

# FOODS OF THE TOAD, *BUFO WOODHOUSEI FOWLERI* HINCKLEY

W. D. KLIMSTRA and CHARLES W. MYERS

Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, and Gorgas Memorial Laboratory, Apartado 6991, Panamá, República de Panamá

**ABSTRACT.**—The stomach contents of 504 *Bufo woodhousei fowleri*, from southern Illinois, were analyzed. Three phyla of invertebrates were represented in the 497 stomachs containing food. The Mollusca (occurring in 1.2% of the stomachs with food) and Annelida (0.4%) were of minor importance, and of the Arthropoda the classes Insecta (100.0%) and Arachnida (12.9%) were the principal groups. Eleven orders and sixty-seven families of insects were identified; the orders Coleoptera (92.0%) and Hymenoptera (72.8%) were by far the most frequently represented groups. Because of the abundance and variety of prey utilized, food supply probably does not constitute an important factor in population control of Fowler's toad. The diet of Fowler's toad is determined principally by relative availability of prey items, and selectivity of prey is a factor of minor importance. Major aspects of the diet are much the same in southern Illinois, Georgia, and Oklahoma, except that a greater variety of foods is utilized in the first two states, a phenomenon attributed to greater faunal diversity in those areas.

Partly because of their supposed economic value (for example, Bragg, 1943; Garman, 1901; Kirkland, 1897, 1904), the food habits of North American toads (*Bufo*) have received more attention than most other groups of amphibians. Few writers, however, have based their work on adequate samples; for this reason our knowledge of dietary patterns is not as extensive as might be expected. Most of the important literature on the feeding of bufonids has

been reviewed by Smith and Bragg (1949), Hamilton (1954), and Bush and Menhinick (1962).

The data to be presented represent a segment of a study of the biology of *Bufo woodhousei fowleri* Hinckley in southern Illinois. Until recently, analyses of the food habits of Fowler's toad were based on small samples; however, Smith and Bragg (1949) reported on 560 specimens of a related subspecies, *B. w. woodhousei* Girard, in Oklahoma. As our data were being compiled, Bush and Menhinick (1962) published on the stomach contents of 111 *B. w. fowleri* from Georgia. These studies provide an opportunity to compare the diet of *B. woodhousei* from three widely separated localities—Oklahoma, Illinois, and Georgia.

## MATERIALS AND METHODS

A total of 504 stomachs of *B. w. fowleri* was examined (Table 1), representing specimens from Jackson, Union, and Williamson counties, Illinois, for June through September, 1958, and April through May, 1959. Specimens were collected in a variety of habitats, but many came from weedy, recently disturbed sections of new residential areas, agricultural areas, and roadsides; no collecting

was done around potential breeding waters. Stomachs were removed and stored in alcohol until examination. The individual stomach was opened along its greatest curvature and the contents emptied into a small dish of water. Food items were segregated under magnification; materials not readily identifiable were stored in alcohol or mounted on pins or slides for later determination. Tabulation of data was limited to percent frequency of occurrence; the many small food items and miscellaneous insect parts made it virtually impossible to obtain reasonably accurate volumetric measurements; or, in many cases, even counts of individual items.

#### FOODS IN SOUTHERN ILLINOIS

Food items representing three phyla of invertebrates (Mollusca, Annelida, and Arthropoda) were present in the stomachs of 497 Fowler's toads; two additional stomachs contained only unidentifiable matter and five were empty (Tables 1 and 2). Mollusks occurred in only

TABLE 1.—Numbers and conditions of stomachs by months for *Bufo woodhousei fowleri* in southern Illinois.

Month	Number with matter	Number empty	Total
April.....	21	0	21
May.....	115	2	117
June.....	46	1	47
July.....	40	0	40
August.....	125	2	127
September.....	100	0	100
Unknown.....	52	0	52
Totals.....	499*	5	504

\* Of which 497 stomachs contained food material, and two only extraneous matter.

1.2 percent of those containing food, and annelids in only 0.4 percent, hence the arthropods (100% occurrence) comprised the important group. Five classes of arthropods were recorded; the Insecta occurred in every stomach that contained food, being represented by at least 11 orders and 69 families. The orders Coleoptera (92.0%) and Hymenoptera (72.8%) actually comprised the major portion of the diet (Figs. 1 and 3).

Of 32 families of Coleoptera identified, the Carabidae (63.8%), Curculionidae (37.4%), Chrysomelidae Scarabaeidae (29.8%), Elateridae (19.3%), Coccinellidae (18.7%), Cantharidae (13.5%), and Staphylinidae (12.9%) occurred most frequently (Table 2 and Fig. 2). Adult beetles were recorded in 91.3 percent of the stomachs and larvae in 16.5 percent. Only in the case of Cantharidae were larvae (9.9%) more

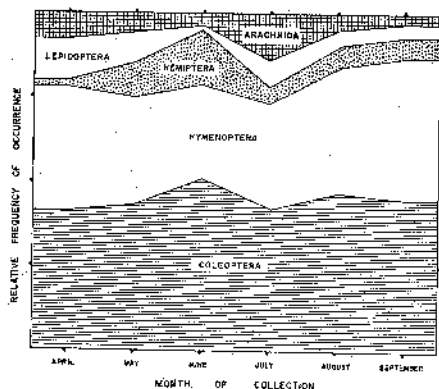


Figure 1.—Relative utilization of major food groups by *Bufo woodhousei fowleri* in southern Illinois (June - September, 1958 and April - May, 1959). The graph does not show cumulative percentage, but rather the width of each segment reflects frequency of utilization of a food group relative to other groups on the graph.

TABLE 2.—Invertebrate groups utilized as food by *Bufo woodhousi forsteri* in southern Illinois.

Food	Month of collection and number of stomachs										Total 497	Percent frequency of occurrence
	April 21	May 113	June 46	July 40	August 125	September 100	Unknown 52					
INSECTA.....	21*	113	45	40	125	100	52	497	100.0			
Undetermined.....	3	5	6	4	24	9	6	57	11.5			
COLEOPTERA.....	20	113	44	39	109	90	42	457	92.0			
Undetermined.....	..	..	11	7	11	7	..	36	7.2			
Adults.....	20	113	44	39	108	90	40	454	91.3			
Larvae.....	15	19	9	3	25	12	14	82	16.5			
Carabidae.....	15	95	38	32	70	46	21	317	63.8			
Curculionidae.....	17	82	17	14	26	22	8	186	37.4			
Chrysomelidae.....	15	34	12	8	51	37	21	170	34.2			
Scarabaeidae.....	15	49	14	16	25	21	8	148	29.8			
Elateridae.....	7	39	11	9	14	12	4	96	19.3			
Coccinellidae.....	..	27	9	9	17	18	13	93	18.7			
Cantharididae.....	..	15	5	4	23	12	8	67	13.5			
Staphylinidae.....	4	15	5	5	20	14	10	64	12.9			
Lampyridae.....	..	9	..	..	1	5	1	14	2.8			
Histeridae.....	..	7	..	1	1	1	1	7	1.4			
Nitidulidae.....	..	2	..	..	2	1	..	6	1.2			
Meloidae.....	..	1	1	1	3	1	..	5	1.0			
Tenebrionidae.....	..	2	1	2	..	..	..	5	1.0			
Cleridae.....	..	3	..	1	..	..	..	4	0.8			
Cucujidae.....	..	..	..	..	2	..	1	3	0.6			
Heteroceridae.....	..	..	..	..	3	..	..	3	0.6			
Byrrhidae.....	..	..	..	..	..	..	2	2	0.4			
Cerambycidae.....	..	..	1	1	..	1	..	2	0.4			
Cicindelidae.....	..	..	..	..	..	..	1	2	0.4			

TABLE 2.—Continued.

Food	Month of collection and number of stomachs								Total 497	Percent frequency of occurrence
	April 21	May 113	June 46	July 40	August 125	September 100	Unknown 52			
Exotylidae.....		2							2	0.4
Lathridiidae.....					1				2	0.4
Alleculidae.....				1					1	0.2
Anthicidae.....							1		1	0.2
Anthrribidae.....				1					1	0.2
Bostriichidae.....			1						1	0.2
Bruchidae.....									1	0.2
Hydrophilidae.....					1				1	0.2
Monotomidae.....						1			1	0.2
Onophromidae.....			1						1	0.2
Ptilodaetylidae.....				1					1	0.2
Scaphidiidae.....					1				1	0.2
Scolytidae.....							1		1	0.2
<b>HYMENOPTERA</b> .....	18	85	24	29	85	75	46		362	72.8
Undetermined.....	1	7	1	2	9	12	1		33	6.6
Formicidae.....	17	81	20	28	78	70	45		339	68.2
Vespidae.....		1	3	4	3	2	1		14	2.8
Ichneumonidae.....		3	1	3					7	1.4
Megachilidae.....				1	2	1			4	0.8
Sphaecidae.....			1	1		1			4	0.8
Bracconidae.....			1	1		1			4	0.8
Mutillidae.....			1				1		3	0.6
Apidae.....								1	1	0.2
Tenthredinidae.....								1	1	0.2
<b>HEMIPTERA</b> .....	1	26	14	5	14	11	7		78	15.7

TABLE 2.—Continued.

Food	Month of collection and number of stomachs								Total 497	Percent frequency of occurrence
	April 21	May 113	June 46	July 40	August 125	September 100	Unknown 52			
Undetermined.....	..	3	2	..	4	2	2	13	2.6	
Cydniidae.....	..	9	13	1	1	1	1	26	5.2	
Pentatomidae.....	1	15	2	1	3	4	3	26	5.2	
Lygaeidae.....	..	3	..	2	2	1	1	11	2.2	
Coreidae.....	..	..	..	1	3	1	1	8	1.6	
Corixidae.....	..	..	..	1	4	1	1	7	1.4	
Nepidae.....	..	1	..	..	1	1	..	2	0.4	
Recurvitidae.....	..	..	..	..	..	..	..	1	0.2	
LEPIDOPTERA.....	6	24	2	8	13	9	7	69	13.9	
Undetermined.....	2	8	1	3	5	5	3	27	5.4	
Adults.....	1	..	1	1	..	..	1	7	1.4	
Larvae.....	6	24	1	7	13	6	6	63	12.7	
Noctuidae.....	4	15	..	1	6	2	3	31	6.2	
Arctidae.....	..	..	..	2	1	1	1	5	1.0	
Geometridae.....	..	1	1	2	1	1	..	5	1.0	
Psychidae.....	..	..	..	..	..	..	..	1	0.2	
ORTHOPTERA.....	3	4	6	7	11	6	5	42	8.4	
Undetermined.....	..	..	..	1	..	1	..	2	0.4	
Tettigidae.....	2	3	3	4	5	1	1	19	3.8	
Locustidae.....	..	1	3	1	4	2	3	13	2.6	
Gryllidae.....	..	..	1	1	2	2	1	7	1.4	
Blattidae.....	1	..	..	1	..	..	..	2	0.4	
Tettigoniidae.....	..	..	..	..	..	1	..	1	0.2	

TABLE 2.—Continued.

Food	Month of collection and number of stomachs								Total 497	Percent frequency of occurrence	
	April 21	May 113	June 46	July 40	August 125	September 100	Unknown 52				
HOMOPTERA.....											
Cicadellidae.....		4	2	2	5	13	4	30		6.0	
Membracidae.....		3	2	2	5	12	3	27		5.4	
Fulgoroidea.....		1				1	1	3		0.6	
DIPTERA.....		3				1		1		0.2	
Undetermined.....				2	3	6	3	17		3.4	
Tipulidae.....				2	3	3	2	10		2.0	
Tachinidae.....		1		1	1	1		4		0.8	
Culicidae.....		1				1		2		0.4	
Stratiomyidae.....		1						1		0.2	
Syrphidae.....						1	1	1		0.2	
EPHEMEROPTERA.....								1		0.2	
NEUROPTERA (Chrysopidae).....					7			7		1.4	
PLECOPTERA.....											
DERMAPTERA (Labiidae).....					1			1		0.2	
ARACHNIDA.....	5	20	4	12	11	6	6	64		12.9	
ARANEAE.....	4	19	4	12	11	6	6	62		12.5	

TABLE 2.—Continued

Food	Month of collection and number of stomachs								Total 497	Percent frequency of occurrence
	April 21	May 113	June 46	July 40	August 125	September 100	Unknown 52			
ACARINA.....	1	1							2	0.4
CRUSTACEA (ISOPODA).....	5	15		2	12	2	1		37	7.4
DIPLOPODA.....		16			1	3			20	4.0
CHILOPODA.....		1	1	1	1	1			5	1.0
GASTROPODA.....		1			2	2	1		6	1.2
Snails.....		1			1	2	1		5	1.0
Slugs.....					1				1	0.2
OLIGOCHAETA (Earthworms).....					1	1			2	0.4

\* All but the last column show numbers of stomachs in which given food items occurred.

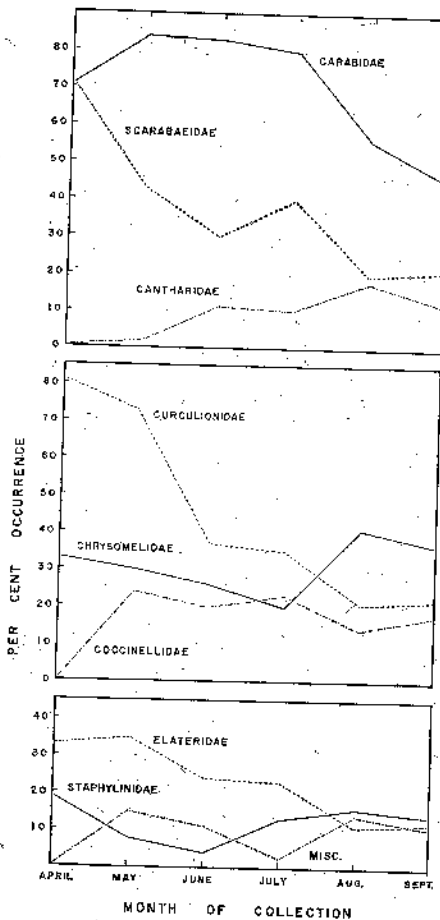


Figure 2. — Monthly variation in the utilization of some families of Coleoptera by *Bufo woodhousei fowleri* in southern Illinois (June - September, 1958 and April - May, 1959).

frequently utilized than adults (3.6%).

Of the Hymenoptera, Formicidae appeared in 68.2 percent of the samples in contrast to 2.8 percent for the next most frequent family, the Vespididae (Table 2). More than a dozen types of ants were observed, although identification below family level was not attempted.

Hemiptera yielded a 15.7 percent occurrence, Lepidoptera (mostly larvae) 13.9 percent, Orthoptera 8.4 percent, Homoptera 6.0 percent, and Diptera 3.4 percent. Four other orders of insects each appeared in less than 2.0 percent of the sample. The Arachnida, mainly spiders, was the most frequently occurring (12.9%) of the non-insect prey.

Although no special attempt was made to relate foods eaten with the type of habitat from which toads were collected, it was generally apparent that such a relationship existed. The majority of specimens came from recently disturbed areas such as residential subdivision development and rural roadsides, where such plants as smartweed (*Polygonum*), ragweed (*Ambrosia*), lamb's quarter (*Chenopodium*), pigweed (*Amaranthus*), and isolated clumps of foxtail (*Setaria*) and barnyard grasses (*Echinochloa*) dominate the vegetational pattern. In such sites, the vegetation creates shaded, cool, moist environments alternating with extensive patches of bare ground. This kind of habitat seemed to be preferred not only by the toads but also by many species of invertebrates (especially ants and certain beetles), as was evident from field observation as well as examination of stomach contents. Such habitats provide excellent places for daytime hiding and also opportunity for longer feedings periods, as light intensity at ground level is markedly reduced in the morning and afternoon. These conditions of the habitat surely enhance the feeding opportunities for resident toads, but introduce some bias into the study, inasmuch as somewhat specialized

conditions are emphasized while other habitats, such as forests, are poorly represented. For example, toads were not collected at breeding sites and, consequently, very few aquatic or semiaquatic insects were found in the stomachs; but Gehlbach and Collette (1959) found rather high percentages of aquatic insect larvae (Coleoptera: Dytiscidae 7.7%, Hydrophilidae 7.7%; Diptera: Stratiomyidae 15.4%) in a series of 13 *Bufo w. woodhousei* from Nebraska, because their sample was (by inference) collected at or near breeding waters.

Factors to be acknowledged in analyzing foods used are increased food requirements as a result of fasting during hibernation and of preparing for breeding activities, especially in the case of females. Smith and Bragg (1949:342-343) in their study of *Bufo w. woodhousei* in Oklahoma, noted that adult females consumed much more than adult males during spring and summer months. Analyses of such results must account for the fact that males spend a longer period in breeding activities and thus may have fewer feeding opportunities; this does not, however, account for the greater food utilization by females following breeding activities. One might assume that females require greater food supplies in order to compensate for physiological demands related to egg production. Because this physiological stress may actually begin well in advance of hibernation, females may feed more heavily in summer in order to compensate for such demands during and immediately following hibernation. The fact that females also attain a larger body

size is important, but probably not the only factor involved, as just indicated. Certainly, the factors responsible for greater food utilization by females bear further investigation.

Annual availability and hence utilization of food items are dynamic phenomena in each type of habitat. This reflects aspects of reproduction and life cycles of the prey, relative abundance of each species of prey, and conditions of the environment at any given time of the season. These features are reflected in the diet of *Bufo w. fowleri*, being best shown by the use made of several families of Coleoptera (Fig. 2). To illustrate, the family Carabidae was extensively utilized as food during April through September, with the greatest frequency of occurrence being May through July. During the time of maximum utilization of the carabids, there was a general decrease in the relative occurrence of several other families of beetles (Fig. 2). Because many beetles tend to show population increments comparable to those of carabids, it might be concluded that carabids were the preferred foods. We think the answer is not so simple, and that the carabids, being a readily available food, were proportionately more abundant than other forms. Certainly the Carabidae are among the most abundant of terrestrial beetles in southern Illinois. The decline in utilization of the Carabidae after July seems compensated for by increased utilization of other forms. A heavy spring utilization and a late summer and early fall decline in some kinds of Coleoptera (Fig. 2) probably are not due to a decrease in numbers of prey, for

biological activities in late spring and early summer result in large fall populations of many kinds of beetles (Dr. Milton W. Sanderson, verbal communication); mortality factors in over-wintering beetle populations somewhat reduce the number by spring. The answer probably lies in differential activities of prey and/or predator, and in the fact that juvenile toads represent much of the late summer and fall samples; although little qualitative difference has been noted between the diets of juvenile and adult toads, (Smith and Bragg, 1949) it is obvious that juveniles cannot ingest as large objects as can adults (Bragg, 1948). In spite of marked fluctuations in the utilization of various families of beetles, it is of interest that the Coleoptera remained notably constant, relative to other groups, in the degree to which it was utilized by toads throughout their season of activity (Fig. 1). The Hymenoptera also showed relative month-to-month stability. The Coleoptera and Hymenoptera are without question the major dietary constants of Fowler's toad.

A variety of non-prey items were found in the stomachs (Table 3); the most frequent of which were various plant materials (mainly dead leaf fragments, grass blades, twigs, and small blossoms). Most of the vegetation was probably ingested along with animal prey, but some possibly represents active "capture" of falling or wind-blown items; that this sometimes happens is demonstrated by observations made by Harold Lyon (cited in Oliver, 1955:198) in the Hawaiian Islands, where *Bufo marinus* snapped up falling blossoms

TABLE 3.—Non-prey and unidentified material from the stomachs of *Bufo woodhousei fowleri* in southern Illinois.

Item	Number of Stomachs (Sample Size - 499)	Percent Frequency of Occurrence
Vegetable debris...	94	18.8
Rocks.....	29	5.8
Undetermined matter.....	21	4.2
Castoff <i>Bufo</i> skin.....	8	1.6
Nematodes.....	7	1.4
Bird feather.....	1	0.2
Mammal hair (1).....	1	0.2

from Strychnine Trees and subsequently died of strychnine poisoning! A single mammal hair and a small bird feather in stomachs of Fowler's toads do not suggest predation on vertebrates, as there were no other associated remains. Toads are not normally predators of vertebrates but, contrary to the claims of some authors, there are records of predation by *Bufo* on other vertebrates. Smith and Bragg (1949:347) reported the ingestion of a small lizard by a captive *B. w. woodhousei*; Bragg (1960) observed a captive *B. houstonensis* swallow a small spadefoot toad, and thought that cannibalism also occurred; Hazelwood (1949) observed the ingestion of a snake by *B. bufo*; King (1960) had a captive *B. w. woodhousei* that ate a small turtle. As sight of moving prey seems to be the primary triggering mechanism for feeding, it seems likely that occasional predation on small vertebrates occurs in nature.

AVAILABILITY  
VERSUS SELECTIVITY

*Bufo woodhousei*, like most other vertebrate predators (for example, the red fox, Scott and Klimstra, 1955), within the limits of its ability to take food, awareness of potential food, and to a limited extent food preferences, is largely regulated in its feeding by the relative availability of foods. The occurrence of wasps, velvet ants, blister beetles, and stinkbugs (items obnoxious to some predators) in the diet of this species suggests that few insects are not acceptable. Considering the numerical abundance of invertebrates and their wide occurrence, food supply is probably rarely, if ever, a limiting factor of this toad. Nutritional aspects of various foods, however, have not been investigated. Some factors influencing the diet of Fowler's toad have been discussed in preceding paragraphs; additional considerations, and the relative importance of availability versus selectivity of food items, are discussed below.

Unquestionably, the degree of activity of prey species (and predator) is important when considering foods utilized. Adult dipterans and lepidopterans, mostly strong flyers, are rare in the diets of this and other species of toads, although such insects are numerically abundant and many are nocturnal. Certain fast moving terrestrial insects, such as crickets and roaches, although relatively abundant in habitats frequented by Fowler's toads, are infrequently eaten in nature (Table 2), and often escape capture even in terraria (Martof, 1962a). In contrast, beetles and ants, the main food items,

are mostly infrequent flyers and many are common ground dwellers, factors that probably account for the high frequency of occurrence of these insects in the diet of toads generally.

The time of feeding also places restrictions on available foods. Toads in general are well known for their crepuscular and nocturnal habits (although there is some seasonal and ontogenetic variation in diel cycles). Martof (1962a) found that captive Fowler's toads can feed in very dim light and complete darkness, and that feeding is triggered by accidental contact with the prey as well as by visual stimulation. Many abundant diurnal insects (e.g. grasshoppers and some bugs) are not often eaten, whereas insects mostly active at night (e.g. carabid beetles) or active night and day (e.g. ants) are well represented in the diet.

Stomachs of Fowler's toads were only occasionally gorged with single species of insects, indicating times when the toads had taken advantage of food concentrations. As mentioned by Smith and Bragg (1949:345) for *B. w. woodhousei*, concentration on single species of prey seems to be a rare event. Large concentrations of only one kind of prey probably are not often encountered by toads, except in agricultural areas where there are uniform stands of vegetation; Pack (1922) observed a concentration of young *B. woodhousei* feeding almost exclusively on an abundant supply of sugar-beet webworms. None of the toads used in the present study were collected under street lights, although *B. w. fowleri* and *B. w. woodhousei* do congregate at such sites of ready food

supply (Ferguson, 1960, 1963; Smith and Bragg, 1949:336) and, under certain conditions, probably engorge on one or a few species of prey. Pearse (1910) and Martof (1962b) demonstrated that Fowler's toad is positively phototropic; the observation that some species of toads react differently to light (Smith and Bragg, 1949:336) invites further experimentation.

As Fowler's toad feeds regularly on very small insects, as well as large ones, it apparently has good vision. Morphological features of the toad that prohibit side or backward head movements may somewhat restrict the range of vision, but this is probably largely compensated by the location and functional aspects of the eyes. One of us (Myers) has seen a Fowler's toad repeatedly lap up steel shot that were rolled to it, thereby attesting to indiscriminant feeding and the importance of vision in the feeding process. Kaess and Kaess (1960) demonstrated for *Bufo terrestris* that ingestion of non-living food (hamburger) could be induced by either real or apparent motion of the food. Fowler's toads are possibly alerted by sounds made by potential prey (Martof, 1962a), but olfaction does not seem an important factor in selection of food items, although olfactory powers are seemingly well developed (Martof, 1962a, e). Touch is another stimulus for feeding, as blinded Fowler's toads will eat insects with which they come in contact (Martof, 1962a).

We agree with Hamilton (1954), Berry and Bullock (1962), Smith and Bragg (1949), and others, that availability of prey is the important factor, and that toads are potential

predators of most invertebrates which are small enough to be captured.

We do not claim that toads of the genus *Bufo* do not exhibit some selectivity in kinds of foods eaten, but, except for the cases of a few species of highly noxious insects (see below), there is a decided lack of convincing evidence for selectivity. Cott (1957:297-299) contrasted stomach contents of *Bufo bufo* and *Rana temporaria* from the same habitat, and concluded that differences in foods eaten were due to differences in food preferences. Similarly, Inger and Marx (1961:25-26) noted that African *Bufo melanopleura* and *B. ushoranus* ate more Isoptera and Acarina than the larger *B. regularis* and *B. funereus*, and that Acarina was not eaten by some small species of *Phrynobatrachus* to the same extent as by *Bufo* spp. in the same habitat; they concluded (p. 25) that "Selectivity, as well as availability, plays a role in predation . . ." Such data can be taken as indications of food selectivity, but it seems just as probable that they reflect differences in microhabitat utilization, times of feeding, or foraging behavior. Because of these and other variables, comparisons of stomach contents are not the best indications of food preferences. As stated by Smith and Bragg (1949:336), "differences in habits and movements . . . give differential opportunities for food capture and thus must be taken into account in analyzing stomach contents. Only in this way are we to avoid ascribing to food selection differences in the foods eaten which may be due only to availability of the food objects."

Insects having aposematic colors

(e.g. wasps of the family Vespidae) or behavior, or those having noxious secretions (e.g. blister beetles, Meloidae; stinkbugs, Pentatomidae) are sometimes acclaimed as being immune from predation. This is true only in a relative sense, for there is no reason to believe that such animals are immune from *all* predators, or that they always enjoy *complete* protection from any single predator. We suspect that the utilization of such insects (Table 2) depends in large part on their availability to toads; many of these insects are diurnal, resting in vegetation above ground at night, and hence are not often available. Smith and Bragg (1949:347) noted that the stings of scorpions did not protect them from toads, and that the outside walls of many toad stomachs were bristly from the stings of mound-building ants. Nevertheless, there is proof that toads can learn to recognize and refuse to accept certain kinds of unpalatable prey. Bröwer et al. (1960) demonstrated that *B. terrestris* could learn to reject bumblebees and their robberfly mimics; Cott (1936) described the reactions of *B. bufo* to hive bees. Noble (1954:415) "found in the laboratory that toads could learn after a single experience to avoid an obnoxious insect," but unfortunately never published the details of his experiments. Haber (1926:208) observed a toad trying to disgorge a stinkbug; it seems likely that many small but potentially obnoxious items are swallowed too fast for their properties to become apparent to the toad, but that larger objects which offer difficulties of ingestion might be voided.

Earthworms are generally avail-

able to toads after hard rains, but only two were found in stomachs of *B. w. fowleri* in southern Illinois. Dickerson (1937:85) and Smith (1961:77) indicate that earthworms are not very acceptable foods to captive *B. americanus* and *B. w. fowleri*, respectively. Smith and Bragg (1949:341) thought that Oklahoma toads (including *B. woodhousei*) generally avoid earthworms even when these are readily available in nature. Thus, there is some indication for negative selection of earthworms by some species of toads. Even a high degree of negative selection of earthworms and certain noxious insects would probably have little important bearing on the diets of toads, when one considers the wide variety and abundance of acceptable prey.

#### GEOGRAPHIC VARIATION

There is seemingly little geographic variation in major aspects of the diet of *Bufo woodhousei fowleri*. Frequencies of occurrence of the major food groups utilized in southern Illinois and the vicinity of Athens, Clarke County, Georgia (Bush and Menhinick, 1962), are compared in Fig. 3; the differences are seen to be relatively slight and the similarities pronounced. A similarity is also found in the most commonly occurring families of beetles in each sample. Bush and Menhinick (pp. 111-112) give as the most important families the Carabidae, Curculionidae, Staphylinidae, Elateridae, Scarabaeidae, Chrysomelidae, Coccinellidae, and Trogidae. With the exception of the Trogidae, which was not represented in the Illinois sample, these families fairly well

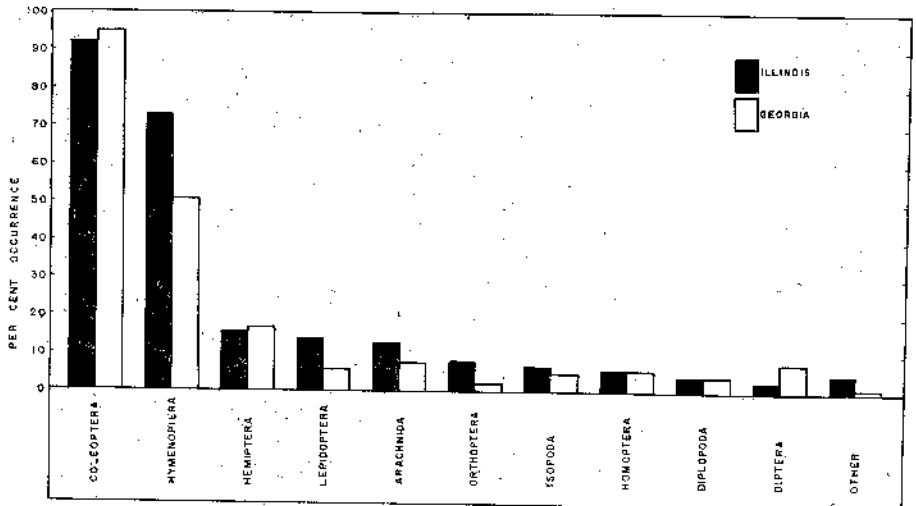


Figure 3.—Comparative utilization of foods by *Bufo woodhousei fowleri* in southern Illinois and northern Georgia. Data for the latter state from Bush and Menhinick (1962).

match the first eight families listed in Table 2. More specific differences would undoubtedly be found were comparable data available for lower taxa (genera and species) of food groups. Although Bush (1959) reported on only 18 specimens, his data for Kentucky *fowleri* are similar to the results from Illinois and Georgia. Other authors have reported on too few specimens to allow reasonable comparison.

Smith and Bragg (1949) studied a large sample (560 specimens) of *B. w. woodhousei* from Oklahoma, but, unfortunately, their results cannot be compared directly because of our different methods of data tabulation. However, their volumetric data suggest that not only the same orders, but also the same families of insects as those recorded for *B. w. fowleri* are of greatest importance. As in Illinois and Georgia, Coleoptera, especially the Carabidae, and Hymenoptera, especially the Formi-

cidae, are the main food groups in Oklahoma, and spiders are the most important of the non-insect foods.

Although there may be little geographic variation in the utilization of major food groups by *Bufo woodhousei*, it seems plausible that the effects of latitude, major vegetational units, and other environmental factors influence the *variety* of prey available in any one geographic region. The Coleoptera, as the major food group and with its many families, offers perhaps the best test of the above hypothesis. Smith and Bragg (1949:336-337) recorded 17 families of Coleoptera from a sample of 560 *B. w. woodhousei* in Oklahoma; Bush and Menhinick (1962) reported 12 families of Coleoptera from 111 *B. w. fowleri* in Georgia; 32 families of Coleoptera were found in the sample of 504 *B. w. fowleri* from southern Illinois. These figures break down roughly into nine stomachs per coleopterous family for

Georgia, 16 stomachs per family for Illinois, and 33 stomachs per family for Oklahoma. The Illinois and Georgia data would probably become more similar at comparable sample sizes; the Oklahoma data are quite dissimilar from those of Illinois, and probably dissimilar to about the same magnitude from the Georgia data at comparable sample sizes. Georgia and southern Illinois lie well within the great Eastern Deciduous Forest; Oklahoma lies on the western fringe of this region. The greater variety of prey utilized by the Georgia and Illinois *Bufo* is taken as a reflection of the greater faunal diversity in those areas, as compared with a more depauperate fauna in the forest-edge habitats of Oklahoma.

## ACKNOWLEDGMENTS

For assistance in the identification of insects, we wish to thank Drs. Milton W. Sanderson (Coleoptera) and H. B. Cunningham (Lepidoptera), of the Illinois Natural History Survey, and Dr. John Downey of Southern Illinois University. The insect collection in the Department of Zoology, Southern Illinois University, was valuable in checking identifications; we are grateful to Dr. Downey for access to this collection. Most of the toads were collected by Mr. Paul Moore, formerly a research assistant with the Wildlife Research Laboratory.

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*Manuscript received July 27, 1964.*