern Bluebird

Status.—Resident and common in general area, but of somewhat erratic occurrence on Reservation; habitat conditions most favorable in winter, worsening in late spring as growing season progresses, to detriment of those individuals that attempt to breed on area.

Habitat.—Parkland, with medium to large trees for perches, and short grass or other low ground vegetation.

Open groves of walnut and honey locust, especially on hilltops where soil is shallow and grass is short, provide preferred situations in winter. In summer, as brome and other grasses grow longer, and mature, bluebirds are handicapped in their foraging and they tend to shift from the Reservation to fallow fields, stubble or grazed pastures where, evidently, the shorter vegetation facilitates the detection and capture of ground-living insects.

Movements.—Bluebirds are present on the area throughout the year, but their numbers and local distribution vary. Regularly each year a pair established a territory in the vicinity of the Reservation headquarters, and invariably their nesting attempt failed. Each year singing began on clear, mild days of late winter. In the six-year period, 1952 through 1957, singing was first heard on the following dates: March 16, February 28, February 14, March 11, March 22 and March 12. As singing begins winter flocks break up into pairs, and each sets up a territory. Disintegration of the flocks is gradual, and may be temporarily halted by inclement weather. For periods of weeks the birds may spend part of each

day on the territory and the remainder with the flock. On March 24, 1952, nearly a month after first singing, four bluebirds flying high together, headed south southeast, came to the field near the headquarters, and the two pairs lit in trees approximately 100 feet apart. They remained most of the day, the males singing from top-most branches of trees, and tending to keep to different parts of the field. However, from time to time all four gathered in the same tree with no show of hostility. It seemed that all four were members of the same flock.

In early spring the usual procedure was for the birds to remain with the flock for the main foraging period in the morning, and visit the territory later in the day. Several times in early spring small flocks have been seen fluttering about trees with hollow branches that offered potential nest sites. In such instances there was much scolding and quarreling, and occasional short pursuits. Territories seem to be selected originally without regard for the presence of possible nest sites. These are investigated later. In 1953, 23 days elapsed between the time that singing started and the first record of the birds carrying nesting material; in 1954 this interval was 54 days.

In 1952, 1953, and 1954 the movements of bluebirds that were nesting in the headquarters area were observed in detail and territories were mapped (Fig. 20). Nest sites were different in each year but all three were within a hundred-foot radius. Location and conformation of the territory varied from year to year, but its size was approximately the same. Greatest diameter varied from 850 to 950 feet. Outlying areas constituting a large part of each territory were used relatively little and activity was concentrated in a smaller central part that was only about half as broad and half as long as the entire territory. Because the territory studied did not adjoin others, it may have been somewhat expanded in each year that it was observed, and the central part where activity was concentrated may have been more typical of the size in areas where the birds are subject to territorial pressure from neighbors. In the three years territories and their more intensively used central portions were measured as follows: 1952, 5.4 acres and 1.9 acres; 1953, 8.6 acres and 1.5 acres; 1954, 7.0 acres and 1.4 acres.

In 1952 and 1953 fate of the nest was unknown. In 1954 the upright log which contained the nest cavity blew down in a storm. In 1955 the nest was robbed by a black rat snake (a probable fate also in the years for which no information was obtained). The day

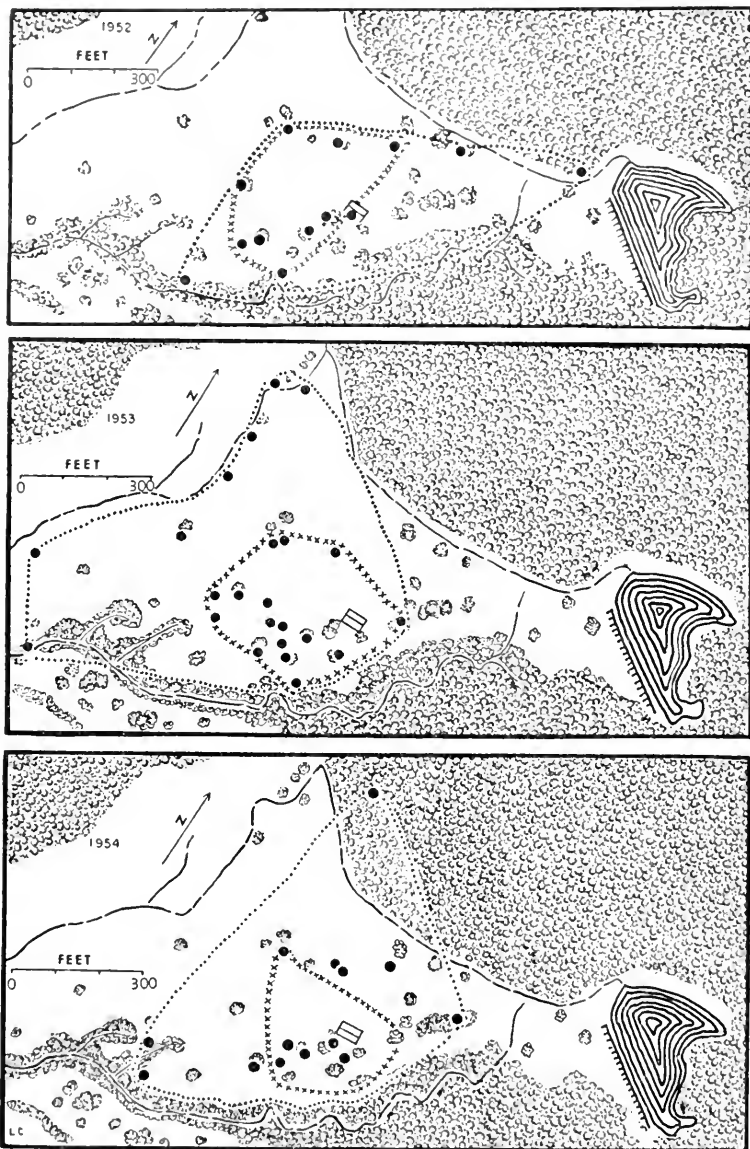


FIG. 20. Territory of a pair of bluebirds, as revealed by singing stations of the male, in 1952, 1953, and 1954. Each year the area of principal activity was concentrated in an elm grove at the Reservation headquarters, but the distance and direction of outlying stations varied from year to year. Invariably nesting attempts in this area failed.

after destruction of the nest the bluebirds deserted their former territories and did not return again that season. Failure to re-nest may have resulted in part from the deterioration of habitat conditions as the season progressed, and herbaceous vegetation grew tall and rank. Disturbance of the natural vegetation in the headquarters area of more than an acre, by trampling and cutting, seemed to render it more favorable for nesting than other parts of the Reservation that were like it.

In two different years shortly after failure of the nest and disappearance of the pair in the headquarters area, bluebirds thought to have been the same, were seen in May, 1953, and May, 1955, frequenting an area 660 yards north at the edge of the Reservation where it adjoined a mowed field. On July 4, 1954, a family group appeared in the headquarters area and spent much of their time there through July, August and early September. Sparseness of vegetation resulting from drought that spring, and unusually heavy cutting of grass and weeds in the yard and clothesline area, probably rendered this place sufficiently favorable for occupancy by the birds.

Laskey (1940:189) who made an extensive study of the nesting of bluebirds in Nashville, Tennessee, stated, "Apparently boxes should be several hundred feet apart to allow sufficient territory for each breeding pair. They should be set out in winter because nest sites are investigated by bluebirds on mild days throughout the cold season, and territorial defense starts in early spring."

Poliophtila caerulea (Linnaeus)

Blue-gray Gnatcatcher

Status.—Common summer resident; many pairs breed on Reservation each year.

Habitat.—Gnatcatchers live in woodland, with preference for more open, drier situations. Large honey locusts in fields near the edge of woodland provide the favorite sites for nesting and foraging. Large elms are the second choice. On south slopes of xeric aspect, with scrubby growth of chinquapin oak, osage orange, and dogwood, gnatcatchers may be abundant. They are least often in oak-hickory woodland with a dense leaf canopy.

Movements.—Earliest recorded dates for gnatcatchers, over the years, 1950 through 1957, were in April each year: the 11th, 23rd,

16th, 3rd, 10th, 15th, 11th, and 23rd. Each year within a few days after the first arrivals the species becomes common. Because of their brisk and frequent movements, often in low or open trees, and their almost constant calling, individual gnatcatchers could be kept under observation more easily than most other kinds of birds, and they were frequently followed. On May 6, 1950, a pair was observed nest-building in the headquarters area. On the following day this nest was completed, having been built mainly or entirely within a 24-hour period. On May 8 the same pair was nest-building again approximately 100 feet from the recently finished nest, which had been abandoned for undetermined reasons. One gnatcatcher visited the first nest and took material from it to be incorporated in the new nest. In mid-July, 1952, a pair was observed feeding young in a nest just south of headquarters. Foraging was chiefly within 50 to 100 feet of the nest, either in the same large American elm or in three adjacent trees, two elms and a walnut. In a period of an hour and a half (3:30 to 5:00 P. M. on July 13), the two parents made a total of 57 trips to the nest to feed their young. The total area encompassed by this pair in foraging for their young was measured as 1.2 acres, but some outlying parts were rarely visited. On July 6, 1953, another pair was observed feeding nestlings, foraging in a willow grove 70 to 120 feet from the nest. In late May and June, 1952, a pair observed on several occasions covered a territory of 2.2 acres. This territory was along a wooded ravine, with a grove on one side and several scattered trees in a field on the other. In May, 1952, a pair was observed in a large honey locust in a hilltop field. They seemed to spend most of their time in this one tree, but occasionally crossed to nearby woodland.

Gnatcatchers have rarely been seen after July. The latest record is September 4, 1953.

Regulus satrapa Lichtenstein

Golden-crowned Kinglet

Status.—Regular winter visitor but variable in numbers. Unlike some other wintering birds these kinglets do not seem to settle in one place to spend winter but are inclined to wander. As result, numbers present at any one time vary from none at all to dozens or even much higher numbers.

Habitat.—Woodland, especially of northern conifers, but on Reservation in winter, most typically where trees are low and dense, with vine tangles.

Movements.—Golden-crowned kinglets have most often been first noted on the area in October (25th in 1950; 25th in 1951; 18th in 1952; 14th in 1953; 27th in 1957). They have also been recorded in November, December and January, but never in late winter or spring. Those seen were usually in flocks of three to fifteen, and they were often associated with brown creepers, black-capped chickadees, tufted titmice, or downy woodpeckers, or with two or more of these kinds simultaneously. Kinglets were never seen on successive days in the same place. Either because they habitually wander, or because habitat conditions were unfavorable, those that came to the area never stayed long.

Regulus calendula (Linnaeus)

Ruby-crowned Kinglet

Status.—Regularly present for short periods in spring and autumn on migration.

Habitat.—On the Reservation the ruby-crowned kinglet most typically frequents edge situations, working through willow, dogwood, redbud, and saplings of elm and other trees.

Movements.—Ruby-crowned kinglets are recorded on the Reservation each spring (March 30 to May 16), and autumn (September 17 to October 27). Unlike golden-crowned kinglets, they are solitary, and individuals tend to settle for periods of days in woodland edge thickets, along ravines or beside the pond. Although none was individually marked, kinglets of this species were often seen on successive days in the same tree or thicket, and those kept under observation for varying periods usually remained within a radius of a few yards, despite the fact that they were almost constantly in motion. In a rocky situation just south of the old quarry, in a thicket of tall elm saplings mixed with redbud and dogwood with tangles of vines, ruby-crowned kinglets were seen much more regularly than at any other one place. Habitat conditions were so favorable in this situation that it invariably attracted some of those migrating across the area.

Bombycilla cedrorum Vieillot

Cedar Waxwing

Status.—Occasional transient.

Habitat.—On Reservation, woodland and edge situations.

Movements.—Definite records are November 2, 1948, November 5, 1952 (flock of ten feeding on bittersweet berries), November

22, 1955 (flock of 15), December 20, 1955, December 26, 1949, and in May, 1956, and April and May, 1957. Unlike those recorded in November and December, which were obviously wanderers, the flocks seen in spring stayed in the same vicinity for several days. In 1956 the flock was first noticed at 5 P. M. on May 23, in the willow grove beside the pond. The birds were feeding avidly on the chrysomelid beetle larvae that were abundant on the willow leaves, often hovering momentarily to reach these larvae. There were approximately 30 waxwings in the entire flock and they were scattered through the grove, but tended to keep together in small groups. This flock was seen frequently in the next four days at the willow grove. On several occasions the flock temporarily left the vicinity, all flushing nearly simultaneously, prepared by the rapid lispings notes uttered for several seconds before the take-off. On such occasions they passed out of sight in high rapid and direct flight, but sometimes returned within a few minutes, obviously having not stopped elsewhere.

Putnam (1949:148) described social nesting habits of the cedar waxwing; each pair's territory consisted of a nest site, a guarding perch, and a small amount of space (225, 270 and 1100 square yards). The shortest distance observed between nests was 38 feet.

Lanius ludovicianus Linnaeus

Loggerhead Shrike

Status.—Resident on nearby areas, but present on Reservation only as rare visitor.

Habitat.—Most typically closely grazed pasture or short-grass prairie with scattered thorny trees.

Movements.—On the Reservation the chief habitat deficiency seems to be the rank growth of herbaceous vegetation, preventing the shrike from seeing its prey on the ground. Shrikes are notably sedentary in habits, and in some instances at least, stay for the entire year within the confines of the small territory. On only two occasions was a shrike definitely recorded from the area, and in each instance it was foraging on adjacent land and did not venture far onto the area.

Through 1954, 1955, and 1956 a pair of shrikes, perhaps the same individuals, were often seen perched on wires along the county road just south of the southwest corner of the Reservation section. The maximum range along the county road was approximately half a mile, but on most occasions they were seen within an interval of

about 200 yards. The extent of the territory in other directions was undetermined.

Throughout 1957 a shrike was seen frequently on the Rockefeller Tract. It kept to the pasture, the vicinity of the buildings, and the telephone line along the road. Occasionally it was accompanied by a second shrike. Its known range was approximately 25 acres, but at times it could not be found within this area.

Sturnus vulgaris Linnaeus

Starling

Status.—Appears on the Reservation chiefly as migrant in spring and autumn; occasionally as wanderer at other seasons.

Habitat.—Requirements including that of hollows for nesting sites and that of open situations permitting easy walking, are not well satisfied on Reservation; therefore starlings never have stayed long.

Movements.—In autumn, especially, spectacular migrations of starlings over the area occur, and the total numbers probably exceed those of any other species. Early season records of migration are: September 16, 1951 (several small groups, stopping to feed in thickets); September 27, 1953 (flock of twelve); September 20, 1954 (a single immature bird); September 30, 1956 (several hundred). These were forerunners of the main migration, which was usually at its peak in approximately the last week of October, and in the first week or two of November. In this period many thousands might pass over in one day, and migrating flocks might be in sight almost continually. Occasional compact flocks of from less than a dozen to several hundred individuals, maneuvered, perched, and fed in close formation. One such flock having several thousand starlings remained on the Reservation most of the day on October 28, 1957. The largest flocks flying high over the area, were strung out on a broad front and straggling in loose formation.

On their northward migration each spring starlings were far less conspicuous. Earliest record is February 22, 1956, when several flocks passed over, flying high, headed northeast. On March 8, 1954, one paused briefly in a tree near the headquarters before continuing on north.

On March 20, 1953, a male was observed quarreling with a pair of bluebirds, in an elm having a hollow limb. This male starling soon flew northwest and did not return. On April 1, 1952, a male was seen moving about slowly, investigating the same nest cavity

and others in nearby trees. On March 28 and April 17, 1954, a male was investigating cavities in trees near the headquarters. In the last four days of March and throughout early April, 1955, a pair was seen frequently in the headquarters area, where they seemed to be preparing to nest. In April, 1956, a male was seen quarreling with a pair of red-bellied woodpeckers near the cavity where they had begun nesting, but he gave up and flew away headed northeast. On May 3, 1956, a pair seemed to be preparing to nest near the headquarters. So far as known, all these nesting attempts were abortive, and the starlings soon left the area.

On the Rockefeller Tract many starlings were present throughout the summer. Their activities were concentrated about the house, barn and sheds, and an elm with hollow limbs in the yard. The relatively open habitat made this area more favorable than the Reservation. In their foraging the starlings often flew half a mile or more to newly plowed fields, pastures, or other areas that were especially favorable for finding food.

Vireo griseus (Boddaert)

White-eyed Vireo

Status.—Moderately common summer resident.

Habitat.—Brush thickets, scrubby woodland, and woodland edge.

The species of plants present seem unimportant as long as the growth habit, with abundance of stems and leaf surface for foraging within a few feet of the ground surface is fulfilled. Dogwood, dwarf oak, plum, blackberry, elm and hackberry saplings, and poison ivy are among the plants most frequently used on the Reservation. Several or many pairs of these vireos nested on the Reservation in most summers of the past few years. The numbers have varied noticeably from year to year.

Movements.—Arrival dates have been notably variable: May 24, 1952; May 6, 1953; April 23, 1954; May 3, 1956; May 3 (approximately), 1957. In 1955 none was seen. Latest dates of record were August 31, 1952; October 5, 1953; July 30, 1954; September 16, 1956; and September 8, 1957. In 1952 and 1953 pairs (or perhaps the same pair) nested near the headquarters. The nest was not found in either year, but the male vireo was a consistent singer, and his course could be easily followed as he moved about through dense vegetation where he could be seen only with difficulty. In 1953 a bob-tailed fledgling was found in the southwestern part of this territory, and it could not have travelled far from the nest.

The nest of a second pair 850 feet farther west along the same ravine was kept under observation for part of the period of incubation and nestling development. When this latter nest was destroyed by a predator, two cowbirds, nearly fledged, were the only remaining occupants.

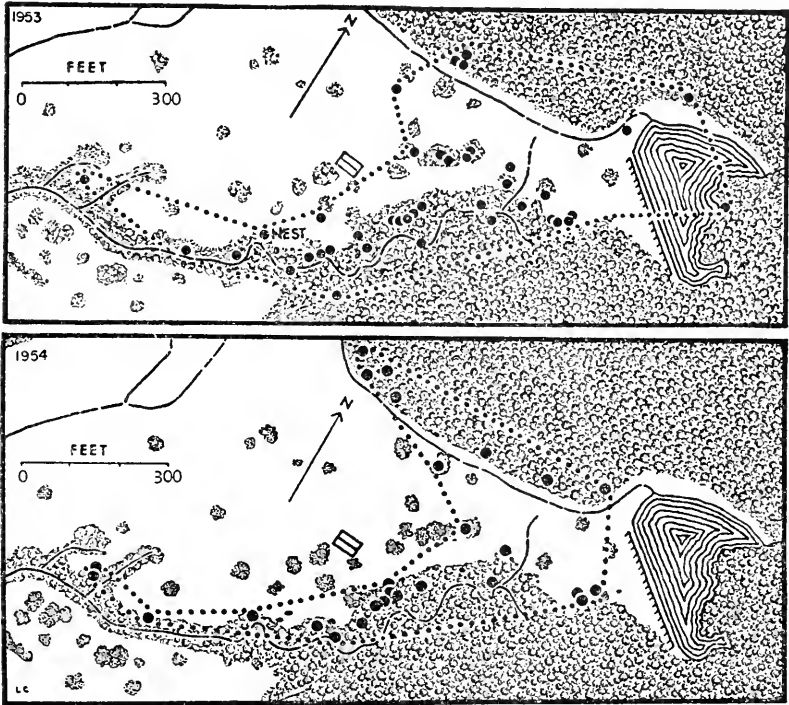


FIG. 21. Territory of a white-eyed vireo in early summer of 1953, and in early summer of 1954. Dots indicate locations where singing male was recorded. In both years the territory covered the same general area, differing only in details. It consisted chiefly of streamside thicket along woodland edge, but included also part of an elm grove in the narrow end of a field, and a strip of woodland edge thicket on the north side of this field.

The territory near headquarters was, in both 1953 and 1954, crescent-shaped, following up the ravine and edge of the woods, northwest and crossing the narrow, brushy east end of the meadow to the woodland on the opposite side. In 1953 the territory was measured as 6.5 acres, and in 1954 as 5.4 acres; the areas corresponded throughout most of their extent (Fig. 21). In every instance territories observed by me were much larger than the .33 acre territory listed by Brewer (1955:141).

In 1955 no white-eyed vireos were heard or seen anywhere on the Reservation, and numbers must have been exceptionally low. In 1956 and 1957 the territory near the headquarters was not occupied and these vireos were heard elsewhere only a few times in the entire season. Their numbers were still low on the Reservation.

Vireo bellii Audubon

Bell Vireo

Status.—Moderately common summer resident.

Habitat.—Brush thickets in open places. Wild plum perhaps provides the optimum habitat. Wild cherry, dogwood, fox grape, crab-apple, and stands of saplings, of elm, honey locust, and sycamore also are used.

Movements.—In 1948 and 1949 these vireos were observed occasionally in roadside thickets at the west edge of the Reservation. Subsequently none was seen until 1953, but thenceforth they were present each summer, chiefly in thickets that had sprung up since discontinuance of grazing in 1949, and were not yet sufficiently developed to provide adequate cover in the period 1950-52, when no Bell vireos were present. Earliest records for a four-year period were May 5, 1954; May 10, 1955; May 13, 1956; and May 8, 1957. The two latest records are August 17, 1953, and August 23, 1954.

Two wild cherry trees (*Prunus serotina*) at the north edge of the Reservation, bordering a wheat field, constituted the focal point of a vireo's territory each year from 1953 through 1956. The singing male spent most of his time in the two adjacent trees, in an area only about 60 x 20 feet, but occasionally he ventured to nearby low thickets along the boundary fence and at the edge of the field. In 1954 this territory was measured as .4 acre. Another territory occupied each year was in a gully having a thicket of wild plum, sumac, prickly ash and saplings of elm and honey locust. In the summer of 1954 the singing vireo was recorded and followed many times and its territory seemed to be co-extensive with this thicket, which was approximately 620 feet long and averaged 50 feet wide (.6 acre). By 1955 thick stands of saplings had grown up in nearby parts of the field west of this gully, and the vireo ranged through them being no longer closely confined to the gully. By 1956 this new thicket area seemed to be the center for a territory, and the vireo was followed about over an area approximately 150 x 60 feet. Another individual, separated from this one by an open meadow 150 feet across, was followed for 450 feet along a woodland edge thicket.

A territory in a brushy field, in June, 1955, was measured as one acre, but a central area comprising about one-fourth of the total was used much more intensively than the remainder. Knowledge of the territory of these vireos was gained almost entirely by following the song. As a bird moved about through thick brush or flitted from clump to clump it was glimpsed only rarely. Females, being relatively silent, were observed on only a few occasions.

Hensley (1950:243) recorded a territory of 3.1 acres for a pair in Piatt County, Illinois. The area was grassland, with scattered trees and shrubs, and it was more open than the areas where my own observations were made. Hensley observed young 30 feet from the nest on the day they left it, and five days later observed the brood congregated 300 feet from the nest.

Vireo flavifrons Vieillot

Yellow-throated Vireo

Status.—Rare migrant or transient.

Habitat.—Deciduous forest.

Movements.—The only record from the Reservation is of one recorded by R. W. Fredrickson on May 6, 1950.

Vireo solitarius (Wilson)

Solitary Vireo

Status.—Rare migrant or transient.

Habitat.—Forest, usually of conifers.

Movements.—The only record from the Reservation is of one seen May 3, 1952, by R. W. Fredrickson.

Vireo olivaceus (Linnaeus)

Red-eyed Vireo

Status.—Regular summer resident; except for the field sparrow is perhaps most abundant species of this category.

Habitat.—Deciduous forest, occurring throughout the woodland on the Reservation except that of more xeric type, as represented on south slopes.

The trees most regularly used, in approximately their order of importance, include American elm, shagbark hickory, black walnut, chestnut, oak, sycamore, black oak, red oak and coffee tree. Trees that are rarely used are honey locust, osage orange, red haw, dwarf oak and wild plum. There is scarcely any overlapping of habitat between the red-eyed vireo and the two other species, Bell and

white-eyed, that nest on the Reservation. However, the warbling and red-eyed overlap broadly in habitat preferences.

Movements.—The arrival dates recorded for several different years were: April 26, 1951; April 25, 1952; April 30 (approximately), 1953; April 26, 1954; April 21, 1955; May 2, 1956; April 24, 1957. Latest records of occurrence were: August 31, 1952; October 5, 1953; and September 6, 1956. In May and June, especially, the red-eyed vireo is a persistent singer. An individual foraging through the treetops might seldom be visible from the ground, but its course could be followed by its frequent bursts of song. Such a bird might move across its small territory several times in the course of an hour. An individual that lived on the wooded slope just southeast of the Reservation headquarters in 1955 was often followed and observed in May and June. The total area encompassed by its records was measured as 2.5 acres, but included many outlying points. Most of its movements were within a smaller area of elliptical shape, measured as .5 acre.

In 31 instances distances between singing males in what seemed to be adjoining territories, were measured, and these ranged from 700 feet to 80 feet, averaging 346. Territories averaging approximately 2.1 acres are indicated.

Vireo gilvus (Vieillot)

Warbling Vireo

Status.—Transient and temporary resident in late spring.

Habitat.—Groves at edge of woodland or near it. In almost all instances these vireos were in large American elms.

Movements.—The species has been recorded on the Reservation only in May and in the last week of April: May 6 to 18, 1953; May 3 to 31, 1954; April 25 to May 12, 1955; May 2 to 7, 1956; and April 29 to May 26, 1957. For periods of days an individual might be heard at about the same place, as if it had settled on a small territory. Often such a bird tended to stay within one tree. Habitat conditions must have been deficient in some respect, as such birds never remained more than a few days.

Mniotilta varia (Linnaeus)

Black and White Warbler

Status.—Known from the Reservation only as transient and temporary resident in spring, although there are breeding records for northeastern Kansas.

Habitat.—Deciduous forests.

Movements.—On April 12, 1951, one was seen moving about with a group of chickadees as it flitted from trunk to trunk. Other specific records are: May 17, 1951; May 8, 14, and 15, 1953; and May 14, 1954. On May 8, 1953, one was seen to fly at another and chase it from the grove south of the Reservation headquarters.

Vermivora peregrina (Wilson)

Tennessee Warbler

Status.—Migrant and temporary resident in late spring; perhaps crosses area on southward migration in autumn also, but no specific records have been obtained.

Habitat.—Northern coniferous forests in the breeding season and tropical forests in winter. During brief sojourn on Reservation seems to prefer large American elms.

Movements.—Because of my unfamiliarity with this species and the brevity of its stay on the Reservation, I have overlooked it in most years, but probably it is present regularly, on migration. On May 14, 1954, many were present within a small area of an elm grove south of the headquarters, and the song could be heard almost continually. Chasing was observed from time to time, and there was a distinct tendency for each individual to keep to his own part of a tree, excluding others. On May 20, 1954, further observations at the same place heightened this impression. An individual observed for 15 minutes foraging rapidly through the crown of a tree stayed within a space perhaps 20 feet across, tending to make a regular circuit as it hopped, flitted and sidled through the leaf canopy, moving only a few inches at a time, and frequently picking off minute food items. It was covering approximately the same beat as one of those observed six days earlier, and quite possibly was the same.

Vermivora celata (Say)

Orange-crowned Warbler

Status.—Migrant and perhaps temporary resident in spring. Probably crosses area on southward migration in autumn but no records have been obtained at that season.

Habitat.—Boreal forests in the breeding season; chiefly Gulf States in winter.

On the Reservation these warblers have been seen in woodland edge—American elms with vine tangles of grape, Virginia creeper,

and poison ivy. On April 19, 1954, these warblers were heard singing at several places and chasing was seen.

Vermivora ruficapilla (Wilson)

Nashville Warbler

Status.—Rare migrant.

Habitat.—Woodland and thickets.

Movements.—Richard W. Fredrickson saw several on the Reservation on April 30, 1949, the only definite date of record.

Dendroica petechia (Linnaeus)

Yellow Warbler

Status.—Regular spring migrant and temporary resident; not known to nest on area, which however, is within breeding range.

Habitat.—Deciduous forest.

Movements.—Heard and seen frequently each year in late April and May. In 1954, for example, it was recorded from April 27 to May 18. In May for five days in succession one was seen at the same place in the elm grove south of the headquarters, and it was suspected that this was the same individual.

Dendroica coronata (Linnaeus)

Myrtle Warbler

Status.—Regular migrant in spring and autumn.

Habitat.—Northern coniferous forests in breeding season, and southern deciduous forests in winter.

Movements.—This is the most conspicuous of migrating warblers on the area, in both spring and autumn.

Fall migration is concentrated in October, especially the first week, and spring migration is chiefly in late April and early May. In 1948 myrtle warblers were recorded on October 13 and 14. On October 13, 1950, several newly arrived migrants were seen in company with white-throated sparrows. At noon on October 11, 1951, many were noticed in elms in the headquarters area, the vanguard of a migration wave. None had been seen earlier, but they were present thenceforth through most of October. In 1953 the first one was seen on October 4, but by the next day they were present in abundance. In 1956 two were seen on October 2, and in 1957 the first record was on October 4. Spring records are April

23, 1953; April 23 and 27, 1954; April 25 and 27, May 8, 22 and 25, 1956; and April 23, 24, and 26, 1957. The species has been recorded on the area only in April, May and October.

Dendroica virens (Gmelin)

Black-throated Green Warbler

Status.—Rare migrant.

Habitat.—Chiefly northern coniferous forest in nesting season.

Movements.—Seen on several occasions in late spring. No definite date recorded.

Dendroica fusca (Müller)

Blackburnian Warbler

Status.—Rare migrant.

Habitat.—Boreal forest in nesting season; tropical forests in winter.

Movements.—The only recorded occurrence is of a male seen on May 15, 1954.

Dendroica striata (Forster)

Black-poll Warbler

Status.—Uncommon migrant and temporary resident in spring.

Habitat.—Northern coniferous forest in nesting season; tropics in winter.

Movements.—Black-poll warblers were recorded on May 18 and 19, 1953, and May 14 and 15, 1954. The 1953 records probably both pertain to the same individual, as both were in the same tree, an American elm in a field near the edge of the woods. The warbler was silent, and moved deliberately, usually running along small branches rather than flitting. It was in the same part of the tree on the two successive days and on the second day while it was under observation, it spent more than an hour there.

Seiurus aurocapillus (Linnaeus)

Oven-bird

Status.—Rare migrant.

Habitat.—Deciduous forest.

Movements.—My only definite record is of one seen on April 30, 1951.

Seiurus noveboracensis (Gmelin)

Northern Water Thrush

Status.—Rare migrant.

Habitat.—Northern forests, in swampy places.

Movements.—The only record for the Reservation is of one seen April 30, 1949, by R. W. Fredrickson.

Seiurus motacilla (Vieillot)

Louisiana Water Thrush

Status.—Rare migrant.

Habitat.—Deciduous forest.

Movements.—The only one recorded by me was seen on May 5, 1952. It was called up by squeaking.

Oporornis formosus (Wilson)

Kentucky Warbler

Status.—Moderately common summer resident.

Habitat.—Occurs throughout most of woodland on Reservation, but prefers mesic situations, with abundant leaf litter, and with dense understory vegetation to provide concealment for nest.

Movements.—Earliest recorded occurrences of Kentucky warblers in several different years were: April 21, 1952; April 26, 1954; April 28, 1955; May 3, 1956; and April 26, 1957. Arrival was timed when woody vegetation had leafed out, and the individuals first recorded were singing males, which were seen rather than heard. Establishment of territories begins as soon as the males arrive; whether females reach the area simultaneously, or later, is not known. Throughout their summer sojourn on the area, however, Kentucky warblers are rarely seen. Information concerning their movements has been obtained chiefly from the song, and therefore is based on the males, which are persistent singers in May and June.

In 1952, 1954, 1955 and 1957, a pair nested in the headquarters area. Conformation of the territory varied from year to year. In 1952 the territory was measured as 4.3 acres, and it centered on a south-facing slope of thorny woodland with dense undergrowth. A small, disjunct segment of this territory was along a ravine in woodland edge 100 feet south across a meadow from the main portion. In 1954 the entire territory, measured as 3.4 acres, was along this ravine in the woodland edge, and it overlapped only the small

disjunct portion of the 1952 territory. The 1955 territory was measured as 3.9 acres, most of which corresponded with the 1954 territory, but .5 acre was separate, on the north side of the meadow, within the area of the 1952 territory.

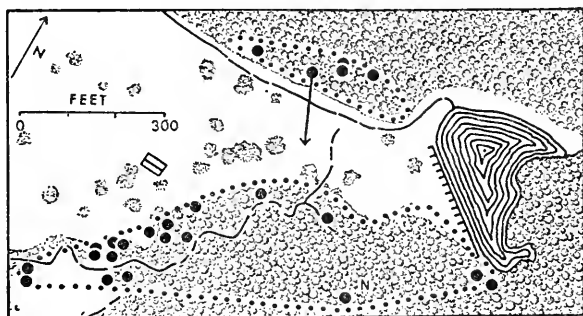


FIG. 22. Territory of a pair of Kentucky warblers in May, 1955, as revealed by singing stations of the male. The territory was in woodland edge thicket. A small part of the territory was separated from the remainder by the narrow end of a field. Arrow indicates the place where the warbler was seen to cross.

In May, 1956, a male that was singing persistently in dense woods on a northwest-facing hillside, was followed and observed frequently. A large elm, that was dead and bare, was the focal point of his activity and he returned to it regularly after frequent short forays in different directions. Unlike most other individuals that were noted, this one did most of his singing from high perches in the trees. His territory was only one acre.

Geothlypis trichas (Linnaeus)

Yellowthroat

Status.—Summer resident; many establish territories in early summer and some may breed on the Reservation.

Habitat.—The swampland habitat most typical of this species has been in some years totally lacking on the Reservation when the pond was dry and in other years at best was limited to much less than an acre in extent, in *Typha* patches at the edges of the pond. Nevertheless, many yellowthroats arriving on migration in late spring, settle on the area temporarily in atypical habitats. Some have been found established in grassy fields, both in bottomland and on hilltops. Others have been seen in woodland edge thickets, and still others in woodland, where undergrowth of gooseberry and

coralberry was plentiful. Just west of the Reservation boundary a small alfalfa field provided the territory for one of these birds in 1949.

Movements.—Yellowthroats were seen and heard most often in May upon their arrival from their northward migration. Earliest recorded dates on the Reservation for several years are: May 14, 1950; May 17, 1952; May 9, 1953; April 26, 1954; May 4, 1955; May 3, 1956; and May 8, 1957. The singing males established themselves temporarily in a variety of situations, such as: fields of brome grass; willow grove beside the pond; thickets at field border; dry, south-facing slope with thorny woods and thick undergrowth; alfalfa field. In June and early July they were seen or heard relatively seldom, and so few were noted after mid-July that it seemed they must have moved away from the area except for occasional stragglers. In 1953 one was seen repeatedly at the pond and near it in late July and early August. In 1955 one was seen at a fence along the edge of a field of tall grass. Only one territory of a yellowthroat was measured. It was 3.4 acres, based on only 5 marginal points. Perhaps the relatively large size of this territory was due to some lack in the habitat.

Stewart (1953:105) recorded territories of ten monogamous males which averaged $1.26 \pm .12$ acres (.8 to 1.8), while one polygamous male occupied a territory of 3.4 acres. Brewer (1955:141) recorded five territories in a swamp habitat in southern Illinois, with an average of .56 acre (.24 to 1.09).

Icteria virens (Linnaeus)

Long-tailed Chat

Status.—Regular summer resident but in variable numbers.

Habitat.—Limited to situations where there are dense thickets such as blackberry, and rank weedy growth.

Movements.—Over a period of several years earliest dates of record on the area for chats were: May 9, 1953; May 12, 1954; May 14, 1955; May 18, 1956; and May 10, 1957. Most records are for May and June, but probably chats remain through the nesting season. Because of their retiring habits and the dense cover of their habitat, they might have easily escaped attention after the singing and use of prominent perches associated with establishment and defense of territory stopped.

In May and June, 1955, a singing male was heard and followed several times in a hilltop field. A sapling thicket with crabapple, American elm, osage orange, honey locust and other woody plants,

up to ten feet high, provided such dense cover that the chat was rarely glimpsed. The thicket area was approximately .9 acre in extent and was well separated from other suitable habitat. The chat's territory seemed to be co-extensive with the thicket. In May and June, 1956, a chat was followed as it moved about and sang, along a gully bordered with thickets of wild plum and various other shrubs and saplings. On both sides of this gully there were formerly cultivated fields, but on one side woody vegetation, chiefly of elm saplings, was invading the field. The chat used this thicket also, though preferring the denser growth adjacent to the gully. The territory encompassed by its movements while singing was 575 feet long and 230 feet wide at the broadest point, covering approximately two acres.

Brewer (*loc. cit.*) recorded four yellow-breasted chat territories that averaged .33 acre (.14 to .71).

Wilsonia pusilla (Wilson)

Wilson Warbler

Status.—Occasional migrant.

Habitat.—Boreal forests in breeding season; tropics in winter.

Movements.—The only definite record is of one seen in the elm grove near the headquarters on May 19, 1953.

Wilsonia canadensis (Linnaeus)

Canada Warbler

Status.—Occasional migrant.

Habitat.—Boreal forests in breeding season, tropics in winter.

Movements.—The only definite record is of a male seen on May 15, 1953. It was working through an elm grove near the headquarters in the morning, and shortly before dusk one (presumably the same) was seen at the edge of the woods 100 feet farther south. It was foraging by catching flying insects, darting out in pursuit at intervals of a few seconds.

Setophaga ruticilla (Linnaeus)

American Redstart

Status.—Rare migrant.

Habitat.—Woodland.

Movements.—On May 3, 1952, a pair was seen and heard in a thicket near the Reservation headquarters by Richard Fredrickson and Mr. and Mrs. Bert Chewning. On May 15, 1953, I saw a male

moving rapidly through the tops of large elms and it chased away another small bird, perhaps of the same species. These are the only definite records for the Reservation.

Passer domesticus (Linnaeus)

English Sparrow

Status.—Frequent but irregular visitant; does not breed on the Reservation.

Habitat.—This introduced species is characteristically associated with man-made structures and altered habitats. In northeastern Kansas, large flocks frequent nearly every farmyard. Roadside hedges of osage orange and other thorny trees and shrubs that border grain fields or are near to farm buildings often are the headquarters for such flocks. Where grain is grown or where poultry or livestock are kept, the food supply encourages sparrows. Lone sparrows, pairs or small groups often were attracted to the buildings at the Reservation headquarters. Nesting sites, thorny thickets for shelter, and grain for food (that used as bait for trapping birds and rodents) were available, but the sparrows never became established on this natural area.

Movements.—All but two of 25 recorded occurrences on the Reservation were in late January, February, March, and April. The visits to the area seemed to be motivated primarily by a search for nesting sites. Individuals or pairs might visit the area daily for several days or even several weeks. They might stay for only part of the day. A barn and farmyard slightly less than a mile to the west were the source of most of the individuals that came, or perhaps of all. These pioneering sparrows were wary, and upon being disturbed they would flush, circle over the area gaining altitude, and, heading west, would pass out of sight in high, rapid flight. Usually they would not return the same day. Those sparrows that came alone were all males. On November 21, 1955, a pair was hovering about the eaves of the garage, probably in search of a nest site. On April 13, 1956, a pair was seen carrying nesting material to an elm at the headquarters, but this nesting attempt was abortive.

In the spring of 1957 there were several dozen sparrows on the Rockefeller Tract. They nested in the barn and several sheds, about the house, and in nearby trees. By July most of these sparrows had left. The buildings were no longer in use, and high weeds had grown up in the adjacent areas that were formerly under cultivation, evidently creating conditions unfavorable for the sparrows.

Sturnella magna (Linnaeus)

Eastern Meadowlark

Status.—Common resident in general area but rarely present on Reservation.

Habitat.—Meadowlarks in this area occur mainly in hay fields, and prairie habitats where grass is fairly short. The habitat deficiencies of the Reservation are not clearly apparent. As compared with nearby occupied habitat on farmlands the habitat on the Reservation differs in having a heavy accumulation of dead vegetation on the ground, and in having denser grass. Neither the extensive areas of brome grass fields, the original bluestem prairie patch nor the re-established prairie have meadowlarks ordinarily. In view of this bird's great abundance in the general area, its sporadic appearance and brief sojourns on the Reservation are somewhat remarkable. In most instances the individuals heard or seen on the area have not remained for more than a few minutes, but nesting has been attempted on several occasions.

Movements.—In 1948, when the area was still grazed, the habitat was unfavorable for meadowlarks. The first time one was seen on the area was on June 1, 1949, in a hilltop field, where a crop of new grass provided cover. None was known to have nested on the Reservation that summer, but several were seen there in October and November. In 1950, 1951 and 1952, meadowlarks appeared briefly on the area in April and early May. Obviously these individuals were dispersing in search of territories for the nesting season. Some were in pairs. Singing and pursuit were common, but in each instance the birds soon moved off the area. In 1953 on March 20, a pair was found established in a hilltop field dominated by brome grass. In the next two months these birds were seen many times, and on several occasions were followed and caused to flush several times in succession. The area covered was 2.8 acres. In 1956 a male appeared on March 24, singing in the field near the headquarters. Subsequently he appeared there regularly, sometimes accompanied by another. After arriving together, the two would separate and sing from different trees, or from lower perches, usually with no show of hostility. However, on April 12 three were seen circling and dodging over the field in a high rapid pursuit. The area which the male was seen to cover was 1.4 acres, and two trees 250 feet apart were his favorite singing stations. He did not acquire a mate, and he disappeared from the area in mid-April.

The failure of the meadowlarks that settled on the Reservation almost every spring to consummate their nesting cycle there probably was due to the presence of grain fields nearby. As the grain grew tall, these fields provided better nesting places than the fields of brome grass on the Reservation, which were then deserted by the meadowlarks.

In the spring of 1957 there were several pairs on the Rockefeller Tract. Their activities were concentrated in the former pasture and in the alfalfa field.

Sturnella neglecta Audubon

Western Meadowlark

Status.—Uncommon transient.

Habitat.—Typically, short-grass prairie.

Movements.—On March 3, 1955, one was heard singing in a tall grass prairie hilltop area of the Reservation near its northern edge. Later in the day a flock of 19, probably of this species, were seen flying northwest over the same field. On November 1, 1955, at 9:30 A. M., a small flock was perched on a wooded and brushy hilltop near the west edge of the Reservation. They were resting, and singing from time to time. One chased another, and both flew out of sight to the west. Two days later a flock was seen foraging at the edge of the county road $\frac{3}{4}$ mile farther south, in an area of big bluestem. After heavy snowstorms, in early January, 1956, western meadowlarks were seen and heard frequently in a pasture adjoining the Reservation on the west, and along the county road just southwest of the Reservation section. One was singing in the pasture on the Rockefeller Tract on October 9, 1957.

Xanthocephalus xanthocephalus (Bonaparte)

Yellow-headed Blackbird

Status.—Uncommon transient.

Habitat.—Marshland.

Movements.—On November 17, 1955, a flock of 50 or more was seen flying south over the headquarters, strung out on a wide front, as is characteristic in migrating blackbirds. On November 12, 1956, a similar migrating flock, with a few starlings intermingled, was seen at the same place.

Agelaius phoeniceus (Linnaeus)

Redwing

Status.—Several pairs usually are summer residents at the small pond. Thousands migrate over the area without stopping in spring and autumn, and many stop only for short periods.

Habitat.—The small pond and the marsh habitat about its edges provide the only breeding habitat on the Reservation.

Movements.—Redwings were seen on the Reservation chiefly as migrants in spring and autumn. Each spring the pond attracted them, but because of the uncertain water supply, they sometimes did not stay to nest. In the period of years 1948 through 1952, and in 1957, with moderate to heavy precipitation, the pond retained water at least through the early summer, and redwings nested in the marsh at the edge of the water. In 1953 through 1956, with more meager precipitation nesting was unsuccessful there. Singing was first heard at the pond on March 20, 1951; February 29, 1952; March 13, 1953; April 6, 1954; and March 15, 1955. Mass migrations were noted each spring, sometimes beginning in early February, and sometimes lasting into late April. Autumn migration was noted chiefly in October and November. In 1954 spring migration reached its peak on approximately March 12, although it had been in progress since early February. On March 12, weather was unseasonably mild, with a high wind from the southwest, and redwings were passing over by the thousands. They were in sight or hearing almost continually. Some were flying alone, others in twos or threes or larger groups up to those numbering many hundreds. Such large flocks strung out on a broad front, sometimes as much as half a mile across.

In contrast to the loose formation of the flocks that were actually migrating was the compactness of flocks that lingered in the vicinity for periods of days, or even weeks, in spring. These flocks came to the Reservation to roost in late afternoon or early evening, usually not appearing until near sunset, and otherwise their daily routine of activity was unknown. Presumably they foraged and visited prospective nesting areas within a radius of a few miles. Flying swiftly, in close formation, a flock of up to 200 birds would maneuver over the area and then settle in the top of one of the tallest trees available, where they would chatter and sing in chorus.

In the hour or more that sometimes elapsed between its appearance and its final settling to roost, the flock would normally shift several times from one high tree to another, sometimes splitting into two or more units, and sometimes joined by new contingents. When finally it had become nearly dark, the redwings would fly into tall grass to roost, each bird choosing its own moment for the descent, and finding its own spot to settle. Usually only part of a flock would settle in any one small area, and the remainder might shift uneasily to another tree before finally going to roost. That such roosting aggregations consisted largely of the same individuals over periods of days or longer was strongly indicated by return of the flock to the same trees in more or less the same sequence on successive evenings. In 1954 the roosting aggregations were seen daily over the period March 8 through April 5. Within this period the largest aggregations were seen in late March and April.

In spring male redwings always appeared at the pond and sang, well before any females were in evidence. In some seasons, when habitat conditions were unfavorable, females probably did not come there at all. The entire area about the pond that was used by redwings, was less than two acres in extent; the area actually available for nesting was variable, but usually was considerably smaller. The male redwings that came to the pond in the early part of the nesting season spent only a part of each day there. Often two or more males travelling in high rapid flight, would come to the pond together, and perch separately in tall trees to sing and display. In departing also, they usually kept together, in high rapid flight, probably headed for distant roosting areas.

Nero (1956:130) found the average size of territory for 17 well established males to be about 1/12 of an acre. He found that size of territory varied inversely with the population density. Males are polygamous, and one's territory may have several mutually hostile females living within it. These females may be at different stages of the breeding cycle.

Icterus spurius (Linnaeus)

Orchard Oriole

Status.—Rare visitor.

Habitat.—Parkland, and trees in relatively open situations.

Movements.—On May 16, 1951, a group of at least eight was in a Kentucky coffee-tree (*Gymnocladus dioica*) at the Reservation headquarters. Only two were males in breeding plumage. All

were feeding avidly on the flower buds of the tree. In 1958 orchard orioles were seen or heard on the area almost daily in late May and June, but in the intervening seven years none was recorded.

Icterus galbula (Linnaeus)

Baltimore Oriole

Status.—Moderately common summer resident in general area but not known to breed on Reservation.

Habitat.—Groves of large deciduous trees.

Movements.—Earliest appearances over several years were: April 28, 1951; May 16, 1952; May 6, 1953 (one seen three days earlier at Ottawa, 30 miles south); May 4, 1954; April 27, 1955; May 12, 1956; and May 1, 1957. In each instance the earliest record was of a male, and males may have arrived a little sooner than females. In no instance, so far as known, did Baltimore orioles remain on the area through the nesting season. Records were chiefly from May (19 different dates) and from August (15 different dates), with relatively few between (June 20 and July 16, 1954; July 31, 1955). The species must have found conditions unsuitable for nesting, for those individuals that had stopped on the area soon shifted elsewhere. The reappearance in August probably coincided with the end of the nesting cycle, at least for those individuals involved, which shifted away from their nesting territories as conditions changed there and became less favorable.

In 1953 the August visitation involved a pair and one or more fledglings that were still dependent. These orioles appeared abruptly on August 21; thereafter they were seen or heard daily through the remainder of the month, and from time to time in early September (last record on the fourteenth). The records of this group encompassed an area of 2.1 acres. In 1955, after the first appearance on April 27, a male which probably was the same, was present continuously until May 18. He was singing almost continually during the first few days, but on May 4 he abruptly became much less vocal and remained so during the latter part of his stay. The area encompassed by his movements was approximately 10.6 acres, in the shape of an elongate ellipse, with its long axis 1200 feet from end to end, extending along woodland edge.

In 1957, on the Rockefeller Tract, a cottonwood near the house was much used by an oriole and nesting may have been attempted there.

Euphagus carolinus (Müller)

Rusty Blackbird

Status.—Regular transient in migration in spring and autumn; occasional in winter.

Habitat.—Swampy areas of boreal forest in nesting season; in winter range, which includes region of this study, requires such areas as open fields or closely grazed pastures, because of habit of foraging on ground.

Movements.—On October 21, 1948, several were seen and on the morning of October 25 a flock of several thousand settled in the grove at the edge of a hilltop field. These blackbirds may have stopped to forage in the heavily grazed pastures which at that time still had livestock in them. Soon afterward the livestock were removed, and the blackbirds were never again seen in such numbers.

The two December records were of lone birds; on December 16, 1953, a male was seen foraging at the edge of a frozen pond, and on December 2, 1955, a juvenile was foraging with a flock of starlings and robins beside the headquarters building. This was in the yard where grass and weeds had been cut the preceding summer. On January 28, 1957, when the ground was snow-covered, a flock of 35 was seen at the northwest corner of the Reservation, and foraging in an adjacent field of milo stubble. On October 19, 1955, and November 12, 1954, southward migrating flocks passed over. On November 3, 1948, and November 20, 1951, flocks were seen resting in the headquarters area. In spring, March 11, 14, 22, 23, and 24, 1955; March 14 and 16, 1956; April 9, 1954; and April 3 and 5, 1955, rusty blackbirds were seen in compact flocks on the Reservation. These flocks invariably came to the area in late afternoon, attracted by the dense ground vegetation providing favorable cover for roosting. A compact flock would often perch for 10 minutes or more, chattering and singing, and would shift from tree to tree several times before finally going to roost.

Quiscalus quiscula (Linnaeus)

Bronzed Grackle

Status.—Regular migrant in spring and autumn, but usually as transient flying over area without stopping.

Habitat.—Short ground vegetation, permitting easy walking and an unobstructed view, perhaps is the one requirement that is consistently lacking on the Reservation, making it unattractive to the

grackle, which is a common breeding species locally on farmlands and suburban areas.

Movements.—The only definite record of the grackle stopping on the Reservation was obtained on April 4, 1951, when a flock of more than 2000 were foraging in a hilltop field of brome grass. In flushing they split into two groups that flew west across the area. Within the next few hours a large flock was seen several times maneuvering over different parts of the Reservation. These grackles flew in a compact mass, and as they flushed or turned, their wingbeats produced a roaring sound. While on the ground or perched they kept up a chattering that was audible half a mile away.

In contrast, those that were passing over on migration were flying parallel, strung out on a broad front. Often they were flying with redwings. On October 31, 1952, at 9 A. M., a large flock passed over headed south. On February 14 and 16, 1954, several were seen flying high headed northeast. On March 2, 1954, a flock of several hundred, on a front more than 100 yards wide, passed over headed north.

Molothrus ater (Boddaert)

Cowbird

Status.—Common summer resident.

Habitat.—Groves along edges of bottomland fields are preferred on Reservation in spring and summer, but probably every part of area is used to some extent.

Movements.—Ordinarily cowbirds are present on the area only during the nesting season. An unusually late record was November 7, 1949. A group of 30 or more was in a thicket at the edge of a field, and many of them were feeding on the fruits of dogwood (*Cornus drummondii*). These were probably transients from farther north, that were passing on migration. Flocks of cowbirds winter in the region of the Reservation, but they stay about farmyards and pastures, where there are cattle or other livestock, and none has been seen on the Reservation. These wintering flocks presumably are from farther north in the species' range.

In early spring each year, newly-arrived singing males appeared abruptly on the Reservation. Within a few days their numbers were much augmented by new arrivals and females began to appear. As compared with other kinds of breeding birds on the area, cowbirds were notable for the wide variation in time of ap-

pearance from year to year. Over a seven-year period earliest dates of appearance were: April 14, 1951; March 24, 1952; March 13, 1953; March 28, 1954; March 31, 1955; March 22, 1956; and March 13, 1957. The earliest appearance, March 13, 1953, was somewhat different from those of other years, as three males were seen perched close together feeding on leaf buds, and not singing. On the following day others were seen flying over. On March 16 two were seen on the area, and from March 30 onward they were seen frequently.

Cowbirds were most conspicuous on the area in April, May and June. They were usually seen in small groups of two or three females and a somewhat larger number of males. These groups moved about from tree to tree, usually over an area of several acres, the males singing, displaying, and jostling each other for position. From time to time one bird or several might separate from the sexual aggregation and leave in strong direct flight. For the groups seen near the Reservation headquarters, the destination was obviously a pasture on the farm west of the Reservation, a distance of .5 mile to one mile. Only rarely were cowbirds ever seen on the ground on the Reservation, and the rank vegetation seemed to create conditions unfavorable for their foraging. Occasionally they were seen feeding in trees, but probably they obtained most of their food in pastureland beyond the limits of the Reservation, and came there only for breeding. As the season advanced, throughout most of the summer, the aggregations were seen much less frequently; cowbirds seen were mostly females, which were silent and furtive in behavior, lurking in thickets and crowns of trees. Although a high proportion of all birds' nests on the Reservation are parasitized by cowbirds, fledgling cowbirds have rarely been noticed on the area.

Piranga olivacea (Gmelin)

Scarlet Tanager

Status.—Recorded on Reservation only as spring migrant.

Habitat.—Deciduous forest.

Movements.—My only record of this species was obtained on June 13, 1951, when a pair was seen flying across a field to a large elm near the Reservation headquarters, a few minutes before sunset.

Piranga rubra (Linnaeus)

Summer Tanager

Status.—Moderately common from late April to early September; several nesting pairs each year.

Habitat.—Deciduous forest and edge.

In most instances pairs were observed in dense woods of predominantly oak-hickory type, but they also foraged frequently in more open groves of elm and walnut adjacent to the denser woods. The males tended to choose as singing stations large trees somewhat apart from the main woodland. Several large honey locusts in fields near woodland edges were the most used singing stations of different males.

Movements.—Earliest recorded dates for several years were: April 27, 1951; April 26, 1952; April 28, 1953; April 24, 1954; April 30, 1955; May 4, 1956; and April 30, 1957. In every instance the first individual noted was a male, and possibly the males arrive a little earlier than the females. Nest-building was observed in 1953 (Fitch and Fitch, 1955:48). Only the female carried material, but the male stayed nearby. Some of the stems used were collected on the ground beneath the nest, but nest-building for the first few days proceeded at a leisurely pace. The female was first observed at the nest site on May 11. By May 18 she was observed carrying stems for the nest foundation. Building continued at an accelerated rate through May 24. Much of the nesting material was gathered along a ravine at the edge of woodland 200 feet from the nest.

When the young tanagers in the nest were just one week old, they climbed out along the limb nearby, and one by one fell into tall grass. At this stage they had only begun to feather out, and were almost helpless. After spending three days in the grass near the nest, they were sufficiently developed to fly into nearby trees. The whole family then soon shifted to the wooded ravine 200 feet or more from the nest tree, and were seen there frequently in the following three weeks.

The territory within which most of the activity of the pair of tanagers was limited, was measured as 4.3 acres, in a broadly elliptical area, which was mostly in an open grove of large American elms at the edge of woodland. From time to time, however, one or both

birds were observed well beyond the limits of this usual area. The seven most outlying points encompassed an area totalling 20.8 acres. Lack of territorial pressure probably encouraged these birds to wander frequently beyond their home area. Each year at least six pairs of summer tanagers nested on the Reservation, but their territories were so well spaced that no more than one at a time could be heard singing. Encounters between members of different pairs were never observed, and must have occurred relatively seldom. Each year singing ceased abruptly in the second week of August. My latest records are on September 27 (1953 and 1957).

Richmondia cardinalis (Linnaeus)

Cardinal

Status.—Common resident, using every part of Reservation except extensive open fields; populations fluctuate from year to year and from season to season; greatest numbers present in winter; migrational shift of populations evidently occurs from summer to winter.

Habitat.—Dense thickets in edge situations adjacent to woodland and fields are preferred. Thick thorny shrubs such as osage orange, crab apple and honey locust are favorite nesting sites. Dense woodland edge, and thickets along roads and creeks provide shelter and resting places, but cardinals forage in a wide variety of situations, and utilize many different food sources.

Movements.—In late autumn each year cardinals suddenly became more abundant and conspicuous. Unusual concentrations, probably made up mostly of new arrivals, were noted on: November 8, 1948; November 14, 1951; October 29, 1952; November 30, 1953; and October 17, 1955. Even larger concentrations were sometimes noted in late winter at times when weather was unusually severe, and ground was snow-covered. The extent of population shifts in response to extremes of weather was not determined.

Cardinals sing throughout the year, but singing is at low ebb in November, December, and January. It occurs only on clear, still mornings when weather is unusually mild. Singing tends to increase throughout February, although it is temporarily stopped by wind, low temperature, snow, or rain. By early March males are beginning to establish territories.

In winter individuals are highly tolerant, and several may feed or perch in proximity. However, aggregations are drawn together

by food supply, shelter, or other attractions, rather than by sociability. Usually each individual is more closely associated with other small passerines, such as Harris sparrows, tree sparrows, song sparrows and juncos than with members of its own species.

On November 30, 1953, when a group of cardinals had gathered in a spot exposed to the early morning sunshine, there was brief singing, and a male chased a female persistently. Several other males, excited by the pursuit, were trailing along, chiefly to harass the first male, it seemed, rather than to catch the female.

For the cardinals live-trapped in winter, distances between successive captures averaged 413 feet for 49 marked males, and 565 feet for 31 records of females. Home ranges of 12.2 acres for males and 22.9 acres for females are indicated. Not included in this computation are three exceptionally long movements (one of a male and two of females) of nearly half a mile each. These are thought to represent shifts in range. For those intervals including one or more summers between successive captures, distances averaged no more than for intervals within the same winter.

Approximately the first week of March the males, having established territorial singing stations, become increasingly intolerant. A typical encounter was observed on the morning of March 8, 1957, at the edge of woodland. Two males were hopping about briskly, with crests erect and tails jerking, within a few feet of each other, occasionally giving metallic chirps. When one would fly, the other would follow close behind. There was no actual contact. Usually the chase led back and forth along the edge of the woods in an old diversion ditch, but occasionally the birds crossed a narrow field to edge of woodland on the opposite side, 150 feet or more away.

For a period of weeks stress increases as males defend their newly established territories against the encroachment of neighbors, and against the wintering cardinals still wandering over home ranges in the general area. However, territoriality develops gradually. Singing and hostile behavior is most noticeable in early morning. Later in the day the males may relax their vigilance and mingle with others with little indication of intolerance. In periods of stormy weather, territorial behavior may be suppressed entirely. Formation of pairs occurs only after the males are thoroughly ensconced on their territories. Females still ranging freely over their large winter ranges, are followed and courted by the males whose territories they cross. In competition for mates actual fights are frequent, along with intimidating displays and pursuits. On March 9,

1954, two males that were chasing the same female stopped to fight violently. They fluttered near the ground, sparring, their wings rattling together. In the period March 16 to 19, 1952, two males having newly established territories along the edge of the woods near the Reservation headquarters were observed frequently. Their territorial centers seemed to be about 150 feet apart. Each often strayed into the other's territory and was chased back, the pursuer usually stopping abruptly near the same place, where a mutually accepted boundary seemed to be situated. After such a pursuit the males would stop a few yards apart, each on his own side of the boundary. They would watch each other, flicking their tails and uttering clicking notes, then would fly to high perches and sing. A female seemed to be staying in the general area, ranging over both territories, and she was the object of frequent pursuits, sometimes by both males simultaneously. She would fly rapidly from tree to tree and bush to bush, along the ravine in the edge of the woods avoiding the males with frequent quick turns. In these pursuits the males became so preoccupied as to forget defense of their territories, but occasionally one would dart at another. Once a second female, which had been watching with excited chirping, interposed herself, so that all four birds were strung out in a line, the two males bringing up the rear.

On April 16, 1952, an encounter was observed between four cardinals which seemed to consist of a male chasing a prospective mate, and an established pair whose territory was violated in the course of the pursuit. The paired female was not chased but she followed the pursuit with hostile behavior directed largely toward the unattached female. The paired male followed the other male and from time to time intercepted him and engaged him in short fights. The wrangling continued for approximately half an hour that the birds were watched. On April 22, 1955, when persistent scolding attracted my attention, I observed a male trying to head off a female and drive her back into the area presumed to be his territory. A second male was interfering. Occasionally the two males closed in and struck at each other. Much of the month of March is spent in such maneuvering.

By early April most cardinals are paired. An unusual feature of territoriality in this species is the singing of the female. On occasion, persistently singing birds assumed to have been males turned out to be females. Paired females have been heard to give a burst of song in reply to each burst of the male, as he sang from a nearby territorial perch.

No territories of cardinals were actually measured. The somewhat secretive habits of the birds in the season of nesting made it difficult to follow their movements. Nine intervals between occupied nests ranged from 220 feet to 560 feet and averaged 391. That this distance was somewhat representative of the diameter of a territory was borne out by the distances measured between adjacent singing males in 169 instances. This distance between the singing males averaged 416 feet indicating an average territory of 3.1 acres if it be assumed that the territories are circular and have common boundaries.

Brewer (1955:141) recorded an average area of .37 acre (.31 to .45) covered by five cardinals in a swamp thicket habitat in southern Illinois. The small size of the "minimum home range" obtained by Brewer, in this and other instances probably result from inadequately small series of records.

Pheucticus ludovicianus (Linnaeus)

Rose-breasted Grosbeak

Status.—Regular migrant or transient in spring, some stopping on the Reservation for periods of days or weeks, but not known to nest.

Habitat.—Deciduous forest and parkland situations are occupied in the breeding season. On the Reservation it has been seen and heard chiefly on a northwest slope in mesic mixed forest, with ash, hickory, elm, chestnut oak and black oak, and in a willow grove at the pond.

Movements.—Seen or heard on the following dates: 1951, April 30; 1952, April 29 and 30, May 17 and 22; 1953, May 19; 1954, May 15; 1955, May 8, 9, 13, 14 and 16; 1956, April 26, 28, 29, May 2, 4, 5, 7 and 26. It is noteworthy that each year all had disappeared by June 1, although they seemed to be settling down and establishing territories in May. Often those seen were feeding and moving about in pairs. On April 30, 1951, two males were eating leaf buds of ash in the same tree. Similarly on May 7, 1956, two males were feeding together in the same tree. On other occasions, pursuits were seen, but on May 5, 1956, three pairs were feeding together in a willow grove, all within a 50-foot radius, with no sign of hostility. Abundant larvae of chrysomelid beetles on the willow leaves made this an attractive feeding place. Probably all those seen on the Reservation were recent arrivals, which had not yet settled down permanently or established territory.

Guiraca caerulea (Linnaeus)

Blue Grosbeak

Status.—Summer resident on areas immediately adjoining Reservation, but rarely crosses boundary.

Habitat.—Brush.

A wooded slope of north and west exposure adjoining the west edge of the Reservation, was bulldozed in late winter of 1949. By 1952 the area had grown up into a thicket, with numerous stump sprouts of hickory, oak and elm, high weeds, and with the partially burned debris of uprooted trees piled at the bottom of the slope. Grosbeaks were first definitely recorded in 1952, and were present regularly thereafter.

Movements.—Two pairs were present on the brushy strip west of the Reservation in 1955 and 1956. The male of one pair was frequently seen along a 250-foot stretch of road, perched on telephone wires and occasionally his mate was with him. The territory was at least 200 feet wide, and thus included a minimum area of $1\frac{1}{4}$ acres. Farther south along the road a second pair was often seen, but a stretch of some 350 feet intervened where none was recorded.

Passerina cyanea (Linnaeus)

Indigo Bunting

Status.—Common summer resident, late April through September.

Habitat.—Low thickets in or near fields with grass, weeds or cultivated crops provide the preferred habitat of the indigo bunting. From 1948 through 1958 conditions have steadily improved for the bunting, because thickets have encroached into formerly pastured areas. These thickets, of crab apple, honey locust, osage orange, elm, and a few other trees, have created abundant shelter and nesting sites for the buntings. The most dense population of buntings noted was on a north slope just west of the Reservation, wooded until 1948, when it was cleared by bulldozing. The piles of broken tree trunks, limbs and roots were partly burned. In the next few years saplings of oaks, hickories and other trees sprang up in large numbers. Also, there were many vines and thick weeds, so that by June, 1955, the area was an almost impenetrable tangle.

Movements.—Earliest recorded occurrences of the indigo bunting for the period 1952 through 1957 on the Reservation were in early May each year, the third, fourteenth, ninth, second, fourth and

fourth. Singing was chiefly in May and June, but continued into early August. My latest record is for September 15, 1953.

Despite the abundance of indigo buntings on the area, it proved difficult to trace out the territory of any one individual because of their shyness and frequent flight, and the difficulty of recognizing individuals. One territory, measured on the basis of 15 recorded movements within it, was 2.7 acres. In 32 instances the distances between adjacent singing males were recorded, and they varied from 1300 feet to 110 feet, averaging 504 feet. A territory of this latter diameter would cover approximately 4.6 acres. Brewer (1955:141) recorded an average area of only .26 acre (.15 to .52) for five indigo buntings in swamp thicket habitat in southern Illinois.

Passerina ciris (Linnaeus)

Painted Bunting

Status.—Rare, probably occurs on Reservation only as summer transient.

Habitat.—Brush and woodland edges.

Movements.—The only recorded occurrence of this species was obtained on May 14, 1950, by Mr. and Mrs. Bert Chewning. The bunting was heard (but not seen) singing at the edge of a brushy, south-facing slope where the woodland adjoined a meadow.

Spiza americana (Gmelin)

Dickcissel

Status.—The dickcissel is one of the most abundant of breeding birds in the general area. Since 1948, when the Reservation consisted of woodland, closely grazed pasture and cornfields, plant succession has proceeded. Certain areas have grown up to tall grass and weeds and have become favorable habitat for dickcissels.

Habitat.—Grassland.

Under modern conditions in northeastern Kansas most dickcissels nest in fields of wheat, barley, oats, or alfalfa. Singing stations are provided mainly by fence posts and by telephone wires at the fields' margins, and the singing males tend to be rather regularly spaced. On the Reservation dickcissels have become abundant in an old field that was sown to seeds of native grasses in 1949 and has taken on the aspect of a prairie since then, with tall grass clumps (big bluestem, little bluestem, switch grass, Indian grass, side-oats grama) in varying density interspersed with goldenrod and other

weeds in patches, with numerous saplings of elm, locust and other trees.

It is noteworthy that dickcissels are more numerous on parts of this field where a mixture of several kinds of grass had been planted than they were on parts where the several kinds were growing in separate strips.

In 1953 a single pair of dickcissels nested in the field of brome grass and bluegrass with numerous small trees, near the Reservation headquarters. In the years 1953 through 1955 another pair had a territory which included part of a field of bluegrass and brome, and part of a formerly cultivated field with stunted giant ragweed, and large patches of foxtail grass. In 1954 and 1955 several pairs were located in the southwestern part of the Reservation in a field of brome and bluegrass with thickets of saplings, adjoining an oat field.

Movements.—Arrival dates for the years 1951 through 1957 were April 30, May 3, May 4, April 29, May 1, May 2, and May 6. Within a few days after the first arrival males were abundant and conspicuous, spending much of their time singing from territorial perches. No dickcissels have been seen on the area after the end of July. If they remain on the area at all, they must become extremely silent and secretive.

Because of their tameness, and the open nature of their habitat, dickcissels could be studied, with respect to territory, more readily than any other species of bird present on the Reservation. While singing, they would often allow approach to within 25 feet, and when flushed, they would usually show no alarm but might move only a few yards, to a nearby perch. By following such an individual from perch to perch for a short time, it was easy to determine the approximate extent of its territory. Nine territories investigated in this way ranged from 1.4 to .5 acres and averaged .9 acre. In 14 instances the distances between adjacent singing males, where the habitat appeared to be continuous, varied from 450 to 60 feet and averaged 296. Assuming that this distance represents the diameter of an average territory, an area of 1.6 acres would be represented. Presumably the discrepancy between this figure and the .9 acre of territories actually measured results in part from the fact that some territories were incompletely recorded, and in part from the fact that there are some unoccupied spaces between territories. Therefore, an intermediate figure of approximately $1\frac{1}{4}$ acres may be most typical.

The largest territory measured, one of 1.4 acres, was in the meadow of brome grass near the headquarters, a habitat different from the tall-grass prairie where most of the dickcissels were observed. In the absence of competition this pair tended to cover a larger area than they would have otherwise. Records are far more complete for this pair, than for any of the other pairs observed. The territory of 1.4 acres was plotted from 30 locations, many of which were used many times by the birds during the course of observations. Occasionally the male was noted to sing from perches well beyond the limits of the area usually occupied, in each direction. The total area encompassed by these outlying points totalled 5.6 acres, but obviously most of this area fell outside the regular territory (Fig. 23).

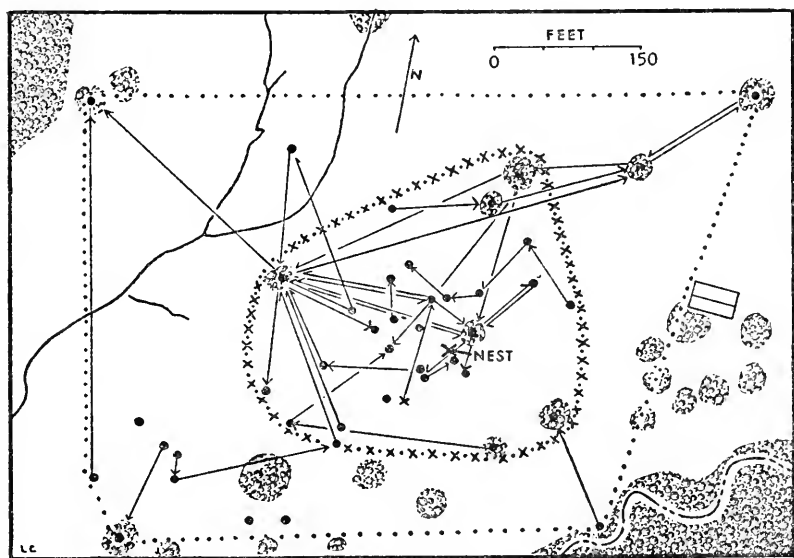


FIG. 23. Territory of a pair of dickcissels in June and July, 1953. So far as known the female kept to the relatively small central area, but the singing male, in the absence of competitors, often wandered to outlying stations. Lines show observed movements.

The pair first appeared on this territory on June 10, 1953, probably after an unsuccessful nesting attempt elsewhere, because more than a month had elapsed since arrival of dickcissels and establishment of territories in the general area. Each time the male sang, the female answered with a low buzzing sound. The female was seen carrying nesting material on the morning of July 9, and in the

afternoon of the same day the nest was found completed with one egg in it. By July 14 the clutch of four eggs had been completed, and hatching occurred on July 23-24. The nest was robbed on July 31, and on the following day the adults had left the territory.

On a few occasions, singing males that were followed too persistently and caused to take alarm, moved somewhat beyond the limits of their territories, with accompanying change in behavior. Ceasing to sing, they would skulk through low vegetation, instead of perching on the highest and most exposed perches available, as is usual with singing males.

Elsewhere in the general region, telephone wires at the edges of grain fields provide the most favored territorial perches. In the prairie area where most of the pairs were studied on the Reservation, there were no trees other than saplings. A telephone line along the north edge of the Reservation, on the edge of the prairie tract, therefore provided the best perches for singing males and it was used regularly by all those having territories along the north edge of the field. It was used also by several others whose territories did not adjoin the edge, unless a narrow corridor of travel to and from the wire be considered part of the territory.

In this area where several pairs lived in adjacent territories, pursuits were frequent, but usually they were brief and did not involve actual fighting. So far as observed, these territorial pursuits involved only the male.

Carpodacus purpureus (Gmelin)

Purple Finch

Status.—Occasional transient in winter.

Habitat.—On the Reservation purple finches were most often seen near the pond, which was the focal point of their activity. Stands of sunflower and other weeds attracted them, the seeds supplying an abundant food source. At other times, in fall, they were seen foraging in treetops, probably for dried fruits and berries.

Movements.—Purple finches recorded on the Reservation were usually travelling in small groups in high, rapid flight and they were among the most vagile of all birds in the area. Also, they were more wary than any except raptors and water birds, and generally would not permit approach closer than 200 feet. Twenty-two specific records were distributed as follows: October—8, November—6, December—3, January—1, February—none, March—2,

April—2. Earliest fall records were October 8, 1956; October 15, 1955; October 24, 1954; and October 15, 1957. Latest spring records were April 2, 1955, and April 12, 1956.

Spinus pinus (Wilson)

Pine Siskin

Status.—Occasional transient.

Habitat.—In breeding season, northern forests, usually associated with coniferous trees.

In its more southern winter range the species may prefer conifers also. No conifers are present on the Reservation, and in any case the area is, in general, unattractive to siskins, which have been observed there on only a few occasions.

Movements.—In the first week of November, 1954, siskins were seen many times at the pond where they were attracted by sunflower patches, and were feeding on the seeds. Again in late October and November, 1955, siskins were abundant at this same place and at a fallow field on the east side of the Reservation, where there were patches of sunflower.

Spinus tristis (Linnaeus)

Eastern Goldfinch

Status.—Common resident, using every part of Reservation; moves about freely, and numbers vary markedly according to season and food supply.

Habitat.—Activities are concentrated about weedy fields. Seeds of sunflower seem to be the one most important food source, and are used throughout the fall, winter, and early spring. Seeds of various other composites are used to a lesser extent. Since 1948 when formerly cultivated fields produced their first crop of pioneer annual weedy vegetation, the quantity of sunflower has steadily decreased, because this plant is most characteristic of the early stages of secondary succession. As a result, the area is used less by goldfinches. The dwindling sunflower patches continue to be focal points of their activity. In late March and April, when seeds of elm are maturing and are still on the trees, they are preferred food, and large restless flocks of goldfinches are much in evidence, moving about in the treetops or maneuvering over them.

Movements.—Goldfinches have not been recorded on the area in the months of February or June. While they doubtless visit

the area occasionally at all seasons, they are relatively scarce in winter and summer, and are much more frequent in September and October, and again in late March and early April. Those present in fall are seen singly or in pairs, while those present in spring are in large roving flocks attracted to the area by the abundant supply of elm seeds for food. Occasionally at this time of year they may be among the most abundant of birds present. Nesting activity has been noted chiefly in August and September. In August, 1954, several were noted in different places circling and singing at heights between 100 and 200 feet over hilltop grassland areas. In September, 1953, a pair nested in the headquarters area. Frequently they flew over the territory, in circles of perhaps 200 yards diameter, keeping a little above the level of the treetops. To forage, these goldfinches almost always left the Reservation, and on many occasions were seen to make flights of at least half a mile west or north to pastures and cultivated fields. Sometimes both members of the pair travelled together on these foraging expeditions, but more often they travelled alone. On September 14, a family group of five was seen maneuvering over the territory, and on September 15 a group of seven was noted flying toward the same area. In mid-October, 1954, goldfinches seen foraging in sunflower patches were in pairs.

Stokes (1950:114) studying the goldfinch's nesting habits in a dry marsh near Madison, Wisconsin, found territories were only 95 feet in diameter in an area of favorable habitat. He found that the territory, including the nest site, did not necessarily provide food, water, or nesting material. Territorial defense was strongest at the beginning of the nesting cycle, and was much reduced by the time the young had hatched. Nickell (1951:450) found three nests within a 50-yard radius in a dry swamp habitat, and concluded that the species is highly tolerant. His findings contrasted with those of Drum (1939:71-72) in a different type of habitat. The latter author found that territories were vigorously defended by the male, and sometimes also by the female, and that feeding areas were sometimes a mile or more from the nest.

Pipilo erythrophthalmus (Linnaeus)

Red-eyed Towhee

Status.—The towhee is moderately common throughout most of the year on the Reservation. However, the breeding population present in summer is of a subspecies different from the one present in winter. It is not definitely known whether there is seasonal over-

lapping between the summer and winter populations. Representatives of both populations may be present for a short time in April. Towhees have not been definitely recorded in September; there may be a period in autumn when neither population is represented on the area.

Habitat.—Blackberry thickets at or near the edge of woodland seem to provide the essential habitat feature for the wintering population. The birds seem to do much of their foraging in the ground litter beneath these thickets, and in their daily routine they shift from one thicket to another, spending relatively little time in other situations. They are seen most often away from thickets at times when the ground is snow covered and food is scarce. In summer the same blackberry thickets are used by the breeding population, but these towhees also use a variety of other situations. Thickets of wild plum, crab apple, fragrant sumac, osage orange, and locust along roadsides, streamsides or woodland edge provide preferred habitat. Territories may also include parts of the woodland where the crown canopy is not continuous and there is underbrush.

Movements.—The earliest spring records of the recently arrived singing males for the years 1951 through 1957 were: March 19, March 28, April 19, April 4, April 14, April 14, and April 6. Late dates of singing for the breeding population are: August 21, 1953; August 13, 1954; and August 10, 1956. Each year territories were established in the area of the Reservation headquarters. Most complete information was obtained in 1953, 1954, and 1956. In each of those years sizes of territories covered by singing males were measured. In 1956 there were two contiguous territories of 6.7 and 4.4 acres, one consisting of two woodland edge areas separated by a field, and the other consisting of three such units (Fig. 24). The towhees crossed the fields from one to another of the thicket areas—a maximum distance of approximately 500 feet, but they did none of their foraging there and ordinarily they stayed in the edge of the woods. In 1954 the same area was divided between three territories, of 4.7, 2.4, and 1.9 acres, of which only the largest had separate units. In 1953 there were two territories with 6.2 and 4.2 acres, the larger divided into separate units. Pursuits were observed from time to time. Only males were involved. In at least one instance the same tree was used by two different males for singing, on different occasions. On 14 occasions the distances between males, in adjoining territories, singing and answering each other, were recorded. These distances ranged from 1000 feet to 100 feet and averaged 238. If this distance represents the average

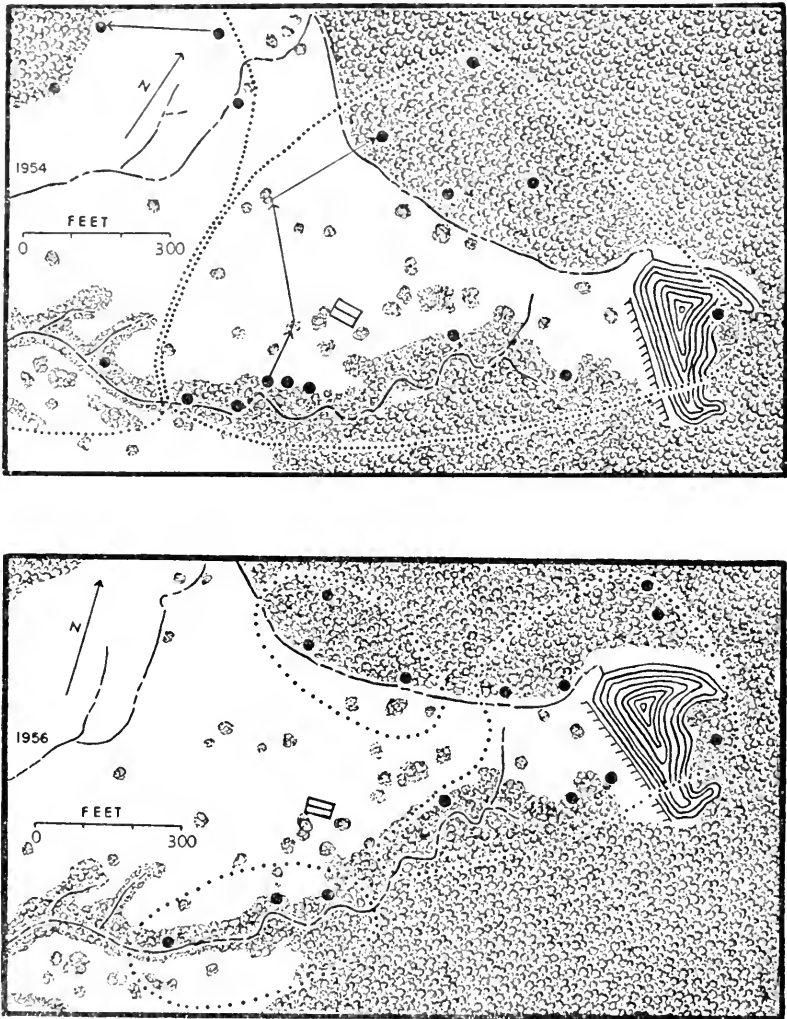


FIG. 24. Territories of spotted towhees, as revealed by singing stations of males (dots) in 1954 and 1956. Activity centered in blackberry thickets about margins of a field. In 1954 territories were relatively large; one encompassed the entire east end of the field and adjoining woodland. In 1956 most of this area was divided between three smaller territories. Although the towhees usually kept to woodland edge tangles, they occasionally crossed open fields. Routes followed in two such crossings in 1954 are shown by arrows in upper figure.

diameter of a territory, the latter would cover approximately 4.1 acres. This figure agrees fairly well with the 4.4-acre average of the seven territories actually measured. In the nesting season of 1955 territories near the Reservation headquarters were not continuously occupied. Towhees arrived on April 13 and singing and chasing were noted frequently in the following three weeks. Then they disappeared from the area and were not recorded again until June 30.

On several occasions a surprising degree of tolerance was noted between cardinals and towhees, which might even sing from the same tree simultaneously with no indication of hostility.

Towhees wintering on the area were much more vagile than those present in summer. A series of 50 distances between successive captures in males averaged 492 feet (2080 to 40) indicating an average home range of approximately 17.4 acres. Females probably wander less widely. Of 16 towhees that were banded and recaptured, 11 were males, three were females and sex was unrecorded in two. One female was caught four times in succession at the same place, and nowhere else. Another female made a movement of 220 feet and then was caught twice in the same place, and the third female made a movement of 380 feet.

Barbour (1941:593) studied wintering populations of the red-eyed towhee in eastern Kentucky. He found them to be associated in loosely organized flocks. Only 23.7 per cent of the towhees in these flocks were females, and Barbour surmised that the females tend to migrate farther south than the males. One flock covered an area of approximately 31 acres, another 9.4 acres.

Ammodramus savannarum (Gmelin)

Grasshopper Sparrow

Status.—Occasional resident or transient.

Habitat.—Grassland.

Movements.—In the first week of June, 1958, one was seen and heard several times, singing in fields north of the buildings on the Rockefeller Tract. When followed, it moved about in an area approximately 500 feet in diameter, including parts of two fields that were formerly cultivated and the northwest part of the adjacent

pasture. In early July, two were singing in the northern part of the pasture. No grasshopper sparrows have been recorded on the Reservation.

Passerherbulus caudacutus (Latham)

Leconte Sparrow

Status.—Transient and temporary resident in spring and autumn, and occasionally in winter.

Habitat.—Dense grass.

Movements.—Specific dates recorded are: October 23, 1953; November 2 and 6, 1954; March 11 and 14 and October 21 and 23, 1955; several times from March 22 to April 14, 1956; and on March 12 and October 17, and October 24, 1957.

Pooecetes gramineus (Gmelin)

Vesper Sparrow

Status.—Occasional transient.

Habitat.—Meadows and fields; patches of bare ground seem to be essential.

Movements.—On October 14, 1949, two were seen in a hilltop field of brome grass near the quarry, in the wheel tracks where there was little vegetation. On April 10, 1957, one was watched as it foraged in an almost barren field at the south edge of the Rockefeller Tract.

Chondestes grammacus (Say)

Lark Sparrow

Status.—Occasional summer resident.

Habitat.—Meadows, pastures and short-grass prairies where there are occasional trees.

In 1948 and earlier, when livestock grazed the area keeping herbaceous vegetation cropped short, lark sparrows were of much more general occurrence.

Movements.—Earliest records are: April 7, 1952, and April 11, 1953. An old eroded upland cornfield in the northeastern part of the Reservation had lost most of its topsoil and become dissected with deep gullies in the nineteen thirties. By 1952 the vegetation was still sparse, consisting chiefly of three-awn grass, lespedeza, and bindweed; patches of bare ground remained. Because of its barrenness this area was still used by lark sparrows after they had disappeared from other parts of the Reservation. On June 11, 1952,

a pair seen in this field behaved as if they had a nest nearby. On June 11, 1954, in another part of the field, a bob-tailed fledgling was flushed, and the parents were nearby. On April 11, 1953, and May 29, 1955, lark sparrows were seen in the meadow near the headquarters. On the latter date a male and female were moving about together, and the male repeatedly chased away another male in different directions from an area of approximately 300 feet by 500 feet along a gully beside which there were several perch trees. On April 5, 1956, a group was seen foraging at the northwest corner of the Reservation where bluestem prairie had been burned off the previous month, and new grass was beginning to appear.

In 1957 lark sparrows were present in abundance on the Rockefeller Tract, in formerly cultivated fields and a pasture. Most arrived in the first week of May. One pair was observed and followed frequently in the second week of May, this pair moved about in an area that was 1050 feet across in one direction and 650 feet across in another. The entire area encompassed by the birds' movements was more than 15 acres, but foraging was concentrated in relatively small parts of it, usually within 100 feet of woodland edge, or of isolated trees. An adjoining pair had a territory 700 feet across, and they were seen to defend both boundaries against their neighbors. In foraging, the lark sparrows of a pair tended to keep within a few yards of each other as they wandered on open ground. When one flew the other usually would follow within a few seconds. Many territorial encounters were seen. The males were most active in these encounters. They would approach each other with wings drooping and tails spread, and such meetings usually led to fighting or pursuit. In one encounter between two pairs a male seemed sexually excited by the presence of the second pair. After each short flight he would momentarily mount the female.

Junco hyemalis (Linnaeus)

Slate-colored Junco

Status.—Regular winter visitor, usually most abundant of all birds during time it is present on area—early October to late April.

Habitat.—Chiefly open situations; fields, meadows and woodland edge.

There is some habitat shift according to weather conditions. The first juncos to arrive in autumn may be present while weather is still warm, and they tend to keep in deep shade in cool and sheltered situations. When ground is snow-covered they forage mostly

in open fields. To roost, the juncos of a flock usually settle in thick grass—most often they have been flushed from awnless brome grass which is the dominant grass on the Reservation. When fields are snow-covered many roosting juncos have been flushed (usually one at a time) from the protected niches beneath overhanging banks along ditches and gullies.

Movements.—From 1949 through 1957 the earliest records of juncos on the area in fall were: October 22, October 17, October 20, October 4, September 29, October 17, October 24 and October 11. Late records in spring include: April 23, 1950; April 8, 1953; May 6, 1954; April 22, 1955; April 20, 1956; April 25, 1957. A few stragglers remain in spring, weeks after most juncos of the wintering population have left. Likewise in early fall while weather is still mild, weeks before the main influx of wintering juncos, small groups appear.

In several instances the same banded individuals were caught on the area after an intervening breeding season. One male was recorded in each of four consecutive winters, but each winter most of the juncos caught were individuals not recorded in previous years. Of the juncos banded, many were never recaptured. A total of 76 were recaptured at new locations providing data concerning movements. For a total of 122 recorded movements (distances between successive points of capture), the average was 485 feet. Not included in this average are movements of five individuals recaptured after an intervening summer. Distances for these averaged 858 feet, probably indicating that returned migrants altered their home ranges somewhat, according to changed availability of food and shelter or other essentials. For 57 movements of males the average was 604 feet, indicating an average home range of approximately 26 acres, while for 47 movements of females the average was 434 feet, indicating an average home range of approximately 13 acres. These figures apply to the areas where individuals foraged, but do not necessarily include the places where these juncos roosted. Observations on flocks of juncos going to roost or those flushed after dark have suggested that they may travel beyond the usual daytime range to find a suitable roosting place. Loose flocks have been seen streaming across fields and hillsides and gathering in bushes or low trees before going to roost on the ground in thick brome grass. Occasionally in walking across fields of brome grass at night I have flushed juncos in large numbers in areas where none was to be found by day. These may have travelled considerable distances, even from beyond the limits of the Reservation, to find suitable roosting cover.

Spizella arborea (Wilson)

Tree Sparrow

Status.—Regular winter visitor, late October to April, exceeded in numbers only by junco.

Habitat.—Various types of open land and edge situations, usually where there are brush piles or thickets for shelter.

Old fields with weedy mixtures of herbaceous plants provide a type of foraging ground favored by the tree sparrow. Thickets whether at woodland edges or in open fields, are preferred escape shelters. Flocks of tree sparrows mingle with flocks of juncos, but the latter are somewhat more arboreal.

Movements.—Earliest fall records, 1951 through 1957, are November 3, November 12, November 13, October 16, October 29, October 26, and October 23. The latest definite spring record is April 10, 1957. On that date a large wintering flock was still present. Wintering tree sparrows are highly gregarious. Flocks of several hundred may move about and forage together. Often these flocks are mixed with juncos. The two species are sufficiently similar in their habits that they prefer the same type of food and cover, and they seem completely tolerant. Song sparrows also frequently intermingle in the flocks, although they prefer denser low cover and more moist situations. Less regularly, Harris sparrows, white-throated sparrows, cardinals, and towhees associate with the flocks.

A large flock of several hundred tree sparrows stayed in an area that included weedy fallow fields on the Reservation near its western edge and adjoining it, a milo field bordered on one side by an intermittent creek with weeds and brush, and on the other by a county road, and by thickets and debris from a bulldozed hillside. The milo field and bordering thickets comprised approximately five acres, and this was the headquarters of the flock, but their entire range covered a little more than 20 acres, along the creek, and adjacent areas of fields and thickets. The range was some 2200 feet long and 550 feet wide. The flock tended to keep together, concentrated in one small part of the range, and moved about slowly, usually following the line of brush along the edges of the field. Travelling from one part of the range to another the sparrows would move in small straggling groups.

In recaptured banded tree sparrows, distances between successive captures averaged 378 feet, indicating home ranges of approximately ten acres in winter.

Spizella passerina (Bechstein)

Chipping Sparrow

Status.—Migrant and occasional temporary resident in spring.

Habitat.—In the breeding season chipping sparrows choose for territories areas of parkland and groves, with short ground vegetation. Lack of such areas with suitably short ground vegetation seems to prevent establishment of a permanent population on the Reservation.

Movements.—In 1951, in the last week of April and the first two days of May, a chipping sparrow was heard and seen frequently, singing from a large elm beside the house at the Reservation headquarters. It soon disappeared from this area. In early May, 1957, one briefly established a territory on the Rockefeller Tract. This sparrow was nearly always heard singing from the same large elm, in the edge of woodland adjoining a cultivated field. It disappeared within a week of the time it was first noticed.

Spizella pallida (Swainson)

Clay-colored Sparrow

Status.—Occasional transient.

Habitat.—Thickets and woodland edges.

Movements.—The only record is of an individual foraging in short grass and weeds beside the Reservation residence at mid-day on April 29, 1951.

Spizella pusilla (Wilson)

Field Sparrow

Status.—Regular summer resident; one of most abundant birds from April till October.

Habitat.—Border between woodland and grassland, and especially former pastures and cultivated fields that are in process of growing up into thickets.

Since cultivation and grazing were discontinued on the Reservation in 1948, the habitat has steadily improved, as brush and saplings have encroached into the fields. Occasionally, field sparrows have been found established in woodland, where canopy was open and understory vegetation was not dense. So far as observed, they occupy open areas only where thickets are available.

Movements.—Field sparrows appear on the area earlier than any

other summer residents that do not spend the winter there. Table 3 illustrates the seasonal schedule.

Each year singing was first heard on mild sunny days of late winter. Such early season singing was of a peculiarly subdued quality. With the return of stormy or cold weather, singing stopped altogether for periods of days, or even weeks. In February and

TABLE 3.—YEAR BY YEAR RECORD OF EVENTS IN THE ANNUAL CYCLE OF THE FIELD SPARROW ON THE UNIVERSITY OF KANSAS NATURAL HISTORY RESERVATION.

YEAR	Earliest record	Earliest singing	Earliest pairing	Last record
1950.....	.....	.....	.....	October 26
1951.....	March 5	March 16	March 25	.....
1952.....	February 10	March 16	March 16	October 30
1953.....	February 7	February 7	March 13	October 5
1954.....	March 25	March 25	April 2	November 12
1955.....	March 3	March 3	.....	.....
1956.....	March 17	March 17	April 1	.....
1957.....	March 11	March 11	.....	.....

early March the sparrows were present in small numbers, and newcomers might arrive gradually over a period of weeks. By mid-April most or all had arrived and established themselves in territories.

At this time of year males sing persistently from elevated perches wherever these are available in the territory. Males usually sing from perches five to twenty feet above the ground. In singing the bird is usually perched well inside the crown of the tree, and almost never perches on the top, unless it is a small sapling. Arrival of additional field sparrows makes necessary readjustments of territories as those established early are compressed. On March 26, 1954, only one field sparrow was present in the field near the Reservation headquarters. As it moved from tree to tree singing along woodland edge it was followed for a distance of 820 feet, indicating an unusually large territory. At times when the sparrows were present in normal numbers 500 feet seemed to be about the maximum diameter of any territory.

Even in April, territoriality may be temporarily suppressed in inclement weather. This was strikingly demonstrated when as many as six field sparrows were caught simultaneously in the same funnel trap in rainy weather. In rain singing stopped. The spar-

rows were reluctant to forage in their usual place, in high grass where their plumage might soon become soaked; instead they congregated in open places chiefly along the road. Several pairs might forage within a few square yards, with no evidence of hostility, although the area involved was within the territory of one pair and beyond the usual boundaries of the others. With the return of clear weather the sparrows withdrew to their established territories with resumption of singing, and intolerant behavior toward intruders. However, even in mild weather singing and territorial behavior was much more prominent in the morning and was partly suppressed later in the day, with some intermingling between different pairs.

The approximate extent of a territory could soon be determined by flushing a singing male from perch to perch. Within a few minutes he would make the circuit of his territory. Seven territories that were traced in some detail, in 1952, 1953, 1954, and 1956, averaged 1.6 acres (2.5, 2.2, 1.8, 1.6, 1.4, 1.0, .8). The largest were those that extended over open areas. Those that were relatively small were partly beneath trees and in brushy places.

In 1950, 58 pairs were located in an area of approximately 300 acres, the northwestern half of the Reservation. They tended to be linearly arranged in edges of fallow fields and former pastures bordering woodland. In a few instances there were intervals of hundreds of yards between pairs, but in most instances territories were contiguous and actual distances between the birds of adjacent pairs were 100 to 600 feet. For 46 such intervals the average was 320 feet. A territory of this diameter would cover 1.8 acres.

Territorial fighting and pursuits were seen frequently, especially in April. In 1954 a remarkably prolonged territorial quarrel was observed. On April 6, when the population was increasing rapidly through an influx of new migrants, two males were noticed perching and hopping about nervously within a few inches of each other, each trying to round up the other and force it back. There was no actual fighting, and neither bird would give ground. On April 13 two males, probably the same, were observed in the same area, and there were frequent long chases. Both males had been banded. The pursued sparrow, always the same, fled consistently but would not leave the territory. Several times the chase led to a female, who did not participate in the quarrel. After several hours the chase was still in progress. It was continued on the following day. Seldom more than a few seconds elapsed until the aggressor renewed

the pursuit, and the birds might be in motion 30 seconds or more before the next pause. As before, the pursued persistently remained within the disputed area, and the pursuer, so far as observed, did not press to the point of actual attack. Continuations of the pursuit were observed on the 16th, 19th, 20th, 23rd, 24th, and 26th. Whenever the pursuer flew back to the female he was followed by the other male, whose presence distracted him and disrupted the normal course of courtship and nesting. Eventually the pursuits became less spirited, with longer intervening pauses, during which the pursued, the pursuer and the female perched or foraged in close proximity. On the morning of April 26, the pursuing male was bedraggled in appearance, with feathers disarranged and some missing. Obviously the continuous tension was telling on him. The pursued showed no such effects. However, the pursuer may have become involved in fights with other outsiders and could not have maintained his boundaries against adjoining pairs while distracted by the rival within the area. Later the same day he was located singing in a more open and less favorable area beyond the limits of his former territory. It seemed that he had abandoned both territory and mate to the interloper whom he had failed to dislodge in two weeks of almost unremitting effort.

In 1953 the same territory contested by these two males was occupied by different individuals. The bob-tailed male was color-banded on April 6, probably soon after his arrival. On April 7 he was seen associating briefly with each of two different females, one of which had been color-banded. On April 8 he had obtained a mate, and the pair moved together about the territory. As they foraged near together on the ground, movements involved a steady advance of the male, and retreat of the female to avoid actual contact. When the male moved toward her for a few inches, the female would quickly hop away, maintaining her distance, and then would pivot around facing the male or standing broadside to him. However, whenever the male flew, she promptly followed. Later in the day the male became increasingly aggressive, and frequently would cause the female to flush and would chase her back and forth across the territory several times without pause. Finally he caught her, and both fell into the wet grass, fluttering and pecking. They lay sprawled and interlocked, fluttering feebly and pecking at each other for more than two minutes. The female broke away but immediately the male gave chase and caught her, and again they fell into the grass, interlocked, and remained there almost as long

as they had the first time. After disengaging, they flew to a foraging place preening and shaking, the hostilities ended. On the following day the female was no longer present. The male's overly aggressive and hostile behavior may have caused her to desert the territory, and for several weeks thereafter the male remained unpaired.

Singing reaches a peak in April and tapers off later in the season. In April song may be heard at any time of day, or even at night. In June and July singing occurs chiefly at daybreak. Occasionally singing is heard in August and early September.

On several occasions the development and dispersal of broods were observed. On October 2, 1952, three or four fledglings of an unusually late brood, probably just out of the nest, were chirping within an area of a few square yards. On the following day they had shifted about 70 feet farther east and were more scattered, still concealed in high grass. The adults were delivering food frequently. On the following day they had moved still farther in the same direction. Two were flushed 200 feet and 270 feet from the original location. They were still bob-tailed (tails less than one inch long) and their flights were short and weak. On October 7 one was observed near the same place it was seen October 4. It had emerged from the grass, and was fluttering about in a bush as the adults came to feed it at frequent intervals. On October 8, one was near the same place perched ten feet above ground in a small tree, chirping steadily. The two other young were chirping in bushes 30 feet farther southeast. One hopped and fluttered along the ground to the base of the tree where the first young bird was perched, and an adult came and fed it there. Soon afterward the young that was perched ten feet high flew strongly for 100 feet west and within a few minutes made several more flights. Late in the afternoon all three young were assembled in the same tree. Their tails were about $1\frac{1}{2}$ inches long. Later one young was seen following an adult as the latter moved about slowly, foraging on the ground in high grass. The fledgling's peeping changed to more metallic chirps as the adult approached to feed it.

In the following two weeks the family group remained intact and the young and adults were often seen foraging together in or about a dry pond bed some 450 feet east of the nesting area, outside the original territory. By October 21 the fledglings' tails had grown to full length, and the young birds were able to fly rapidly and strongly. They were moving about freely with no attempt at concealment. On October 24 the fledglings were foraging independently most of

the time though occasionally one would give a juvenal chirp. The young field sparrows were mingling freely with recently arrived juncos and song sparrows, and with field sparrows of other families.

Zonotrichia querula (Nuttall)

Harris Sparrow

Status.—Common winter resident, also migrant in spring and autumn.

Habitat.—Thick brush for shelter adjoining open land, with weeds or cultivated crops providing a food supply, are the chief requirements on the winter range in northeastern Kansas.

Movements.—In the winter of 1956-1957, a flock of these sparrows made their headquarters in several large brush piles where a grove of osage orange trees had been cut and bulldozed, on the southern edge of the Rockefeller Tract adjoining the Reservation. They foraged in an adjacent field of milo stubble, and ranged across this field to the brushy woodland edge, 900 feet north of the favored brush piles. Also they ranged 800 feet east of the brush piles, in thickets bordering the county road.

Of 71 Harris sparrows banded, only 11 have been recaptured. In eight recaptured within a few weeks of banding, distances (in feet) were as follows: 0, 0, 40, 50, 70, 180, 360, 1030. One that was caught at a brush pile on the Rockefeller Tract was brought to the Reservation headquarters for banding, and released there. Several hours later it was recaptured only 100 yards from the place of release, having remained in the vicinity instead of returning half a mile to the flock and home range. Two of those banded were recaptured in later seasons. One of these, banded March 17, 1955, was recaptured 600 feet farther along the same fence row thicket on February 3, 1956. The other, banded on January 22, 1955, was retrapped on January 28, 1957, 1800 feet away (near the brush pile on the Rockefeller Tract). Harris sparrows have been seen as early as October 5 (1953) in fall and as late as May 10 (1957), in spring.

Zonotrichia leucophrys (Forster)

White-crowned Sparrow

Status.—Occasional migrant.

Habitat.—Thickets, especially those at margins of weedy fields.

Movements.—On October 30, 1952, one was seen at the brushy edge of a ravine near the Reservation headquarters. On November 8, 1954, one was seen one hundred yards farther east at the pond.

One was trapped with a group of Harris sparrows on February 5, 1958. These are the only definite records for the area, but on October 21, 1951, several were seen in an osage orange thicket beside the county road near the southeast corner of the section.

Zonotrichia albicollis (Gmelin)

White-throated Sparrow

Status.—Regular migrant in spring and fall, and occasional winter resident.

Habitat.—On Reservation chiefly in woodland edge thickets.

Movements.—Autumn appearances in several years were: October 14, 1949; October 13, 1950; October 17, 1951; October 30, 1952; October 15, 1953. For a week or two after the first arrival these sparrows were abundant and conspicuous in such situations as brush piles, woodland edge thickets, and weedy margins of the pond, but they soon moved on. Spring influxes were noted on April 26, 1951; April 28, 1952; April 21, 1953; April 17, 1954; and April 25, 1956. These migrants were gregarious, and flocks of a dozen or more settled temporarily in thickets providing shelter and food, often remaining two or three weeks. Latest spring records are May 8, 1954, and May 4, 1956. The woodland edge thickets between the pond and the Reservation headquarters had a flock almost every spring. At times their song was one of the most prominent in the spring chorus. They were usually associated with Harris sparrows. Occasional individuals remain all winter in the same situations where flocks are seen in spring and fall. One banded on December 9, 1954, was recaptured regularly (14 times in all) up to April 10, 1955. The area encompassed by its records was 700 feet long and 150 feet wide. The flocks present in spring have often been seen feeding in trees, on leaf buds and seed clusters of elm, while in autumn seeds of weeds seem to provide most of the food.

Borrer (1948:428) found that migrating white-throated sparrows settled temporarily in "stopover ranges" up to an acre or two in size (average of greatest distances between captures for 74 repeaters was 58 yards). Borrer found that in fall the stay was somewhat longer and the range somewhat larger than in spring. Fischer and Gill (1946:407) in a report based on analysis of the data from 43,000 banded white-throated sparrows, found that returns from the birds banded while on migration were rare.

***Passerella iliaca* (Merrem)**

Fox Sparrow

Status.—Occasional transient.

Habitat.—Woodland thickets.

Movements.—Recorded from the Reservation on only a few occasions. On November 5, 1954, several were seen in weed thickets near the edge of the pond. These birds must have settled temporarily in the vicinity, as they were seen frequently through November 17. R. W. Fredrickson reported seeing one on October 23, 1955. On March 1, 1956, one was seen at a weed patch beside the pond. It had perhaps stopped for the day at this place, as it was seen twice, with several hours intervening.

***Melospiza lincolnii* (Audubon)**

Lincoln Sparrow

Status.—Regular transient and temporary resident.

Habitat.—Low, dense thickets in swampy places; on Reservation thick grass is usual habitat.

Movements.—Arrival dates recorded over several years were April 28, 1951; April 25, 1952; April 25, 1953; April 10, 1954; April 26, 1956. Curiously, none was seen in the spring of 1955. In 1952 one was banded and was caught a total of six times within the period April 27 to May 7. All captures were made with live-traps set for mice, and all were well within the area covered with traps in a 50-foot grid. The most remote points of capture were 500 feet apart; however all but the first capture were within a 30-foot radius. Although only one other banded Lincoln sparrow was recaptured (50 feet from the original site), the impression is borne out that individuals stopping on their northward migration settle for periods of days or weeks in small areas. Patches of foxtail grass (*Setaria viridis*) near the edge of woodland at the Reservation headquarters were much used by these sparrows in late April, 1956. When disturbed, they would fly back to brush a few yards away, and were seen at these small grass patches many times daily. In 1956 the sparrows were observed in much greater numbers than they had been in any previous year. One was seen on October 13, 1955, and in the last week of September, 1956, and on October 1,

many were seen at the foxtail patches near the headquarters. Another was caught many times at the same brush pile in late December, 1955, indicating that occasional individuals winter in the area.

Melospiza georgiana (Latham)

Swamp Sparrow

Status.—Rare migrant.

Habitat.—Swamps and marshes.

Movements.—R. W. Fredrickson reported one on April 14 and another on April 27, 1952. On several other occasions in late autumn swamp sparrows have been flushed from a patch of smartweed beside the dry pond bed.

Melospiza melodia (Wilson)

Song Sparrow

Status.—Regular winter resident, present in abundance from October into April.

Habitat.—Fields, meadows, and marshy places with dense ground vegetation satisfy the habitat requirements of the song sparrow in winter. Fence row thickets of dogwood, various saplings and vines are frequented, and brush piles provide preferred escape covert. Greatest concentrations were noted in marshy areas about the edge of the small pond, where there were tangles of smartweed, rice cutgrass, cat-tail and other marsh vegetation. In old-field areas with weedy mixtures, patches of foxtail grass (*Setaria* sp.) provided preferred types of food and shelter.

Movements.—From 1952 to 1957, inclusive, October appearances of immigrating song sparrows were on the 19th, 11th, 5th, 17th, 21st and 16th. Last dates of record, in April each year from 1953 through 1956, were the 24th, 10th (except for a transient heard singing on the evening of June 3), 20th, and 26th. Though requiring dense cover, a song sparrow having settled in its winter quarters requires only a small area. For 29 banded and recaptured song sparrows, distances between successive capture points, representing a total of 35 movements, ranged from 1040 feet to 40 feet and averaged 300 feet. Assuming this distance to represent an average home range radius, home ranges of approximately 6.8 acres are indicated. The records of one individual caught eleven times in the winter of 1953-54, encompassed 8.9 acres. Only one individual was recaptured in the same winter range after an intervening summer.

SUMMARY AND CONCLUSIONS

In this study of spatial relationships, 3 species of fish, 10 of amphibians, 24 of reptiles, 29 of mammals, and 167 of birds are discussed. In an area under observation so regularly and intensively as the University of Kansas Natural History Reservation, the negative evidence obtained through the lack of records of species that might be expected to occur is significant. For example, among the species recorded in Douglas County, or on all sides of it, but never recorded from the Reservation itself, there are five kinds of amphibians, 22 kinds of reptiles, 20 kinds of mammals, and 131 kinds of birds. Many of these are rare species which might be expected to appear only at widely spaced intervals, and several of them perhaps ultimately will appear on the Reservation. Another large group of species are those characteristic of extensive fluvial or marshland habitats that are not represented on the Reservation. A total of 81 species belong to this category. They include river turtles, water snakes, beaver, otter, mink, loons, grebes, herons, ducks, shorebirds, terns, and others. Among the mammals are eight species of bats which might be expected but have not yet been recorded because of inadequate sampling. Approximately 26 species are characteristic of prairie habitat, and presumably do not occur on the Reservation because of the limited extent, isolation, or unsuitability of the prairie relict there. About the same number of kinds are characteristic of deciduous forest habitats of the eastern United States (notably the warblers, among birds).

Among those species that have been recorded from the Reservation approximately half the total reach the area only as wanderers, and have no permanent population on the area. These include the tiger salamander, spadefoot toad, painted turtle, woodchuck, house cat, American rough-legged hawk, goshawk, bald eagle, killdeer, Franklin's gull, barn owl, belted kingfisher, and a number of other kinds of birds that merely fly over the area, without stopping on it. Also included in this category are the great majority of individuals of Woodhouse's toad, muskrat, starling, house sparrow, marsh hawk and perhaps a few others, although individuals of each of these kinds has been known to live on the Reservation.

There are few species, if any, which wander completely at random. However, there seems to be no clear-cut line of demarcation between those that habitually wander and those that occupy definite home ranges. All degrees of intermediacy have been found between the two categories. The snapping turtle may be considered

a typical representative of the species with strongly developed nomadic tendencies. At times individuals of various sizes and of both sexes wander for long distances up and down the intermittent stream courses. They also may frequent certain pools or ponds or sections of a stream, habitually using an available shelter or food supply. That a home range having definite boundaries exists is not demonstrable. In the bullfrog, leopard frog, narrow-mouthed toad, cricket frog and chorus frog, wandering tendencies are marked, and the animals' habits of staying at the same pool, or beneath the same rock, for periods of days or weeks may be forced upon them by drought limiting their movements, rather than by any affinity for the location where the animal happens to be. In the American toad and Woodhouse's toad, an individual returns regularly to the same diurnal shelter, over periods of days or weeks, at least, and emerging to forage in the evening, it may cover more or less the same area on successive occasions. However, even in these animals, the home range seems to have no definite limits, except where natural barriers prevent free movement, and wandering tendencies may at almost any time cause the toad to shift to a new area more or less remote from its former range.

In most kinds of lizards, snakes, small mammals, and birds for which sufficient data were obtained, the trend was somewhat similar, with varying degrees of attachment to a familiar area, but with, at best, vaguely defined boundaries that are subject to frequent alteration, and with occasional wandering. Dice and Clark (1953:10) have emphasized that one respect in which home ranges differ from territories is the poorly defined boundaries of the former, and they have suggested defining the home range in terms of the average radius, rather than as a definite area.

In a few species, notably the collared lizard, the larger snakes (*Coluber*, *Elaphe*, *Agkistrodon*), the blue jay, and (in winter) chickadee, titmouse, and cardinal, attachment to a home area is strong, and the same adult may remain for periods of years in approximately the same range. In these same species other individuals may wander, both frequently and extensively, and the average occupancy of an area is short.

Territoriality exists in most of the species of birds that breed on the area, and is less developed in the collared lizard, the woodrat and perhaps a few other kinds of small mammals. In its most typical form a territory constitutes a defended home range, and possession of a well defined home range is a prerequisite to ter-

itoriality. All stages in the development of territoriality were seen in the numerous species investigated. In some, like the skinks (*Eumeces* sp.), the possession of a regular home range is associated with hostility (in the adult male, especially in the breeding season). Fighting is frequent, and the establishment of a true territory is perhaps prevented only by the retiring and secretive habits, which normally prevent detection of a rival until it has come within close range.

Among the birds there are relatively few kinds having permanent territories that live on the area; the red-tailed hawk, horned owl, barred owl, hairy woodpecker and Carolina wren are the most typical of those kinds that do have permanent territories. Even in these species territorial boundaries are flexible, and are subject to seasonal alteration. In other species, some of which may remain permanently mated, territorial boundaries are largely dissolved at times of year other than the breeding season. A pair may continue to use its former territory, but at the same time may mingle with other members of a social group, and range over a much more extensive area than the territory had encompassed. The blue jay, crow, tufted titmouse, black-capped chickadee, downy woodpecker and red-bellied woodpecker are among the best examples of this group. In contrast, only temporary and seasonal attachment to territory and mate is characteristic of the bob-white, mourning dove, Cooper's hawk, bluebird and goldfinch among resident species. Most species of birds that breed on the area make annual migrations, abandoning both territory and mate. The territory seems especially subject to alteration, and may change continually in size, shape and position, according to immediate needs at the particular stage of the nesting cycle in these species that have only temporary attachment to it.

Size of territory is somewhat characteristic of each species. Among the migratory species, males that are early arrivals in spring may occupy unusually large territories; an instance is cited in the species account of the field sparrow. In this sparrow the breeding population increases over periods of weeks and the new arrivals must usurp parts of areas that are already occupied in order to establish their territories. The males or pairs that are established early are then subjected to increasing territorial pressure, with enforced retrenchment. In many other species, whose populations are sparse, including the barred owl, Carolina wren, bluebird, wood

thrush, Kentucky warbler, and summer tanager, a pair establishing a territory was usually subject to but little territorial pressure or to none at all, because territories seldom occupied adjoining areas. Even under these conditions, the pair usually tended to confine their activities to a relatively small central area, which perhaps should be considered the whole territory, but the daily routine was varied from time to time by visits to any of several outlying points.

For territories and home ranges alike, one of the chief factors determining size was the distribution of suitable habitat. Where the essential features of the habitat were scarce and scattered, the individual was forced to cover a relatively large area. This is well illustrated by the red-tailed hawk territories shown in Fig. 11; the one including a high proportion of cultivated land, unproductive of prey was consistently larger than the other. A more extreme example is provided by the territories of towhees shown in Fig. 24. Blackberry thickets at the edges of woodland were the essential features and the territory might include several of the thickets and also intervening areas of less favorable habitat—brush, groves, or even open fields. Towhees crossed the fields regularly in moving from one blackberry patch to another. Although they did not forage in the fields, they occasionally did stop in isolated trees to sing there. Therefore, part of a field might be considered part of a towhee's territory, even though it furnished neither food nor shelter, and was significant to the bird only as an intervening space, to be crossed at some hazard. In the mourning dove and goldfinch, activities are still more extended; in some instances foraging areas are so remote from the nest that they could not be construed as part of the territory, and intermediate stages of all degrees exist.

Odum and Kuenzler (1955) have emphasized the ephemeral nature of territories in many kinds of birds, and have described fairly rapid alteration in size and shape. They imply that territories become progressively smaller later in the season, with the transition from nest building to incubation, to feeding of young. Most territories are established early in the breeding season, and the pair, having successfully defended their chosen area against interlopers during this stage, may not be required to withstand much territorial pressure in later stages. Rather, they may be free to wander through the original territory, and to concentrate on those parts of it that best satisfy their seasonal requirements.

In certain kinds of birds, exemplified by the raptors, phoebe, chickadee, titmouse and others, the members of a pair share more

or less equally in defense and utilization of their territory, and characteristically travel together. In other kinds exemplified by the horned lark, the redwing, the indigo bunting and the dickcissel, the sexes differ greatly in habits, and territorial defense devolves chiefly upon the male. He moves about more frequently and more conspicuously than the female, and usually covers a somewhat larger area. In mammals, although most are not clearly territorial, the same tendency toward a larger range in the male was manifest. In the opossum, fox squirrel, gray squirrel, deer mouse, and prairie vole, the male's range is markedly larger than the female's. In the cotton rat, harvest mouse, white-footed mouse and cottontail, the difference between the sexes, in size of area covered, is slight. In the larger snakes (garter snake, yellow-bellied racer, black rat snake, copperhead) the adult male's range is at least twice the size of the female's, and in the common lizards including collared lizard, Great Plains skink, and glass lizard, a comparable disparity exists. The six-lined racerunner seems to be a notable exception to the general trend, as the female's range averaged 40 per cent larger than the male's, in my sample.

In general, young animals ranged less widely than adults of the same species. As the young animal grows and becomes familiar with its surroundings, it gradually increases its range. Although individuals of some kinds of animals remain permanently near the place where they were born, dispersive wandering is characteristic of the young of most kinds. In amphibians dispersal occurs chiefly at the time of metamorphosis, and in reptiles it may occur after birth or hatching. In mammals the dispersal takes place after weaning, and in birds usually just after the fledglings have learned to forage for themselves.

Among the factors that determine size of home range, potential mobility of the animal is, of course, important, but the correlation is not close. The smallest home ranges, less than half an acre in area, were found in lizards, toads, voles, the woodrat, and the white-footed mouse—animals with limited capacity for rapid travel. Home ranges or territories in the size range of half an acre to two acres were found in the remaining small mammals, the short-tailed shrew, jumping mouse, cotton rat, harvest mouse, house mouse, and in several species of birds, mostly the smaller kinds, and especially those that live in thick woods or in dense ground vegetation—pewee, Bell vireo, gnatcatcher, long-tailed chat, blue grosbeak, and bob-white. Areas from two to ten acres in extent are occupied

by individuals of most kinds of small birds, by the cottontail, and the ornate box turtle. Relatively large areas, ten to fifty acres in extent, are utilized by the larger snakes, including the copperhead, black rat snake, yellow-bellied racer, and common garter snake, by certain birds, including those that are persistent fliers—the horned lark, barn swallow, whip-poor-will, chuck-will's-widow and hairy woodpecker—and by various small passerines on their winter ranges when they are not territorial—junco, tree sparrow, towhee, chickadee, and titmouse. The opossum, fox squirrel, and gray squirrel also have home ranges within this size range. Territories and home ranges larger than 50 acres were found to be maintained by only a few kinds of vertebrates, nearly all of them predators and all relatively large. They include most, if not all, of the hawks and owls living on the area (the screech owl is a probable exception), the turkey vulture, the coyote, red fox, spotted skunk, and white-tailed deer.

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15. The pigmy woodrat, *Neotoma goldmani*, its distribution and systematic position. By Dennis G. Rainey and Rollin H. Baker. Pp. 619-624, 2 figs. in text. June 10, 1955.

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12. Geographic variation in the pocket gopher, *Thomomys bottae*, in Colorado. By Phillip M. Youngman. Pp. 363-384, 7 figs. in text, 1 table. February 21, 1958.
13. A new bog lemming (genus *Synaptomys*) from Nebraska. By J. Knox Jones, Jr. Pp. 385-388.

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2. Comparative breeding behavior of *Ammodramus caudacuta* and *A. maritima*. By Glen E. Woolfenden. Pp. 45-75, 6 plates, 1 figure. December 20, 1956.
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 5. Birds found on the Arctic Slope of northern Alaska. By James W. Bee. Pp. 163-211, 2 plates, 1 figure in text. March 12, 1958.
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UNIVERSITY OF KANSAS PUBLICATIONS

MUSEUM OF NATURAL HISTORY

Volume 11, No. 4, pp. 327-334, 2 figs.

January 28, 1959

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BY

JOHN M. LEGLER

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LAWRENCE

1959

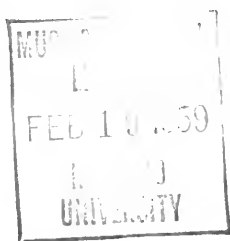
UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

Editors: E. Raymond Hall, Chairman, Henry S. Fitch,
Robert W. Wilson

Volume 11, No. 4, pp. 327-334

Published January 28, 1959

UNIVERSITY OF KANSAS
Lawrence, Kansas



PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1959



27-6682

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BY

JOHN M. LEGLER

In July, 1957, members of a field party from the University of Kansas Museum of Natural History, under the direction of Mr. Sydney Anderson, spent 12 days collecting vertebrates in the vicinity of Creel in southwestern Chihuahua. Among the specimens are two snakes representing an undescribed species of the genus *Geophis*. A description and illustrations of these two specimens were prepared and submitted for publication in the spring of 1958. At that time it came to my attention that Dr. Norman Hartweg, Museum of Zoology, University of Michigan, was also preparing a report on four specimens of the same species from two additional localities in southwestern Chihuahua. Upon learning of my work on the species, Dr. Hartweg generously loaned me his specimens and notes and allowed me to incorporate them in the present report. The snakes may be known and described as:

Geophis aquilonaris new species

Holotype.—Adult female, KU 44265, alcoholic; 23 mi. S and 1½ mi. E Creel, Chihuahua, Mexico; 23 July 1957; original number 198, Ronald H. Pine.

Paratypes.—(Total of five alcoholic specimens, all from Chihuahua) Male (probably subadult), KU 44266, same data as holotype; male, UMMZ 117770, Mojarachic, 23 July 1957, Irving W. Knobloch; females, UMMZ 111501-2, Maguarachic, August 1954, and UMMZ 117771, Maguarachic, August 1957, Irving W. Knobloch.

Diagnosis.—Size small; 15 rows of smooth scales; a high number of ventral (173 to 183) and subcaudal (55 to 64) scales; alternating dark and pale rings on body and tail; dark rings, and often pale rings, complete.

Description of Holotype.—Snout-vent length 327 mm.; length of tail 93 mm.; anal scale entire; ventral scales 181 + anal; subcaudal scales 63 + tip; dorsal scales in 15 rows on all parts of body; six supralabials (fifth and sixth fused on left side), third and fourth entering orbit; fifth supralabial largest and in broad contact with parietal, posterior temporal, and postocular; six infralabials on each side, first pair in contact behind mental; enlarged chin shields in two pairs, anterior pair longer than posterior pair; anterior chin shields in contact for half their length with fourth infralabials; rostral nearly as high as broad; internasal and prefrontal scales paired and distinct; anterior and posterior segments of nasals distinct and nearly equal in size; loreal twice as long as high, in contact with eye; preocular lacking (represented by minute scale on left side); vertical diameter of eye equal to distance from lower rim

of orbit to free edge of upper lip; temporal formula $0 + 1$, the single temporal scale separating sixth supralabial and parietal; one postocular and one supra-

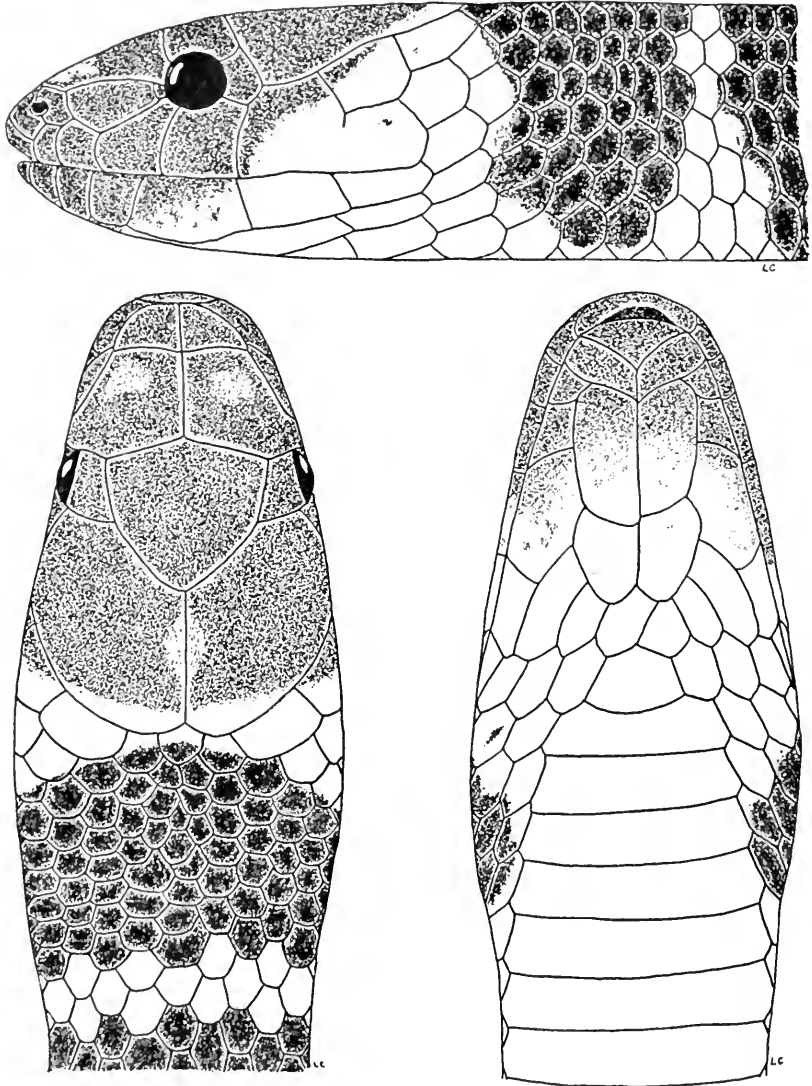


FIG. 1. *Geophis aquilonaris* new species, KU 44265, Holotype; lateral, dorsal, and ventral views of head and neck (approximately $\times 6$).

ocular on each side; all scales perfectly smooth; no scale-pits evident; dentary bone bearing eight teeth; maxillary bone bearing seven teeth; posterior tooth longest, thinnest, and separated from other teeth by slight diastema (maxillary

teeth in UMMZ 111502, 6/7, dentary teeth 8/8, no diastema in maxillary series).

Head slate-black above, having dim pale mark on anterior part of each prefrontal and another on interparietal seam; an indistinct pale gray crescent on posterior border of nostril; narrow cream band covering posterior edges of parietal and half of first dorsal scale row, widening laterally to include

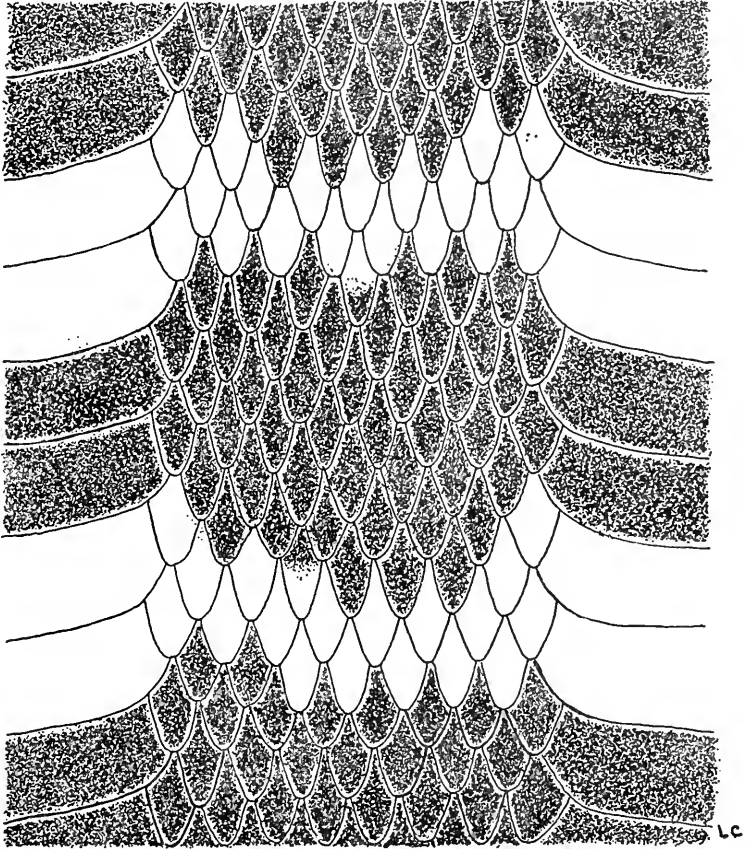


FIG. 2. *Geophis aquilonaris* new species, KU 44265, Holotype; scalation and coloration at mid-body showing 19th and 20th white rings (approximately $\times 7$).

temporal and posterior two or three supralabials; throat cream (except for dark markings on mental, on first three infralabials, and on anterior chin shields), its pale area continuous with pale band on head; body and tail marked with alternating white and black rings; white rings (excluding band on head) 38 on body, 17 on tail; each white ring alternately one and two scales wide dorsally (producing wavy or zigzag effect), widened laterally, and three to four scales wide on belly; black rings three to four and one half

scales wide on middorsal line, and two to three scales wide on belly; black and white rings (excepting first black ring behind head) continuous around body and tail. Colors described above nearly same as in living specimens.

Range.—The species is known only from three localities on the Pacific drainage of southwestern Chihuahua; the geographic range probably includes parts of southern Sonora and northern Sinaloa. The discovery of *Geophis* in southern Chihuahua increases to 21 the number of species of the genus known to occur in Mexico and extends the known range of the genus approximately 560 miles northwestward from the type locality of *G. latifrontalis*, a point 50 miles south (in Guanajuato?) of San Luis Potosí, or, a slightly lesser number of miles north-northwestward from an indefinite locality for *G. bicolor* in western Jalisco (La Cumbre de los Arrastrados) (Boulenger, Catalogue of the snakes in the British Museum, Vol. 2, 1894, p. 298).

Variation.—Standard counts of scales are given for the paratypes as well as the holotype in table 1. The fifth and sixth supralabial scales are fused on both sides of one specimen (UMMZ 117771) as is the case on the left side of the holotype. Except for one specimen (UMMZ 117770) that has a small anterior temporal separating the posterior two-thirds of the fifth supralabial from the parietal on each side, the temporal formula in the type series is uniformly 0 + 1.

TABLE 1.—COUNTS OF SCALES, MEASUREMENTS, AND OTHER DATA PERTAINING TO HOLOTYPE AND PARATYPES OF *Geophis aquilonaris* NEW SPECIES.

		Sex	Dorsal scale rows	Ventrals	Sub-caudals	Pale rings		Snout-vent length	Length of tail
						Body	Tail		
UMMZ	111501	♀	15	173	55	29	12	237	60
UMMZ	111502	♀	15	181	58	34	14	355	88
UMMZ	117771	♀	15	182	55	39	16	371	90
KU	44265	♀	15	183	63	38	17	327	93
KU	44266	♂	15	175	60	30	13	160	43
UMMZ	117770	♂	15	174	64	34	15	245	74

Considerably more variation occurs in color and in the arrangement of markings than in squamation. The ground color of the two specimens from Creel is black with little or no trace of brown, and the rings are white. Ground color in the remaining paratypes ranges from grayish black, with some brownishness on the belly, to dark brown, the colors in one specimen approximating the range from Mummy brown to Dresden brown, becoming paler posteriorly and ventrally. The head is slate gray to blackish brown in all the specimens. Those having a suggestion of brown on the head tend also to have more brown on the body.

The dark band on the neck is complete in four of the paratypes and in-

complete (as in holotype) in one. Pale marks on the prefrontals are lacking in three of the paratypes and the pale mark between the parietals is lacking in two specimens (fused with white band on neck of one specimen). Pale postnarial crescents are evident in three paratypes.

As stated above, the rings on the holotype are mostly complete. Exceptions occur between the 13th and 15th white rings where two black rings are fused on the left side, rendering one black and one white ring (the 14th) incomplete. Also, where the ninth and tenth white rings fuse on the left side, they enclose a black ring and render it incomplete. The markings of the three smaller paratypes are substantially the same as those of the holotype—complete rings with a small number of variations in each specimen. In the two largest paratypes nearly all the white rings are incomplete ventrally, appearing to have been encroached upon by the darker ground color. In the larger specimens there is a tendency also for the white rings to be one scale wide (rather than alternately one and two scales wide) and to lack a zigzag appearance; this appears to be due to the darkening of entire scales and to the darkening of the edges of other scales.

Relationships.—*Geophis aquilonaris* is distinct from all other Mexican representatives of the genus in having, on the body and tail, numerous, alternating pale and dark bands. Both sets of bands are in the form of complete rings or the dark bands are joined ventrally rendering the belly dark.

Of the seven other Mexican *Geophis* having 15 rows of scales, four species (*cancellatus*, *dugesii*, *chalybeus*, and *semidoliatus*) have alternating pale and dark transverse markings and therefore superficially resemble *aquilonaris*. Of the latter two species, the poorly known *G. chalybeus* (Veracruz) has a much lower (137 to 142) number of ventrals than *aquilonaris*, and *G. semidoliatus* (southeastern Mexico—Veracruz, Hidalgo, and Oaxaca) has a narrower head, fewer supralabials (four to five with only the third entering the orbit), and fewer ventrals (136 to 169) than *aquilonaris*. *Geophis aquilonaris* seems to be most closely allied to *G. cancellatus* (Chicharras, Chiapas) and *G. dugesii* (known from two localities in northern Michoacán); all three species resemble one another in the number and arrangement of the scales of the head, in general coloration, and in having relatively high numbers of ventral scales (171 in *cancellatus*, 150 to 164 in *dugesii*). *G. cancellatus* differs from the other two species in lacking internasal scales. *Geophis aquilonaris* differs from both species in having a higher number of ventral and subcaudal scales, a longer tail (tail contained in snout-vent length three to four times in *aquilonaris*, four and one half to six times in *dugesii*, 11 to 12 times in *cancellatus*), and in having more bands on the body (28 to 32 in *cancellatus*),

latus, two to seven in *dugesii*). The belly in *dugesii* and *cancellatus* is pale but in *aquilonaris* it is ringed or of a solid dark color.

As more specimens of *Geophis* become available from intermediate localities in Mexico, it will perhaps be demonstrated that many of the kinds now thought of as full species (including those discussed above) are subspecies of a few wide-ranging species.

Remarks.—The type locality of *G. aquilonaris* is the small village of Barranca at the bottom of the valley of the Río Urique, several miles south and west of the continental divide. The Urique Valley, known as the Barranca del Cobre in the region south of Creel, is a deep canyon, the walls of which slope abruptly from approximately 7300 to 3000 feet and are dissected by deep side-canyons. Coniferous forest on the upper rim of the canyon is replaced by scrub vegetation on the rocky walls and by an arid tropical flora on the bottom.

Maguarachic (elevation approximately 5400 feet, longitude and latitude respectively, 108 degrees, 03 minutes W and 27 degrees, 50 minutes N) and Mojarachic (elevation approximately 7000 feet, longitude and latitude respectively, 108 degrees W and 27 degrees, 52 minutes N) are situated approximately three miles from each other and approximately 27 miles northwest of Creel. Maguarachic is given as "Mafuarachic" on the American Geographical Society map (NG 12, Baja California-Mexico, Prov. Ed., 1924). Mojarachic is not on any map of Chihuahua that I have examined.

The type and topotypic paratype were given to a member of the K. U. field party by a Mexican youth who had obtained them the previous night on the lower rocky slopes of the canyon. Both specimens were damaged by the collector piercing their heads with thorns, presumably to kill them. The type contained three oviducal eggs, each about four millimeters long. The stomachs of both specimens from Creel contained earthworms.

The presence of *Geophis* in this area suggests that the distribution of the genus is more or less continuous, on the western slope of the Sierra Madre Occidental, from Jalisco to southern Sonora.

I am grateful to Mr. Sydney Anderson and Mr. Ronald Pine for permission to use their field notes, to Dr. Hobart M. Smith for his examination of the specimens from Creel, to Mrs. Lorna Cordonnier for the drawings of the type, to Dr. Norman Hartweg for permitting me to study materials in his care and upon which he was making an independent study, and to Mr. Thomas M. Uzzell for locality data pertaining to the UMMZ paratypes.

Transmitted November 10, 1958.



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Volume 11, No. 5, pp. 335-343, pls. 7 and 8

April 24, 1959

A New Tortoise, Genus *Gopherus*,
From North-central Mexico

BY

JOHN M. LEGLER

UNIVERSITY OF KANSAS

LAWRENCE

1959

UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

Editors: E. Raymond Hall, Chairman, Henry S. Fitch,
Robert W. Wilson

Volume 11, No. 5, pp. 335-343

Published April 24, 1959

UNIVERSITY OF KANSAS
Lawrence, Kansas

PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1959



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A New Tortoise, Genus *Gopherus*, From North-central Mexico

BY

JOHN M. LEGLER

In the course of taxonomic studies of the genus *Gopherus* it was found that specimens from north-central Mexico belong to an hitherto unrecognized species, which is named and described below.

Gopherus flavomarginatus new species

Holotype.—U. S. National Museum 61253, adult; stuffed specimen with disassociated skull; 30 to 40 miles from Lerdo, Durango, Mexico; obtained by Dr. Elswood Chaffee, 1918.

Paratypes.—USNM 61254, adult, stuffed specimen with skull in place, other data the same as those for holotype; USNM 60976, adult, stuffed specimen with disassociated skull, Lerdo, Durango, Dr. Elswood Chaffee, May 1918; University of Illinois 42953-4, adults, two carapaces, Carrillo, Chihuahua, Pete S. Chrapliwy and Kenneth L. Williams, 1 August 1958; University of Kansas 39415, adult, carapace only, 8 mi. E and 2 mi. S Americanos, Coahuila, Robert W. Dickerman, 19 May 1954.

Diagnosis.—A large tortoise of the genus *Gopherus*, having a flat-topped, posteriorly-flared shell, carapacial laminae that are pale with contrasting dark centers (at least on the lateral margins of the carapace), intergular seam longer than interhumeral, obtuse gular projections, and a relatively wider skull than other Mexican representatives of the genus.

Description of species.—Ground color of carapace pale yellow to straw in smaller specimens, pale brown in larger specimens; in some specimens a slight indication of darker radial markings on carapace; epidermal areolae of carapace (if present) and first two or three zones of growth (around areolae) dark brown to black, their contrast with the ground color greater in smaller specimens; ground color of lateral marginals yellowish, much paler than remainder of carapace; black areolae of marginals contrasting sharply with ground color even in old individuals; plastron pale, approximately the same shade of yellow as lateral marginals, marked with sharply contrasting blotches of black or dark brown in younger specimens, becoming immaculate with age.

Carapace low, evenly arched or slightly flat-topped in cross section, its height slightly more than 50 per cent of its length; top of carapace, between highest parts of first and fourth central laminae, more or less flat in profile; carapace flared, wider posteriorly than anteriorly; central laminae all broader than long, the first not (or but slightly) narrower posteriorly than anteriorly; plastron deeply notched behind, the inner margins of the notch straight, neither convex nor concave; gular projections truncate (not pronglike) having no notch or but a shallow notch between them; greatest combined width of gular laminae much greater than greatest length; interlaminal length of gular greater

than that of humeral; one large axillary scute on each side, approximately rectangular but slightly wider below than above; one or two inguinal scutes on each side, the anterior roughly triangular and much larger than posterior.

Anterior surface of antebrachium having enlarged, juxtaposed (or slightly imbricated), osteodermal scales arranged in seven to eight longitudinal rows, each scale yellowish with a black or dark brown center; scales on lateral edge of antebrachium, from fifth claw to elbow, ten in number and darker than other antebrachial scales; two enlarged black-tipped, yellow spurs on posterior surface of thigh, inner spur approximately half the size of outer. Head relatively wide, greatest width of skull slightly more than 80 per cent of condylobasilar length; width of head 1.3 to 1.7 times diameter of hind foot; scales on top of head large but irregularly arranged (see table 1 for measurements of type and paratypes).

TABLE 1. MEASUREMENTS, IN MILLIMETERS, OF THE HOLOTYPE AND PARATYPES OF *GOPHERUS FLAVOMARGINATUS* NEW SPECIES

CATALOGUE NUMBER AND COLLECTION	Length of carapace	Width of carapace	Length of plastron	Height	Diameter of hind foot	Width of head
USNM 60976.....	246	212	252	108	31	41
USNM 61253.....	222	166	212	96	21	36
USNM 61254.....	371	292	358	157	43	55
IU 42953.....	281	220	.....	.....	.....	.....
IU 42954.....	278	214	.....	.....	.....	.....
KU 39415.....	303	232	.....	.....	.....	.....

Duges (1888:146-147, and 1896:479) twice reported specimens of *Gopherus polyphemus* from Chihuahua (see discussion of distribution); his description of two living examples (1888) agrees generally with the above description of *G. flavomarginatus*. He stated that the iris of his smaller specimen was yellow and the iris of a larger specimen brown.

It will be most interesting to learn the color of juveniles of *G. flavomarginatus*. Considering the dark color of the epidermal areolae of adults, I would expect the color of hatchlings to be dark brown to nearly black, with each lamina acquiring paler borders as it grew, rather than acquiring darker borders as is usually the case in *G. berlandieri* (personal observation), *agassizii* (Miller, 1932:194, pl. 2; Woodbury and Hardy, 1948:165, figs. 9 and 10), and *polyphemus* (personal observation).

PLATE 7

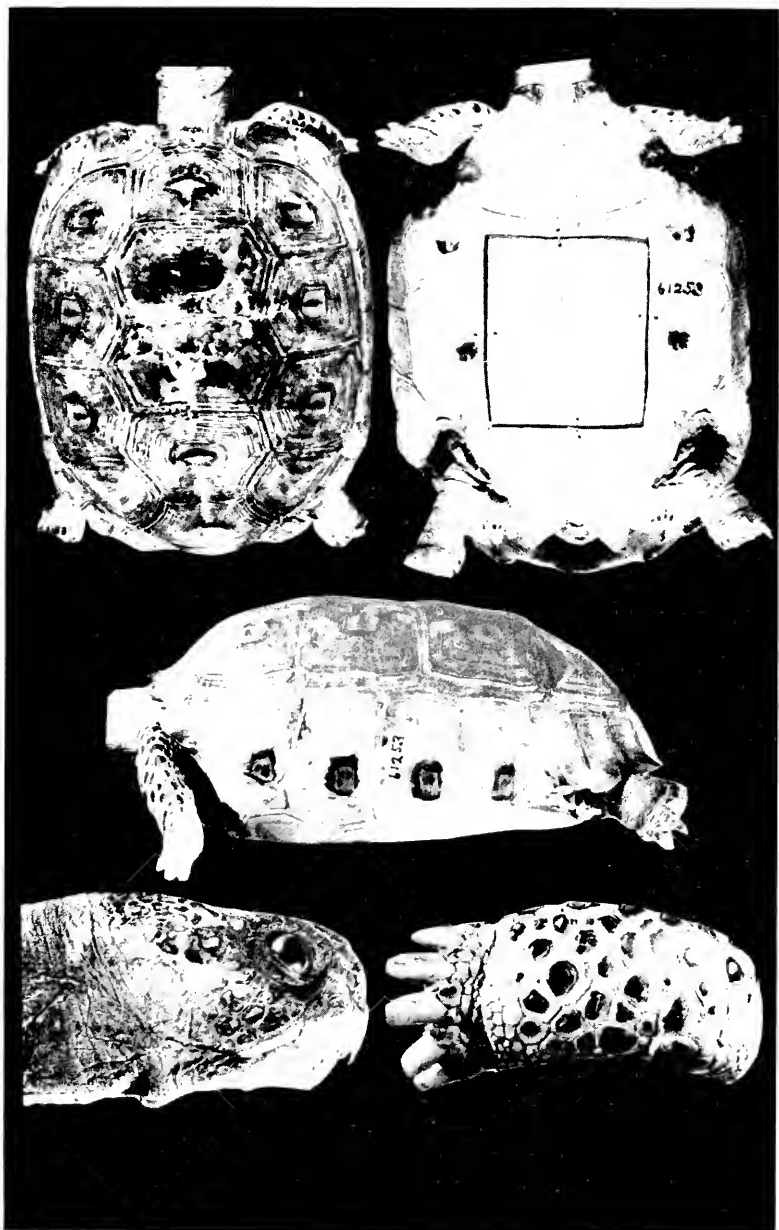


PLATE 7. *Gopherus flavomarginatus* new species: *Top*—Dorsal and ventral views of holotype ($\times \frac{2}{3}$); *Middle*—Lateral view of holotype ($\times \frac{2}{3}$); *Bottom*—Head of paratype (USNM 61254) ($\times \frac{1}{2}$) and antebrachium of holotype ($\times \frac{5}{6}$). Dark outline on plastron of holotype indicates where portion of shell was removed (and then replaced) in course of preparation.

PLATE 5

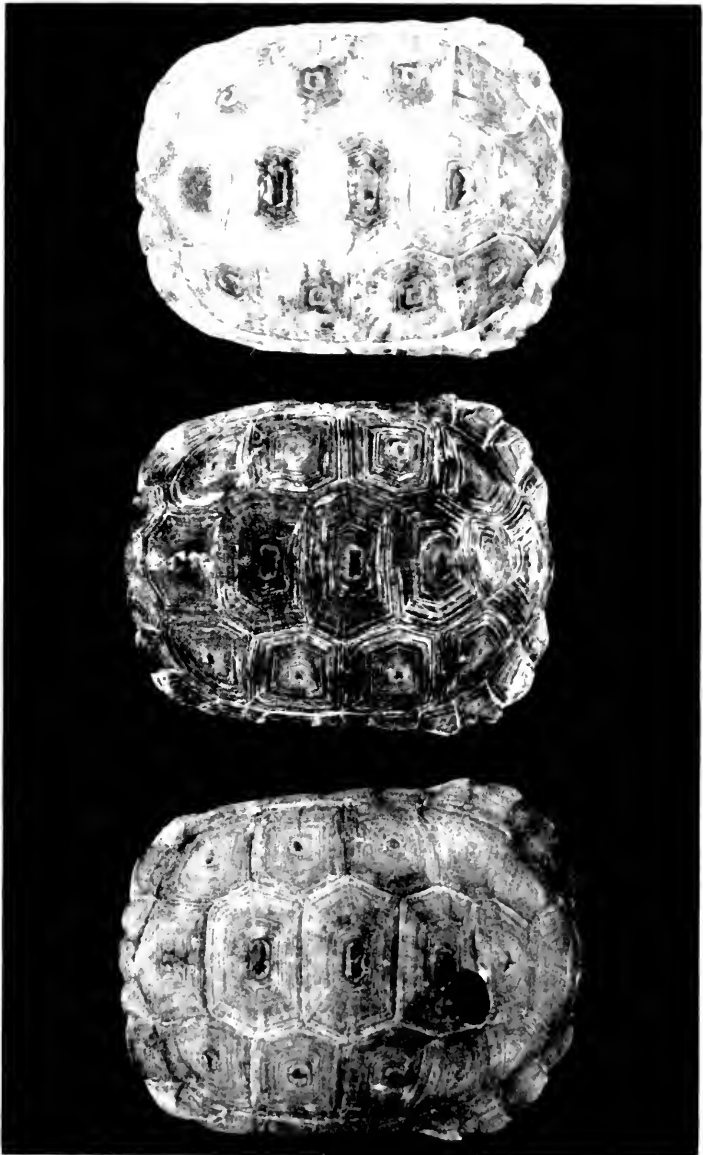


PLATE 8. *Gopherus flavomarginatus* new species: Dorsal views of paratypes (from top to bottom, IU 42953, IU 42954, and KU 39415), approximately $\frac{1}{3}$ natural size.

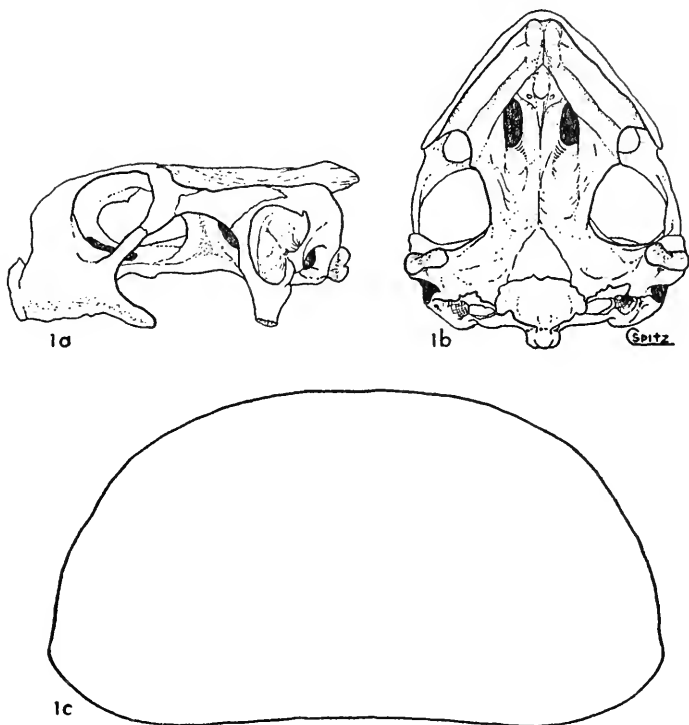


FIG. 1. *Gopherus flavomarginatus* new species: 1a and 1b—Lateral and ventral views of skull of holotype ($\times 1$); 1c—Cross section of paratype (USNM 60976) taken through middle of third central lamina ($\times \frac{2}{5}$).

Anomalies.—There is a high incidence of anomaly in the type series. Three of the specimens (USNM 60976, IU 42954, and KU 39415) have a supernumerary central lamina. All of the specimens from Durango are anomalous in regard to the marginal laminae. In the holotype the first marginals are small, approximately as wide as the small precentral. In the largest paratype (USNM 61254) the first and second marginals are fused to form a single large scute on each side. In the remaining Durangan paratype (USNM 60976) there are eleven normal marginals on each side but a supernumerary lamina occurs between the first and second marginal on the left and between the precentral and first marginal on the right side. The remaining three paratypes have the number of marginals that is normal for the genus.

Relationships.—*Gopherus flavomarginatus* differs from all other species of the genus by its larger size and by having an intergular seam that is longer than the interhumeral seam. The possession of a single, rectangular axillary scale, wider below than above, also tends to distinguish *flavomarginatus* from other living *Gopherus*; in the other species this scute (frequently paired in *berlandieri*) is generally triangular or at least pointed below. Femoral spurs are developed to varying degrees in the other species of *Gopherus*; they are

usually lacking in individuals of small to medium size. In large specimens of *agassizii* and *polyphemus* that I have examined, there is but one enlarged spur, although several pointed osteodermal scales may be present on the back of the thigh.

Gopherus berlandieri, the closest relative of *G. flavomarginatus* in a geographic sense, has a highly arched shell and pronglike gular projections, between which there is nearly always a deep notch. *Gopherus agassizii*, morphologically the closest Mexican relative of *flavomarginatus*, differs from it in having a narrower head and in lacking the contrasting pale and dark coloration of the plastron and lateral marginal area. *Gopherus polyphemus* seems to be the closest relative of *flavomarginatus* and differs from it in having an unflared shell (anterior and posterior widths of carapace subequal or carapace narrower behind) and in the characteristics of color mentioned above. Certain proportional differences between the living species of *Gopherus* are summarized in table 2.

Distribution.—The discovery of a new *Gopherus* from north-central Mexico increases to four the recognized forms of the genus and extends the known range of the genus onto the Mexican highlands, approximately 410 miles eastward from Alamos, Sonora (*G. agassizii*), approximately 100 miles westward from a point 2 mi. W of Monclova, Coahuila (*G. berlandieri*), and approximately 200 miles westward from Monterrey, Nuevo León (*G. berlandieri*).

TABLE 2. BODILY PROPORTIONS IN THE KNOWN SPECIES OF GOPHERUS. TWO SPECIMENS OF *G. POLYPHEMUS* FROM HARMON, MISSISSIPPI (USNM 53166-7), ARE CONSIDERED SEPARATELY BECAUSE OF THEIR NOTABLY NARROWER HEADS. THE SIZE OF EACH SAMPLE IS GIVEN IN PARENTHESES ABOVE THE AVERAGE; EXTREMES ARE IN PARENTHESES FOLLOWING THE AVERAGES.

SPECIES AND GENERAL LOCALITY	Greatest width of skull as a percentage of condy- lobasilar length	Height of shell as a percentage of width of carapace	Height of shell as a percentage of length of carapace	Diameter of hind foot as a percentage of width of head
<i>G. polyphemus</i> (Florida)	(6) .94 (.92-.97)	(13) .53 (.48-.58)	(13) .39 (.36-.42)	
<i>G. polyphemus</i> (Mississippi)	(2) .87 (.84-.89)	(2) .53 (.52-.54)	(2) .43 (.40-.45)	
<i>G. berlandieri</i> (Texas and NE Mexico)	(21) .78 (.70-.83)	(22) .56 (.48-.62)	(21) .46 (.43-.51)	
<i>G. agassizii</i> (U.S. and N. Sonora)	(6) .77 (.70-.83)	(8) .53 (.49-.58)	(8) .41 (.38-.44)	
<i>G. agassizii</i> (Alamos, Sonora)		(4) .56 (.52-.59)	(4) .39 (.37-.41)	(4) .92 (.87-1.00)
<i>G. flavomarginatus</i> (North-central Mexico)	(2) .83 (.82-.83)	(3) .54 (.51-.58)	(3) .43 (.42-.44)	(3) .71 (.58-.78)

Thus far, *G. flavomarginatus* is known only from the three localities represented in the type series and from the indefinite locality, "Bolson de Mapimi", Chihuahua, given by Duges (1888:146-7, and 1896:479). These long-doubted references of Duges to *Gopherus polyphemus* seem clearly to represent *G. flavomarginatus*, which probably occurs in several or all of the internally drained basins in northeastern Chihuahua, western Coahuila, and northern Durango. This region is within the Basin and Range physiographic province of Fennerman (1931:326-8) and the Mapimí biotic province of Smith (1949:231). Duges (*supra cit.*) seems to have used "Bolson de Mapimi" in a restricted sense, as it is shown on some recent maps (Nat. Geog. Soc., Map of Mexico and Central America, 1953) (American Geog. Soc., Culican Map, NG 13, 1935). Other maps show this bolson to include internally drained portions of the Mexican highlands from northeastern Chihuahua to the region near Lerdo and Torreon. Thayer (1916:73) pointed out that the Bolson de Mapimí, in its larger sense, consists of a series of basins separated by mountains of considerable elevation.

The range of *G. flavomarginatus* appears to be limited ultimately by the higher elevations of the Sierra Madre Occidental and the Sierra Madre Oriental to the west and east, respectively, and to the south by the Mexican plateau. The northern limits of the range are less clear; possibly the range extends as far as the portions of the United States adjacent to northeastern Chihuahua, but this is doubtful. The range seems not to overlap that of any other species of *Gopherus*, although the ranges of *G. flavomarginatus* and *G. berlandieri* closely approximate each other in central Coahuila.

In September, 1958, when I was collecting turtles near Cuatro Ciénegas, Coahuila, I took the opportunity to query natives, as well as an American rancher, about the possible occurrence of tortoises in the area. Most persons had seen no tortoises in the area or said they had seen them only rarely. Several older men who had herded goats in the area all their lives said that tortoises (referred to as "Tortuga del Monte") were common on the other side of the Sierra de La Madera and Sierra de La Fragua ranges west of Cuatro Ciénegas. These men referred probably to *G. flavomarginatus*. Americanos lies approximately 75 miles west-northwest of Cuatro Ciénegas.

It is indeed remarkable that a population of large tortoises in northern Mexico has so long escaped the notice of naturalists. Also remarkable is the fact that the late Dr. Leonhard Stejneger, in view of his intense interest in North American chelonians and his familiarity with the genus *Gopherus*, did not remark on the specimens from Durango when he saw them; a thorough search of Stejneger's notes revealed no clue that he had ever studied the specimens. Perhaps his first reaction to the specimens, like mine when I first examined the two disassociated skulls, was to consider "Lerdo" a misspelling of "Laredo." However, a check of old correspondence and accession records at the National Museum confirmed, beyond doubt, the validity of the locality data for these specimens. Dr. Chaffee, the collector, frequently sent specimens of plants and animals to the Museum from Durango and Zacatecas; his home was in Lerdo.

Size.—The largest specimen of *Gopherus flavomarginatus* (USNM 61254) exceeds by more than 50 millimeters the length of the largest known specimens of *G. agassizii*, and slightly exceeds the length of the largest specimen

of *G. polyphemus* that I have examined (USNM 51357, length of carapace 360 millimeters, a specimen formerly kept at the National Zoological Park). *G. polyphemus* is the largest tortoise inhabiting the United States; the maximum length of 343 millimeters given for the species by Carr (1952:334) probably more closely approaches the true maximum in free-living populations. *G. agassizii* rarely attains a length greater than 300 millimeters (Woodbury and Hardy, 1948:152-5). The fact that representatives of the genus do not attain a larger size in the United States may be due to the decimation of natural populations by man for food and souvenirs.

There have been several indications that a large species of tortoise existed in north-central Mexico. The Chihuahuan specimens reported by Duges (248 and 202 millimeters long, respectively) rank in size with the smaller paratypes of *G. flavomarginatus*; Duges stated, however, that the species was said to attain a length of one meter but that he thought such large size surely to apply to another species.

Mr. Charles M. Bogert recently related to me two stories that are here worthy of note. One of them, which Bogert learned from the late Dr. Karl P. Schmidt, concerns a collector who was sent by the Chicago Natural History Museum (then Field Museum) to Coahuila in the early part of the century to obtain materials for a desert exhibit. When the exhibit had been completed several decades later, the collector, visiting the museum, inquired as to where the large tortoises were that he had collected in Coahuila. Dr. Schmidt could find no record of such tortoises and suggested that possibly they had been confused with Galapagos tortoises (*Geochelone*). Dr. Robert F. Inger is unable to locate the specimens or add anything to the story. The collector stated that the large tortoises had been found in only one bolson in Coahuila.

Mr. Bogert further related that, in 1946 when he was camped at Las Delicias, Coahuila, a Mexican mule herder told him of seeing a large tortoise "three bolsos north" of the bolson in which Las Delicias is located (the general area referred to would be near Americanos). The man awoke one morning to find his saddle missing; following tracks from the place where the saddle had been left, the man eventually found it on the back of a large tortoise. The tortoise had apparently sought shelter beneath the saddle and, finding it unsatisfactory, had walked away with the saddle on his back.

Either of the incidents related above, or the reference of Duges (*loc. cit.*) to large size, since they are based on second or third-hand accounts, would seem to be unrealistic and of little scientific value when considered alone and at face value. However, in the light of the discovery of *Gopherus flavomarginatus*, these accounts have new meaning and tend to support my proposal that the species is the largest tortoise in North America.

Remarks.—The paratypes at the University of Illinois were found in a trash-dump in Carrillo. According to what the collectors learned from local inhabitants, the species is used for food and the shells are sometimes used for poultry dishes or even for eating utensils. Although the species is found on the flat, sandy desert near Carrillo, it is more common on the nearby mountain slopes and is seen there most frequently after rains. Dickerman (field notes, 1954) likewise noted that the species was eaten near Americanos; the K. U. paratype represents the best (and only specimen saved) of several broken shells found in that area. Judging by the habits of other members of the genus and by the notes of Duges (1888:147), *G. flavomarginatus* is probably herbivorous.

Acknowledgments.—A portion of this study was completed in the summer of 1958, while I was an internee at the United States National Museum. I am grateful to Dr. Doris M. Cochran of that institution for helpful information regarding the origin of the type and for permission to study other specimens in her care. Thanks are due also to Messrs. Pete S. Chrapliwy and Kenneth L. Williams who collected two of the paratypes and who generously provided their notes on the specimens when learning of my study, to Dr. Hobart M. Smith and Mr. Charles M. Bogert for offering helpful suggestions and for the loan of specimens, and to Mr. Jebb Taylor for assistance with taking data. The drawings are the work of Mrs. Connie Spitz; the photographs are by the author.

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May 6, 1959

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Chautauqua, Cowley and
Elk Counties, Kansas

BY

ARTIE L. METCALF

UNIVERSITY OF KANSAS

LAWRENCE

1959

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12. Geographic variation in the pocket gopher, *Cratogeomys castanops*, in Coahuila, Mexico. By Robert J. Russell and Rollin H. Baker. Pp. 591-608. March 15, 1955.

13. A new cottontail (*Sylvilagus floridanus*) from northeastern Mexico. By Rollin H. Baker. Pp. 609-612. April 8, 1955.

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UNIVERSITY OF KANSAS PUBLICATIONS

MUSEUM OF NATURAL HISTORY

Volume 11, No. 6, pp. 345-400, 2 plates, 2 figs. in text, 10 tables

May 6, 1959

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Chautauqua, Cowley and
Elk Counties, Kansas

BY

ARTIE L. METCALF

UNIVERSITY OF KANSAS

LAWRENCE

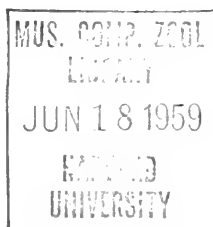
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Editors: E. Raymond Hall, Chairman, Henry S. Fitch,
Robert W. Wilson

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UNIVERSITY OF KANSAS
Lawrence, Kansas

A CONTRIBUTION FROM
THE STATE BIOLOGICAL SURVEY OF KANSAS

PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1959



27-7079

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INTRODUCTION

Aims of the distributional study here reported on concerning the fishes of a part of the Arkansas River Basin of south-central Kansas were as follows:

- (1) Ascertain what species occur in streams of the three counties.
- (2) Ascertain habitat preferences for the species found.
- (3) Distinguish faunal associations existing in different parts of the same stream.
- (4) Describe differences and similarities among the fish faunas of the several streams in the area.
- (5) Relate the findings to the over-all picture of east-west distribution of fishes in Kansas.

(6) List any demonstrable effects of intermittency of streams on fish distribution within the area.

Cowley and Chautauqua counties form part of the southern border of Kansas, and Elk County lies directly north of Chautauqua. The following report concerns data only from those three counties unless otherwise noted. They make up an area of 2,430 square miles having a population of 50,960 persons in 1950 (55,552 in 1940, and 60,375 in 1930). The most populous portion of the area is western Cowley County where Arkansas City with 12,903 inhabitants and Winfield with 10,264 inhabitants are located. Each of the other towns has less than 2,000 inhabitants. In the Flint Hills, which cross the central portion of the area surveyed, population is sparse and chiefly in the valleys.

Topographically, the area is divisible into three general sections: the extensive Wellington formation and the floodplain of the Arkansas River in western Cowley County; the Flint Hills in the central part of the area; and the "Chautauqua Hills" in the eastern part. The drainage pattern is shown in Figure 1.

The Wellington formation, which is devoid of sharp relief, borders the floodplain of the Arkansas River through most of its course in Cowley County. A short distance south of Arkansas City, however, the Arkansas is joined by the Walnut River and enters a narrow valley walled by steep, wooded slopes. Frye and Leonard (1952:198) suggest that this valley was originally carved by the Walnut River, when the Arkansas River flowed southward west of its present course. They further suggest that during Nebraskan glacial time the Arkansas probably was diverted to the rapidly downcutting Walnut. The Arkansas River has a gradient of 3.0 ft. per mile in Cowley County. This gradient and others cited were computed, by use of a cartometer, from maps made by the State Geological Survey of Kansas and the United States Geological Survey.

Northward along the Walnut, steep bluffs and eroded gulleys characterize both sides of the river, especially in southern Cowley County. Two massive limestones, the Fort Riley and the Winfield, form the bluffs in most places. The well-defined Winfield limestone is persistent on the west bank of the river across the entire county. The Walnut has only a few small tributaries in the southern half of Cowley County (Fig. 1). In the northern half, however, it is joined from the east by Timber Creek and Rock Creek. Timber Creek drains a large level area, formed by the eroded upper

portion of the Fort Riley limestone, in the north-central portion of the county. The gradient of Timber Creek is 12.9 feet per mile. The gradient of the Walnut River is only 2.3 ft. per mile from its point of entrance into the county to its mouth.

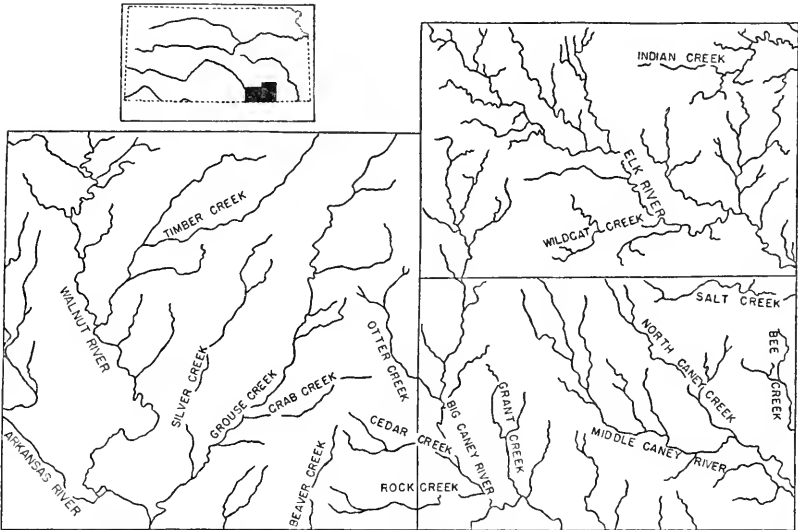


FIG. 1. Map of Cowley, Chautauqua and Elk counties, Kansas, showing the streams mentioned in the text.

Grouse Creek, like the Walnut, has formed a valley of one to three miles in width, rimmed by prominent wooded bluffs. Those on the west side are capped by the Fort Riley limestone with the resistant Wreford and Crouse limestones forming lower escarpments. On the east side the Wreford and Crouse limestones provide the only escarpments along the stream above the Vinton community, except for occasional lower outcrops of Morrill limestone. Below Vinton the Fort Riley limestone again appears, capping the hills above the Wreford limestone. The headwaters of the western tributaries of Grouse Creek are generally in the Doyle shale formation; the eastern tributaries are in the Wreford limestone, Matfield shale, and Barnestone limestone formations. The gradient of Grouse Creek is 9 ft. per mile, of Silver Creek 14.6 ft. per mile, and of Crab Creek 14.4 ft. per mile.

The Big Caney River (Fig. 1), having a gradient of 15.4 ft. per mile in the area studied, drains an area with considerable geological and topographic variation. The main stream and its western trib-

utaries originate in Permian formations, whereas the eastern tributaries originate in Pennsylvanian formations. Cedar Creek is exemplary of western tributaries of Big Caney. This creek arises in the Wreford limestone, as do several nearby tributaries of Grouse Creek. Although the Grouse tributaries descend through only part of the Council Grove group, Cedar Creek flows downward through the entire Grove, Admire, and Wabaunsee groups and part of the Shawnee Group (Moore, 1951). In only 15 miles, Cedar Creek traverses formations comprising more than 60 per cent of the entire exposed stratigraphic section in Cowley County. Bass (1929:16) states that reliefs of 350 feet within a mile are present in parts of this area.

Large terraces of limestone characterize the eastern flank of the Flint Hills, which the western tributaries of Big Caney drain. Most striking is the Foraker limestone. It characteristically consists of three massive members in Cowley County, the uppermost of which forms the prominent first crest of the Flint Hills. As the rapid-flowing western tributaries of Big Caney descend over these successive limestone members, large quantities of chert and limestone rubble are transported and deposited in stream beds of the system. In many places the streams of the Big Caney system flow over resistant limestone members, which form a bedrock bottom. The eastern tributaries of Big Caney drain, for the most part, formations of the Wabaunsee group of the Pennsylvanian. Most of these streams have lower gradients than those entering Big Caney from the west. The tributaries of Big Caney, along with length in miles and gradient in feet per mile, are as follows: Spring Creek, 7.1, 54.5; Union Creek, 6.3, 42.9; Otter Creek, 14.6, 27.4; Cedar Creek, 11.6, 31.0; Rock Creek, 15.9, 26.5; Wolf Creek, 9.3, 17.2; Turkey Creek, 8.5, 26.4; Grant Creek, 13.9, 23.4; and Sycamore Creek, 8.9, 27.0.

Spring Creek and Union Creek are short and have formed no extensive floodplain. The high gradients of these creeks are characteristic also of the upper portions of several other tributaries such as Cedar Creek and Otter Creek.

Middle Caney Creek (Fig. 1) has its source in the Wabaunsee and Shawnee groups of the Pennsylvanian but its watershed is dominated by the "Chautauqua Hills" of the Douglas Group. This area is described by Moore (1949:127) as "an upland formed by hard sandstone layers." The rough rounded hills supporting thick growths of oaks differ in appearance from both the Big Caney watershed on the west and the Verdigris River watershed on the east. The gradient of Middle Caney in Chautauqua County is

10.8 feet per mile. Its largest tributary, North Caney Creek, has a gradient of 15.5 feet per mile.

The Elk River Basin resembles the Big Caney River Basin topographically. Elk River has a gradient of 14.4 feet per mile.

PHYSICAL CHARACTERISTICS OF STREAMS

The stream channels derive their physical characteristics from the geological make-up of the area and from land-use. The Arkansas River typically has low banks; however, in a few places, as in the NE $\frac{1}{4}$ of Section 21, T. 33 S, R. 3 E, it cuts into limestone members to form steep rocky banks. The bottom is predominantly sand. In years of heavy rainfall the river is turbid, but during 1956, when it occupied only a small portion of its channel, it was clear each time observed. All streams surveyed were clear except after short periods of flooding in June, and except in some isolated pools where cattle had access to the water.

In the Walnut River, sand bottoms occur in the lower part of the stream but the sand is coarser than that of the Arkansas River. Upstream, gravel and rubble bottoms become more common. Steep rocky banks border most of the course of the Walnut. During 1956, stream-flow was confined to the center of the channel, remote from these rocky banks.

The rubble and bedrock bottoms found in most streams of the Flint Hills have been described. In the alluvial valleys of their lower courses mud bottoms are found. Gravel is present in some places but sand is absent. Banks are variable but often steep and wooded. Along east- or west-flowing streams the north bank characteristically is low and sloping whereas the south bank is high, rises abruptly, and in many places is continuous with wooded hills. The lower sections of Otter Creek, Cedar Creek, and Rock Creek fit this description (Bass, 1929:19) especially well, as does Elk River near Howard.

Streams in the Chautauqua Hills resemble those of the Flint Hills in physical characteristics, except that a larger admixture of sandstone occurs in the rubble.

CLIMATE

The climate of the area is characterized by those fluctuations of temperature, wind, and rainfall typical of the Great Plains. The mean annual temperature is 58 degrees; the mean July temperature is 81 degrees; the mean January temperature is approximately 34 degrees. The mean annual precipitation is 32.9 in Cowley County, 38.5 in Chautauqua County, and 35.1 in Elk County. Wind movement is great; Flora (1948:6) states that south-central Kansas ranks close to some of the windiest inland areas in the United States.

The area has been periodically subjected to droughts and floods. Such phenomena are of special interest to ichthyological workers in the area. At the time of this study drought conditions, which began in 1952, prevailed. Even in this period of drought, however, flooding occurred on Grouse Creek and water was high in Big Caney River after heavy local rains on the headwaters of these streams on June 22, 1956. Some of the lower tributaries of these same streams (such as Crab Creek and Cedar Creek) did not flow while the mainstreams were flooding. This illustrates the local nature of many of the summer rains in the area.

Table 1 indicates maximum, minimum, and average discharges in cubic feet per second at several stations in the area and on nearby streams. These figures were provided by the U. S. Geological Survey.

TABLE 1.—CUBIC FEET PER SECOND OF WATER DISCHARGED AT GAUGING STATIONS IN CHAUTAUQUA, ELK, MONTGOMERY, AND COWLEY COUNTIES FOR YEARS PRIOR TO 1951.

Gauging station	Drainage area (sq. mi.)	Average discharge	Maximum discharge	Date	Minimum discharge	Date
Arkansas River at Arkansas City	43,713	1,630	103,000	June 10, 1923	1	October 9, 1921
Walnut River at Winfield	1,840	738	105,000	April 23, 1944	0	1928, 1936
Big Caney River at Elgin	445	264	35,500	April 10, 1944	0	1939, 1940, 1946, 1947
Elk River near Elk City	575	393	39,200	April 16, 1945	0	1939, 1940, 1946
Fall River near Fall River	591	359	45,600	April 16, 1945	0	1939, 1940, 1946
Verdigris River at Independence	2,892	1,649	117,000	April 17, 1945	0	1932, 1934, 1936, 1939, 1940

Something of the effect that drought and flash-flood have had on Big Caney River is shown by the monthly means of daily discharge from October, 1954, to September, 1956, at the stream-gauging station near Elgin, Kansas (Table 2). Within these monthly variations there are also pronounced daily fluctuations; on Big Caney River approximately $\frac{1}{4}$ mile south of Elgin, Kansas, discharge in cubic feet per second for May, 1944, ranged from .7 to 9,270.0 and for May, 1956, from .03 to 20.0.

TABLE 2.—MONTHLY MEANS OF DAILY DISCHARGE IN CUBIC FEET PER SECOND FOR BIG CANEY RIVER AT ELGIN, KANSAS

Month	1954-55	1955-56	Month	1954-55	1955-56
October	103.00	69.60	April	4.91	.47
November	.31	.78	May	624.00	7.37
December	.18	1.92	June	51.30	35.20
January	.78	1.65	July	1.20	1.85
February	4.76	2.08	August	0.00	0.00
March	3.37	1.27	September	.04	0.00

PRESENT FLORA

The flora of the region varies greatly at the present time. Land-use has altered the original floral communities, especially in the intensively cultivated area of western Cowley County and in the river valleys.

The sandy Arkansas River floodplain exhibits several stages ranging from sparsely vegetated sandy mounds near the river through stages of Johnson grass, willow, and cottonwood, to an elm-hackberry fringe-forest. The Wellington formation bordering the floodplain supports a prairie flora where not disturbed by cultivation; Gates (1936:15) designates this as a part of the mixed bluestem and short-grass region. *Andropogon gerardi* Vitman., *Andropogon scoparius* Michx., *Sorghastrum nutans* (L.), and *Panicum virgatum* L. are important grasses in the hilly pasture-lands. Although much of this land is virgin prairie, the tall, lush condition of the grasses described by early writers such as Mooso (1888:304), and by local residents, is not seen today. These residents speak of slough grasses (probably *Tripsacum dactyloides* L. and *Spartina pectinata* Link.) that originally formed rank growths. These no doubt helped conserve water and stabilize flow in small headwater creeks. Remnants of some of these sloughs can still be found. The streams in the Flint Hills have fringe-forests of elm, hackberry, walnut, ash, and willow.

Eastward from the Flint Hills these fringe-forests become thicker with a greater admixture of hickories and oaks. The north slopes of hills also become more wooded. However, grassland remains predominant over woodland in western Chautauqua and Elk counties, whereas in the eastern one-half of Chautauqua County and the eastern one-third of Elk County the wooded Chautauqua Hills prevail. This is one of the most extensive wooded upland areas in Kansas. Hale (1955:167) describes this woodland as part of an ecotonal scrub-oak forest bordering the Great Plains south through Texas. He found stand dominants in these wooded areas to be *Quercus marilandica* Muenchh., *Quercus stellata* Wang., and *Quercus velutina* Lam.

Few true aquatic plants were observed in the Arkansas River although mats of duckweed were found in shallow backwater pools at station A-3 (Fig. 2) on December 22, 1956. In the Walnut River *Najas guadalupensis* Spreng. was common at station W-2. Stones were usually covered with algae in both the Arkansas and Walnut rivers. A red bloom, possibly attributable to *Euglena rubra* (Johnson), was observed on a tributary of the Walnut River on July 9, 1956, at station W-4.

Green algae were abundant at all stations in the Caney, Elk, and Grouse systems during May and June, 1956, and reappeared late in September. *Chara* sp. was common in these streams in April and May.

The most characteristic rooted aquatic of streams in the Flint Hills was *Justicia americana* L. At station G-7 on Grouse Creek and Station C-8 on Big Caney River (Fig. 3), *Nelumbo lutea* (Willd.) was found. *Myriophyllum heterophyllum* Michx. formed dense floating mats at a number of stations. Other aquatic plants observed in the Caney, Elk, and Grouse systems included *Potamogeton gramineus* L., *Potamogeton nodosus* Poir., *Potamogeton foliosus* Raf., *Sagittaria latifolia* Willd., *Typha latifolia* L., and *Jussiaea diffusa* Forsk.

HISTORY

In 1857, a survey was made of the southern boundary of Kansas. Several diaries (Miller, 1932; Caldwell, 1937; Bieber, 1932) were kept by members of the surveying party, which traveled from east to west. These accounts contain complaints of difficulty in traversing a country of broken ridges and gulleys as the party approached the area now comprising Chautauqua County. One account by Hugh Campbell, astronomical computer for the party (Caldwell, 1937) mentions rocky ridges covered with dense growth of "black jack," while another by Col. Joseph Johnson, Commander (Miller, 1932) speaks of "a good deal of oakes in the heights"—indicating that the upland oak forest of the Chautauqua Hills was in existence at that time. On reaching Big Caney River near Elgin, Campbell wrote of a stream with very high banks and of a valley timbered with oak and black walnut. While the party was encamped on Big Caney River some fishing was done. Campbell (Caldwell, 1937:353) described the fish taken as "Cat, Trout or Bass, Buffalo and Garr." Eugene Bandel (Bieber, 1932:152) wrote, "This forenoon we did not expect to leave camp, and therefore we went fishing. In about two hours we caught more fish than the whole company could eat. There were some forty fish caught, some of them weighing over ten pounds." It was noted that the waters of Big Caney and its tributaries were "very clear." Progressing up Rock Creek, Johnson wrote of entering a high rolling plain covered with fine grass, and crossed occasionally by clear wooded streams (probably Big and Little Beaver Creeks and Grouse Creek). The diary of Hugh Campbell (Caldwell, 1937:354) contains a description of the Arkansas River Valley near the Oklahoma border. "The Arkansas River at this point is about 300 yards wide, its waters are muddy, not quite so much so, as those of the Mississippi or Rio Bravo. Its valley is wooded and about two miles in width, the main bottom here, being on the east side. On the west it is a rolling prairie as far as the eye can see, affording excellent grass." Some seining was done while encamped on the Arkansas River and "buffalo, catfish, sturgeons, and gars" were taken (Bieber, 1932:156).

An editorial in the Winfield Courier of November 16, 1899, vigorously registers concern about a direct effect of settlement on fish populations in rivers of the area:

"The fish in the streams of Cowley County are being slaughtered by the thousands, by the unlawful use of the seine and the deadly hoop net. Fish are sold on the market every day, sometimes a tubful at a time, which never swallowed a hook.

"The fish law says it is unlawful to seine, snare, or trap fish but some of the smaller streams in the county, it is said are so full of hoop and trammel nets that a minnow cannot get up or down stream. These nets not only destroy what fish there are in the streams but they keep other fish from coming in, they are not operated as a rule by farmers to supply their own tables but by fellows who catch the fish to sell with no thought or care for the welfare of others who like to catch and eat fish.

"If there is a fishwarden in Cowley County so far as his utility goes the county would be as well off without him and his inactivity has caused many of those interested to get together for the purpose of seeing that the law is enforced.

"Depredations like this work injury in more ways than one. They not only deplete the streams of fish large enough to eat and destroy the source of supply but if the U. S. Fish Commission discovers that the law is not enforced and the fish not protected, there will be no free government fish placed in Cowley County streams. It is useless for the Government to spend thousands of dollars to keep the streams well supplied if a few outlaws are allowed to ruthlessly destroy them. The new organization has its eye on certain parties now and something is liable to drop unexpectedly soon."

Graham (1885:78) listed 13 species of fish that had already been introduced into Kansas waters prior to 1885 by the State Fish Commission.

These early references indicate that direct effects of settlement on the native flora and fauna were recognized early. Concern such as that expressed in the editorial above persists today; however, it is not clear whether the fish fauna of the streams of the area has been essentially changed by man's predation. The indirect effects through human modifications of the environment seem to be of much importance. Three modifications which have especially affected streams have been agricultural use, urbanization, and industrialization.

The effect of land-use on streams is closely related to its effect on the flora of the watershed. Turbidity, sedimentation, and the rate, periodicity, and manner of flow all bear some relationship to the land-use of the watershed. Stream-flow in the area has been discussed in the section on climate.

The effects of urbanization are more tangible and better recognized than those of agricultural land-use. Streams that flow through cities and other populous areas undergo some modification, especially of the streamside flora. Another effect of urbanization has been increased loads of sewage discharged into the streams. The combined populations of Arkansas City and Winfield rose from 3,986 in 1880 to 23,167 in 1950. Arkansas City found it necessary to construct a sewage system in 1889; Winfield in 1907.

There are, at the present time, nine towns within the area that have municipal sewage systems. The State Training Home at Winfield also has a sewage system. The Kansas State Board of Health, Division of Sanitation, has provided information concerning adequacy of these systems and certain others in nearby counties as of February 5, 1957. This information is shown in Table 3.

Representatives of the Division of Sanitation, Kansas State Board of Health, expressed the belief that pollution by both domestic sewage and industrial wastes would be largely eliminated in the "lower Arkansas" and in the Walnut watershed by 1959.

Important oil and gas resources have been discovered in each of the three counties. The first producing wells were drilled between 1900 and 1902 (Jewett and Abernathy, 1945:24). The Arkansas River flows through several oilfields in its course across Cowley County (Jewett and Abernathy, 1945:97). A number of producing wells have been drilled in the Grouse Creek watershed since 1939 and many of these wells are near the banks of the creek. In the Big Caney watershed of Cowley and Chautauqua counties there has been little oil production in recent years; however, a few small pools are presently producing in southwestern Elk County.

Clapp (1920:33) stated that "Many of the finest streams of our state are now destitute of fish on account of oil and salt pollution. The Walnut River,

TABLE 3.—SEWAGE DISPOSAL FACILITIES IN SOME SOUTH-CENTRAL KANSAS COMMUNITIES.

Community	Status on February 5, 1957	Remarks
Cowley County:		
Arkansas City.....	Discharging raw sewage....	Adequate plant in design stage.
Geuda Springs.....	Discharging raw sewage	
Winfield.....	Inadequate	
State training school	Adequate	
Udall.....	Adequate	
Chautauqua County:		
Cedar Vale.....	Inadequate	
Sedan.....	Adequate.....	In operation 30 days.
Elgin.....	Adequate	
Elk County:		
Moline.....	Inadequate	
Howard.....	Adequate	
Sumner County:		
Belle Plaine.....	Discharging raw sewage....	Adequate plant under construction.
Mulvane.....	Discharging raw sewage....	Adequate plant under construction.
Oxford.....	Discharging raw sewage....	Construction on adequate plant to start soon.
Butler County:		
Augusta.....	Adequate	
El Dorado.....	Discharging raw sewage....	Adequate plant under construction.
Douglass.....	Discharging raw sewage....	Adequate plant to go into operation within 30 days.

once as fine a bass stream as could be found anywhere, and a beautiful stream, too, is now a murky oil run, and does not contain a single fish so far as I know. The Fall and Verdigris rivers are practically ruined. Both the Caney rivers are affected, and may soon be ruined for fishing." Doze (1924:31) noted "Some of the finest streams in the state have been ruined as habitat for wild life, the Walnut River is probably the most flagrant example."

Pollution by petroleum wastes from refineries has also affected the streams studied. The only refinery within the area is at Arkansas City. In Butler County there are four refineries on the Walnut watershed upstream from the area surveyed. Metzler (1952) noted that "fish-kills" occurred from the mid-1940's until 1952 in connection with wastes periodically discharged from these refineries. However, the largest kill, in 1944, was attributed to excessive brine pollution.

In Arkansas City a meat-packing plant, a large railroad workshop, two flour mills, two milk plants, and several small manufacturing plants contribute wastes which may figure in industrial pollution. There are milk plants and small poultry processing plants at Winfield. In Chautauqua and Elk Counties there is little industrial activity.

CONSERVATION

In recent years several measures have been implemented or proposed to conserve the water and land resources of the Arkansas River Basin. Droughts and floods have focused public attention on such conservation. Less spectacular, but nevertheless important, problems confronting conservationists include streambank erosion, channel deterioration, silting, recreational demands for water, and irrigation needs.

Congress has authorized the U. S. Corps of Engineers (by the Flood Control Act of 1941) to construct six dam and reservoir projects in the Verdigris watershed. Two of these—Hulah Reservoir in Osage County, Oklahoma, on Big Caney River, and Fall River Reservoir in Greenwood County, Kansas—have been completed. Other reservoirs authorized in the Verdigris watershed include Toronto, Neodesha, and Elk City (Table Mound) in Kansas and Oologah in Oklahoma. Construction is underway on the Toronto Reservoir and some planning has been accomplished on the Neodesha and Elk City projects.

The possibilities of irrigation projects in the Verdigris and Walnut River basins are under investigation by the United States Bureau of Reclamation (Foley, *et al.*, 1955:F18).

An area of 11 square miles in Chautauqua and Montgomery Counties is included in the Aiken Creek "Pilot Watershed Project," a co-operative effort by federal, state, and local agencies to obtain information as to the effects of an integrated watershed protection program (Foley, *et al.*, 1955:131).

PREVIOUS ICHTHYOLOGICAL COLLECTIONS

Few accounts of fishes in the area here reported on have been published. Evermann and Fordice (1886:184) made a collection from Timber Creek at Winfield in 1884.

The State Biological Survey collected actively from 1910 to 1912, but localities visited in the Arkansas River System were limited to the Neosho and Verdigris River basins (Breukelman, 1940:377). The only collection made in the area considered here was on the Elk River in Elk County on July 11, 1912. The total species list of this collection is not known.

In the years 1924-1929 Minna E. Jewell collected at various places in central Kansas. On June 30, 1925, Jewell and Frank Jobes made collections on Timber Creek and Silver Creek in Cowley County.

Hoyle (1936:285) mentions collections made by himself and Dr. Charles E. Burt, who was then Professor of Biology at Southwestern College, Winfield, Kansas. Records in the Department of Biology, Kansas State Teachers College at Emporia, indicate that Dr. Burt and others made collections in the area which have not been published on.

TABLE 4.—COLLECTIONS MADE BY DR. FRANK B. CROSS OF THE STATE BIOLOGICAL SURVEY IN 1955.

Collection number	Date	River	Location
C-131	April 5, 1955	Elk	Sec. 3, T31S, R11E
C-132	April 5, 1955	Sycamore	Sec. 5, T34S, R10E
C-133	April 5, 1955	Big Caney	Sec. 12, T34S, R8E
C-136	April 6, 1955	Walnut	Sec. 29 or 32, T32S, R4E

Claire Schelske (1957) studied fishes of the Fall and Verdigris Rivers in Wilson and Montgomery counties from March, 1954, to February, 1955.

In the annotated list of species that follows, records other than mine are designated by the following symbols:

E&F—Evermann and Fordice

SBS—State Biological Survey (1910-1912)

J&J—Jewell and Jobs (collection on Silver Creek)

C—Collection number—Cross (State Biological Survey, 1955)

UMMZ—University of Michigan Museum of Zoology

OAM—Oklahoma A&M College Museum of Zoology

ACKNOWLEDGMENTS

I am grateful to Professor Frank B. Cross for his interest in my investigation, for his counsel, and for his penetrating criticism of this paper. This study would have been impossible without the assistance of several persons who helped in the field. Mr. Artie C. Metcalf and Mr. Delbert Metcalf deserve special thanks for their enthusiastic and untiring co-operation in collecting and preserving of specimens. Mrs. Artie C. Metcalf, Miss Patricia Metcalf, Mr. Chester Metcalf, and Mr. Forrest W. Metcalf gave help which is much appreciated. I am indebted to the following persons for numerous valuable suggestions: Dr. John Breukelman, Kansas State Teachers College, Emporia, Kansas; Dr. George Moore, Oklahoma A&M College, and Mr. W. L. Minckley, Lawrence, Kansas.

MATERIALS AND METHODS

Collections were made by means of: (1) a four-foot net of nylon screen; (2) a 10x4-foot "common-sense" woven seine with $\frac{1}{2}$ -inch mesh; (3) a 15x4-foot knotted mesh seine; (4) a 20x5-foot $\frac{1}{2}$ -inch mesh seine; (5) pole and line (natural and artificial baits). At most stations the four-foot, ten-foot, and twenty-foot seines were used; however, the equipment that was used varied according to the size of pool, number of obstructions, nature of bottom, amount of flow, and type of streambank. Usually several hours were spent at each station and several stations were revisited from time to time. Percentages noted in the List of Species represent the relative number taken in the first five seine-hauls at each station.

COLLECTING STATIONS

Collecting was done at stations listed below and shown in Fig. 2. Each station was assigned a letter, designating the stream system on which the station was located, and a number which indicates the position of the station on the stream. This number increases progressively upstream from mouth to source. Code letters used are as follows: A—Arkansas River; W—Walnut River System; B—Beaver Creek System; C—Big Caney River System; G—Grouse Creek System; M—Middle Caney Creek System; E—Elk River System. All dates are in the year 1956.

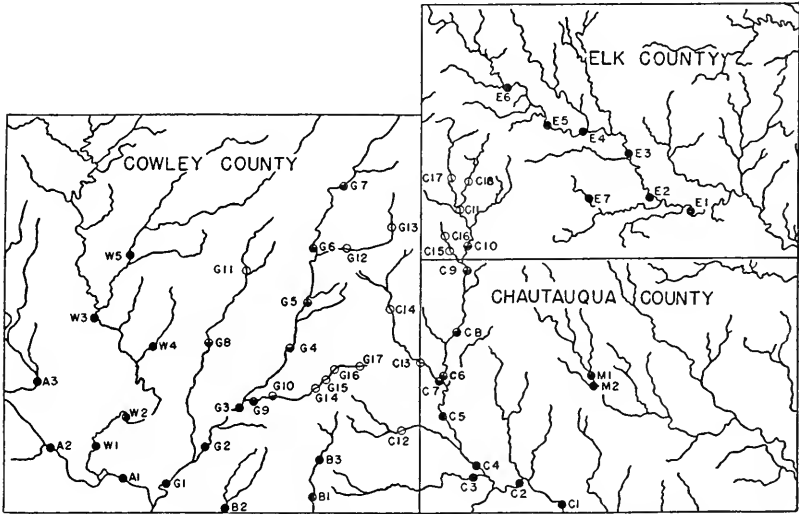


FIG. 2. Map of Cowley, Chautauqua and Elk counties, Kansas, showing stations at which collecting was done.

A-1. Arkansas River. Sec. 2 and 3, T. 35 S, R. 4 E. June 14 and August 20. Braided channel with sand bottom. Water slightly turbid, with layer of oil sludge on bottom.

A-2. Arkansas River. Sec. 22, T. 34 S, R. 3 E. August 25. Flowing through diverse channels. Average depth 12 inches. Bottom sand. (Plate 9, fig. 1.)

A-3. Arkansas River. Sec. 21, T. 33 S, R. 3 E. August 27 and December 22. Flowing over fine sand. Average depth 11 inches. Some areas of back-water with oil sludge on bottom.

W-1. Walnut River. Sec. 20, T. 34 S, R. 4 E. July 7. Flowing rapidly, with large volume, because of recent rains. Average width 300 feet. Bottom gravel. Water turbid.

W-2. Walnut River. Sec. 11, T. 34 S, R. 4 E. July 20. Rubble riffles and large shallow pools with gravel bottoms. Average width, 100 feet. Water clear.

W-3. Walnut River. Sec. 29, T. 32 S, R. 4 E. July 17. Pools and riffles below Tunnel Mill Dam at Winfield. Water clear.

W-4. Badger Creek. Sec. 6, T. 33 S, R. 5 E. July 17. Small pools. Average width 7 feet, average length 40 feet, average depth 8 inches. Water turbid and malodorous. Bottoms and banks mud. Much detritus present.

W-5. Timber Creek. Sec. 35, T. 31 S, R. 4 E. June 6. Intermittent pools, widely separated. Average width 9 feet, average depth 8 inches. Bottom mud and gravel.

B-1. Big Beaver Creek. Sec. 8, T. 35 S, R. 7 E. May 28. Isolated pools. Average width 10 feet, average depth one foot. Water turbid. Bottom rubble.

B-2. Little Beaver Creek. Sec. 18, T. 35 S, R. 6 E. July 21. Intermittent pools. Average width 10 feet, average length 35 feet, average depth 10 inches. Bottoms rubble, mud, and bedrock.

B-3. Big Beaver Creek. Sec. 28, T. 34 S, R. 7 E. July 22. Series of small turbid pools.

G-1. Grouse Creek. Sec. 5, T. 35 S, R. 5 E. May 30, September 5, and September 24. Intermittent pools in close succession. Average width 22 feet, average depth 16 inches. Water turbid on May 30 but clear in September. Bottom rubble. Steep banks. Little shade for pools.

G-2. Grouse Creek. Sec. 23, T. 34 S, R. 5 E. August 29. Series of shallow intermittent pools. Average width 42 feet, average length 120 feet, average depth 15 inches. Bottom bedrock and mud. (Plate 9, fig. 2.)

G-3. Grouse Creek. Sec. 6, T. 34 S, R. 6 E. July 12. Intermittent pools. Average width 20 feet, average length 65 feet, average depth 14 inches. Bottom bedrock and gravel. *Justicia americana* L. abundant.

G-4. Grouse Creek. Sec. 12, T. 33 S, R. 6 E. June 1 and September 7. Intermittent pools. Average width 15 feet, average length 100 feet, average depth 18 inches. Water turbid in June, clear in September. *Najas guadalupensis* Spreng., and *Myriophyllum heterophyllum* Michx. common.

G-5. Grouse Creek. Sec. 19, T. 32 S, R. 7 E. July 2. Succession of riffles and pools. Water clear. Volume of flow approximately one cubic foot per second, but creek bankful after heavy rains on June 22. Average width 20 feet, average depth 18 inches.

G-6. Grouse Creek. Sec. 32, T. 31 S, R. 7 E. July 8. Small intermittent pools to which cattle had access. Water turbid, bottom mud and rubble. Average width 10 feet, average depth 8 inches. Stream-bed covered with tangled growths of *Sorghum halepense* (L.).

G-7. Grouse Creek. Sec. 34, T. 30 S, R. 7 E. July 8. Stream flowing slightly. Water clear. Average width of pools 30 feet; average depth 20 inches. Bottom bedrock and gravel. *Myriophyllum heterophyllum* Michx., *Nelumbo lutea* (Willd.), and *Justicia americana* L. common in shallow water.

G-8. Silver Creek. Sec. 1, T. 33 S, R. 5 E. July 17. Intermittent pools. Average width 30 feet, average length 120 feet, average depth 12 inches. Water clear.

G-9. Silver Creek. Sec. 4, T. 32 S, R. 6 E. July 17. Small upland brook with volume less than one-half cfs. Average width 12 feet, average depth 10 inches. Water clear, bottom mostly rubble.

G-10. Crab Creek. Sec. 33, T. 33 S, R. 6 E. June 24. Intermittent pools, showing evidence of having flowed after rains on June 22. Average width 15 feet, average depth 16 inches.

G-11. Crab Creek. Sec. 35, T. 33 S, R. 6 E. July 16. Small intermittent pools. Average width 13 feet, average length 55 feet, average depth 11 inches. Water clear. Bottom rubble and mud.

G-12. Crab Creek. Sec. 28, T. 33 S, R. 7 E. June 2 and July 20. Isolated pools. Average width 18 feet, average depth one foot. Water turbid. Bottom bedrock and rubble. *Myriophyllum heterophyllum* and *Justicia americana* abundant.

G-13. Crab Creek. Sec. 21, T. 33 S, R. 7 E. July 29. Isolated pools 300 feet by 24 feet. Average depth 12 inches. Water turbid.

G-14. Unnamed creek (hereafter called Grand Summit Creek). Sec. 26, T. 31 S, R. 7 E. August 30. Intermittent pools. Average width 15 feet, average length 45 feet, average depth 11 inches. Water clear. Bottom rubble.

PLATE 9



1. Station A-2. Arkansas River. (Cowley County, Section 22, T. 34 S, R. 3 E.)



2. Station G-2. Grouse Creek. (Cowley County, Section 23, T. 34 S, R. 5 E.)

PLATE 10



1. Station C-12. Cedar Creek. (Cowley County, Section 17, T. 31 S., R. 8 E.)



2. Station C-16. Spring Creek. (Elk County, Section 26, T. 31 S., R. 8 E.)
Volume of flow of this small creek is indicated by rillle in foreground.

G-15. Unnamed creek (same as above). Sec. 17, T. 31 S, R. 8 E. July 27. Small upland creek bordered by bluestem pastures. Pools with average width of 10 feet, average length 30 feet, average depth 9 inches. Water slightly turbid. Bottom rubble and mud.

G-16. Crab Creek. Sec. 22, T. 33 S, R. 7 E. July 25. Small isolated pools. Average width 17 feet, average length 58 feet, average depth 9 inches. Water turbid.

G-17. Crab Creek. Sec. 23, T. 33 S, R. 7 E. July 25. Upland brook bordered by bluestem pastures. Unshaded intermittent pools. Average width 7 feet, average length 40 feet, average depth 9 inches. Water turbid.

C-1. Big Caney River. Sec. 16, T. 33 S, R. 10 E. July 19. Intermittent pools. Average width 47 feet, average length 90 feet, average depth 13 inches. Bottom rubble and bedrock. Water clear to slightly turbid.

C-2. Big Caney River. Sec. 1, T. 35 S, R. 9 E. September 5. Series of intermittent pools. Bottom rubble and large stones.

C-3. Big Caney River. Sec. 29, T. 34 S, R. 9 E. June 17. Large shallow pool below ledge 3 feet high forming "Osro Falls." Bottom bedrock.

C-4. Big Caney River. Sec. 32, T. 34 S, R. 9 E. June 3. Three large pools (50 feet by 300 feet) with connecting riffles. Water turbid. Bottom bedrock and rubble.

C-5. Big Caney River. Sec. 11 and 12, T. 34 S, R. 8 E. May 27, May 29, June 11, June 18, June 19, and June 27. From a low-water dam, 6 feet high, downstream for $\frac{1}{4}$ mile. Pools alternating with rubble and bedrock riffles. Collecting was done at different times of day and night, and when stream was flowing and intermittent.

C-6. Big Caney River. Sec. 26, T. 33 S, R. 8 E. June 16. Intermittent pools with bedrock bottom. Water slightly turbid. Average width 16 feet, average depth 10 inches.

C-7. Otter Creek. Sec. 26, T. 33 S, R. 8 E. June 16. Pools and riffles. Water clear. Algae abundant. Average width 10 feet, average depth 10 inches.

C-8. Big Caney River. Sec. 1, T. 33 S, R. 8 E. June 10. Intermittent pools. Average width 10 feet, average depth 14 inches. Water clear. Bottom rubble and gravel. Aquatic plants included *Chara* sp., *Sagittaria latifolia* Willd., *Jussiaea diffusa* Forsk., and *Nelumbo lutea* (Willd.).

C-9. Big Caney River. Sec. 6 and 7, T. 32 S, R. 9 E. June 27. Clear, flowing stream, 20 feet wide, volume estimated at 5 cfs. Bottom gravel and rubble. Extensive gravel riffles.

C-10. Big Caney River. Sec. 29 and 32, T. 31 S, R. 9 E. June 27. Water clear and flowing rapidly, volume estimated at 5-6 cfs. Bottom rubble with a few muddy backwater areas.

C-11. Big Caney River. Sec. 7, T. 31 S, R. 9 E. July 26. Flowing, with less than 1 cfs. Average width 20 feet, average depth 22 inches. Water extremely clear. Bottom gravel and rubble. *Myriophyllum heterophyllum*, *Potamogeton foliosus*, and *Justicia americana* common.

C-12. Cedar Creek. Sec. 17, T. 34 S, R. 8 E. March 10, April 2, June 1, June 6, and August 24. Pools and riffles along $\frac{1}{4}$ mile of stream were seined in the early collections. In August only small isolated pools remained. Bottom bedrock and rubble. Much detritus along streambanks. (Plate 10, fig. 1.)

C-13. Otter Creek. Sec. 16, T. 33 S, R. 8 E. June 15. Flowing, less than 1 cfs. Pools interspersed with rubble riffles. Water clear.

C-14. Otter Creek. Sec. 30, T. 32 S, R. 8 E. May 31, and September 3. Series of small pools. Average width 10 feet, average depth 15 inches. Shallow rubble riffles. Water extremely clear. Temperature 68° at 6:30 p. m. on May 31; 78° at 2:00 p. m. on September 3.

C-15. Spring Creek. Sec. 35, T. 31 S, R. 8 E. June 28. Small, clear,

upland brook with rubble bottom. Pools 10 feet in average width and 11 inches in average depth. Numerous shallow rubble riffles.

C-16. Spring Creek. Sec. 26, T. 31 S, R. 8 E. July 9. Small intermittent pools. Average width 10 feet; average depth 8 inches. Bottom gravel. (Plate 10, fig. 2.)

C-17. West Fork Big Caney River. Sec. 36, T. 30 S, R. 8 E. July 27. Small pool below low-water dam. Pool 20 feet by 30 feet with average depth of 20 inches.

C-18. East Fork Big Caney River. Sec. 31, T. 30 S, R. 9 E. July 27. Isolated pool 25 feet by 25 feet with an average depth of 15 inches.

M-1. Middle Caney Creek. Sec. 23, T. 33 S, R. 10 E. July 4. Intermittent pools. Average width 45 feet, average depth 15 inches. Water stained brown. Oil fields nearby but no sludge or surface film of oil noted. Bottom rubble and bedrock.

M-2. Pool Creek. Sec. 25, T. 33 S, R. 10 E. May 26. Pool 120 feet by 40 feet below limestone ledge approximately 12 feet high forming Butcher's Falls. Other smaller pools sampled. Water clear. Bottom bedrock and rubble.

E-1. Elk River. Sec. 12, T. 31 S, R. 11 E. July 9. Four intermittent pools seined. Average width 32 feet, average depth 13 inches. Bottom bedrock, rubble, and mud. Water turbid.

E-2. Elk River. Sec. 3, T. 31 S, R. 11 E. June 28. Intermittent pools below and above sandstone ledge approximately 6 feet high forming "falls" at Elk Falls. Average width 33 feet, average depth 15 inches. Bottom bedrock, rubble and mud. Water slightly turbid.

E-3. Elk River. Sec. 21, T. 30 S, R. 11 E. June 28. Two small pools, 10 feet by 30 feet with average depth of 6 inches. Bottom bedrock.

E-4. Elk River. Sec. 12, T. 30 S, R. 10 E. June 28. One long pool 500 feet by 50 feet with a variety of depths and bottom conditions ranging from mud to bedrock. Average depth 18 inches. Water turbid and pools unshaded.

E-5. Elk River. Sec. 32, T. 29 S, R. 10 E. August 30. Intermittent pools. Average width 21 feet, average depth 20 inches. Bottom rubble. Water clear.

E-6. Elk River. Sec. 23, T. 29 S, R. 9 E. August 30. Small isolated pools. River mostly dry. Bottom bedrock. Water slightly turbid with gray-green "bloom."

E-7. Wildcat Creek. Sec. 11, T. 31 S, R. 10 E. Volume of flow less than one cfs. Average width 20 feet, average depth 18 inches. Domestic sewage pollution from town of Moline suspected.

ANNOTATED LIST OF SPECIES

Lepisosteus osseus oxyurus (Linnaeus): Stations A-1, W-2, W-3, G-2, G-3, G-4, C-1, C-2, C-3, C-5, C-8.

Of 34 longnose gar taken, 27 were young-of-the-year. The latter were from shallow isolated pools (bedrock bottom at C-1, C-3, C-4; gravel bottom at C-6). At station W-1 in moderate flood conditions several young-of-the-year were found in the most sheltered water next to the banks.

The longnose gar was found only in the lower parts of the streams surveyed (but were observed by me in smaller tributaries of these streams in years when the streams had a greater volume of flow). A preference for downstream habitat is suggested in several other surveys: Cross (1950:134, 1954a:307) on the South Fork of the

Cottonwood and on Stillwater Creek; Cross and Moore (1952:401) on the Poteau and Fourche Maline rivers; Moore and Buck (1953:21) on the Chikaskia River.

Lepisosteus platostomus Rafinesque: One shortnose gar (K. U. 3157) has been taken from the Arkansas River in Cowley County. This gar was taken by Mr. Richard Rinker on a bank line on April 10, 1955, at station A-3.

Dorosoma cepedianum (Le Sueur): Stations W-3, G-4, C-4, C-5, M-1, E-1, E-4.

In smaller streams such as the Elk and Caney rivers adult gizzard shad seemed scarce. They were more common in collections made in larger rivers (Walnut, Verdigris, and Neosho). In impoundments of this region shad often become extremely abundant. Schoonover (1954:173) found that shad comprised 97 per cent by number and 83 per cent by weight of fishes taken in a survey of Fall River Reservoir.

Carpionodes carpio carpio (Rafinesque): Stations A-1, A-2, A-3, W-3, G-1, C-3.

Hubbs and Lagler (1947:50) stated that the river carpsucker was "Mostly confined to large silty rivers." Of the stations listed above C-3 least fits this description being a large shallow pool about $\frac{1}{2}$ acre in area having bedrock bottom and slightly turbid water. The other stations conform to conditions described by Hubbs and Lagler (*loc. cit.*).

Carpionodes velifer (Rafinesque): SBS. Three specimens of the highfin carpsucker (K. U. 177-179) were collected on July 11, 1912, from an unspecified location on Elk River in Elk County.

Ictiobus bubalus (Rafinesque): Stations W-3, G-1, G-2, C-1, C-3, C-4, C-6, E-1, E-2, E-3.

The smallmouth buffalo shared the downstream proclivities of the river carpsucker. In half of the collections (G-2, C-1, E-1, E-2, E-3) only large juveniles were taken; in the other half only young-of-the-year were found. In one pool at station C-1 hundreds of young buffalo and gar were observed. This large shallow pool was 100 x 150 feet, with an average depth of 8 inches. The bottom consisted of bedrock. Station C-6 was a small pool with bedrock bottom, eight feet in diameter, with an average depth of only 4 inches. Station E-3 was also a small isolated pool with bedrock bottom and an average depth of 6 inches.

Ictiobus niger (Rafinesque): Station C-5.

Only two specimens of the black buffalo were taken. An adult

was caught on spinning tackle, with doughballs for bait. The second specimen was a juvenile taken by seining one mile below Station C-5 on September 22.

Ictiobus cyprinella (Valenciennes): Station G-2.

Two juvenal bigmouth buffalo were taken in a shallow pool, along with several juvenal smallmouth buffalo.

Moxostoma aureolum pisolabrum Trautman and *Moxostoma carinatum* (Cope): SBS.

Two specimens of *Moxostoma aureolum pisolabrum* (K. U. 242-243) and one specimen of *Moxostoma carinatum* (K. U. 223) were taken from an unspecified locality on Elk River in Elk County on July 11, 1912. There are no other records for any of these fish in the collection area. *M. aureolum pisolabrum* has been taken in recent years in eastern Kansas (Trautman, 1951:3) and has been found as far west as the Chikaskia drainage in northern Oklahoma by Moore and Buck (1953:21). That occasional northern redborse enter the larger rivers of the area here reported on seems probable.

M. carinatum has been reported only a few times from Kansas. The only recent records are from the Verdigris River (Schelske, 1957:39). Elkins (1954:28) took four specimens of *M. carinatum* from cutoff pools on Salt Creek in Osage County, Oklahoma, in 1954. This recent record suggests that occurrences in southern Kansas are probable.

Moxostoma erythrurum (Rafinesque): Stations G-5, G-7, G-10, G-12, C-4, C-5, C-6, C-8, C-10, C-11, C-12, C-13, C-15, E-1, E-2, E-4 (C-131, C-133, C-136).

The golden redborse was common in several of the streams surveyed, and utilized the upland parts of streams more extensively than any of the other catostomids occurring in the area. *M. erythrurum* and *Ictiobus bubalus* were taken together at only two stations. In no case was *I. bubalus* taken from a tributary of Grouse Creek or of Big Caney River. In contrast *M. erythrurum* reached its greatest concentrations in such habitat, although it was always a minor component of the total fish population. Stations C-5 and E-2 were the lowermost environments in which this redborse was taken.

The largest relative number of golden redborse was found at station G-12 on Crab Creek where 7.5 per cent of the fishes taken were of this species. This station consisted of intermittent pools averaging one foot in depth. Bottoms were bedrock and rubble and the water was clear and shaded. The fish were consistently

taken in the deeper, open part of the pool where aquatic vegetation, which covered most of the pool, was absent.

Another station at which *M. erythrurum* was abundant was C-12 on Cedar Creek. Here a long, narrow, clear pool was the habitat, with average depth of 17 inches, and bottom of bedrock.

Minytrema melanops (Rafinesque): Stations G-10, C-4, C-12, E-1.

Occurrences of the spotted sucker were scattered. At stations C-4 and G-10 single specimens were taken. At station E-1 (July 9) one specimen was taken at the mouth of a small tributary where water was turbid and quiet. This specimen (K. U. 3708) was the largest (9½ inches total length) found, and possessed pits of lost tubercles.

Cyprinus carpio Linnaeus: Stations A-1, W-1, W-2, W-3, W-4, G-3, G-4, G-6, G-8, C-3, C-5, E-4.

Carp were taken most often in downstream habitat. No carp were taken above station C-5 on Big Caney River.

The earliest date on which young were taken was July 7, when 46 specimens, approximately ½ inch in total length, were taken from the Walnut River at station W-1. The small carp showed a preference for small shallow pools; adults were found in deeper pools.

Hybopsis aestivalis tetranemus (Gilbert): Station A-3.

Only one specimen of the speckled chub was taken. The species has been recorded from nearby localities in the Arkansas River and its tributaries both in Kansas and Oklahoma. Its habitat seems to be shallow water over clean, fine sand, and it occurs in strong current in mid-channel in the Arkansas River. Suitable habitat does not occur in other parts of the area covered by this report.

Notropis blennioides (Girard): Stations A-1, A-2, A-3.

The river shiner was taken only in the Arkansas River and in small numbers. In all instances *N. blennioides* was found over sandy bottom in flowing water. Females were gravid at station A-1 on June 14. To my knowledge there are no published records of this shiner from the Arkansas River Basin in Kansas. In Oklahoma this species prefers the large, sandy streams such as the Arkansas River. Cross and Moore (1952:403) found it in the Poteau River only near the mouth.

Notropis boops Gilbert: Stations G-5, G-7, C-3, C-5, C-8, C-9, C-10, C-11, C-12, C-15, C-16, E-4, E-5, M-1, M-2.

Widespread occurrence of the bigeye shiner in this area seems surprising. Except for this area it is known in Kansas only from

the Spring River drainage in the southeastern corner of the state (Cross, 1954b:474). *N. boops* chose habitats that seemed most nearly like Ozarkian terrain. The largest relative number of bigeye shiners was taken at C-11 in a clear stream described in the discussion of *Notropis rubellus*. At this station *N. boops* comprised 14.11 per cent, and *N. boops* and *N. rubellus* together comprised 24.78 per cent of all fish taken.

At station G-7 on Grouse Creek the percentage of *N. boops* was 7.15. Here, as at station C-11, water was clear. At both stations *Myriophyllum heterophyllum* was abundant and at G-7 *Nelumbo lutea* was also common. At G-7 *N. boops* seemed most abundant in the deeper water, but at C-11 most shiners were found in the shallower part of a large pool.

Two other collections in which *N. boops* were common were from Spring Creek. It is a small, clear Flint Hills brook running swiftly over clean gravel and rubble. It had, however, been intermittent or completely dry in its upper portion throughout the winter of 1955-'56 and until June 22, 1956. In collections at C-15 on June 28, *N. boops* formed 6.5 per cent of the fish taken. Farther upstream, at C-16 on July 9, in an area one mile from the nearest pool of water that existed prior to the rains of June 22, *N. boops* made up 7.2 per cent of the fish taken.

In streams heading in the hilly area of western Elk County, the relative abundance of *Notropis boops* decreased progressively downstream. On upper Elk River percentages were lower than on upper Grouse Creek and upper Big Caney River.

Hubbs and Lagler (1947:66) characterize the habitat of this species as clear creeks of limestone uplands. There are numerous records of the bigeye shiner from extreme eastern Oklahoma. It has been reported as far west as Beaver Creek in Osage County, Oklahoma. Beaver Creek originates in Cowley County, Kansas, near the origin of Cedar Creek and Crab Creek. Drought had left a few pools of water in Beaver Creek in Kansas at the time of my survey. The fish-fauna seemed sparse and *N. boops* was not among the species taken. Of interest in considering the somewhat isolated occurrence of the bigeye shiner in the Flint Hills area of Kansas is a record of it by Ortenburger and Hubbs (1926:126) from Panther Creek, Comanche County, Oklahoma, in the Wichita Mountain area of that state.

Notropis buchanani Meek: Stations G-1, E-4 (C-131).

At station G-1 the ghost shiner was taken in small numbers in the shallow end of a long pool (150 x 40 feet.) The three individuals taken at station E-4 were in an isolated pool (50 x 510 feet) aver-

aging 1½ feet in depth. Water was turbid, and warm due to lack of shade.

The habitat preferences of this species and of the related species *N. volucellus* have been described as follows by Hubbs and Ortensburger (1929b:68): "It seems probable that *volucellus* when occurring in the range of *buchanani* occupies upland streams, whereas *buchanani* is chiefly a form of the large rivers and adjacent creek mouths." The results of this survey and impressions gained from other collections, some of which are unpublished, are in agreement with this view. A collection on the Verdigris River at Independence, Kansas, directly downstream from the mouth of the Elk River, showed *N. buchanani* to be common while *N. volucellus* was not taken. At station E-5 upstream from E-4, however, *N. volucellus* was taken but *N. buchanani* was not found.

In the upper Neosho basin, Cross (1954a:310) took *N. volucellus* but not *N. buchanani*. Other collections have shown *N. buchanani* to be abundant in the lower Neosho River in Kansas. Moore and Paden (1950:85) observe that *N. buchanani* was found only near the mouth of the Illinois River in Oklahoma and was sharply segregated ecologically from *N. volucellus* that occupied a niche in the clear main channels in contrast to the more sluggish waters inhabited by *N. buchanani*.

Notropis camurus (Jordan and Meek): Stations C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, E-1, E-5 (C-131).

Highest concentrations of the bluntface shiner were found close to the mouths of two tributaries of Big Caney River: Rock Creek and Otter Creek. On Rock Creek (Station C-4) this shiner was abundant in a shallow pool below a riffle where water was flowing rapidly. Many large males in breeding condition were taken (June 3). The species formed 20.2 per cent of the fish taken.

On Otter Creek (Station C-13) the species was common in shallow bedrock pools below riffles. It formed 12.1 per cent of the fish taken.

At station C-5, *N. camurus* was characteristically found in an area of shallow pools and riffles. At station C-10 it was found in clear flowing water over rubble bottom and in small coves over mud bottom. At C-11 (July 26) *N. camurus* was taken only in one small pool with rapidly flowing water below a riffle. In this pool *N. camurus* was the dominant fish. At station C-12, on April 2, *N. camurus* was abundant in the stream, which was then clear and flowing. On August 24, it was not taken from the same pool, which was then turbid and drying.

The frequent occurrence of this species in clear, flowing water

seems significant. Cross (1954a:309) notes that the bluntface shiner prefers moderately fast, clear water. Hall (1952:57) found *N. camurus* only in upland tributaries east of Grand River and not in lowland tributaries west of the river. Moore and Buck (1953:22) took this species in the Chikaskia River, which was at that time a clear, flowing stream. They noted that in Oklahoma it seems to be found only in relatively clear water.

N. camurus did not seem to ascend the smaller tributaries of Big Caney River as did *N. rubellus* and *N. boops* even when these tributaries were flowing.

Notropis deliciosus missouriensis (Cope): Stations A-1, A-2, A-3, W-1, W-2, W-3 (C-136).

Sand shiners seemed to be abundant in the Arkansas River, rare in the Walnut River and absent from other streams surveyed. This shiner was most abundant in shallow, flowing water in the Arkansas River; in backwaters, where *Gambusia affinis* prevailed, *N. deliciosus* formed only a small percentage of the fish population.

Notropis girardi Hubbs and Ortenburger: Stations A-2 and A-3.

At station A-2 the Arkansas River shiner made up 14.6 per cent of all fish taken. At A-2, it was found only in rapidly-flowing water over clean sand in the main channels. It was absent from the shallow, slowly-flowing water where *N. deliciosus missouriensis* was abundant. At A-3 *N. girardi* made up 22 per cent of the total catch, and again preferred the deeper, faster water over clean-swept sand. Failure to find *N. girardi* at station A-1 is not understood.

Females were gravid in both collections (August 25 and 27). In neither collection were young-of-the-year taken. Moore (1944:210) has suggested that *N. girardi* requires periods of high water and turbidity to spawn. Additional collecting was done at station A-3 on December 22, 1957. A few adults were taken in flowing water but no young were found.

In this area, *N. girardi* showed no tendency to ascend tributaries of the Arkansas River. Not far to the west, however, this pattern changes as shown by Hubbs and Ortenburger (1929a:32) who took this fish at seven of ten stations on the Cimarron, Canadian, and Salt Fork of the Arkansas. *N. girardi* was taken only in the lowermost stations on both Stillwater Creek (Cross, 1950:136) and the Chikaskia River (Moore and Buck, 1953:22). In the next major stream west of the Chikaskia, the Medicine River, *N. girardi* seems to occur farther upstream than in the Chikaskia. (Collection C-5-51 by Dr. A. B. Leonard and Dr. Frank B. Cross on Elm Creek near Medicine Lodge on July 20, 1951.)

Notropis lutrensis (Baird and Girard): Stations A-1, A-2, W-1, W-2, W-3, W-4, G-1, G-2, G-4, G-5, G-8, G-9, G-10, G-11, G-12, G-13, G-14, G-15, G-16, B-1, B-2, B-3, C-1, C-2, C-3, C-4, C-5, C-6, C-9, C-10, C-11, C-12, C-13, C-14, M-1, E-1, E-2, E-4, E-7 (E&F, C-131, C-133, C-136).

The red shiner was taken in every stream surveyed. The relative abundance seemed to be greatest in two types of habitat which were separated geographically. The first habitat was in large rivers such as the Arkansas and Walnut. In the Arkansas River the red shiner consistently made up 20 per cent to 25 per cent of the catch. On the Walnut River percentages ranged from 10 per cent (station W-3) to 45 per cent (station W-2).

The second habitat in which numbers of *N. lutrensis* reached high proportions was in the upper parts of the most intermittent tributaries. At the uppermost station in Silver Creek this species formed 30 per cent of the fish taken. In Crab Creek the following percentages were taken in six collections from mouth to source: 20.6%, 26.1%, 25%, 85%, 14.6%, and 1%. In the mainstream of Grouse Creek the highest percentage taken was 19.27 near the mouth at station G-1. In middle sections of Grouse Creek this species was either absent or made up less than 2 per cent of the fish taken.

At no station on Big Caney River was the red shiner abundant. The smallest relative numbers were found at upstream stations, in contrast to collections made on tributaries of Grouse Creek. This distributional pattern possibly may be explained by the severe conditions under which fish have been forced to live in the upper tributaries of Grouse Creek. Water was more turbid, and pools were smaller than in Big Caney. These factors possibly decimate numbers of the less hardy species permitting expansion by more adaptable species, among which seems to be *N. lutrensis*. In the upper tributaries of Big Caney River conditions have not been so severe due to greater flow from springs and less cultivation of the watershed in most places. Under such conditions *N. lutrensis* seems to remain a minor faunal constituent.

Notropis percobromus (Cope): Stations A-1, A-2, W-1, W-2, W-3, G-1.

At station W-1 the plains shiner constituted 20 per cent of the fish taken. The river was flowing rapidly with large volume at the time of this collection, and all specimens were taken near the bank in comparatively quiet water over gravel bottom. At station W-3, below Tunnel Mill Dam at Winfield, *N. percobromus* comprised 18.7 per cent of the fish taken, second only to *Lepomis humilis* in

relative abundance. Immediately below the west end of the dam, plains shiners were so concentrated that fifty or more were taken in one haul of a four-foot nylon net. The amount of water overflowing the dam at this point was slight. Water was shallow (8-12 inches) and the bottom consisted of the pitted apron or of fine gravel. At the east end of the dam where water was deeper (1-3 feet) and the flow over the dam greater, large numbers of *Lepomis humilis* were taken while *N. percobromus* was rare.

In the Arkansas River smaller relative numbers of this shiner were obtained. At station A-2, it formed 4.68 per cent of the total. At this station *N. percobromus* was taken with *N. lutrensis* in water about 18 inches deep next to a bank where the current was sluggish and tangled roots and detritus offered some shelter.

At station G-1 on Grouse Creek the plains shiner made up 7.68 per cent of the fish taken. The habitat consisted of intermittent pools with rubble bottoms at this station, which was four miles upstream from the mouth of the creek. The plains shiner seems rarely to ascend the upland streams of the area.

Notropis rubellus (Agassiz): Stations C-3, C-5, C-6, C-7, C-8, C-10, C-11, C-12, C-13, C-14 (J&J).

No fish in these collections showed a more persistent preference than *Notropis rubellus* for clear, cool streams. All collections of the rosyface shiner were in the Big Caney River system, but at only four stations in this system was it common. At station C-11 the highest relative numbers (10.6 per cent) were obtained. This site possessed the most limpid water of any station on the mainstream of Big Caney. Aquatic plants (*Myriophyllum heterophyllum* and *Potamogeton nodosus*) were common. Other fishes that flourished at this station were *N. boops*, *N. camurus*, *Campostoma anomalum*, and *Etheostoma spectabile*. The water temperature was 86° at surface and 80° at bottom whereas air temperature was 97°.

N. rubellus was common at all stations in Otter Creek, the clear, upland character of which has been discussed. In May and June only adults were found. On September 1, examination of several pools in upper Otter Creek revealed numerous young-of-the-year in small spring-fed pools.

Literature is scarce concerning this shiner in Kansas. Cross (1954a:308) stated that it was abundant in the South Fork of the Cottonwood River and was one of those fishes primarily associated with the Ozarkian fauna, rather than with the fauna of the plains. Elliott (1947) found *N. rubellus* in Spring Creek, a tributary of

Fall River which seems similar to Otter Creek in physical features. Between the Fall River and Big Caney River systems is the Elk River, from which there is no record of the rosyface shiner. Perhaps its absence is related to the intermittent condition of this stream at present. The Elk River is poor in spring-fed tributaries, which seem to be favorite environs of the rosyface shiner.

N. rubellus was taken by Minna Jewell and Frank Jobes in Silver Creek on June 30, 1925 (UMMZ 67818). The shiner was not found in any stream west of the Big Caney system in my collections.

In Oklahoma, Hall (1952:57) found *N. rubellus* in upland tributaries on the east side of Grand River and not in the lowland tributaries on the west side. Martin and Campbell (1953:51) characterize *N. rubellus* as preferring riffle channels in moderate to fast current in the Black River, Missouri. It is the only species so characterized by them which was taken in my collections. Moore and Paden (1950:84) state "*Notropis rubellus* is one of the most abundant fishes of the Illinois River, being found in all habitats but showing a distinct preference for fast water . . ."

Notropis topeka (Gilbert): Two specimens (formerly Indiana University 4605) of the Topeka shiner labeled "Winfield, Kansas" are now at the University of Michigan Museum of Zoology. Collector and other data are not given. Evermann and Fordice (1886:185) noted that two specimens of *N. topeka* were taken from Sand Creek near Newton in Harvey County, but do not list it from Cowley County near Winfield. They deposited their fish in the museum of Indiana University.

Notropis umbratilis (Girard): Stations G-1, G-3, G-4, G-7, G-8, G-9, G-12, G-14, B-2, B-3, C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14, C-15, C-16, E-1, E-2, E-4, E-5, M-1, M-2 (J&J, C-131, C-132).

The redfin shiner flourished in all the streams surveyed except the Arkansas and Walnut Rivers. *N. umbratilis* has been found in upland tributaries of the Walnut River, some of which originate in terrain similar to that in which Elk River, Big Caney River, and Grouse Creek originate. (Collection C-26-51 by Cross on Durechon Creek, October 7, 1951.) This suggests downstream reduction in relative numbers of this species, a tendency which also seemed to exist on both Big Caney River and Grouse Creek. *N. umbratilis* was the most abundant species in Big Caney River except at the lowermost stations where it was surpassed in relative abundance by *N. lutrensis* and *Gambusia affinis*.

N. umbratilis was a pool-dweller, becoming more concentrated in the deeper pools as summer advanced. In May and early June, large concentrations of adult *N. umbratilis* were common in the shallow ends of pools together with *N. rubellus*, *N. boops*, *Pimephales notatus*, and *Pimephales tenellus*. By July and August, only young of the year were taken in shallow water, and adults were scarcely in evidence.

Notropis volucellus (Cope): Stations G-5, G-8, C-3, C-5, C-7, C-8, C-9, C-10, M-1, E-4, E-5.

The mimic shiner was a minor element in the fauna, 2.02 per cent at station C-5 being the largest percentage taken. In the Big Caney River system *N. volucellus* was taken only in the main stream. In the Grouse Creek drainage it was found at two stations in the upper part of the watershed, where water is clearer, gradient greater, and pools well-shaded and cool.

In the Elk River the mimic shiner was taken only in the upper part of the main stream. The dominant shiner in situations where *N. volucellus* was taken was, in all cases, *N. umbratilis*. Elliott (1947) found *N. volucellus* in Spring Creek, a tributary of Fall River. Farther north in the Flint Hills region, *N. volucellus* was reported by Cross (1954a:310).

Notemigonus crysoleucas (Mitchell): Station W-5.

This isolated record for the golden shiner consisted of nine specimens collected on June 6 in Timber Creek, a tributary of the Walnut River. Most of the creek was dry. *N. crysoleucas* was taken in one pool with dimensions of 8 feet by 4 feet with an average depth of 4 inches. This creek is sluggish and silt-laden, even under conditions of favorable precipitation. Hubbs and Ortenburger (1929b:89) observed that the golden shiner prefers sluggish water. Hall (1952:58) took the golden shiner only in the lowland tributaries west of Grand River and not east of the river in upland tributaries.

Phenacobius mirabilis Girard: Stations W-3, C-3.

In no case was the suckermouth minnow common; it never comprised more than 1 per cent of the fish population.

Pimephales notatus (Rafinesque): Stations W-4, G-5, G-7, G-9, G-12, G-13, B-3, C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14, C-15, C-16, C-17, C-18, M-1, M-2, E-1, E-2, E-4, E-5, E-7 (J&J, C-131, C-132, C-133).

This was much the most abundant of the four species of *Pimephales* in this area. It was taken at 33 stations as compared with 10 for *P. tenellus*, 8 for *P. promelas*, and 3 for *P. vigilax*.

The bluntnose minnow was taken almost everywhere except in the main stream of the Arkansas and Walnut rivers and in lower Grouse Creek. *P. notatus* seemed to prefer clearer streams of the Flint Hills part of my area. There was a marked increase in percentages taken in the upland tributaries of both Caney River and Grouse Creek. In the Elk River, too, higher concentrations were found upstream.

The highest relative numbers of bluntnose minnows were taken at station G-12 on Crab Creek, station C-12 on Cedar Creek and station C-16 on Spring Creek. At G-12, this minnow was abundant in the deeper isolated pools. Males in breeding condition were taken on June 9. In Cedar Creek the population of bluntnose minnows was observed periodically in one pool in which they were dominant. This pool was 100 feet by 50 feet, shallow, and with bedrock bottom. At its upper end, however, there was a small area of heavily-shaded deeper water. Throughout the spring bluntnose minnows were found in large schools in the shallow area. As the summer progressed they were no longer there, but seining revealed their presence in the deeper, upper end.

At station C-16 on Spring Creek on July 9 male *P. notatus* were taken in extreme breeding condition, being light brick-red in color and with large tubercles.

Pimephales tenellus (Girard): Stations G-1, C-2, C-3, C-5, C-6, C-7, C-8, M-1, E-2, E-4 (C-131 C-133).

The mountain minnow was never taken far from the mainstream of Big Caney, Middle Caney, or Elk River. In this respect it differed from *P. notatus*, which reached large concentrations in the small upland tributaries. On the other hand, *P. tenellus* was not so abundant as *P. vigilax* in the silty larger streams. In no collection was the mountain minnow common. The highest percentages were 2.4 per cent (Station C-5), and 2.1 per cent (Station C-7) on Big Caney River. These stations consisted of clear, flowing water over rubble bottoms. Males at C-7 (June 16) were in breeding condition.

Moore and Buck (1953:23) reported finding this species among rocks in very fast water rather than in the quiet backwaters frequented by *P. vigilax*. Other records of the mountain minnow from the Flint Hills indicate that it seeks areas of maximum gradient and flow; in this distributional respect it is like *Notropis camurus*. The two species are recorded together from other streams in this region such as the Chikaskia (Moore and Buck, 1953:23), Cottonwood (Cross, 1954a:310), and Spring Creek, tributary of Fall River (Elliott, 1947). It is conceivable that a preference for flow-

ing water might explain its restriction to the medium-sized, less intermittent streams in this area. The only tributary which the species seemed to ascend to any extent was Otter Creek, which is seldom intermittent downstream.

Pimephales vigilax perspicuus (Girard): Stations A-3, C-1, C-4.

The parrot minnow was found only in downstream habitats. Collection C-4 (June 3) on Rock Creek was made about ½ mile from the mouth of this tributary of Big Caney and the creek here had almost the same character as the river proper. The presence of other channel fishes such as *Ictiobus bubalus* indicates the downstream nature of the creek. Some males of *P. vigilax* in breeding condition were taken in this collection.

At C-1, only one specimen was found in a turbid, isolated pool with bedrock bottom. At A-1 only one parrot minnow was taken; it was in deep, fairly quiet water near the bank.

Other collections outside the three-county area revealed the following: In the Neosho River, several parrot minnows were found in quiet backwaters and in shallow pools. In the Verdigris River three were taken directly under water spilling over the dam at this station, while others were found, together with *P. promelas*, in the mouth of a small creek that provided a backwater habitat with mud bottom.

Cross and Moore (1952:405) found this species only at stations in the lower portion of the Poteau River. Farther west the minnow may ascend the smaller sandy streams to greater distances. Moore and Buck (1953:23) took parrot minnows at six of 15 stations on the Chikaskia River and found the species as far upstream as Drury, Kansas. Elliott (1947), in comparing the South Ninescah and Spring Creek fish faunas, found only *P. vigilax* and *P. promelas* on the sandy, "flatter" Ninescah and only *P. notatus* and *P. tenellus* on Spring Creek, an upland, Flint Hills stream in Greenwood County.

Pimephales promelas Rafinesque: Stations A-2, A-3, W-3, W-4, G-9, B-1, M-1, E-4 (E&F, C-136).

Occurrences of the fathead minnow were scattered, but included all streams sampled except Big Caney.

Three of the collections were in small intermittent streams where conditions were generally unfavorable for fishes and in one instance extremely foul. Two of these stations had turbid water and all suffered from siltation.

In Middle Caney Creek the species was rare but in the Elk River

(June 28) more than 100 specimens, predominantly young, were taken. This station consisted of a large isolated pool with a variety of bottom types. Water was turbid and the surface temperature was high (93° F.). In different parts of the pool the following numbers of specimens were taken in single seine-hauls: 15 over shallow bed-rock; 35 over gravel (1½ feet deep); 50 over mud bottom (1 foot deep).

P. promelas was found also in the large, flowing rivers: Arkansas, Walnut, Verdigris, and Neosho. The species was scarce in the Arkansas River, and was found principally in muddy coves. In the Walnut (W-3), this minnow comprised 7.65 per cent of the fish taken and was common in quiet pools.

Campostoma anomalum Rafinesque: Stations W-4, G-4, C-1, C-3, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14, C-15, C-16, C-17, C-18, B-3 (E&F, C-131, C-136).

Although the stoneroller was found in most streams surveyed, it was taken most often in the Big Caney system, where it occurred at 16 of the 18 stations. In contrast, it was represented at only one of 17 stations on Grouse Creek. High percentages were found in three creeks—Cedar, Otter, and Spring. As noted above, these streams are normally clear, swift and have steep gradients and many rubble and gravel riffles. On these riffles young stonerollers abounded. Station C-16 on Spring Creek typifies the habitat in which this species was most abundant. The stream has an average width of 10 feet and depth of a few inches. The volume of flow was less than 1 cubic foot per second but turbulence was great. Water was clear and the bottom was gravel and rubble. Following rains in June, stonerollers quickly occupied parts of Spring Creek (upstream from C-16) that had been dry throughout the previous winter.

On April 2 many *C. anomalum* and *Etheostoma spectabile* were taken in shallow pools and riffles in an extensive bedrock-riffle area on Cedar Creek near station C-12. Most of the females were gravid and the males were in breeding condition. On June 6 these pools were revisited. Flow had ceased and the pools were drying up. Young-of-the-year of the two species were abundant, but only a few mature stonerollers were taken. On August 24, prolonged drought had drastically altered the stream and all areas from which stonerollers and darters had been taken were dry. Seining of other pools which were almost dry revealed no stonerollers.

Collections on May 31, June 15, and June 16 in Otter Creek re-

vealed large numbers of stonerollers. They were found in riffle areas, in aquatic vegetation, and especially in detritus alongside banks. Most of the specimens were young-of-the-year.

Anguilla bostoniensis (Le Sueur): An American eel was caught by me in Grouse Creek in 1949.

Gambusia affinis (Baird and Girard): Stations A-1, A-2, A-3, W-1, W-2, W-3, W-4, W-5, G-1, G-2, G-3, G-4, G-5, G-7, G-8, G-9, C-1, C-2, C-3, C-4, C-6, C-15, E-1.

Mosquitofish occurred widely but in varied abundance. Huge populations were in the shallow sandy backwaters and cut-off pools of the Arkansas River. In the shallow pools of several intermittent streams such as station G-8 on Silver Creek this fish also flourished.

G. affinis was taken at every station in the Arkansas, Walnut and Grouse systems except those stations on two upland tributaries of Grouse Creek (Crab Creek and Grand Summit Creek). The mosquitofish was not observed in the clear upland tributaries of Big Caney, nor on upper Big Caney River itself in May, June, and July. On September 3, however, *Gambusia* were taken at station C-15 on Otter Creek and others were seen at station C-14 on the same date.

Hubbs and Ortenburger (1929b:99) and Cross and Moore (1952:407) observed that *G. affinis* usually was absent from small upland tributaries, even though it was abundant in lower parts of the same river systems.

Fundulus kansae (Garman): Stations A-2, A-3, Evermann and Fordice as *Fundulus zebrinus*.

At station A-2, seven plains killifish were taken together with a great many *Notropis deliciosus* and *Gambusia affinis* in a shallow, algae-covered channel with slight flow and sand bottom. At station A-3 many young killifish were taken in small shallow pools on December 22. *Fundulus kansae* has been found in the lower part of the Walnut River Basin, especially where petroleum pollution was evident. Eastward from the Walnut River plains killifish have not been taken.

Fundulus notatus (Rafinesque): Stations B-1, G-1, G-2, G-3, G-4, G-5, G-7, G-8, G-10, G-11, G-14, C-1, M-1, E-1, Evermann and Fordice as *Zygonectes notatus*.

The black-banded topminnow was not taken in the Arkansas River but was common in the Walnut and Grouse systems. It was common also in Middle Caney, but in Big Caney and Elk River it was taken only at the lowermost stations.

This species did not seem to ascend far into smaller tributaries of Grouse Creek. In Crab Creek it was taken at the lower two of six stations and in Grand Summit Creek at the lower of two stations.

The highest relative numbers were taken at stations G-3 (17.5 per cent), G-4 (24 per cent), G-10 (25.75 per cent) and G-11 (41.52 per cent), on Crab Creek and Grouse Creek. Both upstream and downstream from these stations, which were within five miles of each other, the relative abundance dropped off sharply. The bottoms at these stations were mostly rubble and mud, and water was turbid at three of the stations. At G-10 (June 24) and G-11 (July 16) young-of-the-year were abundant.

Ictalurus melas (Girard): Stations W-2, W-3, W-4, W-5, B-1, B-2, B-3, G-1, G-2, G-3, G-4, G-5, G-8, G-9, G-11, G-12, G-13, G-14, G-17, C-1, C-9, C-11, C-12, C-14, C-15, C-17, C-18, E-1, E-2, E-4, E-5, E-6, N-1, Evermann and Fordice as *Ameiurus melas* (C-133).

The black bullhead was taken at slightly more than half of the stations, and probably was present at others. Larger numbers were taken in Grouse Creek than in any other stream system. In many small, shallow pools in the Grouse Creek system young black bullheads shared dominance with *Gambusia affinis* in the late summer. *I. melas* was also abundant in isolated pools at the extreme upper ends of Crab Creek, Beaver Creek and Grand Summit Creek. *I. melas* was most common in areas with silty bottoms. The species seemed scarce in the main stream of Big Caney River but was common in some of its tributaries.

Pygodictis olivaris (Rafinesque): Stations A-3, G-1, C-5.

Flathead catfish were taken by angling at stations A-3 and C-5. At station G-1 (September 5) a flathead catfish five inches long was taken in the four-foot nylon net.

Ictalurus punctatus (Rafinesque): Stations A-3, W-2, W-3, G-2, C-5, E-4.

Channel catfish from stations W-3, A-3, and C-5 were taken on hook and line. At station G-2 (August 29) twenty young-of-the-year were seined from the shallow narrow end of a large pool. All collections of both *I. punctatus* and *P. olivaris* were in the larger streams surveyed.

Ictalurus natalis (LeSueur): Stations G-1, G-2, G-3, G-4, G-8, G-11, C-12, C-14, C-15.

The yellow bullhead was taken at only 9 stations, compared with 33 stations for the black bullhead. *I. natalis* was represented

in 7 of 17 stations in the Grouse Creek system but in only 3 of 18 stations in the Big Caney system. Of the seven records from Grouse Creek four were from the main stream. At every station where yellow bullheads were taken, black bullheads were found also and were abundant, usually several times more abundant than *I. natalis*.

At G-11 on Crab Creek (July 16), *I. natalis* made up 3.8 per cent of the fish taken. All were young-of-the-year, existing in a tiny, gravelly pool containing not more than five gallons of water, and were the only fish present. Young yellow bullheads were also found in small pools with gravel bottoms at station G-4 on September 7.

Labidesthes sicculus (Cope): Stations G-1, G-2, G-3, G-7, G-10, B-2, C-1, C-2, C-3, C-4, C-5, C-12, E-1, E-2, E-3, E-7, M-1 (E&F, C-131).

The brook silversides was taken, sometimes abundantly, in all stream systems except the Walnut and Arkansas. At station G-7 on July 8, 41.8 per cent of the fish taken were of this species. *L. sicculus* was most abundant in large pools where the bottom was predominantly bedrock and gravel. The highest concentrations were in the mainstreams of Big Caney, Grouse, and Elk Rivers. Brook silversides were taken rarely in the smaller tributaries of these streams.

Percina phoxocephala (Nelson): Stations C-2, C-3, C-5, G-1 (C-133).

Slenderhead darters were scarce, and were found only over gravel bottoms. Specimens were taken from flowing and quiet water, and from both shallow and deep water.

Larger numbers of *P. phoxocephala* were taken by the writer in other collections made during 1956 on the Neosho and Verdigris Rivers over bottoms of rubble or gravel. Restriction of this darter to the larger streams follows a pattern observed by Cross (1954a:313) who noted it was absent from smaller riffles in minor tributaries. Elliott (1947), however, took one specimen of *P. phoxocephala* in Spring Creek, a tributary of Fall River.

Percina caprodes carbonaria (Baird and Girard): Stations G-3, G-4, G-7, G-12, C-5, C-6, C-7, C-9, C-12, C-13, C-14 (J&J, C-131, C-133).

The logperch was generally distributed in the Caney, Elk, and Grouse systems. This species usually comprised less than 1 per cent of the fish taken; however, at station G-12 it formed 3.76 per cent of the total.

In many instances the logperch was taken over submerged gravel bars, often along the edges of the larger pools. At 8 of 13 stations where the logperch was taken, the golden redhorse was also found. At every station where logperch were found, *Notropis umbratilis* was taken and *Pimephales notatus* also occurred at all but three of these stations.

Percina copelandi (Jordan): Stations C-4, C-5, C-6, C-8, G-1 (C-131, C-133, J&J).

Channel darters were collected over bottoms of rubble or gravel, both in flowing streams and in isolated pools. Although *P. copelandi* was found only in Big Caney River and at the lowermost station on Grouse Creek (G-1) in this survey, this species has been taken previously from Elk River (K. U. 3463 and K. U. 3197) and from Silver Creek. *Notropis camurus* occurred everywhere that *H. copelandi* was found. In several instances the two species were taken in the same seine-haul.

Etheostoma spectabile pulchellum (Girard): Stations W-4, G-1, G-4, G-5, C-6, C-9, C-11, C-12, C-13, C-14, C-15, C-16, C-17, C-18, E-1, E-5. Evermann and Fordice as *Etheostoma coeruleum* (C-131, C-132).

The habitat preferences of the orangethroat darter seemed similar to those of *Campostoma anomalum*. There were sixteen stations at which both species were taken, seven where only *E. spectabile pulchellum* was taken and six where only *C. anomalum* was taken. The largest relative numbers of both species were found in the same small, clear upland tributaries of Big Caney River. On May 31, collections from riffles at station C-15 (upper Otter Creek) consisted almost entirely of these two species. On September 1 at this station the stream was intermittent, but even the tiniest pools abounded with young darters and stonerollers.

Gravid females and males in breeding condition were taken in riffles in Cedar Creek on April 2. During June numerous young and adult orangethroat darters were taken in Cedar Creek, in partly decayed leaves which lined the banks. On June 15 in Otter Creek young darters were abundant in streamside detritus and in clear, shallow, rubble riffles. At station C-11 a few darters were taken on rubble riffles; however, large numbers were found inhabiting thick mats of *Potamogeton foliosus* Raf., which grew in shallow water. Many darters (*Etheostoma spectabile pulchellum* and *Percina phoxocephala*) were taken in September along gravelly banks at stations C-2 and C-3 by disturbing small rocks and leaf-litter along the shores. Young orangethroat darters seemed to seek

out sheltered areas and in some cases were found in sluggish, even foul, water (Stations W-4, B-1 and G-12). Moore and Buck (1953:26) note that the orangethroat darter is able to thrive in Oklahoma in rather sluggish and even intermittent waters which reach quite high summer temperatures.

Unlike other darters taken in this survey, the orangethroat darter was common to abundant at several stations and was found at a great many more stations than any other darter. The comparatively great tolerance of this species to varying habitats, suggested by this survey, is also reflected by its widespread distribution in Kansas.

Micropterus salmoides salmoides (Lacepede): Stations B-1, G-4, G-5, G-7, G-12, C-1, C-3, E-1, E-2, E-3.

Most of the largemouth bass taken were young-of-the-year. In Big Caney River this species seemed rare, being found at only two downstream stations compared with eight stations at which *M. punctulatus* was taken.

Many ponds in the Flint Hills have been stocked with largemouth bass. At present largemouth bass are frequently caught by hook and line in Crab Creek (Station G-12); however, Mr. A. C. Metcalf, who has fished this stream for approximately 45 years, states that he took no bass in the creek prior to the building and stocking of large ponds on nearby ranches.

Micropterus punctulatus (Rafinesque): Stations C-4, C-5, C-6, C-7, C-8, C-10, C-14, C-15, E-2, E-5 (C-133).

The spotted bass was taken only in tributaries of the Verdigris River, where it seemed more numerous than the preceding species. It has been reported from other Verdigris tributaries such as Fall River (Elliott, 1947) and is common eastward from the Verdigris Basin. A spotted bass (K. U. 3467) was taken by Cross on the Little Walnut River in Butler County on April 5, 1955. This seems to be the only record of this species from the Walnut River Basin at the present time.

Pomoxis annularis (Rafinesque): Stations W-3, W-5, G-1, G-2, G-5, G-10, G-11, G-12, C-1, C-2, C-4, C-5, C-6, M-1, E-1, E-2, E-4, E-5 (C-136).

White crappie were found in almost all habitats and were taken in all rivers except the Arkansas. The relative abundance of this species was greater at downstream than at upstream stations on Grouse Creek, Big Caney, and Elk River. Schools of young crappie were frequently found and the factor of chance in taking or failing to take a school of crappie prevented confident appraisal of abundance. White crappie usually sought quiet waters. Often they

were found in backwaters and many times schools were taken over bottoms where mud and detritus had been deposited. It was not uncommon to take *Pomoxis annularis* and *Ictalurus melas* in the same seine-haul in such areas.

Pomoxis nigromaculatus (LeSueur): Station C-1.

Black crappie were taken in Otter Creek on May 29 and September 3. Several ponds in eastern Cowley County are stocked with black crappie, but none was taken from streams into which these ponds drain.

Lepomis cyanellus (Rafinesque): Stations W-3, W-4, W-5, B-1, B-2, B-3, G-1, G-2, G-3, G-4, G-5, G-8, G-9, G-10, G-12, G-13, G-14, G-15, G-16, G-17, C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14, C-16, C-17, C-18, E-1, E-4, E-5, E-6, E-7, M-2 (C-131, C-132, C-133, C-136, E&F).

The green sunfish was taken at 45 of 60 stations, which is the greatest number recorded for one species. The only stream from which it was not obtained was the Arkansas River. Green sunfish constituted a minor but consistent part of the fauna in Big Caney River except for some intermittent pools on small tributaries, where it was high in relative abundance. It usually comprised approximately 4 per cent of the fish taken at stations on Grouse Creek. In some intermittent tributaries of Grouse Creek and Elk River percentages also were high.

Funk and Campbell (1953:74) observed that *L. cyanellus* held a definite but minor place in all collections made on the Black River in Missouri. This pattern was also observed by the writer in collections made on the Neosho and Spring Rivers in southeastern Kansas. This seems to indicate that the Big Caney River populations (exclusive of the upstream stations in intermittent streams) follow a pattern commonly found in southeastern Kansas and probably in the Ozark region.

Lepomis humilis (Girard): Stations A-3, W-2, W-3, W-4, W-5, G-1, G-2, G-3, G-4, G-5, G-7, G-8, G-9, G-10, G-11, G-12, G-14, G-15, C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-16, C-17, B-2, B-3, E-1, E-2, E-4, E-5, E-6, E-7, M-1. (C-131, C-132, C-133, C-136, J&J, E&F.)

The orangespotted sunfish was found in every stream surveyed, although only one specimen was taken from the Arkansas River.

The largest relative number of this species (44.6) was taken at station G-1. Percentages at other stations on Grouse Creek and its tributaries progressively declined in an upstream direction.

In Big Caney River representation of *L. humilis* in collections

varied from 1.56 per cent at station C-1 to 23.47 per cent at station C-7. This sunfish was usually the dominant species in collections made from the Elk River, where the relative abundance ranged from 10 to 30 per cent.

The orangespotted sunfish is widespread in Kansas and seems to be a diagnostic constituent of the Plains Fauna. Moore and Buck (1953:26) found it "very common" in the Chikaskia River in Kansas and Oklahoma. Cross (1950:140) noted that in Stillwater Creek it seemed to be the most tolerant and consequently the most abundant of the stream's centrarchids. Moore and Paden (1950:91) note that *L. humilis* is most common in muddy waters and found in overflow pools, backwaters, and oxbow lakes. This species is frequently found in farm ponds in the area surveyed, which further suggests a wide range of habitat tolerance.

Lepomis megalotis breviceps (Baird and Girard): Stations W-3, W-4, W-5, B-1, B-2, G-1, G-4, G-5, G-7, G-8, G-9, G-10, G-11, G-12, G-13 (all Big Caney River stations except C-18), E-1, E-2, E-3, E-4, E-5, E-6, M-1, M-2 (C-131, C-132, C-133, J&J, E&F).

In Big Caney River the longear sunfish shared dominance with the redbfin shiner (*Notropis umbratilis*) at almost every station. The average of its relative abundance at all stations in the Big Caney system was 16.5 per cent. It was also abundant at several stations on Grouse Creek and made up 43.25 per cent of all fish taken at station G-4.

Cross (1950:140) observed that *L. megalotis breviceps* increased in Stillwater Creek probably as a result of clearer water and stabilized water level.

In collections made west of the area treated here (Moore and Buck, 1953:26; Elliott, 1947) the longear sunfish is less abundant than in Big Caney River and Grouse Creek.

Lepomis macrochirus (Rafinesque): Stations W-3, G-3, G-4, G-5, C-3, C-5, E-1, E-2 (C-131, C-132, C-133).

The bluegill was, in all cases, a minor constituent in the fish fauna. No clear pattern of habitat preference can be deduced. In the Verdigris River at Independence (collection AM-53, August 22, 1956) bluegills were common in quiet pools and coves below a low-water dam. Moore and Paden (1950:91) note that *L. macrochirus* prefers quiet waters and Hubbs and Lagler (1947:94) state that it is "generally restricted to the quieter pools."

The bluegill is widely-stocked in impoundments of the area treated here.

Aplodinotus grunniens (Rafinesque): Stations C-4, E-2.

The dearth of stations from which the freshwater drum is reported may indicate difficulty in taking this species with seines, rather than scarcity. Both collections were at downstream stations. At station C-4 three half-grown drum were taken. Fishermen take "drum" at least as far upstream as station C-5 on Big Caney River. In the Elk River one specimen was taken in a 20-foot seine below a dam at Elk Falls.

FISHES OF DOUBTFUL OR POSSIBLE OCCURRENCE

In addition to the species listed above, the following species have been reported nearby and may occur within the area surveyed.

Lepisosteus productus (Cope)—This gar has not been reported from Kansas. It has been taken at several points in the northern half of Oklahoma and as far west as Canton Reservoir by Buck and Cross (1951). A specimen of the spotted gar was taken by Elkin (1954:28) in Salt Creek in Osage County, Oklahoma.

Polyodon spathula (Walbaum)—The paddlefish has never been reported from the Arkansas River system in Kansas. Several reports by fishermen were traced by the writer, but authentication was not achieved. One mounted specimen was examined in a sporting goods store in Arkansas City. This fish was said to have been taken on the Arkansas River south of Arkansas City but information on the date and method of capture were vague. Mr. Darrell Wheat of Arkansas City reported taking four paddlefish below a dam at Oxford, Kansas, in 1948 and 1949.

Hiodon alosoides (Rafinesque)—One specimen (K. U. 3095) of the goldeye was taken in 1953 on the Arkansas River near Oxford in Sumner County. Fishermen also report taking this fish occasionally in the Walnut River in Cowley County.

Noturus flavus (Rafinesque)—The stonecat was taken in the Verdigris system by R. D. Lindsay in 1911 (K. U. 2058) and more recently by Cross in Montgomery County (C-120) and Schelske (1957:46) in Wilson and Montgomery Counties. The close proximity of these collection areas to lower portions of the Elk River indicate probable occurrence in Elk River and other Verdigris tributaries.

Noturus nocturnus (Jordan and Gilbert)—The freckled madtom has been taken on all sides of the area studied making its occurrence therein highly probable. This madtom has been taken in Beaver

Creek in Osage County, Oklahoma (OAM 4771); from a tributary of the Walnut River in Sedgwick County by Cross (1954); from the Chikaskia River (Moore and Buck, 1953:24); and from several localities on the Verdigris River (Schelske, 1957:47).

Etheostoma cragini (Gilbert)—One Cragin's darter (K. U. 3470) was taken by Cross in the Arkansas River near the Sumner-Cowley county line (Sec. 25, T31S, R2E). Records of this darter are few and widely scattered geographically. Several collections from north-eastern Oklahoma are noted by Moore and Cross (1950:144).

Etheostoma whipplii (Girard)—Schelske (1957:38) reports the redfin darter from the Verdigris River three miles southeast of Benedict, Kansas. Dr. George Moore of Oklahoma A. & M. College states that it has been taken in the Verdigris drainage in Oklahoma at several locations.

Etheostoma zonale arcansanum (Jordan and Gilbert) — Two banded darters (K. U. 3213) have been reported by Schelske (1957:49) from Fall River near Neodesha, Kansas. Because a tributary of Fall River enters Elk County its presence in this and other Verdigris tributaries in the area seems possible. This darter has been reported from only one other stream in Kansas, Shoal Creek in Cherokee County, where it has been collected often.

Roccus chrysops (Rafinesque)—The white bass has been stocked in Hulah Reservoir on Big Caney River in Oklahoma. To date it has not been reported from the Big Caney in Kansas. White bass are common in many reservoirs of Kansas and Oklahoma and have been taken in rivers in both states. Mr. Clement Gillespie of Arkansas City, Kansas Forestry, Fish and Game Commission wildlife protector for the area, states that two hundred young of *R. chrysops* were released in Grouse Creek several years ago under auspices of the Commission. The fish has not been reported by fishermen since that time to the knowledge of Mr. Gillespie or of the writer.

Lepomis microlophus (Gunther)—One redear sunfish was taken on Salt Creek in Osage County, Oklahoma, by Elkin (1954:28). Because this species has been stocked widely in Oklahoma its eventual occurrence in Kansas seems probable.

Chaenobryttus gulosus (Cuvier)—The warmouth has been taken south of the collection area in Osage County on Salt Creek by Elkin (1954:28).

FAUNAL COMPARISONS OF DIFFERENT STREAMS

The faunas of Elk River, Big Caney River, and Grouse Creek were generally similar. These streams and most of their tributaries originate in the same hilly area of eastern Cowley County and west-

ern Elk and Chautauqua counties; their similarities and differences have been pointed out.

The following species were taken in all of these streams:

<i>Lepisosteus osseus</i>	<i>Fundulus notatus</i>
<i>Dorosoma cepedianum</i>	<i>Gambusia affinis</i>
<i>Ictiobus bubalus</i>	<i>Ictalurus melas</i>
<i>Moxostoma erythrurum</i>	<i>Ictalurus punctatus</i>
<i>Minytrema melanops</i>	<i>Etheostoma spectabile</i>
<i>Cyprinus carpio</i>	<i>Percina caprodes</i>
<i>Campostoma anomalum</i>	<i>Micropterus salmoides</i>
<i>Notropis boops</i>	<i>Pomoxis annularis</i>
<i>Notropis lutrensis</i>	<i>Lepomis cyanellus</i>
<i>Notropis umbratilis</i>	<i>Lepomis humilis</i>
<i>Notropis volucellus</i>	<i>Lepomis megalotis</i>
<i>Pimephales notatus</i>	<i>Lepomis macrochirus</i>
<i>Pimephales tenellus</i>	<i>Labidesthes sicculus</i>

No species was found in Elk River to the exclusion of Big Caney and Grouse Creek. Fish taken exclusively in Grouse Creek were *Ictiobus cyprinella* at station G-2 and *Notropis percobromus* at station G-1. The following species were taken only in Big Caney River: *Ictiobus niger*, *Notropis rubellus*, *Phenacobius mirabilis*, *Pimephales vigilax*, and *Pomoxis nigromaculatus*.

Notropis buchanani and *Pimephales promelas* were taken in Grouse Creek and Elk River, but not in Big Caney River, although the watershed of Big Caney lies largely between these two streams. Three species, *Notropis camurus*, *Micropterus punctulatus*, and *Aplodinotus grunniens*, were found in Elk River and Big Caney but not in Grouse Creek. *Ictalurus natalis*, *Pylodictis olivaris*, and *Percina phoxocephala* were taken in Big Caney River and Grouse Creek but not in Elk River. *Percina copelandi* was taken by Cross on Elk River in 1954 and 1955 (K. U. 3464 and K. U. 3197).

Forty species were taken in Big Caney River, 35 in Grouse Creek and 31 in Elk River. Collections were made from only six stations on Elk River as compared with 18 from Big Caney and 17 from Grouse Creek.

Twenty-four species were taken in the Walnut River system, only one of which (*Notemigonus crysoleucas*) was taken exclusively there.

In the Arkansas River 18 species were found, four of which did not occur elsewhere. These were *Hybopsis aestivalis*, *Notropis blennioides*, *N. girardi*, and *Fundulus kansae*.

Table 5 lists the number of stations in each of the streams surveyed from which each species was taken.

TABLE 5.—SPECIES OF FISHES COLLECTED AND NUMBER OF STATIONS IN EACH STREAM SYSTEM AT WHICH EACH SPECIES WAS FOUND.

Total number of stations	Arkansas River 3 stations	Walnut River 5 stations	Grouse Creek 17 stations	Big Canev River 18 stations	Elk River 6 stations	Middle Canev 2 stations	Beaver Creek 3 stations
<i>L. osseus</i>	1	3	3	6	Seen		
<i>D. cepedianum</i>	Seen	1	1	3	2	1	
<i>Carpiodes carpio</i>	2	1	1	1			
<i>I. bubalus</i>		1	2	4	3		
<i>I. cyprinella</i>			1				
<i>I. niger</i>				2			
<i>M. erythrum</i>			4	10	3		
<i>M. melanops</i>			1	3	1		
<i>Cyprinus carpio</i>	1	4	4	2	1		
<i>C. anomabum</i>		1	1	14	2		1
<i>H. aestivalis</i>	1						
<i>N. blennioides</i>	2						
<i>N. boops</i>			2	14	2	2	
<i>N. buchanaui</i>			1		1		
<i>N. canurus</i>				13	2		
<i>N. deliciosus</i>	3	3					
<i>N. girardi</i>	2						
<i>N. lutrensis</i>	3	4	13	14	5	1	3
<i>N. rubellus</i>				11			
<i>N. percobromus</i>	3	3	1				
<i>N. umbratilis</i>			8	18	4	2	2
<i>N. volucellus</i>			2	5	2	1	
<i>N. crysoleucas</i>		1					
<i>H. placita</i>	3	2					
<i>P. mirabilis</i>		1		1			
<i>P. notatus</i>		1	6	18	5	2	1
<i>P. promelas</i>	2	2	1		1	1	1
<i>P. vigilax</i>	1			3		1	
<i>P. tenellus</i>			1	7	1	2	
<i>F. notatus</i>		4	10	1	1		1
<i>F. kansae</i>	2						
<i>G. affinis</i>	3	5	8	8	1		
<i>I. melas</i>	1	4	12	9	5		3
<i>I. natalis</i>			6	3			
<i>J. punctatus</i>	1	2	1	5	1		
<i>P. olivaris</i>	1		1	1			
<i>E. spectabile</i>		1	4	17	2		1
<i>P. copelandi</i>			1	5			
<i>P. phoxocephala</i>			1	4			
<i>P. caprodes</i>			5	8	1		
<i>M. salmoides</i>			4	2	3		1
<i>M. punctulatus</i>				7	1		
<i>P. annularis</i>		2	7	1	4	1	
<i>P. nigromaculatus</i>				1			
<i>L. cyanellus</i>		3	14	17	5	1	3
<i>L. humilis</i>	1	4	13	17	6	1	2
<i>L. megalotis</i>		3	9	18	6	2	2
<i>L. macrochirus</i>		1	3	3	2		
<i>A. grunniens</i>				1	1		
<i>L. sicculus</i>			5	7	4	1	1

DISTRIBUTIONAL VARIATIONS WITHIN THE
SAME STREAM

An analysis of faunal variations in different parts of the same stream system was made for Big Caney River and Grouse Creek. Collecting was more extensive in these streams, and sampling was done over a wider range of habitat, than in the Arkansas and Walnut rivers.

The fish taken in the first five seine hauls at each station were counted and the number of each species was recorded as a percentage of the total number of fish taken. These percentages were calculated for the main stream and for each tributary in an attempt to discern possible intra-stream faunal patterns. In Table 6 lower, middle, and upper segments of each stream have been segregated and the average of all stations within each segment is shown.

The results are subject to several sources of error, some of which are discussed below:

(1) Seining techniques could not be entirely standardized. One station might present a series of long narrow riffles and narrow, shallow pools in which only a small seine could be used effectively; another station might consist of a large, deep, isolated pool in which a larger seine was needed for effective sampling. In practice, the five seine hauls were made with any of several seines ranging from ten to twenty feet in length.

(2) Seines are species-selective, due partly to the preference of certain fishes for special habitat niches. Fishes that are often found under stones or in weedy pools require special collecting techniques and frequently were not represented in the initial five hauls. If work subsequent to the first five hauls indicated that such fish were a prominent part of the fauna at a particular station, these results were considered before percentages were calculated.

(3) Temporal variations occur in populations at the same station. There were both seasonal and diurnal differences in relative numbers of species taken in these collections. This was noted especially at station C-5 where collecting was done both at night and by day. Spawning by certain species during the course of the study complicated estimates of their relative abundance.

(4) In tabulating percentages of fishes obtained an arbitrary element is often unavoidable in deciding whether a station, especially a station on a tributary, should be considered as part of the lower, middle, or upper segment of a river system.

Despite these disadvantages it is felt that table 6 has factual basis permitting some reliable interpretation.

TABLE 6.—RELATIVE ABUNDANCE IN PER CENT OF FISHES IN COLLECTIONS FROM THREE STREAM SEGMENTS.

	Big Caney River			Grouse Creek		
	Lower	Middle	Upper	Lower	Middle	Upper
<i>L. ossesus</i>.....	.7	.5	.....	.6	.02	.....
<i>D. cepedianum</i>.....	.3	.....	.....	.....	.02	.....
<i>Carpiodes carpio</i>.....	.06	.....	.....	1.0	.....	.....
<i>I. bubalus</i>.....	.6	.45	.....	1.4	.....	.....
<i>I. cyprinella</i>.....	.....	.....	.....	.1	.....	.....
<i>I. niger</i>.....	.01	.....	.....	.....	.....	.....
<i>M. erythrum</i>.....	.2	1.1	1.0	.03	.5	1.1
<i>M. melanops</i>.....	.1	.01	.....	.....	.1	.....
<i>Cyprinus carpio</i>.....	.7	.....	.....	1.3	.2	.....
<i>C. anomalum</i>.....	.6	5.9	18.0	.....	.1	.....
<i>N. boops</i>.....	.6	.6	5.1	.....	1.3	.....
<i>N. buchanani</i>.....	.....	.....	.....	.01	.....	.....
<i>N. camurus</i>	6.4	5.5	.4	.....	.....	.....
<i>N. lutrensis</i>	8.8	1.0	.5	6.4	11.4	15.2
<i>N. percobromus</i>.....	.....	.....	.....	1.1	.....	.....
<i>N. rubellus</i>.....	.4	1.4	3.9	.....	.....	.....
<i>N. umbratilis</i>	17.6	28.3	15.4	2.5	3.9	5.5
<i>N. volucellus</i>.....	.3	.4	.....	.....	.3	.....
<i>P. mirabilis</i>.....	.3	.....	.....	.....	.....	.....
<i>P. notatus</i>	3.5	5.7	13.0	.....	.9	6.6
<i>P. vigilax</i>.....	.8	.....	.....	.....	.....	.....
<i>P. promelas</i>.....	.....	.....	.....	.....	.....	2.9
<i>P. tenellus</i>.....	.7	.5	.....	.01	.....	.....
<i>G. affinis</i>	14.6	.4	.4	20.8	10.2	1.0
<i>F. notatus</i>.....	.1	.....	.....	6.6	17.2	1.4
<i>I. melas</i>.....	.9	2.2	2.4	5.6	2.3	18.0
<i>I. natalis</i>.....	.....	.....	.5	.5	.8	.....
<i>P. olivaris</i>.....	.01	.....	.....	.01	.....	.....
<i>I. punctatus</i>.....	.3	.....	.....	.4	.....	.....
<i>E. spectabile</i>	1.9	4.9	18.0	.4	.3	.3
<i>P. copelandi</i>.....	.8	.1	.....	.01	.....	.....
<i>P. phoxocephala</i>.....	.1	.....	.....	.1	.....	.....
<i>P. caprodes</i>.....	.4	.6	.2	.2	.2	.4
<i>M. salmoides</i>.....	.06	.....	.....	.....	1.1	.3
<i>M. punctulatus</i>.....	.5	1.7	.4	.....	.....	.....
<i>P. annularis</i>	3.9	.8	.....	2.9	4.2	.3
<i>L. cyanellus</i>	3.4	.8	6.6	5.2	1.8	30.5
<i>L. humilis</i>	10.6	13.1	1.8	31.4	17.7	14.8
<i>L. megalotis</i>	12.4	22.3	12.0	3.6	14.0	1.7
<i>L. macrochirus</i>.....	.3	.....	.....	.2	1.3	.....
<i>A. grunniens</i>.....	.1	.....	.....	.....	.....	.....
<i>L. sicculus</i>	7.1	1.6	.4	7.7	10.2	.....

Big Caney River

The "lower segment" of Big Caney River is immediately upstream from Hulah Reservoir, and is not the lowermost portion of the entire river basin, but merely the lower part of the river in the area studied. A conspicuous characteristic of the lower segment was the general restriction of the deep-bodied suckers and the carp to

this part of the stream. Other fishes that were most common in the lower section were *Pimephales vigilax*, *Percina phoxocephala*, *Gambusia affinis*, and *Aplodinotus grunniens*. *Labidesthes sicculus* and *Lepisosteus osseus* ranged into the middle section of the stream, but were present in larger numbers downstream. *Ictalurus punctatus*, *Pomoxis annularis*, and *Lepomis macrochirus* were taken chiefly in downstream habitats; however, stocking has confused the distributional pattern of these species. *Notropis lutrensis*, although found throughout the system, progressively declined in numbers taken in the middle and upper sections. Approximately 18 species were usually taken in downstream collections.

No species were found exclusively in the middle section of the Big Caney system. *Micropterus punctulatus*, *Notropis umbratilis*, and *Lepomis megalotis* tended to be most common in the middle section of the main stream. These three species were taken together at stations C-5, C-6, C-8, and C-10.

The upper section yielded no species that did not occur also in another section. Fishes most abundant in the upper section included: *Campostoma anomalum*, *Etheostoma spectabile*, *Notropis boops*, *Notropis rubellus*, *Pimephales notatus*, and *Lepomis cyanelus*. *Ictalurus natalis* also seemed more common upstream than in lower parts of the basin.

Campostoma anomalum was one of the most common fishes taken at many of the stations on small upland tributaries. In downstream collections its relative abundance was less, although it was often concentrated on riffles.

In the Big Caney system as a whole *Notropis umbratilis* was the most abundant species. Several species were present throughout the system in proportions varying, sometimes greatly, from station to station. *Lepomis megalotis* and *Lepomis humilis* were erratic in occurrence, and the numbers of *Notropis camurus* and *Ictalurus melas* varied without pattern.

Grouse Creek

The fauna of the main stream of Grouse Creek fluctuated more in number and kinds of fish from station to station than did the fauna of Big Caney River. Again, the deep-bodied suckers showed downstream proclivities. In addition, *Notropis buchanani*, *Pimephales tenellus*, *Percina copelandi*, *Percina phoxocephala*, *Notropis percobromus* and *Pylodictis olivaris* were taken only at the lowermost station (G-1). At stations G-2 and G-3 the creek is sluggish and often turbid, meandering between high mud banks in a flood plain. At these stations *Fundulus notatus*, *Gambusia affinis*, *La-*

bidesthes sicculus, *Ictalurus melas*, and *Lepomis humilis* were the most common fishes. Shiners (*Notropis* spp.) and *Lepomis megalotis* were rarely taken. Hall (1953:36) states that *Gambusia affinis*, *Fundulus notatus*, and *Labidesthes sicculus* are usually associated with overflow pools, oxbows, and vegetated backwaters.

Those fishes mentioned in the preceding paragraph remained common in the middle section of the stream. In addition *Notropis lutrensis*, *Notropis umbratilis*, and *Lepomis megalotis* were important members of the fauna.

In the uppermost section shiners (*Notropis* spp.) were common. In the few upstream stations that were still in good condition with clear flowing water, the fauna resembled that of the upstream stations on Big Caney River. Most upstream stations on Grouse Creek were located on highly intermittent streams that are treated below.

FAUNAS OF INTERMITTENT STREAMS

Because of severe, protracted drought, most of the streams studied had ceased to flow by the close of the survey period. However, the duration of intermittency varied greatly in different streams, as did its effect in terms of the number and sizes of residual pools, water temperatures, pollution, and turbidity. Crab Creek, Beaver Creek, and a small unnamed tributary of Grouse Creek were severely affected by intermittency. Their faunas are discussed below.

In Crab Creek six collections were made from points near the mouth to the uppermost pool in which water was found. Pools near the mouth were as large as thirty feet in width and ninety feet in length, while those that were uppermost were shallow puddles averaging ten feet in length and five feet in width. The uppermost station was situated in bluestem pasture without benefit of shade from trees.

The species taken and their relative abundances based on five seine hauls at each station are shown in Table 7. At the uppermost pool (G-17) only small green sunfish were found. At G-16, next downstream, this species was joined by large numbers of black bullheads and a few redbfin shiners and red shiners. G-13 was similar to G-16, but two additional species occurred there. G-12 was a clear, deep pool much larger than any at the stations upstream. Here, seven species were added to the fauna, and the percentages of *Ictalurus melas* and *Lepomis cyanellus* were much less. At G-10 *Fundulus notatus*, *Labidesthes sicculus*, and *Minytrema*

TABLE 7.—PERCENTAGES OF FISHES TAKEN ON CRAB CREEK.

Stations.....	G-10	G-11	G-12	G-13	G-16	G-17
<i>Minytrema melanops</i> ...	8.7					
<i>Labidesthes sicculus</i> ...	20.0	1.0				
<i>Fundulus notatus</i>	25.7	41.0				
<i>Ictalurus natalis</i>		3.8	.43			
<i>Pomoxis annularis</i>	8.8	11.8	1.9			
<i>Lepomis humilis</i>	15.45	9.9	8.5			
<i>Micropterus salmoides</i>			1.9			
<i>Etheostoma spectabile</i> ..	1.0		1.9			
<i>Percina caprodes</i>			3.8			
<i>Moxostoma erythrurum</i>	1.0		7.0			
<i>Lepomis megalotis</i>	5.7	2.3	7.0	2.0		
<i>Pimephales notatus</i>			34.0	9.0		
<i>Ictalurus melas</i>		5.3	.5	29.0	49.0	
<i>Notropis umbratilis</i>			4.7	9.0	1.0	
<i>Notropis lutrensis</i>	20.6	26.0	25.0	14.0	1.0	
<i>Lepomis cyanellus</i>	1.0		1.9	34.0	49.0	100.0

melanops appeared. Nevertheless, fewer species (10) were captured here than at station G-12 upstream.

A series of collections similar to that on Crab Creek was carried out along 1½ miles of Beaver Creek on July 22, 1956. Nine pools were sampled (Table 8) of which number nine was the uppermost

TABLE 8.—FISH TAKEN IN NINE POOLS ON UPPER BEAVER CREEK (PROGRESSING FROM DOWNSTREAM TO UPSTREAM).

	<i>Notropis umbratilis</i>	<i>Notropis lutrensis</i>	<i>Lepomis humilis</i>	<i>Lepomis cyanellus</i>	<i>Ictalurus melas</i>
Pools:					
1.....	5 adults	4 adults 7 young	adults abundant	young abundant	1 juvenile
2.....	2 adults	4 adults	6 adults	young abundant	.....
3.....		1 adult	7 adults	3 juveniles	2 juveniles
4.....			4 adults	young abundant	young abundant
5.....			2 adults		
6.....				28 young	
7.....					
8.....					1 adult
9.....					1 adult

point where water was found (except for farm ponds). Mainly young of *Lepomis cyanellus* and *Ictalurus melas* were found in the uppermost stations, as on Crab Creek. Only adults of *Notropis lutrensis* and *Notropis umbratilis* were taken.

In another small intermittent tributary of Grouse Creek two collections (G-14 and G-15) were made. One was from several isolated pools near the source of the creek and the other was 1½ miles upstream from the mouth. The two stations were approximately four miles apart. Table 9 indicates approximate percentages of fish taken in five seine hauls at these stations.

TABLE 9.—FISHES TAKEN IN A TRIBUTARY OF GROUSE CREEK.

Species	Upstream station	Downstream station
<i>Ictalurus melas</i>	45%	.....
<i>Lepomis humilis</i>	48%	40%
<i>Notropis lutrensis</i>	5%	30%
<i>Lepomis cyanellus</i>	2%	20%
<i>Fundulus notatus</i>.....	.....	10%

At two other stations, only *Lepomis cyanellus* was found. One of these stations consisted of several small spring-fed pools in a dry arroyo tributary to Little Beaver Creek. Around these small "oases" rushes and smartweeds grew and blackbirds were nesting in the rushes. Although green sunfish up to eight inches in length were common in the shallow pools, no other species was found. The second station (C-17) on the East Fork Big Caney River is of special interest. The pool was isolated, had dimensions of about 25 x 25 feet, and had an average depth of 15 inches. The water was foul; cows had been fed fodder in a sheltered area above the pool during the preceding winter and the entire bottom was covered to a depth of 6 inches to 1 foot with a detritus of decomposing fodder, cattle feces, and leaves. The water became almost inky in consistency when the bottom was stirred and its odor was offensive. A thick gray-green bloom lay on the surface. This bloom was full of bubbles indicating gases rising from the bottom muds. One hundred fifty-three green sunfish, all less than 5 inches in length, were taken in one seine-haul at this station.

EAST-WEST DISTRIBUTION

In the Arkansas River system in Kansas there are marked differences between fish faunas of the western and eastern parts of the

state. This can be illustrated by comparison of Spring River in Cherokee County with the Cimarron River in southwestern Kansas. Single collections from Spring River or its tributaries usually contain 25 or more species of fish. Collections from the Cimarron rarely contain more than five or six species. Many of those fishes found in Spring River are characteristic of an Ozarkian fauna, and some are endemic to the Ozark uplands. Fish found in the Cimarron or Arkansas in western Kansas are members of a plains fauna of wide distribution. There is mingling of these two faunal groups across the state, with the number of Ozarkian species diminishing westward, and certain plains species diminishing eastward. A number of species such as *Moxostoma duquesnii* and *Notropis spilopterus* are limited, on the basis of present records, to Spring River and its tributaries in Kansas. Others have not been taken west of the Neosho drainage. The Verdigris River provides the next major avenue of westward dispersal followed by Caney River, Grouse Creek, and the Walnut River. West of the Walnut River system Ozarkian species have been almost always absent from collections. The Chikaskia River is somewhat exceptional. Moore and Buck (1953) reported from this river several species that seem more typical of eastern faunal associations. Table 10 indicates the stream system in which the present westernmost records are located for a number of fishes found in the Arkansas River system in Kansas.

TABLE 10.—PRESENT WESTERNMOST RECORDS OF SOME FISHES IN THE ARKANSAS RIVER BASIN IN KANSAS.

Spring River	Verdigris River
<i>Cottus caroliniae</i>	<i>Etheostoma whipplii</i>
<i>Dionda nubila</i>	<i>Etheostoma zonale arcansanum</i>
<i>Etheostoma blennioides</i>	<i>Percina copelandi</i>
<i>Etheostoma gracile</i>	<i>Moxostoma carinatum</i>
<i>Etheostoma nigrum nigrum</i>	<i>Notropis boops</i>
<i>Etheostoma punctulatum</i>	<i>Notropis volucellus</i>
<i>Etheostoma saxatile</i>	<i>Noturus miurus</i>
<i>Hypentelium nigricans</i>	Chikaskia River
<i>Moxostoma duquesnii</i>	<i>Ictalurus natalis</i>
<i>Notropis spilopterus</i>	<i>Percina phoxocephala</i>
<i>Noturus exilis</i>	<i>Labidesthes sicculus</i>
Neosho River	<i>Lepomis megalotis breviceps</i>
<i>Cypleptus elongatus</i>	<i>Micropterus punctulatus</i>
<i>Etheostoma chlorosomum</i>	<i>Moxostoma aureolum pisolabrum</i>
<i>Etheostoma flabellare lineolatum</i>	<i>Moxostoma erythrurum</i>
<i>Hybopsis amblops</i>	<i>Notropis camurus</i>
<i>Hybopsis biguttata</i>	<i>Pimephales notatus</i>
<i>Hybopsis x-punctata</i>	<i>Pimephales tenellus</i>
<i>Notropis zonatus pilsbryi</i>	<i>Noturus nocturnus</i>

The westernmost records for seven species are in the area studied.

1. *Lepisosteus platostomus*.

2. *Carpionodes velifer*.

3. *Moxostoma carinatum*.

4. *Minytrema melanops*. One specimen taken at station G-10 near the mouth of Crab Creek constitutes the present westernmost record. A specimen has been taken by Cross (C-24-51) in the headwaters of the Walnut River.

5. *Notropis boops*. The westernmost record is station G-5 on Grouse Creek. This fish has been reported slightly west of this in Oklahoma on Big Beaver Creek in Kay County (number 4776, Oklahoma A & M College Museum of Zoology).

6. *Notropis volucellus*. Two specimens were taken at station G-8 on Silver Creek.

7. *Percina copelandi*. The westernmost record is from station G-1, two miles above the mouth of Grouse Creek.

The easternmost occurrences of four species are in the area studied. These species are *Hybopsis aestivalis tetranemus* (Station A-2), *Notropis blennius* (Station A-1), *Notropis girardi* (Station A-2), and *Fundulus kansae* (Station A-2 and Walnut River). These fish are associated with the Arkansas River proper and its sandy western tributaries. In Oklahoma, these fish are found in the Arkansas River as it proceeds eastward and in the downstream portions of some of its tributaries. These fish show little tendency to ascend the streams of the Flint Hills.

SUMMARY

The fish fauna of the area studied is transitional between the Ozarkian and Great Plains faunas.

Fluctuation in water level seemed especially important in determining distribution of fishes in the area studied. Variable climate characteristic of the region studied causes recurrent floods and intermittency in streams. Both of these conditions have probably been accentuated by man's modifications of the habitat. The effects of intermittency were most strikingly demonstrated in small creeks of the uplands. The number of species of fish in the highly intermittent streams was small—especially in the uppermost pools sampled—but the actual number of fish was often high even though the number of species was low. In several instances the only fishes found in these isolated pools were *Lepomis cyanellus* and *Ictalurus melas*. This phenomenon of concentrated numbers of individuals of a few species would indicate the presence of limiting

factors that allow only those species most tolerant of the particular factor to flourish.

Soon after rains restored flow in these intermittent creeks *L. cyanellus* and *I. melas* appeared in parts of the channels that had previously been several miles from the nearest water. Rapid upstream movements of other species after rains was also noted.

It was impossible to ascertain the precise effects of gradient and bottom-type on distribution, but certain species such as *Notropis blennioides*, *Notropis girardi*, and *Fundulus kansae* were taken only in streams with sandy bottoms. *Notropis deliciosus* and *Hybognathus placita* were most abundant over sandy bottoms.

The high gradient of upland tributaries in the Flint Hills area produced turbulence and bottoms predominantly of rubble. A fauna of which *Etheostoma spectabile* and *Campostoma anomalum* were characteristic existed in these waters while they were flowing. As flow decreased and intermittency commenced, qualitative and quantitative changes in the fish faunas were observed. Gradient did not change during drought, but turbulence did. Because turbulence varies with water level as well as gradient, the effect of gradient on fish distribution ultimately is linked to climate.

Probably the small number of fish taken on the Walnut River in comparison with other eastern Kansas rivers (Verdigris, Neosho) results, in part, from the long-term pollution of the stream noted by Clapp (1920:33) and Doze (1924). No percid fishes, black bass, or madtom catfish were taken on the Walnut in Cowley County and the species of *Notropis* numbered only three.

Four faunal associations seem to be recognizable in the area.

Arkansas River Fauna

This fauna contained *Notropis girardi*, *Notropis blennioides*, *Hybopsis aestivalis tetranemus*, and *Fundulus kansae* which, in this area, did not seem to wander far from the sandy main stream of the Arkansas. Minnows abounded; *Notropis lutrensis* and *N. deliciosus missouriensis* predominated; and *Notropis girardi*, *N. percobromus*, and *Hybognathus placita* were common. In quiet backwaters, coves, and shallow pools *Gambusia affinis* occurred in great numbers. *Lepisosteus osseus* seemed to be the most important predator.

Lower Walnut River Fauna

The Walnut River in Cowley County supported large populations of deep-bodied suckers, carp, and gar. *Notropis lutrensis* and *N. percobromus* were characteristic minnows. *Lepomis*

humilis abounded at some stations. The fauna of the main stream of the Walnut River was somewhat intermediate between that of the Arkansas River and that of the three streams considered below. Fifteen of the species common to the Big Caney, Elk, and Grouse systems were also taken in the Walnut River main stream. Thirteen species were common to the Walnut and Arkansas rivers. Seven species were common to all these streams.

Caney-Elk-Grouse Main Stream Fauna

This fauna includes fishes living not only in the main streams but also in the lower parts of the larger tributaries of these streams. The fauna was comparatively rich: in the main stream of Big Caney River 39 species were taken, in Grouse Creek 35 species, in the Walnut River main stream 21 species, and in the Arkansas River 19 species. It has been pointed out that large rivers such as the Walnut and Arkansas have been subjected to greater direct and indirect modification by man, possibly resulting in a less diverse fauna than would otherwise occur in these streams. At present, there is a paucity of ecological niches in the upland tributaries and large rivers, as compared with streams of intermediate size. Fishes typical of the Caney-Elk-Grouse association were *Notropis umbratilis*, *Lepomis megalotis*, *Lepomis humilis*, *Labidesthes sicculus*, *Fundulus notatus*, and the two species of *Micropterus* (*Micropterus punctulatus* was not taken in Grouse Creek).

Upland Tributary Fauna

Tributary faunas were divisible into two categories: (1) Those of the Walnut River and Grouse Creek (intermittency was severe, species were few, with *Ictalurus melas* and *Lepomis cyanellus* predominating); (2) those of Big Caney River (stream-flow was more stable, and eastern fishes, some of which have Ozarkian affinities, occurred in greater abundance than in any other part of the area surveyed). In the latter streams *Campostoma anomalum* and *Etheostoma spectabile* usually were dominant. *Pimephales notatus*, *Notropis volucellus*, *N. camurus*, *N. boops*, and *N. rubellus* characteristically occurred. *Notropis lutrensis* was sparsely represented in flowing tributaries. *Notropis umbratilis*, which seems to prefer habitats intermediate between those of *Notropis lutrensis* and Ozarkian shiners, was usually represented. Deep-bodied suckers and carp were not taken in upland tributaries but *Moxostoma erythrurum* was common and *Minytrema melanops* was taken.

The kinds and numbers of shiners (*Notropis*) taken at different

points along Grouse Creek seem significant. *N. lutrensis* and *N. umbratilis* occurred throughout the stream but were rare in sluggish areas where populations of *Gambusia affinis*, *Fundulus notatus*, and *Labidesthes sicculus* flourished. At the lowermost station *Notropis percobromus* and *N. buchanani* were taken; these were not present in other collections. In the uppermost stations where water remained plentiful, *N. boops* and *N. volucellus* were taken, and *N. rubellus* has been recorded.

In the broader distributional sense those fishes that seemed most tolerant of intermittency (*Lepomis cyanellus*, *Lepomis humilis*, *Ictalurus melas*, *Notropis lutrensis*) are widely distributed in the Arkansas River Basin, and are common in the western part of the Arkansas River Basin. Species less tolerant of intermittency are *Notropis boops*, *Notropis camurus*, *Notropis rubellus*, *Notropis volucellus*, and *Pimephales tenellus*; they have not been taken far west of the area studied, and become more common east of it.

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Volume 11, No. 7, pp. 401-442, 2 plates, 4 figs. in text, 5 tables

May 8, 1959

Fishes of the Big Blue River Basin,
Kansas

BY

W. L. MINCKLEY

UNIVERSITY OF KANSAS

LAWRENCE

1959

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UNIVERSITY OF KANSAS PUBLICATIONS

MUSEUM OF NATURAL HISTORY

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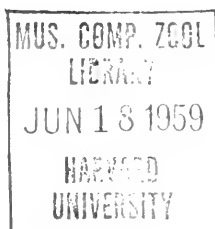
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UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

Editors: E. Raymond Hall, Chairman, Henry S. Fitch,
Robert W. Wilson

Volume 11, No. 7, pp. 401-442, 2 plates, 4 figs. in text, 5 tables
Published May 8, 1959



UNIVERSITY OF KANSAS
Lawrence, Kansas

A CONTRIBUTION FROM
THE STATE BIOLOGICAL SURVEY OF KANSAS

PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1959



27-7080

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INTRODUCTION

The Big Blue River in northeastern Kansas will soon be impounded by the Tuttle Creek Dam, located about five miles north of Manhattan, Kansas. Since the inception of this project by the U. S. Army Corps of Engineers much argument has arisen as to the values of the dam and reservoir as opposed to the values of farmland and cultural establishments to be inundated (Schoewe, 1953; Monfort, 1956; and Van Orman, 1956). Also, there has been some concern about the possible effects of impoundment on the fish-resources of the area, which supports "a catfish fishery that is notable throughout most of the State of Kansas and in some neighboring states (U. S. Fish and Wildlife Service, 1953:9)." The objectives of my study, conducted from March 30, 1957, to

August 9, 1958, were to record the species of fish present and their relative abundance in the stream system, and to obtain a measure of angler success prior to closure of the dam. These data may be used as a basis for future studies on the fish and fishing in the Big Blue River Basin, Kansas.

ACKNOWLEDGMENTS

I thank Messrs. J. E. Deacon, D. A. Distler, Wallace Ferrel, D. L. Hoyt, F. E. Maendele, C. O. Minckley, B. C. Nelson, and J. C. Tash for assistance in the field and for valuable suggestions. Dr. J. B. Elder, Kansas State College, arranged for loan of specimens, and Mr. B. C. Nelson supplied data on *Notropis deliciosus* (Girard) in Kansas, and on specimens in the University of Michigan Museum of Zoology.

I thank the many landowners who allowed me access to streams in the Big Blue River Basin. The U. S. Army Corps of Engineers, Kansas City District, also allowed access in the reservoir area, and furnished information and some photographs. Mr. J. C. Tash did chemical determinations on my water samples.

Dr. Frank B. Cross guided me in this study and in preparation of this report. Drs. E. Raymond Hall and K. B. Armitage offered valuable suggestions on the manuscript. Equipment and funds for my study were furnished by the State Biological Survey of Kansas, and the Kansas Forestry, Fish and Game Commission granted necessary permits.

TUTTLE CREEK DAM AND RESERVOIR

The data on Tuttle Creek Dam and Reservoir that follow were furnished by Mr. Donald D. Poole, U. S. Army Corps of Engineers, Kansas City District. The dam, an earth-fill structure, will be 7,500 feet in length, with a maximum height of 157 feet above the valley floor. Release of water will be from beneath the west end of the dam, through two tunnels 20 feet in diameter that have a capacity of 45,000 cubic feet per second; however, releases exceeding 25,000 c. f. s. are not planned. The gated spillway is located at the east end of the dam. Freeboard will be 23 feet at the top of flood-control pool.

The reservoir will have a maximum pool of 2,280,000 acre-feet capacity, a 53,500-acre surface area, and 368 miles of shoreline. The present operational plan provides for a conservation pool having a surface area of 15,700 acres, a shoreline of 112 miles, and a length of 20 miles.

BIG BLUE RIVER BASIN

Big Blue River and its tributaries, a sub-basin of the Kansas River System, drain approximately 9,600 square miles, of which 2,484 miles are in Kansas (Colby, *et al.*, 1956:44). The head-

waters of the Big Blue River are in central Hamilton County, Nebraska, near the Platte River (Fig. 1). The stream flows generally south and east for 283 miles to its confluence with the Kansas River near Manhattan, Kansas. Little Blue River, the largest tributary to the Big Blue, rises in eastern Kearney and western Adams counties, Nebraska, and flows southeast for 208 miles to join the Big Blue near Blue Rapids, Kansas (Nebraska State Planning Board, 1936:628). The Big Blue River Basin varies in width from 129 miles in the northwest, to approximately ten miles near the mouth (Colby, *et al.*, 1956:44).

GEOLOGY OF THE BASIN

In Kansas, outcrops of Pennsylvanian and Cretaceous age occur along the extreme eastern and western sides of the Big Blue River Basin, respectively, whereas Permian beds (overlain by Pleistocene deposits) occur throughout most of the remainder of the watershed (see Moore and Landes, 1937). The Big Blue and Little Blue rivers and their tributaries have deeply incised the Permian beds of the Flint Hills in Kansas, exposing limestones and shales

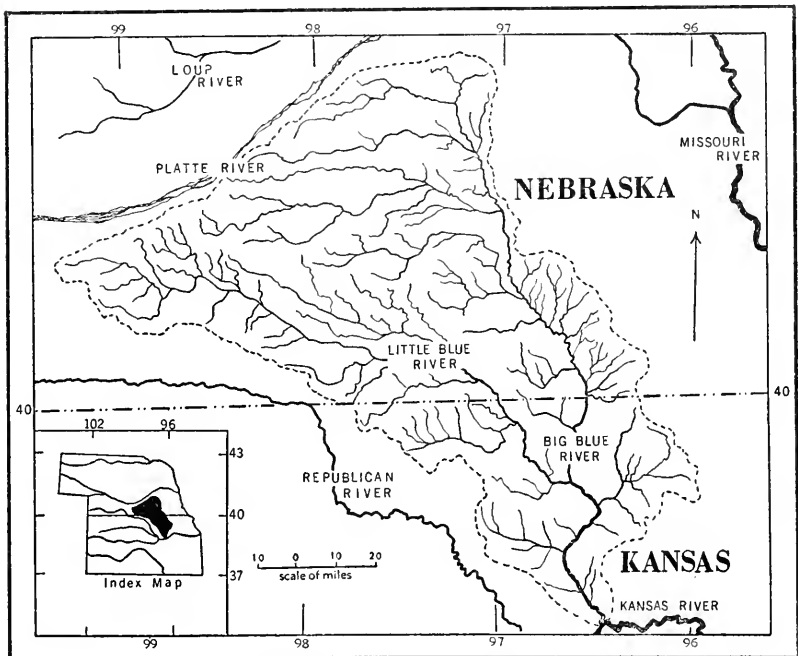


FIG. 1. Big Blue River Basin, Kansas and Nebraska.

of the Admire, Council Grove, Chase, and Sumner groups (Wolfcampian and Leonardian series) (Walters, 1954:41-44). Pleistocene deposits in the Big Blue Basin in Kansas consist of alluvium, glacial till, and glacial outwash from the Kansan glacial stage, overlain by loess deposits of Wisconsin and Recent stages (Frye and Leonard, 1952: pl. 1).

The Big Blue River was formed "in part on the till plain surface and in part by integration of spillway channels," in the latter portion of the Kansan glaciation (Frye and Leonard, 1952:192). This stream, and the Republican River to the west, carried waters from the areas that are now the Platte, Niobrara, and upper Missouri River basins (Lugn, 1935:153). Drainage was southward, through Oklahoma, until establishment of the east-flowing Kansas River (Frye and Leonard, 1952:189-190). As Kansan ice receded the Blue and Republican rivers retained what is now the Platte River Basin. The lower Platte River developed and the surface drainage became distinct in the Iowan (Tazwellian) portion of the Wisconsin glacial stage (Lugn, 1935:152-153). However, according to Lugn (1935:203) the Platte River Basin contributes about 300,000 acre-feet of water per year to the Big Blue and Republican rivers by percolation through sands and gravels underlying the uplands that now separate the basins.

CLIMATE, POPULATION, AND LAND-USE

Climate of the Big Blue River Basin is of the subhumid continental type, with an average annual precipitation of 22 inches in the northwest and 30 inches in the southeast. The mean annual evaporation from water surfaces exceeds annual precipitation by approximately 30 inches (Colby, *et al.*, 1956:32-33).

The average annual temperature for the basin is 53° F. (Flora, 1948:148). According to Kincer (1941:704-705) the average temperature in July, the warmest month, is 78° F., and the coolest month, January, averages 28° F. Periods of extreme cold and heat are sometimes of long duration. Length of the growing season varies from less than 160 days in the northwest to 180 days in the southeast (Kincer, *loc. cit.*).

The human population of the Big Blue Basin varies from about 90 persons per square mile in one Nebraska county in the northwest and one Kansas county in the southeast, to as few as six persons per square mile in some northeastern counties. The population is most dense along the eastern border of the basin, decreasing toward the west. This decrease in population is corre-

lated with the decrease in average annual precipitation from east to west (Colby, *et al.*, 1956:80).

The principal land-use in the Big Blue Watershed is tilled crops, with wheat, sorghums, and corn being most important. Beef cattle are important in some portions of the basin. Colby, *et al.* (1956:24) reported that in 1954 as much as 55 per cent of the land in some counties near the mouth of the Big Blue River was in pasture. Only one Nebraska county had less than 15 per cent in pastureland.

PHYSICAL FEATURES OF STREAMS

Streams of the Big Blue River Basin are of three kinds: turbid, sandy-bottomed streams, usually 150 to 300 feet in width; relatively clear, mud-bottomed streams, ten to 60 feet in width; and clear, deeply incised, gravel-bottomed streams, usually five to 30 feet in width.

SAND-BOTTOMED STREAMS.—The Big Blue and Little Blue rivers represent this kind of stream. The bottoms of these rivers consist almost entirely of fine sand; nevertheless, their channels are primarily deep and fairly uniform in width, rather than broad, shallow, and braided as in the larger Kansas and Arkansas rivers in Kansas (Plate 11, Fig. 1). In the Big Blue River, gravel occurs rarely on riffles, and gravel-rubble bottoms are found below dams (Plate 11, Fig. 2). The Big Blue flows over a larger proportion of gravelly bottom than does the Little Blue.

Big Blue River rises at about 1,800 feet above mean sea level and joins the Kansas River at an elevation of 1,000 feet above m. s. l. The average gradient is 2.8 feet per mile. Little Blue River, originating at 2,200 feet, has an average gradient of 5.3 feet per mile, entering the Big Blue at 1,100 feet above mean sea level (Nebraska State Planning Board, 1936:628, 637). The Little Blue is the shallower stream, possibly because of the greater amount of sandy glacial deposits in its watershed and the swift flow that may cause lateral cutting, increased movement, and "drifting" of the sandy bottom.

For approximately a 50-year period, stream-flow in the Big Blue River at its point of entry into Kansas (Barnston, Nebraska) averaged 603 cubic feet per second, with maximum and minimum instantaneous flows of 57,700 c. f. s. and one c. f. s. The Little Blue River at Waterville, Kansas, averaged a daily discharge of 601 c. f. s. (maximum 50,400, minimum 28). Below the confluence of the Big Blue and Little Blue rivers, at Randolph, Kansas, the

average daily discharge was 1,690 c.f.s. (maximum 98,000, minimum 31) (Kansas Water Resources Fact-finding and Research Committee, 1955:27).

The turbidity of the Big Blue River, as determined by use of a Jackson turbidimeter, varied from 27 parts per million in winter (January 10, 1958) to as high as 14,000 p. p. m. (July 12, 1958). The Little Blue River has similar turbidities, with high readings being frequent. In the summer of 1957, pH ranged from 7.2 to 8.4 in the Big Blue River Basin—values that correspond closely with those of Canfield and Wiebe (1931:3) who made 25 determinations ranging from 7.3 to 8.3 in the streams of the Nebraskan portion of this basin in July, 1930. Surface temperatures at various stations varied from 38° F. on January 10, 1958, to 90° F. in backwater-areas on July 19, 1957. The average surface temperature at mid-day in July and August, 1957, was approximately 86.5° F.

Chemical determinations were made on water-samples from my Station 4-S on the Big Blue River, and Station 50-S on the Little Blue (Table 1). These samples were taken from the surface in strong current. Determinations were made by methods described in *Standard Methods for the Examination of Water and Sewage*, 10th edition, 1955.

TABLE 1.—CHEMICAL DETERMINATIONS IN MILLIGRAMS PER LITER AT FIVE STATIONS IN THE BIG BLUE RIVER BASIN, KANSAS, 1958.

STATION AND DATE	Phenolphthalein alkalinity	Methyl-orange alkalinity	Chlorides	Sulphates	Nitrates	Nitrites	Ammonia	Phosphates
4-S August 9.....	0.0	154	16	28	3.5	.083	.250	.225
50-S August 9.....	0.0	125	24	20	2.5	.669	.427	.240
35-M August 9.....	0.0	366	15	108	9.4	.220	.750	.080
11-G July 8.....	0.0	272	15	60	4.5	.060	.625	.140
18-G July 22.....	0.0	183	10	60	1.6	.938	.293	.240

The banks of both the Big Blue and Little Blue rivers support narrow riparian forests comprised primarily of elm, *Ulmus americanus*, cottonwood, *Populus deltoides*, sycamore, *Platanus occidentalis*, and willow, *Salix* spp. Maple, *Acer* sp., oak, *Quercus* spp., and ash, *Fraxinus* sp. occur where the rivers flow near steep, rocky hillsides. Many of the hills are virgin bluestem prairies (*Andropogon* spp.), but the floodplains are heavily cultivated.

MUD-BOTTOMED STREAMS.—Streams of this kind are present in the watershed of the Black Vermillion River that enters Big Blue River from the east. The area east of the Big Blue River and north of the Black Vermillion River is till plains, where relief seldom exceeds 100 feet (Walters, 1954:12). Streams in this portion of the basin, and streams entering the Little Blue River from the west (Mill Creek and Horseshoe Creek systems), tend to have V-shaped channels, fewer riffles than the Little Blue and Big Blue rivers and in the gravelly streams (to be described later), and have bottoms of mud or clay, with few rocks (Plate 12, Fig. 1). However, in the extreme headwaters of most western tributaries of the Little Blue River (in Washington and Republic counties) sandy bottoms predominate. The Black Vermillion River flows on a broad floodplain and is a mud-bottomed, sluggish stream, with an average gradient of approximately one foot per mile. Fringe-forests of elm, cottonwood, sycamore, and willow persist along most of these stream-courses.

Notwithstanding the mud bottoms, the water in this kind of stream in the Big Blue Basin remains clearer than that of the Big Blue and Little Blue rivers. Heavy algal blooms were noted in the Black Vermillion River and Mill Creek, Washington County, in 1957 and 1958. Temperatures at Stations 45-M and 46-M on Mill Creek, Washington County, averaged 85.5° F. on July 31, 1957. Chemical characteristics of a water-sample from Station 35-M, Black Vermillion River, are in Table 1.

GRAVEL-BOTTOMED STREAMS.—Most streams of this kind are tributary to the Big Blue River; however, streams entering Black Vermillion River from the south are also of this type (Plate 12, Fig. 2). The streams are "characteristically a series of large pools (to 100 feet in length and more than two feet in depth) connected by short riffles and smaller pools" (Minckley and Cross, in press). The average gradients are high: Carnahan Creek, 33 feet per mile; Mill Creek, Riley County, 21 feet; Clear Creek, 16 feet per mile. Stream-flow is usually less than five cubic feet per second. In summer, these streams may become intermittent, but springs and

subsurface percolation maintain pool-levels (Minckley and Cross, *loc. cit.*).

The average temperatures of these small streams (79.5° to 81.0° F. in July and August, 1957) were lower than temperatures in stream-types previously described. Turbidities were usually less than 25 p. p. m. The chemical properties of water-samples from two of these streams (Stations 11-G and 18-G) are listed in Table 1.

PREVIOUS RECORDS OF FISHES

The earliest records of fishes from the Big Blue River Basin are those of Cragin (1885) and Graham (1885) in independently published lists of the fishes of Kansas. Meek (1895) recorded fishes collected in 1891 "from both branches of the Blue River, a few miles west of Crete, Nebraska." Evermann and Cox (1896) reported five collections from the Nebraskan part of the basin. Their collections were made in October, 1892, and August, 1893, and the stations were: in 1892, Big Blue River at Crete; in 1893, Big Blue River at Seward, Lincoln Creek at Seward and York, and Beaver Creek at York.

Canfield and Wiebe (1931) obtained fish from 18 localities in Nebraska in July, 1930; however, their major concern was determination of water quality. Their stations were: Big Blue River at Stromsburg, Polk Co.; Surprise and Ulysses, Butler Co.; Staplehurst, Seward, and Milford, Seward Co.; Crete and Wilber, Saline Co.; Beatrice, Blue Springs, and Barnston, Gage Co.; Little Blue River at Fairbury, Jefferson Co.; Hebron, Thayer Co.; Sandy Creek at Alexandria, Thayer Co.; West Fork of Big Blue River at Stockham, Hamilton Co.; McCool Junction, York Co.; Beaver Crossing, Seward Co.; and Beaver Creek at York, York Co.

Breukelman (1940) and Jennings (1942) listed fishes from the University of Kansas Museum of Natural History and the Kansas State College Museum, respectively, including some specimens collected from the Big Blue River System in Kansas. Because records in these two papers pertain to collections that were widely spaced in the basin and in time, the specific localities are not given herein. One of Jennings' (*loc. cit.*) records, *Scaphirhynchus platyrhynchus* (Rafinesque), was cited by Bailey and Cross (1954:191). More recently, Minckley and Cross (in press) recorded several localities, and cited some papers mentioned above, in a publication dealing with *Notropis topeka* (Gilbert) in Kansas.

Information on the fishes of the Nebraskan portion of the Big Blue River Basin was compiled, and additional localities were reported, in a doctoral thesis by Dr. Raymond E. Johnson, entitled *The Distribution of Nebraska Fishes, 1942*, at the University of Michigan.

METHODS AND MATERIALS

Collection of Fishes

The gear and techniques used are listed below:

ENTRAPMENT DEVICES.—Hoop and fyke nets and wire traps were used for 288 trap/net hours in 1957. The nets were not baited, and were set parallel to the current, with the mouths downstream. Hoop nets were 1½ to three feet in diameter at the first hoop, with a pot-mesh of one inch; fyke nets

were three feet at the first hoop, pot-mesh of one inch; wire traps, with an opening at each end, were $2\frac{1}{2}$ feet in diameter and covered with one-inch-mesh, galvanized chicken wire.

GILL NETS.—Experimental gill nets were set on three occasions in areas with little current. These nets were 125 feet in length, with $\frac{3}{4}$ to two inch bar-mesh in 25-foot sections.

SEINES.—Seining was used more than other methods. An attempt was made to seine all habitats at each station. In swift water, seine-hauls were usually made downstream, but in quiet areas seining was done randomly. Haul-seines six to 60 feet in length, three to eight feet in depth, and with meshes of $\frac{1}{8}$ to $\frac{1}{2}$ inch were used. For collection of riffle-fishes, the seine was planted below a selected area and the bottom was kicked violently by one member of the party, while one or two persons held the seine, raising it when the area had been thoroughly disturbed. Seining on riffles was done with a four-foot by four-foot bobbinet seine.

ROTENONE.—Rotenone was used in pools of smaller streams, mouths of creeks, borrow-pits, and cut-off areas. Both powdered and emulsifiable rotenone were used. The rotenone was mixed with water and applied by hand, or into the backwash of an outboard motor.

ELECTRIC SHOCKER.—The electrical unit used in this study generated 115 volts and 600 to 700 watts, alternating current. The shocking unit consisted of two booms, each with two electrodes, mounted on and operated from a slowly moving boat. Fish were recovered in scape nets, or in many cases were identified as they lay stunned and were not collected.

Estimation of Relative Abundance

Data on relative abundance of fishes were obtained by counts of seine hauls at 29 of the 59 stations, counts of rotenoned fish at seven stations, and results with the electric shocker at nine stations. Counts were usually made in the field; however, in some collections all fish were preserved and counted in the laboratory. Some fish (or "swirls" presumed to be fish) observed while shocking were not identified and are not included in the calculations. However, all fish positively identified while shocking are included.

Age and Growth of Fishes

Fish from selected size-groups were aged in this study. Scales for age-determinations were removed from positions recommended by Lagler (1952: 108). Scales were placed in water between glass slides and were read on a standard scale-projection device.

Pectoral spines of catfish were removed from one or both sides, sectioned, and read by methods described by Marzolf (1955:243-244).

Calculation of length at the last annulus for both scale-fish and catfish was made by direct proportion. All measurements are of total length to the nearest tenth of an inch unless specified otherwise.

Creel Census

From April 6 to May 28, 1957, a creel census was taken below Tuttle Creek Dam. From June 16 to July 24, 1958, I periodically visited the main points of access to the Big Blue River, beginning approximately eight miles downstream from Tuttle Creek Dam and ending six miles upstream from the maximal ex-

tension of the reservoir at capacity level. Access-points consisted of 11 bridges, two power dams, and three areas where county roads approached the river. Eleven eight-hour days were spent in the 1957 census and 22 checks in 15 days were made in 1958. An equal number of morning (6:00 a. m. to 12:00 noon) and afternoon (12:00 noon to 8:30 p. m.) checks were made.

Fishermen contacted were asked the following questions: home address (or residence at the time of the fishing trip); time they started fishing; kind of fish sought; number and kinds of fish in possession; and baits used. Also, the number of poles and type of fishing (from the bank, from boat, *etc.*) were recorded. Fishes caught were examined to confirm identifications. About 80 per cent of all fishermen seen were contacted.

Fish per man-hour, as used in this report, refers to the average number of fish of all species caught by one fisherman in one hour. Fisherman-day is the average time spent fishing in one day by one person. Because some fishermen used more than one pole, the data are also expressed as catch per pole-hour.

COLLECTING STATIONS

In the list that follows, stations are numbered consecutively from the mouth of the Big Blue River, listing stations on each tributary as it is ascended. The letters following station-numbers indicate the general type of stream: S = sandy; M = muddy; and G = gravelly. The Big Blue River is the boundary between Riley and Pottawatomie counties, Kansas, along part of its length. Stations in this area have been designated Riley County. The legal description of each station is followed by the date(s) of collection, and each station is plotted in Figure 2.

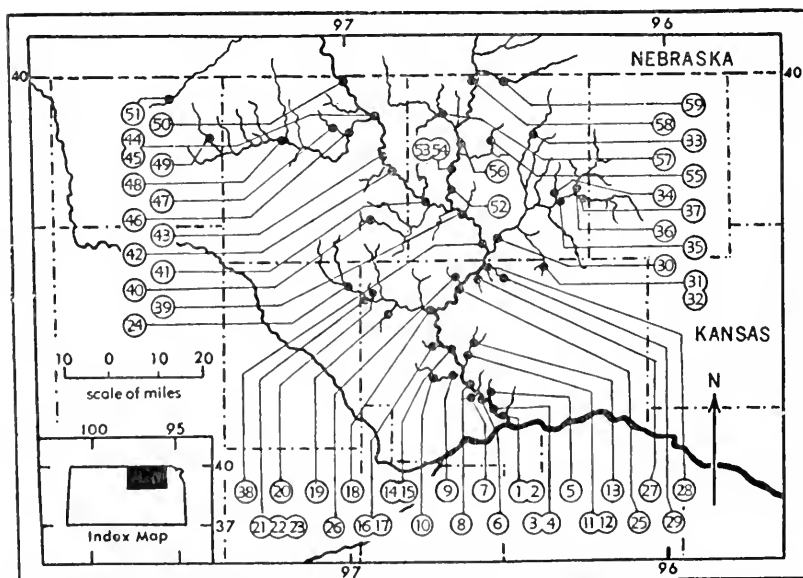


FIG. 2. Collection stations in the Big Blue River Basin, Kansas, 1957 and 1958.

PLATE 11



FIG. 1. Big Blue River at Station 3-S. U. S. Army Corps of Engineers photograph No. 563697.



FIG. 2. Big Blue River at Oketo, Marshall County, Kansas. U. S. Army Corps of Engineers, photograph No. 67516.

PLATE 12



FIG. 1. Black Vermillion River, approximately one mile upstream from its mouth. Photograph by Robert G. Webb.



FIG. 2. Canaan Creek at Station H-G. Photograph by Robert G. Webb.

- 1-S: Pottawatomie Co., mouth of Big Blue River, Sec. 16, T. 10S, R. 8E, June 20, 1958.
- 2-S: Riley Co., Big Blue River, Sec. 4, T. 10S, R. 8E, June 6, 12, and 14, 1957.
- 3-S: Riley Co., Big Blue River, E $\frac{1}{2}$, Sec. 30, T. 9S, R. 8E, Mar. 30, Apr. 6, July 15, 16, 17, Aug. 14, and Dec. 26, 1957; Apr. 26, June 20, and Aug. 5, 1958.
- 4-S: Riley Co., Big Blue River at Rocky Ford Dam, W $\frac{1}{2}$, Sec. 30, T. 9S, R. 8E, Aug. 14, 1957; and Aug. 5, 1958.
- 5-G: Pottawatomie Co., McIntire Creek, Sec. 12, T. 9S, R. 7E, July 14, 1958.
- 6-S: Riley Co., Big Blue River and adjacent borrow-pit, Sec. 24, T. 9S, R. 7E, July 18 and 19, 1957; and July 11, 1958.
- 7-G: Riley Co., Tuttle Creek, Sec. 10, T. 9S, R. 7E, Aug. 5, 1958.
- 8-S: Riley Co., Big Blue River, Sec. 10, T. 9S, R. 7E, Aug. 14, 1957.
- 9-G: Riley Co., Mill Creek, Sec. 4, T. 9S, R. 7E, July 20 and 25, 1958.
- 10-G: Riley Co., Mill Creek, Sec. 2, T. 9S, R. 6E, Aug. 13, 1957.
- 11-G: Pottawatomie Co., Carnahan Creek, Sec. 22, 27, and 34, T. 8S, R. 7E, Aug. 1, 1957; and July 8, 1958.
- 12-G: Pottawatomie Co., unnamed tributary to Carnahan Creek, Sec. 15, T. 8S, R. 7E, Mar. 19, 1956 (collection made before my formal study was begun).
- 13-G: Pottawatomie Co., Carnahan Creek, Sec. 36, T. 7S, R. 7E, Aug. 13, 1957.
- 14-S: Riley Co., Big Blue River, Sec. 18, T. 8S, R. 7E, Mar. 22, 1958.
- 15-S: Riley Co., Big Blue River, Sec. 7, T. 8S, R. 7E, Apr. 3, and June 12, 1958.
- 16-G: Riley Co., unnamed creek, Sec. 1, T. 8S, R. 6E, July 10, and Aug. 5, 1958.
- 17-G: Riley Co., unnamed creek, Sec. 10, T. 8S, R. 6E, June 26, 1958.
- 18-G: Riley Co., Fancy Creek, Sec. 14, T. 7S, R. 6E, July 29, 1957.
- 19-G: Riley Co., Walnut Creek, Sec. 20, T. 7S, R. 6E, June 26, 1958.
- 20-G: Riley Co., Fancy Creek, Sec. 2, T. 7S, R. 5E, Mar. 13, 1957; and June 26, 1958.
- 21-G: Riley Co., Schoolhouse Branch, Sec. 35, T. 6S, R. 5E, July 22, 1958.
- 22-G: Riley Co., Fancy Creek, Sec. 33, T. 6S, R. 5E, June 1, 1957.
- 23-G: Riley Co., West Branch Fancy Creek, Sec. 32 and 33, T. 6S, R. 5E, June 1 and 3, 1957.
- 24-G: Clay Co., West Branch Fancy Creek, Sec. 32 and 33, T. 6S, R. 4E, July 22, 1958.
- 25-S: Riley Co., Big Blue River, Sec. 5, T. 7S, R. 7E, Aug. 7, 1958.
- 26-G: Riley Co., Swede Creek, Sec. 21, T. 6S, R. 7E, Mar. 22, 1958.
- 27-G: Pottawatomie Co., unnamed creek, Sec. 14, T. 6S, R. 7E, Sept. 10, 1957.
- 28-G: Pottawatomie Co., Bluff Creek, Sec. 6, T. 6S, R. 8E, Oct. 6, 1957.
- 29-G: Pottawatomie Co., Bluff Creek, Sec. 15, T. 6S, R. 8E, June 29, 1958.
- 30-M: Marshall Co., Black Vermillion River, Sec. 9, T. 5S, R. 8E, Mar. 5, 1958.
- 31-G: Pottawatomie Co., Clear Creek, Sec. 3, T. 6S, R. 9E, July 14, 1958.
- 32-G: Pottawatomie Co., unnamed creek, Sec. 14, T. 6S, R. 9E, July 14, 1958.
- 33-M: Marshall Co., Robidoux Creek, Sec. 20, T. 2S, R. 9E, July 23, 1958.
- 34-M: Marshall Co., Little Timber Creek, Sec. 10, T. 4S, R. 9E, Oct. 6, 1957.
- 35-M: Marshall Co., Black Vermillion River, Sec. 15, T. 4S, R. 9E, Aug. 9, 1958.
- 36-M: Marshall Co., unnamed creek, Sec. 8, T. 4S, R. 9E, Oct. 6, 1957.

- 37-M: Marshall Co., Black Vermillion River, Sec. 11, T. 4S, R. 10E, Oct. 6, 1957.
 38-S: Marshall Co., Big Blue River, Sec. 18, T. 5S, R. 8E, Aug. 8, 1958.
 39-S: Marshall Co., Big Blue River, Sec. 20, T. 4S, R. 7E, May 29, 1958.
 40-M: Washington Co., Coon Creek, Sec. 27, T. 4S, R. 4E, July 22, 1958.
 41-S: Marshall Co., Little Blue River, Sec. 9, 16, and 17, T. 4S, R. 6E, June 27, 1958.
 42-S: Washington Co., Little Blue River, Sec. 21, T. 3S, R. 5E, Aug. 8, 1958.
 43-S: Washington Co., Little Blue River, Sec. 5 and 8, T. 3S, R. 5E, July 30, 1957.
 44-S: Washington Co., Little Blue River, Sec. 36, T. 1S, R. 4E, July 31, 1957.
 45-M: Washington Co., Mill Creek, Sec. 35 and 36, T. 1S, R. 4E, July 31, 1957.
 46-M: Washington Co., Mill Creek, Sec. 4, T. 2S, R. 4E, July 31, 1957.
 47-M: Washington Co., Spring Creek, Sec. 11 and 12, T. 2S, R. 3E, June 19, 1958.
 48-M: Washington Co., Mill Creek, Sec. 28, T. 2S, R. 2E, June 19, 1958.
 49-M: Republic Co., Mill Creek, Sec. 8 and 17, T. 2S, R. 1W, July 23, 1958.
 50-S: Washington Co., Little Blue River, Sec. 5, T. 1S, R. 4E, Aug. 9, 1958.
 51-M: Republic Co., Rose Creek, Sec. 20, T. 1S, R. 2W, July 23, 1958.
 52-S: Marshall Co., Big Blue River, Sec. 6, T. 4S, R. 7E, Aug. 6, 1958.
 53-S: Marshall Co., Big Blue River, Sec. 18, T. 3S, R. 7E, July 29 and 30, 1957; May 28, and Aug. 6, 1958.
 54-G: Marshall Co., Hop Creek, Sec. 13 and 18, T. 3S, R. 7E, May 28, 1958.
 55-M: Marshall Co., Spring Creek, Sec. 29, T. 2S, R. 8E, July 9, 1958.
 56-S: Marshall Co., Big Blue River at Marysville Dam, Sec. 20, T. 2S, R. 7E, June 16, 1958.
 57-M: Marshall Co., Horseshoe Creek, Sec. 6, T. 2S, R. 7E, July 1, 1958.
 58-G: Marshall Co., unnamed creek, Sec. 2, T. 1S, R. 7E, July 1, 1958.
 59-G: Marshall Co., Mission Creek, Sec. 3, T. 1S, R. 8E, Nov. 30, 1957.

ANNOTATED LIST OF SPECIES

Forty-eight species were obtained in this survey and five others have been recorded in literature or are deposited in museums: KSC = Kansas State College Museum; and UMMZ = University of Michigan Museum of Zoology. Specimens, unless designated otherwise, are in the University of Kansas Museum of Natural History (KU).

In this list, the scientific name of each species is followed by the common name, citations of previous records, and the stations where the species was obtained. I follow Bailey (1956:328-329) in treating *Lepisosteus osseus* (Linnaeus), *Catostomus commersonii* (Lacépède), *Semotilus atromaculatus* (Mitchill), *Notropis lutrensis* (Baird and Girard), *Pimephales promelas* Rafinesque, *Ictalurus melas* (Rafinesque), *Ictalurus punctatus* (Rafinesque), and *Lepomis macrochirus* Rafinesque, in binomial form only.

Scaphirhynchus platyrhynchus (Rafinesque), shovelnose sturgeon:

Jennings (1942:364) as *Scaphirhynchus platorhynchus* (Rafinesque); Bailey and Cross (1954:191). Stations 3-S and 4-S.

Shovelnose sturgeon were found only in the lower portion of the Big Blue River. On April 20, 1957, many were seen in fishermen's creels at Stations 3-S and 4-S. One male and two females that I examined on that date were ripe or nearly so; eggs seemed well developed and milt flowed freely from the male. After April, 1957, none was collected or observed until April 26, 1958, when one specimen was obtained while shocking. Forbes and Richardson (1920:27) reported that shovelnose sturgeon spawn in Illinois between April and June, and Eddy and Surber (1947:80) reported spawning in May and early June in Wisconsin and Minnesota.

Lepisosteus platostomus Rafinesque, shortnose gar: Jennings (1942:364). Stations 3-S and 4-S.

I saw shortnose gar at various times in 1956 and 1957 at Rocky Ford Dam on the Big Blue River (Station 4-S). One was seen while shocking at Station 3-S on December 26, 1957.

Lepisosteus osseus (Linnaeus), longnose gar: Jennings (1942:364) as *Lepisosteus osseus oxyurus* Rafinesque. Stations 1-S, 2-S, 3-S, 4-S, 6-S, 8-S, 9-G, 15-S, 18-G, 25-S, 41-S, 44-S, 52-S, and 53-S.

Longnose gar were abundant in the mainstream of the Big Blue River but usually evaded capture. This species, and the shortnose gar, resided in the larger rivers, with *L. osseus* being taken in only two creeks near their mouths. In periods of high water, gar moved into the flooded creeks, but returned to the river as stream-levels subsided.

Young-of-the-year *L. osseus*, averaging 21.5 mm. in total length (range 13 to 30 mm.), were taken on June 14, 1957, and larger young (estimated 60 to 70 mm. total length) were taken on June 27, 1958.

Dorosoma cepedianum (LeSueur), gizzard shad: Jennings (1942:364). Stations 1-S, 3-S, 4-S, 6-S, 8-S, 44-S, 45-M, and 53-S.

Most gizzard shad were young-of-the-year, taken on July 16 and 17, 1957, at Stations 3-S and 4-S. Twenty specimens from Station 6-S that were in their second summer of life were from 3.8 to 5.9 inches total length at the last annulus (average 4.3). This species was usually found in quiet water and was most abundant near the mouth of the Big Blue River.

Hiodon alosoides (Rafinesque), goldeye. Stations 3-S, 4-S, and 53-S.

I caught five specimens of *H. alosoides* from the Big Blue River,

and another specimen, obtained by Dr. R. B. Moorman in 1954, is at Kansas State College (KSC 4984).

One goldeye that I caught on April 20, 1956, prior to the beginning of my study, was a ripe female measuring 15.5 inches total length. The fish was beginning its seventh summer of life.

Cypleptus elongatus LeSueur, blue sucker. The blue sucker is included on the basis of a single specimen (KSC 2917) collected by I. D. Graham and labeled "Blue River." No other data are with the specimen; however, most fishes deposited at Kansas State College by Graham are dated "1885" or "1886" and were caught near "Manhattan" (Riley County).

Ictiobus cyprinella (Valenciennes), bigmouth buffalo. Stations 3-S, 6-S, and 30-M.

Bigmouth buffalo were rare, and were taken only in quiet parts of larger streams, and in the borrow-pit at Station 6-S.

Ictiobus niger (Rafinesque), black buffalo. Stations 3-S, 41-S, and 53-S.

Only four individuals of *I. niger* were taken. All were large adults (more than 20 inches in total length), and all were shocked in the deeper, swifter areas, where the channel narrowed.

Ictiobus bubalus (Rafinesque), smallmouth buffalo. Stations 1-S, 3-S, 6-S, 7-G, 18-G, 38-S, 41-S, 43-S, 46-M, and 53-S.

This species was found in relatively quiet waters in the main channel, in cut-off areas, and in creek-mouths. The ages and total lengths of 30 individuals obtained at Station 6-S were (average followed by number of fish in parentheses): I, 2.4 (11); II, 4.4 (14); and III, 6.6 (5).

Canfield and Wiebe (1931:6-7, 10) recorded "buffalo-fish" and "buffalo" from the Big Blue Basin in Nebraska; however, no specific designation was given.

Carpiodes forbesi Hubbs, plains carpsucker. Station 3-S.

This represents the first record known to me of the plains carpsucker from Kansas. The specimen (KU 4180), 430 mm. in standard length, has the following characters: lower lip without a median, nipple-like projection; dorsal fin-rays, 25; lateral-line scales, 38; diameter of orbit into distance from anterior nostril to tip of snout, 1.1; body-depth into standard length, 3.3; and head-length into standard length, 3.9. The specimen was taken while shocking a wide, shallow channel, over sand bottom.

Carpiodes carpio carpio (Rafinesque), river carpsucker: Jennings (1942:364). Stations 1-S, 2-S, 3-S, 4-S, 5-G, 6-S, 7-G, 8-S,

9-G, 11-G, 14-S, 15-S, 18-G, 19-G, 23-G, 25-S, 27-G, 28-G, 30-M, 38-S, 39-S, 41-S, 42-S, 43-S, 44-S, 45-M, 50-S, 52-S, and 53-S.

The river carpsucker occurred at most stations on the larger streams, and in many of the smaller tributaries. In smaller streams *C. c. carpio* frequented the largest pools, in or near the floodplains of larger streams. A marked preference for still water, soft, silty bottoms, and areas with drift or other cover was apparent; however, the species also occurred in open waters with moderate to swift currents.

The sizes attained by the river carpsucker at different ages were (averages followed by number of fish in parentheses): I, 1.9 (10); II, 3.9 (5); III, 5.3 (8); IV, 7.7 (5); V, 11.9 (2); VI, 11.6 (7); VII, 12.8 (6); VIII, 13.1 (1); IX, 14.9 (2); X, 15.8 (8); and XI, 17.6 (1). These averages are significantly less than those reported by Buchholz (1957:594) for the river carpsucker in the Des Moines River, Iowa.

Examination of the gonads of river carpsucker in summer, 1957, indicated that spawning occurred in late July. Young-of-the-year, averaging 21 mm. in total length, first appeared in my collections on July 30, 1957.

Carpiodes velifer (Rafinesque), highfin carpsucker: Meek (1895:135); Evermann and Cox (1896:389).

The highfin carpsucker was not taken in my survey. Meek (1895:135) reported "this small sucker [*C. velifer*] . . . common in Blue River at Crete," characterizing the specimens as having "Dorsal rays, 24 to 30; scales in the lateral-line, 36 to 41; head $3\frac{1}{2}$ to 4; and depth $2\frac{1}{2}$ to 3." The ranges in the number of dorsal rays and the number of scales in the lateral-line are higher than usual in *C. velifer*, or in *C. c. carpio*, which is now common in the Big Blue River Basin. Both species normally have 33 to 37 lateral-line scales and 27 or fewer dorsal rays (Bailey, 1956:352-353; Moore, 1957:79; and Trautman, 1957:81-82). The other characters listed by Meek would fit the young and some adults of either species, or possibly a composite including *C. forbesi*.

Graham (1885:72) and Cragin (1885:107) reported *Ictiobus velifer* (= *Carpiodes velifer*) from "Eureka Lake," Riley County, Kansas. This lake, which no longer exists, was in the Kansas River Valley, about ten miles upstream from the mouth of the Big Blue River. Other, more recent records from the Kansas River Basin, in the vicinity of the Big Blue River, are: Maple Leaf Lake, Riley

Co., Oct. 4, 1925; Deep Creek, Riley Co., no date; Wildcat Creek, Riley Co., Sept. 7, 1923; and Wildcat Creek, Riley Co., Sept. 29, 1925 (UMMZ 122187-90). Most of the collections were made by Minna E. Jewell (Nelson, personal communication).

Moxostoma aureolum (LeSueur), northern redhorse: Cragin (1885:108) as *Moxostoma macrolepidotum* LeSueur; Meek (1895:136) as *Moxostoma macrolepidotum duquesnei* (LeSueur); Evermann and Cox (1896:394-395); and Jennings (1942:364) as *Moxostoma erythrurum* (Rafinesque). Stations 41-S, 43-S, 44-S, and 53-S.

I collected three northern redhorse from the Big Blue River Basin, and another specimen was seined in the mouth of Mill Creek, Riley County (my present Station 9-G) by the Kansas State College class in fisheries management in 1954 (KSC 5068). I reidentify as *M. aureolum* the two specimens recorded by Jennings (*loc. cit.*) as *M. erythrurum*.

The subspecific status of *M. aureolum* in the Kansas River Basin is to be the subject of another paper.

Catostomus commersonnii (Lacépède), white sucker: Canfield and Wiebe (1931:8) as "common suckers"; and Breukelman (1940:380). Stations 7-G, 11-G, 12-G, 13-G, 16-G, 18-G, 19-G, 23-G, 29-G, 31-G, 53-S, 57-M, and 58-G.

The white sucker occurred primarily in upland streams of the Flint Hills, with one occurrence in muddy habitat, and one in the main stream of the Big Blue River. Young *C. commersonnii* were often taken in riffles, but adults were in the larger, deeper pools. The ages and total lengths at the last annulus for 12 white suckers were: I, 2.8 (4); II, 3.9 (6); III, 8.2 (1); and IV, 9.2 (1).

Cyprinus carpio Linnaeus, carp: Canfield and Wiebe (1931:5-8, 10) as "carp." Stations 1-S, 2-S, 3-S, 4-S, 6-S, 7-G, 8-S, 15-S, 16-G, 18-G, 23-G, 24-G, 25-S, 27-G, 30-M, 35-M, 38-S, 41-S, 42-S, 43-S, 44-S, 45-M, 52-S, 53-S, and 56-S.

Carp occurred throughout the basin. The habitat of this species closely approximated that of the river carpsucker; however, carp were more often taken in moderate to swift water than were *C. c. carpio*.

The ages and average lengths at the last annulus for 40 carp from the Big Blue River Basin were: I, 2.3 (4); II, 4.7 (10); III, 7.0 (10); IV, 9.0 (3); V, 11.3 (4); VI, 18.6 (1); VII, 18.9 (3); VIII, no fish; IX, 20.6 (3); X, 19.1 (2); XI, 21.1 (1); XII, 22.0 (1); and XIII, 24.1 (2).

Carassius auratus (Linnaeus), goldfish. Station 4-S.

I saw goldfish seined from Station 4-S by anglers obtaining bait on April 20, 1957. Goldfish were commonly used for bait at Stations 4-S and 54-S.

Semotilus atromaculatus (Mitchill), creek chub: Evermann and Cox (1896:399); and Jennings (1942:364) as *Semotilus atromaculatus atromaculatus* (Mitchill). Stations 5-G, 7-G, 10-G, 11-G, 12-G, 13-G, 16-G, 17-G, 18-G, 23-G, 24-G, 27-G, 28-G, 29-G, 31-G, 32-G, 33-M, 34-M, 36-M, 37-M, 40-M, 46-M, 47-M, 48-M, 49-M, 50-S, 53-S, 54-G, 55-M, 56-S, 57-M, 58-G, and 59-G.

Creek chubs were found in all habitats in the Big Blue River Basin, but were abundant only in the headwaters of muddy streams and in clear upland creeks.

Chrosomus erythrogaster (Rafinesque), southern redbelly dace: Jennings (1942:365). Stations 11-G, 12-G, 13-G, 16-G, 27-G, 29-G, and 53-S.

This colorful species occupied the headwaters of the clear, spring-fed creeks where it was abundant. Only one specimen was taken in muddy or sandy habitat (at the mouth of a small creek at Station 53-S), where it may have been washed by floods just prior to my collecting.

Hybopsis storeriana (Kirtland), silver chub. Station 3-S.

One specimen of *H. storeriana* (KU 3810) was seined in swift water near a sandbar on April 6, 1957, and another was taken at the same locality on April 26, 1958.

Hybopsis aestivalis (Girard), speckled chub: Meek (1895:137); and Evermann and Cox (1896:409), both as *Hybopsis hyostomus* Gilbert. Stations 3-S, 4-S, 14-S, 25-S, 38-S, 39-S, 50-S, and 56-S.

This species was restricted to wide, swift parts of the Big Blue and Little Blue rivers, and was found over clean, sometimes shifting, sand bottoms. On May 29, 1958, three males in breeding condition were collected and on June 16, 1958, a large series of both male and female *H. aestivalis*, all with well-developed gonads, was collected. The water temperature was 77.0° F. Hubbs and Ortenburger (1929:25-26) reported that *Extrarius tetranemus* (Gilbert) (= *Hybopsis aestivalis tetranemus*) spawns in summer especially in early July. Cross (1950:135) reported a single pair of *H. a. tetranemus* that he considered in breeding condition on June 9, 1948.

Breukelman (1940:380) recorded speckled chubs in the Kansas River Basin as *Extrarius* (= *Hybopsis*) *aestivalis: sesquialis* × *tetranemus*; however, the name *sesquialis* is a *nomen nudum*, and

the status of this species in the Kansas River Basin is yet to be elucidated.

Phenacobius mirabilis (Girard), plains suckermouth minnow: Meek (1895:136): and Evermann and Cox (1896:408). Stations 2-S, 3-S, 4-S, 5-G, 6-S, 7-G, 8-S, 9-G, 11-G, 16-G, 18-G, 25-S, 26-G, 27-G, 35-M, 38-S, 39-S, 40-M, 42-S, 47-M, 50-S, 52-S, 53-S, 54-G, and 56-S.

Phenacobius mirabilis was widespread in the basin, occurring most frequently on riffles over bottoms of clean sand or gravel. Young-of-the-year were usually taken in backwaters.

Notropis percobromus (Cope), plains shiner. Stations 3-S and 4-S.

The plains shiner occurred only in the lower part of the main stream of the Big Blue River.

Notropis rubellus (Agassiz), rosyface shiner. Station 5-G.

One rosyface shiner (KU 4195) was taken. This species was previously reported from only two localities in the Kansas River Basin: in the Mill Creek Watershed, Wabaunsee County, and Blacksmith Creek, Shawnee County as *Notropis rubrifrons* (Cope) (Gilbert, 1886:208). Mill Creek and Blacksmith Creek are northward-flowing tributaries of the Kansas River that arise in the Flint Hills. Graham (1885:73) also recorded *N. rubellus* (as *N. rubrifrons*) from the "Kansas and Missouri Rivers"; however, I suspect that his specimens were *Notropis percobromus*, a species not generally recognized in Graham's time (see Hubbs, 1945:16-17). *Notropis rubellus* is now abundant in the Mill Creek Watershed (Wabaunsee County), but, except for my specimen No. 4195, has not been taken recently in other streams in the Kansas River Basin.

Notropis umbratilis umbratilis (Girard), redbfin shiner. Station 3-S.

One specimen of *N. u. umbratilis* was captured near a sandbar on March 26, 1958. The absence of this species in Flint Hills streams of the Big Blue River Basin is unexplained; redbfin shiners occur commonly in southern tributaries of the Kansas River both upstream and downstream from the mouth of the Big Blue River. In Kansas this species is usually associated with the larger pools of clear, upland streams.

Canfield and Wiebe (1931:6-8) may have referred to this species in recording "black-fin minnows" from the Nebraskan portion of the Big Blue River Basin.

Notropis cornutus frontalis (Agassiz), common shiner. Stations 4-S, 5-G, 7-G, 10-G, 11-G, 12-G, 13-G, 18-G, 22-G, 26-G, 27-G, 28-G, 29-G, 31-G, 32-G, and 59-G.

Common shiners were most abundant in middle sections of the clear, gravelly creeks.

Notropis lutrensis (Baird and Girard), red shiner: Meek (1895: 136); and Evermann and Cox (1896:404-405). All stations excepting 1-S, 17-G, 30-M, and 51-M.

Red shiners were the most widespread species taken in my survey, occurring in all habitats, and in all kinds of streams. On two occasions I observed what apparently was spawning behavior of this species. Both times the specimens collected were in the height of breeding condition, stripping in the hand easily, and often without pressure. At the first locality (Station 29-G) no attempt was made to obtain eggs, but by disturbing the bottom at the second (55-M) I found eggs that were thought to be those of red shiners. The eggs were slightly adhesive, clinging to the hand and to the bobbinet seine.

On June 29, 1958, at Station 29-G, red shiners appeared to be spawning in an open-water area measuring about 15 by 15 feet, over nests of *Lepomis cyanellus* Rafinesque and *L. humilis* (Girard). No interspecific activity was noted between the sunfish and the red shiners. Water temperature at this station was 73.4° F., and the bottom was gravel, sand, and mud. Observations were made from a high cut-bank, by naked eye and by use of 7-X binoculars.

The red shiners moved rapidly at the surface of the water, with one male (rarely two or more) following one female. The male followed closely, passing the female and causing her to change direction. At the moment of the female's hesitation, prior to her turn, the male would erect his fins in display, at the side and a little in front of the female. After brief display, usually less than two seconds, the male resumed the chase, swimming behind and around the female in a spiral fashion. After a chase of two to three feet, the female would sometimes allow the male to approach closely on her left side. The male nudged the female on the caudal peduncle and in the anal region, moving alongside with his head near the lower edge of the left operculum of the female, thus placing his genital pore about a head-length behind and below that of the female. At this time spawning must have occurred; however, possibly because of the speed of the chase, I observed no vibration of the fish as described for other species of *Notropis* at the culmina-

tion of spawning (Pfeiffer, 1955:98; Raney, 1947:106; and others). While the spawning act presumably occurred the pair was in forward motion in a straight course, for three to five feet, at the end of which the male moved rapidly away, gyrating to the side and down. The female then swam away at a slower rate. In instances when the female failed to allow the male to move alongside, the male sometimes increased his speed, striking the female, and often causing her to jump from the water.

Some conflict between males was observed, usually when two or more followed one female. The males would leave the female, swerve to one side, and stop, facing each other or side by side. At this moment the fins were greatly elevated in display. There was usually a rush on the part of one male, resulting in the flight of the other, and the aggressive male would pursue for about two feet. Many times the pursued male jumped from the water.

At Station 55-M, on July 9, 1958, activity similar to that described above was observed in a small pool near a mass of debris. At this station I watched from the bank, three feet from the spawning shiners. Water temperature was not recorded.

The minnows performed the same types of chase and display, all in open water, as described for Station 29-G. However, at Station 55-M, much activity of males occurred near the small deposit of debris. It seemed that conflict was taking place, with males behaving as described above, and milling violently about. Examination of the area revealed nests of *L. cyanellus* near the debris, and some of the activity by the shiners may have been raids on nests of the sunfish. However, females nearing the group of males were immediately chased by one to four individual males, with one usually continuing pursuit after a short chase by the group. The male again moved into position at the lower left edge of the operculum of the female as at Station 29-G.

Another kind of behavior was observed also, in which the female sometimes stopped. The male approached, erecting his fins and arching his body to the left. The female also assumed this arch to the left, and the pair moved in a tight, counter-clockwise circle, with the male on the inside. After a short period in this position, the male moved aside in display, and gyrated to the side and down. Females at both stations moved about slowly, usually remaining in the immediate vicinity of activity by males, and returning to the area even when pursued and deserted some distance away.

Notropis deliciosus (Girard), sand shiner: Meek (1895:136); Evermann and Cox (1896:402), both as *Notropis blennius* (Girard); and Jennings (1942:365) as *Notropis deliciosus missuriensis* (Cope). All stations excepting 1-S, 10-G, 12-G, 17-G, 20-G, 21-G, 22-G, 24-G, 29-G, 30-M, 31-G, 32-G, 33-M, 35-M, 51-M, 55-M, 57-M, 58-G, and 59-G.

Nelson (personal communication) has studied the sand shiner in Kansas, and has found that the Big Blue River is an area of intergradation between the southwestern subspecies (*deliciosus*) and the plains subspecies (*missuriensis*). *Notropis d. deliciosus* prefers cool, rocky habitat, and occurs in small streams of the Flint Hills, whereas *N. d. missuriensis* occupies the sandy, turbid Big Blue and Little Blue rivers. Intergrades occur most frequently in the Big Blue River, but are found in all habitats.

Notropis topeka (Gilbert), Topeka shiner: Meek (1895:136); Evermann and Cox (1896:403); and Minckley and Cross (in press). Stations 10-G, 11-G, 12-G, 19-G, 31-G, and 32-G.

This species was common locally in the upland streams. Female Topeka shiners stripped easily at Station 11-G on July 8, 1958, and adult *N. topeka* in high breeding condition were collected at Station 31-G on July 14, 1958. The water temperature at both stations was 77.5° F. Evermann and Cox (1896:403-404) recorded female Topeka shiners "nearly ripe" on June 29, 1893.

Notropis buchanani Meek, ghost shiner. Stations 3-S and 4-S. Only two specimens of *N. buchanani* were taken, both on August 14, 1957. These specimens (KU 3833), a female with well-developed ova, and a tuberculate male, were near a sandbar in the main channel. To my knowledge, this is the first published record of the ghost shiner from the Kansas River Basin. Mr. James Booth, State Biological Survey, collected *N. buchanani* from two stations on Mill Creek, Wabaunsee County, Kansas, 1953.

Hybognathus nuchalis Agassiz, silvery minnow. Stations 2-S, 3-S, 4-S, 7-G, 8-S, and 16-G.

This species was taken sporadically, but sometimes abundantly, in the Big Blue River. At Stations 7-G and 16-G a few young-of-the-year were found.

Bailey (1956:333) does not consider the southwestern *Hybognathus placita* (Girard) specifically distinct from the northeastern *H. nuchalis*, but little evidence of intergradation has been published. In Table 2, I have compared measurements and counts

TABLE 2. COMPARISONS OF THREE SERIES OF *Hybognathus*, 50 SPECIMENS EACH, FROM DIFFERENT STREAM SYSTEMS. SYMBOLS: \bar{X} = MEAN; σ = ONE STANDARD DEVIATION; AND $2\sigma_m$ = TWO STANDARD DEVIATIONS. RANGES ARE IN PARENTHESES. STANDARD LENGTHS OF SPECIMENS ARE: WALNUT RIVER, KANSAS, 60.0 TO 72.7 MM., \bar{X} = 67.1; BIG BLUE RIVER, 43.3 TO 63.3 MM., \bar{X} = 52.0; AND CHIPPEWA RIVER, WISCONSIN, 57.6 TO 74.4 MM., \bar{X} = 65.9.

COUNT OR PROPORTIONAL MEASUREMENT	Walnut River, Kansas <i>H. n. placita</i> , KU 3869			Big Blue River, Kansas KU 3812			Chippewa River, Wisconsin <i>H. n. nuchalis</i> , KU 2012		
	\bar{X}	σ	$2\sigma_m$	\bar{X}	σ	$2\sigma_m$	\bar{X}	σ	$2\sigma_m$
Lateral-line scales.....	38.9 (37-41)	1.1	0.4	37.2 (35-39)	1.1	0.4	37.3 (35-39)	1.0	0.2
Predorsal scale-rows.....	16.8 (15-19)	0.9	0.7	15.9 (14-17)	0.8	0.2	15.1 (14-17)	0.5	0.1
Scale-rows below lateral-line.....	15.6 (13-18)	1.2	0.3	14.9 (12-16)	1.0	0.3	12.9 (12-15)	0.7	0.2
Scale-rows around caudal peduncle.....	16.2 (15-19)	1.1	0.3	15.8 (14-18)	0.8	0.2	13.8 (12-15)	0.6	0.2

TABLE 2.—Concluded.

COUNT OR PROPORTIONAL MEASUREMENT	Walnut River, Kansas <i>H. n. placita</i> , KU 3869		Big Blue River, Kansas KU 3812		Chippewa River, Wisconsin <i>H. n. nuchalis</i> , KU 2012	
	\bar{X}	σ	$2 \sigma_m$	\bar{X}	σ	$2 \sigma_m$
Orbit ÷ standard length.....	.051 (044-61)	.0035	.0010	.059 (047-71)	.0047	.0013
Gape-width ÷ standard length....	.066 (055-75)	.0046	.0013	.064 (055-74)	.0044	.0013
Orbit ÷ gape-width.....	.776 (647-945)	.0083	.0024	.907 (712-1.067)	.0080	.0023
				.068 (059-77)	.0044	.0013
				.056 (046-64)	.0038	.0011
				1.223 (953-1.566)	.0119	.0034

of 50 specimens of *Hybognathus* from the Big Blue River, 50 *H. n. placita* from the Walnut River, Kansas (Arkansas River Basin), and 50 *H. n. nuchalis* from Wisconsin. Measurements and counts were made by methods described by Hubbs and Lagler (1947:8-15) and measurements are expressed as thousandths of standard length.

Hybognathus from the Big Blue River tend to have fewer, larger scales than *H. n. placita* from the Walnut River, Kansas, but more and smaller scales than *H. n. nuchalis* from Wisconsin. In specimens from the Blue River, the size of the orbit divided by standard length, and the width of gape divided by standard length and width of orbit, are also intermediate between the Walnut River and Wisconsin specimens, but tend toward the former. Specimens from the Big Blue River resemble *H. n. placita* from the Walnut River in body shape, robustness, and in the embedding of scales on the nape.

Pimephales notatus (Rafinesque), bluntnose minnow: Meek (1895:136); and Evermann and Cox (1896:399). Stations 2-S, 3-S, 5-G, 6-S, 8-S, 9-G, 10-G, 11-G, 12-G, 13-G, 16-G, 19-G, 27-G, 29-G, 53-S, 54-G, and 58-G.

The bluntnose minnow preferred the clearer creeks, with gravel or gravel-silt bottoms, but occurred rarely in the mainstream of the Big Blue River. Males and females in high breeding condition were taken on July 14, 1958. The temperature of the water was 75.5° F.

Pimephales promelas Rafinesque, fathead minnow: Meek (1895:136); and Evermann and Cox (1896:397-398). All stations excepting 1-S, 4-S, 12-G, 30-M, 43-S, 44-S, and 56-S.

Small muddy streams were preferred by *P. promelas*; however, the fathead minnow was taken in all habitats, and in association with most other species.

Canfield and Wiebe (1931:6-7) may have recorded *P. promelas* from the Big Blue River Basin, Nebraska, as "blackhead minnows."

Camptostoma anomalum plumbeum (Girard), stoneroller. All stations excepting 1-S, 2-S, 3-S, 14-S, 15-S, 21-G, 22-G, 28-G, 30-M, 33-M, 34-M, 35-M, 36-M, 37-M, 38-S, 41-S, 44-S, 45-M, 51-M, 52-S, and 55-M.

Stonerollers were usually taken in riffles with gravel-rubble bottoms. Those individuals collected in areas with mud or sand bottoms were almost invariably in the current, or in the edge of currents.

Specimens from the Big Blue River Basin have an average of 47.4 scale-rows around the body (range 42-54).

Ictalurus melas (Rafinesque), black bullhead: Evermann and Cox (1896:387) as *Ameiurus melas* (Rafinesque); and Canfield and Wiebe (1931:5-7, 10) as "bullheads." Stations 2-S, 6-S, 7-G, 11-G, 16-G, 20-G, 22-G, 23-G, 24-G, 28-G, 35-M, 40-M, 51-M, 53-S, 55-M, 56-S, 57-M, and 58-G.

Black bullhead occurred in all habitats, but were less commonly taken in the Big Blue and Little Blue rivers than in other streams.

Ictalurus natalis (LeSueur), yellow bullhead. Stations 7-G, 9-G, 10-G, 11-G, 17-G, 18-G, 19-G, 34-M, 35-M, 36-M, 37-M, 40-M, 47-M, 48-M, 53-S, and 55-M.

The yellow bullhead inhabited the muddy-bottomed streams and the upland, gravelly creeks, usually occurring in the headwaters. I obtained only one *I. natalis* in the sandy Big Blue River.

Ictalurus punctatus (Rafinesque), channel catfish: Cragin (1885:107); Meek (1895:135); Evermann and Cox (1896:386); and Canfield and Wiebe (1931:6-7, 10) as "channel catfish." Stations 1-S, 2-S, 3-S, 4-S, 5-G, 6-S, 7-G, 8-S, 9-G, 11-G, 14-S, 15-S, 16-G, 18-G, 25-S, 27-G, 30-M, 35-M, 38-S, 39-S, 41-S, 42-S, 43-S, 44-S, 46-M, 50-S, 51-M, 52-S, 53-S, and 56-S.

Channel catfish were most common in the larger, sandy streams, but occurred in other kinds of streams. The ages and calculated total lengths at the last annulus for 40 channel catfish were: I, no fish; II, 7.3 (16); III, 10.6 (5); IV, 12.3 (5); V, 13.3 (6); VI, 15.5 (4); VII, 18.0 (3); and VIII, 21.9 (1). These lengths are slightly lower than averages reported by Finnell and Jenkins (1954:5) in Oklahoma impoundments.

The length-frequency distribution of 438 channel catfish, collected by rotenone on August 5 and 7, 1958, indicated that two age-groups were represented. Without examination of spines, I assigned 265 fish to age-group O (1.3 to 2.9 inches, average 2.5) and 173 fish to age-group I (3.1 to 5.8 inches, average 4.5). The average total length of age group I (4.5 inches) is only slightly higher than the total length at the first annulus reported as average for Oklahoma (4.0 inches, Finnell and Jenkins, *loc. cit.*). It seems unlikely that my yearling fish taken in August, 1958, would have reached the length at the second annulus recorded in my study of spines (7.3 inches) by the end of the 1958 growing season.

From 1952 to 1956, severe drought was prevalent in Kansas, probably causing streams to flow less than at any previously recorded time (Minckley and Cross, in press). This drought must have resulted in reduced populations of fishes in the streams. The channel catfish hatched in 1956 were therefore subjected to low

competition for food and space when normal flow was resumed in 1957, and grew rapidly, reaching an average total length of 7.3 inches at the second annulus, while channel catfish that were members of the large 1957 and 1958 hatches suffered more competition and grew more slowly.

Noturus flavus Rafinesque, stonecat: Jennings (1942:365). Stations 3-S, 4-S, 6-S, 16-G, 25-S, 28-G, 38-S, 41-S, 42-S, 43-S, 52-S, 53-S, and 56-S.

Noturus flavus frequented riffles and swift currents along sandbars in the Big Blue and Little Blue rivers. Cross (1954:311) reported that "the shale-strewn riffles of the South Fork [of the Cottonwood River, Kansas] provide ideal habitat for the stonecat." In my study-area, this species was found not only on rubble-bottomed riffles, but occurred along both stationary and shifting sandbars where no cover was apparent.

Pylodictis olivaris (Rafinesque), flathead catfish: Canfield and Wiebe (1931:7) as "yellow catfish." Stations 3-S, 4-S, 6-S, 8-S, 15-S, 25-S, 38-S, 41-S, 43-S, 44-S, 53-S, and 56-S.

Flathead catfish were found only in the larger rivers. The species was taken rarely by seine, but was readily obtained by electric shocker. Data on the age and growth and food-habits of this species are to be the subject of another paper.

Anguilla bostoniensis (LeSueur), American eel: Jennings (1942:365).

American eels are now rare in Kansas, and none was taken in my survey. The specimen reported by Jennings (*loc. cit.*) is at Kansas State College (KSC 2916), and was taken by I. D. Graham from the Big Blue River, Riley County, 1885.

Fundulus kansae Garman, plains killifish. Station 42-S.

The plains killifish was collected by me only at Station 42-S. Specimens were collected from my Station 4-S by the Kansas State College class in fisheries management in 1954 (KSC 4985). My specimens were 11 to 13 mm. in total length.

Roccus chrysops (Rafinesque), white bass. Station 3-S.

That the white bass is indigenous to Kansas is evidenced by records of Graham (1885:77) and Cragin (1885:111); however, since that time, and prior to the introduction of this species into reservoirs in the State, *R. chrysops* has rarely been recorded in Kansas. I collected young white bass at Station 3-S in both 1957 and 1958, and I collected them also in an oxbow of the Kansas River four miles west of Manhattan, Riley County, Kansas, in the mouth

of McDowell's Creek, Riley County, and in Deep Creek, Wabunsee County, and I saw other specimens from an oxbow of the Kansas River on the Fort Riley Military Reservation, Riley County, Kansas. The apparent increase in abundance of white bass in the Kansas River Basin must be attributable to introductions in reservoirs, with subsequent escape and establishment in the streams.

Micropterus salmoides salmoides (Lacépède), largemouth bass. Stations 6-S, 11-G, 43-S, and 45-M.

Four largemouth bass were taken. This species has been widely stocked in farm-ponds and other impoundments in Kansas.

Lepomis cyanellus Rafinesque, green sunfish: Breukelman (1940:382); and Canfield and Wiebe (1931:5, 7-8, 10) as "green sunfish." All stations excepting 1-S, 2-S, 4-S, 8-S, 9-G, 15-S, 22-G, 25-S, 30-M, 32-G, 34-M, 38-S, 39-S, 41-S, 42-S, 43-S, 44-S, 45-M, 46-M, 47-M, 50-S, and 52-S.

Green sunfish occurred primarily in the muddy streams. The ages and total lengths at the last annulus for 25 specimens are as follows: I, 1.1 (9); II, 2.2 (4); III, 3.1 (7); IV, 5.4 (4); and V, 6.0 (1). Male green sunfish were seen on nests on June 29, July 1, and July 9, 1958.

Lepomis humilis (Girard), orangespotted sunfish: Meek (1895:137); Evermann and Cox (1896:418); Canfield and Wiebe (1931:6) as "orange spots"; and Breukelman (1940:382). All stations excepting 1-S, 9-G, 13-G, 15-G, 17-G, 21-G, 26-G, 34-M, 36-M, 38-M, 43-M, 44-S, 47-M, 50-S, and 52-S.

Lepomis humilis was most common over sand-silt bottoms. Only two age-groups were found; their calculated total lengths were I, 1.7 (15); and II, 2.4 (10). Orangespotted sunfish were seen nesting on the same dates as *Lepomis cyanellus*.

Lepomis macrochirus Rafinesque, bluegill. Stations 7-G, 13-G, 16-G, 24-G, and 59-G.

This species has been widely stocked in Kansas. Only young-of-the-year and sub-adults were taken, and these were rare.

Pomoxis annularis Rafinesque, white crappie: Canfield and Wiebe (1931:5-8, 10) as "white crappie." Stations 3-S, 6-S, 8-S, 12-G, 42-S, and 53-S.

White crappie were rare, except in a borrow-pit at Station 6-S. Ages and calculated total lengths at the last annulus for 50 specimens from 6-S are as follows: I, 3.6 (22); II, 5.0 (14); III, 7.1 (5); IV, 8.3 (7); and V, 10.7 (2).

Pomoxis nigromaculatus (LeSueur), black crappie. Station 6-S.

One black crappie (KU 4174) was taken. Canfield and Wiebe (1931:10) noted: "The Black Crappie has been planted here [Big Blue River Basin in Nebraska] by the State, but, apparently, is not propagating itself."

Stizostedion canadense (Smith), sauger. Station 56-S.

Mr. Larry Stallbaumer, of Marysville, Kansas, obtained a sauger (KU 4179) while angling on May 25, 1958.

Stizostedion vitreum (Mitchill), walleye.

Though I failed to obtain the walleye in my survey, Dr. Raymond E. Johnson (personal communication) reported that the species occurred in the Nebraskan portion of the Big Blue River in recent years. Canfield and Wiebe (1931:6, 10) reported that "yellow pike are taken at Crete [Nebraska]," but may have referred to either the walleye or the sauger.

Perca flavescens (Mitchill), yellow perch: Canfield and Wiebe (1931:5-6, 10) as "ring perch" and "yellow perch."

This fish was not taken in my survey. Canfield and Wiebe (*loc. cit.*) reported that the yellow perch "had been planted by the State [Nebraska]."

Etheostoma nigrum nigrum Rafinesque, johnny darter: Jennings (1942:365) as *Boleosoma nigrum nigrum* (Rafinesque). Stations 10-G, 11-G, 12-G, 13-G, 16-G, 29-G, 40-M, 53-S, and 54-G.

The larger pools of gravelly streams were preferred by johnny darters, but one specimen was taken from the main stream of the Big Blue River, and the species was abundant in one stream over hard, sand-silt bottom.

Etheostoma spectabile pulchellum (Girard), orangethroat darter: Jennings (1942:365) as *Poecilichthys spectabilis pulchellus* (Girard). Stations 5-G, 7-G, 10-G, 11-G, 12-G, 13-G, 16-G, 17-G, 18-G, 21-G, 23-G, 27-G, 28-G, 29-G, 33-M, 40-M, 49-M, 53-S, 54-G, and 59-G.

The orangethroat darter was less restricted in habitat than the johnny darter, occurring in all stream-types, but most often in the riffles of gravelly streams. Most specimens from muddy or sandy streams were small.

Aplodinotus grunniens Rafinesque, freshwater drum. Stations 3-S, 4-S, 6-S, 7-G, 8-S, 15-S, 38-S, 39-S, 53-S, and 56-S.

The ages and calculated total lengths at the last annulus for 42 freshwater drum from the Big Blue River were: I, 3.0 (10); II, 5.7 (6); III, 9.4 (7); IV, 12.1 (13); V, 14.0 (3); VI, 15.1 (2); and VII, 16.3 (1).

HYBRID COMBINATIONS

I obtained two hybrid fishes in my study-area. One specimen of *Notropis cornutus frontalis* \times *Chrosomus erythrogaster* was taken at Station 29-G. This combination was recorded by Trautman (1957:114) in Ohio. The other hybrid was *Lepomis cyanellus* \times *Lepomis humilis*, captured at Station 24-G. This combination was first recorded by Hubbs and Ortenburger (1929:42).

Hubbs and Bailey (1952:144) recorded another hybrid combination from my area of study: *Campostoma anomalum plumbeum* \times *Chrosomus erythrogaster*, UMMZ 103132, from a "spring-fed creek on 'Doc' Wagner's farm, Riley County, Kansas; September 21, 1927; L. O. Nolf [collector]."

RELATIVE ABUNDANCE AND DISCUSSION OF SPECIES

The relative abundance of different species was estimated by combining counts of individual fishes taken in 290 seine-hauls, 26 hours and 15 minutes of shocking, and seven samples obtained with rotenone. At some stations all seine-hauls were counted. At other stations the seine-hauls in which complete counts were recorded had been selected randomly in advance; that is to say, prior to collecting at each station. I selected those hauls to be counted from a table of random numbers (Snedecor, 1956:10-13). I did not use the frequency-of-occurrence method as proposed by Starrett (1950:114), in which the species taken and not the total number of individuals are recorded for all seine-hauls. However, the frequency of occurrence of each species is indicated by the number of stations at which it was found, and those stations are listed in the previous accounts. Table 3 shows the percentage of the total number of fish that each species comprised in three kinds of streams: sandy (Big Blue and Little Blue rivers), muddy, and gravelly streams.

The habitat preferences of some species affect their abundance in different stream-types. *Notropis lutrensis* and *P. mirabilis* seemed almost ubiquitous. *Notropis deliciosus* also occurred in all kinds of streams (rarely in muddy streams); however, this species was represented by the sand-loving *N. d. missuriensis* in the Big Blue and Little Blue rivers, and *N. d. deliciosus* in the clear, gravelly, upland creeks (Nelson, personal communication). Because of its widespread occurrence, and for purposes of later discussion, I refer to this minnow also as an ubiquitous species in the Big Blue River Basin.

Carpiodes carpio, *Cyprinus carpio*, *I. punctatus*, *I. melas*, and *L.*

TABLE 3. RELATIVE ABUNDANCE OF FISHES IN PER CENT OF THE TOTAL NUMBER TAKEN, BIG BLUE RIVER BASIN, KANSAS. TRACE (Tr.) IS USED FOR VALUES LESS THAN .05 PER CENT, AND DASHES SIGNIFY THAT THE SPECIES DID NOT OCCUR IN THE COUNTED COLLECTIONS ALTHOUGH IT MAY HAVE OCCURRED IN UNCOUNTED COLLECTIONS FROM THE SAME STREAM-TYPE. THREE SPECIES, *C. auratus*, *N. buchmanii*, AND *S. canadense*, WERE NOT TAKEN IN COUNTED COLLECTIONS.

SPECIES	Sandy streams		Muddy streams	Gravelly streams
	Big Blue River	Little Blue River		
<i>N. lutrensis</i>	43.5	55.9	27.6	56.0
<i>I. punctatus</i>	14.0	7.0	1.2	4.2
<i>Carpiodes carpio</i>	11.9	2.0	5.0	0.5
<i>N. deliciosus</i>	8.2	28.2	3.1	11.1
<i>I. melas</i>	2.5	—	1.3	0.5
<i>Cyprinus carpio</i>	2.3	1.9	2.7	0.2
<i>P. olivaris</i>	1.8	0.8	—	—
<i>L. humilis</i>	1.7	—	9.0	5.1
<i>I. bubalus</i>	1.4	0.1	—	Tr.
<i>P. mirabilis</i>	1.3	0.7	0.3	1.3
<i>H. nuchalis</i>	1.2	—	—	Tr.
<i>P. promelas</i>	0.8	1.0	28.7	4.0
<i>H. aestivatis</i>	0.7	0.2	—	—
<i>A. grunniens</i>	0.5	—	—	0.2
<i>L. osseus</i>	0.5	1.0	—	—
<i>C. anomalum</i>	0.4	0.2	2.7	4.6
<i>C. commersonii</i>	0.4	—	—	0.7
<i>D. cepedianum</i>	0.4	Tr.	0.1	—
<i>N. percobromus</i>	0.3	—	—	—
<i>P. annularis</i>	0.3	Tr.	—	—
<i>N. flavus</i>	0.2	0.4	—	Tr.
<i>S. atromaculatus</i>	0.2	0.1	12.2	1.7
<i>M. aurcolum</i>	0.1	0.2	—	—
<i>I. cyprinella</i>	0.1	—	0.1	—
<i>P. notatus</i>	0.1	—	—	2.2
<i>I. niger</i>	0.1	0.1	—	—
<i>H. alosoides</i>	0.1	—	—	—
<i>E. spectabile</i>	0.1	—	1.4	1.6
<i>R. chrysops</i>	0.1	—	—	—
<i>L. cyanellus</i>	0.1	—	3.5	Tr.
<i>H. storeriana</i>	Tr.	—	—	—
<i>L. platostomus</i>	Tr.	—	—	—
<i>M. salmoides</i>	Tr.	—	—	—
<i>P. nigromaculatus</i>	Tr.	—	—	—
<i>I. natalis</i>	Tr.	—	1.0	Tr.
<i>N. umbratilis</i>	Tr.	—	—	—
<i>C. forbesi</i>	Tr.	—	—	—
<i>S. platyrhynchus</i>	Tr.	—	—	—
<i>F. kansae</i>	—	Tr.	—	—
<i>E. nigrum</i>	Tr.	—	0.1	0.2
<i>N. rubellus</i>	—	—	—	Tr.
<i>N. topeka</i>	—	—	—	1.0
<i>N. cornutus</i>	—	—	—	1.0
<i>C. erythrogaster</i>	—	—	—	1.0
<i>L. macrochirus</i>	—	—	—	1.0

humilis were widespread, but each was absent or rare in one of the kinds of streams (Table 3). *Carpiodes carpio*, *Cyprinus carpio*, and *I. punctatus* occurred most frequently in the sandy streams, whereas *L. humilis* was most common in muddy streams. The high per cent of *I. melas* in collections from the Big Blue River is a direct result of one large population that was taken with rotenone in a borrow-pit at Station 6-S. In my opinion, this species actually was most abundant in the muddy streams.

Some fish were almost restricted to the sandy streams, apparently because of preference for larger waters, or sandy stream-bottoms: *P. olivaris*, *I. bubalus*, *H. nuchalis*, *H. aestivalis*, *A. grunniens*, *L. osseus*, *D. cepedianum*, *N. percobromus*, *P. annularis*, *N. flavus*, *M. aureolum*, *I. niger*, *H. alosiodes*, and *R. chrysops*. Other species that were taken only in the larger rivers, and that are sometimes associated with streams even larger (or more sandy) than the Big Blue River are *H. storeriana*, *L. platostomus*, *M. salmoides*, *P. nigromaculatus*, *C. forbesi*, *S. platyrhynchus*, *F. kansae*, *N. buchmanii*, *S. canadense*, and *C. auratus*. *Ictiobus cyprinella* also occurred more frequently in the larger streams.

The muddy-bottomed streams supported populations composed primarily of *P. promelas*, *N. lutrensis*, and *S. atromaculatus*. No species was restricted to this habitat, but the following were characteristic there: *P. promelas*, *S. atromaculatus*, *L. humilis*, *L. cyanellus*, and *I. natalis*. *Carpiodes carpio*, *Cyprinus carpio*, *C. anomalum*, *E. spectabile*, and *E. nigrum* were locally common in muddy streams, but the first two were most frequent in larger, sandy streams, and the last three in gravelly streams.

In gravel-bottomed, upland streams, *N. cornutus*, *N. rubellus*, *N. topeka*, and *C. erythrogaster* characteristically occurred; with the exception of *N. rubellus* (only one specimen taken), all were common at some stations. Other species in gravelly creeks were *N. lutrensis*, *C. anomalum*, *C. commersonii*, *P. notatus*, *L. macrochirus*, *E. spectabile*, and *E. nigrum*. Although the one specimen of *N. umbratilis* taken in this survey was from the Big Blue River, this species is more characteristic of the clearer creeks in Kansas.

In order to illustrate the composition of the fauna in some specific streams in the Big Blue River Basin, I segregated the fishes into ecological groups, as in the above discussion: ubiquitous types; species of larger, sandy streams; fishes of muddy streams; and fishes of clear, gravelly creeks.

The total number of species taken in each of the streams was

divided into the number of species from that stream that were in each of these units, to give a percentage. The resultant data are presented graphically in Figure 3.

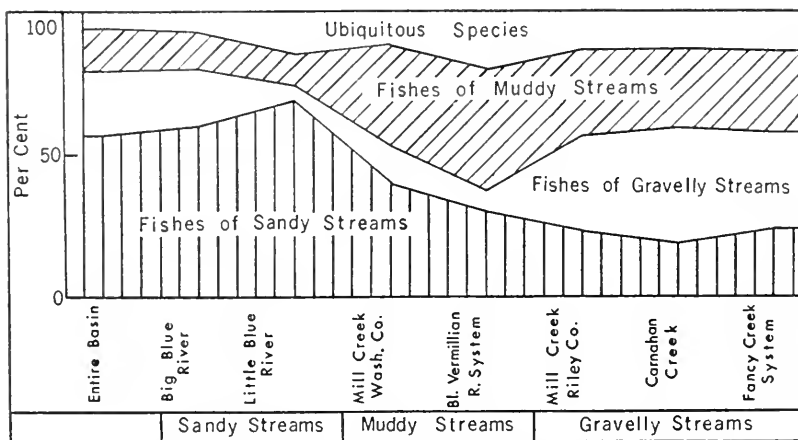


FIG. 3. Composition of the fauna of the entire Big Blue River Basin, and of seven streams or stream systems in that basin. "Mill Creek, Wash. Co." refers to all streams in the Mill Creek System, Washington and Republic counties. "Bl. Vermillion R. System" includes all streams in that watershed excepting Clear Creek and one of its tributaries (Stations 31-G and 32-G).

Figure 3 gives a generalized picture of the faunal composition in different kinds of streams. However, the fauna of a small tributary becomes more distinct from the fauna of the larger stream into which the small stream flows as one moves toward the headwaters (Metcalf, 1957:92, 95-100). Figure 4 illustrates this in Carnahan

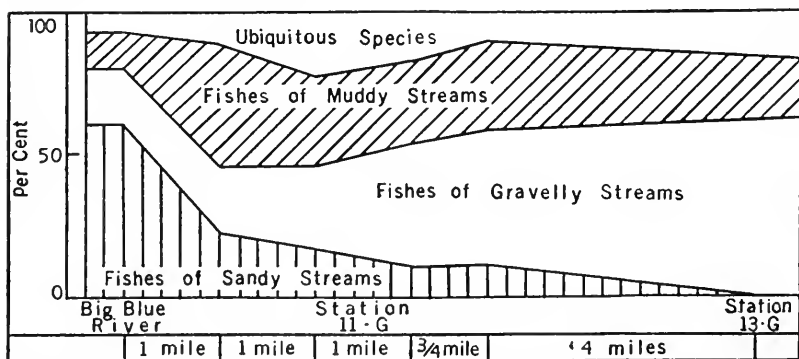


FIG. 4. Composition of the fauna of the Big Blue River, and of five collecting-sites on Carnahan Creek, Pottawatomie County. Lowermost sites are at the left of the figure.

Creek. Station 11-G included four sampling-sites, which were approximately one, two, three, and four miles upstream from the mouth of Carnahan Creek. Station 13-G (one collection) was about four miles upstream from the closest sampling-site of Station 11-G. Applying the same methods as for Figure 3, my findings show a gradual decline in the per cent of the fauna represented by the "large-river-fishes," and an increase in the segment classified as "upland-fishes," from downstream to upstream.

CREEL CENSUS

Fifty-three fishermen were interviewed in the 1957 creel census period, and 152 in 1958. Only those fishermen using pole and line were interviewed. In the area censused, much additional fishing is done with set-lines, that are checked periodically by the owners.

In the 1958 census, 22 checks along approximately 80 miles of river were made, and seven of these trips were made without seeing one fisherman. The average fishing pressure for the entire area was estimated at one fisherman per 7.9 miles of stream, or one fisherman per 15.7 miles of shoreline.

Seven species of fish were identified from fishermen's creels in 1957 and 1958. These, in order of abundance were: channel catfish; carp; freshwater drum; flathead catfish; shovelnose sturgeon; smallmouth buffalo; and river carpsucker. Shovelnose sturgeon occurred in fishermen's creels only in April, 1957, and freshwater drum occurred more frequently in the spring-census of 1957 than in the summer of 1958.

Sixty-two of the fishermen interviewed in 1958 were fishing for "anything they could catch," 68 were fishing specifically for catfish, and 22 sought species other than catfish. The order of preference was as follows: channel catfish, 21.1 per cent; flathead catfish, 15.1 per cent; unspecified catfish, 12.5 per cent; carp, 9.2 per cent; freshwater drum, 1.3 per cent; and unspecified, 40.8 per cent. The kinds of fish desired by those fishermen checked in 1957 were not ascertained.

Of all fishermen checked in 1957 and 1958, 165 were men, 17 were women, and 24 were children. Ninety-three per cent were fishing from the bank, five per cent were fishing from bridges, and two per cent were wading. All but two per cent of those checked were fishing "tightline"; the remainder fished with a cork.

The ten baits most commonly used, in order of frequency, were worms, doughballs, minnows, liver, beef-spleen, chicken-entrails, coagulated blood, crayfish, shrimp, and corn.

For purposes of later comparison the data on angler success (Table 4) have been divided according to areas: Area I, below Tuttle Creek Dam; Area II, in the Tuttle Creek Reservoir area; and Area III, above the reservoir. Areas I and III received the most fishing pressure, especially Station 4-S (in Area I), and Station 56-S (in Area III).

In Area I, the success ranged from 0.91 fish per fisherman-day in 1957 to 0.26 fish per fisherman-day in 1958. The 1957 census was made in April and May, when fishing in warm-water streams is considered better than in July (Harrison, 1956:203). The 1958 census was from late June through July, and stream-flow in this period was continuously above normal. Therefore, fewer people fished the river, and catches were irregular. Catches in 1958 ranged from 0.26 fish per fisherman-day in Area I to 0.44 fish per fisherman-day in Area III. In 1951, in the Republican River of Kansas and Nebraska, the average fisherman-day yielded 0.36 fish, 0.09 fish per man-hour, and 0.06 fish per pole-hour (U. S. Fish and Wildlife Service, 1952:13-14). The average fisherman-day in the Republican River study was 3.0 hours, whereas the average on the Big Blue River was 2.2 hours for all areas in 1958 (Table 4).

In the Big Blue River 47.7 per cent of all fishermen were successful in Area I in 1957, while only 13.1 per cent were successful in the same area in 1958 (Table 5). In the Republican River, 24 per cent of the fishing parties were successful (1.64 persons per party) (U. S. Fish and Wildlife Service, *loc. cit.*). The average

TABLE 4. ANGLING SUCCESS IN THE BIG BLUE RIVER, KANSAS, 1957 AND 1958.

AREA, YEAR, AND NUMBER OF FISHERMEN	Average length of fisherman-day	Number fish per fisherman-day	Number fish per man-hour	Number fish per pole-hour*
Area I, 1957 53 fishermen	2.7 hours	0.91	0.33	0.23
Area I, 1958 84 fishermen	2.5 hours	0.26	0.10	0.07
Area II, 1958 27 fishermen	1.7 hours	0.37	0.22	0.14
Area III, 1958 41 fishermen	2.4 hours	0.44	0.16	0.11
All areas, 1958 152 fishermen	2.2 hours	0.33	0.14	0.09

* Fishermen used an average of 1.44 poles.

distance that each fisherman had traveled to fish in the Big Blue River was 15.7 miles. Seventy-nine per cent of the persons contacted lived within 25 miles of the spots where they fished. In the study on the Republican River, 77 per cent of the parties interviewed came less than 25 miles to fish.

TABLE 5. PER CENT OF TOTAL FISHERMEN SUCCESSFUL, AND DISTANCES TRAVELLED TO FISH, BIG BLUE RIVER BASIN, KANSAS, 1957 AND 1958. ALL DISTANCES WERE MEASURED IN AIRLINE MILES.

	1957 Area I	1958 Area I	1958 Area II	1958 Area III	1958 All areas
Per cent of fishermen successful	47.1	13.1	18.5	19.5	15.8
Distances traveled to fish. (averages in parentheses)	0-121 (15.6)	1-197 (20.5)	0-124 (13.5)	0-60 (7.4)	0-197 (15.7)

RECOMMENDATIONS

My primary recommendation is for continued study of the Tuttle Creek Reservoir, and the Big Blue River above and below the reservoir, to trace changes in the fish population that result from impoundment.

Probably the fishes that inhabit the backwaters, creek-mouths, and borrow-pits in the Big Blue River Basin (gars, shad, carpsucker, buffalo, carp, sunfishes, and white bass) will increase in abundance as soon as Tuttle Creek Reservoir is formed. Also, as in eastern Oklahoma reservoirs (see Finnell, *et al.*, 1956:61-73), populations of channel and flathead catfish should increase. Because of the presence of brood-stock of the major sport-fishes of Kansas (channel and flathead catfish, bullhead, bluegill, crappie, largemouth bass, and white bass), stocking of these species would be an economic waste: exception might be made for the white bass. It may be above Tuttle Creek Dam, but was not found there.

I do recommend immediate introduction of walleye, and possibly northern pike (*Esox lucius* Linnaeus), the latter species having been successfully stocked in Harlan County Reservoir, Nebraska, in recent years (Mr. Donald D. Poole, personal communication). These two species probably are native to Kansas, but may have been extirpated as agricultural development progressed. Reservoirs may again provide habitats suitable for these species in the State.

If Tuttle Creek Reservoir follows the pattern found in most Oklahoma reservoirs, large populations of "coarse fish"—fishes that

are, however, commercially desirable—will develop (Finnell, *et al.*, *loc. cit.*). To utilize this resource, and possibly to help control “coarse fish” populations for the betterment of sport-fishing, some provision for commercial harvest should be made in the reservoir.

SUMMARY

1. The Big Blue River Basin in northeastern Kansas was studied between March 30, 1957, and August 9, 1958. The objectives were to record the species of fish present and their relative abundance in the stream, and to obtain a measure of angling success prior to closure of Tuttle Creek Dam.

2. Fifty-nine stations were sampled one or more times, using seines, hoop and fyke nets, wire traps, experimental gill nets, rotenone, and an electric fish shocker.

3. Forty-eight species of fish were obtained, and five others have been recorded in literature or found in museums. One species, *Carpionodes forbesi*, is recorded from Kansas for the first time.

4. *Notropis lutrensis* was the most abundant fish in the Big Blue River Basin, followed by *Notropis deliciosus* and *Ictalurus punctatus*. The most abundant sport-fishes were *I. punctatus*, *I. melas*, and *Pylodictis olivaris*, respectively.

5. The spawning behavior of *Notropis lutrensis* is described.

6. A creel census at major points of access to the Big Blue River, was taken in 1957 (below Tuttle Creek Dam) and in 1958 (above, in, and below the dam-site). Fishing pressure averaged one fisherman per 15.7 miles of shoreline. The average length of the fisherman-day averaged 2.2 hours, with an average of 0.33 fish per fisherman-day being caught in 1958. The average number of fish per man-hour in 1958 was 0.14 and 15.8 per cent of the fishermen were successful. Distances traveled in order to fish ranged from 0 to 197 miles (airline) and averaged 15.7 miles.

7. The primary recommendation is that studies be continued, to document changes that result from impoundment. Because broodstock of the major sport-fishes is already present, stocking is unnecessary, except for walleye and northern pike. Also, I recommend commercial harvest of non-game food-fishes.

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August 1, 1959

Birds From Coahuila, México

BY

EMIL K. URBAN

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4. Birds from the state of Veracruz, Mexico. By George H. Lowery, Jr., and Walter W. Dalquest. Pp. 531-649, 7 figures in text, 2 tables. October 10, 1951.
- Index. Pp. 651-681.
- *Vol. 4. (Complete) American weasels. By E. Raymond Hall. Pp. 1-466, 41 plates, 31 figures in text. December 27, 1951.
- Vol. 5. Nos. 1-37 and index. Pp. 1-676, 1951-1953.
- *Vol. 6. (Complete) Mammals of Utah, *taxonomy and distribution*. By Stephen D. Durrant. Pp. 1-549, 91 figures in text, 30 tables. August 10, 1952.
- Vol. 7. *1. Mammals of Kansas. By E. Lendell Cockrum. Pp. 1-303, 73 figures in text, 37 tables. August 25, 1952.
2. Ecology of the opossum on a natural area in northeastern Kansas. By Henry S. Fitch and Lewis L. Sandidge. Pp. 305-338, 5 figures in text. August 24, 1953.
3. The silky pocket mice (*Perognathus flavus*) of Mexico. By Rollin H. Baker. Pp. 339-347, 1 figure in text. February 15, 1954.
4. North American jumping mice (*Genus Zapus*). By Philip H. Krutzsch. Pp. 349-472, 47 figures in text, 4 tables. April 21, 1954.
5. Mammals from Southeastern Alaska. By Rollin H. Baker and James S. Findley. Pp. 473-477. April 21, 1954.
6. Distribution of Some Nebraskan Mammals. By J. Knox Jones, Jr. Pp. 479-487. April 21, 1954.
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8. A new subspecies of bat (*Myotis velifer*) from southeastern California and Arizona. By Terry A. Vaughan. Pp. 507-512. July 23, 1954.
9. Mammals of the San Gabriel mountains of California. By Terry A. Vaughan. Pp. 513-582, 1 figure in text, 12 tables. November 15, 1954.
10. A new bat (*Genus Pipistrellus*) from northeastern Mexico. By Rollin H. Baker. Pp. 583-586. November 15, 1954.
11. A new subspecies of pocket mouse from Kansas. By E. Raymond Hall. Pp. 587-590. November 15, 1954.
12. Geographic variation in the pocket gopher, *Cratogeomys castanops*, in Coahuila, Mexico. By Robert J. Russell and Rollin H. Baker. Pp. 591-608. March 15, 1955.
13. A new cottontail (*Sylvilagus floridanus*) from northeastern Mexico. By Rollin H. Baker. Pp. 609-612. April 8, 1955.
14. Taxonomy and distribution of some American shrews. By James S. Findley. Pp. 613-618. June 10, 1955.
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UNIVERSITY OF KANSAS PUBLICATIONS
MUSEUM OF NATURAL HISTORY

Volume 11, No. 8, pp. 443-516

August 1, 1959

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EMIL K. URBAN

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LAWRENCE
1959

UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

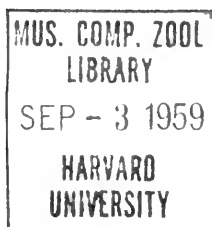
Editors: E. Raymond Hall, Chairman, Henry S. Fitch,
Robert W. Wilson

Volume 11, No. 8, pp. 443-516

Published August 1, 1959

UNIVERSITY OF KANSAS

Lawrence, Kansas



PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1959



27-7905

Birds From Coahuila, México

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INTRODUCTION

The following account is a summary of the present knowledge of the birds of Coahuila. Some 500 specimens from Coahuila in the Museum of Natural History at the University of Kansas are the basis for this report; these are supplemented by records of birds previously listed from the State.

In Coahuila, habitats vary from those characteristic near tree-line to those of the floors of the low deserts. Because of the variety of habitats, many kinds of birds are present in the State; at least 312 living named kinds of 249 species have been recorded. Possibly another 100 species will be reported after further studies have been made there. At least 154 of the species listed in this paper probably breed in Coahuila. The bird fauna in the State includes species characteristic of eastern North America and of western North America, species that range from the Atlantic to the Pacific Ocean, and species found only, or mostly, in México.

I thank Professor E. Raymond Hall, Doctor Richard F. Johnston and Doctor Robert M. Mengel for their kind help, and Doctor Harrison B. Tordoff for first suggesting this study to me. Unless otherwise stated, the nomenclature in this paper is that of the A. O. U. Check-list Committee (1957). Catalogue numbers are those of the Museum of Natural History at the University of Kansas. In so far as known to me, all birds recorded in the literature from Coahuila are listed below. In a few instances the only support for occurrence is the ascription of a given kind to Coahuila (without mention of date, catalogue number, or precise locality) by Friedmann, Griscom, and Moore (1950), and/or the A. O. U. Check-list Committee (1957); when this is so the entire entry is inclosed within brackets. In the accounts beyond, an asterisk indicates that the kind breeds in Coahuila; two asterisks indicate probable breeding in the State.

LIST OF COLLECTORS

Persons who have obtained specimens of birds from Coahuila for the Museum of Natural History are as follows:

Albert A. Alcorn	John William Hardy
Joseph Raymond Alcorn	Gerd H. Heinrich
Sydney Anderson	William McKee Lynn
Rollin Harold Baker	Jack M. Mohler
James Sheldon Carey	Roger O. Olmstead
Peter Stanley Chrapliwy	Robert Lewis Packard
W. Kim Clark	Robert Julian Russell
Robert William Dickerman	William J. Schaldach, Jr.
John R. Esther	Harrison Bruce Tordoff
James Smith Findley	South Van Hoose, Jr.
John Keever Greer	Olin Lawrence Webb

GAZETTEER OF LOCALITIES IN COAHUILA

The following place-names were used to record the localities of Coahuilan birds now specimens in the University of Kansas Museum of Natural History. Each place-name is followed by its location in degrees and minutes of latitude and longitude, respectively.

Acebuches.—28°17', 102°56'.	Ocampo.—27°22', 102°26'.
Americanos.—27°12', 103°14'.	Paila.—25°38', 102°09'.
Australia.—26°18', 102°18'.	Parras.—25°25', 102°12'.
Bella Unión.—25°26', 100°51'.	Piedras Blanca.—29°02', 102°33'.
Boquillas.—29°11', 102°55'.	Piedras Negras.—28°43', 100°32'.
Castillón.—28°21', 103°33'.	Sabinas.—27°52', 101°07'.
Cuatro Ciénegas.—26°58', 102°04'.	Saltillo.—25°26', 101°00'.
Diamante.—25°22', 100°54'.	San Antonio de las Alazanas.— 25°16', 100°37'.
Don Martín.—27°32', 100°37'.	San Buenaventura.—27°06', 101°32'.
Fortín.—28°48', 101°41'.	San Francisco.—27°37', 102°37'.
General Cepeda.—25°22', 101°28'.	San Gerónimo.—28°30', 101°48'.
Gómez Farías.—24°58', 101°02'.	San Isidro.—27°33', 102°27'.
Hermanas.—27°13', 101°13'.	San Juan de Sabinas.— 27°55', 101°17'.
Iglesias.—27°34', 101°20'.	San Lorenzo.—25°28', 102°12'.
Jaco.—27°50', 103°55'.	San Marcos.—26°41', 102°07'.
Jiménez.—29°04', 100°42'.	San Miguel.—29°14', 101°22'.
La Babia.—28°33', 102°03'.	San Pedro de las Colonias (San Pedro).—25°45', 102°58'.
La Gacha.—28°09', 101°31'.	Santa Teresa.—26°27', 101°21'.
La Mariposa.—28°12', 101°49'.	Tanque Alvarez.—27°56', 102°38'.
La Ventura.—24°48', 100°38'.	Torreón.—25°33', 103°27'.
Las Delicias.—26°10', 102°49'.	Villa Acuña.—29°19', 100°56'.
Las Margaritas.—28°42', 101°14'.	
Mesa de Tablas.—25°14', 100°24'.	
Múzquiz.—27°53', 101°32'.	
Nava.—28°25', 100°46'.	

For mountain ranges, the approximate center of the highland of each range is used as the point of reference.

Pico de Jimulco.—25°08', 103°16'.	Sierra de Guadalupe.—
Sierra del Carmen.—	25°13', 101°32'.
29°00', 102°30'.	Sierra del Pino.—28°15', 103°03'.
Sierra de la Encantada.—	Sierra de la Madera.—
28°25', 102°30'.	27°03', 102°30'.

DISTRIBUTION OF THE KNOWN BREEDING BIRDS OF COAHUILA

Topography and Climate

Coahuila lies in the broad northern end of México, immediately east of the center of the continental mass. The mountains of Coahuila, which are part of the Rocky Mountain-Sierra Madre Oriental Axis, extend in a north-south direction and divide the lower lands into two areas, a larger one, a part of the Central Plateau, to the westward and a smaller one, a part of the Gulf Coastal Plain, to the northeastward. Most of the mountains of Coahuila do not exceed 6000 feet in elevation. A few peaks such as in the Sierra del Carmen, Sierra del Pino, Sierra de la Madera, Sierra Encarnación, and Sierra de Guadalupe, are more than 9000 feet high, and some more than 10,000 feet in elevation occur near the southeastern border of the State in the Sierra Madre Oriental. The Gulf Coastal Plain of northeastern Coahuila ranges from 700 feet to 1800 feet. The desert plains of the Mesa del Norte to the west of the Sierra Madre Oriental Axis are higher, more rugged, and more dissected than those of the Coastal Plain and are marked by scattered desert ranges, buttes, low hills, and knobs.

Most of Coahuila is arid. Rainfall is moderate on the Coastal Plain and is low west of the central mountains. Baker (1956:128-132) and Muller (1947:35-38) give good summary discussions of the topography and climate of Coahuila, and the reader is referred to these for further details.

Biotic Communities

Baker (1956:132) stated that "the biotic communities of Coahuila might be divided in accordance with the three physiographic areas of the State: the Gulf Coastal Plain, the mountains, and the desert plains of the Mesa del Norte." Goldman and Moore (1945:348-349) listed three biotic provinces in Coahuila: the Chihuahua-Zacatecas Biotic Province, in the western half of the State; the Tamaulipas Biotic Province, in the northeastern part of the State;

and the Sierra Madre Oriental Biotic Province, in the southeastern part of the State. Merriam (1898) noted that definable portions of the Lower Sonoran Life-zone, the Upper Sonoran Life-zone, the Transition Life-zone, and the Canadian Life-zone can be distinguished in Coahuila. In my study of the distribution of the avifauna of Coahuila, I found that the three biotic provinces listed by Goldman and Moore (*op. cit.*) as major headings and Merriam's life-zones as supplements are the most satisfactory divisions.

The Tamaulipas Biotic Province.—This province consists of lowland plains and a few isolated ranges of low mountains. The average rainfall is 23 inches (Baker, 1956:130), considerably more than the 10 inches falling in the western part of the State. In the northeastern section of the State, the moderate amount of rain, mesic vegetation, and close proximity to the eastern migration pathway importantly influence the types of birds found.

In Coahuila, the Coastal Plain and the Río Grande Plain lie in the path of the northernmost trade winds; they account for the more humid eastern slopes of the mountains of the northeastern part of the State (Muller, 1947:38). Nevertheless, the northeastern section of the State is semi-arid and can be placed in the Lower Sonoran Life-zone. The vegetation consists mainly of thorny shrubs and small trees with a liberal admixture of yuccas, agaves, and cacti, and closely resembles that of southern Texas, northern Nuevo León, and northern Tamaulipas (Goldman and Moore, 1945:354).

Migrant birds from the eastern flyway and less commonly migrants from western North America pass through northeastern Coahuila. The following breeding birds seem to be associated with this province: Harris' Hawk, Bobwhite (*C. v. texanus*), Scaled Quail (*C. s. castanogastris*), Yellow-billed Cuckoo, Groove-billed Ani, Green Kingfisher, Golden-fronted Woodpecker, Hairy Woodpecker (*D. v. intermedius*), Ladder-backed Woodpecker (*D. s. symplectus*), Vermilion Flycatcher (*P. r. mexicanus*), Cave Swallow, Gray-breasted Martin, Black-crested Titmouse (*P. a. atricristatus*), Carolina Wren, Long-billed Thrasher, Curve-billed Thrasher (*T. c. oberholseri*), Blue-gray Gnatcatcher (*P. c. caerulea*), Hutton's Vireo (*V. h. carolinae*), Bell's Vireo (*V. b. medius*), Yellow-throated Vireo, Red-eyed Vireo, Summer Tanager (*P. r. rubra*), Olive Sparrow, Cassin's Sparrow, and Black-throated Sparrow (*A. b. bilineata*).

The Sierra Madre Oriental Biotic Province.—Southeastern Coahuila is in this province that includes mountains in southern Nuevo

León, southwestern Tamaulipas, and eastern San Luis Potosí. Areas classifiable as Canadian, Transition, Upper Sonoran, and Lower Sonoran in life-zone are found in this province. This region of Coahuila receives the highest rainfall; this is evidenced by the luxuriant growth of boreal plants living in the higher places there (Baker, 1956:131). Spruce, pine, and aspen occur at higher elevations and oaks, thorny shrubs, and grasslands are present lower down.

Birds of central or southern México reach the southern part of Coahuila; the Thick-billed Parrot, Hooded Yellowthroat, and Rufous-capped Atlapetes are examples. A boreal forest on the higher slopes of the mountains of southeastern Coahuila is suitable for certain northern birds such as Goshawks, Pine Siskins, and Brown Creepers. Some species of birds ordinarily associated with western North America are present in Coahuila only in its southeastern part; striking examples of disjunction in range thus occur. Probably sometime in the past these birds were distributed throughout most of Coahuila. When this area became arid, these species disappeared from all of Coahuila except from the high mountains in the southeastern part. For example, Steller's Jay and the Scrub Jay are absent in the Sierra del Carmen of northwestern Coahuila but do occur in southeastern Coahuila.

Migrants of the eastern flyway as well as migrants associated with western North America pass through this section of Coahuila. The following breeding birds are associated with this province: Goshawk, Band-tailed Pigeon, Thick-billed Parrot, Golden-fronted Woodpecker, Ladder-backed Woodpecker (*D. s. giraudi*), Pine Flycatcher, Buff-breasted Flycatcher, Vermilion Flycatcher (*P. r. mexicanus*), Steller's Jay, Scrub Jay, Mexican Chickadee, Black-crested Titmouse (*P. a. atricristatus*), Cactus Wren (*C. b. guttatus*), Robin, Blue-gray Gnatcatcher (*P. c. amoenissima*), Hutton's Vireo (*V. h. stephensi*), Bell's Vireo (*V. b. medius*), Hartlaub's Warbler, Summer Tanager (*P. r. cooperi*), Pine Siskin, Rufous-capped Atlapetes, and Black-throated Sparrow (*A. b. grisea*).

The Chihuahua-Zacatecas Biotic Province.—This province in Coahuila covers the arid, interior, western desert area; it consists of rolling plains with mountains that rise islandlike above the general surface. Some of the mountains, such as in the Sierra del Carmen and the Sierra del Pino, are more than 9000 feet high. The major part of this biotic area lies within the Lower Sonoran Life-zone. Areas of the Transition and Canadian life-zones are

present on some of the higher mountains; their discontinuity results in a discontinuous distribution of the conifer-dependent avifauna.

The large desert restricts the movement of birds considerably. Major results of this include isolation of certain populations and absence of others in the boreal islands. For example, Miller (1955a: 157) noted that the "dispersal of conifer-belt birds to and from the Sierra del Carmen, although not as difficult as to well separated islands [such as off the coast of Baja California], is nevertheless a formidable matter to accomplish across the great deserts of Texas, Chihuahua, and Coahuila." Miller (*loc. cit.*) noted also that the avifauna of the Sierra del Carmen, due to its insularity, is unbalanced and stated that "as a consequence of unbalance, species that are present show ecologic extension and unusual numerical relations." At least in this type of environment, an extension or expansion of the ecologic habits of the related types takes place when some species are absent.

This isolation influences local variation among some of the birds found in Coahuila. Niches elsewhere usually occupied by certain species, absent here, are occupied by other species. These other species thus enjoy an ecologic freedom and can expand their niches in the absence of related types of similar ecologic scope. For example, Miller (1955a:158-159) reported that Hairy Woodpeckers occurred only casually in the Sierra del Carmen and that the Ladder-backed Woodpecker has spread out and seems to occupy the niche or niches usually characteristic of the Hairy Woodpecker. Changes usually thought of as of subspecific character seem to be taking place between the Ladder-backed Woodpeckers of the Sierra del Carmen and of other areas, possibly because the Ladder-backed Woodpecker in the Sierra del Carmen is extending its ecologic sphere more than in areas where the Hairy Woodpecker exists. Restriction in dispersal due to geographic isolation has probably hindered gene flow, thus allowing rapid local adaptation, recognizable in variation at the infraspecific level. Miller (*loc. cit.*) listed other birds that have expanded their ecologic scope; his work should be referred to for further details.

The following birds are associated with this province: Black Vulture, Scaled Quail (*C. s. pallida*), Turkey, Elf Owl, Green Kingfisher, Hairy Woodpecker (*D. v. icastus*), Ladder-backed Woodpecker (*D. s. cactophilus*), Wied's Crested Flycatcher, Buff-

breasted Flycatcher, Vermilion Flycatcher (*P. r. flammeus*), Black-crested Titmouse (*P. a. dysleptus*), Cactus Wren (*C. b. couesi*), Curve-billed Thrasher (*T. c. celsum*), Blue-gray Gnatcatcher (*P. c. amoenissima*), Hutton's Vireo (*V. h. carolinae*), Summer Tanager (*P. r. cooperi*), and Black-throated Sparrow (*A. b. opuntia*). Several kinds of birds, such as the Band-tailed Pigeon, occur in the "pine islands" in this province rather than on the desert floor.

There remain several kinds of birds that are not especially associated with any one or two of the above-named provinces. These birds are widely distributed and vary geographically without corresponding to the Biotic Provinces. Examples of these species are: Black Phoebe (*S. n. semiatra* in northern Coahuila; *S. n. nigricans* in southern Coahuila), Violet-green Swallow (*T. t. lepida* in northwestern Coahuila; *T. t. thalassina* in southeastern Coahuila), Black-eared Bushtit (*P. m. lloydi* in northern Coahuila; *P. m. iulus* in southeastern Coahuila), White-breasted Nuthatch (*S. c. nelsoni* in northern Coahuila; *S. c. mexicana* in southern Coahuila), Brown-throated Wren (*T. b. cahooni* in northern Coahuila; *T. b. compositus* in southern Coahuila), Crissal Thrasher (*T. d. dorsale* in northern Coahuila; *T. d. dumosum* in southern Coahuila), and Rufous-crowned Sparrow (*A. r. tenuirostris* in northern Coahuila; *A. r. boucardi* in southern Coahuila).

Some representatives of the avifauna of the central and southern sections of the Central Plateau reach southwestern Coahuila. The subspecies *squamata* of the Scaled Quail and *eurhyncha* of the Blue Grosbeak are examples. Each in Coahuila seems to be at the northern limit of its range.

In summary, there are three associations of vegetation in Coahuila and each has characteristic birds. Gross climate and topography, through their influence on vegetation, are the prime factors in the distribution and kinds of birds in the State. Some birds of central and southern México reach southeastern and southwestern Coahuila. Representatives of the Gulf Coastal Plain in Tamaulipas and Nuevo León as well as migrants of the eastern flyway occur in northeastern Coahuila. Most of the species that occur in Coahuila seem to be associated with western North America. The aridity of western Coahuila restricts, to a large extent, the diversity of the breeding populations of its avifauna. Xeric conditions surrounding some of the higher mountains are barriers to movement of some species.

ORIGIN OF BREEDING BIRDS OF COAHUILA

Probably beginning in the late Pliocene and ending in the Ice Age (Griscom, 1950:379) the refrigeration of climate in the Northern Hemisphere initiated a period of southward withdrawal of birds from the northern part of North America. Some members of the avifauna of Coahuila probably reached the State in this time. When the continental deserts were formed, or reformed, many tropical and subtropical Middle American species were forced to leave Coahuila. Species associated with arid conditions found their way there. Many representatives of the Old World element also seem to have found their way to the State during the refrigeration of climate in the Northern Hemisphere. The separation of North and South America in the greater part of the Tertiary (Mayr, 1946:9) that deterred mammals from intercontinental colonization seemingly did not hinder birds. Some South American species moved northward into México, all the way north to Coahuila.

The avifauna of Coahuila today is a mixture of the several mentioned elements. Of the breeding populations, 43 per cent breed in the western rather than the eastern United States, 6 per cent breed in the eastern rather than the western United States, 30 per cent breed in both the eastern and western United States, 20 per cent are restricted to the Republic of México, and the southern parts of Arizona, New Mexico, and Texas, and 1 per cent (Aztec Thrush and Rufous-capped Atlapetes) is endemic to the Republic of México.

It is instructive to consider also the origin of avifaunal elements at the level of Family. According to Mayr (1946:11) most North American families and subfamilies clearly originated in the Old World, in South America, or from a North American element that developed in the partial isolation of North America in the Tertiary. Three other elements, the Panboreal, the Pan-American, and the Pantropical are represented by some North American families and subfamilies. Because of the obscurity of the place of origin of certain groups, an additional unanalyzed element must be recognized.

The Caprimulgidae and Picidae probably originated in North America (Mayr, 1946:26). Although the Psittacidae are Pantropical in distribution, indications are that they probably originated in the Old World (Mayr, 1946:17). The Phasianidae, Turdidae (*Myadestes-Hylocichla* group), and Sylviidae (Poliptilinae) seem to

have originated in the Old World (Mayr, 1946:27). However, Mayr considered these groups to have had a secondary center of proliferation in North America, and I thus consider these groups to have a North American origin. Mayr (1946:27) considered the Trochilidae, Tyrannidae, and Icteridae Pan-American in distribution; however, he suggested that they probably originated in South America, and I here treat them as South American in origin. No representatives of the Pan-American element that probably originated in North America have been recorded from Coahuila nor have members of the Panboreal element (Mayr, 1946:11) been recorded in the State. According to my analysis, representatives of families of birds known to breed in Coahuila and those that probably breed there thus seem to have been derived historically from the following sources:

Old World.....	24.7%	South America.....	24.0%
North America.....	37.0%	Unanalyzed.....	14.3%

Mayr (1946:28-29) gave examples of analysis by geographic origin of the breeding species of several districts of North America. For instance, at Yakutat Bay in southeastern Alaska the South American element of breeding passerine species was 3 per cent, the North American element 39 per cent, and the Old World element 58 per cent whereas at Sonora, México, the South American element of breeding passerine species was 27 per cent, the North American element 52 per cent, and the Old World element 21 per cent. The breeding avifauna of Coahuila is thus in line with Mayr's analysis, resembling that of Sonora to a considerable degree at the taxonomic level of Family.

ACCOUNTS OF SPECIES

*****Podiceps caspicus* (Hablzl).**—On March 31, 1952, Olmstead saw "many Eared Grebes" on a pond 10 mi. E Hacienda La Mariposa. This is the first record of the Eared Grebe in Coahuila.

[*Pelecanus erythrorhynchos* Gmelin.—The White Pelican is uncommon, if not rare; Friedmann, Griscom, and Moore (1950:21) list it.]

***Anhinga anhinga* (Linnaeus).**—On March 31, 1952, Olmstead noted an Anhinga perched on a submerged fence post in a lake 10 mi. E Hacienda La Mariposa. This is the first record of the Anhinga in Coahuila.

*****Ardea herodias* Linnaeus.**—Two subspecies of the Great Blue Heron, *treganzai* and *wardi*, have been recorded from Coahuila. Friedmann, Griscom, and Moore (1950:27) listed *A. h. treganzai* from the State; presumably this subspecies occurs widely in low density. They (*loc. cit.*) remarked also that a record of *A. h. wardi* from Coahuila "cannot be allocated subspecifically."

Dickerman saw two Great Blue Herons in a marshy area at San Marcos (=20 mi. S Cuatro Ciénegas) on May 4, 1954. Van Tyne and Sutton (1937:12) noted the Great Blue Heron "near Boquillas [Texas], along the Rio Grande, on May 10 and 15. . . ."

***Butorides virescens* (Linnaeus).—Olmstead saw a Green Heron at Boquillas, 700 feet, on March 10, 1952. Findley reported seeing Green Herons 2 mi. W Jiménez, 850 feet, on June 19, 1952, and 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952.

***Casmerodius albus egretta* (Gmelin).—The Common Egret is an uncommon migrant in Coahuila. Friedmann, Griscom, and Moore (1950:30) recorded *C. a. egretta* from the "extreme northern part" of Coahuila. Van Tyne and Sutton (1937:12) saw the Common Egret "along the Rio Grande on the Graham ranch just west of Boquillas," Texas, on May 16, which might well be the locality to which Friedmann, Griscom, and Moore referred. Olmstead saw a Common Egret at Don Martín on March 22, 1952.

***Nycticorax nycticorax hoactli* (Gmelin).—This subspecies of the Black-crowned Night Heron was listed from the "extreme north" section of Coahuila by Friedmann, Griscom, and Moore (1950:32). Van Tyne and Sutton (1937:14) saw three Black-crowned Night Herons along the Rio Grande about two miles west of Boquillas, Texas, on May 16. This record probably represents the locality to which Friedmann, Griscom, and Moore (*op. cit.*) referred.

Nyctanassa violacea violacea (Linnaeus).—A Yellow-crowned Night Heron in immediate post-juvinal plumage, No. 36413, was obtained on September 7, 1958, 16 km. south of Cuatro Ciénegas, by W. L. Minckley. According to him the bird was accompanied by "several" other herons seemingly of the same species and condition of plumage. The species seems not to have been recorded previously from Coahuila [Eds.].

Botaurus lentiginosus (Rackett).—Friedmann, Griscom, and Moore (1950:34) listed the American Bittern from the "extreme northern part" of Coahuila. Van Tyne and Sutton (1937:14) saw two representatives of this bittern "along the Rio Grande not far from Hot Springs," Texas, on May 15. I suspect that this is the locality to which Friedmann, Griscom, and Moore (*loc. cit.*) referred.

[*Branta canadensis leucopareia* (Brandt).—Friedmann, Griscom, and Moore (1950:38) listed *B. c. leucopareia* from "northern Coahuila."]

***Dendrocygna autumnalis* (Linnaeus).—Evdenden (1952:112) reported a Black-bellied Tree Duck standing beside a reservoir in southern Coahuila along the railroad between Saltillo, Coahuila, and Avalos, Zacatecas.

***Anas platyrhynchos* Linnaeus.—On March 30, 1952, Olmstead recorded a Mallard from 10 mi. E Hacienda La Mariposa, 2000 feet.

Anas strepera Linnaeus.—*Specimen examined*: one, ♂ 31016, from 10 mi. E Hacienda La Mariposa, 2000 ft., March 30, 1952.

The Gadwell is not an uncommon spring migrant; Olmstead saw it 10 mi. E Hacienda La Mariposa on March 30, 1952, and Baker observed it 8 mi. N

and 4 mi. W Múzquiz on March 30, 1952. Friedmann, Griscom, and Moore (1950:42) recorded the Gadwell from Coahuila.

Anas acuta Linnaeus.—Miller (1955a:161) took a Pintail on September 10 in the Sierra del Carmen.

Anas carolinensis Gmelin.—The Green-winged Teal has been recorded from northern Coahuila. Van Tyne and Sutton (1937:15) recorded two mated pairs along the Rio Grande at Lajitas, Texas, on May 10. Miller (1955a:161) remarked that a male of the year was taken in the Sierra del Carmen on September 4.

Anas discors discors Linnaeus.—*Specimens examined*: total 2: sex ? 31646 and sex ? 31647 from .5 mi. S Las Margaritas, 2800 ft., September 28, 1953.

The Blue-winged Teal is a fairly common spring and fall migrant in Coahuila. Van Tyne and Sutton (1937:15) noted the Blue-winged Teal at several different localities along the Rio Grande: "on May 8, four males and several females resting on a mud bar along the Rio Grande near Hot Springs [Texas]; . . . on May 7, three pairs in a flock, along the Rio Grande, Castalon [Texas]; . . . and on May 20, three pairs, along the Rio Grande, San Vicente [Texas]." Miller (1955a:161) reported that Marsh took a male of the year in the Sierra del Carmen on September 10. Dickerman observed Blue-winged Teal 8 mi. E and 2 mi. S Americanos on May 18, 1954. Olmstead listed Blue-winged Teal from 10 mi. E Hacienda La Mariposa on March 30, 1952. Nos. 31646-31647, which are probably females, represent the subspecies *discors* because the light edgings of their crowns are definitely present; the areas of their backs are brownish, not more intensively black, and their underparts are brownish, less blackish.

***Anas cyanoptera septentrionalium* Snyder and Lumsden.—Van Tyne and Sutton (1937:15) listed several localities along the Rio Grande in Brewster County, Texas, where Cinnamon Teal were seen. I suspect that Friedmann, Griscom, and Moore (1950:41) referred to those localities. Dickerman saw four pairs of Cinnamon Teal 14 mi. E and 16 mi. N Ocampo on May 9, 1954, and also saw Cinnamon Teal 8 mi. E and 2 mi. S Americanos on May 18, 1954.

Mareca americana (Gmelin).—The American Widgeon is a fairly common spring migrant in Coahuila. Olmstead observed this duck 10 mi. E Hacienda La Mariposa on March 30, 1952. Dickerman saw five to seven American Widgeons 8 mi. E and 2 mi. S Americanos on May 18, 1954.

Spatula clypeata (Linnaeus).—The Shoveler is a spring and probably fall migrant in Coahuila, and has been observed at several localities. Van Tyne and Sutton (1937:16) saw two pairs along the Rio Grande at Castalon, Texas, on May 7 and saw "a fair-sized flock along the Rio Grande on the Johnson ranch [in Texas] on May 13 and 14." Dickerman saw 12 pairs of Shovelers on two ponds 14 mi. E and 16 mi. N Ocampo on May 9, 1954, and 10 more 8 mi. E and 2 mi. S Americanos on May 18.

Aythya affinis (Eyton).—Olmstead observed Lesser Scaup 10 mi. E Hacienda La Mariposa on March 30, 1952.

[*Bucephala albeola* (Linnaeus).—Friedmann, Griscom, and Moore (1950:44) listed the Bufflehead from the State.]

**Cathartes aura aura* (Linnaeus).—*Specimen examined*: one, ♂ 31017 (skeleton only), from 4 mi. W Hacienda La Mariposa, 2300 ft., March 26, 1952.

Miller (1955a:161) took a female Turkey Vulture, which was in breeding condition, in the Sierra del Carmen on April 17 and stated that "until more statistics are available on breeding birds of northern Coahuila, they must be considered *C. a. aura*. . ." Amadon and Phillips (1947:577) took a Turkey Vulture at Las Delicias which represented *C. a. aura*. Burleigh and Lowery (1942:188) stated that this species was not uncommon, and was noted each day soaring overhead both in the valleys and over the tops of the ridges of southeastern Coahuila.

Friedmann, Griscom, and Moore (1950:47) listed *C. a. teter* from Coahuila. Miller (1955a:161) remarked that the subspecies *aura* and *teter* might intergrade in the Sierra del Carmen. At the present time it is possible to say only that *teter* is present in Coahuila in migrant and wintering populations, but the extent to which *teter* remains in northeastern México is undetermined. However, all indications point to this area as being the region where *aura* and *teter* intergrade.

***Coragyps atratus* (Bechstein).—The Black Vulture is locally common throughout most of eastern Coahuila but is uncommon in the western part of the State. Sutton and Burleigh (1939a:25) noted the Black Vulture "regularly east of Saltillo in low country," but did not see Black Vultures at San Pedro or elsewhere in southwestern Coahuila. Burleigh and Lowery (1942:188) stated that "the Black Vulture apparently avoids to a large extent the higher altitudes, and only rarely was it observed at all, even about Saltillo." Olmstead saw Black Vultures 8 mi. N and 4 mi. W Múzquiz, 1800 feet, on March 31, 1952, and Dickerman observed a flock at La Gacha (=Rancho La Coucha), 1600 feet, on December 2, 1953.

***Accipiter gentilis* (Linnaeus).—On July 6, 1955, Hardy saw a Goshawk 13 mi. E San Antonio de las Alazanas; this is the first record of occurrence of this species from northeastern México.

**Accipiter striatus velox* (Wilson).—*Specimen examined*: one, ♀ 31018, from along the Rio Grande (=Boquillas), 700 ft., March 10, 1952, measurements: wing, 207 mm.; tail, 171 mm.; tarsus, 53 mm.; culmen, 12 mm.

Our specimen of the Sharp-shinned Hawk is referred to *velox* on the basis of the reddish, maculated breast, sides, and thighs. The collector's field notes recorded the iris as blood-red. Marsh and Stevenson (1938:286) thought that this subspecies was resident in the pine and Douglas-fir forest of upper Vivas Canyon of the Sierra del Carmen at 8500 feet, where Marsh observed a family group including three immature birds. Friedmann (1950:196) indicated that the immature male obtained by Marsh and Stevenson is *A. s. suttoni*; Miller (1955a:161), nevertheless, remarked that this male has well barred feathers and thus is *velox*. Miller (*loc. cit.*) obtained also an adult male of *A. s. velox* in the Sierra del Carmen at 7000 feet on April 18.

*****Accipiter striatus suttoni* van Rossem.**—*Specimen examined:* one, ♂ 32626, from 13 mi. E San Antonio, 9950 ft., July 6, 1955, measurements: wing, 186 mm.; tail, 144 mm.; tarsus, 49 mm.; culmen, 11 mm.; weight, 103 gms.

The recording of *A. s. suttoni* in Coahuila by Friedmann, Griscom, and Moore (1950:52), seems to have been based on their knowledge of the specimen earlier mentioned by Friedmann (1950:196) and later identified by Miller (1955a:161) as *A. s. velox*. Therefore the KU specimen seems to be the first record of *A. s. suttoni* in Coahuila. The size of its testes (right, 2.5x4 mm.; left, 3x4 mm.) does not indicate breeding; however, the time of the year in which it was obtained suggests that it may have been a resident.

****Accipiter cooperii* (Bonaparte).**—Miller (1955a:161) found Cooper's Hawk breeding in the Sierra del Carmen on April 26.

***Buteo jamaicensis borealis* (Gmelin).**—The Red-tailed Hawk is common in Coahuila. Burleigh and Lowery (1942:188) noted the Red-tailed Hawk on the higher ridges above an elevation of 6000 feet in southeastern Coahuila. On April 17, Burleigh and Lowery (*loc. cit.*) saw two Red-tailed Hawks "in the open valley south of Diamante Pass" and on April 20, "just outside of Saltillo," these workers obtained an immature male that was referred to *B. j. borealis*.

*****Buteo jamaicensis fuertesi* Sutton and Van Tyne.**—Miller (1955a:161) took a male Red-tailed Hawk, on April 14 at 7000 feet in the Sierra del Carmen, that was referred to as *B. j. fuertesi*. To my knowledge, there are no other records of this subspecies from Coahuila, but this must be the resident form over the bulk of western Coahuila.

There are several sight records of the Red-tailed Hawk. Olmstead saw one 16 mi. S Boquillas, 1600 feet, on March 6, 1952; Dickerman saw a Red-tailed Hawk 16 mi. E and 18 mi. N Ocampo on May 7, 1954, one 20 mi. S Ocampo on April 4, 1954; and an immature at Saltillo on January 17, 1954.

***Buteo platypterus platypterus* (Vieillot).**—*Specimen examined:* one, ♂ 32628, from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955.

The Broad-winged Hawk is rare in Coahuila. No. 32628, if a migrant, was retarded from moving northward by the loss of its right foot and distal one-third of its tarsus. Packard (1957:371) reported this specimen as the first record of the species in Coahuila.

****Buteo swainsoni* Bonaparte.**—*Specimens examined:* total 2: ♂ 32022 from 2 mi. W Jiménez, 850 ft., June 20, 1952; and ♂ 29555 from Iglesias (=15 mi. SW Sabinas), 1000 ft., August 22, 1949.

Swainson's Hawk is not common in Coahuila. The size of the testes (6x4 mm.) of No. 32022, the adult plumage, and the date (June 20) on which it was obtained suggest that it was a breeding bird. Friedmann, Griscom, and Moore (1950:55) reported that this species breeds as far east as Durango and Chihuahua. Findley saw a Swainson's Hawk 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952.

*****Buteo albonotatus* Kaup.**—The Zone-tailed Hawk is uncommon in Coahuila. Sutton and Burleigh (1939a:26) noted the species "a few miles west of Saltillo . . . on January 30."

Buteo regalis (Gray).—The Ferruginous Hawk is uncommon in Coahuila. Sutton and Burleigh (1939a:26) noted a single bird “not far from Parras, on January 30.”

Buteo nitidus (Latham).—Evenden (1952:112) saw a Gray Hawk one mile northeast of Saltillo, at Ramos Arizpe on March 4. Although there are no other records of the Gray Hawk from Coahuila, its occurrence in the State would be expected because this species has been recorded from Nuevo León and Tamaulipas in northeastern México (Friedmann, Griscom, and Moore, 1950:57).

***Parabuteo unicinctus harrisi* (Audubon).—Harris' Hawk is fairly common in southern Coahuila. Sutton and Burleigh (1939a:26) stated that Harris' Hawk “was one of the few birds noted repeatedly in . . . southern Coahuila. . . .”

Circus cyaneus (Linnaeus).—The Marsh Hawk is a common migrant and winter visitant in Coahuila. Miller (1955a:161) remarked that the Marsh Hawk was “seen in northward migratory flight across the desert east of the Sierra del Carmen on March 31 and on April 11 along the west face of Loomis Peak at 8800 feet.” Olmstead saw a female Marsh Hawk 1 mi. W San Buenaventura on April 2, 1952. Burleigh and Lowery (1942:188) noted the Marsh Hawk “about Saltillo” and “above the summit of Diamante Pass at about 8,000 feet” on April 14. Sutton and Burleigh (1939a:26) noted wintering Marsh Hawks “near San Pedro.”

Pandion haliaetus (Linnaeus).—Miller (1955a:161) reported seeing an Osprey on April 9 in Corte Madera Canyon, “apparently in migration;” this is the only record from Coahuila.

***Caracara cheriway* (Jacquin).—From the few records in the literature, I judge that the Caracara is uncommon in Coahuila. Evenden (1952:113) saw three Caracaras “south of Saltillo” on March 5. Baker saw a Caracara in the Sierra del Pino (=6 mi. NW Tanque Alvarez), 3400 feet, on July 6, 1953. No specimens of the Caracara have been taken from Coahuila.

Falco mexicanus Schlegel.—*Specimen examined*: one, ♂ 31596, from Saltillo, January 10, 1954.

The Prairie Falcon is an uncommon winter visitant in Coahuila. Friedmann, Griscom, and Moore (1950:65) indicated that *Falco mexicanus* winters south to Sonora, Oaxaca, Chihuahua, Durango, Zacatecas, Aguascalientes, Hidalgo, Nuevo León, and Tamaulipas.

No. 31596 is the first recorded specimen of the Prairie Falcon from Coahuila. The bird was heavily parasitized by worms in the mesenteries and seems to be an adult. Although its nuchal collar, as in immatures, is washed with pale cinnamon-buff, its thighs are not heavily marked with dark brown spots. The superciliary lines have blackish rather than brownish streaks, and the scapulars do not have four or five dark bars (Friedmann, 1950:624).

Falco columbarius bendirei Swann.—*Specimen examined*: one, ♂ 31634, from Don Martín Dam (=Río Salado), November 27, 1953, measurements: wing, 191 mm.; tail, 111 mm.; tarsus, 37 mm.; culmen, 12 mm.; testes, 3x1 mm.

The Pigeon Hawk seems to be uncommon in Coahuila. No. 31634, the first record of this species in Coahuila, has pale gray interspaces on the rectrices of its tail that are definitely wider than the three black bands, indicating affinity with *bendirei* (Friedmann, 1950:702). Our bird was obtained near the base of the Don Martín Dam of the Río Salado, and was observed hunting dragonflies over the water.

Falco sparverius sparverius Linnaeus.—*Specimen examined*: one, ♂ 31648, from the north foot of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6400 ft., April 17, 1953, weight, 104 gms.

The Sparrow Hawk is locally common in Coahuila. Miller (1955a:162) noted the species occasionally in the lower canyon areas of the Sierra del Carmen at 5000 feet from April 20 to 28. Dickerman saw two Sparrow Hawks in the Sierra del Pino on May 12, 1954. Sutton and Burleigh (1939a:27) took a male at La Rosa on January 30 that was typical for *F. s. sparverius*. Burleigh and Lowery (1942:188) noted Sparrow Hawks almost daily about Saltillo and infrequently in the open valley south of Diamante Pass; they took a female at Saltillo on April 22 that was assigned to *F. s. sparverius*.

**Colinus virginianus texanus* (Lawrence).—*Specimens examined*: total 9: ♂ 29408 and ♀ 29409 from 1 mi. S, 9 mi. W Villa Acuña, April 2, 1950, weights, 169.5 and 174.7 gms.; ♂ 29410 and ♀ 29411-29413 from 3 mi. W, 1 mi. S San Gerónimo, April 9, 1950, weights, 152.6, 158.6, 158.2, 159.0, and 152.8 gms.; and ♂ ♂ 32032-32034 from 9 mi. S, 11 mi. E Sabinas, 1050 ft., June 13 and 14, 1952.

The Bobwhite is locally common in northeastern Coahuila. Aldrich and Duvall (1955:18) indicated that *C. v. texanus* has been recorded from two separate localities in northeastern Coahuila and from several localities in Texas along the Rio Grande. Findley saw Bobwhites 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952. The specimens of Bobwhite from 3 mi. W and 1 mi. S San Gerónimo seem to extend the known range of *texanus* nearly 100 miles west. The sizes of the testes (11, 16, 15, 15 mm.) of Nos. 29408, 32032-32034, respectively, indicates breeding by the Bobwhite in Coahuila.

**Callipepla squamata pallida* Brewster.—*Specimens examined*: total 16: ♂ 29414 from 1 mi. S, 13 mi. W Villa Acuña, April 4, 1950; ♂ ♂ 29415-29417 from 11 mi. W Hacienda San Miguel, 2200 ft., April 4, 1950, weights, 205.3, 198.6, and 182.7 gms.; ♀ ♀ 31019-31021 from 10 mi. S, 5 mi. E Boquillas, 1500 ft., March 2 and 4, 1952, weights, 184.4, 180 and 154.2 gms.; ♂ 34454 from 2 mi. SSE Castillón, 4050 ft., June 29, 1953, weight, 169 gms.; ♂ 29418 and ♀ 29419 from 8 mi. N, 2 mi. E La Babia, April 8, 1950; ♂ ♂ 32023-32024, ♂ 32026, ♀ 32025, and ♀ 32027 from 5 mi. N, 19 mi. W Cuatro Ciénegas, 3250 ft., July 6, 1952; and ♂ 32640 from 2 mi. W Paila, July 3, 1955.

The Scaled Quail is common in Coahuila. The subspecies *pallida* occurs in northwestern Coahuila south to Sierra de los Alamitos. Intergrades of *pallida*, *castanogastris*, and *squamata* are present in the central part of the State. No. 32640, obtained 2 mi. W Paila, has some resemblance to *squamata*. Five specimens of *pallida* from the central part of Coahuila (5 mi. N and 19 mi. W Cuatro Ciénegas), show little or no approach toward *squamata*. Miller (1955a:162) stated that two of the Scaled Quail collected

in the Sierra del Carmen show no approach to the race *castanogastris* of eastern Coahuila nor to *C. s. squamata* of southern Coahuila. From the specimens that I have examined, I judge that the range of *pallida* extends as far south as the Sierra de los Alamitos rather than only to the northwestern part of Coahuila as reported by Aldrich and Duvall (1955:17). In north-eastern Coahuila *pallida* seems to intergrade with *castanogastris*; No. 29414 has an indistinct rusty chestnut patch on its abdomen, thus resembling *castanogastris*.

The sizes of the testes (9-12 mm.) and of the largest ova (14 mm. in diameter and an egg 23 mm. long) of birds labeled with reference to Cuatro Ciénegas indicate breeding activity.

*****Callipepla squamata castanogastris* Brewster.**—*Specimen examined*: one, ♂ 32028, from 9 mi. S, 11 mi. E Sabinas, June 14, 1952.

Typical representatives of *C. s. castanogastris* in Coahuila occur only in the extreme northeastern section of the State, and most specimens of the Scaled Quail from northeastern Coahuila are intergrades between *pallida* and *castanogastris*.

No. 32028 is identified as *C. s. castanogastris* because there is a distinct rusty chestnut patch on its abdomen. This patch, nevertheless, is not so large as in a more nearly typical male *C. s. castanogastris* from 15 mi. NNW Anahuac, Nuevo León.

*****Callipepla squamata squamata* (Vigors).**—*Specimens examined*: total 2: ♂ 32031 and ♀ 32032 from 10 mi. NW San Lorenzo, 4200 ft., February 3, 1951.

The subspecies *squamata* occurs in southern Coahuila. Amadon and Phillips (1947:577) took a Scaled Quail at Las Delicias on August 18 that "was only two-thirds grown, though well able to fly" and obtained an adult 19 mi. W Saltillo that was typical *squamata*. Burleigh and Lowery (1942:188) stated that *C. s. squamata* was one of the characteristic birds of the open desert country of southeastern Coahuila. Scaled Quail were seen by Burleigh and Lowery (*loc. cit.*) "about Saltillo and in the open valley south of Diamante Pass."

The breast and upper back of both specimens from 10 mi. NW San Lorenzo, are plumbeous-gray rather than pale dull gray. Also the lower back, rump, abdomen, forehead, and crown more closely resemble the subspecies *squamata* rather than *C. s. pallida*. However, the upper backs of both specimens are not so plumbeous-gray as on a male (32030) and a female (32031) of the subspecies *squamata* from 1 mi. N Chorro, Durango, 6450 ft., July 11, 1952. The two birds from Durango appear to be slightly darker than the Coahuilan specimens that approach the subspecies *pallida*.

Burleigh and Lowery (1942:188-189) stated that one of their specimens of *C. s. squamata* obtained at Saltillo seems to be "very close to *castanogastris*, suggesting that southeastern Coahuila is in the region of intergradation between the two races." Aldrich and Duvall (1955:17) indicated that *squamata* and *castanogastris* intergrade near Sabinas. The two specimens that I have examined show no sign of approach toward *castanogastris*. More specimens of Scaled Quail from Coahuila are needed to permit accurate definition of the distribution of the subspecies.

**Cyrtonyx montezumae mearnsi* Nelson.—The Harlequin Quail is locally common in Coahuila; *C. m. mearnsi* is present in northwestern Coahuila (Aldrich and Duvall, 1955:20). Miller (1955a:162) stated that an area in the head of Corte Madera Canyon of the Sierra del Carmen at 7500 feet was the principal location for *C. m. mearnsi*. He further suggested that the Harlequin Quail breeds in the Sierra del Carmen and remarked that Marsh took a male on September 7 at Jardín del Sur. He added that the occurrence of *C. m. montezumae* in northern Coahuila as reported by Friedmann, Griscom, and Moore (1950:79) is "possibly an error or was based on individual dark variants. . . ." Baker noted the Harlequin Quail (unidentified to subspecies) 9 mi. W and 1 mi. S Villa Acuña, 1120 feet, on April 4, 1950.

**Cyrtonyx montezumae montezumae* (Vigors).—This subspecies of the Harlequin Quail has been recorded from southeastern Coahuila. Ridgway and Friedmann (1946:396) listed *C. m. montezumae* from Saltillo. Baker saw a pair of Harlequin Quail (unidentified to subspecies) at San Antonio de las Alazanas on March 25, 1950. More collecting is necessary for an understanding of the distribution and intergradation of these subspecies in Coahuila.

**Meleagris gallopavo intermedia* Sennett.—*Specimens examined*: total 4: ♀ 31022 from Fortín (=33 mi. N, 8 mi. W San Gerónimo), 3300 ft., March 28, 1952, weight, 9 lbs.; ♀ 29420 from 3 mi. W, 1 mi. S San Gerónimo, April 9, 1950, weight, 7 lbs.; and ♂ 29421 and ♀ 29422 from 3 mi. W, 2 mi. S San Gerónimo, April 9, 1950, weights, 11.5 and 8.5 lbs.

The Turkey in Coahuila is restricted to the northern section of the State. Miller (1955a:162) remarked that the population of Turkeys in the Sierra del Carmen was sparse and did not range above 7500 feet into the highest pine-oak and Douglas fir areas. Baker saw Turkeys 4 mi. W Hacienda La Mariposa, 2300 feet, on March 23, 1952. William Schaldach, Jr., noted 30 Turkeys "just west of Rancho San Gerónimo" on April 9, 1950. Aldrich and Duvall (1955:22) indicated several localities in northern Coahuila where the Turkey occurs or occurred.

Grus canadensis (Linnaeus).—Sutton and Burleigh (1939a:28) remarked that a flock of Sandhill Cranes was heard "near Mayran . . . on January 30."

Porzana carolina (Linnaeus).—The Sora is an uncommon spring and fall migrant in Coahuila. Amadon and Phillips (1947:577) obtained an adult male Sora at Las Delicias on August 15.

Fulica americana Gmelin.—The American Coot probably occurs in the State as a spring and fall migrant. Dickerman saw two coots 8 mi. E and 2 mi. S Americanos on May 18, 1954.

**Charadrius vociferus vociferus* Linnaeus.—*Specimen examined*: one, ♂ 31023, from the Río Grande (=17 mi. S Dryden, Terrell Co., Texas, in Coahuila), 600 ft., March 19, 1952, weight, 82.7 gms.

In Coahuila the Killdeer seems to be uncommon. Van Tyne and Sutton (1937:28) remarked that it nested in Brewster County, Texas. The species probably nests in northern Coahuila as well; the lengths of the testes (left, 9 mm.; right, 4 mm.) of No. 31023 support this view.

Eupoda montana (Townsend).—Pitelka (1948:118) recorded one female Mountain Plover from Hipólito on February 23. Van Tyne and Sutton (1937:28) reported that the Mountain Plover nested in Brewster County, Texas. Possibly *Eupoda montana* nests in northern Coahuila as well.

Numenius americanus parvus Bishop.—*Specimens examined*: total 3: ♂ 31434 and ♀ 35406 (skeleton only) from 8 mi. E, 2 mi. S Americanos, May 19, 1954, measurements: wing, 250, 258 mm.; tail, 96, 100 mm.; tarsus, 74, 81.5 mm.; culmen, 11.2, 16.5 mm.; ♂ gonad, 6x2 mm.; and ♀ 35400 (skeleton only) from 7 mi. W San Antonio de las Alazanas, January 11, 1954.

The Long-billed Curlew is not common in Coahuila. Dickerman obtained both the specimens from 8 mi. E and 2 mi. S Americanos out of a flock of 35. Sutton and Burleigh (1939a:28) noted the Long-billed Curlew "near San Pedro . . . [on] January 29."

Actitis macularia (Linnaeus).—The Spotted Sandpiper has been obtained from two localities in Coahuila. Miller (1955a:162) stated that an immature in fall migration was taken "at the tank in the western hills" of the Sierra del Carmen on September 4. Burleigh and Lowery (1942:189) found the Spotted Sandpiper "at the Chorro del Agua near Arteaga" on April 17 and 19.

Totanus melanoleucus (Gmelin).—*Specimen examined*: one, ♀ 31024, from the Río Grande (=17 mi. S Dryden, Terrell Co., Texas, in Coahuila), 600 ft., March 18, 1952, weight, 224 gms.

The Greater Yellowlegs is an uncommon spring and probably fall migrant in Coahuila. No. 31024 is the first record of this species in Coahuila.

Totanus flavipes (Gmelin).—Miller (1955a:162) reported that Marsh took a Lesser Yellowlegs "at the tank in the western hills" of the Sierra del Carmen on September 4.

Erolia melanotos (Vieillot).—Miller (1955a:162) reported taking a Pectoral Sandpiper on September 4 "at the tank in the western hills" of the Sierra del Carmen.

[*Erolia minutilla* (Vieillot).—Friedmann, Griscom, and Moore (1950:99) listed the Least Sandpiper from Coahuila.]

**Recurvirostra americana* Gmelin.—*Specimens examined*: total 2: ♂ 31433 and ♀ 31432 from 8 mi. E, 2 mi. S Americanos, May 19, 1954.

Van Hoose (1955:302) reported a small breeding colony of American Avocets 8 mi. E and 2 mi. S Americanos "on a large grassy playa traversed by rows of creosote (*Larrea tridentata*)." No. 31432 was taken from a nest containing four partly-incubated eggs. Van Hoose (*loc. cit.*) also reported that four eggs in a second nest contained well-developed, downy young.

Steganopus tricolor Vieillot.—Wilson's Phalarope occurs in Coahuila as a spring and probably fall migrant. Van Tyne and Sutton (1937:31) saw the species several times along the Río Grande. Friedmann, Griscom, and Moore (1950:102) listed *Steganopus tricolor* from the Río Grande along the borders of Chihauhua and Coahuila on May 10-16.

[*Larus argentatus smithsonianus* Coues.—Friedmann, Griscom, and Moore (1950:104) listed this subspecies of the Herring Gull from the State.]

[*Larus delawarensis* Ord.—Friedmann, Griscom, and Moore (1950:103) stated that the Ring-billed Gull occurs in Coahuila.]

**Columba fasciata fasciata* Say.—*Specimens examined*: total 3: ♂ 35401 (skeleton only) from 22 mi. S and 5 mi. W Ocampo, 7000 ft., April 6, 1954; and ♂ 32035 and ♀ 32036 from 4 mi. N, 21 mi. W Cuatro Ciénegas, 6200 ft., July 2, 1952.

The Band-tailed Pigeon is locally common in Coahuila. Miller (1955a:162) remarked that the Band-tailed Pigeon "was unaccountably rare in 1953" in the Sierra del Carmen, and said that a specimen was taken on August 7 in Vivoras Canyon. Burleigh and Lowery (1942:189) wrote that "small flocks were seen each day . . . on the summit of Diamante Pass, but only on one occasion was a pair noted." Dickerman saw 10 Band-tailed Pigeons 20 mi. S Ocampo, 6000 feet, on April 4, 1954. The enlarged testes (17 mm.) of No. 32035, and an egg (38 mm. long) in No. 32036 show that the species breeds in central Coahuila.

**Zenaida asiatica asiatica* (Linnaeus).—*Specimen examined*: one, ♀ 31025 (skeleton only), from 10 mi. S and 5 mi. E Boquillas, 1500 ft., March 4, 1952.

Miller (1955a:163) took a male White-winged Dove on April 23 "at the mouth of Boquillas Canyon at about 4900 feet" and remarked that this bird might either be a straggler or a representative of a normal breeding population (*Z. a. asiatica*). On January 29 and 30, Sutton and Burleigh (1939a:29) saw White-winged Doves several times in southern Coahuila along the highway from Saltillo to San Pedro.

***Zenaida asiatica mearnsi* (Ridgway).—Amadon and Phillips (1947:577) obtained an adult White-winged Dove of this subspecies at Delicias on August 14.

Zenaidura macroura carolinensis (Linnaeus).—Friedmann, Griscom, and Moore (1950:117) listed this subspecies of the Mourning Dove as a spring and fall migrant on the "Central Plateau" (Coahuila is part of the "Central Plateau,"), "as proven by banding records not indicated in literature."

**Zenaidura macroura marginella* (Woodhouse).—*Specimen examined*: one, ♀ 34455, from 1 mi. W Jaco, June 27, 1953.

Miller (1955a:163) reported *Z. m. marginella* as occurring commonly in the desert border and lower canyons at the base of the mountains of the Sierra del Carmen, "but it occasionally ranged up to 6000 feet in openings in the pine-oak belt." Burleigh and Lowery (1942:189) remarked that this dove was fairly plentiful in the open desert country "about Saltillo, and was . . . noted in small numbers in Diamante Valley on April 17 and 19;" they also said that the Mourning Dove was not seen above an elevation of about 7500 feet. Sutton and Burleigh (1939a:29) observed Mourning Doves along the highway across southern Coahuila. Mourning Doves were seen by Findley 2 mi. W Jiménez, 850 feet, on June 19, 1952, and 2 mi. S and 11 mi. E Nava, 810 feet, on June 15, 1952. Dickerman saw one in the Sierra del Pino on May 12, 1954. Findley saw more than one 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952, as did Dickerman at San Marcos (=20 mi. S Cuatro Ciénegas) on May 4, 1954.

***Columbigallina passerina* (Linnaeus).—The Ground Dove seems to be uncommon in Coahuila. Van Tyne and Sutton (1937:34) saw a single Ground Dove fly across the Río Grande into Coahuila at Lajitas, Texas, on May 10. Findley saw one 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952.

***Scardafella inca* (Lesson).—The Inca Dove has been recorded from two localities in Coahuila. Hellmayr and Conover (1942:510) listed it from Sabinas. Burleigh and Lowery (1942:189) collected a male and female on April 16 and 19, respectively, "outside the city limits of Saltillo."

Leptotila verreauxi angelica Bangs and Penard.—*Specimens examined*: total 2: ♂♂ 31026-31027 (skeletons only) from 4 mi. W Hacienda La Mariposa, 2300 ft., March 25, 1952.

The White-fronted Dove seems to be uncommon in Coahuila. Hellmayr and Conover (1942:570) listed *L. v. angelica* from Sabinas.

***Rhynchopsitta pachyrhyncha terrisi* Moore.—*Specimens examined*: total 4: ♂♂ 31531-31532 from 13 mi. E San Antonio de las Alazanas, 9345 ft., April 10, 1954, weights, 391.5 and 467.5 gms.; ♀ 31533 from 13 mi. E San Antonio de las Alazanas, 10,000 ft., April 10, 1954, weight, 466 gms.; and sex ? 31534 from Mesa de las Tablas, June, 1951.

The Thick-billed Parrot occurs in the southeastern section of the State, where it is fairly common. Moore (1947:27-28) described this parrot as *Rhynchopsitta terrisi*; he thought it differed decidedly from *Rhynchopsitta pachyrhyncha*. However, Hardy and Dickerman (1955:305-306) decided that uniting the two forms as a single species better expresses their relationship.

Burleigh and Lowery (1942:189) reported seeing a small flock of Thick-billed Parrots on the summit of Diamante Pass. Dickerman, in his field notes, wrote that at a place 13 mi. E San Antonio de las Alazanas, 9345 feet, a large flock of about 300 birds was in a spruce-fir-pine-aspen association.

**Coccyzus americanus americanus* (Linnaeus).—*Specimens examined*: total 2: ♂♂ 32037-32038 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952, measurements: wing, 141, 146 mm.; tail, 142, 149 mm.; tarsus, 27, 27 mm.; culmen, 25, 24 mm.

In Coahuila, the Yellow-billed Cuckoo seems to be uncommon. It occurs in the northeastern section of the State, in the Gulf Coastal Plain (Baker, 1956:128), and probably breeds there. One subspecies, *americanus*, has been recorded from Coahuila.

According to Ridgway (1916:13-17) the difference between *C. a. americanus* and *C. a. occidentalis* is size. His (*loc. cit.*) average measurements of males of *occidentalis* are: wing, 149.6 mm.; tail, 147.1 mm.; tarsus, 26.7 mm.; and culmen, 27.7 mm. whereas average measurements given by him of males of *americanus* are: wing, 143.6 mm.; tail, 140.7 mm.; tarsus, 25.2 mm.; and culmen, 26.4 mm. Van Tyne and Sutton (1937:35) question the value of maintaining the subspecies *occidentalis*, because individuals of *americanus* and *occidentalis* are almost impossible to tell apart. Friedmann, Griscom, and Moore (1950:132) stated that *americanus* occurs in eastern North America whereas *occidentalis* occurs in western North America. If the subspecies *occidentalis* exists, then Nos. 32037 and 32038 are, by size, *americanus* and

No. 32038 is an intergrade between the two subspecies (or a large individual of *americanus*).

The Yellow-billed Cuckoo was seen also by Findley 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952, and by Dickerson at Torreón on July 2, 1955. The sizes of the testes of the birds from 12 mi. N and 12 mi. W Jiménez (9, 10 mm. long) and the date (June 19) on which they occurred there indicate that the birds possibly were breeding.

Coccyzus erythrophthalmus (Wilson).—Miller (1955a:163) reported a migrant Black-billed Cuckoo taken in the maples and basswood near a water hole in the bottom of Boquillas Canyon in the Sierra del Carmen, 5200 feet, on April 22. Friedmann, Griscom, and Moore (1950:132) reported that this cuckoo is presumably a regular transient in México, but generally overlooked.

**Geococcyx californianus* (Lesson).—*Specimen examined*: one, ♀ 32049, from 8 mi. N, 2 mi. W Piedras Negras, June 18, 1952.

Miller (1955a:163) heard several Roadrunners calling at Boquillas Canyon in the Sierra del Carmen, where he obtained two females. Burleigh and Lowery (1942:190) stated that the species proved to be "unexpectedly scarce" and was noted but once by them on April 22 when a single bird was observed in "the open desert west of Saltillo." Sutton and Burleigh (1939a:30) noted that the Roadrunner was not common anywhere in southern Coahuila; they obtained one female at San Pedro on January 29. The size of the largest ovum (15 mm. in diameter) of No. 32040 indicates that this species breeds in Coahuila.

**Crotophaga sulcirostris sulcirostris* Swainson.—*Specimen examined*: one, ♀ 32039, from 2 mi. S, 3 mi. E San Juan de Sabinas, June 22, 1952.

No. 32039, obtained by Harrison B. Tordoff in a cypress woods along the shore of a lagoon, provides the first record of the Groove-billed Ani in Coahuila. The size of its largest ovum (10 mm. in diameter) and the date indicate breeding by this species in Coahuila.

***Tyto alba pratincola* (Bonaparte).—The Barn Owl seems to be uncommon in Coahuila. To my knowledge, there are two records of the Barn Owl in Coahuila. Ridgway (1914:607) recorded this owl at the "head of Las Vacas Creek." Miller (1955a:163) heard the Barn Owl at 5000 feet in the oak belt on April 25 in the Sierra del Carmen.

**Otus asio suttoni* Moore.—*O. a. suttoni* is found in the higher country of the Sierra del Carmen and western Coahuila. Miller (1955a:163) stated that Screech Owls were common in groves of oaks both at 7000 feet and 5000 feet in the Sierra del Carmen, and remarked that his series from the Sierra del Carmen matched well a series of *suttoni* from Chihuahua and Durango. Miller (1955a:163-164) also stated that Marsh took an adult at Jardín del Sur on August 28 and said that the specimen from the Sierra del Carmen referred to as *cineraceus* by Marsh and Stevenson (1938:286) agreed well with his series of *suttoni*. *O. a. suttoni* probably occurs no farther east than the Sierra del Carmen.

***Otus asio mcallii* (Cassin).—*Specimens examined*: total 2: ♂ 32041 from 2 mi. W Jiménez, 850 ft., June 20, 1952; and sex ? 31645 from La Gacha, 1600 ft., December 9, 1953.

Three subspecies of the Screech Owl, *Otus asio*, occur in northeastern México; two of these, *suttoni* and *mcallii*, occur in Coahuila, the latter in the eastern part. The third subspecies, *O. a. semplei*, occurs still farther east, for example in the state of Nuevo León on the Mesa del Chipinque 6 miles south of Monterrey (Sutton and Burleigh, 1939b:174).

Nos. 31645 and 32041 differ from *semplei* in that the tops of their heads do not appear to be solid blackish brown at a distance of four to five feet and in that the dark streakings of their backs and scapulars are not so heavy as in *semplei*. The mentioned specimens are brownish, not more black and white throughout as in *suttoni* nor are their toes heavily feathered (see Moore, 1941:154).

Findley observed a Screech Owl 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952. La Gacha would seem to represent the western extent of *mcallii* in Coahuila. *O. a. mcallii* and *suttoni* probably intergrade along the eastern slope of the Sierra del Carmen. Tordoff took No. 32041 near a tree that contained three young Screech Owls.

**Otus flammeolus flammeolus* (Kaup).—*Specimens examined*: total 2: ♂ 31600 from 20 mi. S Ocampo, 6000 ft., April 4, 1954; and ♂ 31581 from 13 mi. E San Antonio de las Alazanas, 9345 ft., April 9, 1954.

Miller (1955a:163) collected seven Flammulated Owls in the pines and oaks at 7000 feet in Carboneras Canyon and said that these owls were common there. Nos. 31600 and 31581 are suffused with cinnamoneous pigmentation, but represent the grayish phase, as described by Ridgway (1914:729). Van Hoose (1955:302) previously recorded Nos. 31600 and 31581 from Coahuila.

**Bubo virginianus pallescens* Stone.—*Specimens examined*: total 2: ♀ 32042 from 2 mi. S, 12 mi. E Nava, June 15, 1952; measurements: wing, 367 mm.; tail, 233 mm.; culmen, 29 mm.; and ♂ 31677 from 1.5 mi. NE Las Margaritas, 3100 ft., May 31, 1954; measurements: wing, 345 mm.; tail, 213 mm.; culmen, 26 mm.; testes, 8 mm. long.

Miller (1955a:164) took a male Great Horned Owl in the Sierra del Carmen on April 22. Ridgway (1914:742) listed *B. v. pallescens* from Sabinas. Sutton and Burleigh (1939a:30) obtained a female "near San Pedro" on January 29. Friedmann, Griscom, and Moore (1950:143) recorded *B. v. pallescens* from Coahuila on February 24, May 26, and June 10. The record of *B. v. mayensis* from Las Delicias (Amadon and Phillips, 1947:578) has been reidentified by Webster and Orr (1958:141) as *B. v. pallescens*. Dickerman saw a Great Horned Owl in the Sierra del Pino on May 12, 1954.

**Glaucidium gnoma californicum* Sclater.—*Specimen examined*: one, ♂ 31582, from 20 mi. S Ocampo, 6500 ft., April 5, 1954, weight, 55 gms.

Concerning forms of Pygmy Owls, Miller (1955a:164) remarked that the best distinguishing characters of *G. g. gnoma* and *californicum* are tail length and wing length. The characters of No. 31582 (wing, 94 mm.; tail, 69 mm.) are clearly those of *californicum* and not those of *gnoma*. Miller (*loc. cit.*) remarked that he "encountered at least five different individuals, chiefly in the pine-oak at 7000 feet" and one in oaks and pifions at 5000 feet in Bo-

quillas Canyon of the Sierra del Carmen. The size of the testes (left, 9x5 mm.; right, 7x4 mm.) of No. 31582 indicates good probability of breeding by the Pygmy Owl in the State.

***Micrathene whitneyi* (Cooper).—Miller (1955a:164) heard the Elf Owl at close range in oaks at 5000 feet in Boquillas Canyon of the Sierra del Carmen on April 24.

***Speotyto cunicularia hypugaea* (Bonaparte).—*Specimens examined*: total 3: ♀ 32043 from 3 mi. S, 9 mi. E Cuatro Ciénegas, 2250 ft., June 30, 1952; ♂ 32653 from 6 mi. W San Antonio de las Alazanas, July 5, 1955; and ♂ 31602 from 14 mi. W San Antonio de las Alazanas, 6500 ft., January 7, 1954.

Although there are no records in Coahuila of specimens of Burrowing Owls north of 3 mi. S and 9 mi. E Cuatro Ciénegas, this owl probably occurs in the northern section of the State. The records of Burrowing Owls from the southern part of Brewster County, Texas (Van Tyne and Sutton, 1937:38), suggest such occurrence. No. 31602 was shot in a prairie dog colony; No. 32043 was captured in a steel trap. Baker saw Burrowing Owls 7 mi. S and 4 mi. E Bella Unión, 7200 feet, on June 25, 1952.

**Caprimulgus vociferus arizonae* (Brewster).—*Specimens examined*: total 4: ♂ 31449 and ♀ 31450 from Sierra del Pino (=5 mi. S, 3 mi. W Acebuches), May 12 and 15, 1954, weights, 48 and 42 gms.; and ♂ ♂ 31028-31029 from 2 mi. N, 18 mi. W Santa Teresa, 7250 ft., April 3, 1952.

The Whip-poor-will occurs between 5000 feet and 9000 feet in Coahuila. Miller (1955a:164) reported *C. v. arizonae* in the Sierra del Carmen. Ridgway (1914:521) stated that *Antrostomus vociferus macromystax* (= *C. v. arizonae*) occurs in the southeastern sector of Coahuila at Sierra Guadalupe. Burleigh and Lowery (1942:190) reported the Whip-poor-will "near the summit of Diamante Pass"; because of its size (wing, 170 mm.; tail, 135 mm.) this Whip-poor-will from Diamante Pass seems to represent the subspecies *arizonae*. Dickerman saw four Whip-poor-wills 20 mi. S Ocampo, 6000 feet, on April 4, 1954. The sizes of the testes of Nos. 31449, 31028, and 31029 (13, 12, and 13 mm. long) and an egg taken from No. 31450 indicate breeding by this species in the State.

**Phalaenoptilus nuttallii nuttallii* (Audubon).—*Specimens examined*: total 6: ♂ 31032 from 37 mi. S, 21 mi. E Boquillas, 4100 ft., March 12, 1952; ♂ 31446 and ♀ 31447 from Sierra del Pino (=5 mi. S, 3 mi. W Acebuches), 6200 ft., May 13, 1954; ♂ ♂ 32048-32049 from 2 mi. S, 11 mi. E Nava, June 16, 1952; and ♀ 31033 from 4 mi. W Hacienda La Mariposa, 2300 ft., March 26, 1952.

Miller (1955a:164) found the Poor-will common along the rocky canyon walls up to 5000 feet in the Sierra del Carmen. Ridgway (1914:550) recorded the Poor-will at Sabinas on May 21 and at Saltillo on May 6. Van Tyne and Sutton (1937:39) stated that *P. n. nuttallii* was not common in the Big Bend Country of Texas; this probably is true for northwestern Coahuila as well. The specimens from the Sierra del Pino, collected by Dickerman in a pine-oak association at 6200 feet, were taken near the upper limit of their range. Findley saw Poor-wills 2 mi. W Jiménez, 850 feet, on June 19, 1952; 2 mi. S and 11 mi. E Nava, 810 feet, on June 15, 1952; and 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952.

Dickerman noted Poor-wills 16 mi. E and 18 mi. N Ocampo on May 7, 1954, and 20 mi. S Ocampo, 6000 feet, on April 4, 1954.

The size of the testes (9x5 mm.) of No. 31446 and an enlarged oviduct and an ovum (4 mm. in diameter) of No. 31447 indicate breeding by the Poor-will in Coahuila.

***Chordeiles minor howelli* Oberholser.—*Specimen examined*: one, ♂ 31443, from 3 mi. N, 4 mi. E San Francisco (=25 mi. N Ocampo), 4850 ft., May 16, 1954.

Van Hoose (1955:302) wrote that nighthawks were heard and seen frequently 3 mi. N and 4 mi. E San Francisco. Blake (1953:227) said that the Common Nighthawk breeds in Sonora, Chihuahua, Tamaulipas, and Durango; the size of the testes (7x4.5 mm.) of No. 31443 indicates the possibility of breeding by this species in the State.

**Chordeiles acutipennis texensis* Lawrence.—*Specimens examined*: total 4: ♂ 32044 and ♀ 32045 from 2 mi. W Jiménez, 850 ft., June 20, 1952; ♀ 31442 from 5 mi. N, 13 mi. E Ocampo, May 6, 1954; and ♂ 32046 from 2 mi. N, 1 mi. W Ocampo, 4050 ft., July 6, 1952.

Specimens of the Lesser Nighthawk, subspecies *C. a. texensis*, have been recorded in the literature from representative localities throughout most of Coahuila. Burleigh and Lowery (1942:190-191) obtained, on April 18, at "a small pond at the edge of Saltillo," one male that was exceedingly fat; they (*loc. cit.*) suggested that their specimen was a migrant. Goldman (1951:377, 389) stated that *C. a. texensis* occupied the Lower and Upper Sonoran and Upper Austral life-zones of Coahuila. Dickerman saw Lesser Nighthawks at San Marcos (=20 mi. S Cuatro Ciénegas) on May 4, 1954. Van Tyne and Sutton (1937:41) reported that the Lesser Nighthawk was common throughout the lower parts of the Big Bend in Texas. This is probably true for northwestern Coahuila as well.

The presence of an egg in the oviduct of No. 32045 and the dates (May 6, June 20, and July 6) on which Nos. 31442, and 32044-32046 were obtained indicate breeding by this species in Coahuila.

***Aëronautes saxatalis saxatalis* (Woodhouse).—*Specimen examined*: one, ♂ 31672, from Pico de Jimulco, 5600 ft., April 5, 1953, weight, 35 gms.

Burleigh and Lowery (1942:191) found the White-throated Swift to be common at "the summit of Diamante Pass and on the nearby ridges." Miller (1955a:164) saw the species from 4800 feet up to the crest of the Sierra del Carmen. Several White-throated Swifts were seen flying overhead at Pico de Jimulco on April 5.

No specimens of *A. s. sclateri* from México are known. Miller (1955a:165) listed one specimen with dimensions (wing, 145 mm.) that approaches *sclateri*. The measurements of No. 31672 (wing, 143 mm.; tail, 58 mm.) also approach the dimensions of specimens of *sclateri* but are best referred to *A. s. saxatalis*.

***Calothorax lucifer* (Swainson).—Burleigh and Lowery (1942:191) obtained a male Lucifer Hummingbird at the Chorro del Agua on April 19. Van Tyne and Sutton (1937:43) reported a male from the Río Grande (=3 mi. W Boquillas, Texas).

Archilochus colubris (Linnaeus).—Friedmann, Griscom, and Moore (1950:180) remarked that the Ruby-throated Hummingbird is a moderately common migrant, wintering from sea level to 9350 feet throughout México, except in a few states. The only published record of a specimen of this hummer in the State is of a male taken on April 22 in a small arroyo twenty miles west of Saltillo (Burleigh and Lowery, 1942:191).

**Archilochus alexandri* (Bourcier and Mulsant).—*Specimens examined*: total 2: ♂ 31035 from the Río Grande (=17 mi. S Dryden, Terrell County, Texas, in Coahuila), 600 ft., March 18, 1952; and ♂ 32052 from 2 mi. S, 11 mi. E Nava, 810 ft., June 16, 1952.

Miller (1955a:165) stated the Black-chinned Hummingbird was common in the desert area at the base of the mountains of the Sierra del Carmen, and that Marsh, on July 25, obtained this hummingbird "near Piedra Blanca (Conejo)." Burleigh and Lowery (1942:191) obtained a female in an arroyo about twenty miles west of Saltillo on April 22.

***Selasphorus platycercus platycercus* (Swainson).—*Specimens examined*: total 2: ♂ 31583 from 20 mi. S Ocampo, 6500 ft., April 4, 1954; and ♀ 32673 from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955.

Miller (1955a:165) indicated that the Broad-tailed Hummingbird was fairly common in the Sierra del Carmen. According to Burleigh and Lowery (1942:191) this species is not uncommon in the pine woods bordering the summit of Diamante Pass; they saw the bird between 4900 and 10,000 feet.

**Eugenes fulgens fulgens* Boucard.—Miller (1955a:165) obtained a male Rivoli's Hummingbird on Loomis Peak, 8800 feet, on April 11 in the Sierra del Carmen.

***Lampornis clemenciae clemenciae* (Lesson).—*Specimens examined*: total 2: ♂ 31036 from 26 mi. W Santa Teresa, 7050 ft., April 5, 1952; and ♀ 32668 from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955.

The Blue-throated Hummingbird occurs between 5000 and 9950 feet in Coahuila. Miller (1955a:165) remarked that it was found in canyon bottoms, "whether at 7500 feet among the rocky slopes, oaks, and white pines . . . or at 5000 feet in the madrone, maples, elms, and basswoods. . . ." No. 32668, was obtained in a Douglas fir-pine-aspen association at 9950 feet.

[*Amazilia yucatanensis chalconota* Oberholser.—The Buff-bellied Hummingbird seems to be uncommon in Coahuila. Friedmann, Griscom, and Moore (1950:172) and the AOU Check-list Committee (1957:306) stated that this hummingbird occurs in Coahuila.]

Megaceryle alcyon alcyon (Linnaeus).—Miller (1955a:165) saw a Belted Kingfisher at Carboneras Canyon in the Sierra del Carmen. Miller, Friedmann, Griscom, and Moore (1957:15) stated that one specimen of *M. a. alcyon* was obtained in Coahuila on November 14.

***Chloroceryle americana hachisukai* (Laubmann).—*Specimens examined*: total 2: ♀ 32053 from 12 mi. N, 12 mi. W Jiménez, June 19, 1952; and ♀ 31038 from 8 mi. N, 4 mi. W Múzquiz, 1800 ft., March 31, 1952.

The Green Kingfisher has been recorded in Coahuila as far south as 8 mi. N and 4 mi. W Múzquiz. The forehead of No. 31038, when compared with

typical representatives of *C. a. hachisukai*, is not extensively streaked with white, nor are all the coverts conspicuously spotted with white, yet it clearly has more extensive white markings than typical representatives of *C. a. septentrionalis*. This specimen from 8 mi. N and 4 mi. W Múzquiz probably is intermediate between *hachisukai* and *septentrionalis*. Miller (1955a:165) stated that Marsh took a specimen at Tanque de los Melones on La Bavia Ranch east of Fresno Mesa in the Sierra del Carmen that is a typical *C. a. hachisukai*.

Colaptes cafer collaris Vigors.—Ridgway (1914:34) listed this subspecies of the Red-shafted Flicker from Saltillo and Agua Nueva.

**Colaptes cafer nanus* Griscom.—*Specimens examined*: total 3: ♀ 31463 from Sierra del Pino (=5 mi. W, 3 mi. S Acebuches), May 13, 1954, weight, 108 gms.; and ♂ 31651 and ♀ 31652 from the north foot of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6500 ft., April 21, 1953.

In suitable habitats in Coahuila the Red-shafted Flicker is common. Miller (1955a:165-166) stated that *C. c. nanus* was common at Corte Madera Canyon, Boquillas Canyon, and Carboneras Canyon in the Sierra del Carmen and recorded a specimen also from Sierra de Jardín on August 7. Burleigh and Lowery (1942:192) recorded *C. c. nanus* from Diamante Pass and Saltillo. Sutton and Burleigh (1939a:31) stated that the Red-shafted Flickers, obtained 5 mi. E La Rosa and at Diamante Pass, may be intermediate between *C. c. collaris* (then called *C. c. chihuahuae*) and *C. c. nanus*. Nesting of the Red-shafted Flicker in Coahuila was reported by Miller (1955a:165) and Burleigh and Lowery (1942:192). Hardy saw Red-shafted Flickers 13 mi. E San Antonio de las Alazanas on July 6, 1955.

**Centurus aurifrons aurifrons* (Wagler).—*Specimens examined*: total 6: ♂ 32054 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; ♀ ♀ 32055-32057 from 2 mi. W Jiménez, 850 ft., June 20, 1952; ♀ 31039 from 8 mi. N, 4 mi. W Múzquiz, 1800 ft., April 1, 1952; and ♂ 33150 (skeleton only) from Parras, July 4, 1955.

The Golden-fronted Woodpecker occurs throughout Coahuila, but uncommonly in the western part. Wetmore (1948:185-186) examined a series of Golden-fronted Woodpeckers that showed a definite cline in dorsal coloration from north-central Texas to Jalisco, Michoacán, and Hidalgo in south-central México. He (*loc. cit.*) stated that "the extremes are easily separable, but in southern and southwestern Texas and in northeastern Mexico the two kinds [*C. a. aurifrons* and *C. a. incanescens*] . . . merge so gradually that over a broad area the whole population is intermediate, making decisions as to any sharply drawn dividing line difficult and in part arbitrary." *C. a. incanescens*, according to Wetmore, occurs in western and central Texas south to northeastern Chihuahua and northern Coahuila whereas *C. a. aurifrons* occurs in north-central Coahuila (Monclova) and southern Texas south to Jalisco, Michoacán, Hidalgo, and central Tamaulipas.

The specimens that I have examined from Coahuila are variably intermediate between the subspecies *aurifrons* and *incanescens*. The dark and white cross-bars on the back of No. 31039 are nearly equal (dark bands wider in *aurifrons*; white bands wider in *incanescens*); the rump and upper tail coverts are more or less mixed with black as in *aurifrons*. The dark

cross-bars on the backs of Nos. 32054-32057 are slightly larger than the white cross-bars; the rump and upper tail coverts of these specimens are somewhat mixed with black.

**Centurus aurifrons incanescens* Todd.—This subspecies of the Golden-fronted Woodpecker is listed by Miller, Friedmann, Griscom, and Moore (1957:34) from “. . . northern Coahuila (upper Río Grande valley).” Burleigh and Lowery (1942:192) stated that the Golden-fronted Woodpecker “apparently avoids the mountain slopes, but was found to be not uncommon on the arid plateau about Saltillo.” Findley saw Golden-fronted Woodpeckers 2 mi. W Jiménez, 850 feet, on June 19, 1952; and 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952. Cory (1919:424) listed the Golden-fronted Woodpecker from Sabinas. Nos. 32055-32057 are juveniles, and thus document breeding by this woodpecker in Coahuila.

**Melanerpes formicivorus formicivorus* (Swainson).—*Specimens examined*: total 5: ♂ 31040 (skeleton only) from Fortín (=33 mi. N, 8 mi. W San Gerónimo), 3300 ft., March 28, 1952; ♂ 29423 and ♀ 29424 from Club Sierra del Carmen (=2 mi. N, 6 mi. W Piedra Blanca), 4950 ft., April 8, 1950; ♀ 31041 (skeleton only) from 26 mi. W Santa Teresa, 7050 ft., April 5, 1952; and ♀ 31668 from Sierra Guadalupe, Cañon d. Meco (=10 mi. S General Cepeda), 6500 ft., April 23, 1953.

The Acorn Woodpecker in Coahuila is common in the oak and pine-oak belts, from 4950 to 8000 feet. Miller (1955a:166) stated that the Acorn Woodpecker in the Sierra del Carmen was an abundant and conspicuous bird throughout the oak and pine-oak belts, from 5000 to 8000 feet. Dickerman saw two Acorn Woodpeckers in the Sierra de la Madera on December 13, 1953, and four 20 mi. S Ocampo, 6000 feet, on April 4, 1954. Breeding of *M. f. formicivorus* was reported by Miller (*loc. cit.*) who took females nearly ready to begin laying; one of our specimens (No. 29423) had enlarged testes (11 mm.).

Sphyrapicus varius varius (Linnaeus).—*Specimen examined*: one, ♀ 31649, from the north foot of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6400 ft., April 19, 1953.

Miller (1955a:166) reported this Yellow-bellied Sapsucker as a winter visitant or migrant in the Sierra del Carmen. Burleigh and Lowery (1942:192) took a female *S. v. varius* at the summit of Diamante Pass on April 14. Ridgway (1914:275) listed *S. v. varius* from Sierra de Guadalupe.

Sphyrapicus varius nuchalis Baird.—Miller (1955a:166) reported this Yellow-bellied Sapsucker as “indeed common” in the Sierra del Carmen, and indicated that both *S. v. nuchalis* and *S. v. varius* were “found only at the upper levels in the pine-oak formation and usually in relatively dense clumps of trees in the canyon bottoms.” Ridgway (1914:280) listed *C. v. nuchalis* from Río Sabinas.

***Dendrocopos villosus icastus* (Oberholser).—Miller, Friedmann, Griscom, and Moore (1957:39) remarked that this subspecies of the Hairy Woodpecker occurs, in northwestern México, from eastern Sonora, Jalisco, Chihuahua, Durango, Zacatecas to southern Coahuila. Ridgway (1914:222) stated that *D. v. icastus* occurs in Coahuila at Carneros and Sierra de Guadalupe, the former being the easternmost known locality for the subspecies.

***Dendrocopos villosus intermedius* (Nelson).—*Specimens examined*: total 2: ♂ 32701 from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955; and ♀ 31604 from 2 mi. E Mesa de Tablas, 8500 ft., January 15, 1954.

In northeastern México this subspecies, according to Miller, Friedmann, Griscom, and Moore (1957:39), occurs in Guanajuato, San Luis Potosí, Hidalgo, Nuevo León, and Tamaulipas. Nos. 31604 and 32701 represent the first records of *D. v. intermedius* from Coahuila.

**Dendrocopos scalaris cactophilus* (Oberholser).—*Specimens examined*: total 2: ♀ 31042 from 7 mi. S, 2 mi. E Boquillas, 800 ft., March 1, 1952; and ♀ 31043 from 10 mi. S, 5 mi. E Boquillas, 1500 ft., March 3, 1952.

These specimens of the Ladder-backed Woodpecker show signs of intergradation with *D. s. symplectus*. Both specimens are pale enough above for *D. s. symplectus*, but the wing and the tail of each (wing, 102, 103 mm.; tail, 60, 65 mm.) are too long for *symplectus*. This suggestion of intergradation is not unexpected because *symplectus* occurs in northeastern Coahuila and *cactophilus* in the Chisos Mountains of Texas. Miller (1955a:166) also obtained one female *D. s. cactophilus* from the Sierra del Carmen that suggested intergradation with *symplectus*.

Miller (*loc. cit.*) wrote that *D. c. cactophilus* was found chiefly in the oaks and was common in the lower oak belt at 5000 feet. The upper limit of the range of the Ladder-backed Woodpecker, according to Miller, is 6800 feet. He reported the species as breeding in the Sierra del Carmen.

Miller (1955b:317) took a hybrid woodpecker representing a cross between *Dendrocopos villosus* and *Dendrocopos scalaris* in the Sierra del Carmen, where, although Ladder-backed Woodpeckers were common, he found no Hairy Woodpeckers.

***Dendrocopos scalaris symplectus* (Oberholser).—*Specimens examined*: total 2: ♂ 32058 from 2 mi. W Jiménez, June 20, 1952; and ♂ 31667 from Sierra Guadalupe, Domingo Canyon (=10 mi. S, 14 mi. W General Cepeda), 6700 ft., April 18, 1953.

This Ladder-backed Woodpecker, according to the AOU Check-list Committee (1957:327) and Oberholser (1912:156), occurs in Texas (east of Pecos), northeastern Coahuila, Nuevo León, and Tamaulipas. The area of intergradation of *D. s. symplectus* and *giraudi* is in southeastern Coahuila. The dark smoky underparts and the equal size of the white and black bars of the upper parts of No. 31667 suggest intergradation with *D. s. giraudi*. Yet, the size of the wing indicates that this specimen is closer to *D. s. symplectus*. No. 32058 has characters of typical representatives of *D. s. symplectus*. Burleigh and Lowery (1942:193) reported *D. s. symplectus* "in the desert country west of Saltillo." Ridgway (1914:257) listed the Ladder-backed Woodpecker from Sabinas. Cory (1919:494) listed *D. s. symplectus* from Pabinas (=Sabinas?).

***Dendrocopos scalaris giraudi* (Stone).—*Specimen examined*: one, ♂ 34623, from 12 mi. N, 10 mi. E Parras, 3850 ft., July 12, 1953, weight, 35 gms.

Ridgway (1914:259) reported that *D. s. giraudi* (then called *Dryobates scalaris bairdi*) has been recorded from La Ventura, Carneros, and Jaral. Oberholser (1912:159) indicated that the subspecies *giraudi* occurs north to Jaral in southern Coahuila, east to La Ventura in southeastern Coahuila, and south through central México. The present specimen is darker ventrally

than specimens of either *D. s. cactophilus* or *D. s. symplectus*, and on its upper surface the black bars are wider than the white. The specimen is in worn plumage, but nevertheless suggests intergradation with *D. s. symplectus*.

Platypsaris aglaiae albiventris (Lawrence).—The Rose-throated Becard, if it occurs in Coahuila at all, is rare in the State. Without giving any specific locality, Sclater (1857:74) described *Pachyrhamphus aglaiae* from Coahuila. Hellmayr (1929:202) considered Sclater's record as representing *Platypsaris aglaiae albiventris* (Lawrence).

**Tyrannus vociferans vociferans* Swainson.—*Specimens examined*: total 2: ♂ 32064 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 24, 1952; and ♀ 31650 from the north foot of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6400 ft., April 15, 1953.

The small number of records of Cassin's Kingbird in Coahuila is surprising, for I would expect the species in most areas of the State between 6000 and 7000 feet. All Coahuilan records are from the southeastern part of the State. Burleigh and Lowery (1942:193) found it "on infrequent occasions in the arid country near Saltillo." Miller, Friedmann, Griscom, and Moore (1957:71) reported that *T. v. vociferans* nested in Coahuila on July 7. The size of the testes (15x7 mm.) of our specimen from near Bella Unión also indicates breeding.

***Muscivora forficata* (Gmelin).—*Specimen examined*: one, ♀ 32063, from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952.

The status of the Scissor-tailed Flycatcher in Coahuila is uncertain. Although the condition of the gonads of No. 32063 was not recorded by the collector, the late date (June 19) on which it was obtained suggests that this female was a resident in northeastern Coahuila. Findley saw a Scissor-tailed Flycatcher 2 mi. S and 11 mi. E Nava, 810 feet, on June 15, 1952. Dickerman saw one 4 mi. N San Isidro on May 10, 1954. Miller, Friedmann, Griscom, and Moore (1957:69) recorded this flycatcher from Sabinas on April 12. No other records of *Muscivora forficata* in Coahuila have come to my attention, but the species probably occurs in the State in migration.

**Myiarchus crinitus crinitus* (Linnaeus).—*Specimens examined*: total 3: ♀ 32065 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; and ♂ 32066 and ♀ 32067 from 2 mi. W Jiménez, 850 ft., June 20, 1952.

The Great Crested Flycatcher seems to be rare in Coahuila. Nos. 32065-32067 are the first specimens that I know of from Coahuila. Bangs (1898: 179-180) said that the subspecies *crinitus* has an "enormous swollen bill" (exposed culmen of male, 20 mm.; breadth of bill at middle of nostril, 10.3 mm.) whereas *M. c. boreus* has a "small slender bill" (exposed culmen of male, 18.6 mm.; breadth of bill at middle of nostril, 8.6 mm.). No. 32066 has a large bill (exposed culmen, 21 mm.; breadth of bill at middle of nostril, 10 mm.). Bangs (*loc. cit.*) did not give any measurements for females of *M. c. crinitus* or *boreus*. Nevertheless, I suspect that Nos. 32065 and 32067 represent *crinitus* (No. 32065: exposed culmen, 19 mm.; breadth of bill at middle of nostril, 9 mm.; No. 32067: exposed culmen, 20 mm.; breadth of bill at middle of nostril, 9.5 mm.). The size of the testes (9 mm. long) of No. 32066 and the dates (June 19 and 20) on which the specimens were collected indicate breeding by this species in the State.

**Myiarchus tyrannulus cooperi* Baird.—*Specimens examined*: total 2: ♂ 32068 and ♀ 32069 from 2 mi. S, 3 mi. E San Juan de Sabinas, 1160 ft., June 22, 1952, measurements: wing, 102, 97 mm.; tail, 93, 90 mm.

Wied's Crested Flycatcher is not common in Coahuila. Eastern Coahuila represents the eastern limit of the range of *M. t. cooperi*. Measurements of our specimens agree well with the average measurements of typical *M. t. cooperi*. According to Ridgway (1907:621), *M. t. cooperi* (then called *Myiarchus mexicanus mexicanus*) has been recorded from Sabinas. The size of the testes (14x7 mm.) of No. 32068 and the date (June 22) on which the specimens were collected indicate breeding by this species in the State.

**Myiarchus cinerascens cinerascens* (Lawrence).—*Specimens examined*: total 7: ♀ 31045 from 15 mi. SE Boquillas, 1500 ft., March 16, 1952; ♂ 32070 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; ♀ 32071 from 2 mi. W Jiménez, 850 ft., June 20, 1952; ♂ 35413 from 6 mi. N, 2 mi. W Castellón, 3750 ft., June 30, 1953; ♂ 32072 from 9 mi. S, 11 mi. E Sabinas, June 14, 1952; ♀ 31584 from 17 mi. S Ocampo, 5300 ft., April 7, 1954; and ♂ 31673 from the west foot of Pico de Jimulco, 5000 ft., April 4, 1953.

The Ash-throated Flycatcher is common in Coahuila. All specimens examined by me from there are typical of *M. c. cinerascens*. Ridgway (1907:626) listed *M. c. cinerascens* from Monclovia (=Monclova?) and Sabinas. Miller (1955a:166) found the species "only in the oak belt at 5000 feet, where it was common." Burleigh and Lowery (1942:193) recorded *M. c. cinerascens* from "near Saltillo." Dickerman obtained No. 31584 in a mesquite-grassland-shrubby area. Miller, Friedmann, Griscom, and Moore (1957:78) stated that *M. c. cinerascens* breeds in Coahuila.

Sayornis phoebe (Latham).—Miller, Friedmann, Griscom, and Moore (1957:66) recorded the Eastern Phoebe from Coahuila on November 4-14.

**Sayornis nigricans semiatra* (Vigors).—*Specimens examined*: total 2: ♀ 31046 from 1 mi. N Boquillas, 700 ft., March 7, 1952; and ♀ 31047 from Fortín (=33 mi. N, 8 mi. W San Gerónimo), 3300 ft., March 27, 1952.

Of the Black Phoebe, the two subspecies *semiatra* and *nigricans* intergrade in Coahuila. Typical representatives of *S. n. semiatra* are present in northern Coahuila. The under tail coverts of Nos. 31046-31047 are immaculate and white. Miller (1955:167) noted the two specimens collected from the Sierra del Carmen to have narrow dark shaft streaks on the under tail coverts. He (*loc. cit.*) remarked also that "the marking of the under tail coverts may indicate a beginning of a gradient in increased darkening of these feathers toward *S. n. nigricans* in southern Coahuila."

**Sayornis nigricans nigricans* (Swainson).—Burleigh and Lowery (1942:193) collected several specimens of *S. n. nigricans* "on the outskirts of Saltillo" and saw a pair at the Chorro del Agua on April 19.

**Sayornis saya saya* (Bonaparte).—*Specimens examined*: total 4: ♀ 31049 from the Rio Grande (=17 mi. S Dryden, Terrell Co., Texas, in Coahuila), 600 ft., March 18, 1952; sex ? 31048 from 10 mi. S, 5 mi. E Boquillas, 1500 ft., March 4, 1952; ♂ 31050 from Fortín (=33 mi. N, 8 mi. W San Gerónimo), 3300 ft., March 29, 1952; and ♀ 32059 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952.

Say's Phoebe occurs commonly in Coahuila. Miller (1955a:167) obtained a female with an active brood patch in Boquillas Canyon of the Sierra

del Carmen, and remarked that Marsh took a juvenile on September 2 at El Rincón. Sutton and Burleigh (1939a:33) saw this phoebe several times in southern Coahuila and obtained a male "near San Pedro" on January 29. Burleigh and Lowery (1942:193) recorded this species as "a common breeding bird both on Diamante Pass and on the arid plateau around Saltillo." No. 32059 was a juvenile.

Empidonax traillii brewsteri Oberholser.—Amadon and Phillips (1947:578) took a Traill Flycatcher of the subspecies *brewsteri* at Las Delicias on August 11.

Empidonax minimus (Baird and Baird).—*Specimen examined*: one, ♂ 31470, from Sierra del Pino (=5 mi. S, 3 mi. W Acebuches), 6200 ft., May 13, 1954.

Amadon and Phillips (1947:578) obtained two Least Flycatchers at Las Delicias on August 12. Dickerman took No. 31470 in pine-oak vegetation.

Empidonax hammondii (Xantus).—*Specimen examined*: one, sex ? 31657, from the north slope of Sierra Guadalupe (=11 mi. S, 7 mi. W General Cepeda), 7800 ft., April 20, 1953.

No. 31657 is similar to *E. wrightii* (Wright's Flycatcher); however, the outmost (tenth) primary is equal to or slightly larger than the fifth primary. Yet, the underparts of No. 31657 are darker and more uniform in coloration than those of typical representatives of *E. wrightii*. Miller, Friedmann, Griscom, and Moore (1957:88) stated that Hammond's Flycatcher is "transient" in Coahuila. Burleigh and Lowery (1942:193-194) reported that *E. hammondii* was the most prevalent of the small flycatchers in southeastern Coahuila. They (*loc. cit.*) obtained specimens of this flycatcher from the Chorro del Agua and Diamante Pass. Miller (1955a:167) characterized *E. hammondii* as a common migrant, "chiefly in stands of low oaks in the pine-oak belt but also occasionally in the desert scrub" of the Sierra del Carmen.

Empidonax wrightii Baird.—Amadon and Phillips (1947:578) reported one Wright's Flycatcher from Las Delicias. Miller (1955a:167) stated that this species was a common migrant and occurred chiefly in the lower oak belt and in the desert scrub. Sutton and Burleigh (1939a:34) obtained specimens of *E. wrightii* from San Pedro on January 29.

Empidonax griseus Brewster.—Sutton and Burleigh (1939a:34) noted that the Gray Flycatcher was common "in the San Pedro region" and collected two at San Pedro on January 29. Burleigh and Lowery (1942:194) collected specimens "near the Chorro del Agua, at Saltillo, and . . . in the open desert some twenty miles west of Saltillo."

***Empidonax affinis trepidus* Nelson.—*Specimen examined*: one, ♂ 32750, from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955.

Ridgway (1907:576) previously reported the little known and poorly defined Pine Flycatcher from Sierra Guadalupe. Because of its small size (wing, 75 mm.; tail, 65 mm.), No. 32750 is referable to *E. a. trepidus*. No indication of breeding of the subspecies *trepidus* exists for Coahuila. Nevertheless, the date (July 6) on which No. 32750 was obtained suggests that this flycatcher may breed in southeastern Coahuila.

**Empidonax difficilis hellmayri* Brodkorb.—*Specimen examined*: one, ♂ 31469, from Sierra del Pino (=5 mi. S, 3 mi. W Acebuches), May 13, 1954, measurements: wing, 71 mm.; tail, 65 mm.; culmen, 11.5 mm.; tarsus, 17.0 mm.

Miller (1955a:167) reported that the Western Flycatcher breeds in the Sierra del Carmen, from 6800 to 7500 feet. According to Miller, Friedmann, Griscom, and Moore (1957:91), this subspecies has been recorded from Sierra Guadalupe. No. 31469 closely resembles, especially in measurements, the specimens of the Western Flycatcher from the Chisos Mountains of Texas as reported by Brodkorb (1935:2).

Empidonax difficilis subsp.—Burleigh and Lowery (1942:194) obtained a specimen of *E. difficilis* "near the summit of Diamante Pass" that they tentatively identified as *E. d. salvini*. However, they considered the specimen as possibly *E. d. immemoratus* or *E. d. occidentalis*.

Localities listed by Miller, Friedmann, Griscom, and Moore (1957:92) of *E. d. salvini* and *E. d. immemoratus* are south of twenty-three degrees north latitude whereas the range of *E. d. occidentalis* includes parts of Nuevo León north of twenty-three degrees north latitude (*occidentalis* intergrades with *hellmayri* at Cerro Potosí, Nuevo León, [Miller, Friedmann, Griscom, and Moore, *loc. cit.*]). Thus, the specimen from Diamante Pass probably is either *E. d. hellmayri* or *E. d. occidentalis*.

***Empidonax fulvifrons pygmaeus* Coues.—Miller, Friedmann, Griscom, and Moore (1957:95) listed this subspecies of the Buff-breasted Flycatcher from the Sierra Guadalupe on April 21. This record represents the eastern limit of the range of *E. f. pygmaeus* in northeastern México.

***Contopus pertinax pertinax* Cabanis and Heine.—Burleigh and Lowery (1942:194) obtained one female Coues' Flycatcher "in a small gully just below the summit of Diamante Pass."

Contopus virens (Linnaeus).—I judge from the paucity of records in the literature that the Eastern Wood Pewee is uncommon in Coahuila. Burleigh and Lowery (1942:194) obtained two males at the Chorro del Agua, and remarked also that "it is possible that as far west as Saltillo, this species is a rather uncommon transient." Ridgway (1907:519) listed *Contopus virens* from Sabinas.

**Contopus sordidulus veliei* Coues.—*Specimens examined*: total 2: ♂ 31467 from Sierra del Pino (=5 mi. S, 3 mi. W Acebuches), May 14, 1954; and ♂ 31653 from the north foot of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6400 ft., April 19, 1953.

Specimen No. 31467 of the Western Wood Pewee was obtained in pine and oak vegetation by Dickerman. Ridgway (1907:523) reported *Contopus sordidulus veliei*, under the name *Myiochanes richardsonii recharadsonii*, from Sierra Encarnación. Amadon and Phillips (1947:578) obtained a specimen of *C. sordidulus* from Las Delicias. Miller, Friedmann, Griscom, and Moore (1957:83) remarked that the Western Wood Pewee breeds in the State.

Nuttallornis borealis (Swainson).—Several records of the Olive-sided Flycatcher from Coahuila are present in the literature. Miller (1955a:167) reported it as a migrant in the desert at the base of the Sierra del Carmen on

April 24. Miller, Friedmann, Griscom, and Moore (1957:82) reported this species from Ocampo on June 16. Amadon and Phillips (1947:578) obtained one at Las Delicias on August 16. Burleigh and Lowery (1942:194) collected two males "near the summit of Diamante Pass" on April 14.

**Pyrocephalus rubinus mexicanus* Sclater.—*Specimens examined*: total 3: ♂ 32060 and ♀ 32061 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; and sex ? 32062 from 2 mi. W Jiménez, 850 ft., June 20, 1952.

The Vermilion Flycatcher is common in Coahuila. Except in the northwestern part of the State, the subspecies *mexicanus* is present throughout Coahuila. The size of No. 32060 (wing, 80 mm.; tail, 62 mm.) suggests that the specimen is an intergrade between *P. r. flammeus* and *mexicanus*. *P. r. flammeus* and *mexicanus* seem to intergrade in northern Coahuila.

Burleigh and Lowery (1942:195) found *mexicanus* to be "quite plentiful on the plains surrounding Saltillo." Sutton and Burleigh (1939a:33) noted the Vermilion Flycatcher "near San Pedro." Cory and Hellmayr (1927:92) listed *P. r. mexicanus* from Sabinas. The size of the testes (6x4 mm. long) of No. 32060 and the dates (June 19 and 20) on which our specimens were collected indicate breeding.

Pyrocephalus rubinus flammeus van Rossem.—This subspecies of Vermilion Flycatcher occupies the northwestern section of Coahuila. Marsh and Stevenson (1938:287) took a specimen of *P. r. flammeus* "near Santo Domingo, east of the Del Carmens. . . ." Miller (1955a:167) re-examined this specimen and stated that "its affinity with the northwest race of the species seems correct in terms of the characters outlined by van Rossem (1934:353)."

Eremophila alpestris enthyimia (Oberholser).—Miller, Friedmann, Griscom, and Moore (1957:105) recorded this subspecies of Horned Lark wintering 4 mi. S Hipólito (November 2 to February 24). They reported also that *E. a. enthyimia* breeds in Coahuila (4 mi. S Hipólito ?).

**Eremophila alpestris diaphora* (Oberholser).—*Specimens examined*: total 9: ♂♂ 32073-32078 and ♀ 32079 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952; and ♂♂ 31605-31606 from 14 mi. W San Antonio de las Alazanas, 6500 ft., January 9, 1954.

Burleigh and Lowery (1942:195) wrote that this subspecies of Horned Lark was uncommon "about Saltillo," but "fairly common" in Diamante Valley, at about 7000 feet. Oberholser (1902:863) recorded the subspecies *aphrasta* from La Ventura. Ridgway (1907:326) listed *Otocoris alpestris apherasta* Oberholser from Saltillo and La Ventura. However, Miller, Friedmann, Griscom, and Moore (1957:105) indicated that *E. a. diaphora* rather than *aphrasta* was recorded from Saltillo and La Ventura. Sutton and Burleigh (1939a:35) remarked that "specimens collected near Ramos Arizpe [in southeastern Coahuila]" proved to be *E. a. apherasta*. However, this record might be questioned, as Miller, Friedmann, Griscom, and Moore (*op. cit.*) indicated, because *diaphora*, rather than *aphrasta*, seems to occupy the southeastern sector of Coahuila. Possibly typical representatives of *aphrasta* and/or intergrades between *aphrasta* and *diaphora* are present in western Coahuila; however, no records of *E. a. apherasta* exist from western Coahuila.

The sizes of Nos. 32073-32077 and 31605-31606 (wing, 98.0-101.5 mm., averaging 99.7 mm.), the bright yellow throat, and the vinaceous color of the

hindneck characterize clearly the subspecies *diaphora*. The sizes of the testes (9x6 mm.; 8x5 mm.; 10x6 mm.; 8x4 mm.; 11x6 mm.) of Nos. 32073-32077, the size of the largest ovum (6.5 mm.) of No. 32079, and the juvenile (32078) are evidence of breeding of *E. a. diaphora* in Coahuila.

**Tachycineta thalassina thalassina* (Swainson).—*Specimens examined*: total 3: ♂ 31471, ♂ 31473, and ♀ 31472 from Sierra del Pino (= 5 mi. S, 3 mi. W Acebuches), May 15, 1954, measurements: wings, 125, 118, 108 mm.; tails, 56, 54, 46 mm.

The two subspecies of the Violet-green Swallow, *thalassina* and *lepida*, intergrade in Coahuila. Specimens from different localities in the State represent various stages of intergradation between the two subspecies; generally those from northern Coahuila seem to be closer to *T. t. lepida*, and those from southern Coahuila are closer to *T. t. thalassina*. Nos. 31471-31473 are intergrades between *T. t. thalassina* and *T. t. lepida*; in size the three resemble *T. t. thalassina*, but in green, rather than purple, backs and scapulars resemble *T. t. lepida*. The rumps of Nos. 31471-31473 show some purple with the green, but are nearer *thalassina* in this character.

Gonadal sizes (testes 10x7, 10x8 mm., one ovum 6 mm.) indicate that the Violet-green Swallow breeds in the Sierra del Pino.

**Tachycineta thalassina lepida* Mearns.—Miller (1955a:167) reported that Violet-green Swallows taken in Boquillas Canyon of the Sierra del Carmen are intermediate between *T. t. lepida* and *thalassina*; however, he referred his sample to *lepida* on the basis of short wing.

Iridoprocne bicolor (Vieillot).—Miller, Friedmann, Griscom, and Moore (1957:114) reported the Tree Swallow from Hipólito on February 22.

Stelgidopteryx ruficollis psammochrous Griscom.—Miller, Friedmann, Griscom, and Moore (1957:111) reported this subspecies of the Rough-winged Swallow from Saltillo.

**Hirundo rustica erythrogaster* Boddaert.—Burleigh and Lowery (1942:195) stated that the Barn Swallow was the most abundant swallow "about Saltillo." Because these swallows occupied houses about Saltillo and neighboring villages, Burleigh and Lowery (*loc. cit.*) concluded that the species nests commonly in the Saltillo area. Findley saw Barn Swallows 2 mi. S and 11 mi. E Nava, 810 feet, on June 15, 1952. Dickerman observed them at San Marcos (=20 mi. S Cuatro Ciénegas) on May 4, 1954.

**Petrochelidon pyrrhonota minima* van Rossem and Hachisuka.—*Specimens examined*: total 2: ♂♂ 31585-31586 from 14 mi. W San Antonio de las Alazanas, April 9, 1954.

Burleigh and Lowery (1942:196) noted the Cliff Swallow "in small numbers about Saltillo and the nearby villages" where the species "showed evidence of beginning to nest in many of the houses. . . ." They (*loc. cit.*) found Cliff Swallows also at the Chorro del Agua and Diamante Valley. According to Dickerman, Nos. 31585-31586 were from a colony, members of which were collecting mud at a stock tank.

***Petrochelidon fulva pallida* Nelson.—The Cave Swallow seems to be uncommon in eastern Coahuila. Selander and Baker (1957:345) list Saltillo,

Sabinas, and Monclova as the three known localities for this swallow in the State.

**Progne subis subis* (Linnaeus).—Miller, Friedmann, Griscom, and Moore (1957:107) reported, presumably on the basis of a published record not found by me, that the Purple Martin breeds in Coahuila.

***Progne chalybea chalybea* (Gmelin).—The only record of the Gray-breasted Martin in Coahuila was given by Ridgway (1904:42) when he listed *P. c. chalybea* from Sabinas.

***Cyanocitta stelleri macrolopha* Baird.—*Specimens examined*: total 2: ♂ 32788 and ♀ 32787 from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955.

From the paucity of records in the literature, I judge that Steller's Jay is uncommon in Coahuila. Nos. 32787-32788 seemingly represent the first records of this species in the State, and are referred to the subspecies *macrolopha* on the basis of relatively long (150, 151 mm.) wing, near the maximum for *stelleri* from México. The date (July 6) of collection suggests that these birds were resident in southeastern Coahuila.

***Aphelocoma coerulescens cyanotis* Ridgway.—The Scrub Jay is common in southeastern Coahuila. Burleigh and Lowery (1942:196) noted this species in small numbers at the summit of Diamante Pass, daily on the lower slopes of the mountains, and a few birds "on the outskirts of Saltillo, where they were probably nesting. . . ." Sutton and Burleigh (1939a:35) also noted several flocks at Diamante Pass. Miller, Friedmann, Griscom, and Moore (1957:123) reported *A. c. cyanotis* from El Diamante. Ridgway (1904:335) listed this subspecies of the Scrub Jay (then called *Aphelocoma cyanotis*) from Carneros, Sierra Encarnación, and Sierra Guadalupe.

**Aphelocoma ultramarina couchii* (Baird).—*Specimens examined*: total 14: ♀ 31051 from Sierra de la Encantada (=38 mi. S, 23 mi. E Boquillas), 4400 ft., March 15, 1952; ♂ ♂ 29425-29426 and ♀ ♀ 29427-29428 from Club Sierra del Carmen (=2 mi. N, 6 mi. W Piedra Blanca), 4950 ft., April 8, 1950; sex ? 31052 (skeleton only) from 4 mi. W Hacienda La Mariposa, 2300 ft., March 25, 1952; ♀ ♀ 31635-31636 from Canyon de Parazos in the Sierra de la Parazos Azula (=9 mi. E Hermanas), 2100 ft., December 7, 1953; ♀ 32082 from 4 mi. N, 21 mi. W Cuatro Ciénegas, 6200 ft., July 3, 1952; ♀ 31053 (skeleton only) from 26 mi. W Santa Teresa, 7050 ft., April 5, 1952; ♂ 32081 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952; ♀ 33173 (skeleton only) from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955; ♂ 31607 from 13 mi. E, 3 mi. S San Antonio de las Alazanas, 8900 ft., January 11, 1954; and ♂ 31654 from Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 7000 ft., April 13, 1953.

The Mexican Jay is common in Coahuila. This species occupies various habitats in the State and has been collected at stations ranging from 2100 to 9950 feet.

Miller (1955a:167) stated that the Mexican Jay was the most abundant species of bird in the Sierra del Carmen. Burleigh and Lowery (1942:196) remarked that specimens of *A. u. couchii* were obtained "in the area surrounding the summit of Diamante Pass." At no time did Burleigh and Lowery (*loc. cit.*) see this species below 6500 feet. The Mexican Jay is restricted to the higher altitudes in southern Coahuila but is more widespread in northern

Coahuila. Dickerman saw Mexican Jays in the Sierra del Pino on May 12, 1954; 16 mi. E and 18 mi. N Ocampo on May 7, 1954; in the Sierra de la Madera on December 13, 1953; and 20 mi. S Ocampo on April 4, 1954.

Ridgway (1904:340) remarked that *Aphelocoma sieberii potosina* Nelson [= *A. u. couchii* (Baird)] has been recorded in southern Coahuila, at Carneros. Miller, Friedmann, Griscom, and Moore (1957:124) recorded *A. u. couchii* from Carneros, Nuevo León. I suspect (Ridgway, 1904:340 and Goldman, 1951: map opposite p. 34) that the locality given by Miller, Friedmann, Griscom, and Moore (*op. cit.*) should be Carneros, Coahuila, rather than Carneros, Nuevo León.

Specimens (31051, 29425-29428, 31635-31636, 32081-32082, 31607, and 31654) of the Mexican Jay increase in size from northern Coahuila to southern Coahuila. The average length of the wings of Nos. 29425-29426 from Club Sierra del Carmen is 152 mm. whereas the average length of the wings of No. 32081 from 7 mi. S and 4 mi. E Bella Unión, of No. 31607 from 13 mi. E and 3 mi. S San Antonio de las Alazanas, and of No. 31654 from Sierra Guadalupe is 164 mm.

Miller (1955a:169) indicated that the Mexican Jay breeds in the Sierra del Carmen. Burleigh and Lowery (1942:196) remarked that the species breeds at Diamante Pass. The sizes of the testes (12, 11 mm.) of Nos. 29425-29426, the size of the ovum (8 mm.) of No. 29428, and the short tail (126 mm.) of the immature female from 4 mi. N and 21 mi. W Cuatro Ciénegas are also evidence of breeding by this species in the State.

**Corvus corax sinuatus* Wagler.—The Common Raven seems to occur in low density in Coahuila. Miller (1955a:168) saw ravens in the pine-oak and cliff areas of the Sierra del Carmen, and took a breeding female at the head of Corte Madera Canyon, 7500 feet. Burleigh and Lowery (1942:196) found this species to be a bird of the higher slopes of the mountains although not uncommon in the broad open valley south of Diamante Pass. Sutton and Burleigh (1939a:35) took a male at Santa Rosa.

**Corvus cryptoleucus* Couch.—*Specimens examined*: total 4: ♂ 32080 from 2 mi. W Jiménez, 850 ft., June 20, 1952; ♀ 35404 (skeleton only) from 4 mi. N San Isidro (=16 mi. N Ocampo), May 10, 1954; and ♂♂ 31474-31475 from R. de Almendárez (=53 mi. NW Ocampo), May 11, 1954.

The White-necked Raven occurs throughout Coahuila. Sutton and Burleigh (1939a:36) observed this species "in the vicinity of Saltillo," but not farther west. Burleigh and Lowery (1942:197) noted *C. cryptoleucus* frequently "on the arid plateau around Saltillo" and obtained a specimen "in the high fertile valley south of Diamante Pass." Burleigh and Lowery (*loc. cit.*) remarked that the White-necked Raven avoids the mountain slopes; 7000 feet was the uppermost limit of occurrence. The sizes of the testes (32080, 20 mm.; 31474: left, 12x20 mm., right, 10x16 mm.; and 31475: left, 10x16 mm., right, 10x14 mm.) of the specimens that I have examined and the dates (May 11, June 20) on which they were collected indicate breeding by the White-necked Raven in Coahuila.

**Parus sclateri eidos* (Peters).—*Specimens examined*: total 4: ♀ 32083 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952; ♂ 31609 from 2 mi. E Mesa de Tablas, 9000 ft., January 15, 1954; ♂ 31656 and ♀ 31655 from the north slope of Sierra Guadalupe (=11 mi. S, 7 mi. W General Cepeda), 7800 ft., April 20, 1953.

The Mexican Chickadee is common in southeastern Coahuila. Miller, Friedmann, Griscom, and Moore (1957:133) stated that *P. s. eidos* and *P. s. sclateri* intergrade in southern Coahuila. The specimens that I have examined also show signs of intergradation, but are closer to *P. s. eidos*.

Sutton and Burleigh (1939a:36) reported taking specimens of *P. s. eidos* at Diamante Pass where they saw several individuals. Burleigh and Lowery (1942:197) also observed these chickadees "in the pine woods about the summit of Diamante Pass. . . ." The size of the testes (6x5 mm.) of No. 31656 and the fact that No. 31655 was incubating eggs at the time it was obtained are evidence of breeding by this chickadee in the State.

*****Parus sclateri sclateri* Kleinschmidt.**—Miller, Friedmann, Griscom, and Moore (1957:133) stated that a specimen (or specimens?) of *P. s. sclateri* which showed evidence of intergradation with *P. s. eidos* was obtained at El Diamante.

*****Parus atricristatus dysleptus* Van Tyne.**—*Specimen examined:* one, ♂ 31054 from 37 mi. S, 21 mi. E Boquillas, 4100 ft., March 13, 1952.

Two subspecies of the Black-crested Titmouse are present in Coahuila. *P. a. dysleptus* occurs in northwestern Coahuila. Miller (1955a:168) stated that the Black-crested Titmouse, identified as *dysleptus*, was the only representative of the genus *Parus* in the Sierra del Carmen. The weak extension of black onto the nape in No. 31054 suggests intergradation between *P. a. dysleptus* and *P. a. atricristatus*; the latter lacks the black nape of *dysleptus*.

****Parus atricristatus atricristatus* Cassin.**—*Specimens examined:* total 4: ♀ 32084 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; sex? 32085 from 2 mi. W Jiménez, 850 ft., June 20, 1952; ♀ 31055 (skeleton only) from Fortín (=33 mi. N, 1 mi. E San Gerónimo), 3300 ft., on March 29, 1952; and ♀ 35399 (skeleton only) from 3.5 mi. W, 22 mi. S Ocampo, December 15, 1953, weight, 16 gms.

Typical *P. a. atricristatus* occurs in Coahuila in the southeastern sector (Dixon, 1955:184). Black-crested Titmice intermediate between *atricristatus* and *dysleptus* were listed from Ciudad Múzquiz and Sabinas by Dixon (*loc. cit.*:189), as *dysleptus* but were shown on his map (*loc. cit.*:184) as *atricristatus*. Our Nos. 32084 and 32085 (wing, 71, 71, tail, 63, 64 mm.) are small and fall in the upper range of size for *atricristatus* to which the specimens are here referred.

****Auriparus flaviceps ornatus* (Lawrence).**—*Specimen examined:* one, ♂ 31056, from Sierra de la Encantada (=38 mi. S, 23 mi. E Boquillas), 4400 ft., March 15, 1952.

The Verdin occurs up to about 5000 feet in Coahuila. Miller (1955a:168) reported that "this desert species followed the catclaw scrub up the washes to about 4800 feet, the limit of such habitat" in the Sierra del Carmen and also gave evidence of breeding by the Verdin in Coahuila. Amadon and Phillips (1947:578) reported a nest of *Auriparus flaviceps* at Las Delicias. Burleigh and Lowery (1942:197) obtained a single specimen "in an arroyo a few miles east of Saltillo" and a single specimen "about twenty miles west" of Saltillo. Ridgway (1904:421) reported *A. f. ornatus* [he referred to it as *A. f. flaviceps*] at Monclova. Hellmayr (1934:88) listed *A. f. ornatus* from Jaral. Findley saw a Verdin 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952.

The size (wing, 50 mm.; tail, 43 mm.) of No. 31056 is small for typical

representatives of *A. f. ornatus*. The yellow of the head of No. 31056 is darker than that of the other subspecies of the Verdin, and I have accordingly allocated the specimen to *A. f. ornatus*.

**Psaltriparus melanotis lloydi* Sennett.—*Specimens examined*: total 5: ♂ 31058 and ♀ 31057 from 37 mi. S, 21 mi. E Boquillas, 4100 ft., March 13, 1952; ♂ 31060 and ♀ 31059 from Sierra de la Encantada (=38 mi. S, 23 mi. E Boquillas), 4400 ft., March 15, 1952; and ♂ 35407 (skeleton only) from Sierra del Pino (=5 mi. W, 3 mi. S Acbuches), 6200 ft., May 14, 1954.

The Black-eared Bushtit is common in Coahuila. Typical representatives of *P. m. lloydi* in the northern part of the State range from 4100 feet to 8000 feet. Miller (1955a:168-169) reported *P. m. lloydi* breeding in the Sierra del Carmen. Marsh and Stevenson (1938:287) obtained a male in the Sierra del Carmen at El Jardín. The size of the testes (3.5 mm.) of No. 31058 suggests breeding by the Black-eared Bushtit 37 mi. S and 21 mi. E Boquillas.

***Psaltriparus melanotis iulus* Jouy.—*Specimens examined*: total 2: ♂ 31659 from the north slope of Sierra Guadalupe (=10 mi. S, 7 mi. W General Cepeda), 7000 ft., April 20, 1953; and ♀ 31658 from the north slope of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6700 ft., April 15, 1953.

Typical representatives of this Black-eared Bushtit are present in the southeastern sector of Coahuila. The backs of Nos. 31658-31659 differ slightly in color from the backs of typical representatives of *lloydi*. I suspect that the specimens from the Sierra Guadalupe are intergrades between *lloydi* and *iulus*.

Burleigh and Lowery (1942:197) took two males and two females of *Psaltriparus melanotis iulus* (they called their specimens *Psaltriparus minimus iulus*) at Saltillo and stated that their specimens tended to approach *lloydi* rather than being typical *iulus*. Sutton and Burleigh (1939a:36) recorded *P. m. iulus* only at Diamante Pass where they took two specimens.

**Sitta carolinensis nelsoni* Mearns.—Miller (1955a:169) reported that this subspecies of the White-breasted Nuthatch breeds and was common in the oaks and open conifers from 6500 to 8000 feet in the Sierra del Carmen and stated also that the populations of the White-breasted Nuthatch in "the Chisos Mountains [of Texas] and the Sierra del Carmen seem best regarded as a stage in the cline of which *nelsoni* and *mexicana* are end points, although falling closer to *nelsoni*."

**Sitta carolinensis mexicana* Nelson and Palmer.—*Specimens examined*: total 2: ♂ 31669 and ♀ 31670 from the Cañon d. Meco, Sierra Guadalupe (=10 mi. S General Cepeda), 6500 ft., April 23, 1953, weights, 17, 18 gms.

Typical populations of this White-breasted Nuthatch occur in southern Coahuila. Ridgway (1904:449) listed *S. c. mexicana* from Sierra Guadalupe in southern Coahuila. The underparts of our specimens are darker than in *nelsoni*, and their bills (culmen, 15, 13 mm.) are shorter than the average (♂, 19.8 mm.; ♀, 18.6 mm. [Ridgway, 1904:447]) in *nelsoni*. The large size of the testes (5x3 mm.) of No. 31669 suggests breeding by *S. c. mexicana* in Sierra Guadalupe.

**Sitta pygmaea melanotis* van Rossem.—In Coahuila the Pigmy Nuthatch seems to be locally common. Miller (1955a:169) reported it so between 7500

and 8000 feet in pine-oak on the mesa tops and in the heads of canyons of the Sierra del Carmen and noted that it breeds there. Hardy saw the Pigmy Nuthatch 13 mi. E San Antonio de las Alazanas on July 6, 1955.

Certhia familiaris americana Bonaparte.—*Specimens examined*: total 2: ♀ 31612 from the base of Don Martín Dam, November 27, 1953, skull partially unossified; and ♀ 31587 from 20 mi. S Ocampo, 6500 ft., April 5, 1954, weight, 7 gms.

This subspecies of the Brown Creeper can be considered a sparse winter visitant to Coahuila. Van Hoose (1955:302) reported that Nos. 31612 and 31587 constitute the southernmost records of *C. f. americana* and represent the first records of occurrence of *americana* in México.

Certhia familiaris montana Ridgway.—Miller (1955a:169) reported this subspecies of the Brown Creeper, which he assumed to be a winter visitant or a migrant, in the Sierra del Carmen. He (*loc. cit.*) remarked also that the higher conifers would seem to constitute favorable habitat for nesting by the Brown Creeper, but did not find any evidence of a breeding population of creepers in the Sierra del Carmen. Miller, Friedmann, Griscom, and Moore (1957:143) reported *C. f. montana* from San Lázaro Mountain on November 9.

***Certhia familiaris albescens* Berlepsch.—*Specimens examined*: total 3: sex ? 32805 from 13 mi. E San Antonio de las Alazanas, July 7, 1955; ♂♂ 31610-31611 from 3 mi. S, 13 mi. E San Antonio de las Alazanas, 8900 ft., January 12, 1954.

Miller, Friedmann, Griscom, and Moore (1957:143) reported *C. f. albescens* from "southern Coahuila." Nos. 31610-31611 and 32805 represent the only other records of this subspecies from the State. The date (July 7) on which No. 32805 was obtained suggests that this bird was a resident 13 mi. E San Antonio de las Alazanas.

Troglodytes aedon parkmanii Audubon.—*Specimen examined*: one, sex ? 29556, from 1.5 mi. N Parras, 5500 ft., November 10, 1949, weight, 9.8 gms.

Burleigh and Lowery (1942:197) recorded the House Wren "in small numbers about Saltillo where occasional birds, presumably migrants, were noted in thickets or stretches of underbrush fringing cultivated fields." They obtained a single male "on the outskirts of Saltillo." Hellmayr (1934:218) listed *T. a. parkmanii* from Sabinas.

**Troglodytes brunneicollis cahooni* Brewster.—Typical representatives of this subspecies of the Brown-throated Wren occur in northern Coahuila. In the Sierra del Carmen, Miller (1955a:170) found *T. b. cahooni* that in no way suggested *compositus* of the Sierra Madre Oriental. Burleigh and Lowery (1942:198) recorded a *cahooni*-like specimen from Diamante Pass in southern Coahuila.

***Troglodytes brunneicollis compositus* Griscom.—*Specimen examined*: one, ♂ 32819, from 13 mi. E San Antonio de las Alazanas, July 6, 1955.

The subspecies *cahooni* and *compositus* of the Brown-throated Wren seem to intergrade in the southern part of the State. Although No. 32819 represents the subspecies *compositus*, the somewhat whitish abdomen and the fairly large spots of the lesser wing coverts suggest some relationship with *cahooni*. In addition to the present record, Miller, Friedmann, Griscom, and Moore

(1957:163) recorded *T. b. compositus* from southern Coahuila at Sierra Guadalupe. The record of *T. b. cahooni* from Sierra Guadalupe (Ridgway, 1904:588) I suspect probably represents *T. b. compositus* or an intergrade between *compositus* and *cahooni*. The date (July 6) on which No. 32819 was obtained 13 mi. E San Antonio de las Alazanas suggests that this bird was resident there.

**Thryomanes bewickii eremophilus* Oberholser.—*Specimens examined*: total 3: ♂ 32088 from 2 mi. W Jiménez, 850 ft., June 20, 1952; ♀ 31061 from 4 mi. W Hacienda La Mariposa, 2300 ft., March 24, 1952, weight, 10.8 gms.; and ♂ 31660 from the north foot of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6500 ft., April 21, 1953, weight, 13 gms.

Bewick's Wren occurs commonly in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:160) reported that, in Coahuila, *T. b. eremophilus* "intergrades in the eastern and southern sections with *T. b. cryptus* and *T. b. murinus*, respectively." The slightly darker coloration of No. 31660, suggesting a resemblance to *T. b. murinus*, is the only evidence of intergradation of *T. b. murinus* and *eremophilus* that I have found.

Miller (1955a:170) stated that *T. b. eremophilus* was "common in the piedmont area on yucca-dotted slopes and along the lower canyon walls in growth of piñon, yucca, and cactus" in the Sierra del Carmen, and reported breeding there. Burleigh and Lowery (1942:198) remarked that *T. b. eremophilus* "proved without question to be the most widely distributed and abundant wren" in the Saltillo region. The series that Burleigh and Lowery (*loc. cit.*) assembled "proved to be uniform and clearly referable to" *T. b. eremophilus*. Sutton and Burleigh (1939a:36) noted *Thryomanes bewickii* at San Pedro on January 29 and 30. Hardy saw a male *T. b. eremophilus* at Parras on July 4, 1955. Ridgway (1904:557) listed *T. b. eremophilus* from Saltillo in April and as breeding at Sabinas.

The sizes of the testes (8 mm.; 6x4 mm.) of Nos. 32088 and 31660, respectively, suggest breeding 2 mi. W Jiménez and Sierra Guadalupe.

***Thryomanes bewickii cryptus* Oberholser.—Miller, Friedmann, Griscom, and Moore (1957:161) recorded *T. b. cryptus* from Saltillo.

**Thryothorus ludovicianus berlandieri* Baird.—*Specimens examined*: total 3: ♂ 32086 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; sex ? 32087 from 2 mi. W Jiménez, June 20, 1952; and ♀ 31063 from 8 mi. N, 4 mi. W Múzquiz, 1800 ft., April 1, 1952, weight, 18.3 gms.

One subspecies of the Carolina Wren, *berlandieri*, occurs in Coahuila in the northeastern section of the State. Ridgway (1904:547) recorded *T. l. berlandieri* from Sabinas. The fact that No. 32086 was a juvenile suggests that the Carolina Wren breeds 12 mi. N and 12 mi. W Jiménez.

**Campylorhynchus brunneicapillum couesi* Sharpe.—*Specimens examined*: total 6: ♂ 29429 from Cañon del Cochino (=16 mi. N, 21 mi. E Piedra Blanca), 3200 ft., April 6, 1950; ♂ 31064 from 7 mi. S, 2 mi. E Boquillas, 800 ft., February 29, 1952, weight, 38.1 gms.; ♀ 31066 (skeleton only) from 10 mi. S, 5 mi. E Boquillas, 1500 ft., March 5, 1952; ♂ 31637 from La Gacha (=La Concha), December 1, 1953, weight, 40 gms.; ♂ 31638 from 18 mi. S Ocampo, December 16, 1953; and sex ? 29557 from 7 mi. S, 1 mi. E Gómez Farías, 6500 ft., November 18, 1949, weight, 41 gms.

This subspecies of the Cactus Wren occurs throughout Coahuila except in the extreme southeastern section of the State, where the subspecies *C. b.*

guttatus occurs. Miller (1955a:169) found *C. b. couesi* breeding and occupying the open swales and mesas at the base of the mountains of the Sierra del Carmen. Burleigh and Lowery (1942:198) found *C. brunneicapillum* "to be rather scarce and decidedly local in its distribution" and observed an occasional bird "in the open desert country west of Saltillo." Miller, Friedmann, Griscom, and Moore (1957:151) recorded *C. b. couesi* "south to [the] vicinity of Monclova."

No. 29557 does not have any characters of *C. b. guttatus*; its under tail coverts and flanks have roundish black spots, rather than black bars as in *C. b. guttatus*.

***Campylorhynchus brunneicapillum guttatus* (Gould).—This subspecies of Cactus Wren seems to occupy the extreme southeastern section of Coahuila. Miller, Friedmann, Griscom, and Moore (1957:152) recorded *C. b. guttatus* from Hipólito.

Telmatodytes palustris plesius (Oberholser).—Miller, Friedmann, Griscom, and Moore (1957:148) reported this subspecies of the Long-billed Marsh Wren from 8 mi. S Cuatro Ciénegas.

**Catherpes mexicanus albifrons* (Giraud).—Miller (1955a:170) found this subspecies of Cañon Wren "in shaded rocky canyons and on larger cliff slopes at the base of the mountains from 4700 to 5300 feet" in the Sierra del Carmen where it nested. Burleigh and Lowery (1942:198) noted that the Cañon Wren was "decidedly uncommon" at Saltillo and obtained a male at the Chorro de Agua on April 19. Ridgway (1904:657) listed *C. m. albifrons* from Patos.

**Salpinctes obsoletus obsoletus* (Say).—*Specimens examined*: total 4: ♀ 31067 from 1 mi. N Boquillas, 700 ft., March 6, 1952, weight, 16.1 gms.; ♀ 31068 from 7 mi. S, 2 mi. E Boquillas, 800 ft., March 1, 1952, weight, 18.2 gms.; sex ? 29558 from 12 mi. N, 10 mi. E Parras, 5000 ft., November 11, 1949, weight, 16.9 gms.; and ♂ 32089 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 24, 1952.

The Rock Wren is common in Coahuila. Miller (1955a:170) found *S. o. obsoletus* "only in the rocky piedmont and on lower bare canyon faces" and stated that Marsh took a bird in fresh fall plumage on September 6 at El Jardín. Sutton and Burleigh (1939a:37) found the Rock Wren "near San Pedro." Burleigh and Lowery (1942:198) wrote that the subspecies *obsoletus* was "characteristically a bird of the arroyos of the arid plateau about Saltillo, where it was fairly common. . . ." The large size of the testes (5x3 mm.) of No. 32089 and the date (June 24) on which it was obtained suggest breeding by the Rock Wren 7 mi. S and 4 mi. E Bella Unión.

**Mimus polyglottos leucopterus* (Vigors).—*Specimens examined*: total 5: ♀ 31070 from 10 mi. S, 5 mi. E Boquillas, 1500 ft., March 5, 1952, weight, 55.1 gms.; ♂ ♂ 32094-32095 from 2 mi. W Jiménez, 850 ft., June 20, 1952; ♂ 32096 from 5 mi. N, 19 mi. W Cuatro Ciénegas, 3250 ft., July 5, 1952; and ♂ 33186 (skeleton only) from Parras, July 5, 1955, testes, 6x3 mm.

The Mockingbird is sparsely distributed throughout Coahuila. Miller (1955a:170) found *M. p. leucopterus* in the mesquite and catclaw at the base of the mountains in the Sierra del Carmen. Sutton and Burleigh (1939a:37) reported *M. p. leucopterus* from Diamante Pass. Amadon and

Phillips (1947:578) found a young Mockingbird out of the nest begging for food from an adult on August 18 at Las Delicias. Burleigh and Lowery (1942:199) found the Mockingbird on the arid plateau "about Saltillo." Hellmayr (1934:308) listed *M. p. leucopterus* from Jaral. Findley saw Mockingbirds 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952. Dickerman saw Mockingbirds in the Sierra del Pino on May 12, 1954, and 8 mi. E and 2 mi. S Americanos on May 18, 1954. The sizes of the testes (8, 7 mm.) of Nos. 32094 and 32096, respectively, suggest breeding 2 mi. W Jiménez and 5 mi. N and 19 mi. W Cuatro Ciénegas, as does No. 32095, a juvenile.

**Toxostoma longirostre sennetti* (Ridgway).—*Specimen examined*: one, ♂ 32090, from 2 mi. S, 3 mi. E San Juan de Sabinas, June 22, 1952.

In Coahuila the Long-billed Thrasher seems to be uncommon. It has been recorded in Coahuila as far west as San Juan de Sabinas. Ridgway (1907:192) recorded *T. l. sennetti* from Sabinas, the only other record of the Long-billed Thrasher, to my knowledge, from the State. The large size of the testes (11x6 mm.) of No. 32090 and the date (June 22) on which it was obtained suggest that *T. l. sennetti* breeds 2 mi. S and 3 mi. E San Juan de Sabinas.

**Toxostoma curvirostre celsum* Moore.—*Specimens examined*: total 2: ♀ 31071 from 7 mi. S, 2 mi. E Boquillas, March 1, 1952, wing, 111 mm., tail, 114 mm., weight, 97.2 gms.; and ♀ 31072 (skeleton only) from 10 mi. S, 5 mi. E Boquillas, 1500 ft., March 5, 1952.

This subspecies of the Curve-billed Thrasher occurs in northwestern Coahuila. Specimens of *T. c. celsum* and *oberholseri* from Coahuila are too few to show clearly the distribution and intergradation in Coahuila.

No. 31071 is referred to *T. c. celsum* because of large size; the spots on its upper abdomen, which are large and pronounced, suggest a relationship with *T. c. oberholseri*. Miller (1955a:170) remarked that *T. c. celsum* was a scarce resident of the desert scrub at the mouth of Boquillas Canyon of the Sierra del Carmen.

**Toxostoma curvirostre oberholseri* Law.—*Specimens examined*: total 5: ♀ 35405 (skelton only) from 4 mi. N San Isidro, May 11, 1954; ♀ 32091 from 5 mi. N, 19 mi. W Cuatro Ciénegas, 3250 ft., July 5, 1952; ♂ 32833 from Parras, July 4, 1955, weight, 76.5 gms.; ♀ 32092 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952; and ♂ 31614 from 16 mi. W San Antonio do las Alazanas, 6500 ft., January 7, 1954, weight, 90 gms.

This subspecies of the Curve-billed Thrasher occurs in eastern and southern Coahuila. Amadon and Phillips (1947:578) took a Curve-billed Thrasher twenty miles west of Saltillo that had an enlarged ovary and a brood patch still somewhat evident on August 27. Burleigh and Lowery (1942:199) stated that *T. c. oberholseri* "was rather widely and commonly distributed, being noted from the area about the summit of Diamante Pass at 7,800 feet down to the desert country about Saltillo." Miller, Friedmann, Griscom, and Moore (1957:177) recorded *T. c. oberholseri* from Sabinas, from 8 mi. S Cuatro Ciénegas, and from El Diamante. Hellmayr (1934:298) also recorded *T. c. oberholseri* from Sabinas, as did Ridgway (1907:199) under the name *T. c. curvirostre* before the subspecies *oberholseri* was named. The female from 4 mi. N San Isidro had an egg in its oviduct. The immature male (32833), the large size of ovum (8 mm.) of No. 32092, and the presence of a brood patch

on No. 32091 also are evidences of breeding by the Curve-billed Thrasher in Coahuila.

**Toxostoma dorsale dorsale* Henry.—The Crissal Thrasher is uncommon in Coahuila. The subspecies *dorsale* occurs in northern Coahuila. Miller (1955a:170-171) found the subspecies *dorsale*, at about 4700 feet, only in the mesquite, desert willow, and walnut scrub along the wash of Boquillas Canyon of the Sierra del Carmen and remarked also that the bird nested there.

***Toxostoma dorsale dumosum* Moore.—*Specimen examined*: one, sex ? 29559, from 8 mi. N La Ventura, 6000 ft., November 17, 1949, weight, 57.0 gms.

The subspecies *dumosum* of the Crissal Thrasher in Coahuila has been reported only from the southeastern section of the State. Burleigh and Lowery (1942:199-200) found *T. d. dumosum* "not uncommon in the lower foot-hills outside of Saltillo as well as on the summit of Diamante Pass." The specimen of *T. d. dorsale* from Diamante Pass reported by Sutton and Burleigh (1939a:37) is closer, according to Burleigh and Lowery (1942:199), to *T. d. dumosum*. No. 29559 is darker above and below than typical specimens of *T. d. dorsale* and represents *T. d. dumosum*.

Oreoscoptes montanus (Townsend).—*Specimen examined*: one, sex ? 30237, from 1 mi. SW San Pedro de las Colonias, 3700 ft., February 8, 1951.

The Sage Thrasher seems to be a winter visitant to Coahuila. Miller, Friedmann, Griscom, and Moore (1957:173) recorded the species in November from 8 mi. S Cuatro Ciénegas.

**Turdus migratorius propinquus* Ridgway.—*Specimen examined*: one, ♀ 31073 (skeleton only) from 4 mi. W Hacienda La Mariposa, 2300 ft., March 24, 1952.

Burleigh and Lowery (1942:200) stated that "the Robin apparently breeds rather sparingly on the higher ridges" in southeastern Coahuila. They collected a pair "in the open pine woods just below the summit of Diamante Pass" on April 15 and noted another at the Chorro del Agua on April 19.

***Ridgwayia pinicola* (Sclater).—*Specimen examined*: one, ♂ 31619, from 5 mi. W, 22 mi. S Ocampo, 6000 ft., December 15, 1953, weight, 88 gms.

The Aztec Thrush is rare in Coahuila. Van Hoose (1955:302) remarked that No. 31619, the skull of which was incompletely ossified, "represents the northernmost record for this species, which was previously unknown in Coahuila."

Hylocichla guttata guttata (Pallas).—*Specimens examined*: total 2: ♂ ♂ 31074-31075 from 4 mi. W Hacienda La Mariposa, 2300 ft., March 25 and 26, 1952, weights, 25, 21 gms.

The Hermit Thrush is a common migrant or winter visitant in Coahuila. *H. g. guttata* has been reported from northern Coahuila. Miller (1955a:171) observed *H. g. guttata* (and *H. g. auduboni*) in the Douglas fir and pine-oak belts and in the lower levels in the oaks at the foot of the Sierra del Carmen. Burleigh and Lowery (1942:200) noted *H. g. guttata* "in small numbers in the open woods surrounding the summit of Diamante Pass, and at infrequent intervals in the arroyos on the arid plateau near Saltillo."

Hylocichla guttata sequoiensis (Belding).—Ridgway (1907:45) recorded this subspecies of Hermit Thrush from Sierra Guadalupe in April. However, Miller, Friedmann, Griscom, and Moore (1957:188) suggest that the material on which this identification was based needs redetermination.

Hylocichla guttata auduboni (Baird).—*Specimens examined*: total 3: ♀ 31488 from Sierra del Pino (=5 mi. S, 3 mi. W Acebuches), May 12, 1954, weight, 25 gms.; ♀ 31076 (skeleton only) from Fortín (=33 mi. N, 1 mi. E San Gerónimo), 3300 ft., March 28, 1952; and ♀ 31077 (skeleton only) from 26 mi. W Santa Teresa, 7050 ft., April 4, 1952.

Miller (1955a:171) found this subspecies of Hermit Thrush wintering with *H. g. guttata* in the Sierra del Carmen. Hellmayr (1934:456) listed *H. g. auduboni* from Sabinas.

***Sialia sialis fulva* Brewster.—Hellmayr (1934:479) listed this subspecies of the Eastern Bluebird from Sabinas.

**Sialia mexicana mexicana* Swainson.—Miller, Friedmann, Griscom, and Moore (1957:199) remarked that the subspecies *mexicana* of the Western Bluebird breeds in the southern mountains of Coahuila where, at El Diamante, on July 7, a specimen (or specimens?) in breeding condition was obtained. Burleigh and Lowery (1942:200) found *S. m. mexicana* "well distributed in the open woods about" Diamante Pass, but at no time below an elevation of approximately 6500 feet. Sutton and Burleigh (1939a:38) also saw "several brown-backed" Western Bluebirds at Diamante Pass on March 6. Ridgway (1907:150) recorded *S. m. mexicana* from Saltillo, Carneros, and Sierra Guadalupe.

Sialia currucoides (Bechstein).—*Specimen examined*: one, ♀ 31078, from Sierra de la Encantada (=38 mi. S, 23 mi. E Boquillas), 4400 ft., March 14, 1952, weight, 23.7 gms.

The Mountain Bluebird is a winter visitant to Coahuila. Miller, Friedmann, Griscom, and Moore (1957:200) recorded *Sialia currucoides* from Hipólito on February 24.

***Myadestes townsendi townsendi* (Audubon).—*Specimen examined*: one, ♀ 31079, from 26 mi. W Santa Teresa, 7050 ft., April 4, 1952.

Miller (1955a:171) detected Townsend's Solitaire in clumps of large pines in two different locations at 7000 and 7500 feet on April 4, 6, and 8 in the Sierra del Carmen. He did not find a breeding population of *M. t. townsendi*, but did note favorable habitat for breeding. Ridgway (1907:164) recorded *M. townsendi* from the Sierra Guadalupe on April 21. Dickerman saw a Townsend's Solitaire in the Sierra de la Madera on December 13, 1953.

The underparts of No. 31079 are not uniformly dark, being paler on the chin, throat, and abdomen than elsewhere as is true of typical representatives of *M. t. townsendi*.

***Polioptila caerulea caerulea* (Linnaeus).—*Specimen examined*: one, ♂ 32097, from 2 mi. S, 11 mi. E Nava, June 15, 1952.

No. 32097 is the first record of occurrence of this subspecies of Blue-gray Gnatcatcher in the State. The white of the underparts of No. 32097 is less grayish than the underparts of typical representatives of *P. c. amoenissima*, and the black at the base of the inner webs of the outermost rectrix does not

extend beyond the tip of the under tail coverts. Representatives of *P. c. amoenissima* have black at the base of the inner web of the outermost rectrix more extended, usually showing beyond the tip of the under tail coverts. The size of the testes (3x2 mm.) of No. 32097 does not suggest breeding, but the date (June 15) indicates that it was a resident.

**Polioptila caerulea amoenissima* Grinnell.—*Specimen examined*: one, ♂ 31080, from 7 mi. S, 2 mi. E Boquillas, 800 ft., February 29, 1952, weight, 5.4 gms.

This subspecies of the Blue-gray Gnatcatcher breeds in Coahuila and occurs throughout all of the State except the northeastern section. Miller (1955a:171) remarked that "this gnatcatcher was apparently established on summer territories in the oaks and walnuts of the wash of Boquillas Canyon at the foot of the mountains" of the Sierra del Carmen. Burleigh and Lowery (1942:200) noted "this species only in the open woods at the summit of Diamante Pass, where, however, it was not uncommon." Miller, Friedmann, Griscom, and Moore (1957:201) recorded *P. c. amoenissima* breeding at El Diamante on July 8.

**Polioptila melanura melanura* Lawrence.—*Specimen examined*: one, ♂ 31081, from 7 mi. S, 2 mi. E Boquillas, 800 ft., March 1, 1952, weight, 5.6 gms.

In Coahuila this subspecies of the Black-tailed Gnatcatcher has been recorded from several localities. Burleigh and Lowery (1942:200) found that it "was limited in its distribution to the lower altitudes and was noted only in the open desert country west of Saltillo." Sutton and Burleigh (1939a:38) noted it "several times near San Pedro" where on January 29 one female was taken. Miller, Friedmann, Griscom, and Moore (1957:205) recorded *P. m. melanura* at Hipólito on June 30 to July 2 in breeding condition.

Regulus satrapa satrapa Lichtenstein.—Miller (1955a:171) found a small wintering flock of Golden-crowned Kinglets in the Sierra del Carmen; this is the only record of the species in Coahuila.

Regulus calendula calendula (Linnaeus).—*Specimens examined*: total 5: ♀ 31085 from the Río Grande (=17 mi. S Dryden, Terrell Co., Texas, in Coahuila), 600 ft., March 19, 1952, weight, 6.3 gms.; ♂ ♂ 31082-31083 from 1 mi. N Boquillas, 700 ft., March 8, 1952, weight, 7.2, 6.5 gms.; ♂ 31084 from Sierra de la Encantada (=38 mi. S, 23 mi. E Boquillas), 4400 ft., March 15, 1954, weight, 5.4 gms.; and ♂ 31661 from the north slope of Sierra Guadalupe (=11 mi. S, 7 mi. W General Cepeda), 7800 ft., April 20, 1953, weight, 5 gms.

In Coahuila this subspecies of the Ruby-crowned Kinglet is a common migrant. Miller (1955a:171) found it (and *R. c. cineraceus*) "common in the conifers and oaks of the upper levels of the mountains [Sierra del Carmen], at 6500 to 7000 feet, as winter visitants or migrants." Burleigh and Lowery (1942:201) took specimens of *R. c. calendula* at Diamante Pass on April 15, at the Chorro del Agua on April 19, and at 20 mi. W Saltillo on April 22. Sutton and Burleigh (1939a:38) noted the Ruby-crowned Kinglet "in the arid parts of southern Coahuila." Hellmayr (1934:513) listed *R. c. calendula* from Sabinas. Dickerman saw Ruby-crowned Kinglets in the Sierra de la Madera on December 13, 1953, 20 mi. S Ocampo on April 4, 1954, and 3 mi. S and 13 mi. E San Antonio de las Alazanas on January 12, 1954.

Regulus calendula cineraceus Grinnell.—Miller (1955a:171) found *R. c. cineraceus* common in the Sierra del Carmen; on April 3, 5, and 10 the birds were "abundant, as though a wave of migrants were passing through."

Anthus spinoletta rubescens (Tunstall).—*Specimens examined*: Total 3: ♂♂ 31086-31087 and sex ? 31088 from 1 mi. N Boquillas, 700 ft., March 6, 7, and 8, 1952, weights, 19.3, 19.9, and 16.6 gms.

This subspecies of the Water Pipit is an uncommon winter visitant or migrant in Coahuila. Burleigh and Lowery (1942:201) found "a flock of ten birds . . . on the outskirts of Saltillo" on April 18. Miller, Friedmann, Griscom, and Moore (1957:210) recorded *A. s. rubescens* from Cuatro Ciénegas in November and from Hipólito in February.

Anthus spinoletta pacificus Todd.—Miller, Friedmann, Griscom, and Moore (1957:209) recorded this Water Pipit from Cuatro Ciénegas in February and from Hipólito in November.

Bombycilla cedrorum Vieillot.—The Cedar Waxwing is an uncommon winter visitant to Coahuila. Miller (1955a:171) recorded a flock in the Sierra del Carmen on April 5, and another flock on April 21. Burleigh and Lowery (1942:201) saw two small flocks on April 15 "in the open woods just below the summit of Diamante Pass."

**Phainopepla nitens nitens* Swainson.—*Specimen examined*: one, ♂ 31674, from the west foot of Pico de Jimulco, 5000 ft., April 3, 1953, weight, 35 gms.

The *Phainopepla* occurs throughout most of Coahuila. Sutton and Burleigh (1939a:39) reported *P. n. nitens* from Diamante Pass on March 6. On April 15 and 17 Burleigh and Lowery (1942:201) saw scattered pairs of the *Phainopepla* "only in the open woods surrounding Diamante Pass." Miller (1955a:171) noted *P. nitens* "on April 20 and 28 in large clumps of mesquite near Piedra Blanca, at about 4500 feet, on the foothills" of the Sierra del Carmen. Dickerman saw a *Phainopepla* 20 mi. S Ocampo on April 4, 1954. Baird (1858:320) listed a male *P. n. nitens* from Coahuila, México. Hellmayr (1935:107) remarked that *Phainopepla nitens* was listed from Coahuila by "Salvin and Godman, Biol. Centr.—Amer., Aves, 1, p. 220, 1883. . . ." Miller, Friedmann, Griscom, and Moore (1957:213) stated that *P. n. nitens* breeds at El Diamante. The long wing (100 mm.) and long tail (96 mm.) of No. 31674 is typical for *P. n. nitens*.

Phainopepla nitens lepida Van Tyne.—Sutton and Burleigh (1939a:39) recorded *P. n. lepida* from Diamante Pass on March 6; Miller, Friedmann, Griscom, and Moore (1957:213) suggest that this individual was a vagrant.

Lanius ludovicianus migrans Palmer.—Burleigh and Lowery (1942:202) obtained this subspecies of Loggerhead Shrike "on the outskirts of Saltillo on April 20." The specimen shows evidence of intergradation with *excubitorides*.

***Lanius ludovicianus excubitorides* Swainson.—Miller, Friedmann, Griscom, and Moore (1957:216) recorded *L. l. excubitorides* from Sabinas and from Hipólito (November 2 to February 24).

**Lanius ludovicianus mexicanus* Brehm.—*Specimens examined*: total 4: sex ? 31089 from 7 mi. S, 2 mi. E Boquillas, 800 ft., February 29, 1952, weight, 45.1 gms.; ♀ 31090 from 36 mi. S, 15 mi. E Boquillas, 2550 ft., March 12, 1952; sex ? 30233 from 1 mi. N San Lorenzo, 4200 ft., February 5, 1951; and ♀ 32098 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952.

Miller (1931:66) suggested that *L. l. mexicanus* and *L. l. excubitorides* intergrade in Coahuila; all of the specimens of Loggerhead Shrike from Coahuila that I have examined are intergrades between *mexicanus* and *excubitorides*. Our four specimens have a superciliary line that is indistinct and the black mask of each extends somewhat posterior to the auricular region. The anterior part of their forehead is somewhat lighter than the remaining part of their head and back.

Miller (1955a:171) detected *L. l. mexicanus* only once in catclaw scrub in the lower part of Boquillas wash at about 4600 feet in the Sierra del Carmen. He (*loc. cit.*) remarked that his individual may best be considered an intergrade between *mexicanus* and *excubitorides*, being "somewhat closer to the former." Burleigh and Lowery (1942:201) obtained a male *L. l. mexicanus* "in the open valley just below the summit of Diamante Pass on April 23" that was typical of this subspecies. Burleigh and Lowery (1942: 201-202) suggested that *L. l. mexicanus* breeds in southeastern Coahuila. Sutton and Burleigh (1939a:39) took a typical representative *L. l. mexicanus* at Mayran on January 30.

Lanius ludovicianus gambeli Ridgway.—Miller, Friedmann, Griscom, and Moore (1957:214) recorded this subspecies from Hipólito on November 6.

**Vireo atricapilla* Woodhouse.—*Specimens examined*: total 4: sex ? 32099-32100 from Sierra del Pino (= 6 mi. N, 6 mi. W Acebuches), 5250 ft., July 3, 1952; and ♂♂ 31493-31494 from 16 mi. E, 18 mi. N Ocampo, May 8 and 9, 1954, enlarged testes.

The Black-capped Vireo seems to breed as far south as central Coahuila. Miller (1955a:171-172) reported this vireo as a summer resident in "the low catclaw-dominated scrub in the lower washes of Boquillas Canyon and its side valleys, at 4600 to 4800 feet" in the Sierra del Carmen. Dickerman found the Black-capped Vireo common on the dry scrub and oak hillside habitat 16 mi. E and 18 mi. N Ocampo.

Vireo griseus noveboracensis (Gmelin).—Ridgway (1904:184) recorded this subspecies of the White-eyed Vireo "west to Sabinas." Miller, Friedmann, Griscom, and Moore (1957:220) also recorded *V. g. noveboracensis* from Sabinas on May 25. I suspect that the specimen of *V. g. noveboracensis* from Sabinas that was taken on May 25 was a vagrant. *V. g. noveboracensis* may occur in Coahuila as a migrant or winter visitant; however, I do not believe that representatives of *noveboracensis* normally are resident in Coahuila.

**Vireo griseus micrus* Nelson.—*Specimen examined*: one, ♂ 32101, from 2 mi. W Jiménez, 850 ft., June 20, 1952, measurements: wing, 58 mm.; tail, 43.5 mm.; culmen, 10 mm.; tarsus, 19 mm.

This subspecies of the White-eyed Vireo breeds in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:221) recorded *V. g. micrus* from Sabinas

on March 9 and May 14. The enlarged testes (5x3 mm.) of No. 32101 and the date (June 20) on which it was obtained suggest breeding in Coahuila.

Vireo huttoni stephensi Brewster.—This subspecies of Hutton's Vireo occurs in southeastern Coahuila as a migrant. Sutton and Burleigh (1939a:39) found *V. h. stephensi* fairly common at Diamante Pass on March 6. Ridgway (1904:198) recorded *V. h. stephensi* from Sierra Guadalupe in April.

* *Vireo huttoni carolinae* Brandt.—*Specimens examined*: total 3: ♂ 31588 from 20 mi. S Ocampo, 6500 ft., April 5, 1954, weight, 11 gms.; ♀ 32851 from 13 mi. E San Antonio de las Alazanas, July 6, 1955, weight, 14.2 gms.; and ♀ 32102 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952.

To my knowledge, *V. h. carolinae* is the only resident subspecies of Hutton's Vireo in Coahuila. Burleigh and Lowery (1942:202) found *V. h. carolinae* in rather limited numbers in the woods bordering the summit of Diamante Pass. Miller (1955a:172) remarked that the subspecies *carolinae* was a common bird from 6500 feet to 8000 feet in the Sierra del Carmen. Miller (*loc. cit.*) took a female on April 12 that was nearly ready to lay and said that his specimens of *carolinae* from the Sierra del Carmen seem to be separate from *V. h. stephensi* and *V. h. mexicanus*. Our specimens showed no overlapping of characters with *V. h. stephensi* and *V. h. mexicanus*. The size of the largest ovum (2 mm.) of No. 32102 and the dates (June 25, and July 6) on which Nos. 32102 and 32851 were obtained suggest that *V. h. carolinae* is a resident in Coahuila.

* *Vireo bellii medius* Oberholser.—*Specimen examined*: one, ♂ 31495, from San Marcos, May 5, 1954, measurements: wing, 56 mm.; tail, 48 mm.; culmen, 9.5 mm.; tarsus, 18 mm.

Although Bell's Vireo seems to have been observed uncommonly in Coahuila, this species does breed in the State. Burleigh and Lowery (1942:202) obtained a single female *V. b. medius* on April 20 "in an arroyo east of Saltillo" and found this subspecies "not uncommon in the open desert twenty miles west of Saltillo, where three singing males were secured." Miller, Friedmann, Griscom, and Moore (1957:226) recorded *V. b. medius* in breeding condition at Hipólito from June 30 to July 3. Ridgway (1904:207) recorded the subspecies from Monclova. Hardy saw a Bell's Vireo at Parras on July 4, 1955. The size of No. 31495 is typical for *V. b. medius*.

* *Vireo flavifrons* Vieillot.—*Specimen examined*: one, ♂ 32103, from 2 mi. W Jiménez, 850 ft., June 20, 1952.

Van Hoose (1955:302-303) suggested that the occurrence of No. 32103 in Coahuila is evidence of a southward extension of the range of the Yellow-throated Vireo within the last generation. The size of the testes (5x3 mm.) of No. 32103 and the date (June 20) on which it was obtained suggest breeding by *Vireo flavifrons* in Coahuila.

Vireo solitarius solitarius (Wilson).—*Specimen examined*: one, ♀ 31640, from 9 mi. E Hermanas (=Canyon de Parajos in the Sierra de Parajos Azule), 2100 ft., December 7, 1953.

This subspecies of the Solitary Vireo is an uncommon migrant or winter visitant to Coahuila. Dickernan obtained No. 31540, whose skull was unossified and whose ovary was small, in an oak and palm habitat. The bright

yellow flanks, large and yellow wing bars, and the uniform olive green back indicate that this specimen is a typical representative of *V. s. solitarius*. This subspecies was previously unrecorded in Coahuila.

Vireo solitarius cassinii Xantus.—*Specimens examined*: total 2: ♀ 35408 (skeleton only) from 5 mi. W, 3 mi. S Acebuches, 6200 ft., May 12, 1954; and ♂ 31589 from 20 mi. S Ocampo, 6200 ft., April 4, 1954, measurements: wing, 75 mm.; tail, 57 mm.; culmen, 10.5 mm.; weight, 14 gms.

This subspecies of the Solitary Vireo seems to be uncommon in Coahuila. No. 31589 provides the first record of *V. s. cassinii* in Coahuila. Van Hoose has (1955:303) erroneously reported that Dickerman obtained No. 31589 on July 4, 1954; the correct date is April 4, 1954.

Although the size of No. 31589 is large for *V. s. cassinii*, the color (sides and flanks with less yellow, more olive; narrow white wing bars) resembles that of typical representatives of *cassinii*. The testes of No. 31589 were not enlarged. Dickerman suggested that the female from 5 mi. W and 3 mi. S Acebuches showed some resemblance to *V. s. plumbeus*. This is not to be unexpected since the subspecies *plumbeus* has been reported from the Chisos Mountains of Texas (Van Tyne and Sutton, 1937:82) and from northern Chihuahua (Miller, Friedmann, Griscom, and Moore, 1957:227).

**Vireo olivaceus* (Linnaeus).—*Specimen examined*: one, ♂ 32104, from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952.

The Red-eyed Vireo has been uncommonly reported from eastern Coahuila. Miller, Friedmann, Griscom, and Moore (1957:229) recorded *V. olivaceus* from Sabinas on May 22 and from Las Vacas Creek on June 7 as late spring migrants. Hellmayr (1935:131) listed the Red-eyed Vireo from northern Coahuila. Findley saw a Red-eyed Vireo 2 mi. W Jiménez on June 19, 1952. The size of the testes (5x3 mm.) of No. 32104 and the date (June 19) on which it was obtained indicate that the Red-eyed Vireo possibly breeds in north-eastern Coahuila; if so, this is the first breeding record of the Red-eyed Vireo in Coahuila.

Vireo gilvus gilvus (Vieillot).—This subspecies of the Warbling Vireo is an uncommon migrant in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:232) recorded *V. g. gilvus* from 12 mi. W Saltillo on September 28.

Mniotilta varia (Linnaeus).—*Specimen examined*: one, ♂ 31662, from the north slope of Sierra Guadalupe (=11 mi. S, 7 mi. W General Cepeda), 7800 ft., April 20, 1953, weight, 10 gms., testes not enlarged.

The Black and White Warbler is an uncommon visitant or migrant in Coahuila. Miller (1955a:172) remarked that Marsh took a fall migrant on September 1 in Chuperosa Canyon in the Sierra del Carmen. Burleigh and Lowery (1942:202) secured a female Black and White Warbler "in an orchard on the outskirts of Saltillo" on April 20 and a male "near the top of Diamante Pass on April 23."

Vermivora celata celata (Say).—*Specimens examined*: total 2: sex ? 31091 from the Río Grande (=17 mi. S Dryden, Terrell Co., Texas, in Coahuila), 600 ft., March 19, 1952, measurements: wing, 57 mm.; tail, 47 mm.; weight, 7.7 gms.; and ♂ 31092 from 4 mi. W Hacienda La Mariposa, 2300 ft., March 25, 1952, measurements: wing, 62 mm.; tail, 48 mm.; weight, 9.2 gms.

This subspecies of the Orange-crowned Warbler is an uncommon migrant

in Coahuila. In Brewster County, Texas, Van Tyne and Sutton (1937:83) found *V. c. celata* "not common as a spring transient." Miller, Friedmann, Griscom, and Moore (1957:239) recorded *V. c. celata* from Coahuila. The quality of the pale yellow color and the sizes of Nos. 31091-31092 suggest that they are representatives of *V. c. celata*.

Vermivora celata orestera Oberholser.—Burleigh and Lowery (1942:202) found *V. c. orestera* "only on infrequent occasions . . . in the open woods surrounding the summit of Diamante Pass" where they obtained one specimen.

Vermivora virginiae (Baird).—Miller (1955a:172) took a male Virginia's Warbler in Boquillas Canyon in the Sierra del Carmen "in scattered scrubby oak growth with grass and cactus beneath." This species in the Sierra del Carmen is considered "casual" by Miller, Friedmann, Griscom, and Moore (1957:241).

** *Vermivora crissalis* (Salvin and Godman).—*Specimen examined*: one, ♂ 31590, from 20 mi. S Ocampo, 7000 ft., April 5, 1954, weight, 10 gms.

The Colima Warbler is common locally in Coahuila. Burleigh and Lowery (1942:203) found this species fairly common on the steep, rugged slopes above the summit of Diamante Pass and saw none below an elevation of approximately 7500 feet. Bangs (1925:251) stated that Nelson and Goldman secured a specimen of the Colima Warbler at Sierra Guadalupe on April 25.

* *Vermivora superciliosa mexicana* (Bonaparte).—*Specimen examined*: one, ♂ 31591, from 13 mi. E San Antonio de las Alazanas, 9350 ft., April 10, 1954.

Hartlaub's Warbler is uncommon in Coahuila and seems to occur only in the southeastern section of the State; No. 31591 is the first record of the species in Coahuila. The size of the testes (5x2 mm.) of No. 31591 and the fact that the bird was singing when first seen suggest the possibility that *V. s. mexicana* breeds in southeastern Coahuila. Breeding there is not unexpected because the species has been found breeding in Nuevo León (Miller, Friedmann, Griscom, and Moore, 1957:242).

Parula americana (Linnaeus).—Miller (1955a:172) obtained a migrant Parula Warbler in an oak grove at 7000 feet on April 16 in the Sierra del Carmen, and remarked that it was "apparently the first record of this species in Coahuila."

* *Parula pitiayumi nigrilorla* Coues.—The AOU Check-list Committee (1957: 486) recorded this subspecies of the Olive-backed Warbler as a resident at Sabinas.

* *Peucedramus taeniatus arizonae* Miller and Griscom.—This subspecies of the Olive Warbler is locally common in Coahuila. Miller (1955a:172) found *P. t. arizonae* common in the pine timber above 6800 feet in the Sierra del Carmen and suggested that this warbler breeds in these mountains. Burleigh and Lowery (1942:203) found the Olive Warbler in a thick pine wood at an elevation of 9500 to 10,000 feet and remarked that this species was "decidly uncommon in the Diamante Pass area." They (*loc. cit.*) obtained a female (not identified to subspecies) on April 23 that had a "well developed

brood patch and was unquestionably incubating eggs." Sutton and Burleigh (1939a:40) took a single female at Diamante Pass on March 6 which also was not identified to subspecies. Dickerman saw Olive Warblers in the Sierra de la Madera on December 13, 1953, and 13 mi. E San Antonio de las Alazanas on April 10, 1954.

Dendroica petechia morcomi Coale.—Miller, Friedmann, Griscom, and Moore (1957:246) reported this subspecies of the Yellow Warbler as having been recorded from Coahuila.

Dendroica auduboni auduboni (Townsend).—*Specimens examined*: total 2: ♂ 31094 (skeleton only) from Fortín (=33 mi. N, 1 mi. E San Gerónimo), 3300 ft., March 29, 1952; and ♂ 31093 from 4 mi. W Hacienda La Mariposa, 2300 ft., March 25, 1952, weight, 12.3 gms.

Audubon's Warbler is a common winter visitant and migrant in Coahuila. Miller (1955a:173) recorded *D. a. auduboni* as a migrant from April 7 to 26 in the Sierra del Carmen; he found no suggestion of breeding by the Audubon's Warbler in the northwestern section of the State. One individual that Miller (*loc. cit.*) obtained was extensively black and approached the characters of the subspecies *nigrifrons* of Chihuahua. He (*loc. cit.*) suggested that the black individual was taken from "part of a cline of blackness and size in which *D. a. auduboni* of the northwest and *D. a. nigrifrons* of Mexico are extremes." Burleigh and Lowery (1942:203) remarked that Audubon's Warbler "is doubtless a common winter bird in the area around Saltillo." Two specimens obtained by Burleigh and Lowery (*loc. cit.*) "might be considered intermediate" between *auduboni* and *memorabilis*. Sutton and Burleigh (1939a:40) saw Audubon's Warbler "in some numbers near San Pedro . . . [on] January 29 and 30." Dickerman saw Audubon's Warblers 13 mi. E San Antonio de las Alazanas on April 10, 1954. Miller (1955a:173) also obtained, in the Sierra del Carmen, a hybrid between *D. coronata* and *D. auduboni*.

Dendroica auduboni memorabilis Oberholser.—Oberholser (1921:246) recorded *D. a. memorabilis* from Saltillo on April 17. This subspecies seems to winter commonly in western México and less commonly in the Central Plateau and Sierra Madre Oriental (Miller, Friedmann, Griscom, and Moore, 1957:249-250).

Dendroica nigrescens (Townsend).—*Specimen examined*: one, ♂ 31095, from Fortín (=33 mi. N, 8 mi. W San Gerónimo), 3300 ft., March 28, 1952, weight, 9.3 gms.

The Black-throated Gray Warbler is an uncommon spring and possibly fall migrant in Coahuila. Miller (1955a:173) found *D. nigrescens* uncommon in the Sierra del Carmen. He saw and heard a spring migrant singing on April 12 at 7000 feet and obtained a male on April 16.

Dendroica townsendi (Townsend).—Townsend's Warbler is a spring and fall migrant in Coahuila. Miller (1955a:173) recorded *D. townsendi* on September 2 at Jardín del Sur in Chuperosa Canyon in the Sierra del Carmen. Burleigh and Lowery (1942:203) saw two individuals of Townsend's Warbler at Diamante Pass on April 14. Amadon and Phillips (1947:578) secured this species "in mesquite about twenty miles west of Saltillo on August 28." Dickerman saw Townsend's Warblers in the Sierra de la Madera on December 13,

1953; 20 mi. S Ocampo on April 4, 1954; and 13 mi. E San Antonio de las Alazanas on April 10, 1954.

Dendroica virens (Gmelin).—Dickerman saw one Black-throated Green Warbler 13 mi. E San Antonio de las Alazanas, 9350 feet, on April 10, 1954, in a white pine-Douglas fir-aspen association. This seems to be the first record of this species in Coahuila.

**Dendroica chrysoparia* Sclater and Salvin.—Miller, Friedmann, Griscom, and Moore (1957:251) listed the Golden-cheeked Warbler from Hipólito on July 3.

Dendroica occidentalis (Townsend).—*Specimen examined*: one, ♂ 31592, from 13 mi. E San Antonio de las Alazanas, April 10, 1954.

The Hermit Warbler seems to be an uncommon spring and probably fall migrant in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:252) reported *D. occidentalis* from the State. No. 31592, whose testes were not enlarged, was obtained in a pine-spruce-aspen association.

Geothlypis trichas brachidactylus (Swainson).—Miller, Friedmann, Griscom, and Moore (1957:261) listed this subspecies of the Yellowthroat as recorded from Coahuila.

Geothlypis trichas occidentalis Brewster.—Burleigh and Lowery (1942:204) found the Yellowthroat "only on the outskirts of Saltillo, where . . . [this species] was not uncommon in the thickets, especially around a small stand of marsh grass bordering a pond." Three males that Burleigh and Lowery (*loc. cit.*) obtained were tentatively identified as *G. t. occidentalis*. Dickerman saw one male Yellowthroat at San Marcos (=20 mi. S Cuatro Ciénegas) on May 4, 1954.

Geothlypis nelsoni nelsoni Richmond.—Burleigh and Lowery (1942:204) noted the Hooded Yellowthroat "only on the open slopes above the summit of Diamante Pass at an elevation of about 8,000 feet" where they obtained an adult male.

**Icteria virens virens* (Linnaeus).—*Specimens examined*: total 3: ♂♂ 32105-32106 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; and ♀ 32107 from 2 mi. W Jiménez, 850 ft., June 20, 1952.

From the paucity of records in the literature, I judge that the Yellow-breasted Chat is uncommon in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:265) listed *I. v. virens* from Coahuila. Findley saw a Yellow-breasted Chat 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952. The sizes of the testes (7x4 mm.; 12 mm.) of Nos. 32105-32106, the size of the largest ovum (2 mm.) of No. 32107, and the dates (June 19, 20) on which these specimens were obtained indicate breeding by *I. v. virens* in northeastern Coahuila, an area southwest of the previously documented breeding range.

***Icteria virens auricollis* (Deppe).—Miller, Friedmann, Griscom, and Moore (1957:264) listed this subspecies of the Yellow-breasted Chat as recorded from Coahuila.

Wilsonia pusilla pileolata (Pallas).—*Specimens examined*: total 3: ♂ 31501 and ♀ 31500 from Sierra del Pino (=5 mi. S, 3 mi. W Acebuches), May 13 and 14, 1954, measurements: wing, 59, 55 mm.; tail, 50, 49 mm.; culmen, 8, 8.5 mm.; tarsus, 16, 16 mm.; weight: 6, 7 gms.; and ♂ 31663 from the north foot of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6500 ft., April 21, 1953, measurements: wing, 58 mm.; tail, 46 mm.; culmen, 8.5 mm.; tarsus, 16 mm.; weight, 7 gms.

Wilson's Warbler is a common spring and probably fall migrant in Coahuila. Miller (1955a:173) took spring migrants of *W. p. pileolata* from April 9 to April 27; he found *W. p. pileolata* at 4800 feet and at 7000 feet. Amadon and Phillips (1947:579) saw a Wilson's Warbler at Las Delicias on August 17. Burleigh and Lowery (1942:204) found Wilson's Warbler to be the most abundant of the warblers that they recorded in southeastern Coahuila. They saw *W. p. pileolata* on the top of the high ridges and in the arid desert country in the southeastern section of the State. Several specimens were collected by Burleigh and Lowery (*loc. cit.*) including an immature male from the Chorro del Agua on April 19. Dickerman saw Wilson's Warblers 16 mi. E and 18 mi. N Ocampo on May 7, 1954, and at San Marcos (=20 mi. S Cuatro Ciénegas) on May 4, 1954. The sizes of our specimens as well as their color (bright olive-green above, bright yellow below) are typical for the subspecies *pileolata*.

Setophaga ruticilla ruticilla (Linnaeus).—The American Redstart seems to be uncommon in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:268) listed one specimen of *S. r. ruticilla* from the State.

* *Setophaga picta picta* Swainson.—*Specimens examined*: total 2: sex ♀ 31096 from 26 mi. W Santa Teresa, 7050 ft., April 5, 1952; and ♂ 31671 from Cañon d. Meco in Sierra Guadalupe (=10 mi. S General Cepeda), April 23, 1953, weight, 11 gms.

The Painted Redstart seems to be locally common in Coahuila. Miller (1955a:173) found these warblers breeding in the Sierra del Carmen and said that they were "common from 6000 to 7500 feet in canyon bottom growth, in oaks, and in mixed pines and oaks;" however, he did not see any of these warblers above 7500 feet where conifers tended to dominate the vegetation. Marsh and Stevenson (1938:287) obtained a male Painted Redstart in annual molt on August 11 in oak and juniper forest at Vivoras Spring in the Sierra del Carmen and reported seeing two other Painted Redstarts at 9000 feet (see also Miller, 1955a:173). Dickerman also saw seven Painted Redstarts 20 mi. S Ocampo on April 4, 1954. The size of the testes (7x4 mm.) of No. 31671 suggests breeding by *S. p. picta* in the Sierra Guadalupe.

** *Passer domesticus domesticus* (Linnaeus).—Burleigh and Lowery (1942:204) remarked that the House Sparrow was not "a common bird around Saltillo" although they noticed *P. d. domesticus* regularly. They reported House Sparrows also from the Chorro del Agua and in the high mountain valley south of Diamante Pass. Miller, Friedmann, Griscom, and Moore (1957:275) recorded *P. d. domesticus* from Sabinas. Baker captured House Sparrows in a bat net 12 mi. E San Antonio de las Alazanas, 9950 feet, on July 5, 1955. Although there are no other records, the House Sparrow is probably fairly common in the villages and towns of the State.

[***Sturnella magna hoopesi* Stone.—The Eastern Meadowlark is uncommon in Coahuila. The AOU Check-list Committee (1957:523) listed this subspecies of the Eastern Meadowlark from northern Coahuila.]

** *Sturnella neglecta neglecta* Audubon.—*Specimen examined*: one, ♀ 31098, from the Río Grande (=17 mi. S Dryden, Terrell Co., Texas, in Coahuila), 600 ft., March 18, 1952, weight, 71.8 gms.

This subspecies of the Western Meadowlark seems to be locally common in the open country of Coahuila. Burleigh and Lowery (1942:205) found this meadowlark common "about Saltillo" where a "small series" of *S. neglecta* was obtained. Miller, Friedmann, Griscom, and Moore (1957:295) recorded the Western Meadowlark from El Diamante on July 7. To my knowledge, no specific breeding records of this meadowlark from Coahuila exist.

***Xanthocephalus xanthocephalus* (Bonaparte).—*Specimen examined*: one, ♂ 32494 (skeleton only) from Las Margaritas, August 4, 1955.

The Yellow-headed Blackbird occurs in Coahuila in migration. Miller (1955a:173) found this blackbird at Noria "in the flats immediately east of the Sierra del Carmen" on April 28, and reported also that Marsh took a male in worn breeding plumage on July 24 at Tanque de los Melones on La Bavía Ranch east of Fresno Mesa. Amadon and Phillips (1947:579) took two adult males at Las Delicias on August 11 and 15. Dickerman also saw a female 8 mi. E and 2 mi. S Americanos on May 18, 1954. Van Hoose saw a male at Torreón on July 2, 1955.

**Agelaius phoeniceus megapotamus* Oberholser.—*Specimens examined*: total 5: ♂ 32124, ♀ 32126, and ♀ 32128 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; ♂ 32125 from 2 mi. W Jiménez, 850 ft., June 20, 1952; and ♀ 32127 from 9 mi. S, 11 mi. E Sabinas, June 14, 1952.

This subspecies of the Redwinged Blackbird is common in eastern Coahuila. There are no records of the species from western Coahuila. Burleigh and Lowery (1942:205) obtained a male at "the edge of Saltillo" on April 24. Oberholser (1919a:23) recorded *A. p. megapotamus* from Porfirio Diaz on June 2, 5, and 6. The presence of juveniles (32126, 32128) from 12 mi. N and 12 mi. W Jiménez and (32125) from 2 mi. W Jiménez, respectively, and the dates (June 14, 19, 20) on which the University of Kansas specimens were obtained are evidence of breeding by *A. p. megapotamus* in northeastern Coahuila.

**Icterus spurius* (Linnaeus).—*Specimens examined*: total 8: ♂ ♂ 31536-31537 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; ♂ 31538 from 2 mi. S, 3 mi. E San Juan de Sabinas, 1160 ft., June 23, 1952; ♂ ♂ 32605-32607 from Parras, July 4, 1955; ♂ 32604 and ♀ 32603 from Hacienda San Lorenzo, July 3, 1955, weights, 19.4, 18.5 gms.

The Orchard Oriole seems to occur fairly commonly in eastern and southern Coahuila and breeds in the State. Amadon and Phillips (1947:579) reported that Orchard Orioles were common in the desert "about Las Delicias" in August and September and probably were migrants. Dickerman collected Nos. 32605-32606 along an irrigated field-edge that consisted of cottonwood and oak; he obtained Nos. 32603-32604 in an irrigated pecan orchard. The sizes of the testes (10x5 mm.; 10x5 mm.; 8x7 mm.; 8x7 mm.; 10x8 mm.) of

Nos. 31536, 31537, 32605, and 32604, respectively, and the size of the largest ovum (2 mm.) of No. 32603 as well as the dates (June 19, 23; July 3, 4) on which all these specimens were collected indicate breeding by this species in the State.

* *Icterus cucullatus cucullatus* Swainson.—*Specimens examined*: total 2: ♂ 32123 from 2 mi. W Jiménez, 850 ft., June 21, 1952; and ♂ 32122 from 2 mi. S, 3 mi. E San Juan de Sabinas, 1160 ft., June 23, 1952.

The Hooded Oriole apparently is uncommon in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:290) listed *I. c. cucullatus* from Sabinas. The size of the testes (11x6 mm.) of No. 32122 and the dates (June 21, 23) on which Nos. 32123 and 32122 were collected as well as the juvenile male (tail, 80.5 mm.) from 2 mi. W Jiménez suggest breeding by this subspecies in Coahuila.

* *Icterus parisorum* Bonaparte.—*Specimen examined*: one, ♀ 32121, from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952.

Scott's Oriole is common in Coahuila. Miller (1955a:173) found this oriole breeding in the canyons at the base of the Sierra del Carmen. Burleigh and Lowery (1942:205) found this oriole limited to the higher altitudes above 7000 feet, and took specimens at Diamante Pass and at the Chorro del Agua on April 19. Amadon and Phillips (1947:579) found Scott's Oriole "not uncommon in the arroyos near Las Delicias" and reported a juvenile "barely out of the nest and able to fly only a few feet . . ." on August 15. No. 32121 had an egg in its oviduct. Dickerman saw Scott's Orioles in the Sierra del Pino on May 12, 1954, and 16 mi. E and 18 mi. N Ocampo on May 7, 1954.

** *Icterus wagleri wagleri* Sclater.—Ridgway (1902:268) recorded *Icterus wagleri* from Saltillo. Hellmayr (1937:122-123) referred this record of Wagler's Oriole to *I. w. wagleri*.

* *Icterus bullockii bullockii* (Swainson).—This subspecies of Bullock's Oriole was listed as breeding by Miller, Friedmann, Griscom, and Moore (1957:282) at Monclova on May 12-19.

Euphagus cyanocephalus (Wagler).—Brewer's Blackbird is a common migrant in Coahuila. Miller (1955a:174) found a few as migrants in the Sierra del Carmen on April 27. Burleigh and Lowery (1942:205) remarked that "this blackbird was characteristically a bird of the towns and villages, the scattered flocks being invariably seen feeding in the streets and near the houses." They (*loc. cit.*) obtained three specimens at Diamante Valley on April 23 and remarked that the departure of these birds in spring was "extremely late."

* *Cassidix mexicanus prosopidicola* Lowery.—*Specimens examined*: total 3: ♀ 32893 from Parras, July 4, 1955, weight, 98.8 gms.; and ♂ ♂ 35418-35419 from Torreón, January 8, 1954.

This subspecies of Boat-tailed Grackle has been recorded from several localities in Coahuila. In southeastern Coahuila, Burleigh and Lowery (1942: 205-206) noted this grackle "somewhat local in its distribution; it was found in cultivated fields about the towns and villages." These authors noted it

at Saltillo, the Chorro del Agua, and "occasionally in the open valley south of Diamante Pass" and obtained specimens from "near Saltillo" and Diamante Valley. On August 18 Amadon and Phillips (1947:579) found *C. m. prosopidicola* at Las Delicias where "a fledged young was noticed begging for food. . . ." Lowery (1938:4) recorded one specimen of *C. m. prosopidicola* from Monclova. Findley saw Boat-tailed Grackles 2 mi. W Jiménez on June 19, 1952, and 2 mi. S and 11 mi. E Nava on June 15, 1952.

The distribution and intergradation of Boat-tailed Grackles in Coahuila is presently poorly understood. *C. m. prosopidicola* from southeastern Coahuila may approach *C. m. mexicanus*, and there is probable intergradation of *prosopidicola* with *monsoni* in northwestern Coahuila (Phillips, 1950:78).

Molothrus ater ater (Boddaert).—*Specimen examined*: one, ♀ 31513, from 21 mi. S, 11 mi. E Australia, 4400 ft., May 3, 1954, measurements: wing, 102 mm.; tail, 64 mm.; tarsus, 26 mm.; culmen, 17 mm.

This subspecies of the Brown-headed Cowbird is uncommon in Coahuila. Amadon and Phillips (1947:579) took an adult male and a juvenal female *M. a. ater* at Las Delicias on August 15, both of which were considered early migrants. Dickerman obtained No. 31513 from a flock of eight cowbirds. Although the measurements of this specimen agree equally well with those of *M. a. ater* and *M. a. artemisiae* (Grinnell, 1909:275-281), the shape of the bill most closely resembles that of *ater*. Grinnell (1909:278) said that "*ater* has a tumid bill, broad and high at [the] base with [a] conspicuously arched culmen" whereas "*artemisiae* has a longer and relatively much slenderer bill, vertically shallow at [the] base and laterally compressed, with the culmen in its greater portion straight or even slightly depressed." The size of the ovary (8x4 mm.) of No. 31513 and the date (May 3) on which it was obtained suggest that this individual was a late migrant, still south of the breeding range of *M. a. ater*.

Molothrus ater artemisiae Grinnell.—This subspecies of the Brown-headed Cowbird is an uncommon migrant in Coahuila. Amadon and Phillips (1947:579) obtained, at Las Delicias, a juvenal male on August 15 and an adult male on August 17.

**Molothrus ater obscurus* (Gmelin).—*Specimens examined*: total 18: ♂♂ 32112-32115 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 18 and 19, 1952; ♂♂ 32108-32111, ♂ 32116, and ♀♀ 32117-32120 from 2 mi. W Jiménez, 850 ft., June 20, 1952; ♀ 32491 from Las Margaritas, August 4, 1955; ♂ 31511 and ♀ 31510 from 16 mi. E, 18 mi. N Ocampo, May 8 and 7, 1952; and ♂♂ 35409-35410 (skeletons only) from 4 mi. N San Isidro, May 11, 1954.

This subspecies of the Brown-headed Cowbird is common in Coahuila and breeds there. Amadon and Phillips (1947:579) suggested that *M. a. obscurus* breeds at Las Delicias. Burleigh and Lowery (1942:206) saw the Brown-headed Cowbird in "small numbers on the outskirts of Saltillo. . . ."

Measurements of the adult males that I have examined are: wing, 101.1 mm. (97-106); tail, 66.5 mm. (62-69); tarsus, 25.6 mm. (24.5-28); culmen, 17.3 mm. (16-18.5). Measurements of the adult females that I have examined are: wing, 92.3 mm. (90-97); tail, 60.1 mm. (56.5-62.5); tarsus, 23.5 mm. (22.5-24); culmen, 14.4 mm. (14-15). The sizes of the testes of three of the males (6-7 mm. long) and of the largest ova of four of the females (6-9

mm. in diameter) indicate breeding by this subspecies in Coahuila, as does the small size of one of the juvenal males (tail, 33.5 mm. long).

Piranga ludoviciana (Wilson).—In Coahuila the Western Tanager occurs fairly commonly as a migrant. There are no records of it breeding in the State. Miller (1955a:174) remarked that Marsh took a migrant Western Tanager at Jardín del Sur in the Sierra del Carmen on September 7. Amadon and Phillips (1947:579) took an adult male Western Tanager at Las Delicias on August 12. Miller, Friedmann, Griscom, and Moore (1957:305) also recorded this tanager from 12 mi. W Saltillo. Dickerman saw Western Tanagers in the Sierra del Pino on May 12, 1954, and 16 mi. E and 18 mi. N Ocampo on May 7, 1954.

**Piranga flava dextra* Bangs.—*Specimen examined*: one, ♂ 31526, from Sierra del Pino (=5 mi. S, 3 mi. W Acebuches), May 12, 1954, weight, 41 gms.

Miller (1955a:174) found this subspecies of the Hepatic Tanager "in the pine-oak belt at 7000 feet on April 12 [in the Sierra del Carmen], when a male was seen and a female taken." No. 31526 was with a female when taken; this male was not fat and its testes were not enlarged. The size of the wing (105.5 mm.) of No. 31526 represents the extreme maximum in this subspecies.

Piranga flava hepatica (Swainson).—Miller, Friedmann, Griscom, and Moore (1957:303) stated that *P. f. hepatica* is found in northwestern and central Arizona and southwestern New Mexico south into the highlands of México, west of the Sierra Madre Oriental, to Oaxaca and in winter and migration extends eastward and south to Chiapas. These authors remarked also that *P. f. dextra* occurs in the mountains east of the continental divide in New Mexico and western Texas south through eastern México to Chiapas. Specimens of the Hepatic Tanager from Coahuila in winter might well be either *P. f. hepatic* or *P. f. dextra*. Miller, Friedmann, Griscom, and Moore (*loc. cit.*) recorded migrants of *P. f. hepatica* from the Sierra de Guadalupe on April 24-27.

**Piranga rubra rubra* (Linnaeus).—*Specimens examined*: total 6: ♂ 32129, ♂ 32132, and ♀ 32133 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 18 and 19, 1952; ♂ 32130 from 2 mi. W Jiménez, 850 ft., June 20, 1952; and ♂ 32131 and ♀ 32134 from 2 mi. S, 11 mi. E Nava, June 15, 1952.

This Summer Tanager occurs in northeastern Coahuila. The specimens from 12 mi. N and 12 mi. W Jiménez, 2 mi. W Jiménez, and 2 mi. S and 11 mi. E Nava are typical representatives of *P. r. rubra*. The large testes (12 mm.) of No. 32129 and the well-developed brood patch of No. 32134 are evidence of breeding by this subspecies in the State. Heretofore this subspecies has not been recorded from Coahuila.

**Piranga rubra cooperi* Ridgway.—*Specimens examined*: total 4: ♂♂ 32828-32829, ♂ 32831, and ♀ 32830 from Parras, July 4, 1955.

This subspecies of Summer Tanager seems to occur throughout Coahuila except in the northeastern section of the State. Miller, Friedmann, Griscom, and Moore (1957:302) listed *P. r. cooperi* from Sabinas and Sierra de Guadalupe. Miller (1955a:174) saw a Summer Tanager in a canyon in the Serañas de Burros, about 40 miles east of the Sierra del Carmen on April 28.

Although there are no other records of *P. r. cooperi* from northwestern Coahuila, Van Tyne and Sutton (1937:96) recorded this tanager as a common nesting species in Brewster County, Texas, in cottonwood, mesquite, or willow trees. I suspect that *P. r. cooperi* is a common nesting bird in northwestern Coahuila as well.

Nos. 32828-32831 approach *P. r. rubra*. The measurements of No. 32829 are: wing, 98 mm.; tail, 80 mm.; the measurements of No. 32831 are: wing, 98 mm.; tail, 79 mm. The specimens of *P. r. cooperi* from Parras are somewhat small and seemingly approach *P. r. rubra*. The sizes of the testes (8x5 mm.; 9x5 mm.) of Nos. 32829 and 32831, respectively, and the size of the largest ovum (4x4 mm.) of No. 32830 indicate breeding by this subspecies in southern Coahuila, as does the presence of No. 32828, a juvenal male.

* *Richmondia cardinalis canicaudus* (Chapman).—*Specimens examined*: total 3: ♂ 31099 from 1 mi. N Boquillas, 700 ft., March 8, 1952, weight, 45.3 gms.; ♂ 32135 from 2 mi. W Jiménez, 850 ft., June 20, 1952; and ♂ 32136 from 2 mi. S, 3 mi. E San Juan de Sabinas, June 22, 1952.

In Coahuila the Cardinal is common. Miller (1955a:174) found it singing in the Boquillas drainage of the Sierra del Carmen at 4800 feet, and gave evidence that the Cardinal breeds there. Sutton and Burleigh (1939a:43) found the species to be common in the low country "east of Saltillo." Hellmayr (1938:69) recorded *R. c. canicaudus* from Sabinas. The sizes of the testes (9 mm.; 7x4 mm.) of Nos. 32135-32136 indicate breeding by this subspecies in northeastern Coahuila.

* *Pyrrhuloxia sinuata sinuata* (Bonaparte).—*Specimens examined*: total 4: ♂ 31100 from 10 mi. S, 5 mi. E Boquillas, 1500 ft., March 4, 1952, weight, 37.3 gms.; ♂ 32137 from 5 mi. N, 19 mi. W Cuatro Ciénegas, 3250 ft., July 5, 1952; ♂ 35403 (skeleton only) from San Marcos, May 5, 1954; and ♂ 30234 from 3 mi. SE Torreón, 3800 ft., January 12, 1951.

In Coahuila, the Pyrrhuloxia is common. Hellmayr (1938:76) listed it from Sabinas. Ridgway (1901:628) recorded *P. s. texana* (= *sinuata*) from La Ventura. Burleigh and Lowery (1942:206) found the species "only in the open desert country west of Saltillo where, on April 22, several pairs were seen in a small arroyo." Amadon and Phillips (1947:579) took an immature *P. s. sinuata* at Las Delicias; Sutton and Burleigh (1939a:43-44) found this subspecies fairly common in the San Pedro district on January 29 and 30. Miller, Friedmann, Griscom, and Moore (1957:330) recorded breeding by *P. s. sinuata* at Hipólito on July 2. The size of the testes (8 mm.) of No. 32137 indicates breeding in central Coahuila.

* *Pheucticus melanocephalus melanocephalus* (Swainson).—*Specimen examined*: one, ♂ 31664, from Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 7500 ft., April 30, 1953, measurements: wing, 105.5 mm.; tail, 78 mm.; culmen, 19 mm.; weight, 48 gms.

Miller (1955a:174) reported that the Black-headed Grosbeak first appeared in the Sierra del Carmen on April 13 and was soon seen patrolling territories. He remarked that these specimens from the Sierra del Carmen conformed adequately with the rather poorly differentiated race *P. m. melanocephalus* and stated that Marsh took an immature male at Jardín del Sur on September 7. Oberholser (1919b:416) listed *Hedymeles melanocephalus papago* (= *P. m. melanocephalus*) from Sierra Guadalupe on April 27.

Dickerman saw Black-headed Grosbeaks in the Sierra del Pino on May 12, 1954, and 16 mi. E and 18 mi. N Ocampo on May 7, 1954. The size of No. 31664 represents the characters of *P. m. melanocephalus* as presented by Oberholser (1919b:413). No specimen of *P. m. melanocephalus* from Coahuila, to my knowledge, approaches *P. m. maculatus*. The size of the testes (7x5 mm.) of No. 31664 suggests breeding by this subspecies in the Sierra Guadalupe.

**Guiraca caerulea interfusa* Dwight and Griscom.—*Specimens examined*: total 2: ♂ 32138 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 18, 1952; and ♀ 32139 from 2 mi. W Jiménez, 850 ft., June 21, 1952.

Burleigh and Lowery (1942:206) recorded this Blue Grosbeak from "about twenty miles west of Saltillo" on April 22. Miller (1955a:174) stated that Marsh obtained a male *G. c. interfusa* at Vivoras Spring on August 3. Miller, Friedmann, Griscom, and Moore (1957:334) remarked that the Blue Grosbeak breeds in the northern and eastern sections and reported *G. c. interfusa* from Hipólito on July 2. Amadon and Phillips (1947:580) reported examining material from Sabinas referable to *G. c. interfusa*. Dickerman saw Blue Grosbeaks 4 mi. N San Isidro on May 10, 1954. Findley saw Blue Grosbeaks 4 mi. W Jiménez on June 19, 1952, and 2 mi. S and 3 mi. E San Juan de Sabinas on June 22, 1952. Nos. 32138-32139 are typical representatives of *G. c. interfusa*. The size of the testes (12 mm.) of No. 32138, the size of the largest ovum (2 mm.) of No. 32139, and the dates (June 18, 21) on which they were collected are evidence of breeding by this subspecies.

***Guiraca caerulea eurhyncha* Coues.—Amadon and Phillips (1947:580) obtained an adult male of this Blue Grosbeak from Las Delicias on August 12. This subspecies, according to Miller, Friedmann, Griscom, and Moore (1957:334), is resident at middle and lower elevations through most of central and southern México. Except for the occurrence of intergrades of *G. c. interfusa*, *caerulea*, and *eurhyncha* in southern Nuevo León and Tamaulipas (Miller, Friedmann, Griscom, and Moore, 1957:335), the record from Las Delicias represents the northern limit of the range of the subspecies *eurhyncha*.

**Passerina cyanea* (Linnaeus).—*Specimen examined*: one, ♂ 31544, from San Marcos, May 5, 1954.

The Indigo Bunting is rare in Coahuila. Van Hoose (1955:303) reported that No. 31544 seems to provide the first record of the species in the State. The Indigo Bunting is a summer resident in southwestern Oklahoma and southeastern Texas (Miller, Friedmann, Griscom, and Moore, 1957:336). No. 31544 seemingly represents a large extension in the summer range of the Indigo Bunting. Van Hoose (*loc. cit.*) stated that No. 31544 was observed chasing another male, and the pursuer in turn was followed by a female; he thought that the territorial behavior of this bird suggested breeding.

**Passerina versicolor versicolor* (Bonaparte).—*Specimens examined*: total 2: ♂ 35414 from 6 mi. N, 2 mi. W Castillón, 3750 ft., June 30, 1953, weight, 8 gms.; and ♂ 35415 from 5 mi. S Castillón, 4150 ft., June 28, 1953.

Although the Varied Bunting has been recorded only from northwestern Coahuila, I suspect that this bird is locally common throughout most of the

State. Miller (1955a:174) stated that the habitat of this species consisted of catchaw-covered bottom lands at the base of the Sierra del Carmen at 4700 feet. Miller's records indicate incipient breeding by *P. v. versicolor* in the Sierra del Carmen on April 26. The size of the testes (11 mm.) of No. 35415 and the dates (June 28, 30) on which Nos. 35414-35415 were collected are strong evidence of breeding by the Varied Bunting 6 mi. N and 2 mi. W Castillón and 5 mi. S Castillón.

* *Passerina ciris pallidior* Mearns.—*Specimens examined*: total 6: ♂ 32141 and ♀ 32142 from 2 mi. S, 11 mi. E Nava, 810 ft., June 15 and 16, 1952; ♂ 35416 from 6 mi. N, 2 mi. W Castillón, 3750 ft., June 29, 1953, weight, 15 gms.; ♂ 32140 from 2 mi. S, 3 mi. E San Juan de Sabinas, June 22, 1952; ♂ 31547 from 16 mi. N, 14 mi. E Ocampo, May 10, 1954, weight, 16 gms.; and ♂ 31546 from San Marcos, May 5, 1954.

The Painted Bunting is a common summer resident in Coahuila. Marsh and Stevenson (1938:287) wrote that Painted Buntings were common in summer in the foothills of the Sierra del Carmen, and they took a male at Piedra Blanca on July 25 and a female at Jardín del Sur on September 1. Amadon and Phillips (1947:580) remarked that two immature Painted Buntings, "apparently migrants, were taken at Las Delicias on August 10 and 11." Miller, Friedmann, Griscom, and Moore (1957:339) recorded breeding by *P. c. pallidior* at Hipólito, 4200 feet, on July 1. Findley saw Painted Buntings 2 mi. S and 11 mi. E Nava on June 15, 1952. Dickerman saw Painted Buntings 4 mi. N San Isidro on May 10, 1954. Hardy saw Painted Buntings at Parras on July 4, 1955.

All the University of Kansas specimens are typical of the larger subspecies *pallidior*. The dates (May 5, 10; June 15, 16, 22, 29) on which these specimens were collected, the sizes of the testes (9x6 mm.; 6x5 mm.; 7x3 mm.) of Nos. 32140, 31547, and 31546, respectively, and the size of the largest ovum (2.5 mm.) of No. 32142 indicate breeding by *P. c. pallidior* in Coahuila.

Carpodacus cassinii Baird.—Cassin's Finch is an uncommon winter migrant in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:314) listed *C. cassinii* from Sierra Guadalupe.

* *Carpodacus mexicanus potosinus* Griscom.—*Specimens examined*: total 8: ♂ 35417 from 13 mi. S, 5 mi. W Castillón, 4000 ft., June 28, 1953, testes, 6 mm., weight, 19 gms.; ♀ 35411 (skeleton only) from Sierra del Pino (=5 mi. W, 3 mi. S Acebuches), 6200 ft., May 14, 1954; ♂ 32145 from 5 mi. N, 19 mi. W Cuatro Ciénegas, 3250 ft., July 5, 1952; ♂ 32144 and ♀ 32147 from 3 mi. S, 3 mi. E Bella Unión, 6750 ft., June 27, 1952, ♂ gonads, 7 mm.; ♂ 32143 and ♀ 32146 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 24, 1952; and ♂ 31675 from the west foot of Pico de Jimulco, 5000 ft., April 4, 1953, weight, 20 gms.

The House Finch is common in Coahuila. Miller (1955a:174) reported a sparse population of this species in the foothills adjoining Boquillas Canyon at 4800 feet of the Sierra del Carmen and observed young just out of the nest on April 25. He remarked also that specimens of the House Finch from the Sierra del Carmen seem to show no intergradation toward *frontalis*. Burleigh and Lowery (1942:206) noted *C. m. potosinus* at "Saltillo, in the desert country west of there, at the Chorro del Agua, and in the open valley south of Diamante Pass." Miller, Friedmann, Griscom, and Moore (1957:316) listed breeding by *C. m. potosinus* at El Diamante on July 6. Dickerman

also saw the House Finch at San Marcos on May 4, 1954, and Hardy saw it at Parras on July 4, 1955. No. 32147 had a distinct brood patch; the largest ovum of No. 32146 was 7 mm. in diameter. No. 32145 was a juvenal male.

The University of Kansas specimens agree well with descriptions of *C. m. potosinus* as given by Moore (1939:195). No approach toward *C. m. frontalis*, *centralis*, or *nigrescens* is exhibited by any of these specimens. No. 31675, from Pico de Jimulco in southwestern Coahuila, is paler above and below than any other specimens of *C. m. potosinus*. Also the crown of No. 31675 is suffused with more red than in typical representatives of *C. m. potosinus*.

**** *Spinus pinus pinus* (Wilson).**—*Specimen examined*: one, sex ? 33219 (skeleton only) from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955.

On April 5, 7, and 21, Miller (1955a:175) recorded winter visitant or vagrant flocks of Pine Siskins in the Sierra del Carmen. Miller, Friedmann, Griscom, and Moore (1957:318) listed *S. p. pinus* south to Sierra Guadalupe. Dickerman saw Pine Siskins 13 mi. E San Antonio de las Alazanas on April 10, 1954.

***Spinus pinus macropterus* (Bonaparte).**—Miller, Friedmann, Griscom, and Moore (1957:319) recorded a vagrant *S. p. macropterus* from 50 mi. S Monclova, 2850 feet, on November 9.

***Spinus tristis pallidus* Mearns.**—*Specimen examined*: one, ♀ 31101, from Fortín (=33 mi. N, 8 mi. W San Gerónimo), 3300 ft., March 28, 1952, weight, 11.5 gms.

The American Goldfinch is an uncommon migrant or winter visitant in Coahuila. Hellmayr (1938:296) recorded *S. t. pallidus* from Sabinas. Fortín and Sabinas are the only places in Coahuila where *S. t. pallidus* has been collected. No. 31101 is a typical representative of *S. t. pallidus*.

**** *Spinus psaltria psaltria* (Say).**—*Specimens examined*: total 7: ♂♂ 32148-32149 and ♀ 32151 from 12 mi. N, 12 mi. W Jiménez, 850 ft., June 19, 1952; ♂ 32150 from 2 mi. W Jiménez, June 20, 1952; ♂ 33220 (skeleton only) from Parras, July 4, 1955; and ♂ 32939 and ♀ 32940 from Mesa de las Tablas, July 7, 1955, weights, 9.5, 11 gms.

In Coahuila, the Lesser Goldfinch seems to be common. Although Miller (1955a:175) did not find it in the Sierra del Carmen, he reported that Marsh took a specimen on August 22 in Chuperosa Canyon that was "presumed to" be *S. p. psaltria*. Burleigh and Lowery (1942:206) observed the Lesser Goldfinch "on the outskirts of Saltillo in an orchard on April 20."

Nos. 32148-32151 and 32940 were typical for the subspecies *psaltria*. A partial albino (32939), which was obtained from a pine-oak-wheat field edge, has upper parts that lack the black coloring of typical representatives of *S. p. psaltria*. Instead the crown and back of No. 32939 is yellow, resembling the color of its underparts, the wing coverts are white, and its primaries are black with white edgings.

*** *Atlapetes pileatus dilutus* Ridgway.**—*Specimens examined*: total 2: ♂ 32942 and ♀ 32943 from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955.

The Rufous-capped Atlapetes occurs uncommonly in southeastern Coahuila. The male and female *A. p. dilutus* from 13 mi. E San Antonio de las Alazanas

represent the first records of occurrence of this subspecies in the State. The smaller size, grayer upper parts, and pale yellow color of the underparts of Nos. 32942-32943 characterize the subspecies *dilutus*. The size of the testes (7x6 mm.) of No. 32942 and the date (July 6) on which both specimens were collected indicate breeding by this species in Coahuila.

**Arremonops rufivirgata rufivirgata* (Lawrence).—*Specimens examined*: total 2: ♂ 32152 and ♀ 32153 from 2 mi. S, 3 mi. E San Juan de Sabinas, June 22 and 23, 1952.

The Olive Sparrow is uncommon in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:349) listed *A. r. rufivirgata* from Sabinas on February 10. Sabinas and southeast of San Juan de Sabinas seem to be the only localities in Coahuila where the Olive Sparrow has been collected and also are at the westernmost extremity of range of this species. The size of the testes (9x7 mm.) of No. 32152 and the dates of collection indicate breeding by the Olive Sparrow in Coahuila.

Chlorura chlorura (Audubon).—*Specimen examined*: one, ♂ 30238, from 1 mi. N San Lorenzo, 4200 ft., February 5, 1951.

The Green-tailed Towhee is a common migrant and winter visitant in Coahuila; the species has been found at several localities. Miller (1955a:175) noted several migrants "each day in the last week of April . . . at the mouth of Boquillas Canyon" of the Sierra del Carmen. Burleigh and Lowery (1942:207) noted the species "in an arroyo in the open desert country about twenty miles west of Saltillo on April 22." Miller, Friedmann, Griscom, and Moore (1957:351) listed the Green-tailed Towhee from 12 mi. W Saltillo on September 28 and from Sabinas.

**Pipilo erythrophthalmus gaigei* Van Tyne and Sutton.—*Specimens examined*: total 3: ♀ 31102 from Fortín (=33 mi. N, 8 mi. W San Gerónimo), 3300 ft., March 28, 1952, weight, 38.8 gms.; ♂ 35412 (skeleton only) from Sierra del Pino (=5 mi. W, 3 mi. S Acebuches), 6200 ft., May 15, 1954, testes enlarged, weight, 34 gms.; and ♂ 31593 from 17 mi. S Ocampo, 5300 ft., April 7, 1954, weight, 38 gms.

The Rufous-sided Towhee is locally common in Coahuila; *P. e. gaigei* is present in northern Coahuila. Miller (1955a:175) remarked that "between 6800 and 7500 feet these towhees were sparsely distributed in areas of scattered low ceanothus and hawthorne, chiefly in canyon bottoms, but also on slopes where ceanothus was intermingled with downed timber and young pines." He (*loc. cit.*) indicated that the adult obtained by Marsh from Vivoras Canyon on August 25 was *P. e. gaigei* rather than *P. maculatus montanus* (see also Sibley, 1950:127). Dickerman saw Rufous-sided Towhees in the Sierra de la Madera on December 13, 1953. I have referred Nos. 31102 and 31593 to *gaigei* although both are close to *orientalis*. The size of the testes (14x8 mm.) of No. 31593 suggests breeding.

**Pipilo erythrophthalmus orientalis* Sibley.—*Specimens examined*: total 3: ♂ 32154 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952; ♂ 33223 (skeleton only) from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955; and ♂ 31630 from Mesa de Tablas, 8600 ft., January 15, 1954, weight, 46 gms.

This subspecies of the Rufous-sided Towhee occurs in southeastern Coahuila. Burleigh and Lowery (1942:207) stated that it "was limited in its distribution to the mountain sides . . . [and was] noted in the arroyos at the base of the mountains and from there up to about 8,000 feet." These authors identified their specimens from Diamante Pass and from Saltillo as *Pipilo maculatus gaigei*. Sibley (1950:129) reidentified them, as well as a series from Sierra de Guadalupe, as *P. e. orientalis*. The size of the testes (12x7 mm.) of No. 32154 as well as the date (June 25) on which it was obtained suggests breeding by the Rufous-sided Towhee in southeastern Coahuila.

* *Pipilo fuscus potosinus* Ridgway.—*Specimens examined*: total 3: ♂ 32155 from 7 mi. S, 4 mi. E Bella Unión, 7200 ft., June 25, 1952; ♂ 31676 from the west foot of Pico de Jimulco, 5000 ft., April 5, 1953, weight, 45 gms.; and sex ? 29560 from 7 mi. S, 1 mi. E Gómez Farias, 6500 ft., November 19, 1949, weight, 46.5 gms.

The subspecies *potosinus* has been recorded from several localities in Coahuila. Davis (1951:70) listed the following localities in the State from which *P. f. potosinus* has been collected: Muralla, San Lázaro Mountains, 50 mi. S Monclova, 2850 ft., Saltillo; Saltillo (Chorro de Agua); 19 mi. W Saltillo; Cresta Blanca, 12 mi. W Saltillo, 5500 ft.; Diamante Pass, 11 mi. S Saltillo, 6000-8000 ft.; and Carneros. Miller, Friedmann, Griscom, and Moore (1957:358) recorded a "small juvenile" from El Diamante on July 5. Sutton and Burleigh (1939a:45) recorded *P. f. texanus* from Diamante Pass on March 6. I suspect that Davis (*op. cit.*) reidentified the specimen concerned from Diamante Pass as *P. f. potosinus*. Burleigh and Lowery (1942:207) indicated that *P. f. potosinus* "was fairly common and of general distribution in the area, occurring both on the arid plateau about Saltillo and on the mountain sides up to an elevation of about 8,000 feet." Nos. 32155, 31676, and 29560 are typical for *P. f. potosinus*. The size of the testes (14x7 mm.) of No. 32155 suggests breeding by the Brown Towhee in southeastern Coahuila.

* *Pipilo fuscus texanus* van Rossem.—*Specimen examined*: one, ♀ 31103, from 10 mi. S, 5 mi. E Boquillas, 1500 ft., March 5, 1952, weight, 46.9 gms.

This subspecies of the Brown Towhee occurs in northwestern Coahuila south through the Sierra del Carmen. Miller (1955a:176) reported that his series of Brown Towhees from the Sierra del Carmen agreed satisfactorily with *texanus* although revealing some sign of intergradation with *potosinus*. Davis (1951:70) thought that *P. f. potosinus* is present in northern as well as southern Coahuila. Miller (1955a:176), however, remarked that *P. f. texanus* is more characteristic of the population of Brown Towhees of northwestern Coahuila. He indicated that a single juvenile taken by Marsh on August 28 from Jardín del Sur and allocated to *P. f. potosinus* by Davis probably is *P. f. texanus*.

Calamospiza melanocorys Stejneger.—*Specimen examined*: one, ♂ 30239, from 10 mi. E Torreón, 3700 ft., January 9, 1951.

The Lark Bunting is an uncommon winter visitant in Coahuila. Other than the present specimen, the only record of the Lark Bunting in Coahuila is that of Burleigh and Lowery (1942:207), who reported a small flock of this species from which several specimens were collected "on April 20 in a field on the edge of Saltillo."

Passerculus sandwichensis oblitus Peters and Griscom.—Miller, Friedmann, Griscom, and Moore (1957:364) recorded *P. s. oblitus* from Sabinas on February 25 and March 18 and 24. These records represent sparse winter visitants to Coahuila.

Passerculus sandwichensis brooksi Bishop.—Burleigh and Lowery (1942:208) recorded *P. s. brooksi* from Diamante Pass in April; Miller, Friedmann, Griscom, and Moore (1957:363) remarked that this specimen is perhaps best regarded as a variant of one of the races normally wintering in this area.

Passerculus sandwichensis anthinus Bonaparte.—*Specimens examined*: total 3: ♂ 31104 from 10 mi. E Hacienda La Mariposa, 2000 ft., March 30, 1952, weight 15 gms.; ♀ 31105 from 8 mi. N, 4 mi. W Múzquiz, 1800 ft., April 1, 1952, weight, 19.0 gms.; and ♀ 31594 from 17 mi. S Ocampo, 5300 ft., April 7, 1954, weight, 16 gms.

Burleigh and Lowery (1942:208) recorded *P. s. anthinus* from Diamante Pass. This subspecies is not uncommon in Coahuila. The University of Kansas specimens showed no indication of breeding.

Passerculus sandwichensis nevadensis Grinnell.—This subspecies of the Savannah Sparrow is uncommon in Coahuila; Hellmayr (1938:490) listed one specimen from Sabinas.

Passerculus sandwichensis brunnescens (Butler).—Burleigh and Lowery (1942:208) recorded this subspecies of the Savannah Sparrow from Diamante Pass in April.

Ammodramus savannarum perpallidus (Coues).—*Specimen examined*: one, ♀ 31562, from 3 mi. N, 4 mi. E San Francisco (=25 mi. N Ocampo), 4850 ft., May 16, 1954, weight, 15 gms.

The Grasshopper Sparrow is an uncommon spring and possibly fall migrant in Coahuila. Miller, Friedmann, Griscom, and Moore (1957:367) recorded *A. s. perpallidus* from Sabinas on March 12. No. 31562, which was obtained in a yucca and acacia association, had little fat.

Ammodramus bairdii (Audubon).—Miller, Friedmann, Griscom, and Moore (1957:368) remarked that Baird's Sparrow is a rare winter visitant to the northern states of México and recorded *A. bairdii* from Saltillo on May 8.

Poocetes gramineus confinis Baird.—The Vesper Sparrow seems to be an uncommon winter visitant in Coahuila. Miller (1955a:176) found *P. g. confinis* "on two occasions in the grass of the dry ciénega at the head of Corte Madera Canyon at 7500 feet" on April 9 and 14 in the Sierra del Carmen. In April, Burleigh and Lowery (1942:208) found *P. g. confinis* only in Diamante Valley where this sparrow "appeared to be quite uncommon." Sutton and Burleigh (1939a:45) took a male *P. g. confinis* at San Pedro on January 29.

* *Chondestes grammacus strigatus* Swainson.—*Specimen examined*: one, ♂ 32156, from 8 mi. N, 2 mi. W Piedras Negras, June 18, 1952.

The Lark Sparrow is not uncommon in Coahuila. Miller (1955a:176) saw one male, "apparently on a breeding territory, on April 27 in an open, rather barren desert flat adjoining the lower part of Boquillas wash at 4600 feet." He reported that Marsh took a young of the year, still largely in

juvenile plumage, on September 6 in the Sierra del Carmen. Amadon and Phillips (1947:580) remarked that Lark Sparrows were common "about Las Delicias" after August 18. Findley saw Lark Sparrows 2 mi. W Jiménez on June 19, 1952, and 2 mi. S and 11 mi. E Nava on June 15, 1952. Dickerman saw Lark Sparrows at San Marcos on May 4, 1954. The pale and narrowly streaked upperparts of No. 32156 are typical for *C. g. strigatus*. The size of the testes (9x4 mm.) of No. 32156 and the date (June 18) on which it was obtained suggest breeding by the Lark Sparrow in northeastern Coahuila.

* *Aimophila ruficeps tenuirostris* Burleigh and Lowery.—This subspecies of the Rufous-crowned Sparrow is resident in the northern part of Coahuila. Miller (1955a:176) remarked that the species "ranged up to 7000 feet on open south-facing slopes within the oak belt" of the Sierra del Carmen. Specimens collected by him showed no approach to *boucardi* of southern México and seem to be closest to *tenuirostris*. Miller referred the specimen that Marsh and Stevenson (1938:287) took on August 22 in Chuperosa Canyon to *tenuirostris* rather than *boucardi*. Miller, Friedmann, Griscom, and Moore (1957:376) listed *A. r. tenuirostris* from 50 mi. S Monclova on November 8 and 10.

* *Aimophila ruficeps boucardi* (Sclater).—This subspecies of the Rufous-crowned Sparrow is common in southern Coahuila. Burleigh and Lowery (1942:208) indicated that *A. r. boucardi* was common throughout the mountainous areas and to some extent in the arroyos of the open desert country of southeastern Coahuila. Sutton and Burleigh (1939a:46) took a female *A. r. boucardi* "near Diamante Pass." Ridgway (1901:252) listed *A. r. boucardi* from Carneros. *A. r. tenuirostris* and *boucardi* seem to intergrade in central and even southern Coahuila. Miller, Friedmann, Griscom, and Moore (1957:376) recorded intermediate populations of the Rufous-crowned Sparrow from 12 mi. W Saltillo.

* *Aimophila cassinii* (Woodhouse).—*Specimens examined*: total 2: ♂ 32157 from 9 mi. S, 11 mi. E Sabinas, June 14, 1952; and ♂ 32158 from 18 mi. S, 14 mi. E Tanque Alvarez, 4000 ft., July 6, 1952.

Cassin's Sparrow seems to be common in Coahuila. The AOU Check-list Committee (1957:603) listed *A. cassinii* from 10 mi. E Saltillo. Miller, Friedmann, Griscom, and Moore (1957:378-379) recorded Cassin's Sparrow from Sabinas, on April 25; from 25 mi. SW Monclova, on November 20; from 12 mi. W Saltillo, on September 28; and from 10 mi. NE Saltillo, on July 3. These authors stated that Cassin's Sparrow was breeding 10 mi. NE Saltillo. The sizes of the testes (5x3 mm.; 7x5 mm.) of Nos. 32157-32158, respectively, and the dates (June 14, July 6) on which they were obtained are additional evidence of breeding by Cassin's Sparrow in Coahuila.

* *Amphispiza bilineata bilineata* (Cassin).—*Specimens examined*: total 5: ♂ 32159 and ♀ 32163 from 2 mi. W Jiménez, 850 ft., June 20, 1952; ♂ 32160 from 8 mi. N, 2 mi. W Piedras Negras, June 18, 1952; ♂ 32161 and sex ? 32162 from 5 mi. N, 19 mi. W Cuatro Ciénegas, 3250 ft., July 5, 1952.

The Black-throated Sparrow is common in Coahuila. Typical representatives of *A. b. bilineata* occur in eastern Coahuila. The center of the State is occupied by intergrades between *A. b. bilineata*, *opuntia*, and *grisea*. Miller,

Friedmann, Griscom, and Moore (1957:381) reported *A. b. bilineata* from the "Saltillo area." Hellmayr (1938:539) recorded *A. b. bilineata* from Sabinas. The sizes (13, 14 mm.) of the white spot on the lateral tail feathers of Nos. 32163 and 32160, respectively, suggest *A. b. bilineata*. The short wing (61-64.5 mm.) and the lighter and browner color of the backs of Nos. 32163, 32160, and 32161 are suggestive of *A. b. bilineata*. Nevertheless, the size (8 mm.) of the white spot on the lateral tail feather of No. 32161 indicates intergradation with *A. b. opuntia*.

The sizes of the testes (6x4 mm.; 8 mm.) of Nos. 32160 and 32161, the size of the largest ovum (2 mm. in diameter) of No. 32163, and the presence of the juveniles from 2 mi. W Jiménez and 5 mi. N and 19 mi. W Cuatro Ciénegas indicate breeding by *A. b. bilineata* in Coahuila.

* *Amphispiza bilineata opuntia* Burleigh and Lowery.—*Specimens examined*: total 2: ♀ 31106 from 10 mi. S, 5 mi. E Boquillas, 1500 ft., March 3, 1952; weight, 12.3 gms.; and ♂ 31108 from 35 mi. S, 14 mi. E Boquillas, 2350 ft., March 12, 1952.

This subspecies of the Black-throated Sparrow occurs in northwestern Coahuila. Miller (1955a:176) stated that the Black-throated Sparrow was moderately common in the open desert scrub at the base of the Sierra del Carmen below 4800 feet. He said that the series of Black-throated Sparrows from the Sierra del Carmen "resembles most the race *opuntia* of western Texas . . . but shows some intergradation toward *grisea* of southern Coahuila and toward *A. b. bilineata* of eastern Coahuila." He remarked also that the specimen from Jardín del Sur, which Marsh and Stevenson (1938:287) reported as *A. b. grisea*, was in extremely worn, dirty summer plumage and contributed nothing reliable to racial determination.

* *Amphispiza bilineata grisea* Nelson.—*Specimen examined*: one, ♂ 31665, from the north foot of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6500 ft., April 25, 1953.

A. b. grisea is the subspecies of Black-throated Sparrow in southern Coahuila. Burleigh and Lowery (1942:208) saw this sparrow "frequently on the arid plateau around Saltillo" and obtained specimens there that were identified as *A. b. grisea*. Amadon and Phillips (1947:581) saw individuals on August 8 and 28 that were feeding "fledged young near Saltillo." The size of its wing (68.5 mm.), the slaty color of its back, and the size (8 mm.) of the white spot on its lateral tail feather suggest that No. 31665 is characteristic of *A. b. grisea*. The size of the testes (4.5x3 mm.) of No. 31665 indicates that *A. b. grisea* may breed in southern Coahuila.

* *Junco phaeonotus palliatus* Ridgway.—*Specimens examined*: total 3: ♂ 35402 (skeleton only) from 13 mi. E San Antonio de las Alazanas, 9345 ft., April 10, 1954; ♀ 33226 (skeleton only) from 13 mi. E San Antonio de las Alazanas, 9950 ft., July 6, 1955; and ♂ 31633 from Mesa de Tablas, 8600 ft., January 16, 1954, weight, 22 gms.

In Coahuila the Mexican Junco seems to be common. Miller (1955a:177) found it in the conifers of the upper Corte Madera drainage at 7500 feet and up to 8800 feet on Loomis Peak in the Sierra del Carmen. Marsh and Stevenson (1938:287) took an adult in Vivoras Canyon on August 14 in the Sierra del Carmen. Sutton and Burleigh (1939a:46) found small flocks at Diamante Pass in March. Burleigh and Lowery (1942:208-209) noted *J. p.*

*palliatu*s as a common bird of the mountain slopes above an elevation of about 7000 feet in southeastern Coahuila, and obtained specimens at Diamante Pass. Ridgway (1901:300) recorded *J. p. phaeonotus* from Sierra Encarnación. His record should be of *J. p. palliatu*s as indicated by Miller, Friedmann, Griscom, and Moore (1957:386). Dickerman saw Mexican Juncos in the Sierra de la Madera on December 13, 1953.

No. 31633 shows no sign of intergrading with *J. p. phaeonotus* to the south. The outermost rectrix of No. 31633 is wholly white; the second rectrix is nearly as white. No. 31633 is paler than representatives of *J. p. phaeonotus* from the southern part of the Central Plateau of México.

Spizella passerina arizonae Coues.—*Specimens examined*: total 4: ♂ 31110 from the Río Grande (=17 mi. S Dryden, Terrell Co., Texas, in Coahuila), 600 ft., March 18, 1952, weight, 10.7 gms.; ♂ 31111 and ♀ 31112 from 4 mi. W Hacienda La Mariposa, 2300 ft., March 24, 1952, weights, 11.0, 11.7 gms.; and ♂ 31666 from the north foot of Sierra Guadalupe (=10 mi. S, 5 mi. W General Cepeda), 6400 ft., April 19, 1953, weight, 14.0 gms.

The Chipping Sparrow is a common spring and possibly fall migrant in Coahuila. Miller (1955a:177) noted small flocks from April 21 to 27 in the Sierra del Carmen where specimens were taken. Burleigh and Lowery (1942:209) indicated that *S. p. arizonae* was "quite common and of general distribution" at Saltillo and Diamante Pass and remarked that specimens were taken at these localities in April. Amadon and Phillips (1947:581) took two Chipping Sparrows "near Las Delicias on August 17." Dickerman saw individuals in the Sierra del Pino on May 12, 1954, and at San Marcos on May 4, 1954. Our specimens, which are typical representatives of *S. p. arizonae*, are pale; the ground color of their backs is grayish buff.

Spizella pallida (Swainson).—The Clay-colored Sparrow is a migrant or winter visitant in Coahuila. Burleigh and Lowery (1942:209) saw "large flocks of sparrows, mostly of this species, . . . on frequent occasions in the cultivated fields and orchards on the outskirts of Saltillo." Four specimens were taken by Burleigh and Lowery (*loc. cit.*) on April 19 and 20 at Saltillo.

Spizella breweri breweri Cassin.—*Specimens examined*: total 2: ♀ 31115 from the Río Grande (=17 mi. S Dryden, Terrell Co., Texas, in Coahuila), 600 ft., March 18, 1952, weight, 8.2 gms.; and ♂ 31114 from 28 mi. S, 11 mi. E Boquillas, 2000 ft., March 12, 1952, weight, 9.7 gms.

Brewer's Sparrow is probably a winter resident in much of Coahuila. Miller, Friedmann, Griscom, and Moore (1957:389) recorded *S. b. breweri* from 25 mi. NW Monclova on November 20 and from 8 mi. S Cuatro Ciénegas on November 15. The only definite records obtained by Burleigh and Lowery (1942:209) of *S. b. breweri* are those of a female and a male taken "near Saltillo" on April 16 and 18. The size of the dorsal area of sandy buff with narrow streakings of Nos. 31114-31115 suggests *S. b. breweri*.

Spizella pusilla arenacea Chadbourne.—*Specimen examined*: one, ♂ 31116, from 4 mi. W Hacienda La Mariposa, 2300 ft., March 24, 1952, weight, 13.1 gms.

The Field Sparrow is an uncommon spring and probably fall migrant in Coahuila. Other than No. 31116, *S. p. arenacea* has only been recorded from Sabinas in March, when three specimens were obtained (Miller, Friedmann,

Griscom, and Moore, 1957:390). The coloration of No. 31116 is much grayer and the black streaks on its back are much narrower than on typical representatives of *S. p. pusilla*.

** *Spizella wortheni wortheni* Ridgway.—The single specimen of Worthen's Sparrow obtained by Burleigh and Lowery (1942:209) "just outside the limits of Saltillo on April 16" represents the only record of occurrence of this species in Coahuila.

** *Spizella atrogularis atrogularis* (Cabanis).—Miller, Friedmann, Griscom, and Moore (1957:391) remarked that the Black-chinned Sparrow is a common resident of the Central Plateau from Durango and southern Coahuila southward. Burleigh and Lowery (1942:212) noted the species only at the foot of the mountains of southeastern Coahuila where, at 6000 feet, scattered pairs were found. Miller (1955a:177) observed a male on April 23 on a slope at the mouth of Boquillas Canyon of the Sierra del Carmen; he presumed it to be a transient.

Zonotrichia leucophrys leucophrys (Forster).—*Specimen examined*: one, ♂ 30243, from 1 mi. SW San Pedro de las Colonias, 3700 ft., February 8, 1951.

The White-crowned Sparrow is a fairly common migrant or winter visitant in Coahuila. Miller, Friedman, Griscom, and Moore (1957:393) recorded *Z. l. leucophrys* from Sabinas on March 16 and February 23. Burleigh and Lowery (1942:212) remarked that "small flocks of White-crowned Sparrows were seen at infrequent intervals in thickets and stretches of underbrush on the outskirts of Saltillo on April 18 and again on April 24 . . . [and] near a small town some twenty miles west of Saltillo on April 22." Specimens that Burleigh and Lowery (*loc. cit.*) collected "near Saltillo" were identified as *Z. l. leucophrys*.

Zonotrichia leucophrys gambelii (Nuttall).—*Specimen examined*: one, ♂ 31117, from Sierra de la Encantada (=38 mi. S, 23 mi. E Boquillas), 4400 ft., March 15, 1952.

Miller (1955a:177) noted *Z. l. gambelii* on April 27 at 4600 feet in Boquillas wash in the Sierra del Carmen. Hellmayr (1938:568) listed *Z. l. gambelii* from Sabinas.

Zonotrichia leucophrys oriantha Oberholser.—This subspecies has been recorded from Sabinas on April 25 and Hipólito on November 5 (Miller, Friedmann, Griscom, and Moore, 1957:393).

Melospiza lincolni lincolni (Audubon).—*Specimen examined*: one, ♀ 31595, from 20 mi. S Ocampo, 7000 ft., April 5, 1954, measurements: wing, 58 mm.; tail, 50 mm.; weight, 12 gms.

Lincoln's Sparrow seems to be a fairly common migrant or winter visitant in Coahuila; *M. l. lincolni* is the common subspecies. Burleigh and Lowery (1942:212) found this sparrow only in a grain field situated between a small pond and a narrow stream on the outskirts of Saltillo; the four specimens collected were identified as *M. l. lincolni*. No. 31595 was obtained in a pine-oak association.

Melospiza lincolni alticola (Miller and McCabe).—Miller, Friedmann, Griscom, and Moore (1957:398) listed *M. l. alticola*, which seems to be uncommon in Coahuila, from Sabinas on March 14.

Melospiza lincolnii gracilis (Kittlitz).—Miller (1955a:177) took an unsexed representative of *M. l. gracilis* on April 7 in Carboneras Canyon of the Sierra del Carmen at 6700 feet. This occurrence is at the extreme eastern range of this subspecies.

Melospiza georgiana ericrypta Oberholser.—In Coahuila this subspecies of the Swamp Sparrow has been recorded as a migrant or winter visitant. Miller, Friedmann, Griscom, and Moore (1957:399) recorded it from Sabinas on February 22 to March 8 and from 8 mi. S Cuatro Ciénegas on November 4.

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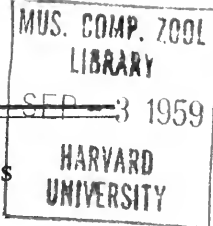
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Volume 11, No. 9, pp. 517-525, 2 pls., 1 fig.

August 14, 1959

Description of a New Softshell Turtle
From the Southeastern United States

BY

ROBERT G. WEBB

UNIVERSITY OF KANSAS

LAWRENCE

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UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

Editors: E. Raymond Hall, Chairman, Henry S. Fitch,
Robert W. Wilson

Volume 11, No. 9, pp. 517-525, 2 pls., 1 fig.

Published August 14, 1959

UNIVERSITY OF KANSAS
Lawrence, Kansas

PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1959



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Description of a New Softshell Turtle From the Southeastern United States

BY

ROBERT G. WEBB

Examination of softshell turtles allied to *Trionyx muticus* from the southeastern United States discloses the presence of an undescribed subspecies inhabiting river systems of the Gulf Coast.

The author is indebted to Mr. Roger Conant for constructive criticism of the manuscript. I am grateful also to many fellow students for assistance in field work or for other courtesies, especially William E. Brode, Franklin Sogandares-Bernal, Ernest A. Liner, Donald W. Tinkle, Paul K. Anderson, and John K. Greer. The photographs were provided through the cooperation of Roger and Isabelle Hunt Conant and John M. Legler.

Collections from which specimens were obtained are as follows: TU (Tulane University), USNM (United States National Museum), MCZ (Museum of Comparative Zoology, Harvard College), CNHM (Chicago Natural History Museum), KU (Museum of Natural History, University of Kansas), UI (Museum of Natural History, University of Illinois).

Measurements (in millimeters) were made with a Vernier caliper and a metal tape; those of the holotype were made to the nearest one-tenth millimeter. Plastral length was measured from the posterior edge of the plastron to the anteriormost edge of the ventral surface; other measurements were maximal. Depth of shell was taken only on hatchlings and an immature female. Hatchlings were arbitrarily designated as specimens having plastrons shorter than 44 mm; sex of all specimens except adult males was determined by dissection unless otherwise noted.

Trionyx muticus calvatus new subspecies

Gulf Coast Smooth Softshell

Amyda mutica (in part), Stejneger, Bull. Mus. Comp. Zool., 94(1):23-24, 1944.

Amyda muticus (in part), Cook, Jour. Mississippi Acad. Sci., 1941-1947, p. 185, 1946.

Trionyx muticus Anderson, Copeia, 3:211, August 28, 1958.

Holotype.—UI 31071, hatchling, sex undetermined, from the Pearl River, Roses Bluff, 14 miles northeast Jackson, Rankin County, Mississippi; obtained by William F. Childers on August 25, 1952 (Plate 1).

Paratypes.—A total of 20 alcoholic specimens: TU 17301, hatchling male (Plate 2). TU 17302-.1, 16682, three hatchling females, and TU 13473,

adult female, from the Escambia River, 2 miles east and 1 mile north of Century, Escambia County, Florida; TU 17306, adult female, from the Pearl River, 9 miles south of Monticello, Lawrence County, Mississippi; USNM 7655, hatchling, sex undetermined, and KU 47117-19, three adult males, from the Pearl River, 1 mile south to 4 miles north of Monticello, Lawrence County, Mississippi; TU 17303-.4, 17304-.3, five hatchling males and four hatchling females, from the Pearl River, Varnado, Washington Parish, Louisiana; TU 17305, immature female, no data.

Diagnosis and definition.—A subspecies of softshell turtle most closely allied to *Trionyx muticus muticus* but differing from that subspecies in having: (1) a juvenal pattern of large, circular spots, (2) no stripes on dorsal surface of snout, and (3) postocular stripe with thick, black borders immediately behind eye in adult males. *T. m. calvatus* resembles *T. m. muticus*, and differs from the several subspecies of *Trionyx spinifer* in having: (1) no enlarged tubercles on anterior edge of carapace, (2) no ridge projecting from nasal septum, and (3) a smooth dorsal surface on carapace in adult males. *T. m. calvatus* and *T. m. muticus* resemble *T. ferox* in having a smooth dorsal surface on carapace in adult males, but differ from *T. ferox* in having: (1) no tubercles along anterior edge of carapace, and (2) no ridge projecting from nasal septum.

Description of holotype.—Carapace circular, widest at region of bridge; margin entire; dorsal surface smooth; anterior margin of carapace lacking tubercles; blunt vertebral ridge evident anteriorly; maximum length, 53.1 mm; greatest width, 46.3 mm; greatest depth, 11.5 mm.

Plastron small, extending slightly farther forward than carapace; anterior lobe truncate with slight midventral indentation; posterior lobe rounded, sides forming acute angle; certain features of bony elements of plastron visible through overlying skin; width of bony bridge, 4.5 mm; maximum length of plastron, 37.5 mm.

Head extended to level of eyes; head terminating in long, rounded, flexible snout; nostrils rounded with no ridges projecting from nasal septum; jaws closed, each covered by fleshy lips except anteriorly where horny portions of jaws are exposed; iris with dark stripe through pupil.

Forefeet and hind feet well-webbed and with five digits each; each limb with nails on first three digits; dorsal surface of each forelimb with four cornified areas, three of which have a free edge; each hind limb with two cornified areas, one smooth on posterodorsal surface and other with free edge on posteroventral surface.

Tail terminating in flexible point and not extending beyond posterior edge of carapace; anus to tip of tail, 2.6 mm; anus to posterior edge of carapace, 8.1 mm.

In preservative: Ground color of carapace dark tan having pattern of 49 brownish spots; 47 spots circular; two spots noticeably elongate, one representing fusion of two circular spots; 17 spots on carapace not exceeding 2.0 mm in diameter, whereas 32 spots range from 2.5 to 4.0 mm in diameter; periphery of carapace pale except anteriorly; maximum width of pale margin (posteriorly), 3.3 mm; junction of pale margin and dorsal ground color formed by rough-edged line composed of small, closely-set dots; pattern of fine punctations and other marks on dorsal surface of forelimbs and hind limbs.

Ground color of underparts whitish, lacking markings; top of head and snout gray, lacking markings; lower eyelids with small dark dots.

Description of paratypes.—Adult females (2 specimens). No striping on dorsal surface of snout; pale postocular stripe not distinct, dark borders obscure (head not extended in TU 13473); carapace circular, pale brown with mottled pattern; carapace lacking pattern of large spots; dark marks present in pale margin of carapace; dorsal surface of soft parts of body finely stippled, larger marks on hind limbs and on anterior surface of forelimbs near their insertions; plastron and ventral surface of soft parts of body without markings. Maximal measurements, respectively, are: length of plastron, 172 and 180 mm; length of carapace, 238 and 263 mm; width of carapace, 203 and 218 mm; width of head, 28 and ? mm.

Immature female (1 specimen). Carapace circular having juvenal pattern of large spots, some of which have borders darker than their centers and are best described as ocelli; junction of pale margin and ground color of carapace formed by ill-defined, ragged dark border; dorsal surface of forelimbs and hind limbs finely streaked and dotted, larger marks occurring toward insertions of forelimbs; lower border of pale postocular stripe in contact with upper margin of postlabial pale stripe; no stripes on dorsal surface of snout; fine markings on dorsal surface of neck. Maximal measurements are: length of plastron, 56 mm; length of carapace, 82 mm; width of carapace, 77 mm; depth of shell, 13 mm; width of head, 12 mm.

Adult males (3 specimens). No striping on dorsal surface of snout; pale postocular stripe with thick, black borders immediately behind eye; width of black borders equal to approximately one-half width of pale postocular stripe; dorsal surface of soft parts of body with indistinct markings that are larger on hind limbs; plastron and ventral surface of soft parts of body without markings; small dark spots posteriorly along ventral edge of carapace; pale margin of carapace lacking markings or having few small black spots; carapace circular with or without pattern of large spots. Maximal measurements of smallest and largest specimens, respectively, are: length of plastron, 108 and 118 mm; length of carapace, 160 and 177 mm; width of carapace, 142 and 152 mm; width of head, 21 mm.

Hatchlings (14 specimens). These paratypes resemble the holotype in all features mentioned; markings on neck tend to form longitudinal streaks in TU 17303 and 17304. There are no secondary sexual differences in hatchling turtles.

There is some variation in hatchling turtles. Four from the Escambia River have dorsal spots 3 mm or larger in greatest diameter and on three specimens the dorsal spots number 27, 37 and 37 (total number not discernable in TU 16682); none of the dorsal spots is ocellate. Maximal measurements of these three hatchlings, respectively, are: length of plastron, 35, 36 and 37 mm; length of carapace, 50, 50 and 52 mm; width of carapace, 44, 45 and 47 mm; depth of shell, 11 mm; width of head, 9 mm. Nine hatchlings from the Pearl River at Varnado have more (all small) dorsal spots, which may be ocellate. The dorsal spots and ocelli do not exceed 2 mm in their greatest diameter except that some of those of TU 17304 are 3 mm; the spots range in number from 38 (TU 17303) to 63 (TU 17304). Maximal measurements of the smallest and largest specimens, holotype excepted, are: length of plastron, 30

and 33 mm; length of carapace, 42 and 46 mm; width of carapace, 37 and 43 mm; depth of shell, 9 and 10 mm; width of head, 9 and 10 mm. The holotype resembles hatchlings from the Escambia River in having large, non-ocellate dorsal spots 3 mm in greatest diameter, and larger measurements.

One other specimen (not designated as a paratype), consisting of a head with a few attached cervical vertebrae, was obtained on a sand bank of the Escambia River, Florida. The postocular stripe, bright yellow with black borders, was especially vivid in this adult male (KU 47116).

Range.—*Trionyx m. calvatus* is known from the Pearl, Pascagoula and Escambia river drainages and is to be expected in the Tombigbee-Alabama river drainage (Fig. 1). Tinkle (1958:41, fig. 53, stippled) has indicated the probable range of *calvatus*. This subspecies is unknown from the Mississippi and Tennessee river drainages, which are inhabited by *T. m. muticus*. The

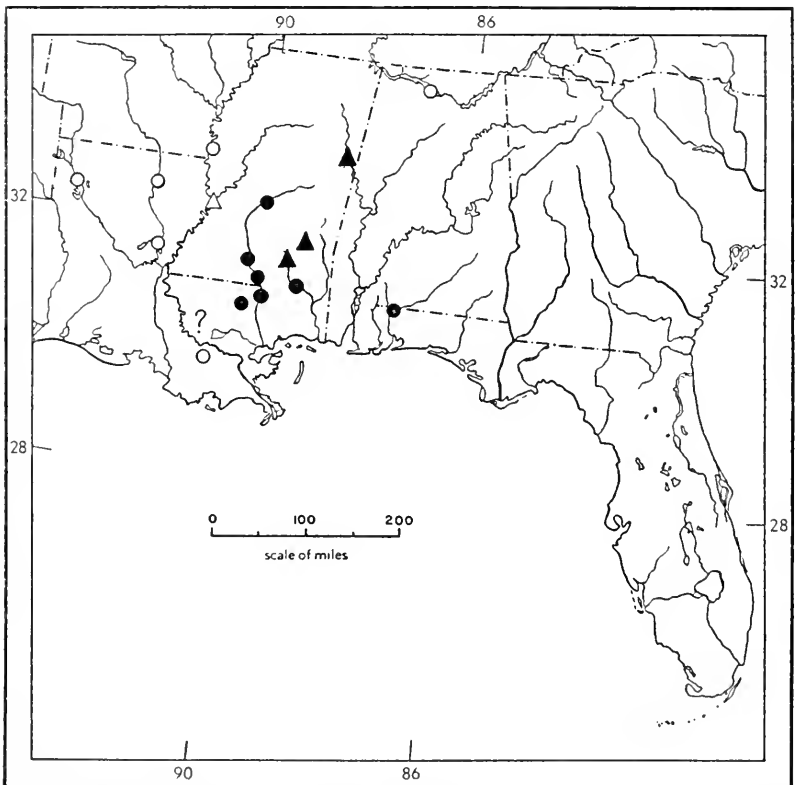


FIG. 1. Map of southeastern United States showing record stations of *Trionyx muticus calvatus* (solid symbols) and *Trionyx m. muticus* (open symbols). Circles indicate specimens examined; triangles indicate records in the literature. The question mark refers to a specimen bearing catalogue number 17236 in the collection of Tulane University (see comments on page 524 concerning No. 17236 from the Amite River).

western limit of distribution is the Pearl River drainage and probably those streams of the Florida Parishes of Louisiana that drain into Lake Ponchartrain. The most easterly record of occurrence for *T. m. calvatus* is in the Escambia River drainage; the eastern extent of geographic range is not known.

I have seen three preserved young turtles having the characteristic spotted pattern from the Pascagoula drainage in eastern Mississippi. These specimens are uncatalogued and in the collections at Mississippi Southern College, Hattiesburg, Mississippi.

There is a specimen of *T. m. muticus* labeled as from Mobile, Alabama (MCZ 1596), for which I believe the locality datum is incorrect. It is a young turtle having a well-defined pattern on the carapace and is without doubt a representative of *T. m. muticus*. Mobile is in the large drainage basin, of the Tombigbee, Black Warrior, Coosa and Alabama rivers, which is between the Escambia and Pearl rivers.

Yarrow (1882:28) reported a specimen of *Amyda mutica*, USNM 11630, from Gainesville, Florida. This record was questioned by Cahn (1937:179), and has been disregarded by subsequent authors. Stejneger (1944:23) lists this specimen number with uncertainty from Mt. Carmel, Illinois. The exact geographic provenance of this specimen is seemingly unknown.

Habitat.—I have collected eggs of *T. m. calvatus* on sand banks of the Escambia River, Florida. The Escambia River has a sand-gravel bottom, extensive sandy banks, a moderately-rapid current, and is flanked by a thick riparian forest. It is approximately 80 feet wide with fallen trees and brush intermittently emergent along the shoreline. The sand bar-habitat along the Pearl River has been mentioned by Anderson (1958:212). All records thus far are from lotic habitats.

Comparisons.—*Trionyx m. calvatus* is most closely related to *Trionyx m. muticus*. Both subspecies have the following characteristics: (1) no enlarged tubercles on the anterior edge of the carapace, (2) no ridge projecting from the nasal septum, and (3) a smooth carapace in adult males. These characters distinguish these two subspecies from the several subspecies of *T. spinifer*, and, except for the smooth carapace in adult males, from *T. ferox*. Another feature of *T. m. calvatus* and *T. m. muticus*, not known to be definitive or diagnostic but noticed on occasion, is the pale orange cast, in life, of the dorsal surface of the carapace and soft parts of the body in young of these turtles.

The spotted pattern of juveniles of *calvatus* is easily distinguished from the pattern of *muticus* (small dots, streaks and dashes) figured by Agassiz (1857, vol. 2, pt. 3, pl. 6, fig. 6), Smith (1950:154, fig. 104), Conant (1938: 192, pl. 21, fig. 1; 1958, pl. 11, opposite p. 94), and Cahn (1937:177, pl. 24C).

Unfortunately, the distinctive dorsal spotting in young *calvatus* becomes obscure or absent in some adults of both sexes. Spotting in large males is not so well-defined as in juveniles; it may be absent (TU 17306.3), or indicated by two obscure spots (KU 17117), but is usually evident, at least posteriorly. The spotted pattern is absent in large females, which have a pale, mottled and blotched pattern of lichen-like figures; dorsal spots are obscure in TU 17305 (length of plastron, 56 mm).

Two additional features are, so far as known, universal in *calvatus*; these are: (1) the absence of striping on the dorsal surface of the snout, and (2)

the presence of thick, black borders of the postocular stripe in adult males. These features have also been observed in some specimens of *muticus*; their presence in *muticus* cannot be properly evaluated at this time, and is seemingly not due to individual variation. These two characters, however, coupled with the distinctive juvenile pattern of spots, serve, in combination, to distinguish *calvatus* from *muticus*.

Discussion.—The two populations are recognized as subspecies because: (1) there is close resemblance, (2) the diagnostic characters pertaining to pattern are few and superficial, and (3) the geographic ranges are allopatric, but juxtaposed. It is probable that *muticus* and *calvatus* would be capable of interbreeding if they were not spatially isolated. It should be pointed out, however, that there is no evidence of intergradation between *muticus* and *calvatus* in the lower Mississippi Valley as has been reported for the subspecies of *T. spinifer* (Conant and Goin, 1948), and that the degree of difference between *calvatus* and *muticus* is greater than that between some subspecies of *T. spinifer*.

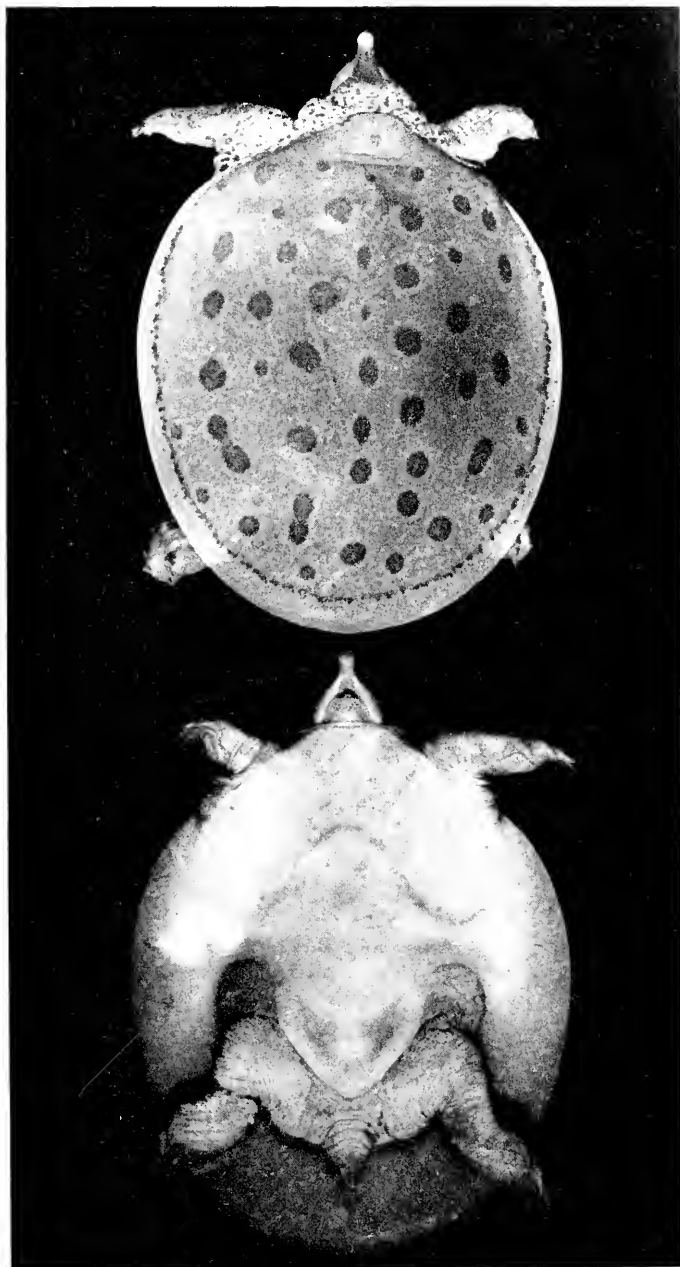
Specimens examined.—All the localities listed below are plotted on the distribution map (Fig. 1). Only those specimens of *T. muticus muticus* are listed that serve to delimit the range of *T. m. calvatus*. Fortunately, the identification of the specimens of *muticus* is certain as all show the characteristic juvenile pattern, except the large female, TU 7543, from southeastern Louisiana. USNM 95133-34 (carapaces and plastrons only) and TU 17236 are females, which lack the diagnostic spotted pattern of *calvatus*; the former are referred to this subspecies on geographic grounds (Pearl River at Columbia, Mississippi). TU 17236, from the Amite River, is dubiously relegated to *calvatus* on the supposition that this river and others in the Lake Ponchartrain drainage will yield the characteristic juveniles.

Trionyx m. calvatus (33 specimens): TU 13473, 16682, 17301, 17302-1, KU 47116 (skull only), Escambia River, 2 miles east, 1 mile north Century, Escambia Co., Florida; TU 17303-4, 17304-3, Pearl River, Varnado, Washington Par., Louisiana; TU 17306-3, Pearl River, 9 miles south Monticello, Lawrence Co., Mississippi; TU 16956, KU 47117-19, USNM 7655, Pearl River, vicinity of Monticello, Lawrence Co., Mississippi; TU 17236?, Amite River, near Baton Rouge, Louisiana; TU 13795, Bogue Chitto River, Enon, Washington Par., Louisiana; TU 17305, no data, Louisiana; USNM 95133-34, Pearl River, Columbia, Marion Co., Mississippi; UI 31071, Pearl River, 14 miles northeast Jackson, Rankin Co., Mississippi; Uncatalogued, see page 523, Leaf River, 3 miles southeast New Augusta, Perry Co., Mississippi.

Trionyx m. muticus (6 specimens): TU 5989, Ouachita River, Monroe, Ouachita Par., Louisiana; TU 7543, Vacherie, St. James Par., Louisiana; CNHM 7845, Gayles, Caddo Par., Louisiana; USNM 92605, Greenville, Washington Co., Mississippi; USNM 113228, Jonesville, Catahoula Par., Louisiana; USNM 118167, Wheeler Reservoir, Tennessee River, Alabama.

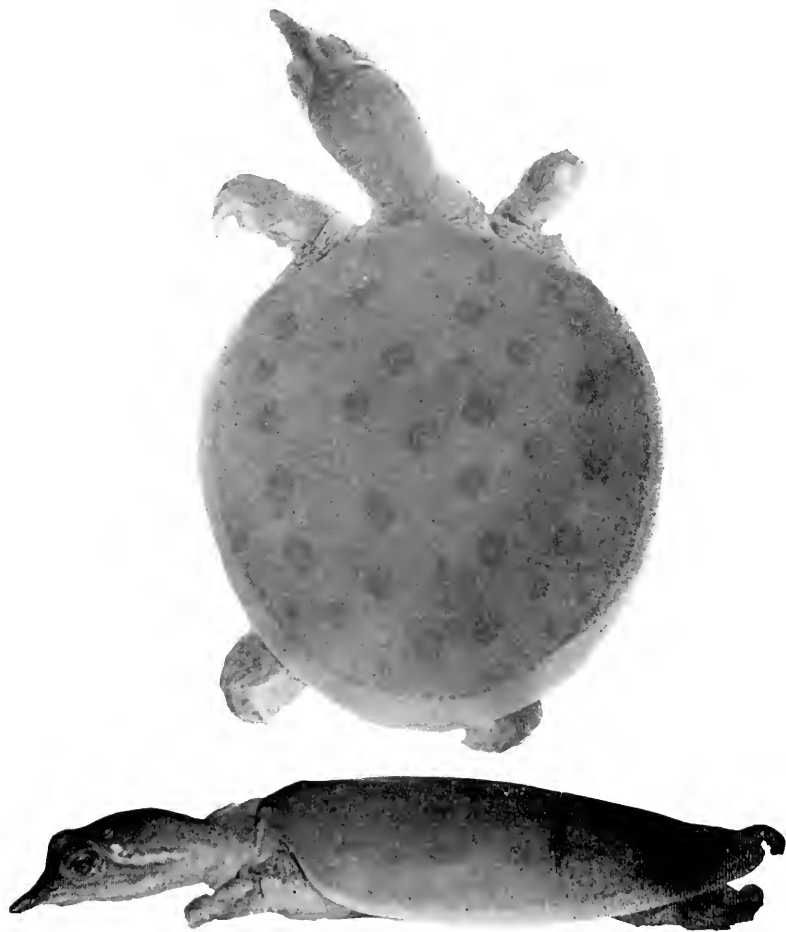
Records in the Literature.—USNM 113228, referred to above as *Trionyx m. muticus* is listed by Stejneger (1944:56) as *Amyda s. spinifera*; four of the specimens listed above (USNM 7655, 92605, 95133-34) are recorded by Stejneger (*op. cit.*:23-34) as *Amyda mutica*. Cook (1946:185) records seven specimens of the *muticus* group from Mississippi as follows: 1, no data; 1, Vicksburg, Warren Co.; 3, Forrest Co.; 1, Crawford Bridge, Jones Co.; 1, Lake Park, Columbus, Lowndes Co. I have not seen these specimens;

PLATE 13



Trionyx muticus calvatus new subspecies, hatchling, UI 31071, holotype ($\times 1.3$). Top, dorsal view. Bottom, ventral view. Photographs by John M. Legler.

PLATE 14



Trionyx muticus calvatus new subspecies, hatchling male, TU 17301, paratype ($\times 1.3$). Top, dorsal view. Bottom, lateral view of left side. Photographs by Isabelle Hunt Conant.

they are plotted on the distribution map—the one from Vicksburg as *muticus* and the others as *calvatus* on geographic grounds. The hatchlings of *Trionyx muticus* referred to by Anderson (*loc. cit.*) include the nine paratypes from Varnado, Louisiana.

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Transmitted April 30, 1959.



27-8360

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Volume 11, No. 10, pp. 527-669, 16 pls., 29 figs.

March 7, 1960

Natural History of the Ornate Box Turtle,
Terrapene ornata ornata Agassiz

BY

JOHN M. LEGLER

UNIVERSITY OF KANSAS
LAWRENCE
1960

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MUSEUM OF NATURAL HISTORY

Volume 11, No. 10, pp. 527-669, 16 pls., 29 figs.

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UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

Editors: E. Raymond Hall, Chairman, Henry S. Fitch,
Robert W. Wilson

Volume 11, No. 10, pp. 527-669, 16 pls., 29 figs.
Published March 7, 1960

UNIVERSITY OF KANSAS
Lawrence, Kansas



PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1960



28-773

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INTRODUCTION

The ornate box turtle, *Terrapene o. ornata* Agassiz, was studied more or less continuously from September, 1953, until July, 1957. Intensive field studies were made of free-living, marked populations in two small areas of Douglas County, Kansas, in the period 1954 to 1956. Laboratory studies were made, whenever possible, of phenomena difficult to observe in the field, or to clarify or substantiate field observations. Certain phases of the work (for example, studies of populations and movements) were based almost entirely on field observation whereas other phases (for example, growth and gametogenic cycles) were carried out almost entirely within the laboratory on specimens obtained from eastern Kansas and other localities.

A taxonomic revision of the genus *Terrapene* was begun in 1956 as an outgrowth of the present study. The systematic status of *T. ornata* and other species is here discussed only briefly.

Objectives of the study here reported on were: 1) to learn as much as possible concerning the habits, adaptations, and life history of *T. o. ornata*; 2) to compare the information thus acquired with corresponding information on other emyid and testudinid chelonians, and especially with that on other species and subspecies of *Terrapene*; 3) to determine what factors limit the geographic distribution of ornate box turtles; and, 4) to determine the role of ornate box turtles in an ecological community.

Acknowledgments

The aid given by a number of persons has contributed substantially to the present study. I am grateful to my wife, Avis J. Legler, who, more than any single person, has unselfishly contributed her time to this project; in addition to making all the histological preparations and typing the entire manuscript, she has assisted and encouraged me in every phase of the study. Dr. Henry S. Fitch has been most helpful in offering counsel and encouragement. Thanks are due Professor E. Raymond Hall for critically reading the manuscript.

Special thanks are due also to the following persons: Professor A. B. Leonard for helpful suggestions dealing with photography and for advice on several parts of the manuscript; Professor William C. Young for the use of facilities at the Endocrine Laboratory, University of Kansas; Professor Edward H. Taylor for permission to study specimens in his care; Dr. Richard B. Loomis for identifying chigger mites and offering helpful suggestions on the discussion of ectoparasites; Mr. Irwin Ungar for identification of plants; and, Mr. William R. Brecheisen for allowing me to examine his field notes and for assistance with field work. Identifications of animal remains in stomachs were made by Professor A. B. Leonard (mollusks, crustaceans), Dr. George W. Byers (arthropods), and Dr. Sydney Anderson (mammals).

Miss Sophia Damm generously permitted the use of her property as a study area and Mr. Walter W. Wulfkuhle made available two saddle horses that

greatly facilitated field work. The drawings (with the exception of Fig. 21) are by Miss Lucy Jean Remple. All photographs are by the author.

I am grateful also to the Kansas Academy of Science for three research grants (totaling \$175.00) that supported part of the work. The brief discussion of taxonomic relationships and distribution results partly from studies made by means of two research grants (totaling \$150.00), from the Graduate School, University of Kansas, for which I thank Dean John H. Nelson.

Systematic Relationships and Distribution

Turtles of the genus *Terrapene* belong to the Emydidae, a family comprising chiefly aquatic and semiaquatic species. *Terrapene*, nevertheless, is adapted for terrestrial existence and differs from all other North American emyids in having a hinged and movable plastron and a down-turned (although often notched) maxillary beak. *Emydoidea blandingi*, the only other North American emyid with a hinged plastron, lacks a down-turned beak. The adaptations of box turtles to terrestrial existence (reduction of webbing between toes, reduction in number of phalanges, reduction of zygomatic arch, and heightening of shell) occur in far greater degree in true land tortoises of the family Testudinidae. Four genera of emyid turtles in the eastern hemisphere (*Cuora*, *Cyclemys*, *Emys*, and *Notochelys*) possess terrestrial adaptations paralleling those of *Terrapene* but (with the possible exception of *Cuora*) the adaptations are less pronounced than in *Terrapene*. A movable plastron has occurred independently in two groups of emyids in the New World and in at least three groups in the Old World.

The genus *Terrapene*, in my view, contains seven species, comprising 11 named kinds. Of these species, five are poorly known and occur only in Mexico. *Terrapene mexicana* (northeastern Mexico) and *T. yucatanana* (Yucatan peninsula) although closely related, differ from each other in a number of characters. Similarly, *Terrapene klauberi* (southern Sonora) and *T. nelsoni* (Tepic, Nayarit—known from a single adult male) are closely related but are considered distinct because of their morphological differences and widely separated known ranges. *Terrapene coahuila*, so far found only in the basin of Cuatro Ciénegas in central Coahuila, is the most primitive *Terrapene* known; it differs from other box turtles in a number of morphological characters and is the only member of the genus that is chiefly aquatic.

Two species of *Terrapene* occur in the United States. *Terrapene carolina*, having four recognized subspecies, has a nearly continuous distribution from southern Maine, southern Michigan, and southern Wisconsin, southward to Florida and the Gulf coast and westward to southeastern Kansas, eastern Oklahoma and eastern Texas, and characteristically inhabits wooded areas.

Terrapene ornata is a characteristic inhabitant of the western prairies of the United States, and ranges from western and southern Illinois, Missouri, Oklahoma, and all but the extreme eastern part of Texas, westward to southeastern Wyoming, eastern Colorado, eastern and southern New Mexico, and southern Arizona, and, from southern South Dakota and southern Wisconsin, southward to northern Mexico (Fig. 1). It is the only species of the genus that occurs in both Mexico and the United States. The northeasternmost populations of *T. ornata*, occurring in small areas of prairie in Indiana and Illinois, seem to be isolated from the main range of the species. The ranges of *T. ornata* and *T. carolina* overlap in the broad belt of prairie-forest ecotone in the central United States. Interspecific matings under laboratory conditions

are not uncommon and several verbal reports of such matings under natural conditions have reached me. Nevertheless, after examining many specimens of both species and all alleged "hybrids" recorded in the literature, I find no convincing evidence that hybridization occurs under natural conditions.

Terrapene ornata differs from *T. carolina* in having a low, flattened carapace lacking a middorsal keel (carapace highly arched and distinctly keeled in *carolina*), and in having four claws on the hind foot (three or four in *carolina*), the claw of the first toe of males being widened, thickened, and turned in (first toe not thus modified in *carolina*). *Terrapene ornata* is here considered to be the most specialized member of the genus by virtue of its reduced phalangeal formula, lightened, relatively loosely articulated shell, reduced plastron, and lightly built skull, which completely lacks quadratojugal bones (Fig. 2); most of these specializations seem to be associated with adaptation for terrestrial existence in open habitats.

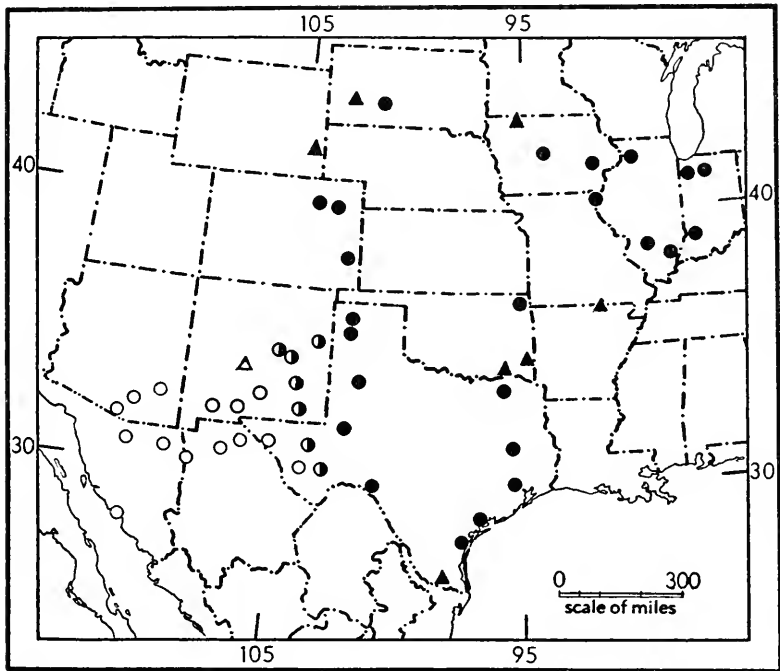


FIG. 1. Geographic distribution of *Terrapene ornata*. Solid symbols indicate the known range of *T. o. ornata* and hollow symbols the known range of *T. o. luteola*. Half-circles show the approximate range of intergradation between the two subspecies. Triangles indicate localities recorded in literature; specimens were examined from all other localities shown. Only peripheral localities are shown on the map.

Two subspecies of *T. ornata* are recognized. *Terrapene o. luteola*, Smith and Ramsey (1952), ranges from northern Sonora (Guaymas) and southern Arizona (southern Pima County) eastward to southeastern New Mexico and Trans-Pecos, Texas, where it intergrades with *T. o. ornata*; the latter subspecies is not yet known from Mexico but almost surely occurs in the northeastern part

of that country. The subspecies *luteola* differs from *ornata* in being slightly larger and in having more pale radiations on the shell (11 to 14 radiations on the second lateral lamina in *luteola*, five to eight in *ornata*). In individuals of *luteola* the markings of the shell become less distinct with advancing age and eventually are lost; shells of most old individuals are uniform straw color or pale greenish-brown; this change in coloration does not occur in *T. o. ornata*.

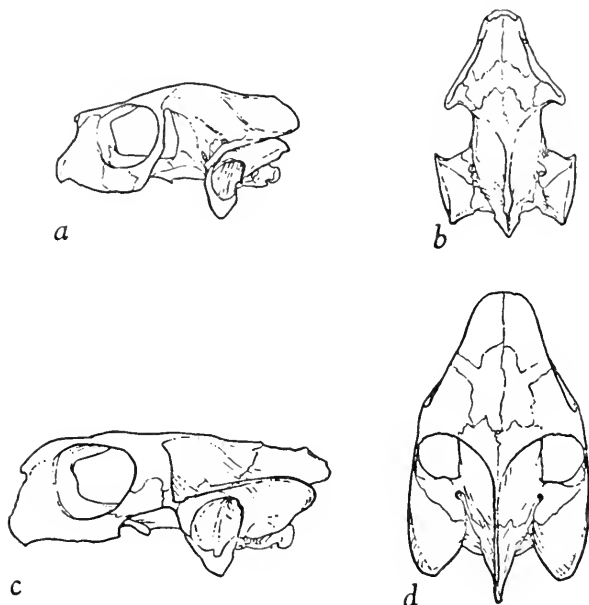


FIG. 2. Dorsal and lateral views of skull of *T. o. ornata* (*a* and *b*) (KU 1172, male, from 6 mi. S. Garnett, Anderson Co., Kansas) and of *T. carolina* (*c* and *d*) (KU 39742, from northern Florida). Note the relatively higher braincase and the incomplete zygomatic arch in *T. o. ornata*. All figures natural size.

Fossils

Of the several species of fossil *Terrapene* described (Hay, 1908b:359-367, Auffenberg, 1958), most are clearly allied to Recent *T. carolina*. One species, *Terrapene longinsulae* Hay, (1908a:166-168, Pl. 26) from ". . . the Upper Miocene or Lower Pliocene . . ." of Phillips County, Kansas, however, is closely related to *T. ornata* (if not identical). I have examined the type specimen of *T. longinsulae*. Stock and Bode (1936:234, Pl. 8) reported *T. ornata* from sub-Recent deposits near Clovis, Curry County, New Mexico.

Economic Importance

Ornate box turtles, referred to as "land terrapins" or "land tortoises" over most of the range of the species, are regarded by most persons whom I have queried as innocuous. These turtles occasionally damage garden crops and

have been known to eat the eggs of upland game birds. *Terrapene ornata* is seldom used for food. A. B. Leonard told me the species was eaten occasionally by Arapaho Indians in Dewey County, Oklahoma. Several specimens in the University of Kansas Archeological Collections were found in Indian middens in Rice County, Kansas, from a culture dated approximately 1500 to 1600 A. D. The flesh of *T. ornata* occasionally may be toxic if the turtle has eaten toxic fungi as has been recorded for *T. carolina* (Carr, 1952:147).

Study Areas

Preliminary studies and collections of specimens were made at a number of localities in northeastern Kansas in 1953 and 1954. Two small areas were finally selected for more intensive study. One of these areas, the University of Kansas Natural History Reservation, five and one-half miles north-northeast of Lawrence in the northeasternmost section of Douglas County, Kansas, is a tract of 590 acres maintained as a natural area for biological investigations. Slightly less than two thirds (338 acres) of the Reservation is wooded; the remainder consists of open areas having vegetation ranging from undisturbed prairie grassland to weedy, partly brushy fields (Fitch, 1952). Although ornate box turtles were not numerous at the Reservation, the area was selected for study because: 1) there was a minimum of interference there from man and none from domestic animals; 2) the vegetation of the Reservation is typical of areas where *T. ornata* and *T. carolina* occur sympatrically (actually only one specimen of *T. carolina* has been seen at the Reservation); and, 3) availability of biological and climatological data there greatly facilitated the present study. Actual field work at the Reservation consisted of studies of hibernation and long-term observations on movements of a few box turtles.

A much larger number of individuals was intensively studied on a tract of land, owned by Sophia Damm, situated 12 miles west and one and one-half miles north of Lawrence in the northwestern quarter of Douglas County, Kansas. The Damm Farm lies on the southern slope of a prominence—extending northwestward from Lawrence to Topcka—that separates the Kansas River Valley from the watershed of the Wakarusa River to the south. The prominence has an elevation of approximately 1100 feet and is dissected on both sides by small valleys draining into the two larger river valleys.

The Damm Farm (see Pl. 15) has a total area of approximately 220 acres. The crest of a hill extends diagonally from the middle of the northern edge approximately two thirds of the distance to the southwestern corner. Another hill is in the extreme northwestern corner of the study area.

The northeastern 22 acres were wooded and had small patches of overgrazed pasture. Trees in the wooded area were Black Walnut (*Juglans nigra*), Elms (*Ulmus americana*, *U. rubra*), Cottonwood (*Populus deltoides*), and Northern Prickly Ash (*Xanthoxylum americanum*). The areas used as pasture had thick growths of Buckbush (*Symphoricarpos orbiculatus*) mixed with short grasses (*Bromus japonicus*, *Muhlenbergia Schreberi*, and *Poa pratensis*). Farm buildings were situated in the wooded area at the end of an entry road. The southeastern 74 acres were cultivated; corn, wheat, and milo were grown here and fallow fields had a sparse growth of weeds.

Most of the western two thirds of the study area, comprising 124 acres, was open rolling prairie (hereafter referred to as "pasture") upon which beef-cattle were grazed (Pl. 16, Fig. 1; Pl. 17, Fig. 1; Pl. 18, Fig. 2). Rock

fences (Pl. 17, Fig. 2) two to four feet high bordered the northern edge, southern edge, and one half of western edge of the pasture. A wagon track lead from a gate on the entry road, along the crest of the hill, to a gate in the southern fence. Except for the latter gate and for occasional under-cut places in low areas, there were no openings in the rock fences through which box turtles could pass. A few trees—American Elm, Hackberry (*Celtis occidentalis*), Red Mulberry (*Morus rubra*), Osage Orange (*Maclura pomifera*), Black Cherry (*Prunus serotina*), Box-Elder (*Acer Negundo*), and Dogwood (*Cornus Drummondii*)—were scattered along fences at the borders of the pasture and in ravines. Larger trees in a small wooded creek-bed at the southwestern edge of the pasture were chiefly Cottonwood, American Elm, Red Mulberry, and Black Willow (*Salix nigra*). The only trees growing on the pasture itself were a few small Osage Orange, none of which bore fruit.

Paths were worn along fences by cattle and in several places near the fence, usually beneath shade trees, there were large bare places where cattle congregated. Vegetation near paths and bare places was weedy and in some places there were tall stands of Smooth Sumac (*Rhus glabra*).

Rich stands of prairie grasses occurred along the top of the hill in the pasture; bluestems (*Andropogon gerardi*, *A. scoparius*) were the dominant species and Switchgrass (*Panicum virgatum*) and Indian grass (*Sorghastrum nutans*) were scattered throughout. A number of small areas on top of the hill were moderately overgrazed, as indicated by mixture of native grasses with an association of shorter plants consisting chiefly of Ragweed (*Ambrosia artemisiifolia* var. *elator*), Mugwort (*Artemisia ludoviciana*), Japanese Chess (*Bromus japonicus*), and Asters (*Aster* sp.).

The upper parts of the hillsides were overgrazed moderately to heavily. Limestone rocks of various sizes were partly embedded in soil or lay loose at the surface. Depressions beneath rocks provided shelter for box turtles as well as for other small vertebrates. Native grasses were sparse in this area and gave way to Sideoats Grama (*Bouteloua curtipendula*), extensive patches of Smooth Sumac, and scattered colonies of Buckbrush.

Tall grasses were dominant on the lower hillsides and small patches of Slough grass (*Spartina pectinata*) grew in moist areas. Ravines originated at small intermittent springs on the sides of the hill. The banks of ravines were high and steep and more or less bare of vegetation. High, dense stands of Slough grass grew at intermittent springs and along the courses of ravines; sedges (*Carex*, sp.) grew where small pools of water formed and created marshy conditions. Prairie grasses along the tops of ravine embankments formed a narrow overhanging canopy of vegetation that was accentuated in many places where the sod was undercut by erosion or by the activities of burrowing animals (Pl. 18, Fig. 1). Box turtles frequently sought shelter beneath this vegetational canopy or burrowed beneath the sod.

On the highest part of the pasture near the entry road several small areas were nearly bare, presumably because of heavy overgrazing; grasses (except for scattered clumps of *Bouteloua curtipendula* and *Setaria lutescens*) were absent and dominant vegetation consisted of Buffalo-bur (*Solanum rostratum*), Blue Vervain (*Verbena hastata*), Mullein (*Verbascum Thapsus*), Ragweed, Asters, and a few Prickly Pear (*Opuntia humifusa*). Two small areas on the pasture completely lacked vegetation; these may have been wallows or the sites of old salt-licks.

Three shallow stock ponds, behind earthen dikes in ravines, were present on the pasture. The pond near the farm buildings ("House Pond") and that in the southwestern part of the pasture ("Far Pond") were present when studies of box turtles were begun. The largest pond, in a deep ravine in the northern part of the pasture, was constructed in June, 1956, and became filled in approximately one month (Pls. 16 and 18). Pond embankments were chiefly bare of vegetation because of trampling by cattle; in a few places at the edge of the water, or in places too steep for cattle to walk, there were small patches of weeds, sedges, and Slough Grass. The ponds contained some water at all times of the year. The only vertebrates permanently inhabiting the ponds in the course of my studies were Bullfrogs (*Rana catesbeiana*) and Leopard frogs (*Rana pipiens*).

The three parts of the pasture in which studies were concentrated were designated as separate subdivisions. The northwest corner area (28 acres) was triangular and bounded on two sides by rock fences and on its third side by a deep ravine. The southern ravine area (17 acres) constituted the part of the lower southern hillside drained by a series of ravines. The house pond area (seven acres) surrounded "House Pond." Habitat in these three subdivisions of the pasture was especially favorable for box turtles.

Materials and Methods

Observations were made at the Damm Farm on 102 days in the two-year period beginning in Autumn, 1954; observations were concentrated in the period from May to October although some observations were made in every month, January and February excepted. Field work was done chiefly in daylight hours but a few trips were made to the study area at night.

Routine handling of each turtle captured at the Damm Farm consisted of: marking, weighing and measuring turtle; recording the exact place of capture, body temperature and environmental temperature; and, recording miscellaneous items such as the presence of ectoparasites, injuries, distinctive markings, and in some instances, the approximate age of the turtle.

Excursions on the Damm Farm were made on foot in 1954 and 1955, and, in 1956, on horseback. By using a horse, more ground could be covered per unit of time, a better view could be obtained of immediate surroundings, and, cattle on the area, being accustomed to horses, did not become agitated as they would when unmounted persons were nearby.

The entire study area could not be inspected thoroughly in a single day. It was usually more profitable to find and mark turtles along fences, in ravines, or in other open areas, and subsequently to follow their movements away from these areas by means of trailing threads. Turtles could be observed from a distance through binoculars. Cultivated areas were regularly scanned with binoculars but turtles were seldom seen there. Behavior was observed by sitting motionless on rock fences or in a blind on top of a stepladder.

No box turtles were removed from the study area. Specimens obtained in other areas were used for studies of growth, reproduction, and food habits. Measurements, weights, and data concerning temperature and ectoparasites were obtained from specimens collected elsewhere as well as from individuals on study areas.

Turtles were obtained by hand-collecting and in unbaited traps; the number captured in a single day ranged from 12 to none. Traps, like those used by

Packard (1956:9) for tree squirrels, were set in the mouths of burrows and dens, or—with leads to channel animals into the trap—along ravines and rock fences. Traps set in the open were covered to prevent death of turtles from overheating in direct sunlight. Live-trapping provided much valuable data, although quail, rabbits, opossums, and box turtles were caught with about equal frequency in the traps.

Turtles were marked by notching the marginal scutes of the carapace by means of a hacksaw blade, following the code system described by Cagle (1939). Notches, one eighth to one quarter of an inch deep and wide could be cut more quickly than filed and were more evident than drilled holes which often became plugged with soil and obscured. Hatchlings and juveniles were notched with a sharp knife.

Movements of individual turtles were studied by means of a turtle-trailing device—similar to the kind first described by Breder (1927) and later modified by Stickel (1950:355-356)—a tin can, cut to fit the shell of a turtle, with an axle that bore a spool of thread (Pl. 27, Fig. 1). The device was taped to the turtle; the free end of the thread was tied to a stationary object. Thread payed out from the spool through a guide-loop and marked the course of the turtle as it moved away from the starting point. Because of its great strength and elasticity (as compared to cotton), nylon sewing thread was used in trailers. Ordinarily, turtles were unable to break the thread if it became snarled or was expended. Cattle frequently tangled the thread and displaced it but did not often break it. Ordinary spools were cut down on a lathe so they would hold 600 to 800 yards of thread. Turtle-trailing provided an accurate record of where and how far a turtle had traveled, and to a lesser extent, the sort of activity in which the turtle had been engaged (evidence of feeding, forms, or trial nest holes). Trailers seemed not to alter the normal activity of turtles.

Prominent landmarks were rare or wanting in most places on the pasture. Locations of captures (or reference points in the movements of trailer-turtles) were determined by triangulation with a Brunton compass, using trees along fences as known points of reference. Rough maps were made in the field and used later, along with compass readings and measurements, to make a more precise record of movements and captures on a large map (scale, 100 feet to one inch) of the study area. Mapped points of capture in grassy areas were accurate within ten to twenty feet; points of capture in areas where landmarks were nearby were nearly exact. Areas were measured with a planimeter; distances traveled by individuals were measured with a cartometer.

Turtles were measured in the field to the nearest millimeter with large wooden calipers (of the type used by shoe salesmen) and a clear plastic ruler. Measurements in the laboratory, especially in studies of growth, were made, to the nearest tenth of a millimeter with dial calipers. Measurements made on each specimen examined in the field were: length of carapace, width of carapace, length of plastron (sum of lengths of forelobe and hind lobe), width of plastron (at hinge), and height. All measurements were made in a straight line. A spring scale of 500 gram capacity, used in the field, gave weights accurately within three grams. A triple-beam balance was used in the laboratory. Unless otherwise noted, measurements are expressed in millimeters and weights are expressed in grams.

Body temperatures were taken by means of a quick-reading Schultheis thermometer inserted into the distal portion of the large intestine with the

bulb directed ventrally to avoid puncturing the bladder. Body temperature of turtles were altered little or not at all in the few seconds the turtles were held and no attempt was made (except for small juveniles) to insulate them from the warmth of my hands. Data recorded with body temperature were: air temperature (in shade, approximately one inch from turtle); ground temperature (or water temperature); behavior of turtle; weather conditions; nature of vegetation or other cover; and, time of day. Unless otherwise noted, temperatures are expressed in degrees Centigrade.

A maximum-minimum thermometer was installed near the buildings at the Damm Farm. Notes on general weather conditions were made on each visit to the study area. Additional climatological data were obtained from the U. S. Weather Stations in Topeka and Lawrence, from records at the Reservation, and from official bulletins of the U. S. Weather Bureau.

Stomachs and gonads were removed and preserved by standard techniques soon after specimens were killed. The dates given to gonads were, in all instances, the dates when the specimens were killed. Eggs were prepared for incubation in the manner described by Legler (1956). Females laying or containing eggs used in studies of incubation were preserved for further studies and comparison with young hatched from the eggs. Histological preparations were fixed in ten per cent formalin or Bouin's fluid, embedded in paraffin, and stained with hematoxylin and eosin.

Terminology

Names used for the epidermal and bony parts of the shell follow the classification proposed by Carr (1952:35-39). The terms "scute," "lamina," and "scale" are used here more or less interchangeably for the epidermal parts as are the terms "plate," "bone," and "element" for the bony parts of the shell.

The term "form" is used here in the same sense that Stickel (1950:358) used it in her study of *T. carolina*—to indicate a depression or cavity made by a turtle in vegetation or soil. Forms correspond closely in shape and size to shape and size of the turtle. Forms of *T. ornata* differ from those of *T. carolina* chiefly in being made most often in soil, over which there is a minimum of vegetational cover. The term "den" refers to natural cavities (or cavities of unknown origin) beneath rocks, in rock fences, or in cut banks. The term "burrow," unless otherwise noted, refers to burrows made by animals other than box turtles.

HABITAT AND LIMITING FACTORS

The known range of *T. ornata* includes the southern half of the Grassland Biome, part of the Desert Biome, and that part of the Temperate Deciduous Forest Biome known as the Prairie-Forest Ecotone. The species is found in microhabitats that differ widely in food supply, temperature, moisture, and kind of soil. In spite of its relatively high degree of morphological specialization, *T. ornata* is remarkably versatile in regard to habitat requirements.

Ornate box turtles are relatively inconspicuous in natural surroundings and collectors seldom seek out and obtain specimens under completely natural conditions as may be done with certain

other reptiles and amphibians by turning rocks, tearing apart logs, or setting traps. Most series of specimens are obtained by hunting after rains on roads or other natural breaks in vegetational cover. Detailed information on habitat preferences is lacking.

Low temperature seems to be an important factor limiting the distribution of *T. ornata* in the northern part of its range. Box turtles, like nearly all other reptiles occurring at these latitudes, spend the winter in underground hibernacula. The depth to which the ground freezes in the coldest part of the winter is therefore a critical factor. The ground freezes to an average depth of 30 inches or less over most of the range of the species; only in the extreme northern part of the range (southern South Dakota, southeastern Wyoming) does the ground freeze to an average depth of as much as 35 inches. Average depth of freezing is, in fact, less than 15 inches over more than one half the range of the species. The average number of frost-free days per year ranges from 130 to 140 days in the northern part of the range to more than 250 days in the southwestern part of the range.

Terrapene ornata occurs from near sea level to elevations of more than 5000 feet. Both subspecies are found at both high and low elevations but *luteola* is more consistently taken at high elevations than *ornata*. The latter subspecies commonly occurs at elevations above 4000 feet on the high plains in extreme western Kansas and eastern Colorado; the highest elevation from which I have examined specimens of *T. o. ornata* is between 4600 and 4700 feet near Akron, Washington County, Colorado. The greater part of the known range of *T. o. luteola* lies above 3000 feet.

Norris and Zweifel (1950:1) observed *T. o. luteola* on the Jornada del Muerto, an elongate plain approximately 4500 feet high, in southeastern Socorro County, New Mexico; box turtles were abundant on the level part of the plain and on the bordering foothills but not at higher elevations where the substratum was rocky. The authors otherwise noted no preference for any kind of soil. The principal elements of the plant associations in which the turtles were found were creosote bush, yucca, mesquite, juniper, tarbush, and grasses. Lewis (1950:3) reported that *T. ornata luteola* inhabited the yucca-grassland zone in Dona Ana County, New Mexico; he stated (*op. cit.*: 10) that individuals were commonly found on roads after rains and in cloudy weather. No specimens were taken at altitudes higher than 4300 feet.

I have examined specimens of *luteola* from elevations of approximately 5500 feet in Cochise County, Arizona, and Lincoln County,

New Mexico. These localities are probably at or near the maximum elevation at which the species occurs. The texture of the substrate is the most important factor limiting vertical distribution. Ornate box turtles, like nearly all other turtles, excavate nests; *T. ornata* is a burrower, at least for purposes of hibernation. Populations of the species, therefore, could not survive in areas of hard unyielding substrata. Such substrata seem to be the most important factor limiting altitudinal distribution.

Most of the area in which *T. ornata* occurs is semiarid or arid. Average precipitation in the warm season (April through September) varies from approximately 25 inches in the northeast to less than ten inches in the southwest. In drier parts of the range, precipitation is unevenly distributed over the warm season. Long, hot, dry periods are unfavorable for reptilian activity. *T. ornata*, like many other reptiles inhabiting dry regions, survives long periods without water by seeking shelter (usually underground) and remaining quiescent. Populations of the subspecies *luteola* live under far more rigorous conditions in this respect than do the more northern populations. Specimens of *luteola* from Arizona that were kept for several years in the laboratory under dry conditions and fed adequately, but at infrequent intervals, were able to remain healthy and even to grow whereas examples of *ornata* kept under the same conditions soon languished and died; *luteola* seems to be physiologically adapted for existence under arid conditions, where normal activity is sometimes possible for only a few weeks in the year.

The prairies of Nebraska, Kansas, Oklahoma, and northern Texas seem to provide the most nearly optimum habitat for the species; in these regions box turtles are active on a large majority of the days from April to October in years having average or better than average precipitation and population density seems to be greater than in the more arid parts of the range.

Activities of man have probably affected the density of populations of the ornate box turtle in many parts of its range but appear not to have acted as limiting factors except in certain areas along the northern edge of the range (Blanchard, 1923:19-20, 24) where disruption of grassland through intensive cultivation probably has excluded the species. Unlike certain other reptiles of the Great Plains (Fitch, 1955:64), *T. ornata* seems not to have been affected—either by direct decimation of populations or by disruption of habitat—by intensive zoological collecting in restricted areas. Environmental changes such as those resulting from overgrazing and

erosion, or from protection of the habitat from grazing could be expected to cause long-term changes in populations of ornate box turtles.

Terrapene o. ornata is an omnivorous, opportunistic feeder, primarily insectivorous but able to subsist on nearly any sort of animal or vegetable food. The general food habits of *luteola* are poorly known but probably resemble those of *ornata*. Although kind of food available probably does not limit the distribution of *T. ornata* there are indications that it influences population density. In Kansas, for example, dung insects are an important staple in the diet and box turtles were found always to be more numerous in areas where domestic cattle provided an abundant supply of dung than elsewhere. A similar relationship probably existed in former times between box turtles and native ungulates. Near extinction of buffalo in the Great Plains possibly caused a decrease in populations of box turtles. Henry S. Fitch told me that the number of *T. ornata* at the Reservation gradually declined after cattle were removed from the area in 1948.

In summary, the distribution of *T. ornata* seems to be limited by: 1) Presence of a substrate too hard to permit digging of nests and forms (southwestern and western edges of range); 2) temperatures causing the ground to freeze deep enough (approximately 30 inches) to kill turtles in hibernacula (northern edge of range); and, 3) the lack of one or more relatively wet periods in the course of the warm season, preventing at least temporary emergence from quiescence (southwestern edge of range).

HABITAT IN KANSAS

Clarke (1958:40-45) reported *T. o. ornata* in all terrestrial communities studied in Osage County; he considered the subspecies to be characteristic of the “. . . cultivated-field community . . .” and to be of frequent occurrence in (but not characteristic of) the “. . . Oak-Walnut Hillside Forest . . ., Buckbrush-Sumac . . ., and Prairie communities . . .”. Brennan (1937:345) found *T. o. ornata* to be equally abundant in mixed prairie and prairie-streamside habitats in Ellis County; the subspecies was much rarer on rocky hillsides and in the habitat surrounding prairie ponds. Carpenter (1940:641) listed *T. o. ornata* as an inhabitant of “. . . tall and mixed-grass prairies . . .” (also in Oklahoma and Nebraska). Fitch (1958:99) found the order of preference for habitats at the Natural History Reservation to be grazed pasture land, woodland, open fields with undisturbed

prairie vegetation, and fallow fields with a rank growth of weeds.

At the Damm Farm the greatest number of box turtles was collected on the pasture, especially in three areas designated in Plate I as the "northwest corner," "southern ravine," and "house pond" areas. These three areas had several features in common. All contained ravines and rocky slopes that provided many places of concealment (dens, burrows of larger animals, and suitable substrate for the excavation of earthen forms). All contained water (in ponds and intermittent streams) for most of the year; and, all were frequented daily by cattle that left an abundant supply of dung in which box turtles foraged. In addition, each of the three areas contained at least one mulberry tree, under which fruit was abundant in the months of June and July.

The relative numbers of box turtles found in different areas on the Damm Farm were, of course, governed to some extent by my activity in these areas and by the relative ease with which box turtles were seen in different types of vegetational cover. Turtles were more easily seen in the pasture (especially in sparsely vegetated or denuded areas) where much of my field work was done on horseback, than in the wooded areas, where excursions were usually made on foot. It was evident, however, after mapping known ranges and studying patterns of movement in marked turtles, that concentrations in the three above-mentioned areas of pasture were an indication of actual preference by turtles for the more favorable habitat in these areas rather than the result of incomplete sampling.

REPRODUCTION

Mating

Mating takes place throughout the season of activity but is most common in spring—soon after emergence from hibernation—and in autumn. Turtles frequently copulated in the laboratory in spring and autumn. Copulation was observed under natural conditions on several occasions but only once at the Damm Farm.

Norris and Zwiefel (1950:4) saw two captive individuals of *T. o. luteola* copulating on 12 August; copulation lasted two hours. Brumwell (1940:391-2) gave the following description of mating in *T. o. ornata*. A male pursued a female for nearly half an hour, first nudging the margins of her shell and later approaching her rapidly from the rear and hurling himself on her back in an attempt to mount, at the same time emitting a stream of liquid from each nostril. The liquid was presumably water; both sexes had imbibed

water in a pond just before courtship began. Brumwell suggested that pressure on the plastron of the male had forced the water out his nostrils. The pair remained in the coital position for 30 minutes after the male had achieved intromission. In another instance, Brumwell (*loc. cit.*) saw four males pursuing a single female, the males exhibiting the same behavior (nudging and lunging) outlined above. Males that attempted to mount other males were repelled by defensive snapping of the approached male. The female also snapped at some of the males that tried to mount her. One male was finally successful in mounting and was henceforth unmolested by the other males. Brumwell suggested that shell biting and tapping may be methods of sex-recognition.

In the several instances of mating that I observed, the male, after mounting the shell of the female (Pl. 28), gripped her, with the first claws of his hind feet, just beneath her legs or on the skin of the gluteal region and, with the remaining three claws, gripped the posterior edges of her plastron. In most instances the female secured the male's legs by hooking her own legs around them. The coital position of *T. ornata* seems to differ from that of *T. carolina*, at least in regard to the position of the male's legs. The coital positions of *T. carolina* illustrated by Cahn (1937:94, Fig. 13) are physically impossible for *T. ornata*.

In *T. ornata* the pressure exerted on the male's legs by the female probably impairs circulation and probably is painful to the male, especially after coitus, when the male falls backward but is still held by the female. The heavily developed musculature of the legs of males may be an adaptation to strengthen the legs for this temporary period of stress. Evans (1953:191) and Cahn and Conder (1932:87-88) observed the hind legs of males of *T. carolina* to be noticeably weakened after copulation, causing the males to remain inactive for several hours.

Evans (*op. cit.*) observed 72 matings of *T. carolina* and divided the process into three phases as follows: 1) circling, pushing and biting by the male; 2) mounting (female with shell closed); and, 3) coition (female with shell open). Penn and Pottharst (1940:26) reported that captive *T. carolina* in New Orleans mated chiefly under conditions of optimum temperature (21 to 27° C.) and high humidity; some matings took place in a pool of water. Males pushed females about after mating, often rolling them over several times.

Because ornate box turtles observed by me were able easily to right themselves from an inverted position on substrata of all

kinds, males left lying on their backs after copulation are probably in no danger of perishing in this position, as was suggested by Allard (1939) for *T. carolina*.

Insemination

Oviducts of several females were flushed by means of a pipette to determine whether they contained sperm. Approximately half of the females captured in May, 1956, had sperm in their oviducts, but females captured in June and July did not. Sperm flushed from the oviducts were in clumps of several hundred and showed no sign of motility a few minutes after the female was anesthetized with chloroform. No sperm were found in the oviducts of immature females but one female of nearly adult size was observed in copulation with a mature male.

Thorough examination of microscopic sections of oviduct (taken at various times in the season of activity) usually revealed a few sperm lodged in the folds (Pl. 19, Fig. 8) of the cephalic as well as the caudal portion of the tube, but no specialized seminal receptacles such as occur in snakes (Fox, 1956) were present. Fertilization without reinsemination probably occurs in *T. ornata*. Ewing (1943) and Finneran (1948:126) reported that females of *T. carolina* produced fertile eggs for periods of four and two years, respectively, after being removed from all contact with males.

Sexual Cycle of Males

Testes were preserved in each month from April to October. The following description of spermatogenesis is based chiefly on material collected in 1955, although testes were preserved also in 1954. Comparison of material obtained in 1954 and 1955 revealed that spermatogenesis began earlier and was more advanced on any given date in 1955 than in 1954.

Testes of mature individuals are pale yellow and slightly oblong. The epididymis is ordinarily dark brown or black and contrasts sharply with the color of the testes. Size of testes was expressed as the average length (greatest diameter) of both testes. Testes are smallest in April, immediately after emergence from hibernation, and largest in early September (Pl. 20, Figs. 3-4). They are nearly spherical when of maximum size; increase in bulk, therefore, is relatively greater than the increase in size shown in Figure 3. They increase in size from April until early June, recede during most of June, and again increase in size in July and August. They remain

large from early September until hibernation is begun, becoming only slightly smaller in late September and October.

Increase in size following emergence from hibernation may be due in part to proliferation of the sustentacular cytoplasm. Decrease in size in early June is correlated with the end of the period of most active mating; maximal size is coincident with the peak of the spermatogenic cycle in early September.

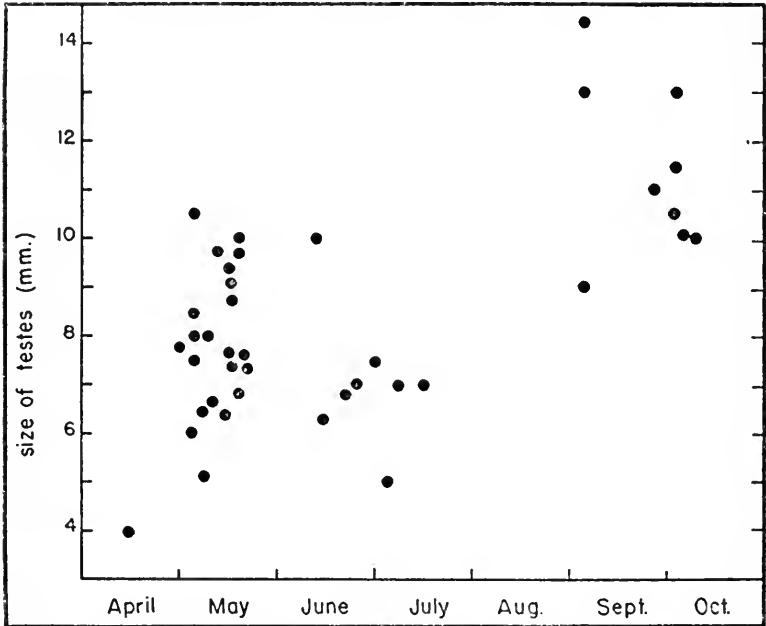


FIG. 3. Seasonal fluctuations in size (average greatest diameter) of testes in *T. o. ornata* as determined by examination of 40 specimens from eastern Kansas.

Spermatogenesis (refer to Pl. 19, Figs. 1-5) begins in early May when a few spermatogonia appear in the seminiferous tubules. The histological appearance of testes preserved in April and May is much the same. Nuclei of Sertoli cells, which outnumber the spermatogonia, are evident at the periphery of the tubules and the clear cytoplasm of the cells extends into and nearly fills the lumina. The few darkly stained spermatids that are present in April are cells that probably were produced in the previous summer. Sperm are present in small groups within the sustentacular cytoplasm, but ordinarily are absent in the lumina.

Primary spermatocytes appear in the tubules from mid-May to early June. By mid-May there are practically no sperm at any place in the tubules. The sustentacular cytoplasm has a less compact arrangement in late May than in April.

Spermatogenesis is well under way by mid-June; at this time, two or three distinct layers of primary and secondary spermatocytes are present and these cells outnumber the Sertoli cells. The lumina are filled with cellular detritus and are no longer bordered by a clear ring of sustentacular cytoplasm. No sperm are present.

Spermatids appear in late June and a few of them undergo metamorphosis in early July; by mid-July, spermatids and secondary spermatocytes are the dominant cells in the seminiferous tubules, although spermatogonia are still active.

By late August, clusters of sperm and metamorphosing spermatids surround the Sertoli cells; large numbers of sperm as well as sloughed cells representing various spermatogenic stages are present in the lumina. Secondary spermatocytes are still evident near the periphery of the tubules but they are much less numerous than spermatids. The germinal epithelium is still semiactive and small groups of primary spermatocytes are present in nearly all of the tubules.

The spermatogenic cycle is completed in the latter half of October when most of the spermatozoa pass into the epididymides. A few spermatozoa and spermatids remain in the seminiferous tubules during hibernation. Although no testicular material was obtained from hibernating turtles, comparisons of sections made in October and April show that the germinal epithelium remains inactive from autumn until spring. Possibly some spermiogenesis takes place in the early phases of hibernation or in the period in late autumn when turtles are intermittently active. It is uncertain whether the reorganization of the sustentacular cytoplasm occurs in autumn, in spring, or in the course of hibernation.

The seminiferous tubules of immature males are small, lack lumina, and contain a few large but inactive spermatogonia (Pl. 19, Fig. 6). The testes of specimens that were nearly mature contained primary and secondary spermatocytes but lacked lumina; it was thought that such individuals would have matured in the following summer and bred in the following autumn.

Mature sperm were found in epididymides at all times of the year but were most numerous in spring and autumn, the period between

spermatogenic cycles (Pl. 19, Fig. 7). Sperm expelled from the epididymides in autumn matings are seemingly replaced by others from the seminiferous tubules; the epididymides become much smaller when their supply of sperm is nearly exhausted after spring mating.

Risley (1938:304) found the testes of the common musk turtle, *Sternotherus odoratus*, to be largest in August and smallest in early May. Recession of testes in spring was coincident with the period of active breeding; increase in size, later in the season, corresponded to increasing spermatogenic activity and enlargement of seminiferous tubules. Altland (1951:600-603) found the spermatogenic cycle of *Terrapene carolina* to be nearly like that of *Sternotherus odoratus*. Fox (1952) found that testes of garter snakes (*Thamnophis sirtalis* and *T. elegans*) in California reached a peak of spermatogenic activity in midsummer, regressed in the latter half of the summer, and were inactive in winter.

The spermatogenic cycle of *T. ornata* as here reported, differs in no important respect from those of *Thamnophis*, *Sternotherus odoratus*, or *Terrapene carolina*, except that in *T. ornata* the cycle begins and ends somewhat later in the season of activity. In most of the lizards that have been studied (Fox, 1952:492-3), spermatogenesis reaches a peak in spring (more or less coincident with the mating period and with ovulation) and the germinal epithelium remains active in winter. *Sternotherus*, *Terrapene*, and *Thamnophis* are alike in completing spermatogenesis late in the season and storing spermatozoa, in the seminiferous tubules or in the epididymides, during hibernation.

It is noteworthy that, in the turtles and snakes mentioned above, sperm produced in autumn are used to fertilize eggs laid in the following year, and mating [with the exception of *Thamnophis elegans*, (Fox, 1956)] occurs in both spring and autumn. It is not definitely known in any of these instances, whether sperm resulting from autumn or spring inseminations (or both) fertilize the eggs. Risley (1933:693) found motile sperm in the oviducts of female *Sternotherus odoratus* that had recently emerged from hibernation; he believed that spring mating, although it commonly occurred, was not necessary to fertilize eggs. Disadvantages, if any, of completing spermatogenesis well in advance of ovulation seem to be at least partly counteracted by two annual mating periods or by mating throughout the season of activity.

remained relatively the same. Preserved material was lighter than fresh by an average of 13 per cent. Follicles less than one millimeter in diameter were not counted. Corpora lutea and corpora albicantia were studied under a binocular dissecting microscope. No histological studies were made of the female reproductive system.

Ovarian follicles and oviducal eggs were recorded separately for the right and left sides. Each ovary was always kept associated with the oviduct of the same side, but in some instances it was not recorded whether the organs were left or right.

Ovaries ordinarily weighed most in October, March, and April, when most females contained enlarged follicles, and least in August and September when the supply of enlarged follicles was usually exhausted (Figs. 4 and 5).

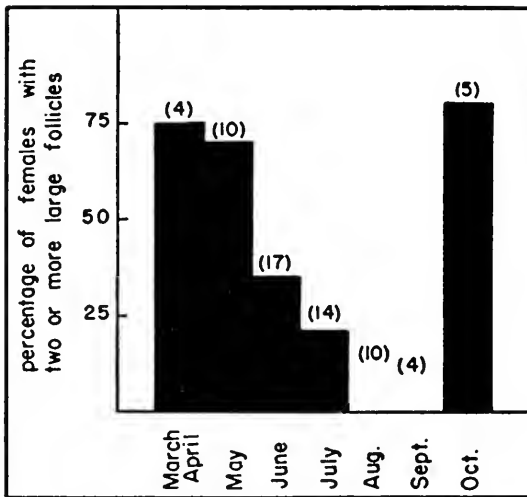


FIG. 5. The seasonal occurrence of enlarged ovarian follicles in females of *T. o. ornata*, expressed, for each month, as the percentage of total females that contained two or more follicles having diameters greater than 15 μ m. Total number of females in each of the samples is shown in parentheses at the top of each bar.

The ovarian cycle begins in July or August, after ovulation has occurred. At that time many minute follicles form on the germinal ridges of the ovaries. On the basis of the material that I examined, it seems that ovarian follicles either grow to nearly mature size in the season preceding ovulation and remain quiescent over winter or grow rapidly in the period of approximately six weeks between spring emergence and ovulation. Altland (1951:603-5) re-

ported that the former condition was the usual one in *T. carolina*; he suggested that possibly some of the enlarged follicles were absorbed during hibernation.

Examination of yolks of oviducal eggs revealed that follicles mature when they reach a diameter of 16 to 20 millimeters and a weight of two to two and one-half grams (Pl. 20, Fig. 1).

The enlarged follicles remaining on the ovaries after ovulation (excluding those smaller than six mm.) can be grouped according to diameter as: large (greater than 15 mm.), medium (11 to 15 mm.), and small (six to 10 mm.). Ten females collected in the period from June 2 to 8, after they had ovulated, all had follicles falling in at least one of these size groups, and eight had follicles falling in two or more of the groups. In females having enlarged follicles of more than one of the size groups, there were several follicles in each of two groups and no follicles, or only one follicle, in the remaining group. Enlarged follicles represent future clutches but whether the enlarged follicles will be ovulated in the same season or in a later season is questionable.

Evidence found in the present study suggested that at least a few females lay more than one clutch of eggs per year. Among 34 specimens obtained in June and July, eight (24 per cent) had corpora lutea (or easily discernible corpora albicantia) and at least two follicles more than 15 millimeters in diameter; in three specimens (9 per cent) the ovaries bore fresh corpora lutea (representing recent ovulations) and a set of older corpora lutea (representing ovulations that had occurred several weeks previously). It was thought that each of these eleven females (33 per cent of sample) had produced or would have produced two clutches of eggs in the season of its capture. The number of large follicles present after the first set of ovulations (mean, 3.5) was fewer in most instances than the average clutch-size (see below), indicating that second clutches are smaller than first clutches. Smaller second clutches were found also in *T. carolina* (Legler, 1958).

Further evidence for multiple clutches was the absence of enlarged ovarian follicles in some females obtained in September. Atretic follicles, ordinarily orange, brown, or purplish, were observed on the ovaries of many of the females examined; in most instances, not more than two follicles of the small or medium size groups were atretic. Atresia was in no instance great enough to account for the complete loss of enlarged follicles.

Further study probably will show that many of the females laying

in May and early June lay again before the end of July, and that eggs in the oviducts of females captured in the latter month frequently represent second clutches. Under favorable conditions, eggs laid by the end of July would have a good chance of hatching before the advent of cold weather in autumn; turtles hatching too late to escape from the nest could burrow into its sides and probably escape freezing temperatures.

Cagle's findings concerning *Pseudemys scripta* (1950:38) and *Chrysemys picta* (1954:228-9) suggest that these species lay more than one clutch per season, at least in the southern parts of their ranges. Carr (1952) indicated that multiple layings were known in most species of marine turtles (families Dermochelyidae and Cheloniidae) and strongly suspected in other species. Other turtles recorded to have produced multiple clutches in a single season (based chiefly on captive specimens or cultured populations) include: the starred tortoise, *Geochelone elegans* (Deraniyagala, 1939:287); the Asiatic trionychid, *Lissemys punctata* (*op. cit.*:304); the diamond-backed terrapin, *Malaclemys terrapin* (Hildebrand and Prytherch, 1947:2); and the Japanese soft-shelled turtle, *Trionyx japonicus* (Mitsukuri, 1895, cited by Cagle, 1950:38).

There is a marked alternation of ovarian activity in *T. ornata*, one ovary being more active than its partner in a given season. The less active ovary is more active than its partner in the following season. For example, a specimen killed in July had four corpora lutea on the right ovary and two on the left and there were five enlarged follicles (of the medium size group), representing the next set of eggs to be ovulated, four on the left ovary and one on the right. Similar alternation of ovarian activity was observed, to a greater or lesser extent, in nearly all of the females examined. Many subadult females that were approaching their first breeding season (as evidenced by the presence of large ovarian follicles but no indication of former ovulation) had but one active ovary. This may account in part for the tendency of small, young females to lay clutches smaller than average. One ovary may become senile in old females before its partner does; this may explain the occasional absence or atrophy of one ovary in large females that I have examined.

In all the specimens examined, it was evident that ovulation had occurred or would occur in two successive seasons. Senile or young females might, however, be expected to skip a laying season if only one ovary was functioning.

After ovulation, the collapsed follicle assumes a cuplike shape

and becomes a glandular corpus luteum (Pl. 20, Fig. 2). Corpora lutea are approximately eight millimeters in diameter and are easily discernible at least until the eggs are laid; they are somewhat less distinct after preservation. Corpora lutea undergo rapid involution following oviposition and, after two to three weeks, are little more than small puckerings on the ovarian epithelium. At this stage they are properly referred to as corpora albicantia and are discernible only after careful examination of the ovary under low magnification. Corpora albicantia remain on the ovary until April of the year following ovulation but disappear in May and are never present after the new set of eggs is ovulated. Ovaries of some sub-adults (that would have laid first in the season following capture) contained enlarged follicles and, but for their lack of corpora lutea and corpora albicantia, were indistinguishable from those of older, fully mature females.

Altland (1951:605-610) gave a histological description of the corpus luteum of *Terrapene carolina*. Corpora lutea were glandular and filled with lipoidal material until the eggs were laid. Atresia of corpora lutea began when eggs were laid, was completed by mid-August, and was coincident with atresia of large follicles that did not undergo ovulation. Altland did not describe the gross external appearance of the corpus albicans.

The corpus luteum of oviparous reptiles seems to be closely associated with the intrauterine life of the eggs and, in viviparous reptiles, it may be an important factor in maintaining optimum gestational environment; however, its functions in all reptiles are poorly understood (Miller, 1948:200-201).

Information gleaned from records of gravid females and known dates of nesting suggests that eggs are retained in the oviducts two to three weeks before laying. Once they are ovulated, the eggs are exposed to but few hazards until laid; counts of corpora lutea are an accurate indication of the number of eggs laid. In the gravid females examined by me, number of corpora lutea on the ovaries was equal, in all but one instance, to the number of oviducal eggs. In the single instance in which an extra corpus luteum was found, one egg had probably been laid before the specimen was captured. The high incidence of correspondence between counts of corpora lutea and counts of oviducal eggs indicates also that *T. ornata* deposits the entire complement of oviducal eggs at one time, not singly or in smaller groups.

Extrauterine migration of ova, whereby eggs from one ovary pass into the oviduct of the opposite side, is of common occurrence in

T. ornata and is known to occur also in *T. carolina*, *Chrysemys picta*, *Emydoidea blandingi*, *Pseudemys scripta*, *Cnemidophorus sexlineatus*, and in several mammals (Legler, 1958). This ovular migration may serve to redistribute eggs to the oviducts when the ovaries are functioning at unequal rates.

The eggs acquire shells soon after they enter the oviducts. No shell-less eggs were found in oviducts but several specimens of *T. ornata* had oviducal eggs, the thin, parchmentlike shells of which lacked the outer calceous layer; in these specimens the corpora lutea were fresh, probably not more than two days old. Eggs that had remained in the oviducts longer had a calceous layer on the outside of the shell. Eggs having incompletely developed shells were successfully incubated in the laboratory. Cagle (1950:38) found shelled but yolkless eggs in the oviducts of several *Pseudemys scripta* but found no yolkless eggs in nests. No yolkless eggs were found in specimens of *T. ornata* in the course of the present study.

The uterine portion of the oviducts becomes darkened (pale gray to intense black) in the breeding season. Darkening of oviducts seemed to coincide with the period when eggs were in the oviducts and it persisted for a variable length of time after the eggs were laid. Oviducts of immature females were ordinarily pale.

Nesting

Ornate box turtles nest chiefly in June. Some females nest as early as the first week of May or as late as mid-July but the nesting season reaches its peak in mid-June. Eggs nearly ready to be laid were in oviducts (determined by bimanual palpation in the field or by dissection in the laboratory) of many females captured in June; nearly half of the records so obtained were in the second week of that month. Early records of shelled oviducal eggs were April 25 (specimen from Ottawa County, Oklahoma), May 5, and May 22. The two latest records are for females retaining oviducal eggs on July 2 and 11. Known dates for nesting of free-living females were distributed rather evenly through the month of June. It is worthy of note that all (four) of the nestings known to occur in July were by captive females. Females of *T. ornata*, like those of some other turtles (Cagle and Tihen, 1948; Risley, 1933:694), seem to retain their eggs until conditions are suitable for nesting. Most of the reports in the literature of nesting after mid-July represent records for captive females.

Nests of *T. o. ornata* were so well-concealed that they were difficult to find even when a gravid female had been followed to the approximate location by means of a trailing thread. Females spend one to several days seeking a site for the nest, usually traveling a circuitous route within a restricted area. Movements of nest-seeking females were more extensive than those of males and non-gravid females observed in the same periods.

Activities of one gravid female, typical in most respects of the activities of several other gravid females observed (for periods of one to 23 days) at the Damm Farm, illustrate pre-nesting behavior (Fig. 29). A trailer was attached to the female on the morning of June 7. She was recovered early on the following afternoon; her movements in the elapsed period had been restricted to a small, deep, ravine 150 feet long and 20 to 30 feet wide. She had traversed each edge of the ravine at least once and had crossed it six or seven times, keeping mostly to areas on the upper parts of south—or west—facing slopes where vegetation was sparse or lacking. In six places she had dug into the ground, probably to test the suitability of the soil for nesting. In three places she dug beneath rocks that jutted out from the bank, and in two places merely scratched away the upper crust of soil. Her most recent attempt at digging (probably late the previous evening or in early morning on the day of her capture) consisted of a flask-shaped cavity that, but for the lack of eggs and a covering of earth, was like a completed nest (Pl. 21, Fig. 1). The cavity was 55 millimeters deep, 80 millimeters wide at the bottom, and 60 millimeters wide at the opening. For several inches about the opening the earth was slightly damp. That piled on the rim of the opening was of the consistency of thick mud, indicating that the female had voided fluid first on the surface of the earth and again inside the cavity to soften the soil. Subsequently during eight days her activities were similar but not so extensive as on the day described above. It was determined by daily palpation that she laid her eggs somewhere in the general area of the ravine on June 15 but the nest could not be found.

No completed nests containing eggs were discovered at the Damm Farm but the locations of several robbed nests and partly completed nests provided some information on preferred sites. The nests found were on bare, well-drained, sloping areas and were protected from erosion by upslope clumps of sod or rocks.

The nest cavity illustrated in Plate 21 was at the edge of the sod-line on the upper lip of the west-facing bank of a ravine. One nest had been excavated in a shallow den beneath an overhanging limestone rock. Three nests were on west- or south-facing slopes and one was on the north-facing bank of a ravine. Box turtles presumably select bare areas for nesting because of the greater ease of digging. One female at the Damm Farm was thought to have laid her eggs in a cultivated field and William R. Brecheisen told me he discovered two nests in a wheat field being plowed in July, 1955.

The repeated excavation of trial nest cavities presumably exhausts the supply of liquid in the female's bladder. Frequent imbibing of water is probably necessary if the search for a nesting site is continued for more than a day or two. Standing water was usually available in ponds, ravines, ditches, and other low areas at the Damm Farm in June. Nesting in June, therefore, is advantageous not only because of the greater length of time provided for incubation and hatching but also because of the amount of water available for drinking. Females can probably be more selective in the choice of a nesting site if their explorations are not limited by lack of water.

Females of *T. ornata*, in all instances known to me, began excavation of their nests in early evening and laid their eggs after dark; Allard (1935:328) reported the same behavior for *T. carolina*.

William R. Brecheisen, on July 22, 1955, at his farm, two miles south and one mile west of Welda, Anderson County, Kansas, observed that a large female began digging a nest in an earth-filled stock tank at 6:00 P. M. At first she moved her body about on the surface of the earth, loosening it and pushing it aside with all four legs, making a depression approximately two inches deep and large enough to accommodate her body. At 7:30 P. M. she began digging alternately with her hind feet at the bottom of the depression. Digging continued until 10:00 P. M., at which time the nest cavity was three inches deep, and three inches in diameter, with a smaller opening at the top. Six eggs were laid in the next half-hour. Covering of the nest probably took more than one hour but observations were terminated after the final egg was laid. By the following morning the nest-site had been completely covered and was no different in appearance from the rest of the earthen floor of the tank. (Brecheisen observed more of the nesting than anyone else

has recorded and I am obliged to him for permission to abstract, as per the above paragraph, the notes that he wrote on the matter.)

A nest made by a captive female at the Reservation was of normal proportions except for an accessory cavity that opened from the neck of the nest, immediately below the surface of the ground. This smaller cavity contained a single egg. This peculiar nest may have resulted from the efforts of two different females since several were kept in the same outdoor pen.

Ten adult females were kept in an outdoor cage in the summer of 1955. The cage was raised off the ground on stilts and its floor was covered with 12 inches of black, loamy soil. A small pan of water was always available in the cage and the turtles were fed greens, fruit, and table scraps each evening. Nesting activity was first noted on June 21, when one of the females was digging a hole in a corner of the enclosure. She dug with alternate strokes of her fully-extended hind legs in the manner described (Legler, 1954:141) for painted turtles (*Chrysemys picta bellii*). Nevertheless, digging was much less efficient than in *Chrysemys*, because of the narrow hind foot of the female *T. ornata*; approximately half of the earth removed by any one stroke rolled back into the nest or was pulled back when she reinserted her leg. The female stopped digging when I made sudden movements or held my hand in front of her. Digging continued for approximately 45 minutes; then the female moved away and burrowed elsewhere in the cage. The nest cavity that she left was little more than a shallow depression. Three other females were digging nests early in the evening on July 3, 5, and 8; in each of these instances the female stopped digging to eat when food was placed in the cage and completed the nesting process, unobserved, later in the evening. In each instance where nest-digging by captive females was observed, the hind quarters of the female rested in a preliminary, shallow depression, and the anterior end of the body was tilted upward at an angle of 20 to 30 degrees. In late June and early July several eggs were found, unburied, on the floor of the cage and in the pan of water.

The excavation of a preliminary cavity by captive females may not represent a natural phenomenon. Allard (1935) made no mention of it in his meticulous description of the nesting process in *T. carolina*. It is worthy of mention, however, that Booth (1958:261) reported the digging of a preliminary cavity by a captive individual of *Gopherus agassizi*.

Eggs

The number of eggs in 23 clutches ranged from two to eight (mean, $4.7 \pm 1.37 \sigma$); clutches of four, five, and six eggs were most common, occurring in 18 (78 per cent) instances. The tendency for large females to lay more eggs than small females (Fig. 6) was not so pronounced as that reported by Cagle (1950: 38) for *Pseudemys scripta*. The small size of *T. ornata*, in comparison with other emydid turtles, seemingly limits the number of eggs that can be accommodated internally. The number of eggs per clutch in *T. carolina* [2 to 7, average 4.2, Allard (1935: 331)], is nearly the same as that of *T. ornata*.

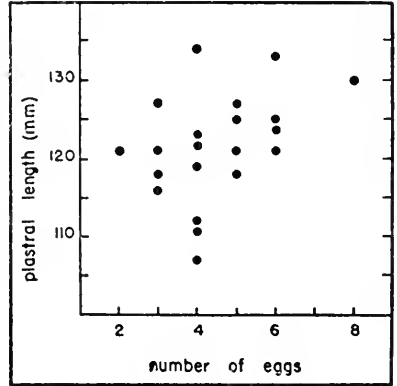


FIG. 6. The relation of plastral length to number of eggs laid by 21 females of *T. o. ornata* from eastern Kansas.

Shells of the eggs are translucent and pinkish or yellowish when the eggs are in the oviducts. After several days outside the oviducts the shells become chalky-white and nearly opaque. Eggs incubated in the laboratory retained the pinkish color somewhat longer than elsewhere on their under-surfaces, which were in contact with moist cotton, but eventually even this part of the shell became white. Infertile eggs remained translucent and eventually became dark yellow, never becoming white; they could be distinguished from fertile eggs on the basis of color alone. Shells of infertile eggs became brittle and slimy after several weeks.

The outer layer of the shell of a freshly laid egg is brittle and cracks when the egg is dented. After a few days, when the eggs begin to expand, the shell becomes flexible and has a leathery texture. The shell is finely granulated but appears smooth to the unaided eye. The granulations are approximately the same as those illustrated by Agassiz (1857:Pl. 7, Fig. 18) for *T. carolina*.

Eggs are ellipsoidal. Data concerning size and weight (consisting of mean, one standard deviation, and extremes, respectively) taken from 42 eggs (representing 9 clutches) within 24 hours after they were laid, or dissected from oviducts, are as follows: length, 36.06 ± 2.77 (31.3-40.9); width, 21.72 ± 1.04 (20.0-26.3); and weight, 10.09 ± 1.31 (8.0-14.3). There was a general tendency

for smaller clutches to have larger eggs; the largest and heaviest were in the smallest clutch (two eggs) and the smallest were in the largest clutch (eight eggs). Risley (1933:697) reported such a correlation in *Sternotherus odoratus*, as did Allard (1935:331) in *T. carolina*. Measurements in the literature of the size of eggs of *T. ornata* suggest a width greater than that stated above, probably because some eggs already had begun to expand when measured.

Eggs of *T. ornata* expand in the course of incubation, as do other reptilian eggs with flexible shells, owing to absorption of water. In the laboratory, 48 eggs increased by an average of approximately three grams in weight and three millimeters in width over the entire period of incubation; increase in width coincided with decrease in length. Cotton in incubation dishes was kept moist enough so that some water could be squeezed from it. When the cotton was constantly moist, eggs showed a fairly steady expansion from the first week of incubation until hatching. The process could be reversed by allowing the cotton to dry. Eggs that were allowed to dry for a day or more became grossly dented or collapsed. Eggs at the periphery of the incubation dish were ordinarily more seriously affected by drying than were those at the center or in the bottom of the dish. A generous re-wetting of desiccated eggs and cotton caused the eggs to swell to their original proportions within 24 hours. Recessions occurred, however, even in the clutches that received the most nearly even amount of moisture. Increases in weight and size seemed to reach a peak in the middle of the incubation period and again immediately before hatching. Infertile eggs expanded in the same manner as fertile eggs in the first week or two of incubation, but thereafter gradually regressed in bulk or failed to re-expand after temporary periods of dryness. Fertile eggs that were in good condition had a characteristically turgid, springy feel and could be bounced off a hard surface.

Temporary lack of moisture usually did not kill embryos; prolonged dryness, combined with high temperatures, probably could not be tolerated. Lynn and Ullrich (1950), by desiccating the eggs of *Chrysemys picta* and *Chelydra serpentina*, produced abnormalities in the young ranging from slight irregularities of the shell to eyeless monstrosities; eggs desiccated in the latter half of incubation produced a higher percentage of abnormal young than eggs that were desiccated earlier.

In 1956, three fertile eggs, from clutches that were at different stages of incubation, were immersed in water for 48 hours. The eggs rested on the bottom of the bowl in the same position in which they had been placed in the incubation dishes; when turned, they returned invariably to the original position. The embryos in two of the eggs (one and 27 days old at the time of immersion) were still living ten days after the eggs were removed from the water; the embryo in the remaining egg (21 days old at the time of immersion) was dead. Eggs immersed in water increased in size and weight at the same rate as eggs in incubation dishes, indicating that absorption of water probably operates on a threshold principle, the amount absorbed being no more than normal even under wet conditions.

Natural nests usually are in well-drained areas, but water probably stands in some nests for short periods after heavy rains. Provided the nest cavity itself is not damaged, water in the nest is probably more beneficial than harmful to the eggs; however, nests that are inundated during floods probably have little chance of survival.

Embryonic Development

Eggs were examined by transmitted light in the course of incubation. At the time of laying (or removal from oviducts) no embryonic structures were discernible even in eggs that had been retained in the oviducts of captive females some weeks past the normal time of laying; a colorless blastodisc could be seen if eggs were opened. Embryonic structures first became visible at eight to ten days of incubation; at this time vascularization of the blastodisc was evident and the eyes appeared as dark spots. Heart beats were observed in most embryos by the fifteenth day but were evident in a few as early as the tenth day. The pulse of a fifteen-day-old embryo averaged 72 beats per minute at a temperature of 30 degrees. Embryos at fifteen days, measured in a straight line from cephalic flexure to posteriormost portion of body, were approximately nine to ten millimeters long and at 22 days were 14 millimeters long. At approximately 35 days the eggs became dark red; embryonic structures were discernible thereafter only in eggs that had embryos situated at one end, close to the shell.

Incubation periods for 49 eggs (representing 12 clutches) kept in the laboratory ranged from 56 to 127 days, depending on the temperature of the air during the incubation period. In 1955, eggs

were kept at my home in Lawrence where air temperatures were uncomfortably hot in summer and fluctuations of 20 degrees (Fahrenheit) or more in a 24-hour period were common. The following summer eggs were kept in my office at the Museum where temperatures were but slightly cooler than in my home and subject also to wide variation. In 1957 this part of the Museum was air-conditioned and kept at approximately 75 degrees. The greater lengths of incubation periods at lower temperatures are shown in Table 1. Risley (1933:698) found the incubation period of *Sternotherus odoratus* to be longer at lower temperatures; corresponding observations were made by Allard (1935:332) and Driver (1946:173) on the eggs of *Terrapene carolina*. Cagle (1950:40) and Cunningham (1939) found no distinct differences in length of incubation period for eggs of *Pseudemys scripta* and *Malaclemys terrapin*, respectively, at different temperatures within the range tolerated by the eggs.

Most nests observed in the field were in open situations where they would receive the direct rays of the sun for at least part of the day; the shorter average incubation periods (59 and 70 days, respectively), observed in 1955 and 1956, therefore, more nearly reflect the time of incubation under natural conditions than does the excessively long period (125 days at 75 degrees) observed in 1957 under cooler, more nearly even temperatures.

Sixty-five days seems to be a realistic estimate of a typical incu-

TABLE 1.—THE RELATIONSHIP OF TEMPERATURE AND DURATION OF INCUBATION PERIOD AS DETERMINED FROM LABORATORY STUDIES OF 49 EGGS OF *T. ornata*.

Average daily temperature (Fahrenheit)	Period of incubation (Days)		Number of clutches	Number of eggs	Remarks
	Mean	Range			
91	59	56-64	6	24	Wide daily fluctuations in temperature
82	70	67-73	4	21	Wide daily fluctuations in temperature
75	125	124-127	2	4	Temperature thermostatically controlled

bation period under natural conditions; eggs laid in mid-June would hatch by mid-August. Even in years when summer temperatures are much cooler than normal, eggs probably hatch by the end of October. Hatchlings or eggs would have a poor chance of surviving a winter in nests on exposed cut-banks or in other unprotected situations. Overwintering in the nest, hatchlings might survive more often than eggs, since hatchlings could burrow into the walls and floor of the nest cavity. Unsuitable environmental conditions that delay the nesting season and retard the rate of embryonic development may, in some years, be important limiting factors on populations of ornate box turtles.

In areas where *T. ornata* and *T. carolina* are sympatric (for example, in Illinois, Kansas, and Missouri) the two species occupy different habitats, *ornata* preferring open grassland and *carolina* wooded situations. Under natural conditions, the average incubation periods of these two species can be expected to differ, *T. carolina* having a somewhat longer period due to lower temperatures in nests that are shaded. In the light of these speculations, the remark of Cahn (1937:102)—that *T. ornata* nested later in the season (in Illinois) and compensated for this by having a shorter incubation period—is understandable.

The range of temperatures tolerated by developing eggs probably varies with the stage of embryonic development. When temperatures in the laboratory were 102 to 107 degrees Fahrenheit for approximately eight hours, due to a defect in a thermostat, the young in two eggs of *T. ornata*, that had begun to hatch on the previous day, were killed, as were the nearly full-term embryos in a number of eggs of *T. carolina* (southern Mississippi) kept in the same container. A five-day-old hatchling of *T. ornata*, kept in the same container, survived the high temperatures with no apparent ill effects. Cagle (1950:41) found that eggs of *Pseudemys scripta* could not withstand temperatures of 10 degrees for two weeks nor would they survive if incubated at 40 degrees. Cunningham (1939) reported that eggs of *Malaclemys terrapin* could not survive prolonged exposure to temperatures of 35 to 40.6 degrees but tolerated temporary exposure to temperatures as high as 46 degrees.

In the summer of 1955, a clutch of three eggs, all of which contained nearly full-term embryos, was placed in a refrigerator for 48 hours. The temperature in the refrigerator was maintained at approximately 4.5 degrees; maximum and minimum temperatures for the 48 hour period were 2.8 and 9.5 degrees, respectively. When the eggs were removed from the refrigerator they showed gains in

weight and increases in size comparable to eggs, containing embryos of the same age, used as controls. The experimental eggs began to hatch two days after they were removed to normal temperatures—approximately 24 hours later than the controls.

In the late stages of incubation, the outer layer of the shell becomes brittle and is covered with a mosaic of fine cracks or is raised into small welts. Several days before hatching, movements of the embryo disturb the surface of the shell and cause the outer layer to crumble away, especially where the head and forequarters of the embryo lie against the shell. Some embryos could be seen spasmodically thrusting the head and neck dorsally against the shell.

The role of the caruncle in opening the shell seems to vary among different species of turtles. Cagle (1950:41) reported that it was used only occasionally by *Pseudemys scripta*; Allard (1935:332) thought that it was not used by *Terrapene carolina*; and, the observations of Booth (1958:262) and Grant (1936:228) indicate that embryos of *Gopherus agassizi* use the caruncle at least in the initial rupturing of the shell.

In the three instances in which hatching was closely observed in *T. ornata*, the caruncle made the initial opening in the shell; claws of the forefeet may have torn shells in other hatchings that were not so closely observed. In all observed instances, the shell was first opened at a point opposite the anterior end of the embryo. The initial opening had the appearance of a three-cornered tear. A quantity of albuminous fluid oozed from eggs as soon as the shells were punctured.

The initial tear is enlarged by lateral movements of the front feet, and later the hind feet reach forward and lengthen the tear farther posteriorly. In many instances a tear develops on each side and the egg has the appearance of being cleft longitudinally. The young turtle emerges from the anterior end of the shell or backs out of the shell through a lateral tear.

The process of hatching, from rupture of shell to completion of emergence, extended over three to four days in the laboratory. Many hatchlings from time to time crawled back into the shell over a period of several days after hatching was completed. In a clutch of eggs kept in a pail of earth, by William R. Brecheisen, eight days elapsed between onset of hatching and appearance of the first hatchling at the surface.

A nest in an outdoor pen at the Reservation was discovered in

early October. The cap had been recently perforated and the hatchlings had escaped. One of them, judged to be approximately two weeks old, was found in a burrow nearby. The cavity of the nest appeared to have been enlarged by the young. The eggs were probably laid in early July. Emergence of young from the nest had been delayed for a time after hatching, until rain softened the ground in late September and early October.

Fertility and Prenatal Mortality

Eggs were incubated in the laboratory at more nearly optimum temperature and humidity than were eggs in natural nests. Percentage of prenatal mortality probably was lower in laboratory-incubated eggs than in those under natural conditions.

Of sixty eggs studied in the laboratory, 45 (75 per cent) were fertile; 36 (80 per cent) of the fertile eggs (those in which the blastodisc was at some time discernible by transmitted light) hatched successfully. In six clutches all the eggs were fertile and five of these clutches hatched with 100 per cent success. One clutch contained eggs that were all infertile and another clutch had four infertile eggs and two fertile eggs that failed to hatch. Among nine fertile eggs that failed to survive, four casualties occurred in the late stages of incubation or after hatching had begun, indicating that these are probably critical periods.

Fertility of eggs was not correlated with size or age of female, with size of clutch, or with size of egg. Eggs laid in the laboratory had higher rates of infertility and prenatal mortality than did eggs dissected from oviducts. Handling of eggs in removing them from nests to incubation dishes, after embryonic development had begun, might have been responsible for reduced viability (Table 2).

TABLE 2.—COMPARATIVE RATES OF FERTILITY AND PRENATAL MORTALITY FOR EGGS DISSECTED FROM OVIDUCTS AND FOR EGGS THAT WERE LAID IN THE LABORATORY AND SUBSEQUENTLY REMOVED TO INCUBATION DISHES.

NUMBER OR PERCENTAGE	Eggs removed from nests	Eggs dissected from oviducts
Number of eggs examined	22	38
Percentage of fertile eggs	64	82
Percentage of fertile eggs hatched	50	94
Percentage of eggs hatched	32	76

Reproductive Potential

Assuming that 4.7 eggs are laid per season, that all eggs are fertile and all hatch, that all young survive to maturity, that half the hatchlings are females, and that females first lay eggs in the eleventh year, the progeny of a single mature female would number 699 after twenty years. Considering that infertility and prenatal mortality eliminate approximately 40 per cent of eggs laid (according to laboratory findings) the average number of surviving young per clutch would be 2.8 and the total progeny, after 20 years, would be 270, provided that only one clutch of eggs was laid per year. But it is thought that, on the average, one third of the female population produces two clutches of eggs in a single season. If the second clutch contains 3.5 eggs (resulting in 2.1 surviving young when factors of infertility and prenatal mortality are considered), the progeny of a single female, after 20 years, would number approximately 380. Postnatal mortality reduces the progeny to a still smaller number.

The small number of eggs laid each year and the long period required to reach sexual maturity make the reproductive potential of *T. ornata* smaller than that of the other turtles of the Great Plains, and much smaller than nearly any of the non-chelonian reptiles of the same region.

Number of Reproductive Years

The total span of reproductive years is difficult to determine; I am unable to ascertain the age of a turtle that has stopped growing. No clearly defined external characteristics of senility were discovered in the populations studied. A male that I examined had one atrophied testis. In another male both testes were shrunken and discolored and appeared to be encased by fibrous tissue. Both males were large, well past the age of regular growth, and had smoothly worn shells. Several old females had seemingly inactive ovaries. Reproductive processes probably continue throughout life in most members of the population, although possibly at a somewhat reduced rate in later life.

GROWTH AND DEVELOPMENT

Initiation of Growth

Young box turtles became active and alert as soon as they hatched, and remained so until low temperatures induced quiescence. If sand or soil was available, hatchlings soon burrowed into

it and became inactive. Covering containers with damp cotton also induced inactivity; the hatchlings usually made no attempt to burrow through the confining layer. Desire to feed varied in hatchlings of the same brood and seemed not to be correlated with retraction of the yolk sac or retention of the caruncle. Some hatchlings actively pursued mealworms; on subsequent feedings they learned to associate my presence with food and eagerly took mealworms from forceps or from my hand. Meat, vegetables, and most other motionless but edible objects were ignored by hatchlings but some individuals learned to eat meat after several forced feedings. Hatchlings that regularly took food in the first month of life ordinarily grew faster than hatchlings that did not eat. Many of the hatchlings in the laboratory showed no areas of new epidermal growth on the shell in the time between hatching and first (induced) hibernation.

Size and Appearance at Hatching

The proportions of the shell change somewhat in the first few weeks of life. At hatching the shell may be misshapen as a result of confinement in the egg. Early changes in proportions of the shell result from expansion—widening and, to a lesser degree, lengthening of the carapace—immediately after hatching. Subsequent retraction or rupture of the yolk sac and closure of the navel are accompanied by a decrease in height of shell and slight, further widening of the carapace.

The yolk sac retracts mainly between the time when the egg shell is first punctured and the time when the turtle actually emerges from the shell. When hatching is completed, the yolk sac usually protrudes no more than two millimeters, but in some individuals it is large and retracts slowly over a period of several days.

One individual began hatching on November 11 and was completely out of the egg shell next day; the yolk sac was 15 millimeters in diameter, protruded six millimeters from the umbilical opening, and hindered the hatchling's movements. The sac broke two days later, smearing the bottom of the turtle's dish with semifluid yolk. The hatchling then became more active. Twenty-six days later the turtle was still in good condition and its navel was nearly closed. A turtle that hatched with a large yolk sac in a natural nest possibly would benefit, through increased ease of mobility, if the yolk sac ruptured.

A recently hatched turtle was found at the Reservation in Oc-

tober, 1954, and was kept in a moist terrarium in the laboratory where it died the following May. The turtle was sluggish and ate only five or six mealworms while in captivity; no growth was detectable on the laminae of the shell. Autopsy revealed a vestige of the retracted yolk sac, approximately one millimeter in diameter, on the small intestine.

The navel ("umbilical scar") of captive hatchlings ordinarily closed by the end of the second month but in three instances remained open more than 99 days. The position of the navel is marked by a crescent-shaped crease, on the abdominal lamina, that persists until the plastron is worn down in later years (Pl. 24, Fig. 1).

The caruncle ("egg tooth") (Fig. 7) remains attached to the horny maxillary beak for a variable length of time; 93 per cent of the live hatchlings kept in the laboratory retained the caruncle on the tenth day, 71 per cent on the twentieth day, and only 10 per cent on the thirtieth day of life. Few individuals retained the caruncle when they entered hibernation late in November, and none retained it upon emergence from hibernation. Activities in the first few days or weeks of life influence the length of time that the caruncle is retained; turtles that begin feeding soon after hatching probably lose the caruncle more quickly than do those that remain quiescent. The caruncles of some laboratory specimens became worn before finally dropping off. Almost every caruncle present after 50 days could be flicked off easily with a probe or fingernail. The initiation of growth of the horny maxillary beak probably causes some loosening of the caruncle. The caruncle may aid hatchlings in escaping from the nest.

After the caruncle falls off, a distinct boss remains, marking its former place on the horny beak (Pl. 25, Fig. 1); this boss is gradually obliterated over a period of weeks by wear and by differential growth, and is seldom visible in turtles that have begun their first full year of growth. The "first full year of growth" is here considered to be the period of growth beginning in the spring after hatching.

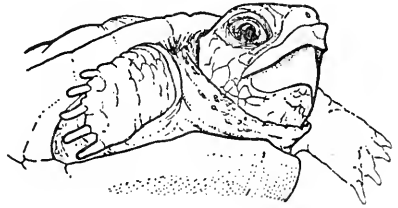


FIG. 7. A hatchling of *T. o. ornata* ($\times 2$) that still retains the caruncle ("egg tooth"). A distinct boss will remain on the maxillary beak after the caruncle is shed.

Growth of Epidermal Laminae

Growth of ornate box turtles was studied by measuring recaptured turtles in the field, by periodically measuring captive hatchlings and juveniles, and by measuring growth-rings on the epidermal laminae of preserved specimens. Studies of growth-rings provided by far the greatest volume of information on growth, not only for the years in which field work was done, but for the entire life of each specimen examined.

It was necessary to determine the physical nature of growth-rings and the manner in which they were formed before growth could be analyzed. Examination of epidermal laminae on the shell of a box turtle reveals that each has a series of grooves—growth-rings—on its surface. The deeper grooves are major growth-rings; they occur at varying distances from one another and run parallel to the growing borders of the lamina. Major growth-rings vary in number from one to 14 or more, depending on the age of the turtle (Pl. 22). In juvenal turtles and in young adults, major growth-rings are distinct and deep. Other grooves on the shell—minor growth-rings—have the same relationship to the borders of the laminae but are shallower and less distinct than major growth-rings. One to several minor growth-rings usually occur on each smooth area of epidermis between major growth-rings. As the shell of an adult turtle becomes worn, the minor growth-rings disappear and the major rings become less distinct. Both sets of rings may be completely obliterated in old turtles but the major rings usually remain visible until several years after puberty.

In cross section, major growth-rings are V- or U-shaped. The inner wall of each groove is the peripheral edge of the part of the scute last formed whereas the outer wall represents the inner edge of the next new area of epidermal growth. The gap produced on the surface of the lamina (the open part of the groove) results from cessation of growth at the onset of hibernation. Minor growth-rings are shallow and barely discernible in cross-section (Fig. 8). It may therefore be understood that growth-rings are compound in origin; each ring is formed in part at the beginning of hibernation and in part at the beginning of the following growing season.

The few publications discussing growth in turtles express conflicting views as to the exact mode of growth of epidermal laminae. Carr (1952:22) briefly discussed growth of turtle scutes in general and stated that eccentric growth results from an entirely new

laminal layer forming beneath, and projecting past the edges of the existing lamina. Ewing (1939) found the scutes of *T. carolina* to be the thickest at the areola and successively thinner in the following eight annual zones of growth; parts of scutes formed subsequent to the ninth year varied irregularly in thickness. He stated that epidermal growth took place at the margins of the laminae rather than over their entire undersurfaces.

It is evident that the mode of scutular growth described by Carr (*loc. cit.*) applies to emyid turtles that shed the epidermal laminae more or less regularly (for example, *Chrysemys* and *Pseudemys*). In these aquatic emyids a layer of the scute, the older portion, periodically becomes loose and exfoliates usually in one thin, mica-like piece; since the loosened portion of the scute corresponds in size to the scute below, it must be concluded that a layer of epidermis is shed from the entire upper surface of the scute, including the area of new epidermal growth. Box turtles ordinarily do not shed the older parts of their scutes; the areola and successively younger portions of the lamina remain attached to the shell until worn off. The appearance of a single unworn scute, especially one of the centrals or the posterior laterals, closely resembles a low, lopsided pyramid.

Examination of parasagittal sections of scutes revealed that they were composed of layers, the number of layers varying with the age of the scute. A scute from a hatchling consists of one layer. A scute that shows a single season of growth has two layers; a new layer is added in each subsequent season of growth. Stratification is most evident in the part of the scute that was formed in the first three or four seasons and becomes increasingly less distinct in newer parts of the scute. It may further be understood that scutes grow in the manner described by Carr (*loc. cit.*).

When the epidermal laminae are removed, a sheet of tough, pale grayish tissue remains firmly attached to the bones of the shell beneath. This layer probably includes, or consists of, germinal epithelium. Contrasting pale and dark areas of the germinal layer correspond to the pattern of markings on the scute removed.

Growth of epidermal laminae is presumably stimulated by growth of the bony shell. As the bone grows, the germinal layer of the epidermis grows with it. When growth ceases at the beginning of hibernation, the thin edges of the scutes are slightly down-turned where they enter the interlaminal seams (Fig. 8). When growth is resumed in spring, the germinal layer of the epidermis, rather than continuing to add to the edge of the existing scute, forms an

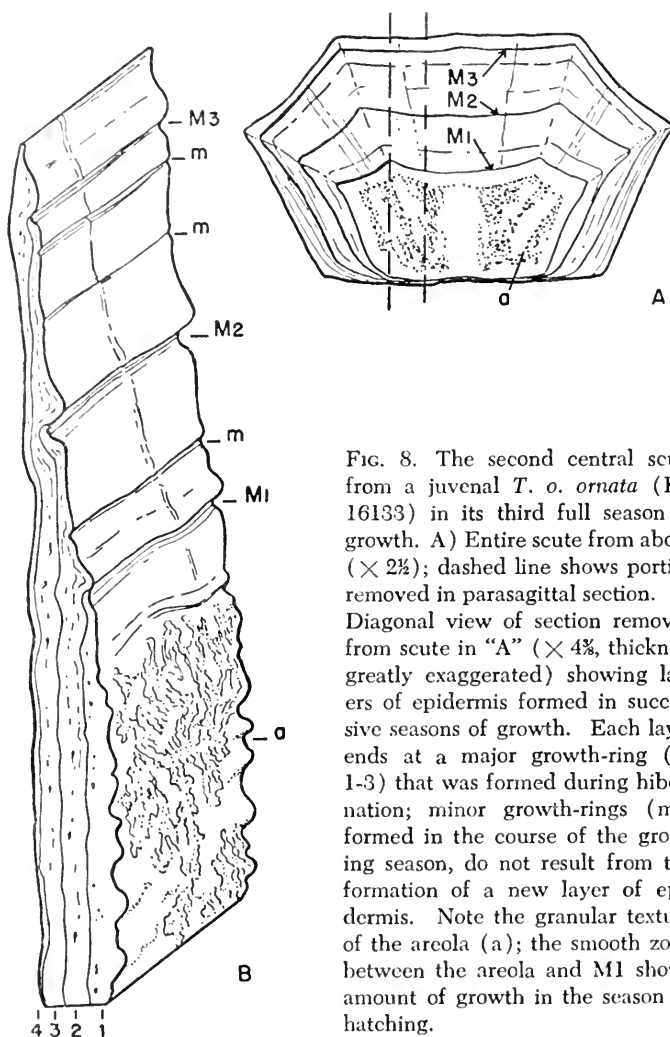


FIG. 8. The second central scute from a juvenile *T. o. ornata* (KU 16133) in its third full season of growth. A) Entire scute from above ($\times 2\frac{1}{2}$); dashed line shows portion removed in parasagittal section. B) Diagonal view of section removed from scute in "A" ($\times 4\%$, thickness greatly exaggerated) showing layers of epidermis formed in successive seasons of growth. Each layer ends at a major growth-ring (M 1-3) that was formed during hibernation; minor growth-rings (m), formed in the course of the growing season, do not result from the formation of a new layer of epidermis. Note the granular texture of the areola (a); the smooth zone between the areola and M1 shows amount of growth in the season of hatching.

entirely new layer of epidermis. The new layer is thin and indistinct under the oldest part of the scute but becomes more distinct toward its periphery. Immediately proximal to the edge of the scute, the new layer becomes greatly thickened, and, where it passes under the edge, it bulges upward, recurving the free edge of the scute above. At this time the formation of a major growth-ring is completed. The newly-formed epidermis, projecting from under the edges of the scute, is paler and softer than the older parts of the scute; the presence or absence of areas of newly formed epidermis

enables one to determine quickly whether a turtle is growing in the season in which it is captured. There is little actual increase in thickness of the scute after the first three or four years of growth. The epidermal laminae are therefore like low pyramids only in appearance. This appearance of thickness is enhanced by the contours of bony shell which correspond to the contours of the scutes.

Minor growth-rings differ from major growth-rings in appearance and in origin. Ewing (*op. cit.*: 91) recognized the difference in appearance and referred to minor growth-rings as "pseudoannual growth zones." Minor growth-rings result from temporary cessations of growth that occur in the course of the growing season, not at the onset of hibernation. They are mere dips or depressions in the surface of the scute. The occurrence of minor growth-rings indicates that interruptions in growth of short duration do not result in the formation of a new layer of epidermis. Slowing of growth or its temporary cessation may be caused by injuries, periods of quiescence due to dry, hot, or cold weather, lack of food, and possibly by physiological stress, especially in females, in the season of reproduction. Minor growth-rings that lie immediately proximal to major growth-rings (Pl. 22, Fig. 2), are the result of temporary dormancy in a period of cold weather at the end of a growing season, followed by nearly normal activity in a warmer period before winter-long hibernation is begun. Cagle (1946: 699) stated that sliders (*Pseudemys scripta elegans*) remaining several weeks in a pond that had become barren of food would stop growing and develop a growth-ring on the epidermal laminae; he did not indicate, however, whether these growth-rings differ from those formed during hibernation.

In species that periodically shed scutes a zone of fracture develops between the old and new layers of the scute as each new layer of epidermis is formed, and the old layer is shed. Considering reptiles as a group, skin shedding is of general occurrence; the process in *Pseudemys* and *Chrysemys* differs in no basic respect from that in most reptiles. Retention of scutes in terrestrial emyids and in testudinids is one of many specializations for existence on land. Retention of scutes protects the shell of terrestrial chelonians against wear. Some box turtles were observed to have several scutes of the carapace in the process of exfoliation but no exfoliation was observed on the plastron. Exfoliation ordinarily occurred on the scutes of the carapace that were the least worn; the exfoliating portion included the areola and the three or four oldest (first formed) layers of the scute. The layer of scute exposed

was smooth and had yellow markings that were only slightly less distinct than those on the portion that was exfoliating.

Wear on the shell of a box turtle reduces the thickness of scutes, as does the shedding of scutes in the aquatic emyids mentioned. It is noteworthy that any of the layers in the scute of a box turtle can form the cornified surface of the scute when the layers above it wear away or are shed.

It is uncertain whether turtles that have ceased to grow at a measurable rate continue to elaborate a new layer of epidermis at the beginning of each season. Greatly worn shells of ornate box turtles, particularly those of the subspecies *luteola*, have only a thin layer of epidermis through which the bones of the shell and the sutures between the bones are visible. I suspect that, in these old individuals, the germinal layer of the epidermis does not become active each year but retains the capacity to elaborate new epidermis if the shell becomes worn thin enough to expose and endanger the bone beneath it. The germinal layer of old turtles loses the capacity to produce color.

Major growth-rings constitute a valuable and accurate history of growth that can be studied at any time in the life of the turtle if they have not been obliterated. They are accurate indicators of age only as long as regular growth continues but may be used to study early years of growth even in turtles that are no longer growing. Minor growth-rings, if properly interpreted, provide additional information on growing conditions in the course of each growing season.

Nichols (1939a: 16-17) found that the number of growth-rings formed in marked individuals of *T. carolina* did not correspond to the number of growing seasons elapsed; he concluded that growth-rings were unreliable as indicators of age and that box turtles frequently skipped seasons of growth. Woodbury and Hardy (1948: 166-167) and Miller (1955:114) came to approximately the same conclusion concerning *Gopherus agassizi*. It is significant that these workers were studying turtles of all sizes and ages, some of which were past the age of regular, annual growth. Cagle's review of the literature concerning growth-rings in turtles (1946) suggests that, in most of the species studied, growth-rings are formed regularly in individuals that have not attained sexual maturity but are formed irregularly after puberty.

Cagle's (*op. cit.*) careful studies of free-living populations of *Pseudemys scripta* showed that growth-rings, once formed, did not change in size, that the area between any two major growth-rings

represented one season of growth, and that growth-rings were reliable indicators of age as long as the impression of the arcola remained on the scutes studied. Cagle noted decreasing distinctness of growth-rings after each molt.

The relative lengths of the abdominal lamina and the plastron remain approximately the same throughout life in *T. ornata*. Measurements were made of the plastron, carapace, and abdominal lamina in 103 specimens of *T. o. ornata* from Kansas and neighboring states. The series of specimens was divided into five nearly equal groups according to length of carapace. Table 3 summarizes the relationship of abdominal length to plastral length, and of carapace length to plastral length. The mathematical mean of the ratio, abdominal length/plastral length, in each of the four groups of larger-sized turtles, was not significantly different from the same ratio in the hatchling group. The relative lengths of carapace and

TABLE 3.—THE RELATIONSHIP OF LENGTH OF ABDOMINAL SCUTE TO PLASTRAL LENGTH, AND OF PLASTRAL LENGTH TO LENGTH OF CARAPACE, IN 103 SPECIMENS OF *T. o. ornata* ARRANGED IN FIVE GROUPS ACCORDING TO LENGTH OF CARAPACE. THE RELATIVE LENGTHS OF ABDOMINAL SCUTE AND PLASTRON ARE NOT SIGNIFICANTLY DIFFERENT IN THE FIVE GROUPS. THE PLASTRON TENDS TO BE LONGER THAN THE CARAPACE IN SPECIMENS OF ADULT OR NEARLY ADULT SIZE.

LENGTH OF CARAPACE	Number of specimens	Length of abdominal as a percentage of length of plastron		Individuals having plastron longer than carapace	
		Mean \pm σm	Extremes	Number	Percentage
Less than 50 mm. (Juveniles)	23	18.3 \pm .498	13.7-20.3	7	38.5
50 to 69 mm. (Juveniles)	20	17.8 \pm .303	15.2-20.2	8	40.0
70 to 100 mm. (Subadults)	20	17.9 \pm .445	14.3-20.6	15	75.0
More than 100 mm. (Adult males)	20	17.8 \pm .236	16.4-20.6	13	65.0
More than 100 mm. (Adult females)	20	18.8 \pm .510	15.1-25.7	19	95.0

plastron are not so constant; the carapace is usually longer than the plastron in hatchlings and juveniles, but shorter than the plastron in adults, especially adult females.

The length of any growth-ring on the abdominal lamina can be used to determine the approximate length of the plastron at the time the growth-ring was formed. Actual and relative increases in length of the plastron can be determined in a like manner. For example, a seven-year-old juvenile (KU 3283) with a plastron 74.0 millimeters long had abdominal growth-rings (beginning with areola and ending with the actual length of the abdominal) 5.9, 7.8, 9.5, 10.7, 12.0, 12.5, 14.3, and 14.9 millimeters long. Using the

proportion, $\left[\frac{AB}{PL} = \frac{AB^1}{X} \right]$, where AB is the abdominal length, PL the

plastral length, AB^1 the length of any given growth-ring, and X the plastral length at the time growth-ring AB^1 was formed, the plastral length of this individual was 29.3 millimeters at hatching, 38.8 at the end of the first full season of growth, and 47.2, 53.2, 59.6, 62.1, and 71.0 millimeters at the end of the first, second, third, fourth, fifth, and sixth seasons of growth, respectively. The present length of the abdominal (14.9 mm.) indicates an increment of three millimeters in plastral length in the seventh season, up to the time the turtle was killed (June 25). This method of studying growth in turtles was first used by Sergeev (1937) and later more extensively used by Cagle (1946 and 1948) in his researches on *Pseudemys scripta*. Because the plastron is curved, no straight-line measurement of it or its parts can express true length. Cagle (1946 and 1948) minimized error by expressing plastral length as the sum of the laminal (or growth-ring) lengths. This method was not possible in the present study because growth-rings on parts of one or more laminae (chiefly the gulars and anals) were usually obliterated by wear, even in young specimens. It was necessary to express plastral length as the sum of the lengths of forelobe and hind lobe.

The abdominal lamina was selected for study because of its length (second longest lamina of plastron), greater symmetry, and flattened form. Although the abdominal is probably subject to greater, over-all wear than any other lamina of the shell, wear is even, not localized as it is on the gulars and anals.

In instances where some of the growth-rings on an abdominal lamina were worn but other rings remained distinct, reference to

other, less worn lamina permitted a correct interpretation of indistinct rings.

Abdominal laminae were measured at the interlaminal seam; since the laminae frequently did not meet perfectly along the midline (and were of unequal length), the right abdominal was measured in all specimens. Growth-rings on the abdominal laminae were measured in the manner shown in Plate 22.

Data were obtained for an aggregate of 1272 seasons of growth in 154 specimens (67 females, 48 males, and 39 of undetermined sex, chiefly juveniles). Averages of calculated plastral length were computed in each year of growth for specimens of known sex (Figs. 9 and 10) and again for all specimens examined. Annual increment in plastral length was expressed as a percentage of plastral length at the end of the previous growing season (Fig. 11). Increment in plastral length for the first season of growth was expressed as a percentage of original plastral length because of variability of growth in the season of hatching; growth increments in the season following hatching are, therefore, not so great as indicated in Figure 11.

Growth of Juveniles

Areas of new laminal growth were discernible on laboratory hatchlings soon after they ate regularly. Hatchlings that refused to eat or that were experimentally starved did not grow. The first zone of epidermis was separated from the areola by an indistinct growth-ring (resembling a minor growth-ring) in most hatchlings, but in a few specimens the new epidermis appeared to be a continuation of the areola. Major growth-rings never formed before the onset of the first hibernation.

Growth in the season of hatching seems to depend on early hatching and early emergence from the nest. Under favorable conditions hatchlings would be able to feed and grow eight weeks or more before hibernation. Hatchlings that emerge in late autumn or that remain in the nest until spring are probably unable to find enough food to sustain growth.

Sixty-four (42 per cent) of the 154 specimens examined showed measurable growth in the season of hatching. The amount of increment was determined in 36 specimens having a first growth-ring and an areola that could be measured accurately. The average increment of plastral length was 17.5 per cent (extremes, 1.8 - 66.0 per cent) of the original plastral length. Ten individuals showed

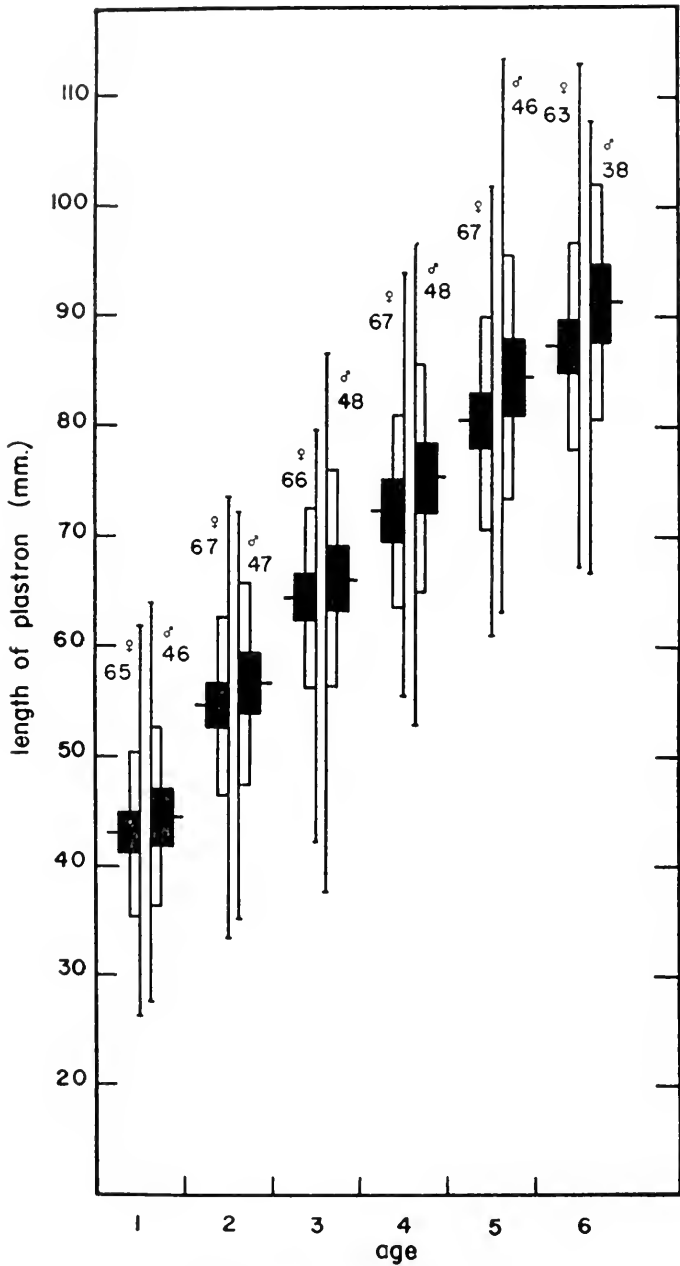


FIG. 9. See legend for Fig. 10.

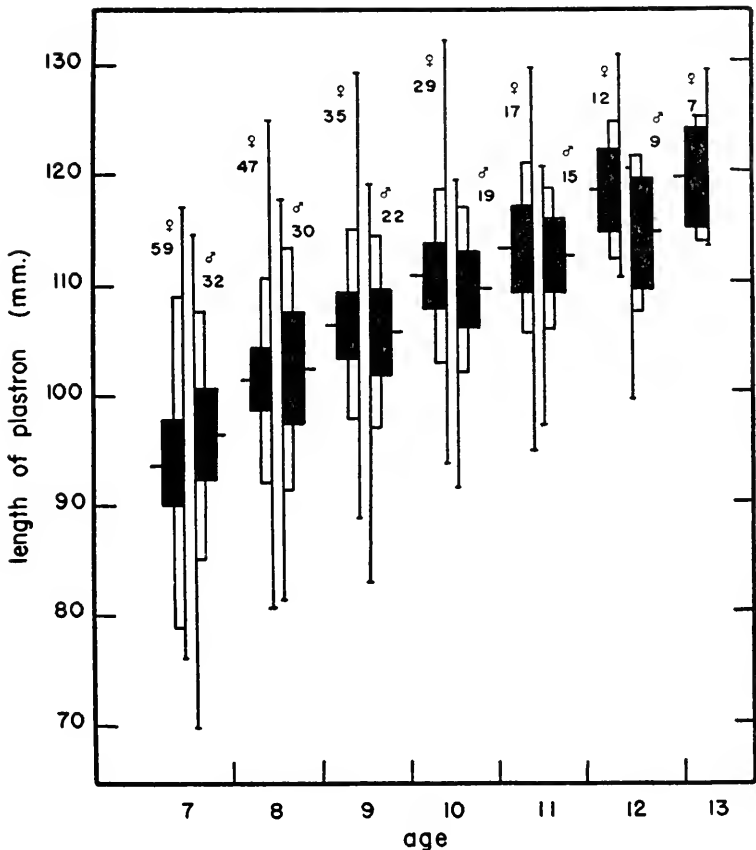


FIG. 10. The relationship of size to age in *T. o. ornata*, based on studies of growth-rings in 115 specimens of known sex (67 females and 48 males) from eastern Kansas. Size is expressed as plastral length at the end of each growing season (excluding the year of hatching) through the twelfth and thirteenth years (for males and females, respectively) of life. Vertical and horizontal lines represent, respectively, the range and mean. Open and solid rectangles represent one standard deviation and two standard errors of the mean, respectively. Age is expressed in years.

an increment of more than 20 per cent; the majority of these individuals (8) were hatched in the years 1947-50, inclusive.

Some hatchlings that grow rapidly before the first winter are as large as one- or two-year-old turtles, or even larger, by the following summer. Individuals that grew rapidly in the season of hatching tended also to grow more rapidly than usual in subsequent seasons; 80 per cent of the individuals that increased in plastral length by 20 per cent or more in the season of hatching, grew faster

than average in the two seasons following hatching. Early hatching and precocious development presumably confer an advantage on the individual, since turtles that grow rapidly are able better to compete with smaller individuals of the same age. Theoretically, turtles growing more rapidly than usual in the first two or three years of life, even if they grew subsequently at an average rate, would attain adult size and sexual maturity one or more years before other turtles of the same age. A few turtles (chiefly males) attain adult size (and presumably become sexually mature) by the end of the fifth full season of growth (Figs. 9 and 10). These individuals, reaching adult size some three to four years sooner than the average age, were precocious also in the earlier stages of post-natal development.

Young box turtles reared in the laboratory grew more slowly than turtles of comparable ages under natural conditions; this was especially evident in hatchlings and one-year-old specimens. Slower growth of captives was caused probably by the unnatural environment of the laboratory. Captive juveniles showed a steady increase in weight (average, .52 grams per ten days) as they grew whereas captive hatchlings tended to lose weight whether they grew or not.

Growth in Later Life

After the first year growth is variable and size is of little value as an indicator of age. Although in the turtles sampled variation in size was great in those of the same age, average size was successively greater in each year up to the twelfth and thirteenth years (for males and females, respectively), after which the samples were too small to consider mathematically.

Increments in plastral length averaged 68.1 per cent in the year after hatching, 28.6 per cent in the second year and 18.1 per cent in the third year. From the fourth to the fourteenth year the growth-rate slowed gradually from 13.3 to about three per cent (Fig. 11). These averages are based on all the specimens examined (with no distinction as to sex); they give a general, over-all picture of growth rate but do not reflect the changes that occur in growth rate at puberty (as shown in Figs. 9 and 10).

Rate of growth and, ultimately, size are influenced by the attainment of sexual maturity. Adult females grow larger than adult males. Males, nevertheless, grow faster than females and become sexually mature when smaller and younger. Examination of gonads showed 17 per cent of the males to be mature at plastral lengths of 90 to 99 millimeters, 76 per cent at 100 to 109 milli-

meters, and 100 per cent at 110 millimeters, whereas the corresponding percentages of mature females in the same size groups were: zero per cent, 47 per cent, and 66 per cent. Of the females, 97 per cent were mature at 120 to 129 millimeters and all were mature at 130 millimeters (Fig. 13). Because growth slows perceptibly at sexual maturity, it is possible, by examination of growth-rings, to estimate the age of puberty in mature specimens.

Attainment of sexual maturity, in the population studied, was

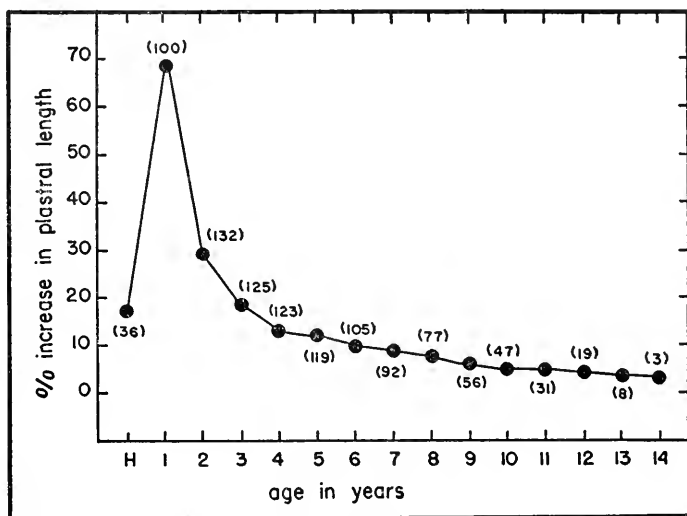


FIG. 11. Average increment in plastral length (expressed as a percentage of plastral length at the end of the previous season of growth) in the season of hatching (H) and in each of the following 14 years of life, based on 1073 growth-rings. The number of specimens examined for each year of growth is shown in parentheses. Records for males and females are combined.

more closely correlated with size than with age. For example, nearly all males were mature when the plastron was 100 to 110 millimeters long, regardless of the age at which this size was attained. The smallest mature male had a plastral length of 99 millimeters; according to the data presented in Figures 9 and 10, therefore, a few males reach sexual maturity in the fourth year, and increasingly larger portions of the population become mature in the fifth, sixth, and seventh years. The majority become mature in the eighth and ninth years. Likewise, females (smallest mature specimen, 107 mm.) may be sexually mature at the end of the sixth year but most of them mature in the tenth and eleventh years.

Annual Period of Growth

In growing individuals, narrow zones of new epidermis form on the laminae in spring. Nearly all the growing individuals collected in May of 1954 and 1955 had zones of new epidermis on the shell but those collected in April did not. Activity in the first week or two after spring emergence is sporadic and regular feeding may not begin until early May. Once begun, growth is more or less continuous as long as environmental conditions permit foraging. The formation of minor growth-rings and adjacent growth-zones in autumn, provides evidence that growth commonly continues up to the time of hibernation. The number of growing days per year varies, of course, with the favorableness of environmental conditions. The length of time (162 days) given by Fitch (1956b: 438) as the average annual period of activity for *T. ornata* is a good estimate of the number of growing days per season.

Environmental Factors Influencing Growth

Zones of epidermis formed in some years are wider or narrower than the zones bordering them (Pl. 22). Zones notably narrower or wider than the average, formed in certain years, constituted distinct landmarks in the growth-histories of nearly all specimens; for example, turtles of all ages grew faster than average in 1954 and zones of epidermis formed in this year were always wider than those formed in 1953 and 1955.

An index to the relative success of growth in each calendar year was derived. Records of growth for all specimens in each age group were averaged; the figure obtained was used to represent "normal" or average growth rate in each year of life (Fig. 12). The over-all averages for the various age groups were then compared with records of growth attained by individuals of corresponding age in each calendar year, growth in a particular year being expressed as a percentage of the over-all average. The percentages of average growth for all ages in each calendar year were then averaged; the mean expressed the departure from normal rate of growth for all turtles growing in a particular calendar year. For example, the over-all average increment in plastral length in the fifth year of life was 12.1 per cent, the increment in the sixth year was 10 per cent, and so on (Fig. 11). In 1953, turtles in their fifth and sixth years increased in plastral length by 11.4 and 9.1 per cent, or grew at 94.2 and 91.0 per cent of the normal rate, respectively. The percentages of normal growth rate for these age groups averaged with percentages of the other age groups in 1953

revealed that turtles grew at approximately 86 per cent of the normal rate in 1953.

Growth rates were computed for the twelve-year period, 1943-1954, because of the concentration of records in these years. Scattered records also were available for many of the years from 1901-1942. Records for individuals in the season of hatching and the first full season of growth were not considered.

Direct correlation exists between growth rate and average monthly precipitation in the season of growth (April to September) (Fig. 12). In nine of eleven years, the curve for growth rate followed the trend of the curve for precipitation; but because other climatic conditions also influenced growth, the fluctuations in the two curves were not proportional to one another.

Grasshoppers form an important element in the diet of box turtles. Smith (1954) traced the relative abundance of grasshoppers over a period of 100 years in Kansas, and this information is of significance for comparison with data concerning growth of box turtles. In general, the growth index was higher when favorable weather and large populations of grasshoppers occurred in the same year.

In the following summary, the numbers (1 to 5) used to express the relative abundance of grasshoppers are from Smith (*op. cit.*). Maxima and minima refer to the twelve-year period, 1943-1954. The growth index for each year (shown as a graph in Fig. 12) appears in brackets and indicates the percentage of normal growth attained by all turtles in that year.

Years Favorable for Growth

1954 [126.3]: Growth was better than average for turtles of all ages. Grasshopper populations were highest (4+) since 1948. Continuously warm weather, beginning in the last few days of March, permitted emergence in the first week of April; thereafter conditions were more or less continuously favorable for activity until late October. Although there was less than an inch of precipitation in September, precipitation in August and October was approximately twice normal and more or less evenly distributed. Warm weather in early November permitted an additional two weeks of activity.

1945 [125.5]: This was the second most favorable year for growth and the second wettest year. Records of growth are all from young turtles (one to four years old), all of which grew more than average. Daily maximum temperatures higher than 60 degrees Fahren-

heit on 18 of the last 19 days of March, combined with twice the normal amount of precipitation in the same period, stimulated early emergence. August and October were both dry (each with less than one inch of precipitation) but diurnal temperatures remained warm through the first week in November and probably prolonged activity of box turtles at least until then. Grasshoppers were more abundant (3.7) than normal.

Years Unfavorable for Growth

1944 [83.1]: This was the poorest growing year for the period considered. The lack of a continuously warm, wet period in early spring probably delayed emergence until the last week in April. Temperatures remained warm enough for activity until early November, but dry weather in September and October probably curtailed activity for inducing long periods of quiescence; most of the precipitation that occurred in the latter two months fell in a one-week period beginning in the last few days of September. Grasshopper populations were higher (4.0) than normal.

1953 [85.6]: This was the second poorest growing year and the driest year in the period considered. Intermittently cold weather in spring delayed emergence until the last week in April when nearly an inch of rain fell. Temperatures were higher than normal from June to October. The period from September to the end of October was dry and the small amount of precipitation that occurred was concentrated chiefly at the beginning and end of that period. Temperatures in late October and early November were lower than normal. Grasshopper populations were low (2.2).

1952 [88.3]: Environmental conditions were poor for growth and much like the conditions described for 1953. In both years growth was much less than normal in turtles of all ages except for one group (adults that were 10 and 11 years old in 1952 and 1953, respectively) that was slightly below normal in 1952 and slightly above normal in 1953.

The small number of records for 1955 were not considered in Figure 12. Warm weather in the last half of March lengthened the growing season, and environmental conditions, as in 1954, were more or less favorable throughout the rest of the summer; 1955 probably ranks with 1954 as an exceptionally good year for growth of box turtles.

Although the number of records available for turtles hatched in the period from 1950 to 1954 is small, a few records are available for all these years except 1951. In general, small samples of turtles

hatched in these years reflect only the difficulty of collecting hatchlings and juveniles. In 1951, conditions for incubation and hatching were poor and the lack of records for that year actually represents a high rate of prenatal and postnatal mortality. Rainfall in the nesting season was two to three times normal and temperatures were below normal. Flooding occurred in low areas of Douglas County and many eggs may have been destroyed when nests were inundated. Cold weather probably increased the time of incubation for surviving eggs so that only a few turtles could hatch before winter. Flooding and cold, wet weather in the season of growth and reproduction, affecting primarily eggs and hatchlings, may act as checks on populations of *T. ornata* in certain years.

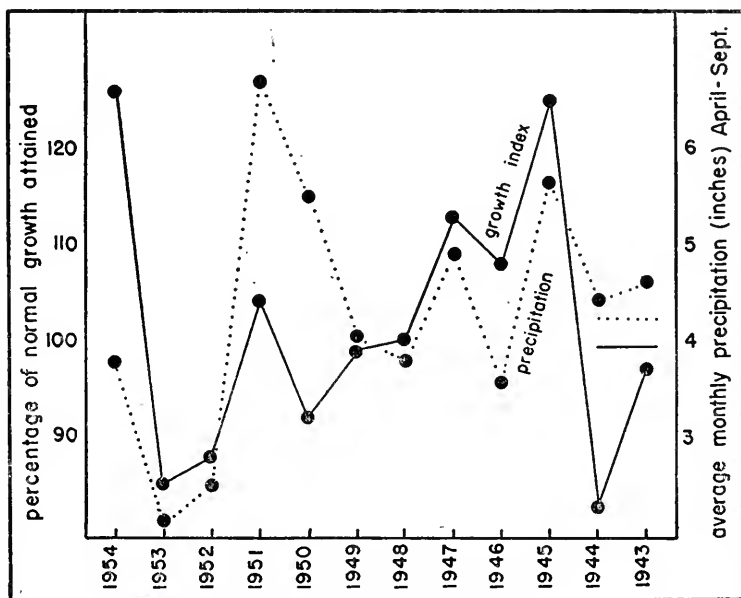


FIG. 12. The relation of growth rate in *Terrapene o. ornata* (solid line) to precipitation (dotted line) in eastern Kansas. "Normal" rate of growth was determined by averaging records of increase in length of plastron for turtles in each age group. The growth index is expressed as a percentage of normal growth and is the mean departure from normal of all age groups in each calendar year. Precipitation is for the period, April to September (inclusive), at Lawrence, Douglas Co., Kansas. The means for precipitation (4.3) and growth index (100) are indicated by horizontal lines at the right of the graph.

The environmental factors governing activity of terrestrial turtles seem to differ at least in respect to threshold, from the factors influencing the activity of aquatic turtles. A single month that was drier or cooler than normal probably would not noticeably affect

growth and activity of aquatic emyids in northeast Kansas, but might greatly curtail growth of box turtles.

Cagle (1948:202) found that growth of slider turtles (*Pseudemys scripta*) in Illinois paralleled the growth of bass and bluegills in the same lake; in the two years in which the fish grew rapidly, the turtles did also, owing, he thought to "lessened total population pressure" and "reduced competition for food." Growth of five-lined skinks (*Eumeces fasciatus*) on the Natural History Reservation paralleled growth of box turtles, probably because at least some of the same environmental factors influence the growth of both species. Calculations of departure from normal growth in *E. fasciatus*, made by me from Fitch's graph (1954:84, Fig. 13), show that relative success of growth in the period he considered can be ranked by year, in descending order, as: 1951, 1949, 1948, 1950, 1952. This corresponds closely to the sequence, 1951, 1948, 1949, 1950, 1952, for *T. ornata*.

Number of Growing Years

Growth almost stops after the thirteenth year in females and after the eleventh or twelfth year in males, approximately three years, on the average, after sexual maturity is attained. The oldest individuals in which plastral length had increased measurably in the season of capture were females 14 (2 specimens) and 15 (1) years old. The age of the oldest growing male was 13 years.

The germinal layer of the epidermis probably remains semi-active throughout life but functions chiefly as a repair mechanism in adults that are no longer growing. Growth-rings continue to form irregularly in some older adults. Growth-rings formed after the period of regular growth are so closely approximated that they are unmeasurable and frequently indistinguishable to the unaided eye. If the continued formation of growth-rings is not accompanied by wear at the edges of the laminae, the laminae meeting at an interlaminal seam descend, like steps, into the seam (Pl. 22, Fig. 2). Interlaminal seams of the plastron deepen with advancing age in most individuals.

Some individuals that are well past the age of regular growth show measurable increments in years when conditions are especially favorable. The three oldest growing females were collected in 1954—an exceptionally good year for growth. Allowing some latitude for irregular periods of growth in favorable years subsequent to the period of regular, more or less steady growth, 15 to 20 years is a tenable estimate of the total growing period.

Longevity

Practically nothing is known about longevity in *T. ornata* or in other species of *Terrapene* although the several plausible records of ages of 80 to more than 100 years for *T. carolina* (Oliver, 1955: 295-6) would indicate that box turtles, as a group, are long-lived. There is no known way to determine accurately the age of an adult turtle after it has stopped growing. It was possible occasionally to determine ages of 20 to 30 years with fair accuracy by counting all growth-rings (including those crowded into the interabdominal seam) of specimens having unworn shells. Without the presence of newly formed epidermis as a landmark, however, it was never certain how many years had passed since the last ring was formed.

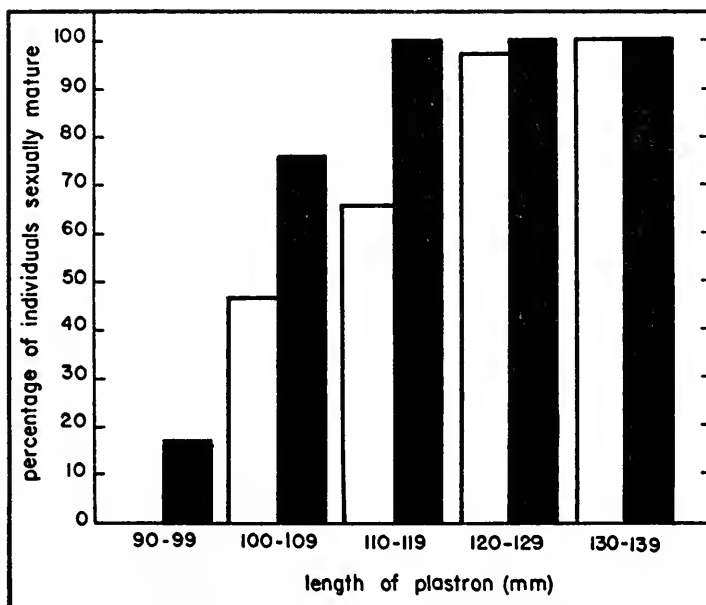


FIG. 13. The relationship of sexual maturity to size in 164 specimens (94 females and 70 males) of *Terrapene o. ornata*, expressed as the percentage of mature individuals in each of five groups arranged according to plastral length. Sexual maturity was determined by examination of gonads. Solid bars are for males and open bars for females. The bar for males in the largest group is based on assumption since no males in the sample were so long as 130 mm. Males mature at a smaller size and lesser age (see also Figs. 9 and 10) than females. Plastral lengths of the smallest sexually mature male and female in the sample were, respectively, 99 and 107 mm.

Mattox (1936) studied annual rings in the long bones of painted turtles (*Chrysemys picta*) and found fewer rings in younger than in older individuals but, beyond this, reached no important con-

clusion. In the present study, thin sections were ground from the humeri and femurs of box turtles of various ages and sizes; the results of this investigation were negative. Distinct rings were present in the compact bony tissue but it appeared that, after the first year or two, the rings were destroyed by encroachment of the marrow cavity at about the same rate at which they were formed peripherally.

The only methods that I know of to determine successfully the longevity of long-lived reptiles would be to keep individuals under observation for long periods of time or to study populations of marked individuals. Both methods have the obvious disadvantage of requiring somewhat more than a human lifetime to carry them to completion. Restudy, after one or more decades, of the populations of turtles marked by Fitch and myself may provide valuable data on the average and maximum age reached by *T. ornata*.

Ornate box turtles probably live at least twice as long as the total period of growing years. An estimated longevity of 50 years would seem to agree with present scant information on age. Considering environmental hazards, it would be unusual for an individual to survive as long as 100 years in the wild.

Weight

Weights of ornate box turtles varied so much that no attempt was made to correlate weight with size. Absolute weights have little significance since weight is affected to a large extent by the amount of fluid in the body. Turtles that had recently imbibed were naturally heavier than those that had not; turtles brought to the laboratory and kept there for several days lost weight by evaporation and by voiding water. Weights of 22 adult females (53 records) and 10 adult males (22 records) averaged 391 and 353 grams respectively, in the period from September, 1954, to October, 1956. Females characteristically gained weight in spring and early summer and were lighter after nesting. Turtles of both sexes gained weight in September and October.

Bony Shell

Fontanelles

At the time of hatching, fontanelles remain where bones of the shell have not yet articulated with their neighbors. In general, the fontanelles of the shell are closed by the time sexual maturity is attained, but some remain open a year or two longer.

The fontanelles of the shell are classified as follows (see Figs. 14 to 16 and 18 to 19):

Plastron

1.) *Anteromedian*. Rhomboidal; limited anteriorly by hyoplastral bones and posteriorly by hypoplastral bones; posterior tip of entoplastral bone may project into this fontanelle.

2.) *Posteromedian*. Limited anteriorly by hypoplastral bones and posteriorly by xiphyplastral bones (since hypoplastral bones do not articulate medially in hatchlings, anteromedian and posteromedian fontanelles form a single, more or less dumbbell-shaped opening).

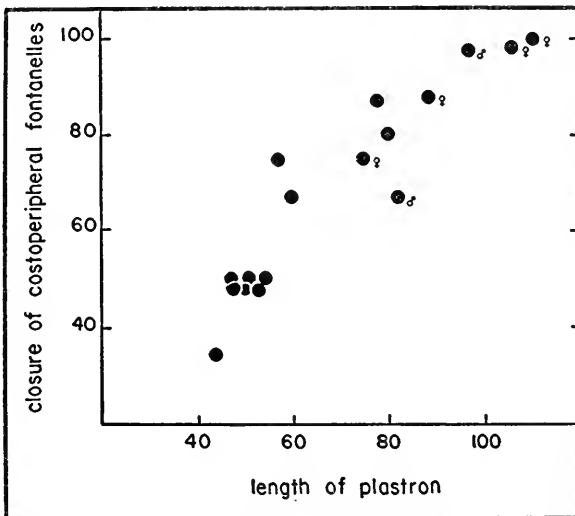


FIG. 14. Extent of closure of the costoperipheral fontanelles in relation to length of plastron in 17 skeletons of *T. o. ornata* from eastern Kansas. Extent of closure is expressed as an estimated percentage of total closure of all the costoperipheral fontanelles, even though some of them close sooner than others. Closure is usually complete by the time sexual maturity is attained.

Carapace

1.) *Costoperipheral*. Openings between the free ends of developing ribs, between nuchal bone and first rib, and, between pygal bone and last rib; limited laterally by peripheral bones; variable in shape.

2.) *Costoneural*. Triangular openings on either side of middorsal line between proximal ends of costal plates and developing neural plates.

The costoneural fontanelles are nearly closed in individuals

of the 70 millimeter (plastron length) class and seldom remain open after a length of 80 millimeters is attained (Fig. 14). Of the costoperipheral fontanelles, the anterior one (between first rib and nuchal bone) closes first and the posterior one (between last rib and pygal bone) last. It remains open in some turtles in which the plastron is longer than 100 millimeters. The remaining costoperipheral fontanelles close in varying sequence but those in the area of the bridge (nos. 2 to 5), where there is presumably greater stress on the shell, close sooner than the others.

The plastral fontanelles are closed in most specimens of the 90 millimeter (plastron length) class; the anteromedian fontanelle closes first.

The meager covering of the fontanelles makes juvenal turtles more susceptible than adults to many kinds of injuries and to predation.

Movable Parts of the Shell

Parts of the shell that are more or less movable upon one another and that function in closing the shell are found in several families of Recent turtles. African side-necked terrapins of the genus *Pelusios* have a movable forelobe on the plastron. Kinosternids have one or two flexible transverse hinges on the plastron. In the Testudinidae the African *Kinixys* has a movable hinge on the posterior part of the carapace and *Pyxis arachnoides* of Madagascar has a short, hinged, anterior plastral lobe. Certain trionychid turtles, such as *Lissemys*, utilize the flexible flaps of the carapace (the flaps of some species are reinforced with peripheral bones) to close the shell.

Movable shell-parts of turtles are, in general, protective in function; they cover parts of the soft anatomy that would otherwise be exposed.

A hinged plastron, capable of wholly or partly closing the shell, occurs in six genera of the family Emyidae (see introduction). In these emyids the plastron is divided into two lobes, which are joined to each other by ligamentous tissue at the junction of the hyoplastral and hypoplastral bones; externally, the hinge occurs along the seam between the pectoral and abdominal laminae. This junction forms a more or less freely movable hinge in adults. The plastron is attached to the carapace by ligamentous tissue. Both lobes of the plastron or only the buttresses of the hind lobe may articulate with the carapace. The former condition obtains in *Emys* and *Emydoidea*; the latter more specialized condition is found in *Terrapene*.

In generalized emyid turtles such as *Clemmys* there are no movable shell parts. The plastron is joined to the carapace by the sutures of the bridge. A long stout process, the axillary buttress, arises on each side from the hyoplastron and articulates with the tip of the first costal. A similar process, the inguinal buttress, arises from the anterior part of each of the hypoplastral elements and meets the sixth costal on each side. The buttresses form the anterior and posterior margins of the bridge. It is clear that movement of the plastron in many emyids is mechanically impossible because of the bracing effect of the buttresses.

In *Terrapene* the movable articulations of the shell are neither structurally nor functionally developed in juveniles. Adults of *T. ornata* have highly modified bony buttresses on the plastron that are homologous with those in more generalized emyids. The inguinal buttresses are low and wide, and have a sheer lateral surface forming a sliding articulation with the fifth and sixth peripheral bones of the carapace. The axillary buttresses are reduced to mere bony points near the posterolateral corners of the forelobe and do not articulate directly with the carapace (Figs. 15 and 16).

The fifth peripheral bone, constituting the lowest point of the carapace, has a medial projection that acts as a pivoting point for both lobes of the plastron; the roughened anterior corners of the hind lobe articulate with these processes. The roughened posterior corners of the forelobe of the plastron likewise articulate with these processes. The posterior process or "tail" of the entoplastron extends to, or nearly to, the bony transverse hinge.

In juveniles that have been cleared and stained, the homologues of the parts that are movable in adults are easily identifiable; the proportions of these parts and their relations to one another are, however, much different.

In juveniles (Figs. 18 and 19) the buttresses are relatively longer and narrower, and are distinct—more nearly like those of generalized emyids than those of adult *T. ornata*. The buttresses enclose a large open space, which in adults is filled by the fifth peripheral. The hyoplastral and hypoplastral bones are in contact only laterally. They are firmly joined by bony processes; the interdigitating nature of this articulation contrasts with its homologue in the adult, the point where the roughened corners of the forelobes and hind lobes meet. The fifth peripheral in juveniles (Fig. 19) lies dorsal to this articulation. The position of the future transverse hinge corresponds to a line passing through the articulations of the hyo-

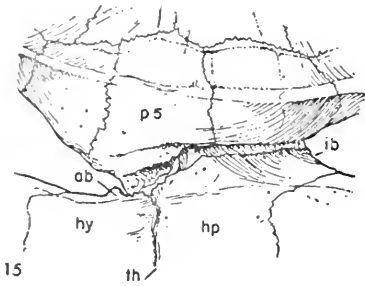


FIG. 15. Lateral view of adult shell ($\times \frac{3}{4}$), showing movable parts with anterior portion at left. (Abbreviations are as follows: ab, axillary buttress; hp, hypoplastron; hy, hyoplastron; ib, inguinal buttress; p5, fifth peripheral bone; th, transverse hinge).

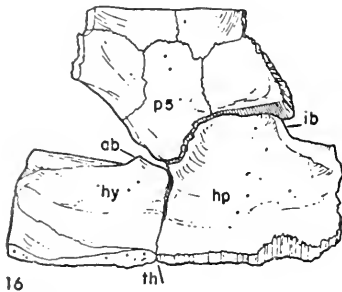


FIG. 16. Medial view of adult shell ($\times \frac{3}{4}$), showing movable parts with anterior portion at left. (Abbreviations as in fig. 15).

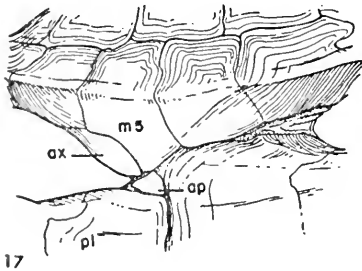


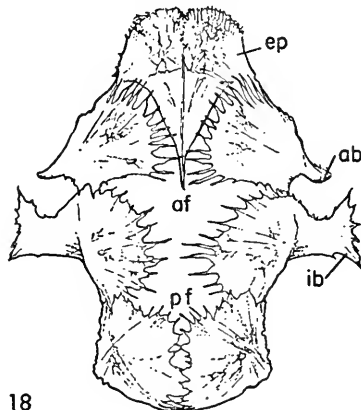
FIG. 17. Lateral view of adult shell ($\times \frac{3}{4}$), showing scutellation of movable parts with anterior portion at left. (Abbreviations are as follows: ap, apical scale; ax, axillary scale; m5, fifth marginal lamina; pl, pectoral lamina.)

plastra and hypoplastra. The tail of the entoplastron ordinarily extends posterior to this line in juveniles.

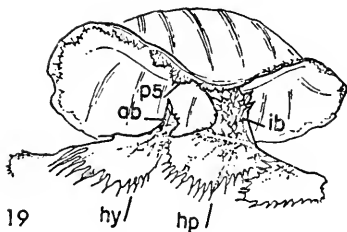
The external scutellation of the plastral hinge in adults also differs from that in juveniles. In adults (Fig. 17 and Pl. 8) the transverse hinge is marked by ligamentous tissue between the pectoral and abdominal laminae; the forelobe of the plastron is distinctly narrower than the hind lobe. Two small scales lie near the corner of the hinge on each side. The larger and more anterior of these scales is the axillary; it is present in box turtles of all ages. The smaller scale (Fig. 17), to my knowledge, has never been named or mentioned in the literature; it is herein termed the apical scale. It is a constant feature in adults but is always lacking in hatchlings and small juveniles. Other scales, much smaller than the axillary

and apical, occur on the ligamentous tissue of the hinge of some adults.

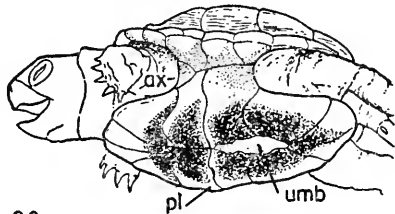
In juveniles (Fig. 20) the pectoroabdominal seam contains no ligamentous tissue and is like the other interlaminal seams of the plastron. A lateral apex of the pectoral lamina projects upward behind the axillary scale on each side, in the position occupied by



18



19



20

FIG. 18. Plastron of hatchling ($\times 2$), cleared and stained to show bony structure. (Abbreviations not listed in legend for Fig. 15 are as follows: af, anteromedian fontanelle; ep, epiplastron; pf, posteromedian fontanelle.)

FIG. 19. Carapace of hatchling ($\times 1\frac{1}{2}$), cleared and stained to show bony structure; lateral view; anterior end at left. (Abbreviations as in Fig. 15.)

FIG. 20. Lateral view of hatchling ($\times 1$); note the lateral process of the pectoral lamina (pl) extending posterior to the axillary scale (ax) in a position corresponding to the apical scale of adults. There is no external indication of the transverse hinge in young individuals. The yolk sac of this individual has been retracted but the umbilicus (umb) has not yet closed.

the apical scale of adults. Examination of a large series of specimens revealed that the apical scale of adults becomes separated from the lateral apex of the pectoral lamina at approximately the time when the hinge becomes functional as such.

Ontogenetic changes in the shell can be summarized as follows:

1) Buttresses become less distinct in the first two years of life (plastral lengths of 40 to 55 mm.); 2) Interdigitating processes of the forelobes and hind lobes become relatively shorter and wider, the entoplastron no longer projects posterior to the hinge, the lateral apex of the pectoral lamina becomes creased, and some movement of the plastron can take place between the second and third years (plastral lengths of 55 to 65 mm.); 3) Plastral lobes become freely movable upon one another and upon the carapace by the end of the fourth year (plastral length approximately 70 mm.) in most individuals.

The plastron of a juvenal box turtle is not completely immovable. The bones of the shell are flexible for a time after hatching and allow some movement of the plastron; but the relatively greater bulk of the body in young box turtles would prevent complete closure of the shell even if a functional hinge were present. Hatchlings can withdraw the head and forelegs only to a line running between the anterior edges of the shell. To do so the rear half of the shell is opened and the hind legs are extended. When the head and forelegs are retracted to the maximum, the elbow-joints are pressed against the tympanic region or behind the head; the forelimbs cannot be drawn part way across the snout, as in adults. Hatchlings can elevate the plastron to an angle of approximately nine degrees; the plastron of an adult, with shell closed, is elevated about 50 degrees. Hatchlings flex the plastron chiefly in the region of the humeropectoral seam, rather than at the anlage of the transverse hinge.

Adult box turtles, when walking, characteristically carry the forelobe of the plastron slightly flexed. This flexion of the plastron, combined with its naturally up-turned anterior edge, cause it to function in the manner of a sled runner when the turtle is moving forward. A movable plastron, therefore, in addition to its primarily protective function, seems to aid the turtle in traveling through tall grass or over uneven ground. The gular scutes, on the anterior edge of the forelobe, become worn long before other plastral laminae do.

An adult female from Richland County, Illinois, had an abnormal but functional hinge on the humeropectoral seam in addition to a normal hinge on the pectoroabdominal seam. The abnormal hinge resulted from a transverse break in which ligamentous tissue later developed. The muscles closing the plastron moved the more anterior of the two hinges; the normal hinge was not functional.

Color and Markings

The markings of the shell change first when postnatal growth begins and again when sexual maturity is attained. They are modified gradually thereafter as the shell becomes worn.

In hatchlings the ground color ordinarily is dark brown but in some individuals is paler brown or tan. Markings on the dark background are pale yellow. Markings on the central and lateral scutes vary from a regularly arranged series of well defined spots and a middorsal stripe to a general scattering of small flecks. In some specimens the pale markings of the carapace are faint or wanting. Lateral parts of marginal scutes are always pale yellow and form a border around the carapace.

Close examination of the carapace of any hatchling shows the following basic arrangement of markings: each lateral scute has a centrally placed pale spot and four to seven smaller pale marks arranged around the edge of the scute; each central scute has a central, longitudinal mark and several (usually two, four, or six) smaller pale marks arranged around the edge of the scute, chiefly the lateral edges (Pl. 23). Variations in pattern result when some or all of the markings divide into two or more parts.

By the end of the first full season of growth, the markings have a radial pattern. At this stage, the markings of the areola, with the exception of the central spot, are obscure. The radial marks, sharply defined and straight-sided, appear only on the newly formed parts of the epidermal laminae. Each radial mark originates opposite one of the peripheral marks of the areola. Other radial marks are developed later by bifurcation of the original radiations.

The ground color of the plastron of hatchlings is cream-yellow, or less often, bright yellow. The solid, dark brown markings on the medial part of each lamina form a central dark area that contrasts sharply with the pale background (Pl. 24). The soft tissue of the navel is pale yellow or cream; when the navel closes, the dark central mark of the plastron is unbroken except for thin, pale lines along the interlaminal seams.

When growth begins, the areas of newly formed epidermal tissue on the anterior and medial borders of each areolar scute are pale. Wide, dark radial marks, usually three per scute, appear on the newly formed tissue. Subsequently, finer dark radiations appear between the three original radiations. The wide radiations later bifurcate. By the time adult or subadult size is reached, the plas-

tron appears to have a pattern of pale radiations on a *dark* background. In general, the markings of the plastron are less sharply defined than the markings of the carapace (Pl. 24).

There is a tendency for the dark markings of the plastron to encroach on the lighter markings, if no wear on the shell occurs. However, as the plastron becomes worn, the pale areas become more extensive and the dark markings become broken and rounded. Severely worn plastra of some old individuals lack dark markings. Wear on the carapace produces the same general effect; but markings of the carapace, although they may become blotched, are never obliterated in *Terrapene o. ornata*.

The top of the head in most hatchlings is dark brown, approximately the same shade as the ground color of the carapace; the part anterior to the eyes is usually unmarked but a few individuals have a semicircle of small pale spots over each eye or similar spots on much of the head. The posterior part of the head is ordinarily flecked with yellow. The skin on the top of the head, particularly between the eyes, is roughened. The granular skin of the neck is grayish brown to cream-yellow. There are one or two large pale spots behind the eye and another pale spot at the corner of the mouth. Smaller, irregularly arranged pale markings on the necks of some specimens form, with the post-orbital and post-rietal spots, one or two short, ragged stripes. The gular region is pale.

In juveniles, the yellow markings of the head and neck are larger and contrast more sharply with the dark ground color than in hatchlings. Markings above the eyes, if present, fuse to form two pale, semicircular stripes. In some older juveniles yellow marks on top of the head blend with the dark background to produce an amber color. The top of the neck darkens or develops blotches of darker color that produce a mottled effect. Spots and stripes on the side of the neck remain well defined. The skin on top of the head becomes smooth and shiny.

Adult females tend to retain the color and pattern of juveniles on the head and neck although slight general darkening occurs with age. Many adult females have the top of the head marked with bright yellow spots. In adult males, the top and sides of the head, anterior to the tympanum, are uniformly grayish green or bluish green; the mandibular and maxillary beaks are brighter, yellowish green. Markings on the head and neck of most adult males are obscure (Pl. 25) but the sides of the neck remain mottled in some individuals.

The antebrachium has large imbricated scales and is distinctly

set off from the proximal part of the foreleg which is covered with granular skin. The antebrachial scales of hatchlings are pale yellow; each scale is bordered with darker color. General darkening of the antebrachium occurs at puberty. In adult females each scale on the anterior surface of the antebrachium is dark brown and has a contrasting yellow, amber, or pale orange center. The anterior antebrachial scales of adult males are dark brown to nearly black and have bright orange or red centers. Old males have thickened antebrachial scales.

The iris of hatchlings and juveniles is flecked with yellow and brown; the blending of these colors makes the eye appear yellow, golden, or light brown when viewed without magnification. Adult females retain the juvenal coloration of the eye; the iris of adult males is bright orange or red. The work of Evans (1952) on *T. carolina* suggests that eye color in box turtles is under hormonal control.

Wear

Presence or absence of areolae on laminae of the shell indicated degree and sequence of wear. The anterior edges of carapace and plastron, and the slightly elevated middorsal line (Pl. 23) wear smooth in some individuals before the first period of hibernation. Subsequent wear on the carapace proceeds posteriorly. For example, turtles that retained the areola of the third central lamina, retained also the areolae of the fourth and fifth centrals; when only one central areola remained, it was the fifth. Lateral laminae wear in the same general sequence. The areola of the fifth central lamina, because of its protected position, persists in adult turtles that are well past the age of regular growth. Areolae that are retained in some older turtles are shed along with the epidermal layers formed in the first year or two of life. Wear on the shell is probably correlated with the habits of the individual turtle; smoothly-worn specimens varied in size and age but were usually larger, older individuals. No smoothly worn individual was still growing.

Wear on the plastron is more evenly distributed than wear on the carapace; wear is greatest on the lowest points of the plastron (the gular laminae, the anterior portions of the anal laminae, and the lateral edge of the transverse hinge).

The claws and the horny covering of the jaws are subject to greater wear than any other part of the epidermis; presumably they continue to grow throughout life. The occasional examples of hypertrophied beaks and claws that were observed, chiefly in

juveniles, were thought to result from a continuous diet of soft food or prolonged activity on a soft substrate. Ditmars (1934:44, Fig. 41) illustrated a specimen of *T. carolina*, with hypertrophied maxillary beak and abnormally elongate claws, that had been kept in a house for 27 years.

The conformation of the maxillary beak in all species of *Terrapene* is influenced to a large extent by wear and is of limited value as a taxonomic character. The beak of *T. ornata* is slightly notched in most individuals at the time of hatching and remains so throughout life. The underlying premaxillary bone is always notched or bicuspidate. The sides of the beak are more heavily developed than the relatively thin central part. Normal wear on the beak maintains the notch (or deepens it) in the form of an inverted U or V, much in the manner of the bicrenate cutting edge on the grooved incisors of certain rodents. In a series of 34 specimens of *T. ornata* from Kansas, selected at random from the K. U. collections, 92 per cent had beaks that were "notched" to varying degrees, four per cent had hooked (unnotched) beaks, and four per cent had beaks that were flat at the tip (neither hooked nor notched).

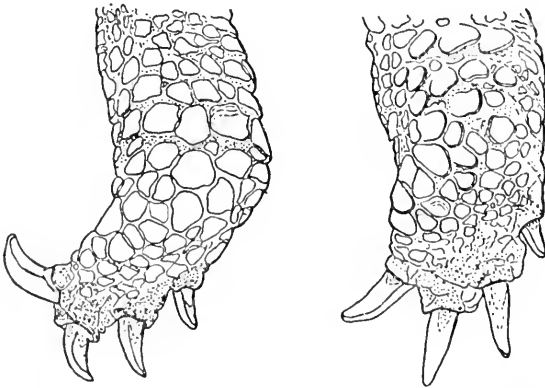


FIG. 21. Plantar views of right hind foot (male at left, female at right) of *T. o. ornata* ($\times 1$), showing sexual dimorphism in the shape and position of the first toe. The widened, thickened, and inturned terminal phalanx on the first toe of the male is used to grasp the female before and during coitus.

SEXUAL DIMORPHISM

Differences between adult males and females of *T. ornata* have been mentioned in several places in the preceding discussion of growth and development. Several sexual characteristics—greater

preanal length, thickened base of the tail, slightly concave plastron, and smaller bulk—are found also in males of many other kinds of emyid turtles. From females, males of *T. ornata* are most easily distinguished by the bright colors of their eyes, heads, and antebrachial scales. An additional, distinctive characteristic of males is the highly modified hind foot. The first toe is greatly thickened and widened; when the foot is extended, the first toe is held in a horizontal plane nearly at right angles to the medial edge of the plantar surface (Fig. 21). The hind foot of females is unmodified in this respect. Males tend to have heavier, more muscular hind legs than females.

The bright colors of males are maintained throughout the year and do not become more intense in the breeding season. Males of *T. o. luteola* become melanistic in old age whereas males of the subspecies *ornata* do not. In old males of *luteola* the skin be-

TABLE 4.—A SUMMARY OF SEXUAL DIMORPHISM IN *Terrapene ornata*.

CHARACTER	MALES	FEMALES
Head.....	Snout truncate in lateral profile, top of head and front of maxillary beak forming an angle of nearly 90°; head yellowish green to bluish green; markings on head and neck reduced; head never spotted dorsally (Pl. 11, Figs. 7 and 8).	Snout relatively round in lateral profile; front of maxillary beak not forming right angle with top of head; head dark brown, distinct pale markings on head and neck; head commonly spotted dorsally (Pl. 25, Figs. 5 and 6).
Iris	Red	Yellowish brown
Hind legs.....	Heavy and muscular; first toe turned in, thickened, and widened (Fig. 21).	Not especially heavy or muscular; first toe, if turned in, never thickened or widened (Fig. 21).
Forelegs.....	Centers of antebrachial scales bright orange or red.	Centers of antebrachial scales yellow, pale orange, or brown.
Carapace.....	Relatively lower, length contained in height (48 specimens) .58 times ($\pm .005\sigma m$, range, .50 to .69).	Relatively higher, length contained in height (94 specimens) .50 times ($\pm .005\sigma m$, range .44 to .60).
Plastron..... (hind lobe)	Ordinarily slightly concave.	Flat or convex, never concave.

comes dark gray, bluish, or nearly black and much of the bright orange or red of the antibrachial scales and the green of the head is obliterated; the iris may also darken but in most specimens it retains some red. Females of *luteola* tend also to darken somewhat in old age but not so much as males; females of *ornata* do not. Table 4 summarizes the more important secondary sexual characters of *T. ornata*.

TEMPERATURE RELATIONSHIPS

Tolerances to environmental temperatures, and reactions to thermal stimuli influence the behavior of ectothermal animals to a large extent. *Terrapene ornata*, like other terrestrial reptiles inhabiting open grassland, is especially subject to the vicissitudes of environmental temperature. Other species of turtles living in the same area are more nearly aquatic and therefore live in a microhabitat that is more stable as regards temperature.

Approximately 500 temperature readings in the field and many others in the laboratory were obtained from enough individuals to permit interpretation of reactions involved in basking, in seeking cover, and in emerging from temporary periods of quiescence at various times of the day.

Box turtles commonly used open places such as cow paths, ravines, and wallows, for basking as well as for feeding and as routes of travel. Burrows, dens beneath rocks, and forms, were used as shelter from high and low temperatures as well as from predators. Determining whether a turtle was truly active (moving about freely, feeding, or copulating), was basking, or was seeking shelter was difficult because the turtle sometimes reacted to the observer; for instance, basking turtles, whose body temperatures were still suboptimum, might take cover when surprised, and truly active turtles might remain motionless and appear to be basking. By scanning open areas from a distance with binoculars, an observer frequently could determine what turtles were doing without disturbing them. In the final analysis of data, temperature records accompanied by data insufficient to determine correctly the state of activity of the turtle, were discarded, as were temperature records of injured turtles and turtles in livetraps.

Cowles and Bogert (1944:275-276) and Woodbury and Hardy (1948:177) emphasized the influence of soil temperatures on body temperatures. It is thought that air temperatures played a more important role than soil temperatures in influencing body tempera-

tures of *T. ornata*. Soil temperatures were taken in the present study only when the turtle was in a form, hibernaculum, or den.

Optimum Temperature

Cowles and Bogert (1944:277) determined optimum levels of body temperature of desert reptiles by averaging body temperatures falling within the range of normal activity; they defined this range as, “. . . extending from the resumption of ordinary routine [activity] . . . to . . . a point just below the level at which high temperatures drive the animal to shelter.” Fitch (1956b:439) considered optimum body temperature in the several species that he studied to be near the temperature recorded most frequently for “active” individuals; he found (*loc. cit.*) that of body temperatures of 55 active *T. ornata*, 66 per cent were between 24 and 30 degrees, and that the temperatures 27 and 28 occurred most frequently. Fitch concluded (*op. cit.*:473) that the probable optimum body temperature of *T. ornata* was 28 degrees and that temperatures from 24 to 30 degrees were preferred. Although Fitch treated all non-torpid individuals that were abroad in daytime as “active” and did not consider the phenomenon of basking, his observations on optimum body temperature agree closely with my own.

Body temperatures of 153 box turtles that were known definitely to be active, ranged from 15.3 to 35.3 degrees. The mean body temperature for active turtles was 28.8 degrees ($\pm 3.78\sigma$) (Fig. 22). Ninety-two per cent of the temperatures were between 24 and 30 degrees and 50 per cent were between 28 and 32; temperatures of 29 and 30 degrees occurred most frequently (22 and 21 times, respectively). The ten body temperatures below 24 degrees all were recorded before 9 A. M. on overcast days when the air was cool and humid. It is noteworthy that two of these low temperatures (18.8° and 19.0°) were from a copulating pair of turtles; two others (21.8° and 22.0°) were from individuals that were eating. The highest temperature (35.3°) was from a large female that was feeding at mid-morning in a partly shaded area.

The mean body temperature for active individuals (Fig. 22) is probably somewhat below the ecological optimum, because a few temperatures were abnormally low. The large number of body temperatures in the range of 29 to 31 degrees indicates an optimum closer to 30 degrees. Optimum body temperatures may vary somewhat with the size, sex, or individual preference of the turtle concerned.

Basking

Although basking is common in terrestrial turtles, only a few authors have mentioned it. Woodbury and Hardy (1948:177-178) did not use the term in their account of thermal relationships in *Gopherus agassizi*; their discussion indicates, however, that the tortoises move alternately from sunny to shady areas to regulate body temperature. Desert tortoises removed from hibernacula and placed in the sun warmed to approximately 29.5 degrees before they became active, although a few did so at temperatures as low as 15 degrees. According to Cagle (1950:45), Sergeev (1939) studied body temperature and activity in the Asiatic tortoise, *Testudo horsefieldi*, and found that individuals basked for as much as two hours in the morning before beginning the first activity of the day (feeding), but that tortoises did not bask after a period of quiescence from late morning to late afternoon, during which body temperatures were seemingly maintained nearer the optimum than they were during nocturnal rest; body temperatures rose to approximately 30 degrees before the tortoises became active. Since body temperatures of 23 to 24 degrees were maintained at night, the basking range of *Testudo horsefieldi* may be considered to be approximately 23 to 32 degrees.

Ornate box turtles basked chiefly between sunrise and 10 or 11 A. M. Body temperatures of 60 basking turtles ranged from 17.3 to 31.4 degrees (mean, $25.5 \pm 3.08\sigma$). More than two-thirds (42) of these body temperatures were higher than the air temperature near the turtle, indicating probably that body temperature rises rapidly once basking is begun. In the instances where body temperature was below air temperature, the turtles had recently begun to bask (many were known to have just emerged from forms or other cover where they had spent the night) or were warming up more slowly because of reduced sunlight. On cloudy days basking began later than on clear days and body temperatures usually remained at a suboptimum level. Turtles that basked on days that were cloudy and windy, or cold and windy, did so in sheltered places, usually on the leeward sides of windbreaks such as limestone rocks, rock fences, or ravine banks. It was evident in these instances that the turtles either sought such shelter from the wind or remained ensconced in the more complete shelter of a form or burrow, not emerging at all.

Open areas of various kinds were used as basking sites. Level ground—such as on roads, cattle pathways, and bare areas sur-

rounding farm ponds—having unobstructed morning sunlight, nearby dense vegetation, and choice opportunities for feeding (cow dung, mullberry trees) was preferred. Basking was frequently combined with feeding; in several instances box turtles were noted early in the morning at suboptimum body temperatures eating grasshoppers, berries, or dung insects. The predilection of box turtles for open areas is probably important in permitting extended activity at suboptimum temperatures. *T. ornata* probably carries on more nearly normal activity on cool days than do reptilian species with more sharply delimited thermal tolerances. Collared lizards (*Crotaphytus collaris*), for example, are chiefly inactive on days when the sky is overcast, although a few individuals having suboptimum body temperatures can be found in open situations (Fitch, 1956a:229 and 1956b:442).

Toleration of Thermal Maxima and Minima

The foregoing remarks on basking indicate the approximate, normal, thermal tolerances of ornate box turtles. Many additional records of body temperature were taken from turtles that were found under cover. Turtles under cover in daylight were usually

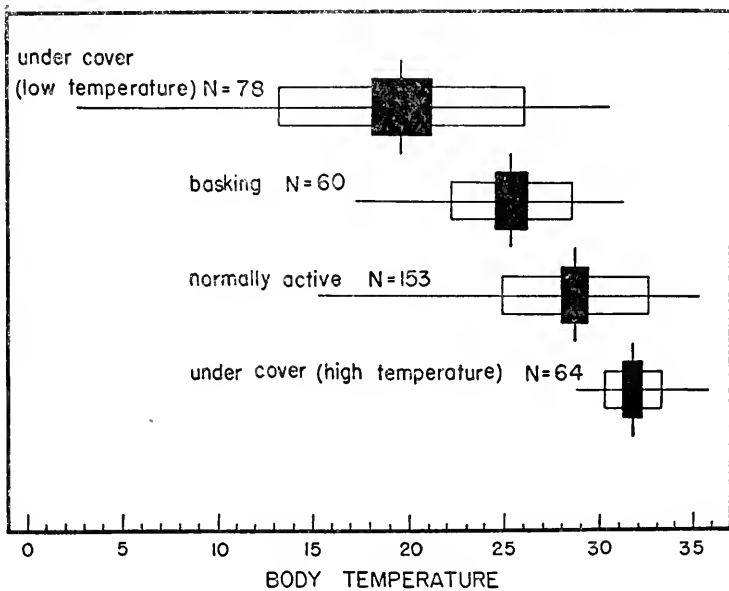


FIG. 22. The relationship of body temperature (Centigrade) and kind of activity in *T. o. ornata*, compiled from 355 field observations. Vertical and horizontal lines represent, respectively, the range and mean. Open and solid rectangles represent one standard deviation and two standard errors of the mean, respectively.

seeking protection from either below-optimum or above-optimum temperatures. In avoiding low temperatures, turtles usually chose more complete and permanent cover than in avoiding high temperatures.

Body temperatures of 64 box turtles that were seeking cover or that were under cover because of high temperatures ranged from 28.9 to 35.8 degrees (mean, $31.9 \pm 1.55\sigma$). Fifty-nine of these temperatures (92 per cent) were 30 degrees or higher. Figure 22 shows this range to overlap broadly with the temperature range of active turtles and the means of the two groups are close to each other. Body temperatures below 30 degrees (5) were all recorded late in the morning on hot summer days when the air temperature was well above 30 degrees; they are somewhat misleading because they are from turtles that were under cover long enough to lower body temperature to the range of activity although the turtles remained under cover because of hazardous environmental temperatures.

The commonest retreats used by box turtles to escape heat were burrows of other animals and small dens under thick limestone rocks, where the air remained cool, even in late afternoon. Most of the burrows and dens on the Damm Farm were known to me and could be checked each day. Turtles seeking temporary refuge from high temperatures characteristically rested just inside the opening of a den or burrow. Less frequently, turtles burrowed into ravine banks or just under the sod on level ground. A number of individuals with above-optimum body temperatures were found in the shade of trees or high weeds in early afternoon on hot days. Mulberry trees provided ample shade for such activity and, in June and July, when ripe mulberries were abundant on the ground, turtles frequently fed on them at times of the day when temperatures were more hazardous in other areas.

Several turtles were found buried in mud or immersed in water at the edges of ponds in the hottest part of the day; they were discovered at first by accident and, on subsequent field trips by systematic probing. Ordinarily the turtles were covered with mud or muddy water and remained motionless, except for periodically raising the head to the surface to breathe. There was little vegetation near the edges of ponds and by late morning on hot days the temperature of the shallowest water was as high as the air temperature or higher. Correspondingly, turtles found resting in mud and water had body temperatures much higher than turtles in dens, burrows, or forms at the same time of day. Box turtles that retreat

to mud or shallow water cool themselves less efficiently than they would in drier, better protected microhabitats. I found no evidence that turtles went into deeper water to cool themselves.

The length of time spent under cover varied; most turtles had two daily periods of activity, the second beginning in late afternoon. Some turtles moved from shelter to shelter in the time between periods of activity. Several turtles were known to remain quiescent continuously for several days in the hottest part of the summer.

The maximum temperature that a reptile can tolerate physiologically is ordinarily higher than the maximum temperature tolerated voluntarily (Cowles and Bogert, 1944:277); but, the two maxima may be separated by only a few degrees. Most poikilothermous vertebrates neither tolerate nor long survive body temperatures exceeding 40 degrees (Cowles and Bogert, *op. cit.*:269).

It is evident (Fig. 22) that ornate box turtles do not often tolerate body temperatures above 33 degrees and that temperatures in excess of 35 degrees are probably never tolerated under natural conditions. At 9:15 A. M. on July 5, 1955, an adult female emerged from mud where she had spent the night (body temperature 28.4°, mud 28.4°, air 30°). After foraging for 40 minutes in bright sunlight on a grassy hillside she had moved approximately 100 feet and her temperature had reached 34.6 degrees (air 33.0°). At 9:56 A. M. she moved rapidly and directly to a den under a rock nearby; 15 minutes later her body temperature had not changed but after 65 minutes it had dropped to 33.4 degrees. The temperature of air in the den was 31 degrees. This female began her activities at nearly optimum body temperature relatively late in the morning and, by foraging intensively for less than one hour, probably was able nearly to satisfy her daily food requirements; by foraging near suitable cover she could remain active until her body temperature reached a critical threshold, and she thereby saved time otherwise required for finding cover or making a form.

The following observations, extracted from field notes, indicate that body temperatures near 40 degrees are the approximate lethal maximum and are well above those temperatures voluntarily tolerated by *T. ornata*. On July 4, 1955, a subadult female was in the water at the edge of a pond. The temperatures of the air, water, and turtle were 32.0, 30.6, and 30.2 degrees, respectively. At 11 A. M. the turtle was tethered in direct sunlight on the hard-baked clay of the pond embankment (temperature of air 33.4°). The turtle's response to steadily rising body temperature over a period of 31 minutes is illustrated by the following notes.

Time (A. M.)	Body temperature	Remarks
11:00	33.0	Tethered on slope.
11:05	34.6	Strains at tether in several directions.
11:09	36.5	Tries frantically to get away; draws in limbs and head rapidly and momentarily at any movement on my part, and hisses loudly.
11:13	37.5	Mouth held open slightly; turtle overturns in effort to escape; frantic scrambling resumed a few seconds after I right turtle.
11:17	38.2	Mouth now held open most of the time; white froth begins to appear around mouth.
11:20	38.6	Stops activities every 10 seconds or so, rests chin on ground and gapes widely; will still pull into shell when prodded with stick.
11:23	39.2	Still wildly active; continues to gape widely every few seconds.
11:27	39.4	Frothing at mouth profusely.
11:30	39.6	Attempts to escape are now in short feeble bursts.
11:31		Turtle released; crawls toward me and immediately seeks shade of my body; when I move off, turtle seeks shade of small isolated weed on pond embankment; turtle removed to damp earth at edge of pond.
11:35	39.5	Attempts to burrow into mud at edge of pond.
11:36		Enters shallow water and moves slowly back to shore.
11:37	38.8	Turtle thrown into center of pond where it remains motionless and drifts with wind to opposite shore; remains inactive in mud and shallow water at edge of pond; temperature of water near turtle 35.5.
11:57	35.0	Moves 50 ft. up slope to shade of low vegetation.
1:55 P. M.	32.5	Turtle has not moved.

The overheating may have incapacitated the turtle since it moved only 50 feet in the next two days; its body temperatures on the two days subsequent to the experiment were 26.8 and 20.6, respectively.

The mentioned gaping, as in higher vertebrates generally, cools the animal by evaporation from the moist surfaces of the mouth and pharynx. By keeping the mouth open for more than a few minutes at a time in hot dry weather, a turtle would surely lose body water in amounts that could not always be easily replaced. Ornate box turtles seem to utilize evaporation for cooling only in emergencies and rely for the most part on radiation and conduc-

tion to lower body temperature after reaching a relatively cool, dark retreat.

Box turtles were never active at body temperatures below 15 degrees and were seldom active at temperatures below 24 degrees. The two lowest temperatures (15.3° and 16.3°) were taken from individuals crossing roads on overcast days in early May.

In 78 box turtles that were under cover because their environmental temperatures were low, the body temperatures ranged from 2.7 to 30.6 degrees (mean $19.8 \pm 6.38\sigma$). The range of body temperatures in this group is greater than in the other groups shown in Figure 22 because low body temperatures were studied over a wide range of conditions, including hibernation.

Box turtles actually seek cover because of low temperatures only in fall and spring and on occasional unseasonable days in summer when temperatures drop rapidly. Retreat to cover, in the normal cycle of daily activity, is governed usually by high temperatures at midday or by darkness at the end of the day. Turtles in dens, burrows, and grass forms, tended to burrow if temperatures remained low for more than a few hours.

Box turtles under cover where they cannot bask have little control over the lower range of body temperatures. The freezing temperatures of winter can be escaped by burrowing deeper into the ground. Temperatures approaching the lethal minimum, however, seldom occur during the season of normal activity. By remaining hidden in a burrow or den therefore, box turtles are fairly well protected from predators but are at a thermal disadvantage.

A number of turtles that had wet mud on their shells were found basking in early morning near ditches, ponds, and marshy areas; several others were partly buried in mud, shortly after daybreak, and another was at the edge of a pond after dark.

Eight adults, located just as they emerged from cover in early morning on sunny days, had body temperatures of 19.7, 21.9, 24.2, 24.5, 25.8, 26.6, 28.7, and 29.5 degrees. In five emerging from earth forms, body temperatures were at least a degree or two below the temperature of the air; the other three came from mud or shallow water and had body temperatures higher than the air temperature.

Temperature is probably the primary stimulus governing emergence after temporary periods of quiescence. Turtles in earthen forms are usually completely covered or are head downward with only the hind quarters exposed. Obviously, the more thoroughly

a turtle protects itself (beneath the insulating cover of a form, burrow, or den) against unfavorable temperatures, the longer it will take for favorable temperatures to bring about normal activity again. Turtles in forms and deep burrows have a minimum of contact with the outer environment; but in dens beneath rocks and in shallow burrows light and air can enter freely. Turtles might be influenced in their activities to some extent by the intensity of light at the opening of a burrow or den; they are surely stimulated by changes in the temperature and humidity of air coming through the opening. Shallow retreats that a turtle can enter and leave with the least effort therefore seem most efficient for purposes of thermocontrol, especially when they provide earthen surfaces into which the turtles can burrow more deeply if more severe environmental conditions develop.

In October, 1955, nine *T. ornata* of various sizes, collected in Douglas County, Kansas, were brought to the laboratory for observation under conditions of controlled temperature. They were kept at room temperature for several days and were fed regularly, with the exception of one hatchling that was fed nothing in this period. On October 22 the turtles were placed in a room where the temperature was maintained constantly at zero degrees. One of the nine turtles, an adult female, was killed with chloroform immediately prior to its removal to the cold room. A list of the turtles used in this experiment is given below.

Age class	Carapace length in mm.	Weight in grams
1) Hatchling	33.1	8.4
2) Hatchling *	29.9	6.7
3) Juvenile	52.5	29.3
4) Juvenile	50.2	26.1
5) Adult ♂	125	376
6) Adult ♀	118	400
7) Adult ♂	119	386
8) Adult ♀	110	325
9) Adult ♀	115	...

* Starved.

Turtles were kept in the cold room for periods of 100 minutes (hatchlings and juveniles) and 200 minutes (adults). The entire experiment, including the time in which the turtles were allowed to warm after they were taken from the cold room, covered a period of nearly six hours (375 minutes) during which the turtles were under constant observation. Individual body temperatures were taken continuously in this period (39 for each juvenile and 24 for each adult) in the order that the turtles were numbered; gaps between records of the body temperature of a given indi-

vidual therefore represent the time required to record temperatures for the rest of the turtles in the group. The rates of rise and fall of temperature for each of the nine turtles considered are shown as a graph in Figure 23. Rate of temperature change was inversely proportional to bulk; hatchlings, for example, cooled and warmed a little more than twice as rapidly as did adults. Rate of temperature change was intermediate in juveniles but was more nearly like that of adults in the warming phase and closer to that of hatchlings in the cooling phase (Table 5).

Considering that hatchling no. 2 was smaller than no. 1, the rate of change in its temperature did not seem to be significantly altered by starvation. The adult males showed a tendency to change temperature faster than adult females even though both males were larger than any of the females. The slight difference in rate of temperature change between the sexes (Fig. 23) may have been fortuitous.

TABLE 5.—AVERAGE RATE OF CHANGE IN TEMPERATURE (EXPRESSED IN DEGREES PER MINUTE) FOR FOUR GROUPS OF TURTLES SUBJECTED TO TEMPERATURE OF ZERO DEGREES AND THEN ALLOWED TO WARM AT 27 DEGREES (CENTIGRADE).

GROUP	Number	Cooling phase	Warming phase (to 25°)
Hatchlings.....	2	.282	.310
Juveniles.....	2	.264	.180
Adult ♂.....	2	.122	.152
Adult ♀.....	3	.119	.130*
Adult (all).....	5	.120	.133

* None of the females reached a temperature of 25° before the experiment was terminated.

One hatchling (No. 1), when its temperature dropped below one degree, fully extended all four limbs and the body was elevated and only the anterior edge of the plastron was in contact with the confining glass dish. Raising the body from an uncomfortably cold or hot substrate is a well known phenomenon in many lizards and in crocodylians, but to my knowledge has not been reported for turtles.

Hibernating turtles and those experimentally chilled were usually comatose but were almost never completely incapacitated, even at temperatures at or near zero degrees. Experimental pinching, probing, and pulling revealed that muscles operating the neck, the

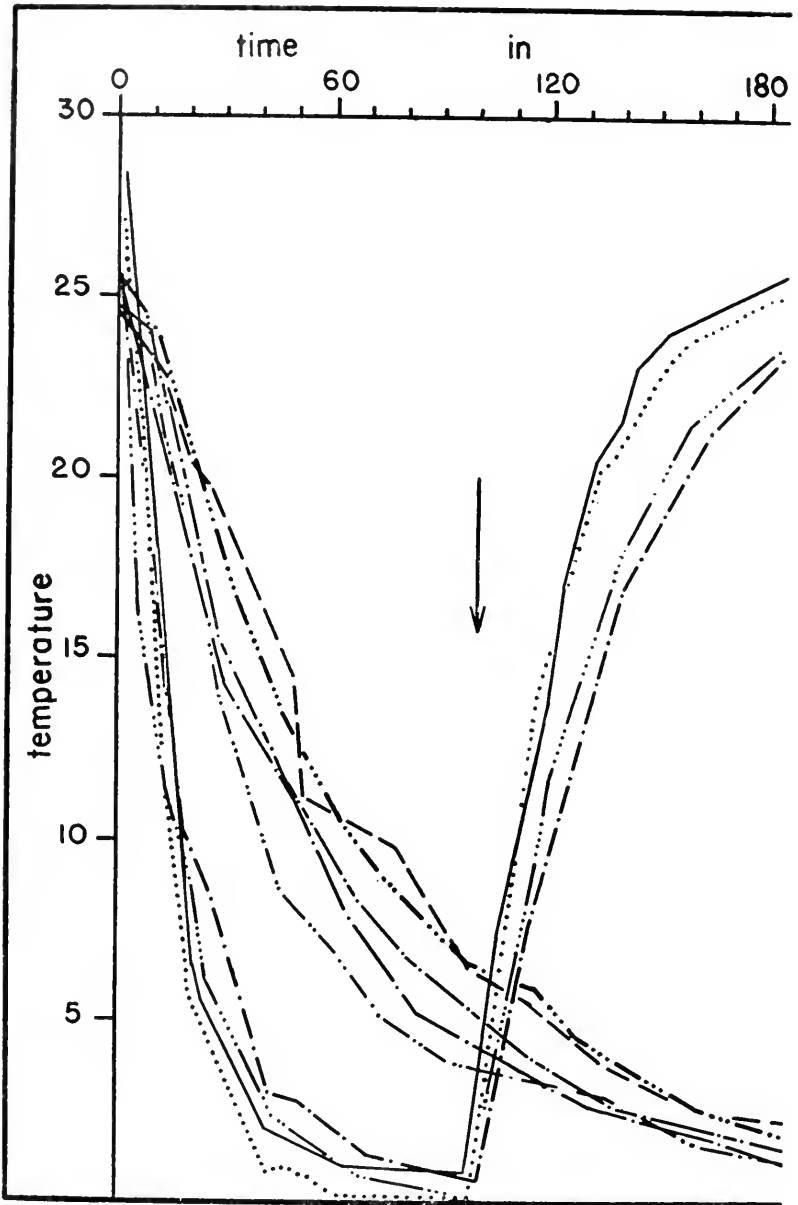
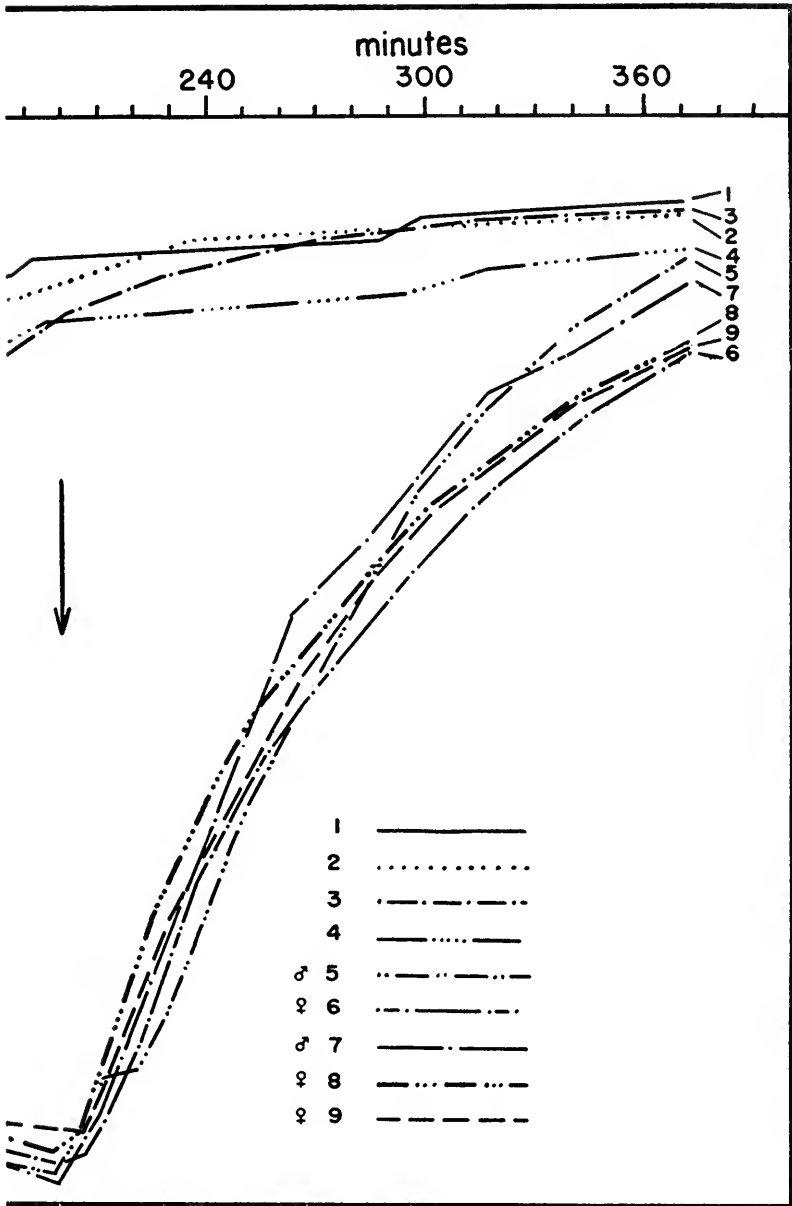


FIG. 23. Changes in temperature of the body of four juvenal (nos. 1 to 4) and five adult individuals of *T. o. ornata* (nos. 5 to 9) exposed to a constant air temperature of zero degrees Centigrade for periods of 100 and 200 minutes, respectively. The vertical arrows indicate when the turtles were removed to



an air temperature of 27 degrees. Sizes and weights of the turtles used are given in the text. Turtle number nine, a female, was killed by means of chloroform before experiment began. Rate of change in temperature in specimens was inversely proportional to size. All turtles survived the experiment.

limbs, and the lobes of the plastron could be controlled by the turtle at low temperatures; hissing, resulting from rapid expulsion of air through the mouth and nostrils (when the head and limbs are drawn in reflexively) occurred at all body temperatures but was sometimes barely audible in the coldest turtles. Of all living turtles observed, only two (hatchlings 1 and 2 in coldroom experiment) were completely immobile at low temperatures, failing to respond even to pinpricks at body temperatures of 0.8 and 1.7 degrees, respectively, although other turtles, under the same experimental conditions, consistently gave at least some response to the same stimulation.

Turtles chilled experimentally continued to move about voluntarily, albeit sluggishly, at temperatures much lower (2.5° for each of four adults; 10.0° and 6.2° for two juveniles) than those at which locomotion was resumed in the warming phase (13° for the adults, 21.7° and 20.1° for the juveniles). Hatchlings chilled so rapidly that it was difficult to ascertain accurately the temperature at which inactivity was induced. Juveniles became active gradually, moving slowly about when the body temperature reached approximately 20 degrees but not attempting more strenuous activities such as climbing the walls of enclosures, until body temperatures of 22 to 25 degrees were attained. Adults, on the other hand, exhibited "normal" activity as soon as they became voluntarily active.

The ability of ornate box turtles to move about when the body temperature is near the lethal minimum probably enables those caught in the open by a sudden drop in environmental temperature to find cover that keeps them from freezing to death. Prolonged chilling, on the other hand, seems to create a physiologically different situation; the temperature at which activity is resumed is higher and subject to less variation.

Juveniles were more rapidly affected by environmental temperatures, were subject to different thresholds, and were inactive over a wider range than were the adults. Indeed, the *rate* of chilling, rather than absolute body temperature alone, might in large measure influence the reactions of turtles to environmental temperatures. If this be so, smaller turtles, having a narrower thermal range of normal activity, must lose at least some of the advantages gained by their ability to warm up more rapidly.

Hatchlings and juveniles at the Damm Farm were always active on days when at least some adults were also active. Fitch (1956b:466) found that, in northeastern Kansas, species of small reptiles and amphibians are active earlier in the season than larger

species and that the young of certain species become active earlier than adults. Fitch stated, “. . . small size confers a distinct advantage in permitting rapid rise in body temperature by contact with warmed soil, rock or air, until the threshold of activity is attained”; he pointed out also that young animals, if able to emerge earlier than adults, would benefit from a longer growing season. Hatchlings and juveniles of *T. ornata* would benefit greatly from an extra period of activity of say, one or two weeks in spring and a similar period in autumn, especially if food were plentiful. The extra growth realized from such a “bonus” period of feeding would significantly increase the chance of the individual turtle to survive in the following season of growth and activity.

Ornate box turtles are active within a narrower range of temperatures than are aquatic turtles in nearby ponds and streams of the same region. Observations by William R. Brecheisen and myself on winter activity of aquatic turtles indicate that, in Anderson County, Kansas, the commoner species (*Chelydra serpentina*, *Chrysemys picta*, and *Pseudemys scripta*) are more or less active throughout the year; although they usually do not eat in winter, they are able to swim about slowly and in some instances (*P. scripta*) even to carry on sexual activity at body temperatures only one or two degrees above freezing. But, ornate box turtles hibernating in the ground a few yards away are incapable of purposeful movement at such low body temperatures.

HIBERNATION

In northeastern Kansas ornate box turtles are dormant from late October to mid-April—approximately five and one half months of the year. Individuals may be intermittently active for short periods at the beginning and end of the season, however. Once a permanent hibernaculum is selected dormancy continues until spring; unseasonably warm weather between mid-November and March does not stimulate temporary emergence. There is little movement during dormancy except for the deepening or horizontal extension of the hibernaculum.

Woodbury and Hardy (1948:171) found desert tortoises (*Gopherus agassizi*) in dormancy from mid-October to mid-April in southwestern Utah; some tortoises became temporarily active on warm days in winter. Cahn (1937:102) was able to compare hibernation in several individuals each of *T. ornata* and *T. carolina*, kept under the same conditions in Illinois. Individuals of *T. ornata* burrowed into the ground in October, two weeks before those of *T. car-*

olina did, and continued to burrow to a maximum depth of 22½ inches. Some individuals of *T. carolina* spent the entire winter in the mud bottom of a puddle and became semiactive on warm winter days. Other individuals of *T. carolina* burrowed nearly as deeply as did *T. ornata*. Individuals of *T. ornata* emerged from hibernation one or two weeks later in the spring than did those of *T. carolina*. There are some indications that populations of *T. carolina* in eastern Kansas are dormant for a shorter period of time than those of *T. ornata* but comparative studies are needed to verify this. Richard B. Loomis gave me a large female of *T. carolina* that he found active beside a highway in Johnson County, Kansas, on November 23, 1954; on that date most individuals of *T. ornata* under my observation had already begun permanent hibernation but a few at the Reservation were still semiactive.

Fitch (1956b:438) listed earliest and latest dates on which box turtles were active at the Reservation in the years 1950 to 1954; in the five year period box turtles were active an average of 162 days per year (range, 140-187) or approximately 5.3 months of the year. It is significant that 1954, having the most days of activity was, according to my studies of growth-rings, an exceptionally good year for growth. Fitch's data indicate the approximate season of growth and reproduction but not of total activity, since he did not take into account the sporadic movements of box turtles in late fall and early spring.

Activity in autumn is characterized by movement into ravines and low areas; many turtles move into wooded strips along the edges of fields or small streams. Sites protected from wind, providing places for basking and for burrowing, are sought. Burrows of other animals, along the banks of ravines, were often used for temporary shelter; overhanging sod at the lips of ravine-banks provided cover beneath which turtles could easily burrow. After mid-October progressively fewer box turtles were found in open places and activity was restricted to a few hours in the warmest part of the day.

Low air temperature probably is the primary stimulus for hibernation. Autumn rains are usually followed by a decrease in general activity. Rain probably hastens burrowing by softening the ground.

Ornate box turtles more often than not excavate their own hibernacula. Digging begins with the excavation of a shallow form which is deepened or extended horizontally over a period of days or weeks. Such hibernacula are sometimes begun at the edges of

rocks or logs; the overhanging edge of an unyielding object acts as a fulcrum on the shell and hastens digging. Ornate box turtles are slow but efficient burrowers.

Forms in open grassy areas are begun at an angle of 30 to 40 degrees; an adult box turtle requires approximately one hour to burrow far enough beneath the sod to conceal itself but can dig into soft, bare earth much more rapidly. Once a hibernaculum is begun, all four feet are used for its excavation, the front feet doing most of the digging and the hind feet pushing loose earth to the rear.

Several turtles were seen entering burrows and dens in late autumn and trailing records showed that some individuals visited several of these shelters in the course of a single day.

By means of systematic probing of known hibernacula it was found that they are deepened gradually in the course of the winter. Depth seems to be governed by the temperature of the soil. Hibernacula in wooded or sheltered areas were ordinarily shallower than hibernacula in open grassland.

In the autumn of 1953-54 two pens were constructed at the Reservation in order to study hibernation; one pen was on a wooded hillside and the other was on open grassland. Turtles in the grassland pen were in newly excavated hibernacula, just beneath the sod, on October 25 and did not emerge for the remainder of the winter, whereas turtles in the woodland pen were intermittently active until November 10. Correspondingly, turtles in the grassland pen descended to depths of eight and one half and 11½ inches, respectively, whereas those in the woodland pen were covered by a scant six inches of loose earth and leaf litter. In 1954 four turtles were traced (by means of trailing threads) to hibernacula on wooded slopes at the Reservation; two entered permanent hibernacula on November 13 and two remained semiactive until sometime after November 20. All four turtles spent the winter in hibernacula that were not more than six inches deep. Temperatures of the soil at a depth of nine inches were usually slightly lower at the grassland pen than at the woodland pen on a given date. It is probably significant that individuals with trailing devices and individuals in experimental pens furnish the latest records for autumn activity. The unnatural conditions created by confining the turtles in pens restricted the number of hibernation sites that were available to them; although trailing devices did not affect the normal movements of box turtles on the surface of the ground these devices certainly hampered the turtles somewhat in digging. How-

ever, it is noteworthy that box turtles are able to move about after mid-November, whether this is of general occurrence under more natural conditions or not. Depths of hibernacula at the Damm Farm were also influenced by amount of vegetation or other cover. Maximum depth of hibernacula in more or less open situations ranged from seven to 18 inches whereas a female hibernating in a ditch that was covered with a thick mat of dead grasses was four inches beneath the surface of the soil, and another female was only two and one half inches below the floor of a den.

Several *T. ornata* kept by William R. Brecheisen in a soil-filled stock tank on his farm in the winter of 1955-56, burrowed to maximum depths of seven to eight inches in the course of the winter. A layer of straw covered the soil. All the turtles were alive the following spring except for one juvenile, found frozen at a depth of one inch on December 30 (the lowest air temperature up to this time was approximately -12°). Three adult and 24 juvenal *T. ornata* hibernating in the earth of an outdoor cage at the University of Kansas in the winter of 1955-56, were all dead on December 3 after air temperatures had reached a low of -12 degrees.

Ornate box turtles are usually solitary when hibernating; in the rare instances in which more than one turtle is found in the same hibernaculum, the association has no social significance and is simply a reflection of the availability and suitability of the hibernaculum. The only communal hibernaculum—the "Tree Den"—at the Damm Farm was discovered on October 16, 1955, after a turtle was traced to it by means of a trailing thread. The flask-shaped cavity, approximately two and one-half feet deep, in the north-facing bank of a narrow ravine, had an entrance one foot wide and nine inches high, nearly flush with the bottom of the ravine. Grasses on the bank of the ravine hung over the entrance and nearly concealed it. The steep sides of the ravine protected the entrance from wind.

Seven turtles were in the den when it was discovered, and on each of five subsequent visits from October 20, 1955, to March 6, 1956, fewer turtles were found in the den. Figure 24 shows the approximate length of stay of each known occupant of the den. Only one of the turtles (an adult female) that left the den returned. Turtles found in the den on three visits in October were more or less torpid and were seen easily from the entrance but on November 6 the two remaining individuals had burrowed into the sides and floor of the den.

Three turtles (one female, one male, and one juvenile) were found in separate form-hibernacula within a few inches of one

another on November 6, 1955 (Pl. 21, Fig. 2). The common entrance to all three hibernacula was a shallow depression that resulted from an old post-hole. Soil in the depression was loose and moist and ideal for burrowing. The three hibernating turtles were situated, in a vertical plane, at depths of 18 (♂), 12 (juvenile), and seven (♀) inches. One of the turtles hibernating at this place on November 6 was basking on October 30 in the shelter of some tall weeds a few feet from the hibernaculum.

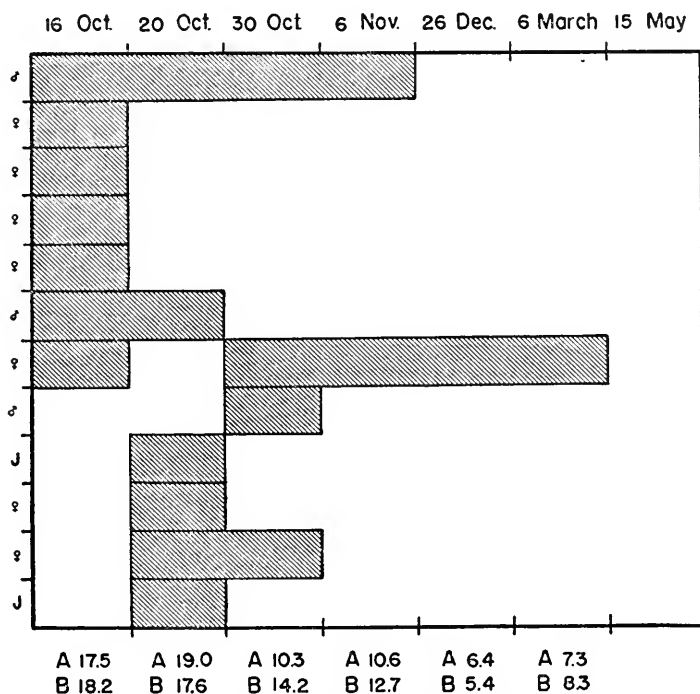


FIG. 24. The approximate length of stay of each known occupant of a den that was examined six times in the winter of 1955-1956 at the Damm Farm. Most of the occupants used the den as a temporary shelter and sought permanent hibernacula elsewhere. One turtle left the den for approximately two weeks and then returned to it for the rest of the winter. The temperature of the air outside the den (A) and the average body temperature of turtles in the den (B) are given at the bottom of the diagram for each date the den was examined. The symbol "J" represents a juvenal turtle.

In general, body temperatures approximated the temperature of the soil around the turtle. Body temperatures tended to be slightly higher than soil temperatures in November and December but were slightly lower than soil temperatures in the months of February and March. The lowest body temperature recorded for any turtle that

survived a winter was 2.7 degrees, taken from an adult female on December 26, 1955. Body temperatures one to three degrees higher were common in the coldest part of the winter. Turtles in shallow hibernacula, like those observed in wooded areas at the Reservation, are probably subjected to freezing temperatures at least for short periods but I have no records of body temperatures this low, except where they were induced experimentally. Turtles exposed to temperatures of zero degrees or slightly lower would retain enough heat to survive without freezing for a period of several hours or even a day if well insulated. A temperature gradient exists within the body; cloacal temperatures, for example, differ from temperatures deep in the colon and temperatures in the dorsal and ventral parts of the body cavity (taken by manipulating the bulb of the thermometer while it was in the colon) differ from one another. Probably, therefore, some parts of some turtles—probably the top of the shell or the extremities—freeze in winter without causing the death of the turtle. Ewing (1939:91) found a female of *T. carolina*, just emerging from hibernation, that had lost some scutes from its carapace; he found the missing scutes in the hibernaculum and attributed their loss to severe temperatures in the winter of 1933-34.

The incidence of mortality due to freezing is unknown for most species of reptiles. The observations of Bailey (1948) on DeKay snakes (*Storeria dekayi*) and Legler and Fitch (1957) on collared lizards suggest that rates of mortality are high in dormant reptiles. Bailey (*op. cit.*) suggested that winter mortality might act as a natural check on snake populations. Neill (1948a:114) thought more box turtles (*T. carolina*) were killed in Georgia by cold weather in late autumn than “. . . by all other factors together,” and that this winter mortality acted as an effective check on population levels. Neill reported that many turtles left their burrows in late autumn and began to forage; if the temperature dropped suddenly, the turtles became “. . . too torpid to dig” and froze.

If ornate box turtles are occasionally caught in the open by a sudden cooling of air temperature, it would occur at a time of year when temperatures would approximate freezing but would drop not far below this level; laboratory and field records show that adults could probably survive these low temperatures overnight and warm up sufficiently on the following day to seek adequate shelter. Box turtles deepening their burrows in winter do so at body temperatures somewhat lower than 10 degrees (near the minimum temperature at which co-ordinated activity was observed

in the laboratory); turtles found in the open in late October were known to burrow into the ground at body temperatures of approximately 15 degrees.

Emergence from hibernation usually occurs in April but in some years a few turtles may emerge as early as the first week of March. Emergence is stimulated by temperature and humidity. Fitch (1956b:438) stated that emergence was delayed until ". . . the ground has been sufficiently moistened and until air temperatures have reached at least 26°." Box turtles at the Reservation emerged on April 21 in 1954 and from April 16 to 17 in 1955. William R. Brecheisen found recently emerged box turtles in Anderson County on April 2, 1955, and March 6, 1956.

Turtles were found facing upward in their hibernacula in early March. As the temperature of the soil rises, they move slowly upward, usually following the route by which they entered. They remain just below the surface of the soil for a week or two before actually emerging; this final phase of emergence is probably hastened by spring rains that soften the soil. Activity may be sporadic after emergence if the weather is cold.

A number of box turtles at the Reservation emerged in a cold rain in 1954 when the temperatures of the air and ground were 16 and 13 degrees, respectively, but remained inactive for several days afterward. In 1955 the air and ground temperatures were higher (28° and 17°, respectively) on the day of emergence and box turtles became active almost immediately.

DIET

Published information on the food of *T. ornata* consists of a few miscellaneous observations. Cahn (1937:103) opened five stomachs that contained partly digested vegetable matter but no insects or other animal food: Ortenburger and Freeman (1930:187) noted that grasshoppers were a main part of the diet of *T. ornata* in Oklahoma and that turtles displayed unsuspected agility in catching them. Those authors also saw turtles eating caterpillars and robber flies. Strecker (1908:79) stated that "The natural diet of this species consists of vegetable matter and earthworms." Norris and Zweifel (1950:3) observed the feeding habits of captive *T. o. luteola*. Coyote melon (*Cucurbita foetidissima*) was eaten with reluctance but a collared lizard (*Crotaphytus collaris*) was quickly devoured. Tadpoles of *Scaphiopus hammondi* were caught in a small pool and eaten. Adults of the same species were rejected after being caught; box turtles were seen wiping their mouths

after rejecting adult toads. The authors suggested that *T. o. luteola* is an important predator of *Scaphiopus hammondi*, since the two species occur together in many areas and the emergence of both is controlled to a large extent by rainfall. One individual of *luteola* was seen eating a dead box turtle on a road.

Captive individuals of *T. ornata*, observed in the present study, ate nearly every kind of animal and vegetable food given to them. Table scraps, consisting chiefly of greens, various fruits and vegetables, meat, and cooked potatoes, formed the main diet of turtles kept in outdoor cages.

A number of persons have told me of ornate box turtles eating the succulent stems and leaves, and the fruits of various garden plants; similar incidents probably occur in areas of native vegetation. J. Knox Jones told me he saw an individual of *T. ornata* eating a spiderwort (*Tradescantia* sp.) in Cherry County, Nebraska.

Sight-records of foods eaten by box turtles at the Damm Farm (excluding the many records of individuals foraging in dung or eating mulberries) were for grasshoppers, caterpillars, and various kinds of carrion. Box turtles were often seen eating grasshoppers on roads in early morning; Sophia Damm told me of frequently seeing individuals catching grasshoppers in her garden. Ralph J. Donahue told me that on his farm in Bates County, Missouri, an individual of *T. ornata* made a circuit of the lawn each morning in summer and ate all the cicadas (*Magicicada septendecim*) found.

Vertebrate remains found in the stomachs of box turtles seem to result chiefly from the ingestion of carrion. One box turtle ate a white egg (unidentified) that had fallen from a nest and another was seen with a blue down feather clinging to its mouth. Several colleagues have told me of box turtles eating small mammals caught in snap-traps and Marr (1944:489) reported a similar incident. J. Knox Jones told me he once found an ornate box turtle in the nest of a blue-winged teal in Cherry County, Nebraska; the three eggs in the nest had been broken. The only authentic record of an ornate box turtle preying on a vertebrate under natural conditions was one supplied by Ralph J. Donahue who saw an adult catch and eat one of a brood of bobwhite quail. In many areas where box turtles are abundant, it is the opinion of local residents that the turtles decimate populations of upland game birds by eating the eggs and young of these birds; these opinions result probably from rare encounters such as the one described by Donahue. I believe that box turtles at the Damm Farm were sometimes able to catch young frogs and tadpoles (chiefly *Rana catesbeiana* and *R. pipiens*)

at the margins of ponds. In autumn literally thousands of young *Rana* were present in these places.

Ornate box turtles ordinarily attempt to catch and, without further examination, to eat, small objects moving on the ground, but are more critical of stationary objects. Captive turtles, for example, would immediately chase and seize a grape that was pulled or rolled slowly across a floor but a stationary grape was examined and then smelled before it was eaten. Similar observations were made a number of times with living and dead insects in the field and in the laboratory. A turtle discovering an object that is of possible value as food, approaches it closely, turns the head from side to side (presumably using the eyes alternately to examine the object), and then, with head cocked at a slight angle, momentarily presses the nostrils against the object (Pl. 28, Fig. 4). If acceptable as food, the object is then swallowed whole or taken into the mouth with a series of bites; large insects are usually broken into several pieces in the process of being bitten and swallowed. Larger objects, such as dead vertebrates, are torn to pieces with the beak and forefeet before they are swallowed. Hatchlings, when fed for the first time, ignored inanimate foods but eagerly chased mealworms, catching them usually by the anterior end. The tendency of the young of certain species of turtles (especially captives) to be more carnivorous than adults is probably due to the association of movement with food; recognition of inanimate objects as food is presumably learned by older individuals.

Mulberries (*Morus rubra*), when they are abundant, constitute all or an important part of the diet of ornate box turtles. On June 4, 1955, William R. Brecheisen and I drove along a road in Anderson County, Kansas, and stopped at each mulberry tree that we saw beside the road; we found at least one specimen of *T. ornata* under nearly every tree. Approximately twenty box turtles were collected in this manner in a little more than one hour. The heads and necks of most were stained dark-red from the fruit and, in some, nearly the entire shell was stained. Dissection of these turtles revealed that their stomachs were distended to two or three times normal size with mulberries; no other kinds of food were found in the stomachs. Some of the turtles voided purplish-black fluid from the cloaca when we handled them; the color of the fluid presumably resulted from mulberries.

Several turtles were observed through binoculars as they foraged. Individuals snapped or lunged periodically at objects on the ground along the route of travel. Upon reaching an area where cow dung

was abundant, a turtle would move directly to a pile of dung and begin tearing it apart with the forelegs or burrowing into it. Turtles most often foraged in cow dung that had a superficial, dried crust. The invertebrate fauna of older dung was probably greater than that of fresh dung. Adult and larval insects were eaten, along with quantities of dung, as they were uncovered. Sometimes box turtles chased and caught larger insects that ran a foot or more away from the pile of dung; the turtles could cover the distance of one foot with three or four quick steps. Depressions made by box turtles in cow dung, as well as drier cow dung that had been more completely dissected, were regarded as characteristic "sign" of *T. ornata* at the Damm Farm and in other areas studied (Pl. 26). Several persons have told me of box turtles "eating cow dung"; these reports, most of them made by competent observers, probably result from observations of box turtles ingesting cow dung incidentally, along with some unseen item of food.

Contents of stomachs were analyzed. Scats and contents of lower digestive tracts, although obtained in large quantity, were unsuitable for analysis because of the fragmentary nature of the foods they contained. Relative amounts of various kinds of foods in stomachs were estimated; volume was determined by displacement of water or fine shot.

Twenty-three stomachs of adults were selected at random (except for the fact that empty stomachs were discarded) from more than a hundred specimens collected in Douglas County, Kansas, in the period from June, 1954, to June, 1957; the sample included stomachs obtained in nearly all the months of the season of activity. Kinds of foods in stomachs did not differ significantly in regard to the sex of the turtles or to time of year. The stomach of each of two juveniles (included in Table 6) contained a greater variety of animal food than did the stomach of any adult, but no kind of animal was eaten by the juveniles exclusively.

Each of the 23 stomachs contained animal matter and, in addition, all but two contained at least some plant material from dung, which constituted up to 20 per cent of total stomach contents.

Insects were present in each of the 23 stomachs and constituted the bulk of the animal matter; beetles, caterpillars, and grasshoppers (ranked in descending order) were the kinds occurring most frequently and constituting the largest average percentages of total stomach-contents. Most of the beetles were scarabaeids and carabids; the bulk of the caterpillars were noctuids and arctiids. Grasshoppers, with one exception, were of a single species, *Mel-*

TABLE 6.—KINDS OF ANIMALS FOUND IN THE STOMACHS OF 25 *Terrapene o. ornata* OF BOTH SEXES (23 ADULTS, 2 JUVENILES) FROM DOUGLAS COUNTY, KANSAS. FREQUENCY OF OCCURRENCE (NUMBER OF STOMACHS IN WHICH FOUND) IS GIVEN FOR EACH ITEM LISTED.

	FREQUENCY OF OCCURRENCE		
	Adults	Larvae	Total
Gastropoda			
<i>Helisoma</i> sp.....	1	.....	1
<i>Succinia</i> sp.....	1	.....	1
<i>Polygyra</i> sp.....	1	.....	1
<i>Retinella</i> sp.....	1	.....	1
Crustacea			
<i>Procambaris gracilis</i>	1	.....	1
<i>Armadillidium vulgare</i>	4	.....	4
Orthoptera (Locustidae)			
Locustinae (<i>Melanoplus differentialis</i>)...	13	.....	13
Oedipodinae.....	1	.....	1
Lepidoptera (unspecified).....		1	1
Arctiidae.....		9	9
Noctuidae.....		10	10
Pyralidae.....		1	1
Sphingidae.....		1	1
Diptera (Sarcophagidae).....		1	1
Coleoptera (unspecified).....	3	.....	3
Cantharidae.....		1	1
Carabidae (unspecified).....	6	.....	6
(<i>Eumolops colossus</i>).....	1	.....	1
Cerambycidae (<i>Prionus fissicornis</i>).....	1	.....	1
Chrysomelidae (<i>Diabotrica 12-punctata</i>)..	1	.....	1
Curculionidae (<i>Calendra parvulus</i>).....	3	.....	3
Lampyridae (<i>Photinus pyralis</i>).....	2	.....	2
(<i>Photuris</i> sp.).....		1	1
Phengodidae.....		1	1
Scarabaeidae.....	11	.....	11
Hymenoptera (Formicidae).....	2	.....	2
Phalangida.....	1	.....	1
Araneida (<i>Epeira</i>).....	1	.....	1
Diplopoda.....	1	.....	1
Vertebrata (carrion).....			4

TABLE 7.—OCCURRENCE OF INSECTS, BY FREQUENCY AND VOLUME, IN STOMACHS OF 23 *Terrapene ornata* FROM DOUGLAS COUNTY, KANSAS. RELATIVE VOLUME IS BASED ON TOTAL AMOUNT OF FOOD MATERIAL PRESENT, EXCLUDING STONES AND VEGETABLE MATERIAL CONTAINED IN DUNG.

	Insects (all)	Orthoptera	Lepidoptera (larvae)	Coleoptera
Average volumetric percentage. . .	88.6	28.7	26.9	32.5
Range (volumetric percentage)..	trace to 100	0 to 100	0 to 100	0 to 100
Frequency of occurrence (percentage of total stomachs in which found)	100	52	65	74

anoplus differentialis. It is noteworthy that two of the kinds of insects frequently eaten (differential grasshoppers and noctuid caterpillars) are of economic importance in that they damage crops.

Snails, sowbugs, and the one individual of crayfish found in stomachs were kinds that could be expected to occur in moist grassland or in wooded stream courses. Mulberries were present in one stomach and fragments of bird's-nest fungi (*Cyathus striatus*) were present in another. Carrion consisted of remains of mammals and birds; the only identifiable items were bones of the eastern cottontail (*Sylvilagus floridanus*) and a chicken. Stones up to seven millimeters in diameter were found in many stomachs; stones constituted as much as half of total stomach-contents. Presumably the stones were accidentally swallowed when food was taken from the ground.

The few adequate reports on dietary habits of *T. carolina* (Alard, 1935:325-326; Carr, 1952:147, 150, 152, 153; Stickel, 1950:361; Surface, 1908:175-177) indicate that the species is omnivorous but that individuals tend to be herbivorous or carnivorous at certain times. Ornate box turtles resemble *T. carolina* in being opportunistic feeders but rely on insects as a staple part of the diet. In this respect the ornate box turtle seems to differ from all other kinds of box turtles in the United States and it is probably unique in its habitual utilization of dung communities as a source of food.

POPULATIONS

Ornate box turtles were probably more numerous on the Damm Farm than any other kinds of reptiles, excepting skinks (*Eumeces fasciatus* and *E. obsoletus*), and were by far the most conspicuous element of the reptilian fauna.

The 194 box turtles that were marked at the Damm Farm were captured a total of 437 times. Seventy-nine (41 per cent) individuals were recaptured at least once, 49 (25 per cent) twice, 29 (15 per cent) three times, and 20 (10 per cent) were recaptured at least four times. Only three individuals were recaptured more than eight times. The greatest number of recaptures for a single individual, an old female, was 23.

In all, 185 turtles (95 per cent of total recorded at Damm Farm) were captured on the pasture. Of these, 73 were in the northwest corner area, 44 in the house pond area, and 35 in the southern ravine area. The density of the population at the Damm Farm, considering the entire area, was .88 turtles per acre; for the woodland area alone, density was .41 turtles per acre and for the pasture alone, density was 1.49. Acreage and population density in the northwest corner, house pond, and southern ravine areas were respectively, 28 acres with 2.6 turtles per acre, 7 acres with 6.3 turtles per acre, and, 17 acres with 2.6 turtles per acre. The densities noted above for the wooded area and for the entire Damm Farm are low as a result of incomplete sampling in the wooded area. Estimates of population density for the subdivisions of the pasture seem more closely to approach the true population density in areas of favorable habitat.

Fewer unmarked turtles were captured as the study progressed, but they were still being captured occasionally when field work was terminated. In order to estimate the number of turtles in the population at the Damm Farm the "Lincoln Index" (Lincoln, 1930) was used to compare the ratio of marked individuals to total number of individuals (17:56) in collections for June, 1956, to the ratio of marked individuals as of July 31, 1955 (87) to total individuals in the population; the result was 286.

Fitch (1958:78) estimated the population of *T. ornata* in one area of the Reservation (including woodland and ungrazed pasture) to be .076 turtles per acre. Stickel (1950:373) estimated the population of adult *T. carolina* to be four to five turtles per acre in favorable habitat at the Patuxent Research Refuge, Laurel, Maryland; juveniles comprised less than ten per cent of the population.

Of the 194 turtles marked at the Damm Farm, 103 (53 per cent) were adult or subadult females, 61 (31 per cent) were mature

males, and 30 (16 per cent) were juveniles of undetermined sex. The ratio of males to females was then, 1.00 to 1.69, and the ratio of juveniles to adults was, 1.00 to 6.47. Eighteen of the 194 individuals were juveniles less than 90 millimeters in plastral length and only six had plastra less than 60 millimeters long (Fig. 25). The unbalanced ratio between males and females may result, in part, from sexual differences in habits. The studies of Carr (1952:9), Fitch (1954:140), Forbes (1940:132), Legler (1954:138), and Risley (1933:690), have shown, however, that unbalanced sex ratios, with females outnumbering males, are found in several species of reptiles, especially in turtles.

Records for 540 adult *T. ornata* collected at the Damm Farm, the Reservation, and on roads in eastern Kansas, show that females outnumber males just before and during the nesting season and again in late autumn (Fig. 26). The high incidence of females in May, June, and July, can be explained by their more extensive movements associated with nesting in these months. I have no explanation for the increased number of females captured in late autumn. In April and August, the only two months in which males were more abundant than females, the samples were small. The number of juveniles collected was too small to allow any trustworthy conclusions concerning their seasonal incidence; a few juveniles were taken in nearly all the periods in which adults were active.

Risley (1933:690), studying *Sternotherus odoratus* in Michigan, found an over-all sex ratio of 1.0 male to 2.3 females; the percentage of females in collections ranged from 50 to 71 per cent in April and most of May and rose to 83 and 85 per cent in late May and mid-June, respectively.

The infrequency with which hatchlings and small juveniles of ornate box turtles are observed is well known to naturalists. Several of my colleagues who are expert field observers and who have lived in areas where ornate box turtles are abundant, have never seen hatchlings; many other persons have seen only one or two. Rodeck (1949:33), noting the abundance of coleopterous insects in the scats of captives and the rarity of individuals of all age groups during dry periods in Colorado, commented, "It is possible that the young are even more subterranean than the adults. Perhaps they spend their early years in rodent or other burrows where there is a fairly abundant insect fauna. Increasing size might force them to the surface for feeding, with a daily return to a burrow for resting and protection."

My own experience in the field has shown that small examples of *T. ornata* are not so rare as previous workers have believed. Small box turtles occupy the same microhabitat as do the adults and seem not to be more aquatic or subterranean in habits. Juveniles are found in burrows, in marshy areas, and in other sheltered places, but so are adults. Most of the juveniles that I found were in open situations where adults were abundant, sometimes within several inches of a place where an adult was feeding or basking. Nearly every one of the smaller turtles was discovered when I was closely scrutinizing some other object on the ground; sometimes juveniles were actually touched before being seen. Most juveniles were covered with cow dung or mud and blended so well with the sub-

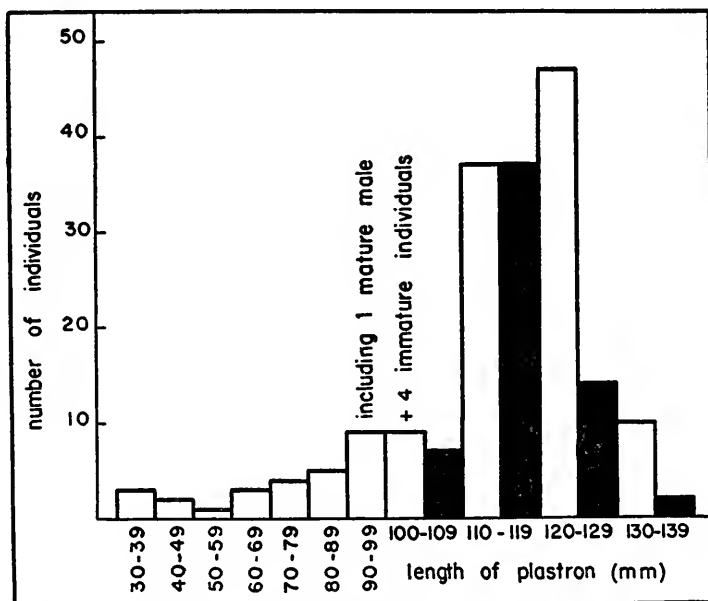


FIG. 25. Composition of the population of *T. o. ornata* at the Damm Farm based on the 194 individuals marked there in the years 1954 to 1956. Individuals smaller than 100 mm, ordinarily could not be sexed accurately and are shown as open bars. Open bars in the groups larger than 100 mm. are for females, whereas solid bars are for males.

strate that they were detected only when they moved. It is likely that only a small number of the young box turtles present in an area is ever actually observed. Young are more vulnerable to predation and injury because of their small size, soft shells, and immovable plastra. They evidently rely, to a large extent, on inconspicuousness for protection.

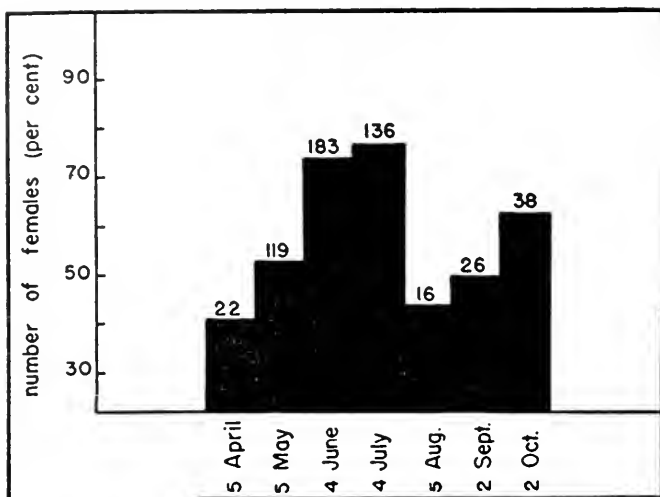


FIG. 26. The seasonal abundance of females of *T. o. ornata* based on 540 adults captured at the Damm Farm, the Reservation, and on roads in eastern Kansas, in the years 1954 to 1956. Records are grouped in periods of 30 days, the periods beginning with the dates shown at the bottoms of the bars. Juveniles are not considered. Numbers at the top of each bar indicate the size of the sample (both sexes) and give an approximate indication of relative seasonal abundance of adults, except for August, when little field work was done.

MOVEMENTS

The only previous study of movements of *T. ornata* is that of Fitch (1958:99-101). He recovered 14 marked *T. ornata* at the Reservation a total of 30 times, the period between recaptures varying from one to seven years. He reported that the average radius of home range was 274 feet (for an area of approximately 5.4 acres), excluding a single (presumably gravid) female that moved 1830 feet in 53 days.

Although published information on *T. ornata* is scant, a considerable amount of information is available concerning its congener, *T. carolina*. The classic studies of Stickel (1950) on it constitute the most complete account of populations and movements for any reptile or amphibian, and probably, for any vertebrate. She found the average home range of adults to be 350 feet in diameter. Home ranges were not defended as territories and nearly all individuals were socially tolerant of one another. Movements (studied by means of a thread-trailing device) were characterized by frequent

travel over the same routes within the home range. Some turtles concentrated their activities in only one part of the home range, moving subsequently to another part, and some turtles had two ranges between which they traveled at varying intervals. Females ordinarily left their home ranges to nest.

Other noteworthy, but less detailed, studies of populations of *T. carolina* are those of Breder (1927) who found evidence of home range and homing behavior, and of Nichols (1939b) who, after observing a marked population on Long Island over a period of twenty years, found evidence of homing behavior and estimated normal home range to be approximately 250 yards in diameter. Numerous shorter papers such as those of Schneck (1886) and Medsger (1919) document the tendency of *T. carolina* to remain in restricted areas over long periods.

Important studies that indicate the presence of home range and homing behavior in other chelonians are those of Cagle (1944) on *Pseudemys scripta* and *Chrysemys picta*, and of Woodbury and Hardy (1948) on *Gopherus agassizi*. Grant (1936) and Bogert (1937) have also indicated that movements of individuals of *Gopherus agassizi* are restricted to limited areas.

Locomotion

Ornate box turtles moving forward over even terrain hold the plastron a quarter to a half inch above the ground and keep the head and neck lowered and extended. Each foreleg is brought forward and the humerus points nearly straight ahead when the foot touches the ground. Nearly all of the palmar surface is initially in contact with the ground but as the body is brought forward and the humerus swings outward, only the claws, and finally, only the two inner claws are in contact with the ground. Of the hind feet, the medial surfaces are the principal parts that touch the ground but some traction is derived from the hind claws at the beginning of each cycle of the hind leg. Under normal conditions, box turtles move slowly and pause to rest and examine their surroundings every few feet. When resting, the plastron is in contact with the ground, the legs relaxed, and the head and neck are extended upward. Some turtles seeking shelter from the heat of sunshine walk rapidly for a hundred feet or more without pausing.

Turtles seen feeding under natural conditions displayed remarkable agility in making lunges, consisting of one or two short steps and a thrust of the head, at moving objects. Turtles kept in my

home were able, after being conditioned to hand-feeding, quickly to intercept a grape rolled slowly across a linoleum-covered floor.

Frederick R. Gehlbach told me that, of several species of captive turtles observed by him, *T. ornata* characteristically walked with the plastron held well above the substrate, as did *Gopherus berlandieri*, but that *T. carolina* (specimens from the northeastern U. S.) dragged their shells as they walked. Apparently *T. carolina* in Kansas (currently referred to the subspecies *triunguis*) differs somewhat in gait from populations in the eastern part of the range; several individuals of *T. carolina* from Kansas that I observed in captivity, kept their plastra raised well above the smooth, hard substrate over which they walked.

Box turtles at the Damm Farm were able easily to climb ravine banks that sloped at an angle of 45 degrees and, with some difficulty, could climb banks as steep as 65 degrees. Most individuals, however, were reluctant to walk directly downward on banks as steep as 45 degrees. Several individuals were seen to lose footing when climbing up or down a steep bank and to roll or slide to the bottom. Ordinarily, *T. ornata* is able to climb over a sheer surface as high as its shell is long, provided the surface is rough enough to give some traction to the foreclaws. The claws of first one, then the other forefoot are placed over the top of the barrier and then a hind foot, extended as far forward as possible, secures a hold as the turtle goes over the barrier.

A number of observations on speed were made in the field where distance traveled and time elapsed were known approximately. Speeds ranged from 20 to 100 feet per hour in the course of foraging. Higher speeds (400 or more feet in one hour) were for turtles moving along pathways or seeking shelter. Gould (1957:346) observed somewhat faster speeds in *T. carolina* (192 feet per hour in cloudy weather and 348 feet per hour in sunny weather); he observed individuals that had been removed from their normal home ranges.

Individuals of *T. ornata* that were placed in water swam moderately well but were clumsy in comparison to individuals of more aquatic emyids such as *Pseudemys* and *Chrysemys*. Box turtles were never observed to swim voluntarily, although they were frequently found in shallow water. On several occasions I confronted individuals at the edge of a pond so that the only unblocked route for their escape was through deeper water; nearly always these individuals attempted to crawl past me, to crawl away in shallow

water parallel to the shore, or to hide in soft mud at the edge of the water. Box turtles floated high in the water with the dorsal side upward and had little difficulty in righting themselves when turned over. The head and neck are extended and submerged when the turtle is swimming; forward progress is interrupted every few moments to elevate the head, presumably for purposes of breathing and orientation. The shell is never submerged. The swimming of *T. ornata* is in general like that of *Pseudemys* or *Chrysemys* that have become dehydrated after long periods out of water and cannot submerge. These more aquatic turtles, however, quickly overcome their bouyancy, whereas examples of *T. ornata*, even if left in water for several days, are unable to submerge. Clarke (1950) saw an ornate box turtle swim a 60-foot-wide stream in Osage County, Kansas; his description of swimming agrees with that given above.

The meager swimming ability of *T. ornata* is of apparent survival value under unusual conditions and enables *T. ornata* to traverse bodies of water that would act as geographic barriers to completely terrestrial reptiles; however, swimming is a mode of locomotion seldom used under ordinary circumstances.

Gehlbach (1956:366) and Norris and Zweifel (1950:2) observed individuals of *T. o. luteola* swimming in temporary rain pools and small ponds in New Mexico; the two authors last named saw an individual quickly enter a pond and dive beneath the water after being startled on the bank. Several of my colleagues, in conversation, have also reported seeing *T. o. luteola* in small bodies of water in the southwestern United States.

Daily Cycle of Activity

The daily cycle of *T. ornata* consists basically of periods of basking, foraging, and rest that vary in length depending upon environmental conditions. Turtles emerge from burrows, forms, and other places of concealment soon after dawn and ordinarily bask for at least a few minutes before beginning to forage; foraging is combined sometimes with basking, especially in open areas that are suitable for both kinds of activity. Foraging usually continues until shelter is sought sometime between mid-morning and noon. Turtles remain under cover (or continue to forage in shaded areas) until mid-afternoon or late afternoon when they again become active. They forage in both morning and afternoon. Study of travel records of a few of the turtles equipped with trailers

suggests that, under normal conditions, activity is slightly greater in forenoon than in afternoon, but that the converse is true of gravid females seeking nesting sites. Strecker (1908:79) reported that captive *T. ornata*, after developing a feeding reflex, ate and retired until feeding time next day.

As environmental temperatures rise in summer, the period of mid-day quiescence is lengthened. In the hottest part of the year, some turtles remain under cover for several days at a time. In periods of clear, cool weather at the beginning and end of the growing season, some turtles remain abroad and bask for most of the day.

Examination of thread trails showed that activity of all individuals except nesting females was terminated at dusk. Breder (1927:236), Allard (1935:336), and Stickel (1950:358) reported a corresponding lack of nocturnal activity in *T. carolina*. *Terrapene o. ornata* in Kansas, and *T. o. luteola* in New Mexico (Norris and Zweifel, 1950:2)—unlike desert tortoises, *Gopherus agassizi*, which are active at night in hot weather (Woodbury and Hardy, 1948:186)—do not utilize the hours of darkness for foraging, even in the hottest part of the year.

Seasonal Cycle of Activity

Data obtained by mapping the movements of turtles that were equipped with trailing devices made it possible to compare distances traveled in the course of daily activities at different times of the year. Some of these data are expressed graphically in Figure 27. It should be noted that movement at all times in the season of activity was uneven; that is to say, an individual would move several hundred feet each day for a period of several days, and then, for an interval of one to several days, move only a few feet from one shelter to another, or not move at all. Such periods of rest could not be correlated definitely with environmental conditions; some individuals were inactive on days that were probably ideal (in terms of moderately warm temperatures and high humidity) for activity of box turtles. Analogous rest periods were noted in *T. carolina* by Stickel (1950:358).

Two males of *T. ornata* that had been removed by me from their normal home ranges traveled the longest average distance per day (429 feet). Gravid females in June traveled the next longest average distance per day (363 feet). The average distances traveled per day by non-gravid females in June (226 feet) and July

(260 feet) and by males (within their known home ranges) in June (289 feet) were thought to approximate normal amount of movement under average environmental conditions. Average distance traveled per day by females in October (152 feet) was shortest because of frequent and extended rest periods. Nevertheless, in October actual distances traveled on days of activity tended to be longer than in any other month. A gravid female traveled farther in a single day than any other individual of *T. ornata* observed;

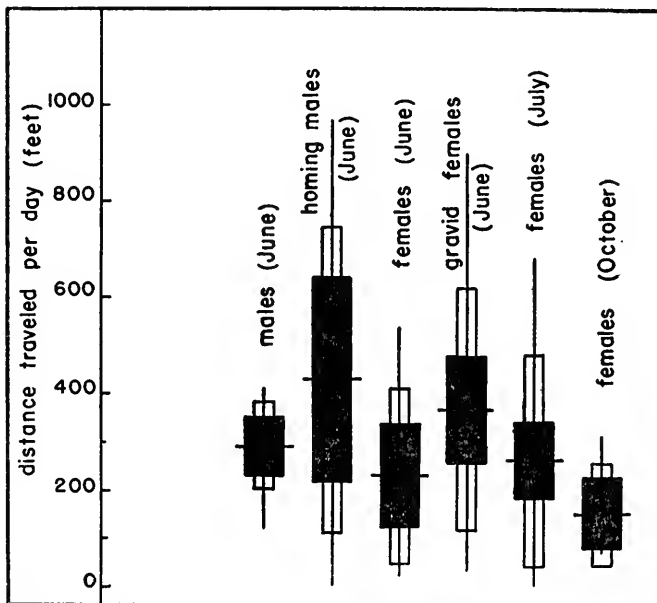


FIG. 27. Average distances traveled per day by males and females at different times of the year, determined by mapping of thread trails at the Damm Farm. The diagram for "homing males" represents the distances traveled by two males removed from their normal home ranges to test homing ability. The data presented are for an aggregate of 136 days of trailing. Vertical and horizontal lines represent, respectively, the range and mean. Open and solid rectangles represent one standard deviation and two standard errors of the mean, respectively.

she moved along a rock fence for approximately 700 feet, then left the study area and moved, in a nearly straight line, 1,200 feet across a cultivated field. Then the thread on her trailer was expended. The total distance moved, therefore, was at least 1,900 feet and probably more.

An adult male at the Reservation traveled 2,240 feet in the 36-day period from October 16 to November 20, 1954, mostly on a wooded

hillside. Eleven forms found along the route of the turtle's travels indicated that movement took place on roughly one out of three days in the elapsed period and demonstrated the sporadic nature of movements in autumn. The turtle remained active for an undetermined time after November 20.

Home Range

Data obtained from trailing and various methods of recapture at the Damm Farm indicated that each individual used only a small part of the total study area in the course of daily activities and tended to remain within a restricted area for a long time.

The number of recaptures of no individual was great enough to permit application of refined calculations of size of home range as described by Odum and Kuenzler (1955). For individuals that were recaptured six or more times, or individuals for which adequate trailing records were available, the area enclosed by a line joining the peripheral points of capture was considered adequately representative of the home range of that individual, unless recaptures were all within a few feet of each other or lay in an approximately straight line. If less than six records of recapture were available, home range was estimated, in the manner described by Fitch (1958:73), by averaging the distance between successive points of recapture and letting this average represent the radius of home range; the actual area of home range was determined by the formula, $\pi(R)^2$, for the area of a circle.

Size of home ranges of males and females did not differ significantly and data for the two sexes were combined in the final analysis. The average radius of the home ranges of 44 adults (captured a total of 146 times) was 278 feet (extremes, 71 to 913) when computed by measuring the distance between successive captures; the average area of these home ranges was 5.6 acres. Data from 10 turtles that had been recaptured only once were combined with data from 34 turtles that had been recaptured more than once when it was found that the average size of home range in these two groups did not differ significantly. Data concerning the home ranges of eight of the 44 individuals were sufficient to permit actual measurement of home ranges with a planimeter; home ranges of these eight individuals had an average area of five acres (extremes, 1.2 to 10.2).

A minimum home range could theoretically consist of the smallest area in which adequate food and shelter were available. Under favorable conditions a turtle could stay in an area ten to twenty feet in diameter. Although several such favorable small areas

existed on the Damm Farm, box turtles seldom stayed in one for more than a day or two. Seemingly, therefore, factors additional to food and shelter influence size of home range. At the Damm Farm these additional factors seemed to be: rock fences that acted as physical barriers; areas that were cultivated, barren, or otherwise unfavorable, acting as ecological barriers; and, cowpaths and ravines that offered relatively unobstructed routes along which box turtles tended to move.

One subdivision of the main pasture, the northwest corner area, is an example of a relatively small natural area in which many individual box turtles had home ranges. This tract of 28 acres was roughly triangular and was bordered on two sides by rock fences that contained no gates or other passageways. On its third (southeastern) side the area sloped into a deep ravine. Habitat in this subdivision of the pasture (as well as in the other two subdivisions) was especially favorable for box turtles because of permanent water, rocky slopes, ravines, and several fruit trees. Box turtles usually foraged near the rock fences and the ravine (where dung was more abundant than in other parts of the area), and tended, as they foraged, to move parallel to these barriers. Turtles crossing the area eventually came either to one of the fences or the ravine. Therefore, most of the turtles in the northwest corner area eventually completed a circuit of the area. Turtles that came to the ravine tended to move along its bottom or sides. Several turtles were known to cross the ravine and to forage in the grassy area on its southeastern side. These turtles usually re-entered the ravine by way of smaller side-ravines. Of 22 box turtles known to have home ranges in the northwest corner area, only two individuals (both gravid females) were known to leave the area in the period in which observations were made.

Two other subdivisions of the main pasture—the house pond area and the southern ravine area—although not so distinct as the northwest corner area in terms of limiting barriers, nevertheless constituted separate areas of favorable habitat, each of which contained a number of individual home ranges. Although the two areas were not far apart, but little movement was observed of turtles from one area to the other. The home range of only one turtle, an adult female, was known to include parts of both areas.

Unbroken expanses of tall grass seem not to be optimum habitat. The crest of the hill at the Damm Farm (Pl. 17, Fig. 1) was an area of more or less homogeneous grassy habitat. Turtles were seldom

found on the crest of the hill although this area was as thoroughly searched for turtles as any other area. Known home ranges of nearly every individual observed were on either one of the sides of the hill but not on both sides.

At several places on the border of the pasture, turtles were able to move freely into cultivated areas but seldom did so except for nesting. Trailing records show that most of the turtles that entered one of the cultivated areas returned again to the pasture.

Ornate box turtles seem to find places of shelter by trial and error along regularly used routes of travel in their home ranges. The individuals that I studied never returned to the same forms, and seldom returned to the same natural burrows and dens. Probably foraging, basking, and watering sites are found also by trial and error.

Stickel (1950:375) placed considerable importance on the occurrence of transient turtles in populations of *T. carolina*; in estimating population density, she added to her study area a peripheral strip, half as wide as the average, estimated home range, to account for turtles that had home ranges only partly within the study area. The study area used by Stickel had no natural boundaries, as habitat conditions on all sides were essentially the same as those of the study area itself. The pasture at the Damm Farm, on the contrary, is a relatively isolated area of natural grassland, bordered by rock fences and cultivated fields. I believe that most of the box turtles found on the pasture were permanent residents there. Individual box turtles at the Damm Farm seemingly occupied but one home range and it did not change from year to year. Populations of *T. ornata* in areas less isolated than the Damm Farm, like the populations of *T. carolina* studied by Stickel (*loc. cit.*), could be expected to have a higher percentage of transient individuals and individuals with multiple or changing home ranges. Henry S. Fitch told me that he considered most of the individuals of *T. ornata* that were captured only once at the Reservation were transients.

Several females at the Damm Farm traveled long distances from their home ranges to nest but other females nested within their known or estimated home ranges. Seemingly a complex of environmental factors, including soil texture, weather, availability of water, and possibly the urge for random wandering in the breeding season, governs the distances traveled by gravid females and the ultimate selection of a satisfactory nesting site. Females, because of their more extensive travels in the nesting season, seem more likely than

males to have multiple or changing home ranges. Males of *T. ornata* did not noticeably alter the extent or pattern of their movements in the breeding season. Hibernacula, unlike nesting sites, were within the known or estimated home ranges of all individuals studied.

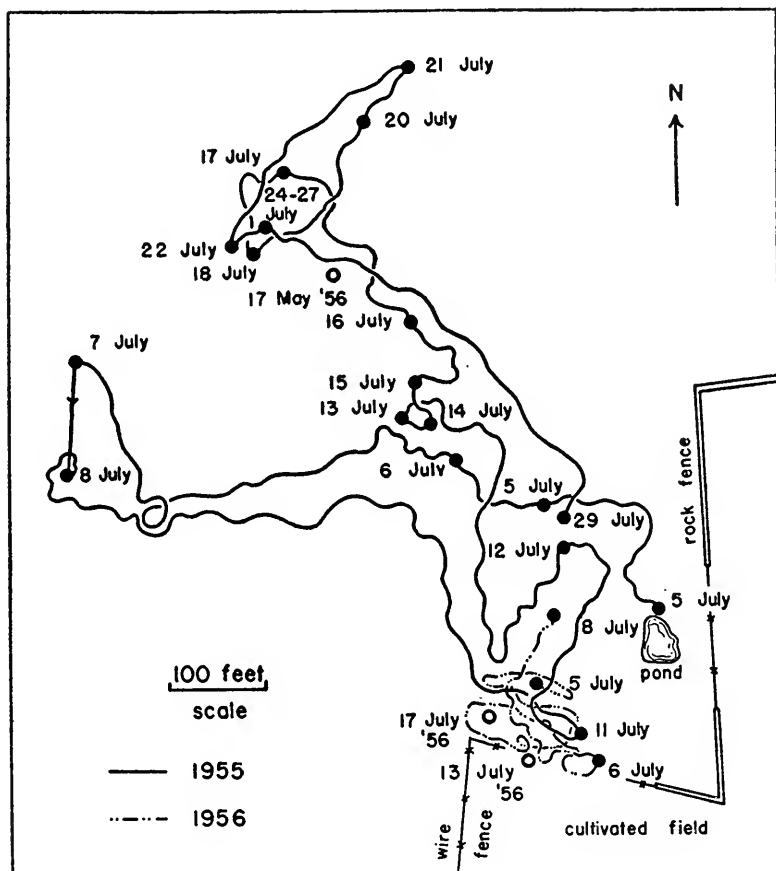


FIG. 28. The movements of an adult (nongravid) female of *T. o. ornata* in the house pond area at the Damm Farm during a period of 24 days in July, 1955 (solid line), and a period of three days (broken line) in July, 1956. Solid dots represent the points where the turtle was found as her thread trail was mapped; hollow symbols represent points of recapture when no trailing thread was attached to the turtle.

The actual home range of almost every individual studied, even of those individuals for which the most data were available, probably differed at least slightly from the observed or estimated home range. One adult female, for example, was captured six times in

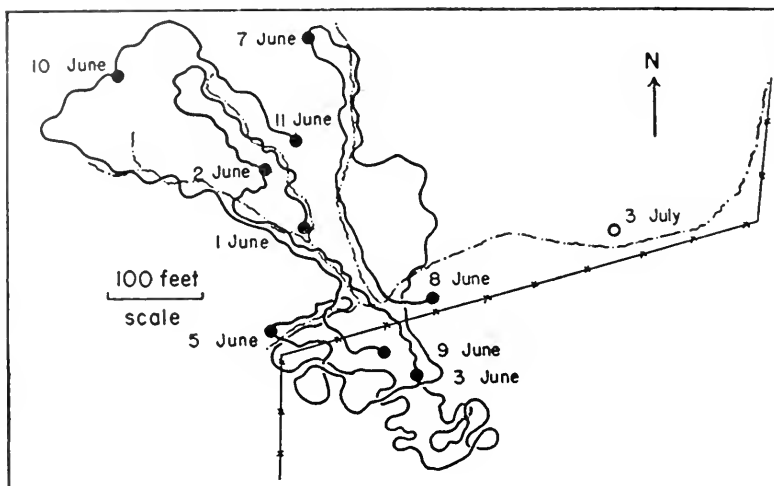


FIG. 29. The movements of a gravid female of *T. o. ornata* in the southern ravine area at the Damm Farm in a period of ten days in June, 1956. Her movements were, for the most part, in and around several ravines (shown on map by broken lines) where she was searching for a nesting site. For explanation of symbols see legend for Fig. 28.

two years within a radius of approximately 50 feet. Another female was found 2780 feet from her last point of capture. These last two records were regarded as unusual; when they were grouped with records of the 44 individuals mentioned above, the average radius of home range for the entire group was much larger (327 feet).

Homing Behavior

Gould (1957) reported that 22 of 43 *T. carolina* moved in a homeward direction when they were released in open fields up to 5.8 miles from their original points of capture. Turtles oriented themselves by the sun; homeward headings were inaccurate or lacking on overcast days and, light reflected from a mirror caused turtles to alter their courses. Seven of ten turtles released more than 150 miles from home headed in directions that corresponded most nearly to the headings last taken (at release-points near home base) and did not necessarily correspond to the direction of home. Gould's studies point out that box turtles perhaps practice a kind of "solar navigation." His work raises the question of whether the movements of box turtles are guided by the sighting of local landmarks or whether such landmarks alter the course of movement only when acting as barriers.

In the present study two experiments were made to determine the homing ability of *T. ornata*. An adult male, taken from his normal home range in the house pond area and released 1200 feet away in the southern ravine area, traveled a generally northward course (not northeastward in the direction of home) for five days, moving a distance of approximately 1900 feet. His detached trailer was recovered several days later 740 feet southeast of the last known point in his travels (a distance that could have been covered in two days) and 150 feet from the point of original capture; he had returned to his home range by a circuitous route in a period of approximately seven days. Another adult male, captured in the southern ravine area, and released in the house pond area 1900 feet away, traveled on a course that bore approximately 25 degrees north of true homeward direction; after five days he was approximately 600 feet north of the original capture point. He then began a northeastward course that took him back to the house pond area where he remained for several days; no further data are available for this individual. It is significant that the homing males discussed above traveled greater average distances per day (based on records for nine days of trailing) than any of the other turtles studied (Fig. 27). Fitch (1958:101) released an individual one half mile from where he captured it and, one year later, recovered the turtle near the point of release.

Social Relationships

Ornate box turtles are solitary except during periods of mating. Meetings with other individuals in the course of foraging, basking, or seeking shelter, are fortuitous and have no social significance. A broad overlapping of home ranges of both sexes at the Damm Farm suggests that box turtles do not intimidate other individuals in the home range or exclude them from it. No instances of fighting were observed.

Allard (1935:336), Penn and Pottharst (1940:26), and Latham (1917) recorded instances of fights between individuals of *T. carolina*; in the latter two instances fights were between males. Stickel (1950:362) observed an incident between two males that may have been a fight; however, she was of the opinion that fights rarely occur in nature and that box turtles do not defend territories. Evans (1954:23-25) considered the behavior of *T. carolina* reported by Penn and Pottharst (*loc. cit.*) to represent "territoriality." He found ". . . a true hierarchy . . ." existing between

four captive males of *T. carolina* and another between three captive females of the same species; young individuals in the group raised their social level in the hierarchy after receiving experimental doses of male hormone. Evans (*op. cit.*:25) pointed out that true tortoises (family Testudinidae) have a more complex pattern of social behavior than do emyid turtles.

Observations made with binoculars from the vantage point of a blind provide the only information that I have concerning the reactions of box turtles to one another under natural conditions. Turtles foraging in a bare area were not startled by the approach of other turtles, and turtles moving across the area seemed to take no notice of turtles already there, regardless of whether these turtles were moving or not. Adults and subadults behaved in approximately the same manner.

Individuals traveling or foraging in rough terrain or in grassy areas probably are unable to see each other even when they are close to one another. Conversely, box turtles can see each other and are surely aware of each other's presence in bare, flat areas. These facts suggest that no social hierarchy exists in *T. ornata*. On one occasion an adult male and a juvenile (hatched the previous autumn) were found foraging next to one another on the same pile of cow dung.

When an individual became motionless in an attitude of wariness after having detected me in my blind, its behavior evoked no response on the part of other turtles, a few feet away.

INJURIES

Fire, freezing, molestation by predators, and trampling by cattle or native ungulates are only a few natural sources of injury to which box turtles have always been exposed. Man's civilization in the Great Plains, chiefly his automobile and other machines, have compounded the total of environmental hazards. Automobiles now constitute a major cause of death and serious injury to box turtles. Each year thousands are struck on Kansas highways alone, not to mention the many casualties resulting from mowing machines, combines, and other farm machinery.

Although grass fires usually occur in early spring or late fall when box turtles are underground, some turtles are surely killed by fires and many are injured. In early April of 1955 the pasture at the Damm Farm was burned. Similar burnings, I discovered, had occurred both intentionally and accidentally in past years at

irregular intervals. No deaths or injuries, attributable to fire were discovered in the course of intensive field work in the spring and summer of 1955, when the new grass was short and conditions for finding and marking box turtles were ideal. Badly burned individuals, if any, may have secreted themselves until their wounds had healed. In June, 1957, an adult female, that had been burned severely, was taken from a small puddle in a ravine on the Damm Farm. The soft parts of her body, excepting her head and neck, were a nearly solid mass of smooth scar tissue, the scales and rugosities of the skin being practically obliterated. The tail was reduced to a mere knob surrounding the anus and dead, exposed bone was visible on most of the dorsal part of the carapace. Possibly this female was burned in the fire of 1955. Lack of injury to the head and neck can probably be accounted for by the additional protection afforded these parts by the folded forelegs when the turtle was withdrawn in the shell.

Turtles that are smashed flat on the highway, of course, have no chance of survival. Highway fatalities are usually the result either of "direct hits," where the tire of a vehicle passes directly over the turtle, or of repeated pummeling by subsequently passing vehicles. The writer, while driving behind other cars that struck turtles or by sitting beside roads, has observed numerous turtle casualties. Most are struck a glancing blow by a tire and are propelled some distance through the air or on the surface of the pavement, often to the side of the road. Such a blow is usually sufficient to crack or chip the shell, or at least to scuff away parts of the epidermal covering. Turtles, so injured, usually survive.

Parts of the shell do not break away easily, even when several deep cracks are present, and only a little bleeding occurs. A common injury inflicted on the highway is the wrenching and subsequent dislocation of the carapaco-plastral articulation. In such instances the ligamentous tissue joining the two parts is torn extensively. Under these circumstances the movable shell parts seem to act as a safety device, giving way under pressure that would crack the shell of a turtle with rigid, fixed buttresses. Dislocations of the carapaco-plastral articulation that have healed are characterized by abnormally heavy development of ligamentous tissue, which may elaborate a horny, scutelike substance on its outer surface.

The extent to which serious injury incapacitates a turtle is not known. Surely open wounds are susceptible to infection and to

various kinds of secondary injury; normal activity is probably interrupted by a period of quiescence, at least in the period of initial healing.

An injured female had a hole, slightly more than one inch in diameter, in the right side of the carapace at the level of the second lateral lamina. A tight, thin membrane stretched between the broken edges of the opening; this membrane contained no bone and was covered externally by scar tissue. It was obvious that this turtle had recovered, at least in part, from a serious injury (inflicted probably by a piece of heavy farm machinery).

Minor chips, scratches, and abrasions on the shell result from a variety of sources, some of them mentioned above. Small rounded pits in the bony shell (shell pitting) due to causes other than mechanical injury, are found in nearly all kinds of turtles according to Carpenter (1956), Hunt (1957), and my personal observation. In *T. ornata*, however, the condition is less common than in the specimens of *T. carolina* described by Carpenter and in the remaining species of *Terrapene* that I have examined.

Carpenter (1956:86) came to no conclusion as to the cause of shell pitting in *Terrapene carolina* but suggested that a variety of factors including parasitic fungi, parasitic invertebrates, and simple shell erosion, might be responsible.

According to my own observations on turtles in the University of Kansas collections, shell pits range in size and shape from shallow, barely discernible depressions to deep borings; I suspect that shell pitting for turtles in general has many causes, some of which may be of more frequent occurrence in one species than in another.

Hunt (1957:20) presumably was referring to shell pitting by a more suitable name when he wrote of, ". . . necrosis . . . of mycotic origin." Hunt (*loc. cit.*) stated that "Of those cases which have been recently examined, the author found all were due to the invasion of Mucorales beneath the plates of the epidermal laminae. This disease is of extremely common occurrence and has been found in all members of the order but is seldom found in marine species. Mycosis more frequently occurs on the plastron than on the carapace." Hunt presented no evidence to support his statement regarding invasion of the shell by Mucorales.

Evidence that injury to the soft parts of the body is also fairly common is seen in the many *T. ornata* with missing feet and legs. Stumps resulting from amputations are covered with tough, caloused skin and sometimes by horny tissue similar to that of the

antebrachial scales. Amputees are incapacitated only slightly in normal locomotion if a functional stump remains; probably a cripple is somewhat handicapped in other functions, such as burrowing, nest digging (females), and copulation (males). Causes of amputation are discussed in the section on predators.

Fractures of the limb bones are common. A female from Stafford County, Kansas (Pl. 29, Fig. 4), showed a typical case of fracture and subsequent repair; the right fibula had been broken and the ends dislocated; a great mass of bone joined the repaired break to the middle of the tibia, giving the entire skeleton of the leg the appearance of the letter "H." The fibula, shortened by the dislocation, no longer articulated by its proximal end with the femur; the tibia probably bore the entire load in the period of repair and the transverse connection that formed between the bones later took over the function of the fibula.

There is little doubt that ornate box turtles are stepped on or trampled by cattle, at least occasionally, but I never observed such an incident; the predilection of ornate turtles for dung insects and for moving along cattle pathways brings them to close quarters with cattle and probably did likewise with native ungulates. A steer, stepping on a box turtle, could inflict superficial damage to the shell or cause broken limbs but would probably not crush the turtle unless on a hard substrate.

REPAIR OF INJURIES TO THE SHELL

Most adults and a few juveniles examined in the field and laboratory had one or more small injuries on the carapace that had healed or were undergoing repair. Such injuries almost never occurred on the plastron. In an injury that was undergoing repair, a small piece of smooth, whitened bone was exposed where a piece of epidermis was missing from the shell. One or more edges of the exposed bone characteristically projected over the surrounding epidermis, making the bone appear as though it had been driven forcefully, like a splinter, into the shell (Pl. 29, Figs. 1 and 2). Because of their curious appearance, small areas of repair were referred to in my notes as "splinter scars." The position and number of splinter scars were often recorded as supplementary means of individualizing turtles in the field.

Splinter scars result from minor abrasions that damage a few square millimeters of the shell. Larger areas of exposed bone were noted in only a few specimens. Two turtles at the Damm Farm had

bone exposed on more than one-half the surface area of the carapace; both of these turtles were probably burned in the grass fire of 1955. Ordinarily, a break in the shell does not induce extensive regeneration of tissues; when shells are damaged by crushing or cracking, regeneration of epidermis and bone occurs only along the lines of fracture, unless the broken parts have been dislocated. Ligamentous tissue develops in some breaks on the plastron, the broken area remaining slightly movable after healing is completed (Pl. 24).

Dissection of injured shells revealed the mode of shell regeneration to be the same whether a large or small portion of the shell had been damaged. An abrasion may gouge out a small portion of the shell; burning, freezing, or concussion may kill a portion of the epidermis and a corresponding portion of bone beneath it without actually disfiguring the shell. Dead bone and epidermis become loosened at the margin of the wound. The epidermis sloughs off soon afterward but the bone adheres to the wound. New epidermis and new bone, growing from undamaged tissues at the edges of the wound, encroach on the wound beneath the layer of dead bone. The piece of dead bone is thereby gradually isolated from the rest of the shell and is sloughed off when healing is complete. The dead bone may come off in one piece or slough off gradually at its edges as healing proceeds toward the center of the wound. The layer of dead bone protects the wound during the process of regeneration (Pl. 30). Areas of exposed bone become white and shiny, nearly enamellike in appearance, as a result of wear on the shell.

The above conclusions, in regard to *T. ornata*, agree basically with the findings of Woodbury and Hardy (1948:161-162) and Miller (1955:116) on regeneration of the shell in desert tortoises (*Gopherus agassizi*). Danini (1946:592-4, English summary) made histological studies on regeneration of the shell in specimens of *Emys orbicularis*; he found that new bone trabeculae formed on the surfaces of undamaged trabeculae at the edge of the wound and formed also in connective tissue at the center of the wound. Regeneration of bone was incomplete in some instances where total extirpation of a portion of the shell had occurred. Regenerated epidermis was usually thicker than the original scute.

Exposed bone on the shells of turtles that have been injured in fires, although dead, is unmarked and shows no evidence of being burned. Exposure to fire kills the growing portions of both the epidermis and the bone but seemingly does not actually char or dis-

figure the bone (although the epidermis may be so affected) (Pl. 29, Fig. 3). Injuries from fire result probably from brief encounter with the fire itself or from more prolonged contact with some surface heated by the fire. A turtle that remained in a fire long enough to have its shell charred would presumably have little chance of survival. Grossly disfigured shells therefore do not result directly from burns but are due to the gnarled texture of the regenerated bone and epidermis remaining after the dead portions of the shell have been sloughed off. Information on injuries from fire was supplemented by examination of several badly burned specimens of *T. carolina*. Their shells were nearly covered with exposed bone and regenerated epidermis. One specimen was so badly damaged that the entire anterior rim of its carapace was loose and could be pulled away easily to disclose a gnarled mass of regenerating bone beneath it (Pl. 29, Fig. 3). There were areas near the posterior margin of the carapace of each specimen where regenerated epidermis was evident but where the bone was seemingly uninjured; the regenerated epidermis was nearly transparent.

Areas of regenerated epidermis on specimens of *T. ornata* were rough in texture and slightly paler than the surrounding scutes. Color-pattern is not reproduced in the process of regeneration but irregularly shaped light blotches sometimes occur in the places where radiations or other distinct markings formerly were present. A slight depression remains on the shell after regeneration is completed. I suspect that small injuries may be repaired in the course of a single growing season but that injuries involving a large part of the shell may take several years to heal completely. Cagle (1945:45) reported that a bullet wound in the shell of a painted turtle (*Chrysemys picta*) healed completely in approximately 23 months. Danini (*loc. cit.*) found that regeneration of the shell in *Emys orbicularis* was complete in as short a time as 225 days. Woodbury and Hardy (*loc. cit.*) stated that small injuries to the shell of *Gopherus agassizi* may take as long as seven years to heal.

ECTOPARASITES

Two kinds of ectoparasites were found on ornate box turtles in the course of the present study; larvae of chigger mites (*Trombicula alfreddugesi*) were abundant on specimens collected in summer and, larvae of the bot fly (*Sarcophaga cistudinis*) were found on specimens throughout the season of activity, and, in a few instances, on hibernating turtles. In general, these ectoparasites

do little or no harm to ornate box turtles, although heavy infestations may cause temporary interruption of normal activity or may even cause occasional death.

Concerning the larvae of *T. alfreddugesi*, Loomis (1956:1260) wrote, "In northeastern Kansas, larvae become numerous in early June (shortly after they first appear), increase in numbers to greatest abundance throughout late June and July, decrease slightly in August, become markedly reduced in September, and only a few larvae (mostly on hosts) remain in October and early November." He considered *T. alfreddugesi* to be the most abundant chigger mite in Kansas and stated (*op. cit.*:1265) that it is most common ". . . in open fields supporting good stands of grasses, weeds and shrubs, and where moderate to large populations of vertebrates are present." Loomis listed ornate box turtles (*op. cit.*:1261-2) as important hosts of *Trombicula alfreddugesi* but noted that box turtles are not so heavily infested as are certain other reptiles. The two other species of chigger mites that Loomis (*op. cit.*:1368) found on *T. ornata* in Kansas (*T. lipovskyana* and *T. montanensis*) were not found in the present study.

Box turtles were considered to have chigger infestations when the reddish larvae could be detected with the unaided eye. No chiggers were seen on turtles in the period from spring emergence until June 13, 1955. On the latter date a few scattered chiggers were noted on several individuals and it was on this same date that the writer received his first "chigger bites" of the year. Numbers of chiggers increased in the latter half of June and heavily infested turtles were noted throughout July. No chiggers were seen on box turtles after mid-September in 1955.

Chiggers were ordinarily found only on the soft parts of the turtles' bodies. Early in the season infestations were chiefly on the head and neck. Favorite sites of attachment were the point where the skin of the neck joins the carapace and on the skin around the eyes. Later in the season some chiggers could be found on nearly every part of the body where soft skin was present; concealed areas of skin, such as the axillary and inguinal pockets, the anal region, and the inner rim of the carapace (where it joins the skin of the body), harbored concentrations of chiggers. Juveniles were relatively more heavily infested than adults and, even early in the season, had chiggers attached along many of the interlaminal seams of the shell. Broad areas of soft, newly-formed epidermis on the shells of juveniles probably afforded a better

place of attachment to chiggers than did the interlaminal seams of adults. The interlaminal seams and transverse hinges of adults were not infested until the height of the season of chigger activity. Heavily infested adults, observed in early July, were literally covered with chiggers; red larvae outlined nearly all the scutes of the shell, the anus, the mouth, and the eyes. When turtles were picked up for examination, chiggers could be seen moving rapidly from one interlaminal seam to another.

Box turtles kept in outdoor pens and in the laboratory did not long maintain visible infestations of chiggers, even during the time in summer when turtles found in the field were heavily infested.

A four-year-old juvenile was found nearly immersed in the shallow water of a pond on July 4, 1955; its right eye had been damaged by an especially heavy concentration of chiggers. When I released the turtle, some 50 feet from the pond, it returned to the water and spent the next four days there. The turtle was probably in a period of quiescence induced by the eye injury and the heavy infestation of chiggers; immersion in water could be expected to help free the turtle of chiggers and to relieve trauma resulting from the injured eye. Richard B. Loomis told me that larval chiggers are able to survive under water for several days but that warm water will hasten their demise.

Infestations of larval bot flies (*Sarcophaga cistudinis*) were noted in several turtles at the Damm Farm and, upon closer scrutiny, were found to be common in preserved specimens from other areas. Larvae were always found in flask-shaped pockets (Pl. 27, Fig. 2) beneath the skin; the pockets opened to the outside by a small hole, the edges of which were dried and discolored. One larva sometimes protruded from the opening. The inside of the pocket is lined with smooth, skinlike tissue. Heavily infested box turtles may have four or five such pockets, each containing one to many larvae. The most frequent sites of the pockets are the skin of the axillary and inguinal regions, and the skin of the limbs and neck, especially near the bases of these members. Subadults were more heavily infested than older adults; no infestations of hatchlings or small juveniles were noted.

An adult female, infested with bot fly larvae when she was removed from her hibernaculum in late October, 1955, bore no trace of larvae or of the pocket that had contained them when she was recaptured the following June. According to Rokosky (1948), the larvae eventually fall to earth and pupate. The individuals of *T.*

carolina studied by him were not re-infested by adult bot flies; one turtle ate some of the larvae that dropped from its body.

The manner in which box turtles are infested by bot fly larvae is uncertain. Possibly the eggs are picked up accidentally or laid on the skin while box turtles are foraging in dung. Belding (1952: 841) classifies the genus *Scarophaga* as semi-host-specific, depositing eggs in open wounds.

McMullen (1940), Rodeck (1949), and Rainey (1953), described individuals of *T. ornata* parasitized by *S. cistudinis*. Rokosky (1948) and Peters (1948:473) reported infestations in *T. carolina*. Infestations were the cause of death in the instances noted by Rainey and Rokosky.

PREDATORS

Few first-hand observations on predators of *T. ornata* are available and I have found little direct evidence of predation in the course of this study. In general, adults of the species seem to have few natural enemies other than man. Several of my colleagues at the University of Kansas have observed dogs carrying box turtles in their mouths or chewing on them. Frank B. Cross told me his dog caught and ate young *T. ornata* in Payne County, Oklahoma, and A. B. Leonard once saw a badger carrying one in Dewey County, Oklahoma. At the Reservation, a freshly killed juvenile was found beneath the nest of a crow (*Corvus brachyrhynchos*) and remains of a hatchling were found in a scat of a copperhead (*Agkistrodon contortrix*).

Dr. Fred H. Dale, Director of the Patuxent Research Refuge, Laurel, Maryland, kindly furnished photostatic copies of cards, from the Division of Food Habits Research of the U. S. Fish and Wildlife Service, recording the instances in which *Terrapene ornata* was listed as a food-item. In one instance the stomach of each of two nestlings, in the same nest, of the White-necked Raven (*Corvus cryptoleucus*) in Terry County, Texas, contained remains of recently hatched ornate box turtles; the remains of one turtle made up 64 per cent of the contents of one stomach, and parts of three turtles made up 80 per cent of the contents of the other stomach. Each of two stomachs of the coyote (*Canis latrans*) from Quay County, New Mexico, contained a "trace" of ornate box turtle.

Wild carnivores known to occur on the Damm Farm were raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), badgers (*Taxidea taxus*), and coyotes (*Canis latrans*); all were suspect as predators of ornate box turtles.

On December 10, 1953, ten dead box turtles (eight adults and two juveniles) were discovered at the top of a cut bank on the Damm Farm, within a few feet of a burrow that was used at least part of the time by a striped skunk. The condition of the turtles suggested that they had lain in the open for several weeks. The heads and legs were missing from most of the turtles and tooth marks were discernible on several of the shells. A logical explanation of this occurrence is that the turtles, using the burrow as a hibernaculum, were ousted by a predator that also inhabited the burrow. Turtles moving about sporadically in late autumn may be quickly chilled by a sudden drop in temperature and therefore be more susceptible to predation than at other times of the year. Two of my colleagues at the Museum of Natural History informed me that they had observed similar concentrations of dead *T. ornata* in winter.

In July, 1952, H. B. Tordoff collected eight shells of juvenile *T. ornata* in a dry creek bed near Sharon, Barber County, Kansas. Some of the shells had small tooth-punctures. The stream bed habitat and the appearance of the tooth punctures tended to incriminate raccoons as predators. Raccoons, more than any other carnivore mentioned above, possess the manual dexterity necessary to pry open the shell of a box turtle and bite away the soft parts. Badgers and possibly coyotes are probably the only local carnivores (excluding large dogs) that could crack open the shell of an adult turtle by sheer force.

Adults of *T. ornata*, since they occasionally molest small juveniles, must be considered in the category of predators. When captive adults and juveniles were fed from the same container in the laboratory, the turtles occasionally bit one another accidentally. Serious injury to the young was prevented by watching the adults closely and moving them away when they caught a smaller turtle by the leg or head. Similar accidents presumably occur in nature; juveniles and adults were sometimes found feeding side by side. William R. Brecheisen told me that adults kept in a stock tank at his farm in the summer of 1955 regularly and purposefully chased and bit small juveniles in the same tank. Brecheisen gave me a juvenile that had been so bitten; the right side of its head was badly damaged (the eye gone and a portion of the bony orbit broken) but was partly healed. Ralph J. Donahue told me that he saw an adult *T. ornata* attack a juvenal *T. carolina*, and provided a photograph of the incident. The juvenile was not injured.

Although small box turtles may occasionally be caught and killed by adults in nature, this seems not to constitute a major source of predation on the young.

Other animals that may prey upon young box turtles occasionally (and that were known to occur at the Damm Farm) are bullsnakes (*Pituophis catenifer*), red-tailed hawks (*Buteo jamaicensis*), marsh hawks (*Circus cyaneus*), crows (*Corvus brachyrhynchos*), and opossums (*Didelphis marsupialis*), and domestic cats.

Nest predators probably have greater effect on populations of *T. ornata* than do predators of hatchlings, juveniles, and adults. Four robbed nests were found at the Damm Farm; in each instance, striped skunks were thought to be the predators. E. H. Taylor told me that he once saw a bullsnake swallow an entire clutch of newly laid eggs before the female turtle could cover the nest.

DEFENSE

Box turtles rely for protection on the closable shell and on inconspicuousness; defense reactions, except in the rare instances that biting is provoked, are purely passive.

Box turtles handled in the course of field work varied widely in their reactions. Many struggled violently when being measured or marked whereas others were completely passive, closing the shell tightly and making it difficult for me to examine the soft parts of the body. These differences in behavior did not seem to be correlated either with sex or with age; generally lessened activity was associated with suboptimum body temperatures. All box turtles found in the field were extremely wary. As soon as one sighted me (sometimes at a distance of 200 feet or more), it became motionless with shell raised from the ground and neck extended (Pl. 28, Fig. 5). Some turtles remained in this motionless stance for half an hour or more, finally moving slowly away if I remained motionless. Turtles made no attempt to escape until I approached them closely or until they were in danger of being trampled by my horse; they would then move away with remarkable rapidity. Box turtles seemed unaware of an intruder until he could be seen or until he touched the turtle. When a turtle was approached from the rear, whistling, finger snapping, and normal footfalls did not attract its attention. Latham (1917:16) observed corresponding behavior in *T. carolina*. Wever and Vernon (1956) found the ear of *T. carolina* to be keenly sensitive to sounds in the range of 100-600 cycles per second but progressively less sensitive to sounds of higher and lower frequen-

cies. Surely a predator as stealthy as a coyote could approach a box turtle unseen and could quickly bite off at least one of the turtle's legs. Many of the mutilated box turtles that I observed may have survived such encounters with carnivores. The tendency of some individuals, when handled, to over-extend the limbs and neck (rather than closing the shell) in an attempt to escape, would make them easy victims for any predator.

Ornate box turtles were kept in my home, along with several cats. Initial behavior was characterized by mutual wariness; subsequently the cats would follow a turtle about the house for a time, occasionally pawing at an exposed limb. The turtles withdrew only when touched or when approached from the front. After a day or two the cats and turtles ignored each other, often eating and drinking from the same dishes without incident. Under these circumstances the cats, I believe, could easily have killed or injured the turtles. A turtle would occasionally gain the respect of a cat by biting it.

The strong odor sometimes given off by box turtles is produced by the secretions of four musk glands, two situated anteriorly on each side and opening by small, nearly invisible apertures beneath the fourth marginal scute. According to Hoffman (1890:9), two other musk glands, opening beneath the eighth marginal scute on each side, are also present in *Terrapene*; these posterior glands were not found in the several specimens of *T. ornata* that I dissected.

Strong odors were produced by nearly all small juveniles until they became accustomed to being handled. Older juveniles and adults produced strong odors only in response to pain or injury, as, for example, when they were killed in the laboratory prior to preservation or when they were being marked in the field. Young box turtles were capable of producing strong odors as soon as they hatched.

Norris and Zweifel (1950:3) considered the odor produced by *T. o. luteola* to issue from the ". . . concentrated, highly pungent urine . . ." voided by individuals when they were disturbed, and thought the production of odor to be a defense mechanism. Neill (1948b:130) reported that hatchlings of *T. carolina* with unhealed umbilical scars emitted a musky odor comparable to that of the stinkpot, *Sternotherus odoratus*; he thought the capacity to produce this odor was lost at about the time that the plastral hinge became functional.

The function of musk glands in *Terrapene* and, in all other turtles, is unknown. Since biting and nuzzling of the edges of the shell is

an integral part of the courtship of many turtles, odor produced by the musk glands may well be a means of social recognition or of sexual stimulation. Repellant odor may have a protective value in young box turtles but it is unlikely that larger predators would be frightened away or even discouraged by odor alone. In this respect Neill (*loc. cit.*) and I concur.

DISCUSSION OF ADAPTATIONS

Most of the morphological characteristics distinguishing box turtles from other North American emyid turtles, the most notable of which is the movable plastron, are modifications that have evolved as a result of selectional pressures favoring adaptation to more or less terrestrial existence. Similar adaptations have arisen independently in several branches of the emyid stock (see introduction). The genus *Terrapene* seems to have departed farther from a generalized emyid form than have other kinds of box-turtle-like chelonians. In a morphological sense, *Terrapene ornata* is clearly the most specialized member of its genus now occurring in the United States (my own studies have revealed that populations in western Mexico now referred to as *T. klauberi* and *T. nelsoni* are as specialized as *T. ornata* in some respects but more generalized in others). The present ecological study has demonstrated that *T. ornata* is specialized in habits as well as in structure. It is concluded that these specializations (of more generalized and perhaps more primitive conditions as, for example in *T. carolina*) constitute adaptation for terrestrial existence in open, semiarid habitats. These adaptations in *T. ornata* have resulted, in a few instances, in unique habits and structures; however, in most instances the adaptations have produced slight but recognizable changes that are definable only by degree of difference from other species of box turtles.

The closable shell of box turtles is of obvious survival value in providing protection for the soft parts of the body. In most of the species of *Terrapene*, the lobes of the plastron completely close the openings of the shell; closure is so tightly effected in some individuals that it is difficult to insert the blade of a knife between the adpressed margins of carapace and plastron. In *T. ornata* nevertheless, both lobes of the plastron are deficient on their lateral margins; four narrow openings remain when the lobes are drawn shut. Emargination of the plastron has occurred at the places where the limbs rub against it during locomotion. This

reduction of the plastron permits the body to be held off the ground during forward locomotion and seemingly permits a generally freer range of movement for the limbs. The possible disadvantages of an imperfectly closable shell seem to be compensated for by increased mobility. Reduction of the plastron is correlated with a general lightening of the shell, probably associated with the increased vagility of this species. Lightening of the shell is evident also in the relatively thin, loosely articulated bony elements. Shells of adult *T. ornata* that are old and weathered, or macerated (unless they are partly co-ossified because of injury), can nearly always be disarticulated with ease, whereas the bony elements in the shells of adult *T. carolina* (all races) are nearly always co-ossified or separable only after prolonged maceration.

The relatively low, flattened shell of *T. ornata* is an adaptation associated with the tendency to seek shelter in the limited space of earthen forms, burrows, or small natural cavities in the course of the warm season and to burrow more deeply into the ground in winter. *Terrapene ornata* is, in fact, the only species of the genus that may be considered an habitual burrower. Individuals of *T. carolina* tend to seek shelter in the warm season by making forms in dense vegetation or by digging into yielding substrata such as mud or humus, although they may burrow deeply into the earth in winter. Extreme weakness or absence of the middorsal keel of *T. ornata* seems to be a modification associated with burrowing habits and general adaptation to terrestrial life; the keel is similarly reduced in testudinids.

Retention of epidermal laminae (as opposed to regular exfoliation of the older parts of scutes) occurs in all box turtles, in several other groups of terrestrial emyids, and in testudinids. The phenomenon is here considered to be a specialization of scute shedding—developed in terrestrial and semiterrestrial chelonians—that provides additional protection to the shell against wear and minor injuries.

General shortening of digits—the result of reduction in number of phalanges as well as in their length, and to a lesser degree the shortening of metapodial elements—has occurred in several groups of chelonians with terrestrial tendencies (the opposite—lengthening of phalanges and metapodials, and hyperphalangy—has occurred in certain groups that are highly aquatic). The pes of box turtles has remained relatively unchanged in this respect; a few

phalanges on the lateral digit have been lost (especially in three-toed forms), but little reduction in length has occurred. The chief modification of the pes is a general narrowing brought about by the tendency of the digits to be crowded together, one on top of the other, rather than spread in a horizontal plane. Considerably more modification is seen in the manus of *Terrapene*. Phalangeal formulae (expressing the number of phalanges from the first digit outward) range from 2-3-3-3-2 (primitive in *Terrapene*) to 2-3-3-2-2 in the races of *carolina* and have the same range in the species of eastern Mexico. Extreme reduction in number (2-2-2-2-2) as well as general shortening of phalanges occurs in *T. ornata*. The formula is the same in the one specimen of *T. klauberi* that has been skeletonized. This modification of the forelimb in *T. ornata* has produced a more rigid, stronger manus that is well adapted to the requirements of burrowing and to locomotion over unyielding substrata. Shortening of the manus (and, to a lesser extent, the pes) has been accompanied by reduction and loss of interdigital webbing. It is noteworthy that *T. ornata* has achieved the same reduction in number of phalanges as *Gopherus*, which displays the extreme of specialization in this respect among North American turtles. The manus in *T. ornata* is not shortened so much as in *Gopherus*.

The first toe in males of *T. ornata* is uniquely widened, thickened, and inturned. Males of some other species of *Terrapene* have greatly enlarged rear claws, some of which turn slightly inward, but none has the flexed first toe hooklike as it is in *ornata* (a modified first toe, resembling that described for *T. ornata*, has been observed in a live male of *T. klauberi* [now KU 51430] since the preparation of this manuscript). In males of *T. ornata* the penultimate phalanx of the first toe has a normal, vertical articular surface on its proximal end. However, the distal articular surface (when viewed from the distal end of the phalanx) has its axis rotated away from the vertical plane approximately 45 degrees in a counterclockwise direction. As the foot is pronated and extended, and as the digits are flexed, there is a concomitant inward rotation of the first metatarsal at its proximal joint; this rotation, combined with the divergent planes of the articulating surfaces on the penultimate phalanx, cause the unguis phalanx to be flexed at right angles to the inner side of foot, in a plane perpendicular to that of the other toes (Fig. 21).

The precise function of the modified first toe of males is unknown,

although it is reasonably safe to assume that the modification is closely associated with clasping during coition. In the matings that I observed, the inturned first claw of the male secured a hold on the female's rump or just beneath her legs, whereas the remaining three toes gripped the edge of her plastron. The combined hold, on shell and skin, clearly affords the male a more secure position during coitus (whether the female clasps his legs with hers or not) than would a hold on skin or shell alone. Possibly intromission can be maintained in this position even when the female is attempting to escape. In males the plastron is less concave in *T. ornata* than in *T. carolina*. Furthermore, males of *T. ornata* are, on the average, smaller than females, whereas the reverse is true in *T. carolina*. Possibly the ability of the male to secure an especially firm grip on the female enhances the probability of small males mounting and inseminating larger females, whereas successful matings might otherwise be limited to pairs in which the male was the larger member.

It is worthy of note that turtles of the genus *Terrapene* are seemingly the only North American emyids that carry out the entire process of mating on land; other, semiterrestrial emyids (for example, *Clemmys insculpta* and *Emydoidea blandingi*) return to water for actual coition, although the precoital behavior sometimes occurs on land.

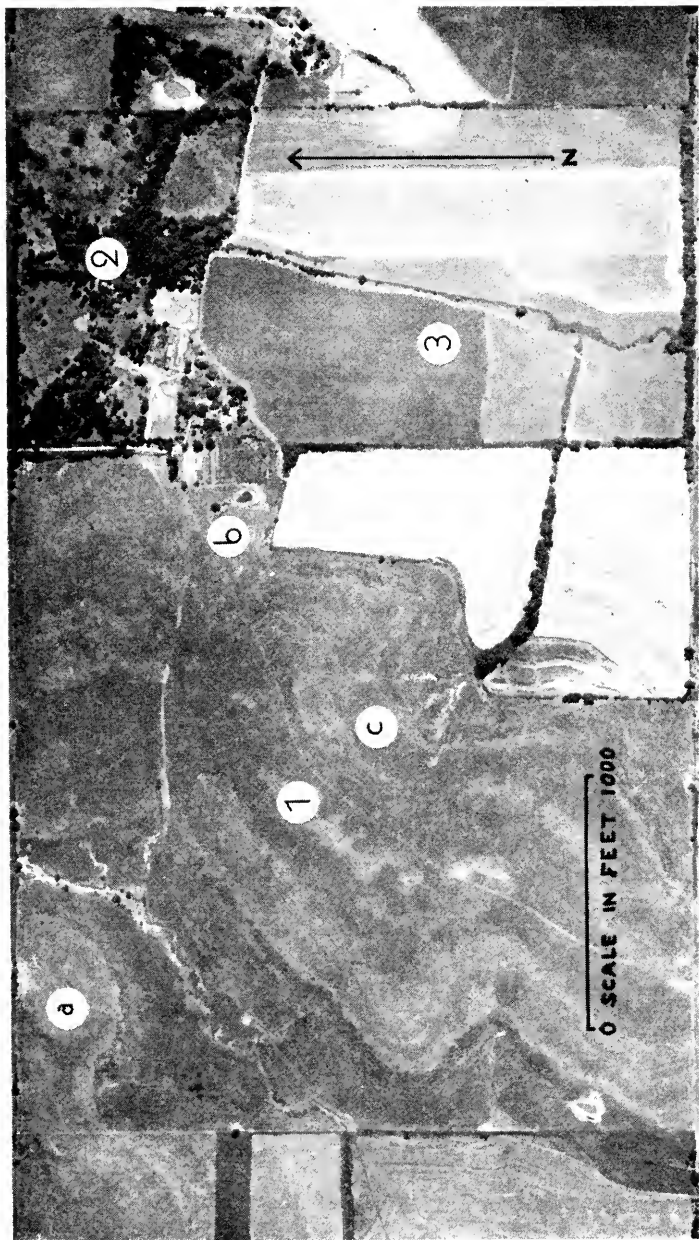
Nearly all gradations from a fully developed zygomatic arch to a greatly reduced arch can be observed in skulls of the various species of *Terrapene* (Fig. 2) (Taylor, 1895:586, Figs. 2-7). The highest degree of reduction is achieved in *T. ornata* and *T. klauberi*, both of which lack the quadratojugal bone and have no zygomatic arch whatever (except for an occasional, poorly defined anterior vestige formed by the postfrontal, the jugal, or both). Reduction of the zygoma clearly represents modification of a more generalized, complete arch. As yet there is no clear evidence that reduction of the zygomatic arch is of adaptive value. It is noteworthy, however, that similar reduction of the arch has occurred independently in a number of emyid and testudinid groups, nearly all of which have terrestrial or semiterrestrial habits. Although discussion of phyletic lines in *Terrapene* is beyond the scope of this report, I tentatively suggest that reduced zygomatic arches have arisen independently in more than one group of *Terrapene* and that similar reduction of the arch in two species of the genus does not necessarily indicate an especially close relationship of such species.

In a recent survey of cloacal bursae in chelonians, Smith and James (1958:88) reported *T. ornata* and *T. mexicana* to be among the few emyids that lacked these structures; in the opinion of the authors (*op. cit.*:94) cloacal bursae evolved in chelonians that required an accessory respiratory organ for long periods of quiescence (hibernation or aestivation) under water, and were secondarily lost in terrestrial forms that hibernated on land. The assumption is a reasonable one, at least in regard to emyids and testudinids. Lack of cloacal bursae in *T. ornata* and in all testudinids, can be correlated with the completely terrestrial habits of those turtles. Cloacal bursae seem to be vestigial in the species of *Terrapene* possessing them and to be of little or no use as respiratory structures (except perhaps in *T. coahuila*).

In most of the species of *Terrapene* the carapace has a pattern of pale markings on a darker background; however, unicolorous individuals are the rule in certain populations (for example, at the western edge of the range of *T. carolina* and in *T. ornata luteola*) and occur as occasional variations in other populations (in *T. yucatanana*, *T. mexicana*, and, throughout the range of *T. carolina*, albeit more commonly in the southeastern part of the range). Personal observation of interspecific and ontogenetic variation of color patterns of box turtles has convinced me that a basic pattern of more or less linear radiations is the one from which all other patterns (including spots, blotches, rosettes, and the unicolorous condition) can be derived, and, that the radial pattern is generalized and primitive for *Terrapene* (possibly for all emyids and testudinids as well). In the light of this conclusion, the radial pattern of *T. ornata* may be considered generalized. I suspect, however, that the pattern of a living species most closely approaching that of the primitive ancestral stock of *Terrapene* is the pattern of fine, wavy, dark radiations (on a paler background) present in young examples of *T. coahuila*.

Box turtles in general have lower reproductive potentials (as indicated by fewer eggs and longer prepuberal period) than do most aquatic emyids. This low potential seems to be compensated for by a lower rate of postnatal mortality (especially in adults) due to the protection afforded by the closable shell and the ability to recover from serious injury. *Terrapene o. ornata* and *T. c. carolina* are the only box turtles the life histories of which are known well enough to permit significant comparison. The reproductive potentials of *T. o. ornata* and *T. c. carolina* seem to be much the same.

PLATE 15



Aerial photograph of Damn Farm (July, 1954). Numbers and letters on photograph denote the following: 1. Main pasture with subdivisions a to c, respectively, northwest corner area, house pond area, and southern ravine area; 2. Wooded area; and, 3. Cultivated area.

PLATE 16



FIG. 1. A water-filled ravine in the northern part of the pasture at the Damm Farm (June 28, 1958). The subdivision of the pasture referred to in text as "northwest corner area" can be seen sloping into the ravine from the west (left background).



FIG. 2. A cow path leading southward away from a ravine, at the Damm Farm (June 28, 1958). Ornate box turtles used such paths as routes of travel in the course of their daily activities.

PLATE 17



FIG. 1. Grassland on crest of hill at Damm Farm with northeastern corner of main pasture in background (June 29, 1958).



FIG. 2. A bare area along the rock fence at northern edge of pasture at Damm Farm. Ornate box turtles could nearly always be found foraging in cow dung here and in similar areas along other fences (June 28, 1958).

PLATE 18

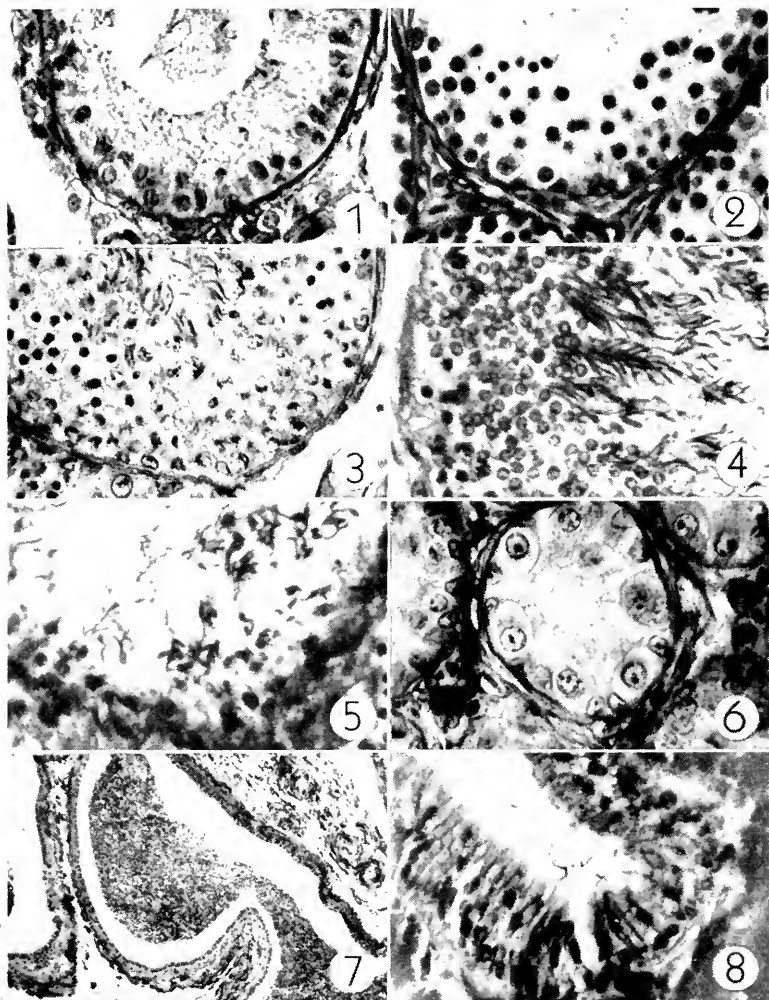


FIG. 1. A ravine in the southern part of the pasture at the Damm Farm (June 28, 1958). Small springs at the heads of such ravines produced marshy conditions at their bottoms and provided drinking water, in the form of shallow pools, for box turtles for at least part of the year. Banks of ravines provided suitable sites for the construction of nests and forms.



FIG. 2. A mulberry tree on the bank of a ravine near northern edge of Damm pasture (June 28, 1958). Box turtles frequented the area beneath the tree when fruit fell to the ground in June and July. The ravine shown here filled with water after being dammed in June, 1956.

PLATE 19



Representative stages in the spermatogenic cycle of *T. o. ornata* (all specimens obtained in Douglas County, Kansas, 1955). Figs. 1 to 5, respectively, are sections of seminiferous tubules obtained on May 17, June 14, July 15, Aug. 31, and Oct. 4. Fig. 6: seminiferous tubule of immature male (plastral length, 88 mm.), six years old, obtained on June 30. Fig. 7: section of epididymis from mature male obtained on April 17, three days after turtle emerged from hibernation; mature sperm form a continuous dark mass in center of epididymis. Fig. 8: sperm in uterine portion of oviduct of female obtained on April 18, 1954. Figs. 1 to 6 and 8 were photographed $\times 430$, and were enlarged 1.4 times. Fig. 7 was photographed $\times 35$, and was enlarged 1.4 times.

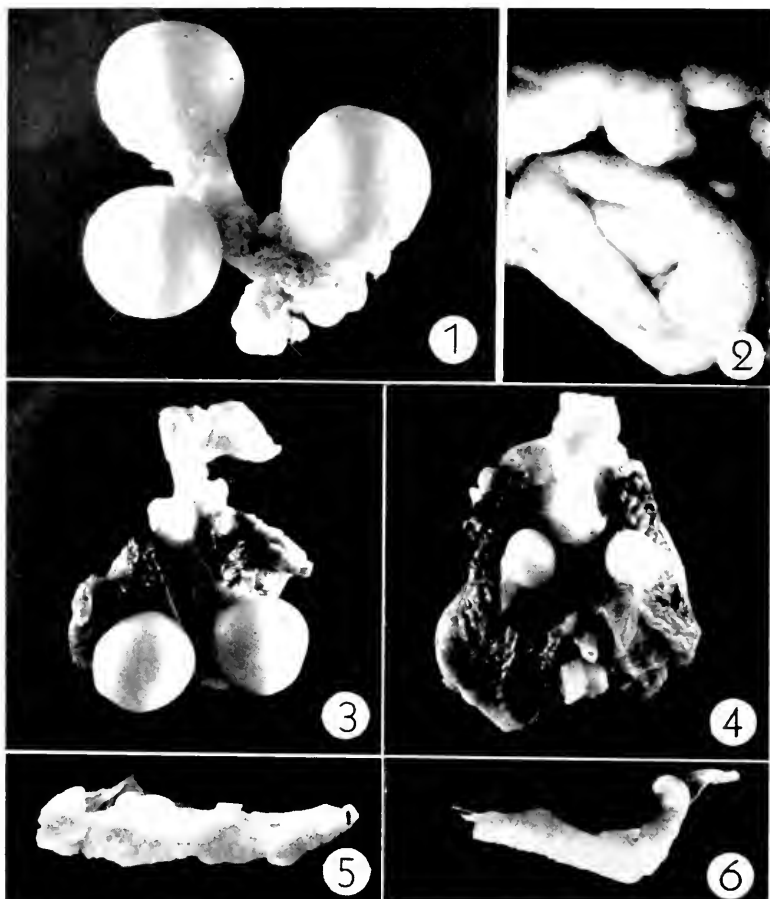


FIG. 1. Left ovary of mature female, prior to ovulation, May 15, 1956 ($\times 1$). FIG. 2. Fresh corpus luteum, June 2, 1956 ($\times 4\frac{1}{2}$). FIG. 3. Testes of mature male, August 31, 1955 ($\times 1$). FIG. 4. Testes of mature male, April 14, 1956 ($\times 2$). FIG. 5. Left ovary of subadult female (seven years old, plastral length, 114 mm.) that would have matured in approximately one year ($\times 1\frac{1}{2}$). FIG. 6. Left ovary of juvenal female (11 years old, plastral length, 95 mm., $\times 1\frac{1}{2}$).

PLATE 21



FIG. 1. A trial nest cavity excavated by a gravid *T. o. ornata* at the Damm Farm on June 8, 1956. The cavity was situated at the edge of a grassy area on the upper rim of a ravine embankment. Twelve-inch ruler shows scale.



FIG. 2. A depression, resulting from an old post-hole, showing the openings made by three box turtles as they left their hibernacula in April, 1956 (photographed May 15, 1956). Twelve-inch ruler shows scale.

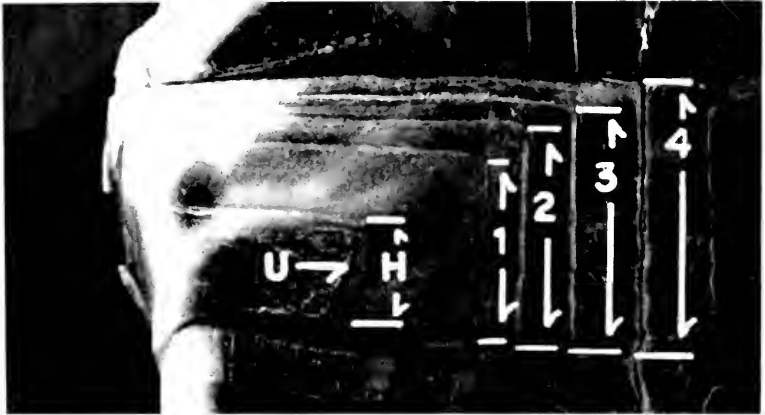


FIG. 1. Right abdominal lamina ($\times 2\frac{1}{2}$) of a four-year-old juvenal male showing method of measuring growth-rings. The last growth-ring (4) was formed at the end of the 1954 growing season. The first growth-ring (1) marks the end of the season of hatching (1950). The umbilical scar (U) is faintly visible. The growth-zone for 1955 (specimen captured June 23) is just beginning to show in interlaminal seam.

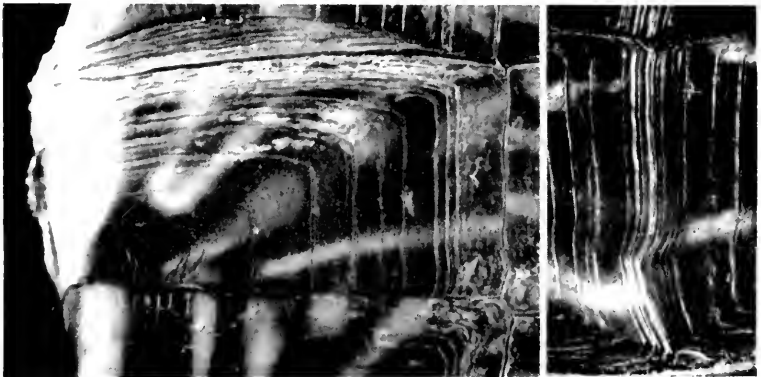
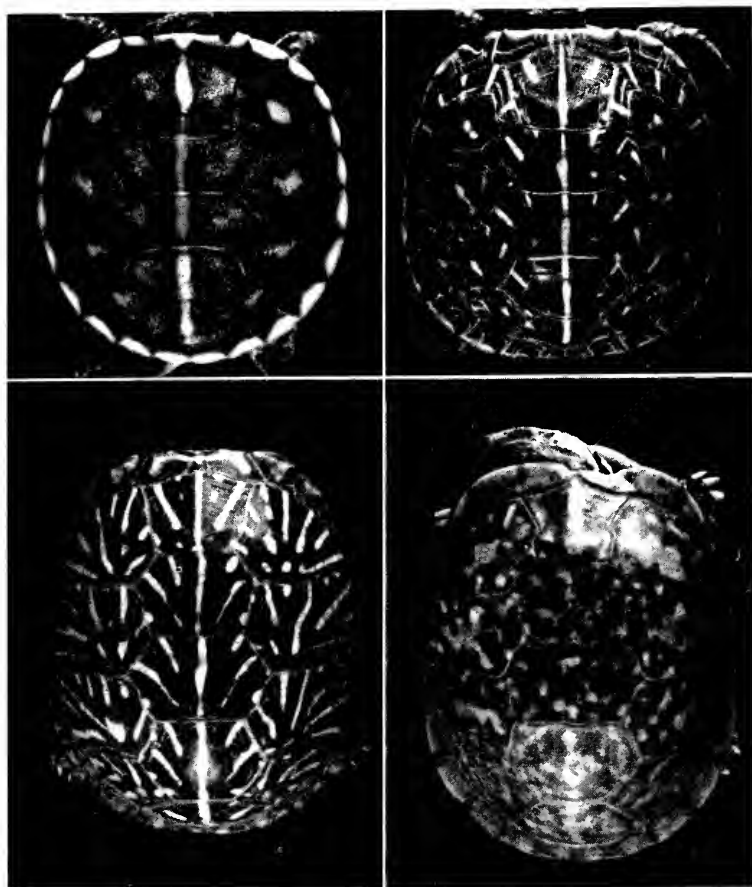


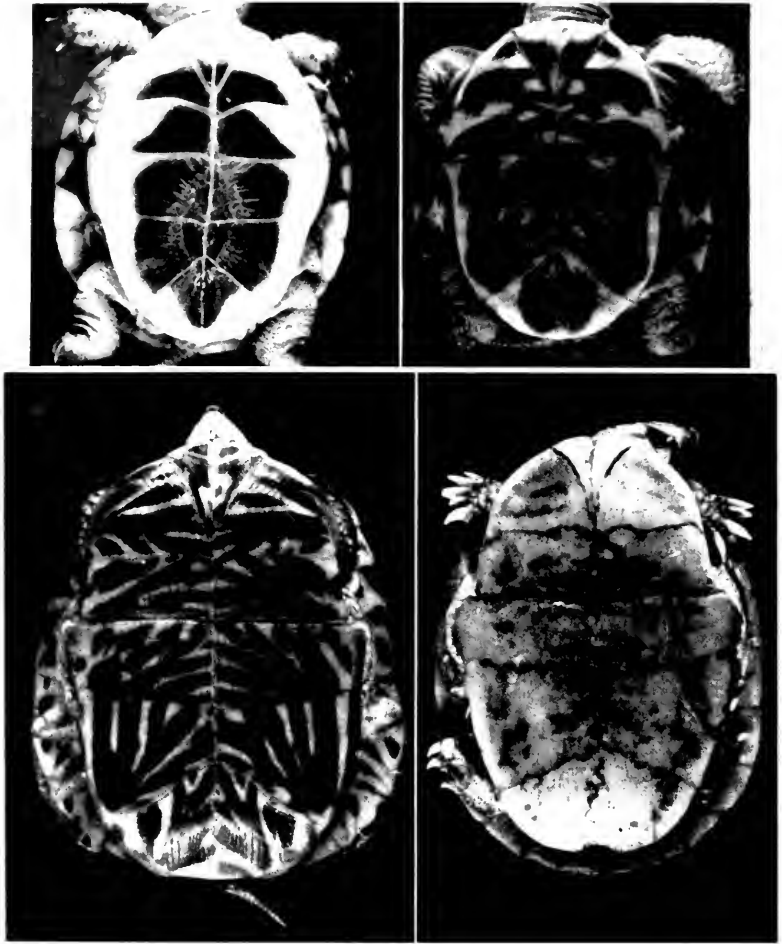
FIG. 2. *Left*—Right abdominal lamina ($\times 2$) of subadult female, eight years old. The last growth-zone was formed in 1954. Note the relatively small growth increments in 1952 and 1953. The growth-zone for 1955 (date of capture, May 8) is not yet visible. This specimen grew more in the season of hatching (1946) than the specimen shown above in Fig. 1. *Right*—Interpectoral seam ($\times 3$) of adult male showing slowness of growth in later life. The widest growth-zone seen here was formed in the tenth year and is followed by four zones too narrow to measure accurately. It is uncertain whether this specimen was still growing in the year it was captured (1923).

PLATE 23



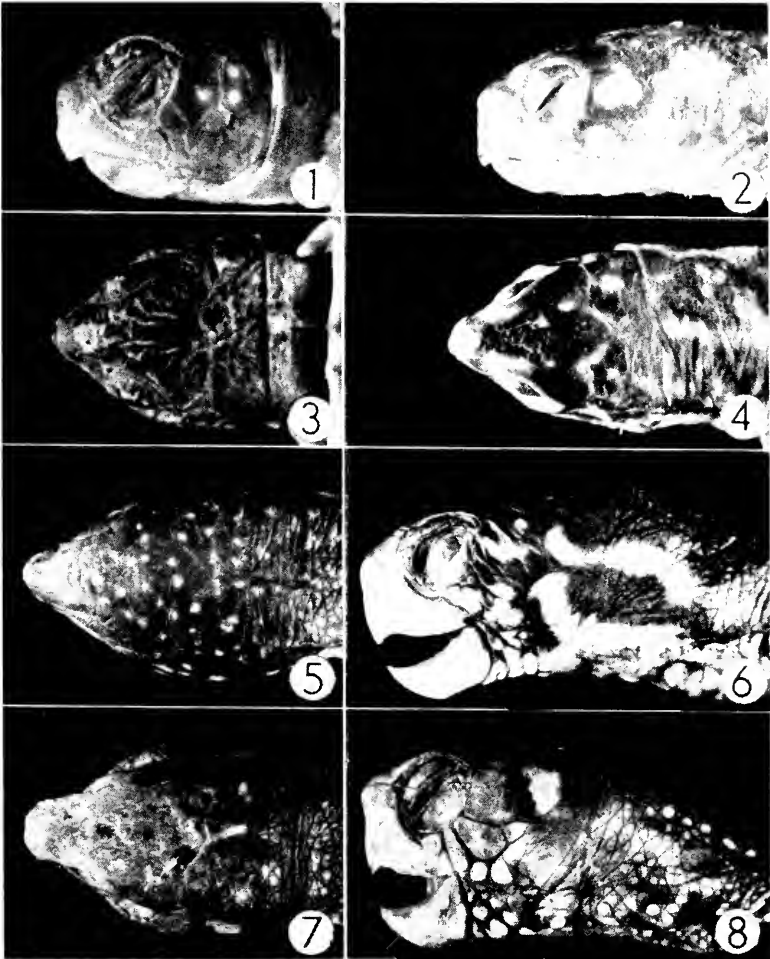
Ontogenetic change in color and markings of carapace. Radial markings begin to develop at the onset of epidermal growth. Markings are sharply defined in juveniles and young adults but may be obscured in later life by the encroachment of dark ground color or by wear on the shell. Figures are as follows: *Upper left*—Hatchling ($\times 1\frac{1}{2}$); *Upper right*—Juvenile ($\times 1$), one year old; *Lower left*—Juvenile ($\times 1$), one year old; *Lower left*—Female ($\times \frac{7}{16}$) showing typical adult markings; *Lower right*—Adult male ($\times \frac{1}{2}$) showing blotched pattern resulting from wear on shell.

PLATE 24



Ontogenetic change in color and markings of plastron. Dark markings on plastra of hatchlings are unbroken. Dark radiations appear when epidermal growth begins. Figures are as follows: *Upper left*—Hatchling ($\times 1\frac{1}{2}$); *Upper right*—Juvenile ($\times 1$); *Lower left*—Female ($\times \frac{7}{16}$) showing typical adult markings; *Lower right*—Adult male ($\times \frac{1}{2}$) showing the effect of wear on markings. Plastra of old individuals are sometimes solid yellow. Note the break in the plastron that has healed and filled with ligamentous tissue.

PLATE 25



Ontogenetic change and sexual dimorphism in shape, color, and markings of head and neck. Females retain much of the juvenal pattern of spots and blotches. In males, the top and sides of the head become greenish or bluish and markings are obscured. Figs. 1 and 3. Lateral and dorsal views of hatchling ($\times 3\frac{1}{2}$); Figs. 2 and 4. Lateral and dorsal views of juvenile ($\times 2$); Figs. 5 and 6. Adult female ($\times 1$); Figs. 7 and 8. Adult male ($\times 1$) showing relatively wider and more truncated snout in this sex.

PLATE 26



FIG. 1. A foraging station next to a rock fence at the Damm Farm (June 28, 1958). The box turtle in foreground was in the act of tearing apart a pile of partially dried cow dung to obtain dung insects.



FIG. 2. A depression ($\times \frac{1}{2}$) made by a foraging box turtle in a pile of partially dried cow dung (June 28, 1958). Similar "sign" of box turtles was found in cow dung everywhere on the pasture at the Damm Farm.

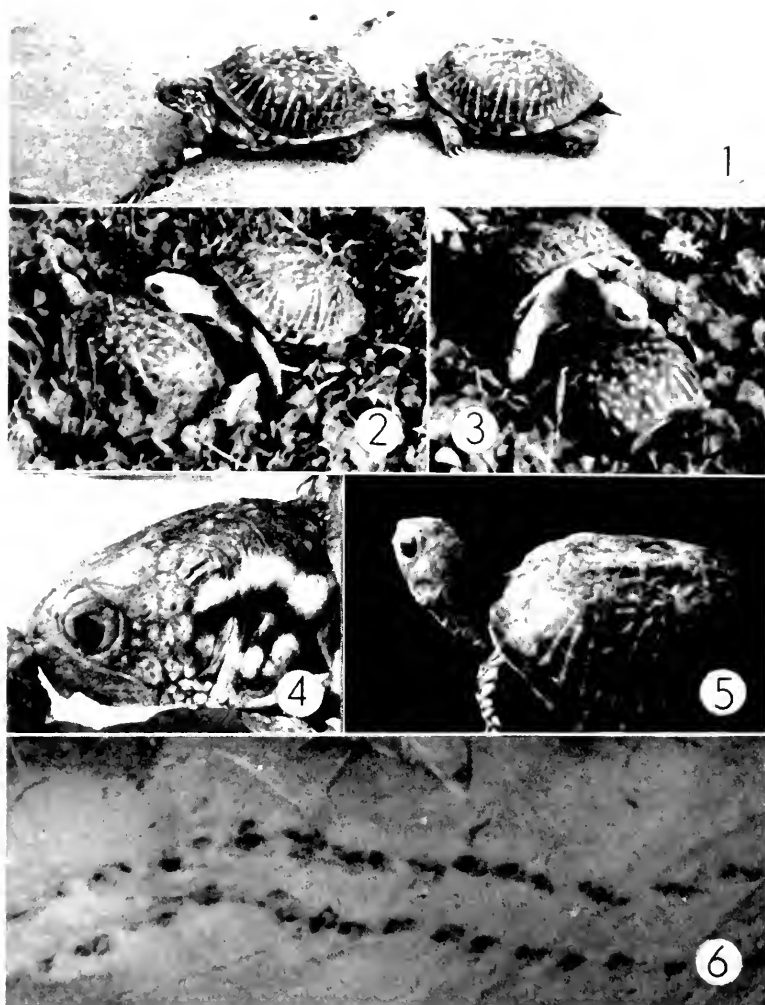
PLATE 27



FIG. 1. Thread-laying device ("trailer") taped to the carapace of an adult female *T. o. ornata*. The squares of tape on the sides are to keep the bent-over ends of the wire axle from catching on vegetation ($\times \frac{1}{2}$).



FIG. 2. A dermal pocket ("cyst") removed from an adult *T. ornata* and cut open to show two larval bot flies (*Sarcophaga cistudinis*) ($\times 2$, May 15, 1956).



FIGS. 1-3. Stages in courtship of *T. o. ornata*: male pursuing female and biting her shell; male hugging at female in attempt to mount; and, male just after mounting female ($\times \frac{1}{2}$). Fig. 4. *T. o. ornata* smelling food ($\times 1$). Fig. 5. *T. o. ornata* in attitude of alertness after detecting intruder ($\times \frac{1}{2}$). Fig. 6. Tracks of *T. o. ornata* in muddy ravine ($\times \frac{1}{2}$) (June 5, 1956).

PLATE 29

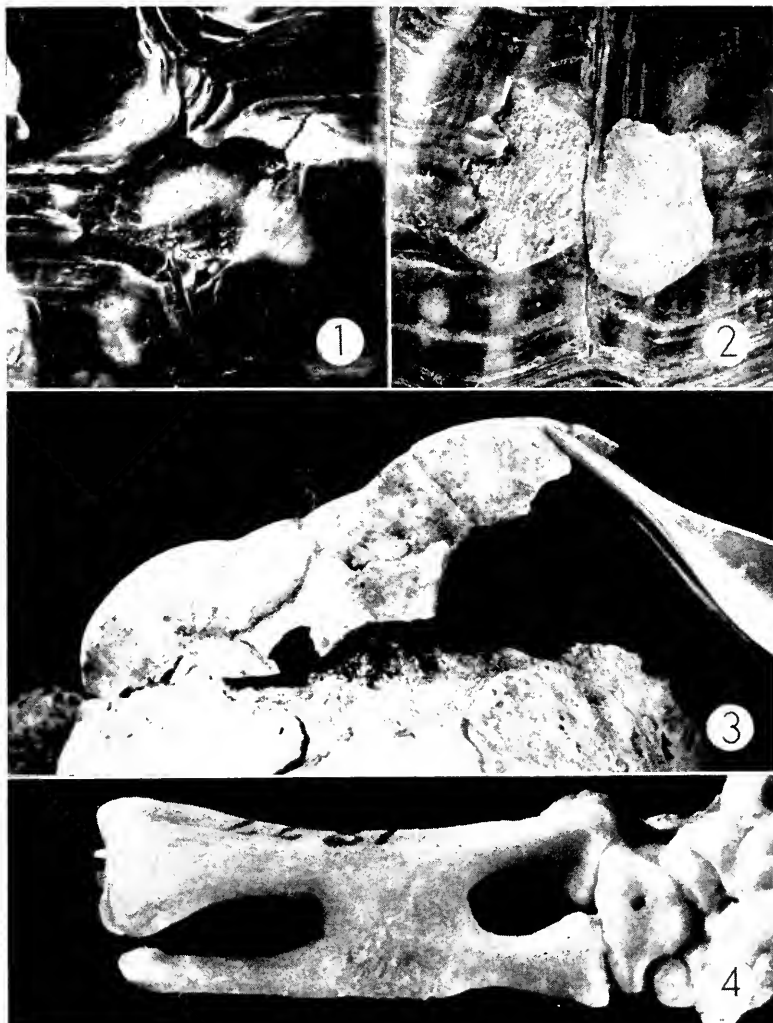
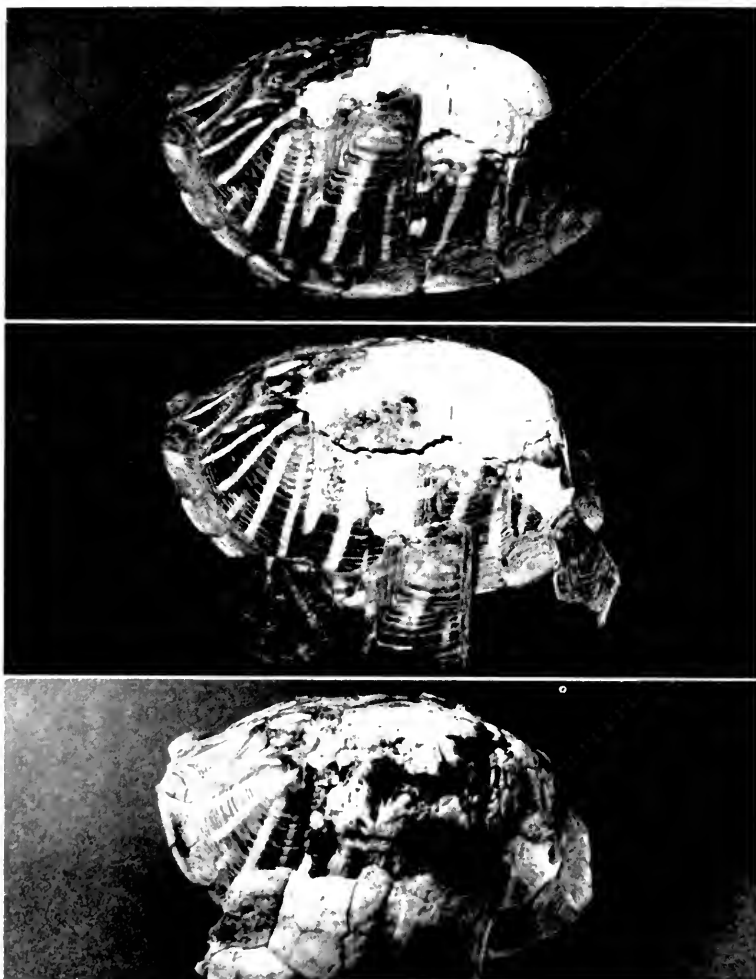


FIG. 1. A small, nearly-healed, injury on the carapace of an adult *T. o. ornata* ($\times 2$). Note regenerated epidermis at bottom of depression and two pieces of dead bone ("splinter scars") at upper right margin of depression. FIG. 2. Injured area on the carapace of a juvenal *T. o. ornata* ($\times 3$) with dead bone removed and laid to the right, exposing regenerating epidermis in its early stages. FIG. 3. Anterior edge of carapace (held away with forceps) of specimen of *T. carolina* (KU 51461, Gulf Co., Florida) that had been badly burned ($\times \frac{5}{8}$). Nearly all the scutes of the shell had fallen off and large pieces of dead bone could be pulled away, exposing a gnarled mass of regenerating bone and epidermis. FIG. 4. A fracture that has healed and joined the tibia (upper bone) to the fibula in a specimen of *T. o. ornata* (KU 1877, $\times 3\frac{1}{2}$).

PLATE 30



Top: A shell of *T. o. ornata* ($\times \frac{1}{2}$) as it was found at the Damm Farm June 1, 1956. A serious injury (probably resulting from burns) had exposed a large area of dead bone on the carapace. *Center:* Same shell with some of scutes removed. *Bottom:* Same shell with dead bone removed to expose regenerating epidermis and bone. Note that the injury involved several of the neural bones; the turtle probably died as a result of this injury but not before regeneration was approximately one-half completed.

Terrapene ornata seems to concentrate its breeding season (laying, incubation, and hatching of eggs) more nearly in the middle of the warm season than does *T. c. carolina*. This concentration probably is an adaptation for breeding in open habitats where, under environmental temperatures less equable than in forest, eggs would develop more rapidly and hatch sooner but would be less able to survive winter temperatures.

Males of *T. o. ornata* become sexually mature when younger and smaller than females and rarely grow as large as females. Nichols (1939a:20) indicated the reverse to be true of *T. c. carolina*; Nichols further indicated that growth continued some six to eight years after puberty. Most individuals of *T. o. ornata* attain maximum size within two to three years after puberty.

Although it is difficult to be certain about the adaptive value of color and pattern, it seems that in box turtles, as in many other kinds of animals, patterns and colors most nearly blending with those of the habitat have some selective value in providing concealment from enemies. The pattern of linear radiations in *T. o. ornata* closely resembles the patterns formed by light passing through grasses and associated vegetation and camouflages the turtle. In a similar manner, partial or complete loss of radial markings in *T. o. luteola* seems to provide concealment in habitats where vegetation is sparse and where blending with the substrate is of survival value. The patterns of blotches and broken radiations in most of the subspecies of *T. carolina* likewise provide camouflage by tending to match patterns formed by the light passing through a leafy canopy.

Although ornate box turtles are omnivorous, they probably depend on insects as a dietary staple. In years when preferred kinds of insects were unusually abundant, the turtles grew more than in other years. A large proportion of the insects eaten is obtained by foraging in or near dung. Alteration of the dung community—at least in a physical sense, but presumably also by influencing the successional stages of the dung biota—is one of the few evident effects of box turtles on the environment. Although certain kinosternids (Carr, 1952:93), emyids (Deraniyagala, 1939:257; Loveridge and Williams, 1957:198), and testudinids (Loveridge and Williams, *op. cit.*:247) eat mammalian feces, *T. ornata* is seemingly the only chelonian that habitually seeks its staple diet in dung. The habit seems to be yet another specialization for terrestrial existence. The carnivorous habits of *T. ornata* reverse the general trend toward omnivorous and herbivorous habits in other turtles

that have become partly (emyids) or wholly (testudinids) terrestrial.

It seems remarkable that none of the species of true tortoises occurring in the grasslands of the world has developed insectivorous habits or utilized the unique food niche (in regard to dung-foraging) filled by ornate box turtles in the Great Plains; tortoises are, as far as is known, strictly herbivorous. The ranges of *Gopherus* and *Terrapene* are now almost mutually exclusive and the two kinds do not compete with each other for food in the few places where they occur together. It is known, however, that box turtles (*T. longinsulae*, *ornata*-like, earliest known box turtle) and true tortoises (genera *Testudo* and *Gopherus*, see Williams, 1950:25-26, Fig. 2) occurred together in what is now the Great Plains in early Pliocene times and probably for some time before and after this. Assuming that food habits of fossil representatives of these genera were somewhat like the habits of recent representatives, ornate box turtles may have developed insectivorous habits at a time when other food niches were filled by herbivorous tortoises. Box turtles possibly survived subsequent changes in habitat that made it impossible for populations of large tortoises to exist in the Great Plains.

SUMMARY

Box turtles of the genus *Terrapene* are emyid turtles that are specialized for terrestrial existence. Two of the seven species now recognized—*T. ornata* and *T. carolina*—occur in the United States. *Terrapene carolina* inhabits forested areas in the east whereas *T. ornata* is characteristic of open grassy areas in the west; the ranges of the two species overlap in the broad belt of prairie-forest ecotone in the central United States. *Terrapene ornata* is considered to be the most specialized of living box turtles.

The natural history of *T. o. ornata* Agassiz was studied in the period, 1953 to 1957. Intensive field studies were made in Douglas County, northeastern Kansas, on a small area of prairie and on the University of Kansas Natural History Reservation. Field observations were made also in a number of other places in eastern Kansas. Laboratory studies supplemented field studies.

Habitats occupied are chiefly open areas; they vary in regard to food supply, temperature, moisture, and kind of soil. The grassy prairies of Nebraska, Kansas, Oklahoma, and northern Texas seem to provide optimum habitat for ornate box turtles; in these areas box turtles are active on a majority of days from April to

October. The subspecies *luteola* is adapted to the more rigorous and arid environment of the southwestern United States, where activity may be possible for only a few weeks in the year. The remainder of the year is spent in a state of quiescence. Factors limiting the distribution of *T. ornata* are: 1) the presence of a substrate too hard to permit digging of nests and forms (altitudinal distribution in southwestern United States and distribution at western edge of the range); 2) temperatures causing the ground to freeze deep enough (approximately 30 inches) to kill turtles in hibernacula (northern edge of range); and, 3) the lack of one or more relatively wet periods in the course of the warm season, preventing at least temporary emergence from quiescence (southwestern part of range). The activities of man probably have affected population density in local areas but limit the geographic range only in the north (Blanchard, 1923:19-20, 24) where intensive cultivation probably has excluded the species.

Preferred habitat in northeastern Kansas is open rolling grassland grazed by cattle; populations are most dense near natural breaks in the grassy vegetation such as fences, scattered rocks on hillsides, ravines, and stream-beds.

Mating occurs most commonly in spring and autumn; courtship behavior includes pushing and biting on the part of the male. In coitus the hind legs of the male are held tightly by the female; the male falls backward after coitus, still clasped by the female. A few sperm are stored in the oviducts; fertilization without re-insemination can occur. The spermatogenic cycle begins in May and reaches its peak in September, when large numbers of sperm and spermatids are present in the testes; the cycle is completed in October, when sperm pass into the epididymides. The testes are smallest in spring and largest in September. Females are inseminated with sperm produced in the preceding year. The ovarian cycle begins in midsummer, soon after ovulation, and continues up to the time of the next ovulation. Follicular growth is rapid in the period from spring emergence to ovulation. Large follicles remaining after ovulation represent, in many instances, eggs that will be laid later in the same season. Follicular atresia is never great enough to account for the destruction of all large follicles remaining after ovulation. All mature females lay at least one clutch of eggs per year. It is estimated that one-third of the females produces two clutches of eggs in a single season. Second clutches contain fewer eggs than first clutches. An alternation

of ovarian activity occurs, whereby one ovary is more active than its partner in one season and less active in the next season. Alternating activity of ovaries accounts in part for the reduced number of eggs in young females, breeding for the first time, and in older, nearly senile females. Extruterine migration of ova results usually in a more even distribution of eggs in the oviducts. Corpora lutea constitute an accurate record of the number of eggs produced by the ovary as well as the number of eggs laid.

Nesting occurs from May through July but is most common in mid-June; some of the females nesting early in the season lay a second clutch of eggs in July. Nests are dug in the earth by the female using her hind legs. Preferred nesting sites are open, well-drained places with a soft substrate. The nesting site is selected after a period of wandering, in which the female tests the substrate at a number of places; some females search for a nest site for more than a week. Nest digging begins in the evening and is usually completed after dark. Captive females dug a preliminary cavity in which the body rested during the digging of the main nest cavity. The entire clutch of eggs is laid in one nest. The average number of eggs in 23 clutches was 4.7 (range, 2 to 8). The average size of eggs tends to be inversely proportional to the number of eggs in a clutch. Eggs increase in bulk by absorption of water in the course of incubation. Immersion in water for short periods does not harm eggs. The incubation period under favorable environmental conditions is approximately 65 days; cool, damp conditions prolong the incubation period and probably constitute an important factor of prenatal mortality in certain years. Eggs that do not hatch before winter probably do not survive. Emergence of hatchlings from the nest may, however, be delayed until spring if the soil is dry in autumn. Hatchlings can probably escape freezing by burrowing into the walls of the nest. Infertility and prenatal mortality account for at least 40 per cent of the eggs laid, according to laboratory findings. Progeny of a single adult female (considering factors of mortality, multiple layings, and average age of puberty) would number approximately 300 after 20 years. Reproductive processes probably continue throughout life, although possibly at a somewhat reduced rate in later life.

Young box turtles are active soon after hatching but become quiescent if allowed to burrow in soil or if they are covered with damp cotton. Some captive hatchlings take live food in the first days of life but others do not eat until the following spring; initia-

tion of growth is coincident with initiation of regular feeding. The yolk sac retracts mainly during hatching; it sometimes ruptures after hatching. The caruncle remains on the beak for a variable length of time, but never is present in the spring following hatching.

Major growth-rings on the epidermal laminae are formed regularly, one after each season of growth, in the first 10 to 14 years of life. Minor growth-rings occur between major rings and are shallower. Growth of epidermal laminae results from the formation, in spring, of a new layer of epidermis beneath the existing scute. The peripheral projection of the new layer is distinct in texture and color from the older part of the scute and is separated from it by a major growth-ring. Minor growth-rings form when growth slows or temporarily stops during periods of quiescence; no new layer of epidermis is formed. Growth-rings constitute an accurate record of growth that can be studied at any time in the life of the turtle; they are accurate indicators of age only as long as regular annual growth persists.

Growth in the season of hatching depends on early hatching and early emergence from the nest. Turtles that remain in the nest until spring probably do not grow. Slightly less than half of the free-living individuals studied grew in the season of hatching. Precociousness in early life often results in the attainment of sexual maturity at an earlier than average age.

Growth is rapid at first (increments in plastral length average 68, 29, and 18 per cent, respectively, in the first three years) and then slows gradually until puberty. Attainment of sexual maturity is more closely correlated with size than with age. Males mature when smaller (76 per cent were mature when plastron 100 to 109 mm. long) and younger (average age, eight to nine years) than females (66 per cent were mature when plastron 110 to 119 mm. long, average age at maturity, ten to eleven years) but females grow larger than males. A few individuals of each sex reach puberty three to four years sooner than average.

The average number of growing days per season is approximately 160. Amount of growth in any season depends on climatic factors that influence food supply and foraging conditions. Growth rate is directly correlated with precipitation, being highest when large populations of grasshoppers and long periods of favorable weather occur in the same year. Zones of epidermis formed in years when growth was especially slow or especially fast constituted landmarks

that were helpful in interpreting growth-histories. Growth stops two to three years after puberty. The total growing period is estimated to be not more than 15 to 20 years. Longevity is estimated to be approximately 50 years.

A number of changes in structure and appearance occur in the period from hatching to puberty. Fontanelles of the bony shell close at or before puberty. Movable parts of the plastron are not functional until the fourth year. Markings on the carapace change from a series of dots to distinct, straight-sided radiations, and a similar pattern develops on the plastron. Markings on the heads of females resemble those of juveniles but males have greenish heads. Males further differ from females in having a red iris, more brightly colored antibrachial scales, and a turned in first toe.

Analysis of some 500 body temperatures (Centigrade) obtained under natural conditions revealed the following: the optimum temperature for activity is near 30 degrees; box turtles emerge from cover usually when body temperature is 24 degrees or higher, and almost never when the body temperature is below 15 degrees; body temperature is raised to optimum by basking in open areas although activity begins at suboptimum temperatures if basking is impossible; cover of dens, burrows, or forms is sought when the body temperature rises above 30 degrees; and, maximum and minimum body temperatures that would be lethal to box turtles (for prolonged periods) are approximately 40 and zero degrees, respectively. Laboratory experiments showed speed of response to environmental temperature to be inversely proportional to bulk; hatchlings could be chilled or warmed more than twice as fast as adults and were active within a narrower range of temperature. Ornate box turtles in general are subject to a narrower range of thermal activity than are aquatic turtles that occur in the same areas.

Box turtles are dormant approximately five and one-half months of the year—from late October to mid-April. Warm weather in November and late March sometimes stimulates temporary activity but dormancy is uninterrupted from mid-November to early March. Forms, dens, and burrows are used as hibernacula. Depth of hibernacula is dependent on severity of temperatures and amount of vegetational cover; hibernacula in open grassland were seven to 18 inches deep whereas those in wooded areas were six inches or shallower. Box turtles are ordinarily solitary when hibernating. Injuries and deaths due to freezing probably occur in the coldest part of the winter. The lowest body temperature of a turtle that

survived a winter was 2.7 degrees; an individual, the temperature of which was nearly zero for several days, subsequently died. Turtles burrow upward at the end of hibernation and remain just below the surface for a week or two before emerging. The primary stimulus for emergence seems to be a period of warm moist weather.

Populations of *T. ornata* observed under natural conditions were chiefly carnivorous, although captives ate a variety of animal and vegetable matter. Insects, consisting chiefly of beetles, caterpillars, and one species of grasshopper, comprised approximately 89 per cent (by volume) of the food present in stomachs. Beetles (chiefly scarabaeids and carabids) are obtained in or near dung and seem to constitute the most important staple element of the diet. Piles of dung, disturbed by turtles in the course of their foragings, were characteristic "sign" of *T. ornata* in the areas studied.

Insects form the bulk of the diet for most of the year, although certain other foods, when especially abundant for short periods (mulberries for example), are eaten in large quantity or eaten to the exclusion of all other foods. Ornate box turtles occasionally eat the eggs and young of ground-nesting birds and slightly damage vegetables, but in no instance do these feeding habits significantly affect the economy of man. Box turtles probably benefit man by destroying large numbers of crop-damaging insects (locustids and noctuid caterpillars).

Box turtles were more numerous than most kinds of reptiles at the Damm Farm and were the most conspicuous of any kind of reptile. One hundred and ninety-four turtles were marked; one-fourth of these were recaptured at least twice. Population density in certain areas of favorable habitat ranged from 2.6 to 6.3 turtles per acre. The total number of individuals on the study area was estimated to be 286. The marked population consisted of 53 per cent adult or subadult females, 31 per cent adult males, and 16 per cent juveniles of undetermined sex. Only six individuals had plastra shorter than 60 millimeters. Small box turtles are not so rare as these samples indicate; they are infrequently obtained because their smallness and ability to blend with the substrate make them difficult to see. More females than males were found in all months of the season of activity, excepting April and August when more males were found; the preponderance of females was greatest in the nesting season (June and July).

Ornate box turtles walk with the shell held off the substrate. They are able to climb steep embankments or low barriers with

some facility. Swimming ability is sufficient to permit survival in water and traversal of water-barriers but ornate box turtles almost never swim voluntarily.

Daily activity consists of periods of basking, foraging, and rest, the durations of which are influenced by temperature and humidity. There is no activity after dark except that of nesting females. After several days of activity there is a period of rest; rest periods seemed not to be correlated with climatic conditions. The average distance traveled per day in summer is 200 to 300 feet. Movements of gravid females are more extensive (average, 363 feet per day) than those of other members of the population; one individual traveled approximately one-fourth of a mile in a single day. Turtles removed from their normal home ranges traveled farther per day than any other group. Movements in autumn are less extensive (average, 152 feet per day) than at other times in the season of activity.

Individual box turtles tended to remain in small areas for long periods; these areas were interpreted as home ranges. The estimated average radius of 44 home ranges was 278 feet (average area, 5.6 acres). The average area of eight home ranges that were actually measured was five acres. General suitability of habitat and certain physical features of terrain (rock fences, ravines, barren fields) that acted as barriers were thought to be the most important factors governing size of home range. Of two turtles removed more than one-fourth of a mile from their home ranges, one homed and one did not. Home ranges of turtles of all ages and sexes overlap broadly. There was no indication that territoriality or social hierarchy existed in the population studied.

Box turtles are subject to injury from natural causes that include fire, cold, molestation by predators, and trampling by cattle. Automobiles and farm machinery now constitute major causes of mortality and serious injury. Capacity to recover after serious injury is great but there is increased chance for secondary injury, infection, and predation in the period of recovery. Pits on the shell from unknown causes ("shell pitting") are less common in ornate box turtles than in other kinds of turtles.

Ectoparasites infesting *T. ornata* are larvae of chigger mites (genus *Trombicula*) and larvae of bot flies (*Sarcophaga cistudinis*). Ectoparasites usually have little adverse effect on the turtles, although heavy infestations cause occasional injury or death.

Few natural enemies other than man are known; however most

wild carnivores as well as opossums, large birds, and domestic dogs and cats are suspect as predators. The incidence of predation on eggs and small juveniles is far greater than on older juveniles and adults. Adults of *T. ornata* occasionally attack smaller individuals.

Ornate box turtles are able to detect the presence of intruders, by sight, from a distance of several hundred feet in open country; apparently, intruders are not detected until seen. Defensive behavior is passive; the shell is closed tightly in response to painful stimuli and, in some instances, at the sight of an intruder. Juveniles usually void odoriferous fluid from the musk glands when handled but adults do so only in response to pain or injury. The function of the musk glands is unknown; possibly the odor of musk is a means of sexual identification or stimulation. Although the musk is probably distasteful to predators, repellent odor alone seems to be of doubtful value as a defense mechanism.

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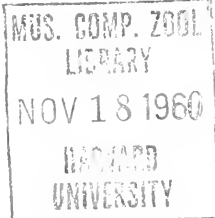
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PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS
1960



28-773



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PRINTED IN
THE STATE PRINTING PLANT
TOPEKA, KANSAS

1960



2S-4430

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 21. Pleistocene pocket gophers from San Josecito Cave, Nuevo León, México. By Robert J. Russell. Pp. 539-548, 1 figure in text. January 14, 1960.
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