An Ecological Study of the Narrow-mouthed Toad (Microhyla) in Northeastern Kansas

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Introduction

An ecological study of the western narrow-mouthed toad *Microhyla olivacea* (Hallowell) was made in Douglas County, Kansas during the spring and summer of 1950. Because of its extremely secretive habits and small size little is known of its natural history, particularly in a woodland habitat. The purpose of this study was to learn as much as possible in one season concerning the habitat requirements, behavior, growth, food habits, movements and reproduction of this species.

Description of the Study Area

The University of Kansas Natural History Reservation is situated three miles north and one and one-half miles east of Lawrence, Kansas. Its topography is extremely irregular, with small valleys, rough, sparsely to heavily wooded slopes, and flat and open hilltop areas. In the valleys between the slopes and on the somewhat drier hilltops there are small fields and meadows which until 1948 were cultivated, or grazed by domestic stock.

An irregular area of about one acre, approximately 875 feet long and 50 feet wide, with two outcropping strata of limestone, and a rock strewn slope between and below them, was selected for concentrated study. This area chosen for special study is fairly typical of grazed portions of the wooded hillsides. Trees form a fairly continuous canopy and sunlight reaches the soil in small flecks or patches only. The soil remains moist longer than in surrounding open areas and the humidity is prevailingly high.

The slope, in the study area, is gentle, averaging a rise of one and one-half inch per linear foot. The soil is loose, and rich in organic matter. There are occasional limestone outcrops, and small flat rocks are scattered over the surface of the soil, affording cover for the toads when the temperature and the humidity are favorable. During adverse periods of drought or cold, however, the crevices of the limestone ledges are used as shelter.

American elm (*Ulmus americana*) is the dominant species of tree throughout the entire area. Honey locust (*Gleditsia triacanthos*) and osage orange (*Maclura pomifera*) common at the base of the slope are partly replaced by black oak (*Quercus velutina*) higher on the hillside,

and on the rocky upper portion yellow oak (*Quercus Muhlenbergii*), shagbark hickory (*Carya ovata*) and black walnut (*Juglans nigra*) predominate. Redbud (*Cercis canadensis*) and coralberry (*Symphoricarpos orbiculatus*) are the most abundant shrubs, although patches of smooth sumac (*Rhus glabra*) are also common. Wild grape (*Vitis* sp.), greenbriar (*Smilax hispida*) and wild rose (*Rosa* sp.) are scattered over the area.

Grazing and trampling of cattle and horses (removed in 1948) and the former use of a road through the length of the area kept understory vegetation to a minimum, and it is still much scarcer than in more protected parts of the woodland. Lack of heavy underbrush apparently is an environmental condition favorable to the toads as the population appears to be largest in the partially barren areas.

Methods

Collecting—Toads were found by lifting all easily moveable rocks on the study area and examining the soil beneath them. Each rock or log lifted was carefully replaced to avoid disturbing the site and discouraging future occupancy by toads. Other specimens were obtained from pitfall traps which were simply buried cans having their open ends flush with the level of the ground. These traps were strategically placed along the base of outcropping ledges, with flat rocks placed loosely over the opening providing concealment and protection from rain. Effort was made to capture as many individuals as possible by a uniform and thorough search, with quick and accurate recording of each site of capture. Toads were collected on 36 different days, from June to October. During this period 158 toads were taken a total of 237 times.

Marking—Each toad was marked by clipping one toe, or a combination of two or three toes through the joints nearest the base. Many different combinations are possible, and a recaptured individual can be identified readily. Fine scissors were used for toe clipping which rendered the operation neat and rapid. Little tissue regeneration was noted on the clipped toes. Several individuals marked by this method in 1949 were recaptured, after a lapse of more than a year, with markings still easily discernible.

Stations—Collecting stations were recorded with reference to designated natural landmarks well distributed throughout the study area. Distances were determined by pacing to the nearest landmark and directions were determined by use of a map. Occasionally two landmarks were used as reference points for a particular station.

Records—For each toad captured, the data recorded included date, station, sex, formula from clipped toes, overall body length, and often

behavior and habitat notes. Newly captured toads were marked and released at the capture site. Determinations of sex were based on the more darkened throat of the male. The buffy fingers of males, contrasting with the white fingers of females, served to substantiate the sex determinations. Sexing on the basis of external appearance, in young specimens, is difficult and uncertain.

Food Examinations—The toads collected for food habits study were immediately placed in individual small clean jars. As soon as they were brought to the laboratory, usually within an hour or two of the time they were collected, 70 per cent alcohol was added to the jars which killed the toads and preserved any materials voided. The contents of a jar were poured into a clean Petri dish for examination. The stomach, intestinal tract and cloaca were opened and the contents were washed out and examined under a dissecting microscope.

Behavior in Relation to Environment

On the Reservation, *Microhyla* utilizes logs and flat limestone rocks as protective cover. In March and April the few that could be found were beneath massive rocks. Later in the season rocks of varying sizes were chosen for cover. The usual choice was a flat rock several inches thick and perhaps one and one-half feet in diameter, although some individuals were taken from beneath rocks scarcely larger than their own bodies. Rocks that were in groups, were more often frequented than were isolated rocks.

Vegetation in the vicinity apparently had little effect on the value of rocks as cover. Toads were taken in large numbers from beneath rocks devoid of surrounding vegetation as well as from beneath rocks heavily overgrown by grasses and weeds. After rains, rocks most frequently used were those with better drainage where quick runoff prevented the formation of mud. Water saturates the soil under rocks in poorly drained areas, forming mud which later dries into a hard crust, creating conditions unfavorable to occupancy by toads. Force (1930) writing of *M. olivacea* in Oklahoma likewise found that this toad was fairly common in loose, damp soil beneath limestone or sandstone rocks.

Apparently more important than the cover is the texture of the substrate. The most favored rocks are those with no leaves nor twigs beneath but with substrate of loose moist soil. A possible explanation for this is that a rock which affords an opportunity for leaves and twigs to be washed or blown under also affords an opening for predators to enter.

Microhyla seems unable to dig, but often utilizes the burrows of lizards, insects and spiders in the area. One individual was taken from a

burrow of a mole (*Scalopus aquaticus*). Blair (1936) noted that in Oklahoma burrows of the tarantula (*Eurypelma hentzi*) were often utilized by this species for shelter, even while the burrows were still occupied by the spiders.

Weather conditions influence toad activity. Optimum conditions are created by high humidity and high temperature with sunshine and frequent rains. Low temperature and drought are unfavorable. During rains, especially those on warm nights, the toads are apparently stimulated to activity. Best catches in pitfall traps were recorded on the mornings following warm night rains. After these rains, however, two or three days elapse before maximum numbers can be found beneath rocks and logs. Abundance in such places continues several days but then, as the soil dries and cracks, numbers begin to decrease. The toads apparently retreat down into the cracks or into crevices of the limestone ledges where they are better protected from desiccation.

Soil moisture varies greatly beneath the rocks or logs used as shelter. Thirty soil samples of approximately 3 ounces each (five samples collected on each of the six dates listed in Table 1) were tested for moisture content. Each sample was removed from the exact spot occupied by a toad on the date of collection, but no attempt was made to take soil specimens from beneath the same rocks for succeeding tests.

Accurately weighed vials were used for containers and were immediately tightly plugged to prevent evaporation. Samples were weighed on an analytical balance before and after being baked for one hour in the drying oven to eliminate moisture. It is apparent that wide variation in moisture content may occur on any one date and between samples taken on various dates.

Table 1. Percentage of Water in Samples of Soil

	June 8	June 13	June 26	July 5	July 22	August 6
	9	17	19	16	9	7
	9	23	32	13	12	16
	9	24	47	14	15	17
	11	20	3	21	14	9
	9	31	46	11	9	7
Averages	9	23	29	15	12	11

Many kinds of animals were noted associated with *Microhyla,* as shown in the following list.

List of Animal Associates Found under Rocks and Logs with M. olivacea.

Sonoran Skink (*Eumeces obsoletus*), Occasional
Five-lined Skink (*Eumeces fasciatus*), Common
Northern Cricket Frog (*Acris crepitans*), Rare
American Toad (*Bufo terrestris*), Rare
Leopard Frog (*Rana pipiens*), Rare
Machilid, Rare (spring only)

Walking Stick, Rare
Grasshopper, Occasional
Black Cricket (*Gryllus* sp.) Common (fall)
Burrowing Bug, Occasional
Stink Bug, Rare
Assassin Bug, Occasional
Cicada, Rare
Tree Hopper, Rare
Tiger Beetle, Occasional
Ground Beetle, Common
Carrion Beetle, Rare
Rove Beetle, Occasional
Lightning "Bug" Beetle, Rare
Soldier Beetle, Rare
Blister Beetle, Rare
Click Beetle, Rare
Metallic Wood Borer Beetle, Occasional (Under logs)
Lady Beetle, Occasional
Darkling Beetle, Rare
Scarabaeid, Occasional
Long-horned Beetle, Rare
Snout Beetle, Rare
Bark Beetle, Rare
Mosquito, Rare
Blow Fly, Occasional
Ichneumon Fly, Rare
Ant, Occasional
Scorpion, Occasional
Spider, Common (fall)
Tick, Common (on other vertebrates)
Harvestman, Common (fall)
Millipede, Common
Centipede, Common

Few data were obtained concerning the natural enemies of *Microhyla.* Thorough stomach examinations of snakes from the study area were impractical because snakes on the Reservation could not be sacrificed. Copperheads (*Agkistrodon contortrix*) are common on the area, and Dr. Henry S. Fitch found a young one which had eaten a *Microhyla.* Another instance of copperhead predation on *Microhyla* was recorded by Anderson (1942) in Jackson County, Missouri. On one occasion on the study area a white-footed mouse built a nest under a rock previously used by a toad, and subsequently no toads were ever found there. Lizards (*Eumeces*) are common on the area and were often discovered beneath the same cover with *Microhyla;* it would appear that they are not predaceous on the toads.

Mutilation, presumably by predators, involving partial or complete

loss of one or more feet, or lacerations leaving scars across the back and thighs, has been noticed frequently in *Microhyla.*

Table 2. Records of Marked Microhyla Recaptured One or More Times

Sex	Days Elapsed Between Successive Captures			Distances in Feet Between Successive Captures		
	1st-2nd	2nd-3rd	3rd-4th	1st-2nd	2nd-3rd	3rd-4th
female	55	....	....	750	....	....
young*	8	1	....	45	45	....
female	8	4	2	15	15	0
male	27	6	....	25	25	....
female	23	25	20	20	9	23
female	15	....	....	450	....	....
female	44	....	....	320	....	....
male	9	....	....	30	....	....
female	3	....	....	21	....	....
young*	9	21	....	20	42	....
female	9	....	....	31	....	....
female	53	....	....	49	....	....
male	44	....	....	17	....	....
young*	1	....	....	.5	....	....
young*	10	....	....	12	....	....
female	3	2	9	10	2	13
female	24	....	....	28	....	....
female	20	....	....	212	....	....
male	20	15	....	150	90	....
young*	35	34	....	60	70	....
young*	5	....	....	8.5	....	....
male	21	....	....	200	....	....
female	56	....	....	150	....	....
female	22	....	....	10	....	....
young*	28	15	....	150	235	....
male	5	1	4	0	20	20
female	30	2	....	12	12	....
female	28	....	....	17	....	....
female	14	....	....	350	....	....
female	46	....	....	37	....	....
female	4	....	....	80	....	....
male	2	2	....	100	235	....
?	30	....	....	78	....	....
male	4	....	....	35	....	....
?	6	....	....	12	....	....
male	3	9	....	335	115	....
male	6	5	....	335	35	....
young*	3	....	....	5	....	....
female	4	....	....	0	....	....
young*	7	5	....	0	325	....
female	2	22	....	7	9	....
young*	12	....	....	60	....	....
young*	6	6	....	500	10	....
young*	8	19	....	6	275	....
female	8	....	....	60	....	....
young*	9	16	....	100	40	....
male	5	10	1	135	12	10
young*	3	....	....	0	....	....
young*	29	....	....	20	....	....
?	1	....	....	0	....	....
female	10	....	....	9	....	....
young*	11	....	....	170	....	....
?	6	....	....	5	....	....

*Individuals too young to sex accurately.

Movements

Between June 7, 1950 and October 14, 1950 a total of 158 toads were marked in the field and released at the sites of capture, and 53 of them were recaptured. Thirty-three of these were recaptured once, 15 were recaptured twice and five were recaptured three times after being marked. An average time of 16 days elapsed between the first and second captures, 11 between the second and third, and seven between the third and fourth. Home ranges, however, are not necessarily indicated as the study

area is enclosed by tracts unfavorable for habitation by toads. The ends of the study area are bordered by open fields and the sides by woodlands with heavy underbrush. Linear distances between sites of capture are recorded in Table 2. In every instance the toad probably moved a greater distance between captures than that actually shown, since travel from one point to another would seldom be in a straight line.

Wright and Wright (1949) consider 19 millimeters to be the minimum size of a sexually mature female. However, in northeastern Kansas 25 millimeters seems to be nearer the minimum breeding size. Most individuals less than 25 millimeters in length could not be sexed accurately. Sex for this group is not indicated in Table 2 and a body length of 25 millimeters is arbitrarily selected as dividing adults and young.

Available data indicate that young and adults of both sexes wander extensively but it cannot be shown that toads of any one sex or age group move more often or farther than the others.

On the study area, remote from any water supply, toads were caught during the breeding season just as readily as they were before and after. Apparently some are going to the breeding sites while other are returning. During this period some individuals were taken in open fields away from the study area, especially beneath fallen stalks in an abandoned corn field.

Reproduction

Microhyla is terrestrial and resorts to water only for breeding. The breeding season is not well defined; a few scattered males were heard calling as early as June 20th from ditches along the county road between the Reservation and U.S. Highway number 24. On July 3, one day after a three inch rain, a great *Microhyla* chorus was heard. Intermittent calling, mainly after rains, continued until early September.

Bragg and Smith (1942) state that in Oklahoma the species is heard calling only occasionally before April 30 and usually not in numbers before May 8. Breeding is intermittent and occurs only after rains but continues through the summer into September. Smith (1934) reports a female taken in August, near Independence, Montgomery County, Kansas which retained large numbers of eggs. Others taken as late as June 16 near Manhattan in Riley County also contained eggs. According to Wright and Wright (1949) the species breeds from March 15 to September during periods of heavy rainfall.

Studies of reproduction in the toads could not be carried on in the study area but were confined to a small artificial pond approximately 100 yards west of the Reservation, which contains water only during and

after periods of wet weather. It is circular in outline, approximately 50 feet in diameter, with pond weed (*Potamogeton foliosus*) in the shallow water near the banks. Vegetation in the immediately surrounding area is mainly smartweed (*Persicaria*) with ironweed (*Vernonia* sp.) and milkweed (*Asclepias* sp.) interspersed a little farther back from the banks. Sunflowers (*Helianthus* sp.) and corn (*Zea mays*) predominate in the surrounding abandoned corn field and there are several cottonwoods (*Populus virginiana*) and elms (*Ulmus americana*) nearby.

At the breeding pond the males normally commence to call at dark although *Hyla versicolor* and *Acris crepitans* begin calling earlier. The call of the *Microhyla* is a low, buzzing sound with slight carrying power, which lasts approximately two to three seconds. Smith (1934) describes it as "a high shrill buzz of some two to three seconds duration, and of such slight volume that a single call cannot be heard more than fifty to a hundred feet away." While calling, the males sit among the pondweeds often partly submerged in water and sometimes beneath the protection of rocks outcropping from the banks. It is not uncommon to hear a dozen or more calling from an area of a few square feet. Bragg (1943) likewise found that in Oklahoma males often call close together in grass clumps, suggesting that they are attracted by one another's calls.

At approach of a person the calls immediately cease and do not commence again until all is quiet for five minutes or more. Males of *Acris crepitans* and *Microhyla olivacea* apparently are attracted to each other. Often, at the breeding pool, both species were captured with one sweep of the hand. Females of *Microhyla* were taken in the same manner. Calling often ceases or is greatly reduced toward midnight or slightly later. During the daylight, breeding adults withdraw from the bank to shelter beneath rocks or corn stalks a short distance from the pond.

Fifteen mature males and fifteen mature females, taken on various dates, were examined to determine the condition of their reproductive organs. The data obtained from these examinations are shown in Tables 3 and 4. In Table 3, eggs described as "minute" were less than 0.5 millimeter in diameter. In females having eggs that were small and underdeveloped the oviducts were small and comparatively straight. In those having large eggs nearly ready to lay, the oviducts were enlarged and convoluted.

Food Habits

An examination of the contents of digestive tracts from 52 toads confirms previous findings (Smith, 1934; Tanner, 1950) that in Kansas *Microhyla* feeds upon ants almost exclusively. The toads used for these

Table 3. Sizes and Numbers of Eggs in Adult Females

Date	Length of Individual in mm.	Egg No.	Egg Size in mm.	Oviducts	Remarks
April 14	34	837	minute	small	
May 31	31	820	minute	small	ovaries 4 mm. x 2 mm.
June 3	33	1194	.7 to .8	.....	One mature egg (with darkened pole .9 to 1mm.) to 20 immature.
June 13	34	1074	.8 to .9	large	
June 17	35	1114	.....	large	95% of eggs mature.
June 26	34	1189	.....	large	97% of eggs mature.
July 1	35	1090	.9 to 1.	large	taken at breeding site.
July 7	30	1217	.9 to 1.	large	
July 13	35	1010	.9 to 1.	large	
July 20	32	630	minute	small	
July 25	29	895	.9 to 1.	large	
August 2	37	532	.....	small	50% of eggs mature.
August 8	33	50	.....	medium	A few very immature eggs also present.
August 16	36	75		medium	Some immature eggs present.
			minute	large	
August 20	28			small	

Table 4. Condition of Testes in Adult Males

Date	Length of Body in. mm.	Length of Testis in mm.	Color of Testis	Remarks
April 14	32	1.5	white	
May 31	28	1.5	white	
June 3	25	.5	.....	
June 13	29	2.	.....	
June 17	31	3.	gray	Taken at breeding site.
June 26	33	3.	.....	
July 1	31	4.	.....	Calling at a breeding pond.
July 7	30	3.5	gray	
July 13	29	1.5	white	
July 20	29	2.5		
July 25	28	1.5	white	
August 2	31	3.5	.....	
August 8	33	4.	.....	
August 16	32	3.	.....	
August 20	29	1.5	white	

examinations were different sizes and ages and were taken at varying times throughout the season.

Counts of ant heads found in 15 of the digestive tracts are shown in Table 5. Contents of the remaining 37 digestive tracts were inspected to determine the kinds and relative amounts of food eaten, but without making actual counts.

In loose, moist soil in protected sites utilized by *Microhyla* certain kinds

Table 5. Numbers of Ant Heads Found in Digestive Tracts of 15 Microhyla

Date	Length of Body in mm.	Sex	Ant Heads
April 14	34	f	56
May 31	31	f	71
June 3	33	f	22
June 13	29	m	13
June 17	35	f	7
June 26	33	m	27
July 1	31	m	19
July 7	30	f	32
July 13	35	f	26
July 20	32	f	35
July 25	28	m	14
August 2	37	f	13
August 8	33	m	51
August 16	32	m	46
August 30	29	m	55

of ants, on which they feed are by far the most numerous insects. Quantities of ants were found in the digestive tracts of all the toads examined, except for those taken from pitfall traps, which usually were empty after 24 hours or less of confinement. When toads are free and active they must feed frequently. The food appears to be confined almost entirely to ants of two kinds, *Crematogaster* sp. and *Lasius interjectus*. Approximately eighty per cent of the toads examined had eaten *Crematogaster* exclusively. On several occasions, however, fragments of other insects were found in the digestive tracts—mostly remains of small beetles, unidentifiable from the small fragments present. Traces of vegetation occasionally found in the digestive tracts were estimated at less than one per cent of the total contents, and may have been ingested accidentally. *Microhyla* apparently has strong digestive juices. Ants found in digestive tracts were largely digested except for segments of chitinous exoskeleton which remained almost intact. These chitinous remains are voided as characteristic "scats," beneath rocks and logs used by toads. They are flat with a fairly round outline, usually 3/8 inch or less in diameter and of a glistening brown color.

Composition of the Population

Since larger young are not always distinguishable from adults, and sexing is uncertain, especially in the smaller young, the trends of changing population composition on the study area during the season are somewhat obscured. In June 1950 those classed as immatures (25 millimeters or less, mainly or entirely young of 1949) made up 30 per cent of the sample. In later monthly samples most of this group having made continued growth, were probably classified as adults. In August the young of 1950 began arriving on the study area in large numbers, and were easily distinguishable from adults because of their much smaller size. The September sample consisted almost entirely of these young of the year, grown to somewhat larger average size, though small ones continued to appear.

Changing sex ratio in the group classified as adults is shown in Table 6.

Table 6. Ratio of Adult Females to Males according to Months

Month	No. in Sample	Female to Male Ratio
June	34	2.8:1
July	13	3.3:1
August	39	1:1
September	10	4:1

Parasites

Most snakes and lizards found beneath rocks along with *Microhyla* were parasitized by ticks. Chigger infestation likewise was common in

the vertebrate fauna of the area. However, in field examinations of more than 200 *Microhyla,* not a single case of ectoparasitism was found. In approximately 20 per cent of the individuals examined small, white nematode worms approximately two millimeters in length were found in the stomachs, intestines and cloacal regions. Superficially they appear much like human pinworms.

Summary and Conclusion

Microhyla was successfully marked in the field by toe clipping. The toes used in each formula were severed from the feet by clipping through the joint nearest the base. Practically no regeneration was noted during the course of the study.

Microhyla apparently prefers as shelter flat limestone rocks which have good drainage, loose soil, and few twigs or leaves beneath them. Deep crevices along outcropping rock ledges also improve the habitat, and during periods of drought or cool weather *Microhyla* withdraws from outlying rocks to this shelter. Burrows made by other animals or natural cracks in the soil may also be utilized during adverse periods. Rain stimulates the toads to activity, especially if it occurs on warm evenings.

Insects of many different families, lizards (*Eumeces obsoletus* and *E. fasciatus*) and other amphibians (*Rana pipiens, Acris crepitans* and *Bufo terrestris*) are also found under the same cover with *Microhyla.* No snakes were taken from the protection of rocks while the toads were also there.

Narrow-mouthed toads appear to have no individual home ranges but seem to wander in any direction where suitable habitat is present. However, a longer continued study of movements of marked individuals in a more extensive area is needed to establish definitely that these animals actually wander at random.

During the height of the breeding season, in July and August, the toads moved to and from the breeding sites individually, some traveling toward the breeding sites while others are leaving. This was the only time that individuals were taken in open fields. Breeding sites in this region are usually temporary or semipermanent shallow pools having abundant aquatic vegetation.

Males commence calling at the breeding sites at dark. Apparently the calling males of *Microhyla* are attracted to each other, as large numbers may congregate within a few square feet. The males of *Acris crepitans* and *Microhyla* while calling are attracted to each other and may be found in close proximity.

In April the ovaries contain eggs at such an early stage of development that they cannot be counted with accuracy. By the first of June

approximately 85 per cent of the eggs are mature. (0.7 to 0.9 millimeters in diameter with a darkened pole). There are from 900 to 1200 eggs in the ripe ovaries, during July and August. In the males the testes remain minute with a length of two millimeters or less, until the middle of June. Then there is a rapid increase in size to a length of approximately 4 millimeters.

Microhyla feeds upon ants almost exclusively. *Crematogaster* sp. and *Lasius interjectus* are the two kinds of ants utilized as food with the former much more commonly used. Scats of *Microhyla* are commonly seen under logs and stones used by the toads as protection.

Young *Microhyla* arrive in the study area mainly in August and September and attain a size of 19-28 millimeters in body length by the time of their first hibernation. There is apparently an extremely rapid growth immediately after metamorphosis as the size of the young toads at the time of transformation is, according to Wright and Wright (1949), 10-12 millimeters. The yearlings continue to grow after emerging from hibernation until July and August when they attain full adult size and no longer can be distinguished from older adults.

Females usually were found in greater numbers than males; in June the ratio was 3:1, in July 3.3:1 and in August 1:1.

No ectoparasites were noted on *Microhyla*, although most amphibians and reptiles associated with them in the area are parasitized by ticks and chiggers.

Nematode endoparasites were discovered in approximately 20 per cent of all toads examined. These parasites inhabit the stomach, intestinal and cloacal regions. They are approximately 2 millimeters in length and superficially resemble the human pin worm.

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