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By Robert F. Clarke

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An Ecological Study of Reptiles and Amphibians In Osage County, Kansas

By Robert F. Clarke*

INTRODUCTION

Seventy-three years ago Cragin (1885b), one of the pioneers of Kansas herpetology stated: "In problems of faunal relations we can direct our attention to no department of zoology more profitably than to that of herpetology, the intimate relations of reptiles and batrachians to their climatic and topographical surroundings (partly dependent on the fact that they do not migrate) rendering them exceptionally important factors in all such problems." Today, the problems of the interrelationships among reptiles, amphibians, and the environmental factors are, as yet, poorly understood. The ecology of the reptiles and amphibians in Osage County has not been studied previously. Of the 105 counties within Kansas, county lists of reptiles and amphibians have been compiled for 7 counties, only. Several lists have been prepared also for more restricted areas, such as lakes and state parks. Most of the lists are merely species accounts and do not elaborate on the ecological factors which were present in the areas at the time of the study. Pertinent lists are cited in the review of the literature.

Bryce Brown (1950), writing on Texas herpetology stated: "Every regional study, whether exhaustive or preliminary, is to be welcomed as a forward step, conventionally though it may be carpeted, toward an idealistic goal. It is likewise a step many can embrace for other ends." It appears that the reptiles and amphibians of each political subdivision of the state should be studied if one is to understand fully the herpetological fauna of the entire state.

Smith (1956) published the most recent report on the reptiles and amphibians of Kansas. In this report, hypothetical ranges were indicated on the distribution maps as well as individual locality records of collection. For Osage County, actual collection localities were given for 39 species, but all, or part, of the county was included in the hypothetical range of 28 other species. Most of the species records given for Osage County were based on collections from one site only for each species. In view of the paucity of information concerning the reptiles and amphibians, the preent study was initiated.

Dice (1952) stated, "In the first part of any investigation the emphasis must be on the identification and enumeration of the organisms that

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are present, the description of the habitat and of its variations and the ascertainment of the relations between the several elements of the community and its habitat."

This study, being an initial investigation of the area, was begun with the following objectives in mind:

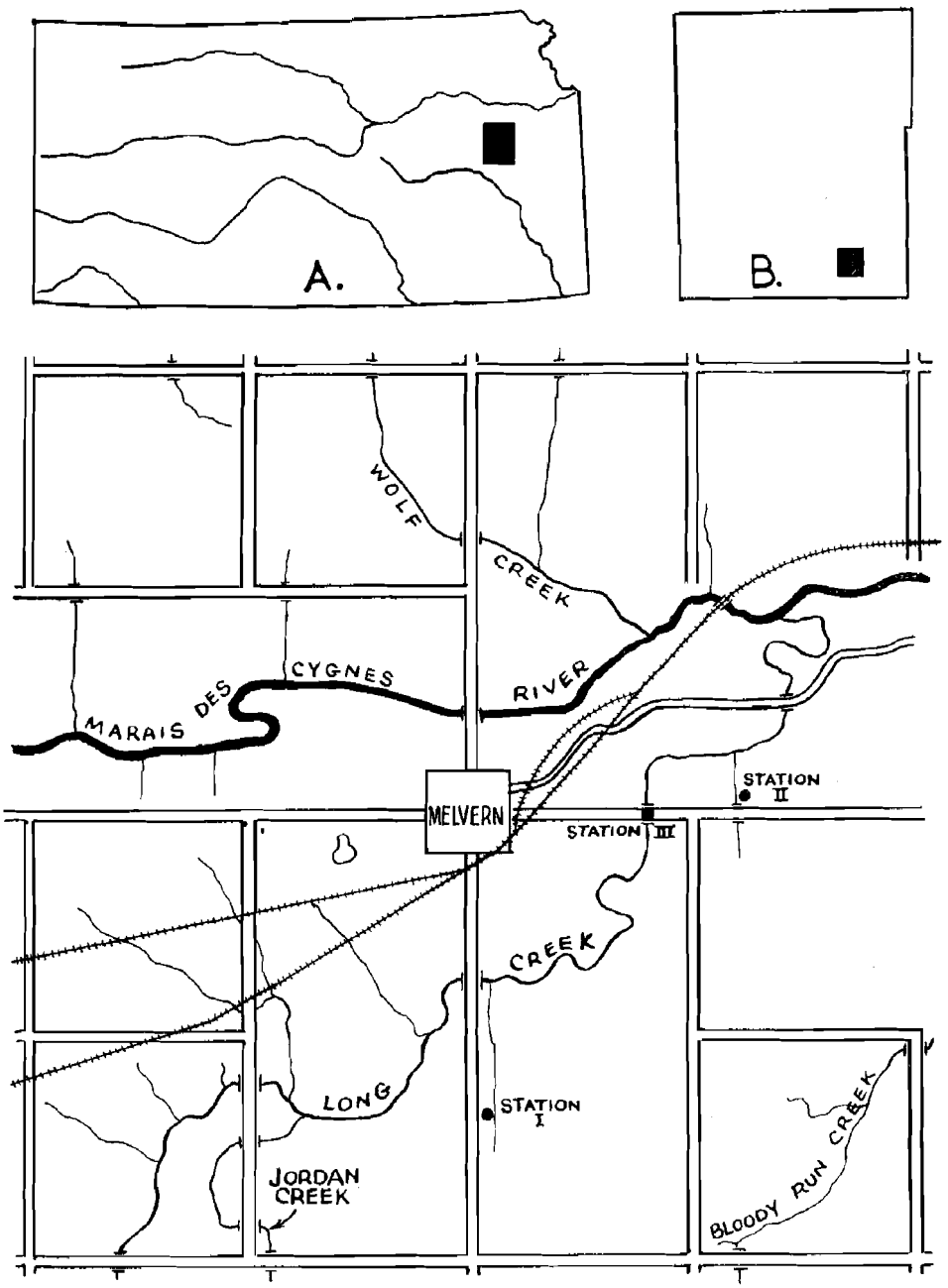


Fig. 1. Map of study area. (A) Location of Osage County in Kansas; (B) Location of study area in Osage County.

1. To prepare as complete a list as possible of the reptiles and amphibians. This list to be based on personal observations and collections from the area.
2. To prepare a list of the dominant vegetation in each of 6 communities present in the area, and to ascertain the relationship between habitat and species of reptiles and amphibians present.
3. To record the seasonal variation in abundance of the species found.
4. To study the association of the various species with each other.

Collections and observations were restricted to a 16 square mile area, having at its center the town of Melvern, Osage County, Kansas (Fig. 1).

The study was begun in January, 1950, and concluded in June, 1956. During the years 1950 through May, 1955, no systematic investigation was undertaken, and collections and observations were frequent, but irregular. In June, 1955, three stations were chosen in different habitats. These stations were visited and records made at least once a month, more often during the period of non-hibernation, until termination of the study in June, 1956. Periods of observation were limited primarily to those made during daylight hours. There were a few observations made during darkness, however. Hibernating animals were not included in this study, nor was any particular effort made to capture or study the aquatic forms. Observations were limited to the recording of the following data: (1) kinds of species, (2) number of individuals, (3) location, (4) habitat, (5) air and ground temperatures, and (6) weather conditions.

REVIEW OF THE LITERATURE

The first of the important accounts of Kansas herpetology was the report by Dr. Edward Hallowell (1857) upon a collection obtained by Dr. W. A. Hammond. This paper cited 24 species and subspecies from Kansas, which at that time included a much larger area than at present.

Other important herpetological accounts prior to 1900 were the list of Kansas snakes in the Kansas University Museum by Mozley (1878), the contributions of Cragin (1881, 1885a, 1885b, 1885c, 1885d, 1886a, 1886b, 1894), and Yarrow's (1883) check list of North American reptiles and batrachians.

The first account of statewide coverage was the preliminary catalog of Kansas reptiles and amphibians (Cragin, 1881). This report listed 88 species and subspecies, many of which subsequently have proven synonymous with other forms or have not been found to occur in the state.

Branson (1904) published a list of the snakes of Kansas, which was revised in 1929 by Edward H. Taylor. In 1928, Charles E. Burt (1928a) published a key to the species of Kansas lizards. Burt (1928b) also wrote a full account of the lizards of Kansas, including ecological notes, in the same year. In this latter publication distributional maps were used to in-

dicate locality records by county. As in Burt's report on the lizards, the *Amphibians of Kansas* by H. M. Smith (1934) also used maps to illustrate distributional records by county. Ecological and taxonomic data were reported in this account.

The only recent comprehensive account of the Kansas herpetofauna was the *Handbook of Amphibians and Reptiles of Kansas* (H. M. Smith, 1st ed. 1950, 2nd ed. 1956). It listed 105 species and subspecies known to occur within the borders of Kansas and 13 others which were of expected occurrence. The keys and distributional records were particularly useful.

Distributional records for Kansas localities have been published in many journals. Some of the important reports are: Breukelman and Smith (1946), Burt (1933), Grant (1937), Hall and Smith (1947), Kirn *et al.* (1949), Maldonado-Koerdell (1950), H. M. Smith (1946b), and Tihen (1938).

Check lists have been published for the following Kansas counties: Chase and Lyon (Breukelman and Downs, 1937; Breukelman and Clarke, 1951), Doniphan (Linsdale, 1927), Ellis (Brennan, 1936), Franklin (Gloyd, 1928), Riley (Burt, 1927; H. M. Smith, 1931), and Morton (Taylor, 1929a). In addition, the herpetological fauna of the Pigeon Lake area of Miami County was reported by Gloyd (1932), and Tihen and Sprague (1939) published a paper on the amphibians, reptiles, and mammals of Meade County State Park.

One of the first reports to discuss faunal relationships of Kansas reptiles and amphibians was by Cragin (1885b). Food habits of Kansas lizards and batrachians was the subject of a paper by Hartman (1907), in which he cited the stomach contents of fifteen species. Later ecological reports were those of Dice (1923), Grant (1927), Hoyle (1936), and Brennan (1938).

Recently, several publications have resulted from studies made at the University of Kansas Natural History Reservation in Douglas County. Fitch (1952) summarized the ecological situation there with a description of the area and check lists of the plants, invertebrates, reptiles, amphibians, and birds. Three ecological studies of single species have appeared from there. Freiburg (1951) reported on the narrow-mouthed toad, *Microhyla*, and Fitch (1954, 1955) on the lizards, *Eumeces fasciatus* and *Eumeces obsoletus*.

There are few distributional records for Osage County in the literature. Blanchard (1921) listed *Lampropeltis getulus holbrooki* from Long Creek and *Lampropeltis c. calligaster* with no specific locality. The latter species was reported 4 miles northeast of Overbrook by Breukelman and Smith (1946).

Burt (1928b) listed *Eumeces obsoletus* from Osage County with no other locality data. Taylor (1936a) did, however, giving Burlingame as the collecting site for two, and did not specify the locality for nine others.

H. M. Smith (1934) listed the following: *Bufo a. americanus* (1 mile southwest of Carbondale), *Acris gryllus* (Quenemo), *Pseudacris nigrita triseriata* (Carbondale), *Hyla versicolor* (Carbondale), *Rana catesbeiana* (Quenemo), and no specific locality for *Rana pipiens.*

In his monograph on the rattlesnakes, Gloyd (1940) gave as the locality for *Crotalus h. horridus* 5 miles northeast of Carbondale. Two localities were listed for the massasauga, *Sistrurus catenatus tergeminus,* 6 miles south of Carbondale for one and Song Creek for the other. "Song Creek" is probably an error of transcription, and should be stated as "Long Creek."

Some recent reports of the ecology and distribution of species near Melvern are: *Terrapene ornata* (Clarke, 1950), *Graptemys geographica* (Clarke, 1953), *Lampropeltis c. calligaster* (Clarke, 1954), *Eumeces s. septentrionalis* (Clarke, 1955), and *Necturus m. maculosus, Ambystoma texanum, Ambystoma tigrinum mavortium, Terrapene carolina triunguis, Pseudemys scripta elegans. Ophisaurus a. attenuatus, Cnemidophorus sexlineatus, Thamnophis radix haydeni* (Clarke, 1956).

H. M. Smith (1950) indicated that 39 species had been taken within Osage County. These records were taken in part from previously published reports.

Six studies were found which were similar to the present study in that seasonal occurrence was noted or that the study comprised observations covering several years. King (1939) studied the herpetofauna of the Great Smoky Mountains National Park for a four-year period. Neill (1951) reported on a 15-acre tract in Georgia on which records were kept for fourteen years. Brattstrom (1953) studied a single population of a single species of snake, but the observations covered 20 years; and seasonal distribution was given by year, month, and number of specimens. A six-year study of the snakes and turtles of Lucas County, Ohio, was reported by Conant (1938a), who stated that all types of habitats were not equally investigated, so that probably the larger, more conspicuous forms were more often captured. Only snakes were reported on by Brimley (1925) for Raleigh, North Carolina, and by Klauber (1931) for the southern border of California, but both papers dealt with seasonal occurrence.

MATERIALS AND METHODS

During the 5-year period, 1950-1954, and for the first 6 months of 1955, observations were made at irregular intervals and at many scattered points throughout the study area. Frequent collecting trips were made to various communities, where observations were recorded. The frequency of these trips varied according to the season and weather conditions. Most

of the trips occurred in the spring and became less frequent as the summer progressed.

In June, 1955, 3 small areas within the general area were chosen for regular, periodic investigation. Each of these areas represented one of three major biotic communities: Prairie community, Oak-Walnut Hillside Forest Community, and Semi-aquatic Community. Observation trips were made at least once each month to each area and more frequently during the months in which reptiles and amphibians were normally active.

Reptiles and amphibians were obtained by active search. In general, reptiles were found by lifting rocks and seizing by hand the exposed individual before it could escape. Amphibians were captured at breeding sites in aquatic situations. Various techniques were developed for obtaining specific species, but many acquisitions were of accidental origin.

Several pertinent data were recorded for each observation. The location was given as miles or part of a mile on a compass bearing from Melvern. The exact linear distance from Melvern was determined from a .75 inch = 1 mile scale map of Osage County. Habitat conditions were noted in reference to plant types, presence or absence of tree cover, rock outcroppings, and proximity of water in the form of ponds, creek, or river. Temperatures were recorded with a Fahrenheit thermometer. Air temperatures were taken at about 3 feet above the ground with the thermometer shaded from direct sunlight unless otherwise noted.

Terrestrial species of snakes and lizards were searched for beneath rocks and all types of surface litter, such as boards, logs, tin, cardboard, and piles of leaves. The type of rocks under which reptiles usually were found were flat, of various sizes, and not imbedded deeply in the earth, with more or less obvious means of entrance beneath them. Rocks and other surface cover always were replaced to the spots from which they were lifted, so as to disturb as little as possible the microhabitat beneath them. Although snakes could be captured beneath these rocks throughout the period of non-hibernation, this method of lizard capture was efficient only on mornings of early spring, when cool nights had made the lizards sluggish. As the temperature increased, the lizards became more active and more difficult to capture. Box turtles and snakes were captured frequently as they attempted to cross roads. Most of those captured in this manner were seen accidentally, but occasionally, slow automobile drives were made along the roads throughout the area specifically for the purpose of collecting in this manner.

When collections were made, a tag was filled out with the following data and placed in the bag or bottle: date, place, and number and kind of species. An entry was made also in a field notebook of the following facts: date, place, habitat, temperature, weather, number and kind of species, and ecological and general interest notes.

Cloth bags were used to hold snakes, lizards, and, occasionally, frogs and toads. Bags varied in size from 6 × 11 inches to 30 × 45 inches; the most-used size being 10 × 24 inches.

Reptiles and amphibians were preserved either in the field at the time of collection or they were collected alive and later preserved. At least one representative of each species found in the area was preserved and series were obtained of the more common species.

DESCRIPTION OF THE AREA

Geography

Osage County, Kansas, has an area of about 721 square miles. It is situated in central eastern Kansas adjacent to Shawnee, Douglas, Franklin, Coffey, Lyon, and Wabaunsee counties (Fig. 1). Physiographically, it is part of the Osage Plains (Schoewe, 1949). The area varies in height above sea level from about 875 feet to 1300 feet. "The topography is that of a dissected plain developed on unequally resistant shale and limestone formations. This gives rise to a gently rolling topography of vales and escarpments with moderate to steep slopes adjacent to most of the river and creek valleys" (O'Connor, 1955).

About 90 per cent of Osage County is drained by the Marais des Cygnes River and its tributaries. The northern 10 per cent of the area is drained by the Wakarusa River.

Melvern, a town of about 400 population, lies in the southeastern portion of Osage County (Fig. 1). The Marais des Cygnes River flows in an easterly direction, passing 0.5 mile north of the town, and a large tributary, Long Creek, passes the same distance to the south, converging with the river 1.25 miles northeast of Melvern. Rock, Jordan, and Bloody Run Creeks also drain the general area and eventually discharge into the Marais des Cygnes River. The altitude of the river at Melvern is 940 feet, and the altitude of the town is 1012 feet.

Approximately 48 per cent of the area embraced by the study was devoted to cultivation. Of the remainder, 28 per cent was used as pasture, and 14 per cent was overgrown with weeds, shrubby vegetation, and small trees. Wooded tracts occupied about 10 per cent of the area, occurring mostly along the river and creeks.

The mean annual temperature is 55.4°F, monthly averages varying from 30.2°F in January to 79.5°F in July. Record temperature extremes were -26°F in February and 118°F in July. Average date of the last killing frost in spring is April 21, and the first killing frost in fall is October 17.

The mean annual precipitation is 34.76 inches. Almost three-fourths of the total falls as rain during the growing season. Minimum monthly

means are 1.05 inches during January and 1.15 during December, and the maximum monthly means are 4.91 inches in May and 4.70 in June.

It is of interest to note that during the period covered by this study both the wettest year, 1951, with a surfeit of 29.12 inches; and the driest year, 1952, which was 11.89 inches below the normal amount, were recorded for Osage County. The years 1953, 1954, and 1955 also were deficient in total precipitation, having respectively the following deficits: −10.38, −5.93, and −7.56 inches.

Biology

Almost all of Kansas lies within the Upper Austral Life-zone (Merriam, *et al.*, 1910). The present study area is part of the Osage Savanna Biotic District, in which ". . . the flora consists of tall and mixed grasses with the admixture of many shrubs, forming a connection between the deciduous forest and the mixed grass plains." (Brumwell, 1951). The ecotonal area was rocky and overgrown with buckbrush and sumac in which there was an intermingling of prairie and forest forms, particularly where ravines extended the wooded habitat into typical prairie.

Cottonwoods, willows, maples, and sycamores lined the watercourses. Elms, oaks, walnuts, and locust trees were conspicuous on the hillsides and ledges. Osage orange trees had been planted as roadside hedgerows and had become scattered throughout many of the overgrown fields. Buckbrush and sumac had formed prominent associations, and cactus was abundant in much of the grassland. Common grasses were big bluestem, *Andropogon gerardi;* little bluestem, *Andropogon scoparius;* sideoats grama, *Bouteloua curtipendula;* Kentucky bluegrass, *Poa pratensis;* foxtail, *Alopecurus sp.* and *Setaria* sp.; and downy bromegrass, *Bromus tectorum.*

Biotic Communities

The major communities into which the region of study was divided are Aquatic (Figs. 2, 3), Semi-aquatic (Figs. 2, 3, 4), Oak-Walnut Hillside Forest (Figs. 5, 6), Cultivated-field (Fig. 7), Buckbrush-Sumac (Fig. 8), and Prairie (Figs. 9, 10).

Aquatic Community

Lotic communities were Marais des Cygnes River (Fig. 2), Jordan Creek, Long Creek (Fig. 3), Wolf Creek, and Bloody Run Creek. During wet years, all of these streams flow throughout the year, but all may cease to flow if precipitation is below normal. Long Creek flows more persistently than the other creeks, and the Marais des Cygnes River stops flowing only during drought years. These streams are generally turbid during periods of run-off and never become quite clear while flowing. The courses of the streams are made up of frequent riffles and pools. These riffles and some shallow sections of the stream bed are composed of gravel and rock,

Fig. 2. Aquatic and Semi-aquatic Communities. Marais des Cygnes River, 0.25 mile north of Melvern.

whereas the deeper pools have mud bottoms. Banks of the watercourses are generally steep and formed of dirt, with numerous trees or herbaceous vegetation. Small sections of each of the streams, however, have cut through rock, and here the banks are composed of limestone ledges that are devoid of vegetation. Fluctuation of the water level is characteristic of the streams of the area, promptly rising after a run-off and lowering again as rapidly. Numerous trees carried downsteam by floods form drifts which are used as basking spots by turtles and water snakes.

Lentic communities were present in the form of farm ponds, sloughs which were filled by flood waters, and pools which were left by prairie streams that flow only during times of run-off. These were minor communities that became dry during times of drought.

Macroscopic plants were not a prominent component of the flora. *Chara* sp. occurred in Jordan Creek, and *Lemna* sp. at one locality on the Marais des Cygnes River. Arrowhead, *Sagittaria latifolia*, was occasional and spotty in its distribution. The alga, *Cladophora* sp., occurred on rocks in many of the riffles, whereas *Spirogyra* sp. was present in the more quiet pools.

Semi-aquatic Community

The edges of the watercourses were generally composed of mudflats or gravel upon which a luxurient growth of grasses, herbs, and trees was

established. Because of the fluctuating water level, there was usually a bare mudflat of varying width between the water's edge and the vegetation. In many places the streams had cut away the banks, leaving vertical or undercut banks and exposing the roots of large trees. In general, the thick vegetation and canopy of trees provided deep shade along the streams. Jordan Creek, however, lacked trees along much of its course, but its banks were lined with grasses and sedges. Dense thickets of sandbar willow, *Salix interior*, were present on gravel banks, riffles, small islands, and along sections of all of the streams, and saplings of cottonwood and sycamore formed thick growths during a series of non-flood years. Many flat stones along the water's edge and piles of drift and leaves formed protective cover for the semi-aquatic animals.

Aside from the streams, semi-aquatic habitats were present around farm ponds, the edges of which usually lacked vegetation. Pools of prairie streamlets and roadside ditches, which in some cases were semi-permanent and supported a stand of cattails, also possessed the Semi-aquatic Community. In times of flood or heavy rains, inundated fields had breeding aggregations of frogs and toads.

Typical of the Semi-aquatic Community was Long Creek, 0.5 mile east of Melvern (Figs. 3, 4).

Plants characteristic of this community were cottonwood, *Populus deltoides;* sandbar willow, *Salix interior;* peachleaf willow, *Salix amygdaloides*; sycamore, *Platanus occidentalis*; silver maple, *Acer saccharinum;* slough grass, *Spartina pectinata;* sedge, *Carex* sp.; cleavers, *Galium aparine*; stinging nettle, *Urtica gracilis;* giant ragweed, *Ambrosia trifida*; and smartweed, *Polygonum lapathifolium.*

Oak-Walnut Hillside Forest Community

The upper hillsides of the river and creeks, as well as numerous large ravines, supported a well-developed deciduous forest, with an upper story of large trees, an understory of smaller trees and shrubs, and an extremely dense mass of herbs and vines at the ground level. This community was also evident on hillsides bordering the river flood plain. There were exposed along these hillsides the edges of rock strata which were broken and cracked, forming abundant fissures and loose surface rocks that provided cover and shelter for a number of small animals. These rock exposures were best developed along the top edge of the hillside. The hillsides were usually quite steep.

Most conspicuous of the larger trees were the chestnut oak, *Quercus Muhlenbergii*; black walnut, *Juglans nigra*; red oak, *Quercus rubra*; bur oak, *Quercus macrocarpa*; and both the American elm, *Ulmus americana,* and the red elm, *Ulmus rubra.* Smaller trees and shrubs present were redbud, *Cercis canadensis*; rough-leafed dogwood, *Cornus asperifolia;*

Fig. 3. Aquatic and Semi-aquatic Communities. Long Creek, 0.5 mile east of Melvern.

Fig. 4. Semi-aquatic Community. Edge of Long Creek at above locality.

Fig. 5. Oak-Walnut Hillside Forest Community. Dead Man's Gulch, 1.25 miles east of Melvern.

Fig. 6. Oak-Walnut Hillside Forest Community. Above locality.

fragrant sumac, *Rhus aromatica;* and gooseberry, *Ribes missouriense.* Ground cover consisted of verbena, *Verbena canadensis*; cleavers, *Galium aparine*; violets, *Viola* sp.; pale dock, *Rumex altissimus*; poison ivy, *Rhus radicans*; Virginia creeper, *Parthenocissus quinquefolia*; greenbriar, *Smilax tamnoides*; and wild grape, *Vitis vulpina.*

A typical Oak-Walnut Hillside Forest Community was Dead Man's Gulch (Figs. 5, 6).

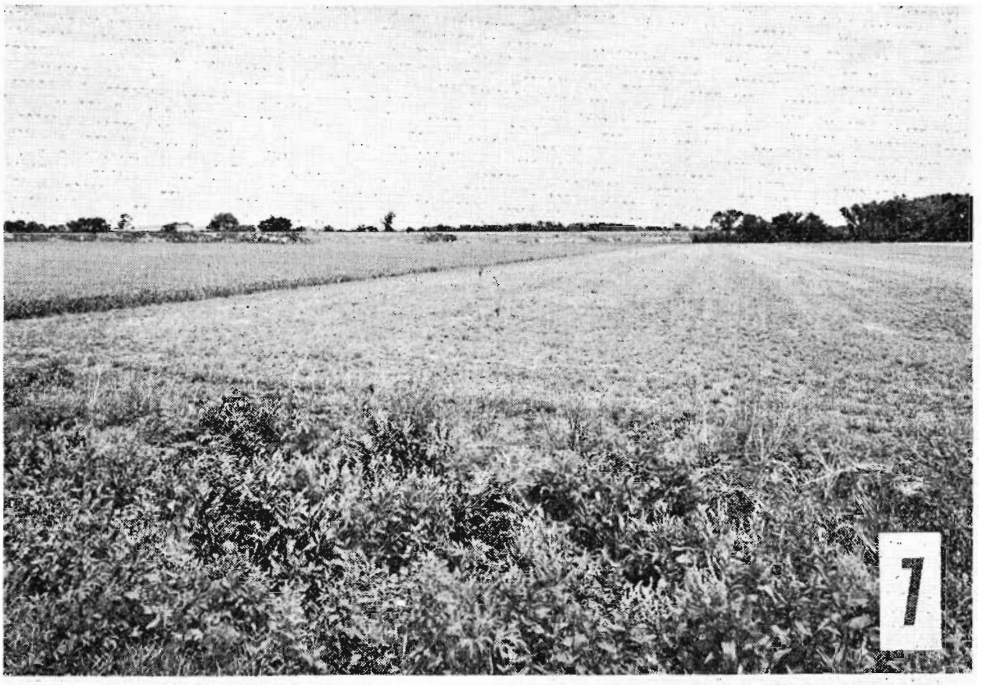
Cultivated-field Community

Almost one-half of the area was under cultivation at the time the study was conducted. Farms were scattered throughout the area, the bottomlands being more extensively cultivated than the upland. Upland farms were on more rocky ground and were often broken up by ravines and overgrown fields. Hedgerows of osage orange, *Maclura pomifera,* were common, and many farms had thickets of smooth sumac, *Rhus glabra,* at their edges. Generally the roadsides were untended, and a profusion of common weeds grew there (Fig. 7). Rocks, gathered from the farm land, were thrown along the roadside, forming hiding places for small mammals and reptiles. The most common crops grown were soybeans, corn, and wheat.

Buckbrush-Sumac Community

Thickets of sumac, *Rhus glabra* and *Rhus aromatica,* and buckbrush, *Symphoricarpos orbiculatus,* grew adjacent to the wooded tracts and dominated overgrown fields (Fig. 8). These marginal areas varied in extent from mere fringes between the forest and prairie (1.25 miles south-southwest of Melvern) to large belts as much as 0.25 mile wide (1 mile southeast and 1.5 miles east of Melvern). The grasses, big bluestem, little bluestem, Indian grass, and Kentucky bluegrass, grew between the thickets, and prickly pear cactus was abundant.

Much of this community was on rocky ground with numerous small flat rocks on the surface of the ground. In places the areas between brush clumps were devoid of other plants. The narrow-leafed sunflower, *Helianthus salicifolius,* was common in the more open areas. Honey locust, *Gleditsia triacanthos,* was common along the forest edge and scattered in small clumps in overgrown areas. Osage orange trees were also present as scattered, individual trees. Dice (1952) stated: "The sumac shrubs produce more shade than the herbs of the prairie, but less shade than the adjacent forest. A considerable number of prairie plants and animals are found in the sumac community associated with a few from the forest. The sumac itself is not a regular member either of the prairie or of the forest. The sumac association, therefore, while it is somewhat intermediate in character, is distinct both from prairie and from forest."



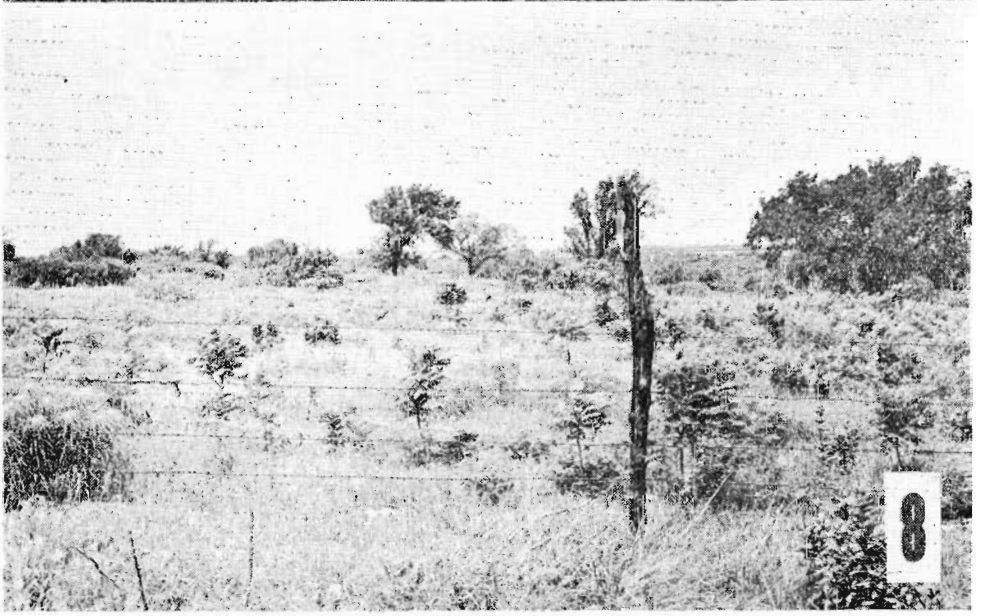


Fig. 7. Cultivated-field Community. 0.25 mile east of Melvern, showing typical roadside weeds.
Fig. 8. Buckbrush-Sumac Community. 1.25 miles southeast of Melvern.

Prairie Community

Large areas of native prairie were present on the hillsides and were used as pasture for cattle (Fig. 9). Grasses present were: big bluestem; little bluestem; Kentucky bluegrass; Indian grass, *Sorghastrum nutans;* and prairie tripple-awn, *Aristida oligantha;* and in the more rocky areas,

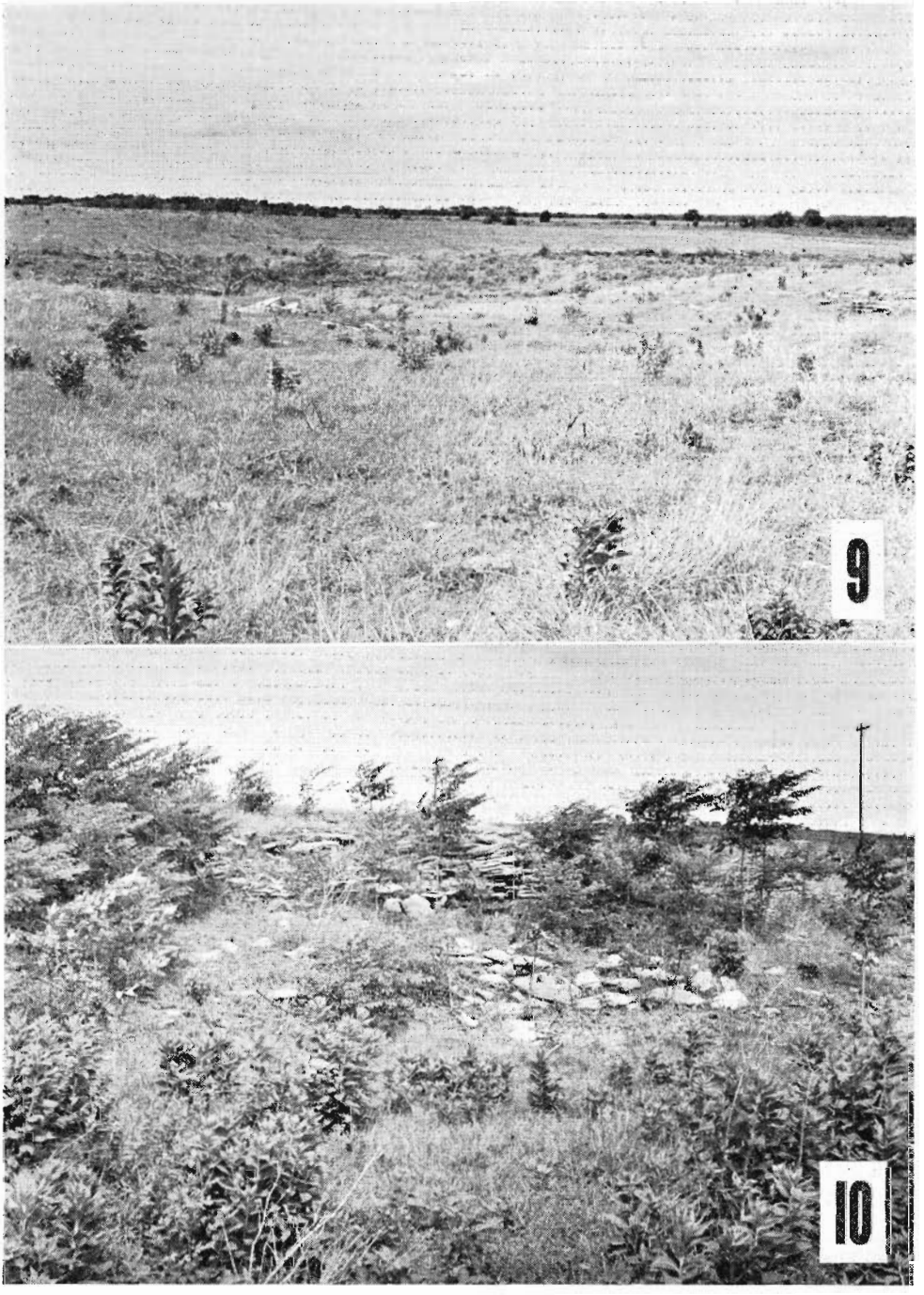


Fig. 9. Prairie Community. 1.25 miles south of Melvern.
Fig. 10. Rocky ravine in prairie. Above locality.

sideoats grama and downy bromegrass. Overgrazing of much of the prairie had resulted in an invasion of weeds, such as broomweed, *Gutierresia dracunculoides;* croton, *Croton monanthogynus;* sunflower, *Heli-*

anthus annuus; ironwood, *Vernonia Baldwini*; yarrow, *Achillea millefolium*; snow-on-the-mountain, *Euphorbia marginata;* and peppergrass, *Lepidium virginicum*. Mullein, *Verbascum thapsus*, occurred in some areas, and some rocky prairie had abundant cactus, *Opuntia humifusa*, and narrow-leafed sunflower, which had almost replaced the grass.

Rocky ravines and ledges occurred in the prairie area (Fig. 10), and it was here that most of the shelter for small mammals, reptiles, and amphibians was found, although small flat rocks were scattered throughout the prairie. Under these rocks was found the red scorpion, *Centruroides vittatus*, which was characteristic of the rocky prairie community.

Scattered osage orange trees had become established in the prairie region, as had occasional cottonwoods.

ANNOTATED LIST OF SPECIES

Following the name of each of the species is an initial or a series of initials in parentheses. These initials indicate that the species was noted in one or more of the following communities described in the preceding chapter: (A) Aquatic, (S) Semi-aquatic, (O) Oak-Walnut Hillside Forest, (C) Cultivated-field, (B) Buckbrush-Sumac, and (P) Prairie.

The scientific names of the species in the following list are those used by Schmidt (1953) in his North American checklist and are listed in the same order. The second edition of the Handbook of Amphibians and Reptiles of Kansas (Smith, 1956) deviates from Schmidt in some cases of taxonomic allocation. These deviations are indicated in the accounts of the species concerned.

Amphibia

Caudata (*salamanders*)

Necturus maculosus maculosus Rafinesque, Mudpuppy, (A). This salamander was taken occasionally by fishermen on the Marais des Cygnes River.

Ambystoma texanum Matthes, Small-mouthed Salamander, (A), (S), (B). The small-mouthed, or Texas, salamander was scarce in the area.

Salientia (*frogs and toads*)

Bufo terrestris americanus Holbrook, American Toad, (S), (O), (C), (B). The earliest date noted was March 9, when one was heard calling at Long Creek, east of Melvern, and the latest date recorded was October 8, when one was found crossing the road in the Melvern park. The lowest air temperature at which an individual was found active was 58°F on April 9, and the highest temperature was 85°F on several occasions.

Acris gryllus blanchardi Harper, Northern Cricket Frog, (S). This species was listed by Smith (1956) as *Acris crepitans blanchardi* Harper.

The earliest date of collection was February 14 and the latest date November 15. The lowest temperature at which they were recorded was 42° and the highest, 100°F.

Hyla versicolor versicolor Le Conte, Common Tree Frog, (S), (O). Tree frogs were observed from May 12 through July 28. Temperatures of the air varied on observation dates from 60° to 88°F.

Pseudacris nigrita triseriata Wied, Striped Chorus Frog, (S). Earliest and latest observations were recorded on March 13 and July 14. Air temperature extremes on observational dates were 40° and 90°F.

Rana castebeiana Shaw, Bullfrog, (S). Active bullfrogs were observed as early as March 16 and as late as October 9. Active tadpoles were also observed under ice. Temperature extremes at which bullfrogs were noted were 47° and 100°F.

Rana pipiens brachycephala Cope, Western Leopard Frog, (S). Leopard frogs were noted as early as March 14 and as late as November 15. The lowest temperature at which leopard frogs called was 40°F.

Reptilia

Chelonia (*turtles*)

Chelydra serpentina serpentina Linnaeus, Common Snapping Turtle, (A). First collecting date was May 1 and the last date August 9.

Terrapene carolina triunguis Agassiz, Three-toed Box Turtle, (O). Only a single specimen of this species was noted.

Terrapene ornata ornata Agassiz, Ornate Box Turtle, (S), (O), (C), (B), (F). Earliest and latest dates of activity were April 1 and October 24. Lowest and highest temperatures on which activity was noted were 55° and 102°F.

Graptemys geographica Le Seur, Map Turtle, (A). Taken while crossing a riffle in Long Creek on August 31, 1952 (Clarke, 1953).

Chrysemys picta belli Gray, Western Painted Turtle, (A). Earliest and latest dates noted were April 8 and November 11. The lowest air temperature at which one was seen was 50°F.

Pseudemys scripta elegans Wied, Elegant Slider, (A). Only 2 individuals were noted in the study area.

Trionyx ferox hartwegi Conant and Goin, Western Spiny Soft-shelled Turtle, (A). It was listed by Smith (1956) as *Amyda ferox hartwegi* Conant and Goin. This aquatic turtle was noted in the Marais des Cygnes River and in Long and Jordan creeks.

Sauria (*lizards*)

Ophisaurus attenuatus attenuatus Baird, Western Slender Glass Snake, (O), (B). One specimen was taken during the investigation.

Cnemidophorus sexlineatus Linnaeus, Six-lined Racerunner, (C), (B), (F). Earliest and latest dates recorded of observation of active indi-

viduals were April 18 and October 1, but specimens were found beneath rocks as early as April 6. The coolest temperature at which individuals were noted in the open was 55°F.

Eumeces fasciatus Linnaeus, Five-lined Skink, (O), (B), (P). The earliest date recorded for an individual that was active in the open was March 29, but specimens were found under rocks as early as March 25. The latest observation date was October 1. These lizards were not noted in the open when the air temperature was below 63°F, but individuals beneath rocks were active when uncovered when the air temperature was as low as 40°F.

Eumeces obsoletus Baird and Girard, Great Plains Skink, (O), (B), (F). The first and last recorded dates of observation were April 1 and September 10.

Eumeces septentrionalis septentrionalis Baird, Northern Prairie Skink, (P). The prairie skink was taken only on 2 occasions, both times slightlv out of the area of study.

Serpentes (*snakes*)

Natrix grahami Baird and Girard, Graham's Water Snake, (A), (S). Extreme dates of collection were May 14 and September 20.

Natrix erythrogaster transversa Hallowell, Yellow-bellied Water Snake, (A), (S). These water snakes were common in the area.

Storeria dekayi texana Trapido, Texas Brown Snake, (S), (O), (B). Brown snakes were found as early in the year as March 26 and as late as November 10.

Thamnophis sauritus proximus Say, Western Ribbon Snake, (S). Only one individual of this species was found.

Thamnophis sirtalis parietalis Say, Red-sided Garter Snake, (S), (O), (C), (B), (P). *Thamnophis ordinatus parietalis* Say is the name used by Smith (1956) for this species. It was observed as early in the year as March 25 and as late as October 20.

Tropidoclonion lineatum Hallowell, Lined Snake, (B), (P). First and last recorded dates of observation were April 18 and October 1.

Diadophis punctatus arnyi Kennicott, Prairie Ring-necked Snake, (O), (B), (P). Ringnecked snakes were taken as early as March 25 and as late as October 9.

Carphophis amoenus vermis Kennicott, Western Worm Snake, (O), (B). The earliest recorded date for this species was March 25 and the latest was October 1.

Coluber constrictor flaviventris Say, Yellow-bellied Racer, Blue Racer, (O), (C), (B), (P). The earliest blue racer noted was on March 26 and the latest on October 23.

Elaphe guttata emoryi Baird and Girard, Great Plains Rat Snake, (C), (B). The rat snake was captured on six occasions: April 8, May 11, May 12, May 21, May 25, and June 2.

Elaphe obsoleta obsoleta Say, Pilot Black Snake, (O), (C), (B). Earliest record for this species was April 16 and the latest date was August 5.

Pituophis catenifer sayi Schlegel, Bull Snake, (C), (B), (P). This species is referred to by Smith (1956) as *Pituophis melanoleucus sayi* Schlegel. Active individuals of this species were taken as early in the year as April 17 and as late as November 11.

Lampropeltis calligaster calligaster Harlan, Yellow-bellied, or Prairie King Snake, (O), (C), (B), (P). The earliest date on which an individual was found was April 10, and the latest date was November 11.

Lampropeltis getulus holbrooki Stejneger, Speckled King Snake, (C), (B), (P). The earliest recorded date of observation was April 16 and the latest date was October 8.

Lampropeltis doliata syspila Cope, Red Milk Snake, (O). Smith (1956) used *Lampropeltis triangulum syspila* Cope as the name for this species. Specimens were found on the following dates: April 13, April 16, May 6, May 12, and July 7.

Ancistrodon contortrix mokeson Daudin, Copperhead, (O), (C), (B), (P). Copperheads were found as early as April 10 and as late as October 9.

Crotalus horridus horridus Linnaeus, timber rattlesnake, (O) (C), (B), (P). The timber rattlesnake was observed on the following dates: April 19, May 7, June 6, June 28, and August 1.

SPECIES INCIDENCE IN RELATION TO TEMPERATURE

The number of observations made of reptiles and the number of individuals seen each month is given in Table I, and the total number of individuals observed during the study period is given in Table II. The table is arranged to show the number of individuals that were observed in each 5°F temperature interval, from 35° to 104°F. In the case of the reptiles, the specific number of individuals was ascertainable, but frogs and toads were commonly seen or heard in large numbers, at which time a count could not be made. When the amphibians could not be counted, a notation was made of the relative abundance, such as "several," which meant that from 3 to 8 were noted; or "many," which indicated that any number over 7 or 8 were observed.

No amphibian or reptile was found active when the temperature was below the freezing mark. Most species were observed between 55° and 90°F. Only a few species were noted in the 35-39° range, whereas the

Table I. Number of observations made of reptiles and the number of individuals seen in each month. Reptiles noted 5 times or less are not included.

	Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Total	
	Obs.	Indv.	Obs.	Indv.	Obs.	Indv.	Obs.	Indv.	Obs.	Indv.	Obs.	Indv.	Obs.	Indv.	Obs.	Indv.	Obs.	Indv.	Obs.	Indv.
Chelonia (turtles)																				
Chelydra serpentina					2	2	3	6	6	6	2	2							13	16
Terrapene ornata			7	11	14	20	13	15	16	18	4	4	3	5	5	6			62	79
Chrysemys picta			8	21	6	7	5	6	3	3	5	30	2	5	0	0	1	1	30	73
Sauria (lizards)																				
Cnemidophorus sexlineatus			8	13	17	49	7	14	1	3	3	5	2	3	1	1			39	88
Eumeces fasciatus	5	21	43	748	19	61	5	16	4	6	3	15	1	1	1	1			81	869
Eumeces obsoletus			15	47	13	33	4	6	1	2	2	4	1	2					36	94
Serpentes (snakes)																				
Natrix grahami					3	3	1	2	1	3	0	0	1	3					6	11
Natrix erythrogaster			3	3	5	5	6	6	2	2									16	16
Natrix sipedon			2	2	4	7	6	12	5	9	4	6							21	36
Storeria dekayi	2	3	12	28	3	3	0	0	0	0	0	0	0	0	0	0	1	1	18	35
Thamnophis sirtalis	6	7	20	30	10	13	2	2	1	1	2	2	5	7	3	3			49	65
Tropidoclonion lineatum			2	4	4	11	1	3	0	0	0	0	0	0	1	1			8	19
Diadophis punctatus	3	10	43	306	16	78	5	14	1	1	0	0	1	1	2	5			71	415
Carphophis amoenus	1	1	30	141	11	19	5	8	1	1	1	1	0	0	1	1			50	172
Coluber constrictor	1	1	16	24	6	9	1	1	0	0	0	0	2	2	5	5			31	42
Elaphe guttata			1	1	4	1	1	1											6	6
Elaphe obsoleta			6	12	5	6	1	1	2	2	1	1							15	22
Pituophis catenifer			1	1	6	6	1	2	5	5	2	2	0	0	0	0	1	1	16	17
Lampropeltis calligaster			8	9	6	7	1	1	1	1	2	2	1	2	1	1	1	1	21	24
Lampropeltis getulus			1	1	5	5	1	1	0	0	0	0	1	1	2	2			10	10
Ancistrodon contortrix			6	18	8	10	5	16	5	7	4	23	0	0	1	2			29	76

Read table thus: 2 observations were made of *Chelydra serpentina* in May and 2 individuals were seen. In June, 3 observations were made in which 6 individuals were seen, etc., etc. There were 13 total observations made of *Chelydra* in which 16 individuals were seen.

number of species and individuals increased as the temperature mounted, until a rapid decrease occurred above 90°F.

Of the amphibians, *Acris* were observed in all temperature intervals from 35° to 104°F, and calling was heard from 55° to 104°F. *Pseudacris*

TABLE II. Number of individuals observed or calling in each 5°F interval. Numbers indicate specific numbers of individuals observed; S indicates several (3-7) observed; M indicates many (8-infinity) observed; c indicates that individuals were heard calling during that temperature interval.

	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99	100-104	Total
Amphibia															
Ambystoma texanum											1				1
Necturus m. maculosus		2													2
Bufo terrestris americanus					2c	Mc	Sc	4c	2	9c	3c				
Acris gryllus blanchardi	2	S	S	S	Mc	Mc	Mc	Mc	Mc	Mc	Mc	Mc	Mc	Mc	
Hyla v. versicolor						Mc	Mc	Mc	Mc	Mc	Mc				
Pseudacris nigrita triseriata		Mc	Sc	Mc	Mc	Mc	Mc	Mc	Mc	Mc	Mc	Sc			
Rana catesbeiana			1	2		3c	6c	5c	M	Mc	Sc	Mc	Mc	M	
Rana pipiens brachycephala		Sc	S	S		Mc	Mc	Mc	Mc	Mc	M	Mc	M	S	
Turtles															
Chelydra s. serpentina								1	3	2	1	7	1		15
Terrapene carolina triunguis													1		1
Terrapene o. ornata			1		5	3	6	5	15	21	14	1	1	7	79
Graptemys geographica												1			1
Chrysemys picta belli				7		7	1	13	6	1	5	21	11	1	73
Pseudemys scripta elegans							1				1				2
Trionyx ferox hartwegi								1			1				2
Lizards															
Ophisaurus a. attenuatus									1						1
Cnemidophorus sexlineatus			4	1	6	10	4	4	26	17	10		1		83
Eumeces fasciatus	43	94	118	72	147	118	60	83	34	50	38	2		1	860
Eumeces obsoletus		6	1	5	11	7	6	13	6	13	17				85
Eumeces s. septentrionalis									2	4					6

TABLE II. (continued)

	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99	100-104	Total
Snakes															
Natrix grahami										2	2				4
Natrix erythrogaster transversa		1		1			1	2	2	4	2	1	1		15
Natrix r. rhombifera								1		1		1	2		5
Natrix s. sipedon						1	2	4	3	8	6	7	3	2	36
Storeria dekayi texana	3	7	2	2	2	11	2	3	2	1					35
Thamnophis sauritus proximus											1				1
Thamnophis sirtalis parietalis	3	5	4	2	6	4	5	1	5	14	8	5	5	3	65
Tropidoclonion lineatum						8	1	1	1	8					19
Diadophis punctatus arnyi	6	23	36	27	57	35	58	74	40	49	25				439
Carphophis amoenus vermis	4	19	31	14	31	5	11	25	12	13	9				174
Coluber constrictor flaviventris	1	3	5	1	2	3	8	4	6	6	3				42
Elaphe guttata emoryi							1		3	2					6
Elaphe o. obsoleta					3		3		6	3	2	4			21
Pituophis catenifer sayi					1		2	1	4	1	1	2	2	1	15
Lampropeltis c. calligaster		1	2		2	1	2	2	3	3	2	3	3		24
Lampropeltis getulus holbrooki					2		2			2	1				7
Lampropeltis doliata syspila				1		1			1	1					4
Ancistrodon contortrix mokeson			5	1	2	6	7	4	15	17	2				59
Crotalus h. horridus					1		1								2

were observed and heard calling through a temperature range of 40° to 94°F. *Rana pipiens* had a similar calling range, but were also observed through the 104°F range. *Rana catesbeiana* were not observed in appreciable numbers under 75°F, but were heard calling through a range from 60° to 99°F. *Bufo terrestris* were heard calling from 55° to 89°F. *Hyla versicolor* were observed and heard calling in the range of temperatures from 60° to 89°F.

Of the species of turtles that were observed, *Chelydra* were seen in the range 70° to 99°, with the median 89.9°; *Terrapene ornata* were observed in the range 45° to 104°, median 81.2°; and *Chrysemys* were noted from 50° to 104°, median 86.0°F.

Lizards were observed most often from 39° through 89°F. Individuals noted at the lowest temperatures were found beneath stones; not active in the open. Only 4 individuals (1 *Cnemidophorus* and 3 *Eumeces fasciatus*) were seen when the temperature was 90°F or above. *Eumeces septentrionalis* were noted on only 2 occasions, and *Ophisaurus* only once. Of the other 3 species observed, *Cnemidophorus* were seen in the range 49° to 95°, median 77.1°F; *Eumeces fasciatus* were noted from 39° to 100°, median 58.0°F; and *Eumeces obsoletus* were seen from 44° to 85°, median 72.0°F.

Each of 15 species of snakes were observed on 5 or more occasions. The temperature range, median, and number of species in each temperature group are given below. Five were seen when the temperature was 39°F. Of these 5, *Storeria* were not noted above 80°, with the median 60.2°F; *Thamnophis sirtalis* were not observed above 95°, median 77.0°F; and 3 were not found when the temperature was above 88°F; *Diadophis,* median 71.6°F; *Carphophis,* median 57.6°; and Coluber, median 68.9°F. Three species were observed when the temperature was in the 40's: *Natrix erythrogaster,* range 44° to 99°, median 80.1°F; *Lampropeltis calligaster,* range 44° to 95°, median 77.8°F; and *Ancistrodon,* range 45° to 85°, median 76.0°F. *Lampropeltis getulus* had a range from 55° to 87°, with a median of 68.3°F. Also with the lower end of the range in the 50's were *Pituophis,* 55° to 98°, median 78.9°F; and *Elaphe obsoleta,* 55° to 90°, median 78.2°F. *Natrix sipedon* were seen from 62° to 100°, median 84.5°F; and *Tropidoclonion* from 63° to 81°, median 72.5°F. *Elaphe guttata* were observed between 70° and 80°, with the median 77.8°F. *Natrix rhombifera* were noted from 73° to 99°, with the median 92.5°F.

Temperature ranges and medians for reptiles are shown graphically in Fig. 11.

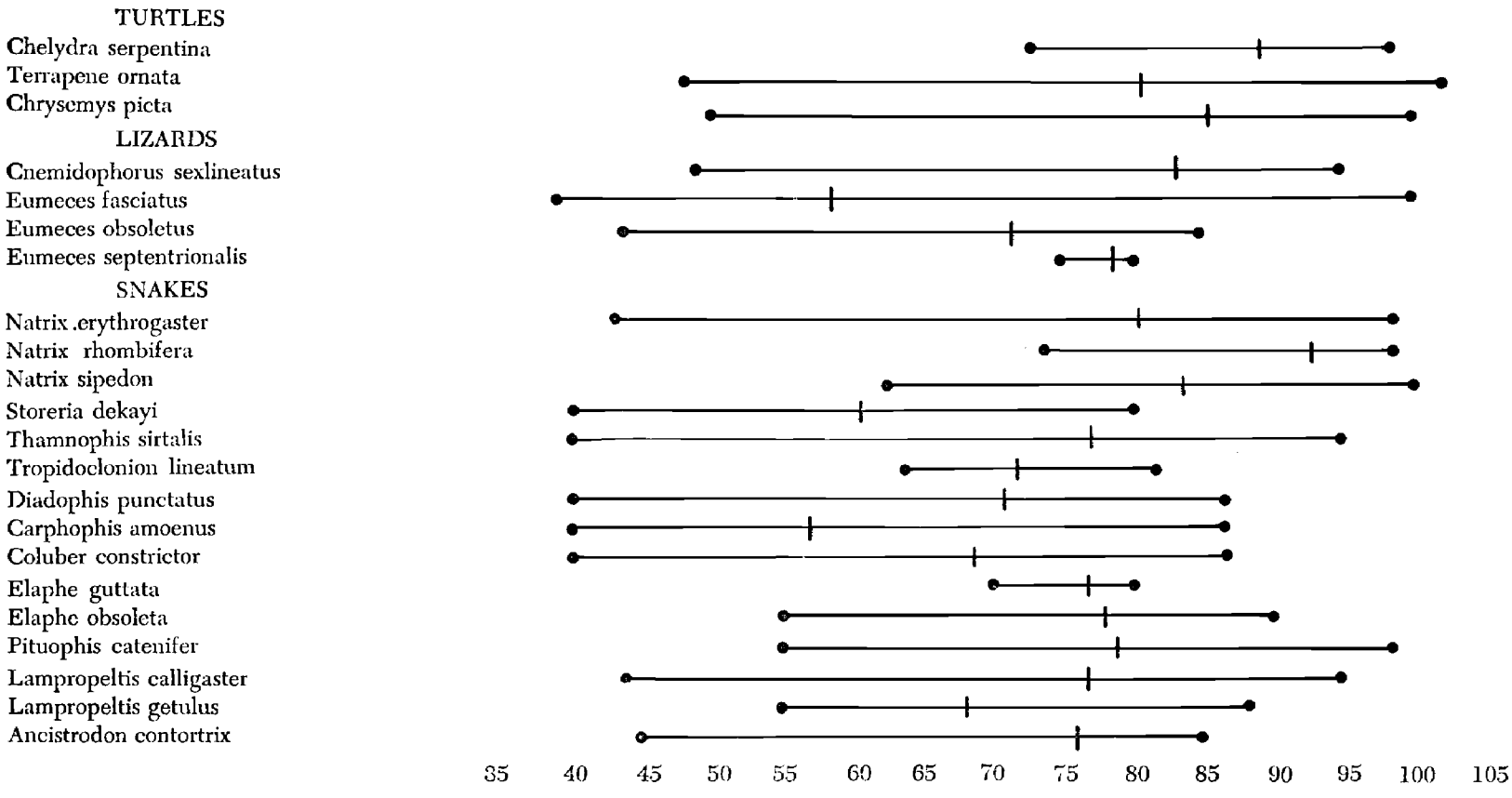


Fig. 11. Incidence of reptiles in relation to temperature. Ranges (horizontal lines) and medians (vertical lines) are given in degrees Fahrenheit.

DISCUSSION

Influence of Physical Factors

Temperature and Seasons

Temperatures control to a large degree the activities of the poikilothermal reptiles and amphibians. A lowering of the air temperature below an optimum range, which varies with the species, causes the individuals to seek protective cover or to go into hibernation. Likewise, a rise in temperature above the optimum induces seclusion or may bring about a period of aestivation.

During the present study, no active reptile or amphibian was found when the air temperature was below 39° or above 102°F. Those noted active in the lower temperatures were amphibians whose seasonal periodicity regularly brought them forth early in the year, and certain lizards and snakes found on wooded hillside ledges. Amphibians and aquatic reptiles, whose proximity to water made them relatively independent of high air temperatures, and several snakes of the Prairie Community were found when the air temperature was above 95°F. The ornate box turtle was found in the open sun on several occasions crossing roads when the air temperature was above 100°F.

The extremely wet year of 1951 was followed by the extremely dry year, 1952. In 1951, temperatures during the period March through August were all below normal, varying from normal —1° in May to —6.8°F in March. In 1952, March and April were 5.9° and 1.9°F below normal, respectively; other months for the same period as above varied above normal from +0.8° in July to +7.7° in June. The abuandance of amphibians in 1951 was due primarily to the precipitation and only secondarily to the lower than normal temperatures which prevailed. More reptiles were observed during each collecting trip in 1951 than each trip in 1952.

Semi-aquatic and terrestrial reptiles and amphibians were observed first in late March in small numbers and in abundance in April. Thereafter, the number observed dropped off sharply, reaching a low in midsummer. A small increase in number observed was noted in the months of September and October. Only a few individuals were seen in the cold months between October and March, and these were noted during periods of unusually high temperatures.

Amphibians were not recorded in specific numbers during the study; therefore, quantitative analyses cannot be made, and abundance can be referred to in general terms only.

Bufo and *Hyla* are terrestrial forms whose activities are more affected by extreme temperatures than are the more aquatic amphibians. *Bufo* was first observed at 55° and *Hyla* at 60°; neither was noted when the air

temperature was above 89°F. Of the more aquatic frogs, *Acris, Pseudacris,* and *Rana pipiens* were seen when the air temperature was as low as 40°F.

The months, April through July, were those of greatest abundance for amphibians. *Pseudacris* were seen rather abundantly in March, however, and the larger frogs, *Rana pipiens* and *Rana catesbeiana* were commonly noted in August, also. *Acris* were observed in all months except December and January. Linsdale (1927) stated that *Acris* were found in the warm water of springs and just below springs throughout the winter.

Calling dates ranged from March through August. *Pseudacris* were heard calling in chorus in March when the air temperature was as low as 40°F. In central Oklahoma, Bragg (1948a) observed *Pseudacris* calling when the air temperature was 43°F. Gloyd (1928) stated that he heard this frog calling as early as the first week in February in Kansas. Smith (1934) reported *Bufo* calling during the last week of March, but it was not heard during the present study until April 9 at 58°F air temperature, the lowest temperature at which calling was heard. *Rana pipiens* were first heard calling when the air temperature was 40°F and as early as April 8. Gloyd (1928) recorded this species singing on March 10. *Rana catesbeiana* did not begin calling in appreciable numbers until May; only one was heard in April. These late dates are indicative of the higher air temperature necessary before this frog begins calling. It was first heard when the temperature was 66°F. Gloyd (1928) collected the bullfrog as early as Febuary 16 and stated that the smaller individuals appeared first, early in March, while the larger ones were not seen until late March and early April. He noted the first calling to occur on May 1. Wright and Wright (1949) stated: "In the North bullfrogs breed the last of June or in July when the air temperature is about 80° and the water was warmed up to 70°. In the South they breed much earlier." They found eggs of this species in San Antonio, Texas, on February 12. The air temperature on this date was 63° to 64°F. Gloyd (1928) reported that *Hyla versicolor* was heard as early as April 9 in Franklin County, Kansas, and Smith (1934) stated that they were heard near Lawrence on April 28. Smith also concluded from the data at hand that the breeding season was at least a month and one-half long over various years. During the present study, *Hyla* were heard in only one year, 1951, when they were abundantly calling from breeding ponds in May, June, and July. The range of dates was from May 12 to July 28, with the lowest air temperature recorded at 60°F. *Acris* were heard calling from April 6 to July 29, with one individual calling on August 20. Gloyd (1928) stated that breeding of *Acris* begins in early April, and Smith (1934) gave July 15 as the latest date they were heard.

Most species of frogs and toads called most abundantly within the temperature range of 60-89°F. *Acris, Rana pipiens,* and *Rana catesbeiana*

were heard at higher temperatures, however, and *Pseudacris* was commonly heard in chorus at much lower temperatures.

The percentage of the reptiles in each 5°F temperature interval of the total reptiles observed in the range of air temperatures from 35° to 104°F is shown in Fig. 12. Turtles were not observed below 45°F, and

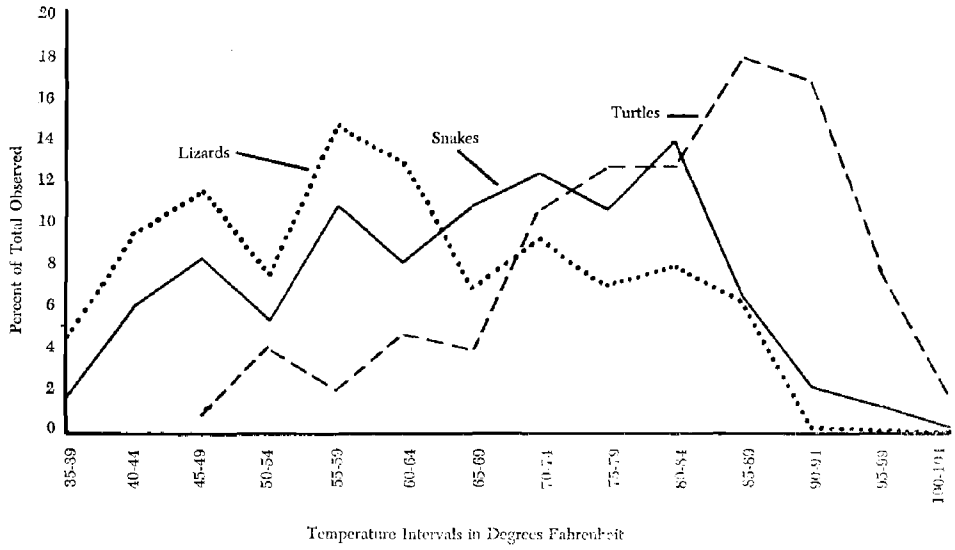


Fig. 12. Percentage of reptiles observed in each 5°F temperature interval.

the percentage does not become significant until the 70-74°F interval is reached. The largest percentages of turtles were observed in the intervals between 70° and 94°F. The curves for lizards and snakes are similar from 35° to 64°F, with the largest percentages of lizards observed in this range. The largest percentages of snakes were noted in the range 55-89°F. Above 89°F the curves for both lizards and snakes decline rapidly, whereas the turtle curve here reaches its maximum. The high temperature peak for turtles is due in part to the large number of aquatic turtles not affected by the higher air temperatures.

The percentage of the average number of reptiles per observation for each month of the total observed is given in Fig. 13. No reptiles were noted in December, January, or February. The curves are similar to those for snakes given by Oliver (1947) in that a large spring peak of activity is indicated, followed by a reduction of individuals noted during the summer and a small peak of activity in the fall. Turtles show a small peak in April followed by a larger, more sustained rise in August, September, and October. This latter peak may be correlated with the principal temperature activity range of 70-99°F shown in Fig. 12. The curves for lizards and snakes are similar, with the largest percentage noted in April. A larger percentage of lizards than of either snakes or turtles was observed in April.

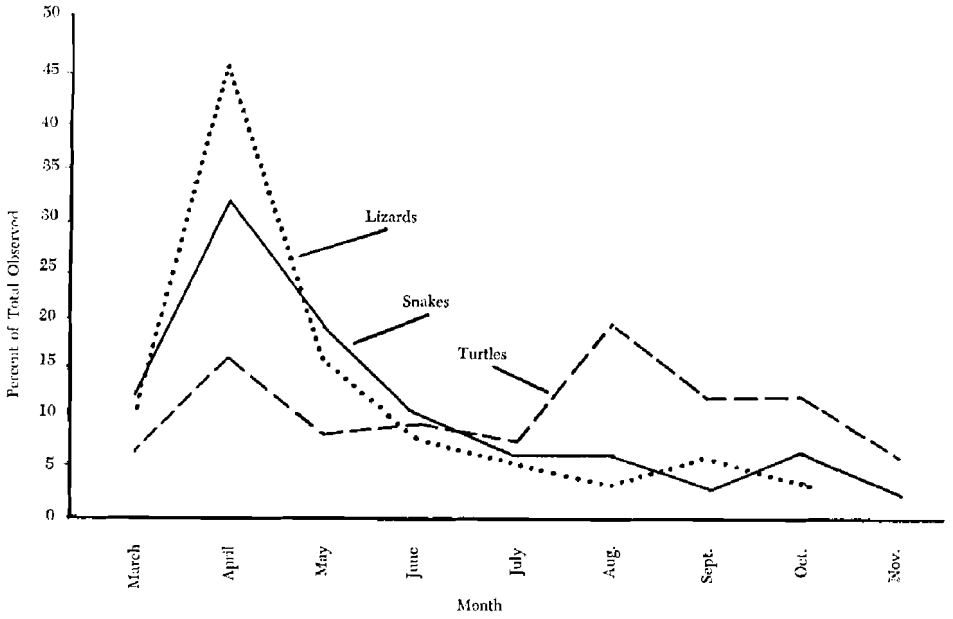


Fig. 13. Per cent of average number of reptiles per observation for each month to total reptiles observed.

The curve for snakes declines less rapidly than does the lizard curve, the percentage of snakes observed on each trip after April being more than lizards in each month, except in September. The fall peak for lizards is in September; for snakes in October. Conant (1938a) stated that the spring and fall peaks for snakes in Ohio occurred at nearly the same monthly average temperature. In Osage County, Kansas, the average April temperature is 55.2° and the average October temperature is 57.9°, a difference of only 2.7°F. These months represent the spring and fall peaks for snakes in Osage County, and are similar to Conant's study. The fall peak of lizard activity, however, is in September, which has an average temperature of 70.1°, a difference of 14.9°F from the April peak. Oliver (1947) stated that within the limits of controlling temperatures the following various factors may influence the monthly fluctuations: "(1) aggregation of some species in the vicinity of hibernation dens; (2) mating activity; (3) increased appetite for food following hibernation, and later decrease in appetite; (4) basking during periods of near-minimal air temperatures; (5) variations in the amount of protective cover provided by deciduous vegetation; (6) change from diurnal to crepuscular or nocturnal habits with an increase in diurnal temperatures; (7) rainfall; (8) seasonal variations in human activity; (9) oviposition; and (10) the appearance of the young of the year."

Upon comparing seasonal incidence of a terrestrial turtle, *Terrapene o. ornata*, with that of an aquatic turtle, *Chrysemys picta belli*, each of

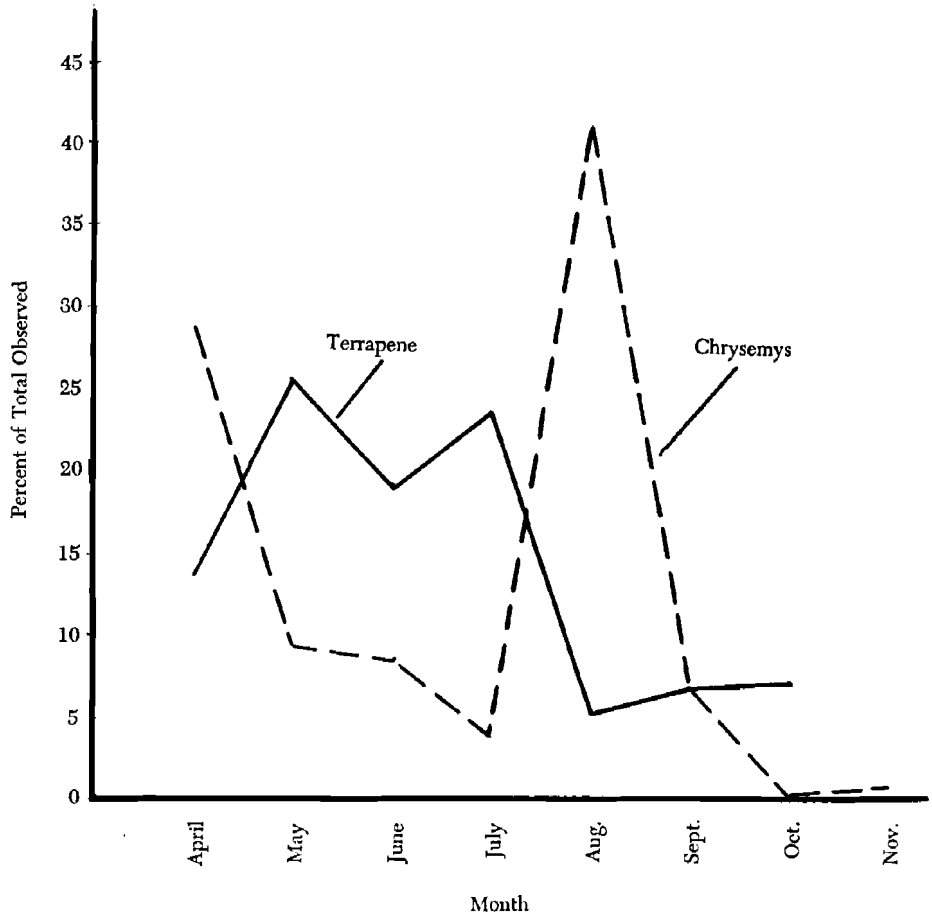


Fig. 14. Percentage of total individuals observed each month of the aquatic turtle Chrysemys and the terrestrial turtle Terrapene.

which was observed approximately the same number of times (79 and 73, respectively), it was found that when percentages of the total individuals observed was plotted against the months (Fig. 14) that the curve for the terrestrial turtle was similar to the curves for the snakes and lizards of Fig. 13, but that the curve for the aquatic turtle exhibited a high spring peak and a higher summer peak, with an abrupt fall decline.

Of the aquatic turtles observed, *Chelydra* was noted earliest on May 1 and latest on August 9. Smith (1956) stated that hibernation in Kansas begins in October or November and ends in March, and Conant (1951) collected the snapping turtle in Ohio in every month except February, with the peak of abundance in May. Cahn (1937), however, found that reappearance from hibernation in Illinois was usually about the middle of May. *Chrysemys* was noted in the present study from April 8 to November 11. Smith (1956) reported that it hibernated in Kansas from October or November to April. Conant (1951) in Ohio, however, took *Chrysemys*

every month of the year, and it was even observed moving about under ice. The terrestrial *Terrapene ornata* was taken earliest on April 1 and latest on October 20 in Osage County. Anderson (1942) observed that in Jackson County, Missouri, the ornate box turtle began hibernation in October and emerged in May, and Cahn (1937) stated that the hibernation period in Illinois was from October to April.

The 3 lizards most frequently observed were *Eumeces fasciatus,* an inhabitant of the Wooded Hillside Community; *Eumeces obsoletus,* which was noted in the partially-shaded intermediate area between forest and prairie; and *Cnemidophorus sexlineatus,* of the Prairie Community. *Eumeces fasciatus* were found as early in the year as late March when the air temperature was as low as 39°, but *Cnemidophorus* were not seen before April 6 or until the air temperature reached 49°F. *Eumeces obsoletus* were seen as early as April 1, and at an air temperature as low as 44°F. Pertinent to an understanding of the reason for this temperature difference between these species is the following statement by Fitch (1954): "Recent studies by Cowles and Bogert (1944:288-289) and Bogert (1949: 198) have brought out the fact that terrestrial poikilotherms, and especially lizards, maintain fairly high and constant body temperatures through behavioral thermoregulation, during their periods of activity. For genera and species of lizards, there are optimum body temperatures, which the individual tends to maintain, fluctuating within a range of only a few degrees while it is active. Forms that are not closely related may differ notably in their optimum temperatures, although within any one genus the range is slight. For example in the iguanid genus, *Sceloporus,* Bogert found that different regions as Arizona and Florida agree in having body temperatures approximating 35° or 36°C., while different members of the teiid genus *Cnemidophorus* in the same two regions were found to approximate 41°C. in mean temperatures. In commenting on the distribution of North American lizards as affected by opportunity for behavioral thermoregulation by direct insolation, Bogert (*op. cit.*:205) wrote: 'Such secretive lizards as skinks (principally *Eumeces* in North America) with low body temperature preferences approximating 30°C. are dominant in Florida and the Gulf Coast, in contrast to the Teiidae and Iguanidae (several genera in the United States), which are far more abundant in the arid regions of the Southwest."

Cnemidophorus and *Eumeces obsoletus* were found in open areas, under rocks, in which situation they could be observed during all the months in which they were active. *Eumeces fasciatus,* however, were found beneath rocks at the tops of wooded ledges in the spring, but as the temperature increased during May they became more active and scattered into the litter of the hillside where observation was difficult. This accounts for the apparent decline in abundance for this species after the large spring

peak. Fitch (1954) stated: "As compared with its reptilian associates in northeastern Kansas, *Eumeces fasciatus* is outstanding in its ability to become active and carry on normal activities at relatively low air temperatures. In spring it is usually seen in the open before any other kind of reptile, because it has the capacity to move about sluggishly at temperatures so low that some other reptiles are numbed and completely immobilized, and because it has small size enabling it to make rapid adjustment upward by insolation, or contact with sunshine-warmed surfaces." He also stated that "by the end of April some kinds of deciduous trees have not yet begun to leaf out, and in most other kinds the leaves are still in an early stage of development. Absence of a leaf canopy during April permits the skinks to utilize the spring sunshine to maintain their body temperatures at almost the same high level that they maintain in the same situations in hot summer weather."

As in the case of the lizards, the snakes of the Wooded Hillside Community appeared earlier in the year and at lower air temperatures than did those of the Prairie Community. Snakes representative of the Hillside Community in spring: *Storeria dekayi, Thamnophis sirtalis, Diadophis punctatus, Carphophis amoenus,* were found in considerable numbers in late March when the temperature was 39 to 44°F. It was not until April that the snakes of the Prairie Community, *Pituophis catenifer, Tropidoclonion lineatum,* and *Lampropeltis getulus,* were observed. The lowest temperature at which they were noted was 55°F. Most of the water snakes were not observed earlier than April nor later than September, but Conant (1951) reported that *Natrix* were found in Ohio from March to October, inclusive, and that the greatest number were taken in May, June, and July.

A comparison of the diagrams of seasonal incidence given by Oliver (1947) based upon data reported by Conant for Ohio, Brimley for North Carolina, Klauber for southern California, and Loveridge for Massachusetts with similar data gathered during the present study shows that a close similarity exists between all of these localities. The seasonal incidence for Ohio is almost indentical with that for Kansas with the exception of a higher fall peak in Ohio, even though the average monthly temperatures are higher in Kansas. The seasonal incidence for Massachusetts, North Carolina, and southern California show the peak of the spring abundance occurring in May rather than in April. All of the smaller fall peaks of abundance occur in October.

Precipitation

During the study period, the wettest year, 1951, and the driest year, 1952, were recorded for Osage County. The years 1952 through 1955 were subnormal, deviating from normal 10.38, 5.93, and 7.56 inches respectively. The results of this study in regard to precipitation are atypical,

and results for normal years may be different. It is of value, however, to present the data for these extreme years.

In normal years, the major part of the precipitation falls as rain, which is heaviest in May, but fairly evenly distributed throughout the period from April through September.

In general, the wet years produced numerous breeding places for amphibians, but made traveling to collecting localities difficult. Lower temperatures and abundant vegetative cover also were results of the wet years. During dry years, breeding sites for some types of amphibians were practically non-existant, and aquatic and semi-aquatic forms became concentrated in and around drying pools of creeks and streams. Reduction in vegetation and the higher temperatures that were prevalent caused some reptiles to leave certain open areas that they once frequented for more shaded locations.

Moisture is a limiting factor, to a greater extent, for amphibians than for reptiles. The effect of the dry and wet years was noticeable to a marked degree on certain amphibians. The tree frog, *Hyla versicolor,* was observed only during 1951, when it was abundant at breeding areas in farm ponds and flooded fields. Small bullfrogs, *Rana catesbeiana,* were noted in great abundance along the edges of the Marais des Cygnes River in 1953 and 1954. The lack of flow of the river in 1952 and the following two years presumably made conditions ideal for the hatching of eggs and welfare of the tadpoles. *Pscudacris* was particularly sensitive to precipitation in late spring, rainfall bringing forth choruses of these frogs, which were mute during periods of no rainfall, even though breeding sites were available.

Bragg (1941) observed that the experience of field naturalists has consistently been that the coming of rain has a differential effect upon the breeding of frogs and toads. He stated that North American Anura may be classified on the basis of the effect of rain on the initiation of breeding behavior. Two of the types of classification which occur in Osage County are described by Bragg as: "(1) Some species usually breed only after rain at any time from March to September when the temperature is not too low. Within these months, rain of one inch or more never fails as a profound stimulus." An example of this group is *Pseudacris nigrita.* "(2) A second group of species has a definite breeding season (usually, but not invariably, coming in the spring) within which breeding occurs irrespective of rain. Within the season, however, local rainfall augments the breeding activity; but after the season, even heavy rains have little effect except that a few males may be stimulated to call." Examples of this group are *Bufo terrestris, Rana pipiens, Rana catesbeiana,* and *Hyla versicolor.* Bragg further states: ". . . .the distribution of these differentials within species and among species is closely correlated with conditions normal to the ecological situation constituting the normal environment within the habitat of each spe-

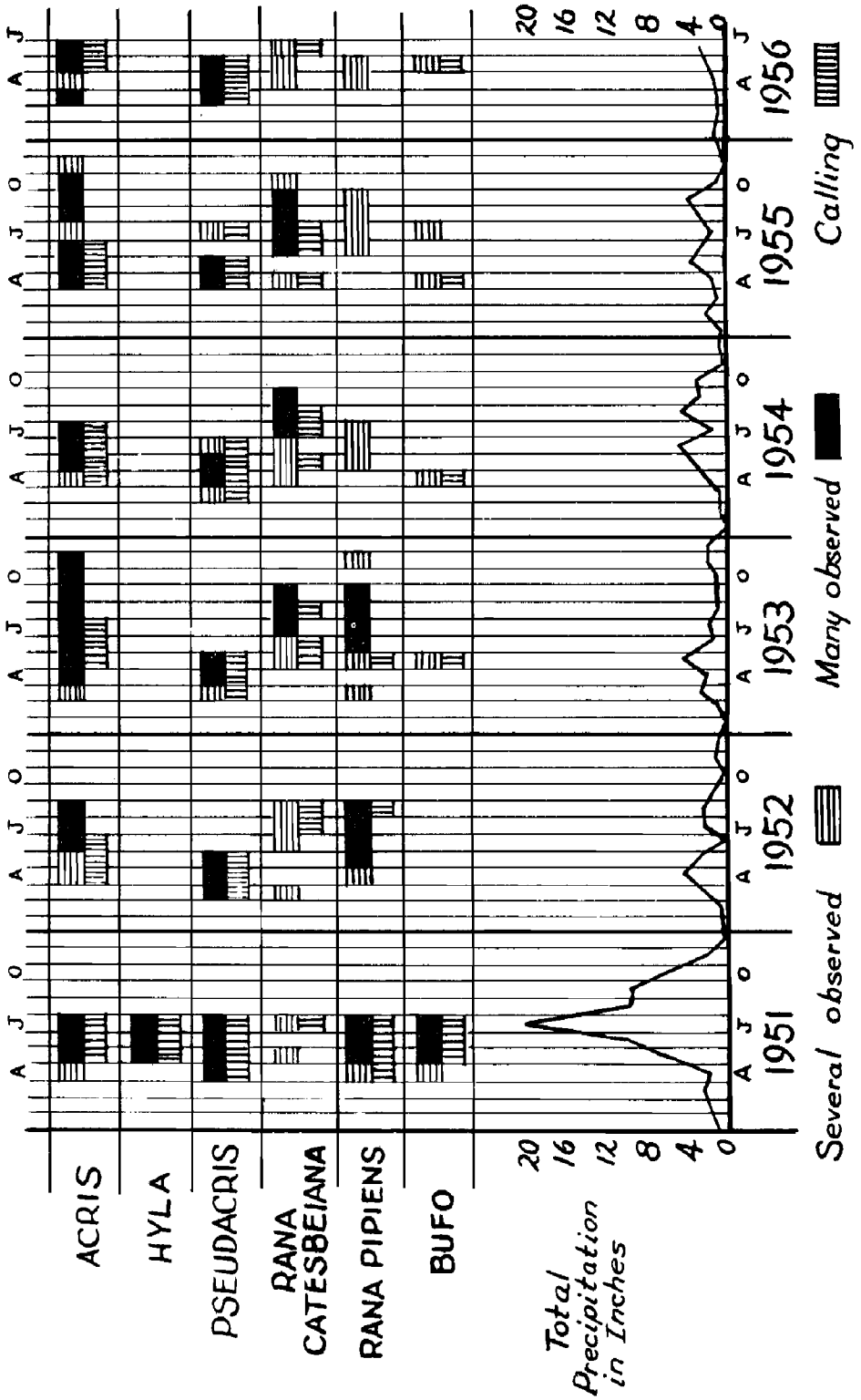


Fig. 15. Relative abundance of amphibian species observed in relation to precipitation: months observed and months in which calling was noted.

cies, those species whose normal living is in dryer climates or habitats being profoundly stimulated by rain, those inhabiting moister situations not being so stimulated . . . ."

The months in which amphibians were observed in each year, the months in which they called, and the relative abundance of individuals for each month in relation to the precipitation in inches is shown in Fig. 15. Data for amphibians were incomplete for 1950, so that year is not included in the figure. *Acris* were seemingly not affected by the drought years, as this small frog made its home at any type of water. The largest number of species and individuals were observed during 1951, when cloudy, cool days and abundant breeding locations afforded ideal conditions for most amphibians. Flood conditions held observations on *Rana catesbeiana*, which lives on larger waterway, to a minimum. The large number of observations on this frog during the following years was the result of the abundant young frogs in evidence. There was decreasing abundance of the terrestrial *Bufo* during the dry years, and *Rana pipiens* also decreased in number after 1953.

In his study on seasonal incidence of snakes, Oliver (1947) stated: "The effect of rainfall varies with the temperature prevailing at the time of the rain. For example, Conant (*op. cit.*) and Klauber (1931) have noted that rain has a detrimental effect in the early spring when temperatures are

TABLE III. The average number of reptiles per observation for each year and the deviation from normal in inches of precipitation.

Year	Deviation	Turtles	Lizards	Snakes
1950	—1.95	1.8	13.5	10.4
1951	29.12	1.0	21.5	12.0
1952	—11.89	1.6	16.2	11.2
1953	—10.38	2.6	23.2	3.3
1954	—5.93	1.2	8.2	4.0
1955	—7.56	3.1	3.8	3.8

near the minimum for a snake's activity, primarily owing to the accompanying drop of the air and ground temperatures. On the other hand, summer and fall rains seem essential in preventing or terminating summer drought, or in lowering excessively high temperatures that result in poor snake collecting. Moreover, the clouds accompanying the rains may reduce solar radiation sufficiently to permit some species to emerge." The relationship of reptile activity and precipitation could only be made in a general manner. Table III gives the average number of reptiles observed for each trip for each year and the annual deviation from normal of precipitation for each year. Turtles were seen slightly more frequently during

the drier years. This may be due to the concentration of aquatic turtles in the increasingly smaller number of available situations. Lizards increased in number during the wet years and decreased in abundance during the dry years. The large number per observation in 1953 is misleading in that lizards were observed on only 4 occasions in that year, 3 of the times in early April, the month of greatest abundance. Snakes, like the lizards, were noted in larger numbers in the wet years, decreasing as the dry spell progressed. The high number of lizards and snakes for 1952, the driest year, may be due to the fact that March and April of that year had normal or above amounts of precipitation, and conditions did not become critical that year until early summer; or the 1952 population may be a reflection of the influence of the 1951 precipitation.

Influence of Biotic Factors

Plant Communities

The types of plants and their abundance in a given area is the result of a complex of physical factors operating in that particular area. Altitude, latitude, soil, humidity, precipitation, temperature, physiographic features, and biotic factors each play a part in forming a distinctive flora, and variation of any one facet can change the makeup of this flora. King (1939) stated: "The importance of vegetation in regulating the environment and thereby creating varied faunal habitats can scarcely be overestimated." The roles of plants in their relationship to the herpetofauna was summarized by Oliver (1955): "For amphibians and reptiles the most important roles of plants are to serve as food, as shelter, and as a general environmental force. As a source of food, plants are of less importance to amphibians and reptiles than animals, because most species are carnivorous. However, many turtles and a few lizards utilize some plants in their diets. Living and dead plants, or plant remains, provide shelter for amphibians and reptiles. Rotting logs and stumps, particularly, serve as protective retreats. The term 'environmental force' is a general one that covers all the roles not easily categorized without a more detailed consideration. It includes the important role of plants in making up a major part of the habitat in which the animals live. In this role living plants not only form one of the primary features of the habitat, but contribute to the formation of the soil and influence the physical features, such as temperature, moisture, light, and wind conditions of the habitat. Plants largely determine the visible characteristics of the habitat and hence give each habitat its general appearance."

Specific relationships may be noted between the plant communities and the amphibians and reptiles observed during the course of this study. It is recognized that the plant communities reflected the physical conditions present, which were probably primarily responsible for the presence

or absence of the species noted. In each of the communities certain species were characteristic of that community in that they occurred in that community only, or were most often found there. Some species were frequently found in one or more communities, but were not characteristically present there; other species were found occasionally in one or more communities. Following is a list of the communities with the occurrence of species in each.

1. *Aquatic Community*: This area was relatively free of living macroscopic plants; yet the drift piles formed by fallen trees and limbs gave shelter and basking places to the species which lived in this community.

Reptiles and amphibians characteristic of this community were *Necturus m. maculosus, Chelydra s. serpentina, Graptemys geographica, Chrysemys picta belli, Pseudemys scripta elegans,* and *Trionyx ferox hartwegi.* Of frequent occurrence but not characteristic were *Natrix erythrogaster transversa, Natrix r. rhombifera,* and *Natrix s. sipedon.* Of occasional occurrence in this community was *Natrix grahami.*

2. *Semi-aquatic Community*: Protective cover for 14 species was afforded by abundant flat stones and shade from the thickly growing waterside weeds and trees.

Reptiles and amphibians characteristic of the community were *Acris gryllus blanchardi, Rana catesbeiana, Rana pipiens brachycephala, Natrix grahami, Natrix erythrogaster transversa, Natrix s. sipedon,* and *Thamnophis sauritus proximus.* Of frequent occurrence but not characteristic were *Bufo terrestris americanus, Hyla v. versicolor,* and *Natrix r. rhombifera.* Of occasional occurrence in this community were *Terrapene o. ornata, Eumeces s. septentrionalis, Thamnophis sirtalis parietalis,* and *Storeria dekayi texana.*

3. *Oak-Walnut Hillside Forest Community*: Deciduous trees and herbaceous vegetation of this community gave to its fauna ample warmth from the sun in early spring and thick, protective shade during the summer. Numerous stones, fallen trees, and a bountiful leaf mould provided a suitable habitat for the members of this community.

No amphibians were characteristic of this community, but the reptiles were *Eumeces fasciatus, Diadophis punctatus arnyi, Carphophis amoenus vermis, Elaphe o. obsoleta, Lampropeltis doliata syspila,* and *Ancistrodon contortrix mokeson.* Of frequent occurrence but not characteristic were *Bufo terrestris americanus, Terrapene o. ornata, Storeria dekayi texana, Thamnophis sirtalis parietalis,* and *Coluber constrictor flaviventris.* Of occasional occurrence in this community were *Terrapene carolina triunguis, Eumeces obsoletus,* and *Crotalus h. horridus.*

4. *Cultivated-field Community*: Thirteen species were observed in this community. Some used these fields only incidentally in passing from one

neighboring area to another, but others lived among the crops during the entire growing season.

No amphibians were characteristic of this community, but the reptiles were *Terrapene o. ornata, Cnemidophorus sexlineatus,* and *Pituophis catenifer sayi.* Of frequent occurrence but not characteristic was *Coluber constrictor flaviventris.* Of occasional occurrence in this community were *Bufo terrestris americanus, Rana pipiens brachycephala, Thamnophis sirtalis parietalis, Elaphe guttata emoryi, Elaphe o. obsoleta, Lampropeltis c. calligaster, Lampropeltis getulus holbrooki, Ancistrodon contortrix mokeson,* and *Crotalus h. horridus.*

5. *Buckbrush-Sumac Community*: This community represented an intermediate ecological area between the hillside forest and the prairie. Dice (1952) stated: "The sumac shrubs produce more shade than the herbs of the prairie, but less shade than the adjacent forest. A considerable number of prairie plants and animals are found in the sumac community associated with a few from the forest. The sumac itself is not a regular member either of the prairie or of the forest. The sumac association, therefore, while it is somewhat intermediate in character, is distinct both from prairie and from forest." More species were noted in this transitional area than in any other community. This is in agreement with Odum (1953), who stated: "Often, both the number of species and the population density of some of the species are greater in the ecotone than in the communities flanking it."

Reptiles characteristic of this community were *Eumeces obsoletus* and *Elaphe guttata emoryi.* Of frequent occurrence but not characteristic were *Terrapene o. ornata, Cnemidophorus sexlineatus, Thamnophis sirtalis parietalis, Coluber constrictor flaviventris, Pituophis catenifer sayi,* and *Lampropeltis c. calligaster.* Of occasional occurrence in this community were *Ambystoma texanum, Ophisaurus a. attenuatus, Eumeces fasciatus, Storeria dekayi texana, Diadophis punctatus arnyi, Elaphe o. obsoleta, Lampropeltis getulus holbrooki, Lampropeltis doliata syspila, Ancistrodon contortrix mokeson,* and *Crotalus h. horridus.*

6. *Prairie Community*: Fourteen species were observed in this community. By far, the majority of these were found at the rocky prairie ledges.

Reptiles characteristics of this community were *Cnemidophorus sexlineatus, Eumeces s. septentrionalis, Tropidoclonion lineatum, Pituophis catenifer sayi, Lampropeltis c. calligaster,* and *Lampropeltis getulus holbrooki.* Of frequent occurrence but not characteristic were *Terrapene o. ornata, Eumeces obsoletus, Thamnophis sirtalis parietalis,* and *Coluber constrictor flaviventris.* Of occasional occurrence in this community were *Eumeces fasciatus, Diadophis punctatus arnyi, Ancistrodon contortrix mokeson,* and *Crotalus h. horridus.*

Restricted to the Aquatic Community were the aquatic turtles and the mudpuppy, *Necturus*. Also found in only one community were *Carphophis* in the Wooded Hillside Community, and *Tropidoclonion* in the Prairie Community. Hudson (1942) found that in Nebraska *Carphophis* were observed in the deciduous forest only, and Smith (1950) stated that they were found in moist woods. Dice (1923) found *Tropidoclonion* in rocky prairie only, but Brumwell (1951) found individuals in a damp, rocky meadow and one in a damp forest. Clarke (1955), Gloyd (1928), and Grant (1937) found *Tropidoclonion* in urban situations in Kansas. Most of the frogs were restricted to the Semi-aquatic Community, as were the watersnakes. *Bufo terrestris* was commonly found elsewhere, though, on wooded hillsides and in cultivated fields and gardens. The leopard frog, *Rana pipiens*, was found occasionally in fields away from water. Once, it was taken in a field of wheat stubble. Dice (1923) reported *Rana pipiens* from the Hillside Forest Community.

Of the lizards noted most often, *Cnemidophorus* was found in unshaded situations in cultivated fields, rough overgrown areas, and in the rocky prairie. Smith (1950) stated, "The chief requirement seems to be a certain degree of dryness." *Eumces fasciatus* were abundant in the Wooded Hillside Community, but were occasionally observed in the Buckbrush-Sumac Community and in rocky prairie. This agrees with the findings of Fitch (1954). Likewise, agreement with the observations of Fitch (1955) was noted in regard to *Eumeces obsoletus*, which was found most frequently in the Buckbrush-Sumac Community and Prairie Community, and occasionally in the Hillside Forest Community.

Snakes which were not found in the Hillside Forest Community and were noted in the more open areas only were *Elaphe guttata, Pituophis, Lampropeltis calligaster*, and *Lampropeltis getulus*. Of these, *Elaphe guttata* was found most frequently in the Buckbrush-Sumac Community and occasionally in cultivated fields. Smith (1950) stated that this snake usually was associated with rocky hillsides or canyons, and seldom, if ever, occurs on the open prairie. The occurrence of the other snakes also agree with his statements of Kansas habitats.

Particularly found on the wooded hillside or the rough intermediate area adjoining it were *Storeria dekayi, Elaphe obsoleta*, and *Lampropeltis doliata*. Gloyd (1928) reported similar findings for these three species in Franklin County, Kansas. Gloyd also stated that two *Storeria dekayi* were found in the near proximity of water. Similarly, during the present study, this snake was noted close to water on several occasions; once beneath a partially submerged stone at the edge of Wolf Creek.

Taken in all of the terrestrial communities were *Terrapene ornata, Thamnophis sirtalis, Coluber constrictor, Ancistrodon contortrix*, and *Crotalus horridus*. *Diadophis punctatus*, although principally found on the

wooded hillside, was also taken in the prairie and intermediate areas.

Species which were observed on one or two occasions only were: *Ambystoma texanum, Ophisaurus attenuatus, Eumeces septentrionalis,* and *Thamnophis sauritus. Ambystoma texanum* was found in a drying streamlet in rocky, overgrown prairie. Gloyd (1928) stated that in Franklin County, Kansas, this species ". . . was frequently taken in early March from shallow pasture streams which after the spring rains connect grassy pools, drying up almost completely during the summer." H. M. Smith (1950) stated that *Ophisaurus* are found on the ground in moist, grassy open areas, and Fitch (1951) collected specimens from a wooded ledge in Douglas County. Only one individual was found during the present study. The area where this specimen was collected was extremely dry, although a more suitable habitat, a forested hillside, was only a short distance away. The *Eumeces septentrionalis* observed were taken on an open grassy hillside provided with small rocks, the habitat described by Smith (1950), and near the edge of a small creek. They were previously reported on by Clarke (1955). *Thamnophis sauritus* was noted on one occasion only. It was crossing a road between cultivated fields. Smith (1950) gives the Semi-aquatic Community as the habitat for this species. Such a habitat was present a short distance away.

Association of Species

In order to obtain measurements of the amount of association between the various species observed, the percentage of the frequency of occurrence of each two species found together was calculated. Table IV gives the results of those species observed on 15 or more occasions. It was thought that observations on fewer than 15 occasions was insufficient, and that calculations based on those observations would yield distorted and misleading results. The numbers given in Table IV are the percentages of occurrence together of each species. The value of using such a percentage to show association or for prediction is increased as the number of observations of the species used as a basis for the association is increased. The species are arranged in descending order of number of observations made. *Acris gryllus* was observed most often (86 occasions) and *Elaphe obsoleta* was observed least often (15 occasions). The observations for the species do not form a continuous series; 3 breaks of 8 or more observations tend to place the species into 4 groups based on total observations, an upper group of 3 species and 3 lower groups composed of 6 species each. Vacant spaces in the table result because the species concerned were members of very different communities.

Of the species observed 71 times or more, *Diadophis* and *Eumeces fasciatus* were observed to be associated to a large degree, whereas very little association was shown between either of these species and *Acris.* Using *Diadophis* as a basis, association with *Eumeces fasciatus* was 80 per

Table IV. Species association. The percentage, to the nearest whole number, of occurrence together of each species observed on 15 or more occasions.

Total observations		*Acris gryllus*	*Eumeces fasciatus*	*Diadophis punctatus*	*Terrapene ornata*	*Rana catesbeiana*	*Pseudacris nigrita*	*Rana pipiens*	*Carphophis amoenus*	*Thamnophis sirtalis*	*Chemidophorus sexlineatus*	*Eumeces obsoletus*	*Bufo terrestris*	*Coluber constrictor*	*Chrysemys picta*	*Ancistrodon contortrix*	*Lampropeltis calligaster*	*Natrix sipedon*	*Storeria dekayi*	*Natrix erythrogaster*	*Pituophis catenifer*	*Elaphe obsoleta*
86	A. gryllus		2		6	43	8	45		5	1		9		19	1		4		6		
81	E. fasciatus	3		70	15	1		1	52	30	16	31	11	22		19	7	3	16		4	9
71	D. punctatus		80		13				51	32	20	31	10	31		16	10	1	19		1	6
62	T. ornata	8	19	14		5	2	5	6	6	18	11	5	3		3	2	3	3	5	3	2
56	R. catesbeiana	66	2		5		4	41		4			4		14			16		5		
55	P. nigrita	14			2	4		11			2	2	16		2							
55	R. pipiens	71	2		6	42	11			16			6		16			18		6		
50	C. amoenus		84	80	8					42	12	26	12	30		18	10		14		2	8
49	T. sirtalis	8	40	47	8	4			43		10	23	8	23	4		6	2	18	4		8
39	C. sexlineatus	3	33	36	28		3		15	13		41	10	15		3	5	5	8		5	5
36	E. obsoletus		69	61	19		3		36	30	44		14	19		11	11	3	6		3	11
31	B. terrestris	26	29	23	10	7	26	10	19	13	13	16		13		19	3				3	6
31	C. constrictor		58	71	7	27			48	36	19	23	13			16	13		16		3	3
30	C. picta	53					3	30		7								14		14		
29	A. contortrix	3	52	38	7				31		3	14	21	17			7		3			3
21	L. calligaster		29	33	5				24	14	10	19	5	19		10			5			5
21	N. sipedon	57	10	5	10	43		48		5	10	5			19				10	24		
18	S. dekayi		72	72	11				39	50	16	11		28		6	6	11				
16	N. erythrogaster	31			19	19		19							25			31				
16	P. catenifer		19	6	13				6	6	13	6	6	6					13			
15	E. obsoleta		47	27	7				27	27	13	27	13	7		7	7					

Read table thus: *Acris gryllus* was observed on 86 occasions. On 2 per cent of these occasions it was found with *Eumeces fasciatus*, on no occasion with *Diadophis punctatus*, on 6 per cent of the occasions with *Terrapene ornata*, on 43 per cent of the occasions with *Rana catesbeiana*, etc., etc. Blank spaces indicate that the species concerned were not found together on any occasion.

cent; using *Eumeces fasciatus* as a basis, association with *Diadophis* was 70 per cent. *Acris* was associated largely with *Rana catesbeiana* and *Rana pipiens,* and to a lesser degree with *Chrysemys.* Lack of association with *Acris* was exhibited by *Diadophis, Carphophis, Eumeces obsoletus, Coluuber, Lampropeltis calligaster, Storeria, Pituophis,* and *Elaphe obsoleta.* Less than 5 per cent association was shown between either *Eumeces fasciatus* or *Diadophis* and the following: *Rana catesbeiana, Pseudacris, Rana pipiens, Chrysemys, Natrix sipedon, Natrix erythrogaster,* and *Pituophis.*

The frogs in Table IV are noted to have occurred together, and also associated with the other aquatic and semi-aquatic turtles and water

snakes, as expected. The small amount of association between *Pseudacris* and the other frogs is because the chorus frog was found primarily at temporary pools and roadside ditches, situations not usually used by the other frogs. Lack of association may be noted between the frogs and the reptiles of the wooded hillsides and the prairies.

Terrapene ornata was found in a variety of habitats. This is evidenced by the amount of association between it and the other reptiles and amphibians. It was found with almost every form, except some of the aquatic turtles. With no species, however, was it associated to a great extent; but more with wooded hillside forms, *Eumeces fasciatus* (19 per cent) and *Diadophis punctatus* (14 per cent), and prairie form, *Cnemidophorus sexlineatus* (18 per cent), than with others. The association exhibited between the terrestrial box turtle and members of the Semi-aquatic Community was due to the occasional observation of *T. ornata* in the mud or water of drying holes of creeks.

Thamnophis sirtalis, like *Terrapene ornata,* was a wide-ranging form found in a variety of habitats. On almost half of the occasions noted, however, it was found associated with the members of the Oak-Walnut Hillside Forest Community: *Diadophis, Carphophis,* and *Eumeces fasciatus.*

About one-third of the times that *Cnemidophorus sexlineatus* was noted, *Diadophis punctatus* and/or *Eumeces fasciatus* were also observed. *Cnemidophorus* was collected with *Diadophis* on only 20 per cent of the occasions that *Diadophis* was observed, and on 16 per cent of the occasions that *Eumeces fasciatus* was noted. *Diadophis* and *Eumeces fasciatus* are characteristic forms of the Oak-Walnut Hillside Forest Community, whereas *Cnemidophorus* was found in more dry, open areas. The amount of association shown based on *Cnemidophorus* observations is because many of the race-runners were seen at rocky prairie ravines which extended into the prairie from a forested hillside. It was in these ravines that members of the Hillside Forest Community were found in considerable numbers.

A large degree of association was exhibited by members of the Oak-Walnut Hillside Forest Community: *Diadophis punctatus, Carphophis amoenus,* and *Eumeces fasciatus.* In each instance the association was over 50 per cent. On 80 per cent of the occasions that *Diadophis* was observed, *Eumeces fasciatus* was also noted; and when *Carphophis* was seen, *Diadophis* was also seen 80 per cent of the times, and *Eumeces fasciatus* on 84 per cent of the occasions.

Eumeces obsoletus was a form found most frequently in the marginal, open areas between the forest and prairie. Its intermediate habitat selection is shown in that on the occasions that *Eumeces obsoletus* was found, the forest species, *Eumeces fasciatus,* was also observed 69 per cent of the times; and the prairie species, *Cnemidophorus,* was noted on 44 per cent of the observations. Fitch (1955) noted that *Eumeces obsoletus* was found

in the Flint Hills of Kansas associated with *Diadophis punctatus, Tropidoclonion lineatum, Coluber constrictor, Lampropeltis doliata, Tantilla gracilis,* and *Crotaphytus collaris.* Following are the percentages of occurrence of *Eumeces obsoletus* with those of the above forms which were observed in the present study area: *Diadophis* (61 per cent), *Tropidoclonion* (3 per cent), *Coluber* (19 per cent), and *Lampropeltis doliata* (8 per cent).

Often, the close proximity of extremely different habitats caused species which would normally not be found together to be associated. *Cnemidophorus,* the arid-land species, was collected with such semi-aquatic forms as *Acris, Pseudacris,* and *Natrix sipedon* at the edge of a small stream which intermittenly flowed through a prairie pasture. At this same location, *Tropidoclonion lineatum* was found with *Natrix sipedon. Eumeces fasciatus* was recorded in association with *Acris, Rana catesbeiana,* and *Natrix sipedon* when a small skink was found foraging at the edge of a drying hole of Long Creek.

SUMMARY

1. An ecological study was conducted of the amphibians and reptiles in 6 biotic communities (Aquatic, Semi-aquatic, Oak-Walnut Hillside Forest, Cultivated-Field, Buckbrush-Sumac, Prairie) in east-central Kansas in the vicinity of Melvern, Osage County, during the period from January, 1950, through June, 1956.

2. The gently rolling topography varied in height above sea level from 875 to 1300 feet. In this area, 48 per cent was devoted to cultivation, 28 per cent pasture, 14 per cent overgrown fields, and 10 per cent wooded tracts. The mean annual temperature is 55.4°F and the mean annual precipitation is 34.76 inches. Both the wettest and driest years ever recorded for the area occurred during the period of study.

3. Observations were made during the daytime and were limited to the recording of the following data: (1) kinds of species, (2) number of individuals, (3) location, (4) habitat, (5) air and ground temperatures, and (6) weather conditions.

4. An annotated checklist of the species observed was prepared. This checklist consisted of 2 salamanders, 1 toad, 5 frogs, 7 turtles, 5 lizards, and 19 snakes.

5. The dominant vegetation and the relative frequency of occurrence of the herpetofauna of each community was reported. The number of characteristic reptiles and/or amphibians in each area were Aquatic 6, Semi-aquatic 7, Hillside Forest 6, Cultivated-field 3, Buckbrush-Sumac 2, Prairie 6.

6. No amphibian or reptile was found active below 39° or above 102°; most species were observed between 55° and 90°F. Abundance of

reptiles reached a peak in April and declined sharply to a summer low, with a small peak in fall. Members of the Hillside Forest Community appeared earlier in the spring and at lower temperatures than did the members of the other communities.

7. Variation in precipitation had a marked effect on the abundance of most amphibians, and to a lesser degree on the abundance of reptiles.

APPENDIX

List of species of probable, but unverified, occurrence in the area.

Ambystoma tigrinum mavortium Baird, Tiger Salamander. Only one specimen, a larva from Carbondale (Clarke, 1956b), has been taken in Osage County, although reports from farmers indicate that the species is not rare in the Melvern area. The larval stage is entirely aquatic and often found in farm ponds, whereas the Texas salamander more often breeds in small prairie streams or sloughs.

Bufo w. woodhousei Girard, Rocky Mountain Toad. Smith (1950) recorded this toad from Carbondale, Osage County, but none have been found in the study area. These toads are partial to prairie regions.

Microhyla carolinensis olivacea Hallowell, Great Plains Narrow-mouthed Toad. This species was not observed in the study area, although it undoubtedly occurs there. Dr. Charles E. Burt collected an individual in Osage County 1.25 miles north of Vassar, which is about 11 miles north of Melvern, on June 6, 1954. It was taken under a rock in a prairie area just above a tree-covered hillside.

Graptemys pseudogeographica, False Map Turtle. Smith (1956) reported this species from Long Creek, and used *G. p. kohnii* as the subspecies present. Schmidt (1953) gave *G. p. pseudogeographica* as the subspecies present in Kansas, whereas Cagle (1953, 1954) listed two species as occurring together in Kansas: *G. p. ouachitensis* and *G. kohnii.*

Crotaphytus c. collaris Say, Collared Lizard. One specimen was collected by Charles E. Burt 1.25 miles north of Vassar, Osage County, on June 6, 1954. Also taken there at the same time were *Microhyla carolinensis olivacea, Eumeces fasciatus,* and *Crotalus h. horridus.*

Lygosoma laterale Say, Little Brown Skink. This species was recorded by Smith (1956) from the counties east and north of Osage County, under the name *Scincella laterale* Say. It has also been recorded from Lyon County, with the locality of collection just across the county line from Osage County on the west. Seemingly similar habitats occur in eastern Osage County as in places where this lizard had been taken. The secretiveness of this small skink probably accounts for its apparent lack of occurrence in the county.

Heterodon p. platyrhinos Latreille, Eastern Hog-nosed Snake. This snake has been recorded as occurring in counties east, north, and west of

Osage County. Farmers in the Melvern area report that they have occasionally seen the "spread-head viper" or "blow viper."

Opheodrys aestivus Linnaeus, Rough Green Snake. Reported in literature from counties adjacent to Osage County on the north and east, the green snake may occur in the eastern part of the county. The description of a snake killed a few miles from Melvern by a railroad section crew could fit this snake alone.

Thamnophis radix haydeni Kennicott, Western Plains Garter Snake. This snake was fairly common in Osage City, but was not taken in the southeastern part of the county (Clarke, 1956b).

Sistrurus catenatus tergeminus Say, Western Massasauga. Gloyd (1940) recorded the massasauga as taken in Osage County at six miles south of Carbondale and at "Song Creek." The latter specimen is number 2314 in the University of Kansas Museum of Natural History. The tag attached to the specimen has been examined and the previously reported locality is believed to be an error of transcription and should read "Long Creek." Farmers in the Melvern area report that this small "prairie" rattlesnake is often found beneath bales of hay left in the fields.

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