HABITAT EFFECTS ON MONTHLY FOODS OF BULLFROGS IN EASTERN TEXAS

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ABSTRACT

A bullfrog food habit study was conducted during 1969 in Nacogdoches County, Texas. Frogs were collected from two diverse vegetational types: (1) open habitat (farm ponds, lakes, and areas void of trees) and (2) wooded habitat (ponds, lakes, and river bottoms in heavily forested areas). There were 55 animal groups and 12 plant groups represented as food items in open habitat samples and 65 animal groups and 20 plant groups in wooded habitat. Total volume of food consumed by all frogs was greater in open habitat than in wooded, however, volume of plant matter consumed was greater in wooded than in open. Crayfish were the main food item consumed, forming over 60 percent by volume in open habitat and over 40 percent by volume in wooded habitat. There was a positive correlation between volume of food consumed and percent crayfish in the diet but a negative correlation between percent insects and volume of food. Amphibians, reptiles, insects, and miscellaneous invertebrates composed the remainder of the diet. The much greater food volume of amphibians, reptiles, and plant materials consumed in wooded habitat and the larger consumption of crayfish in open habitat marked the greatest variations between habitats. Food habits in both habitats varied significantly throughout the study; due mainly to variations in availability of foods. Crayfish and recently metamorphosed bullfrogs were the only examples of gorging on locally abundant foods by bullfrogs. Crayfish, however, were almost absent in bullfrog diets in both habitats during late summer and fall. Amphibians comprised a large percentage of bullfrog diets during this period when crayfish were not taken.

INTRODUCTION

The bullfrog is of greater direct importance to sportsmen and gourmets than is any other North American amphibian. This is due to its wide distribution, large size, and excellent flavor. Bullfrog legs are seldom available in supermarkets or restaurants but when they are a higher price is asked than for most other meats. The sources of most bullfrogs are the ponds, lakes, rivers, and wetlands across the United States where this species, acting as both predator and prey, helps maintain a balanced ecosystem. Hopefully this study will provide additional data on food habits of bullfrogs to better understand the role they play in wetland ecology.

The literature contains numerous references to bullfrog food habits, many of which are from a single frog stomach or relatively small samples (Needham 1905, Dyche 1914, Wright 1920, Frost 1924, and Bush 1959). Most studies were conducted in northern states but there have been a few extensive studies in Missouri, California and Louisiana. Korschgen and Moyle (1955) determined the foods of bullfrogs in central Missouri farm ponds from 455 stomachs. Principal foods were insects, crayfish, frogs, and tadpoles. Cohen and Howard (1958) examined 300 bullfrog stomachs from California and found that insects, especially beetles, were the most common food. Korschgen and Baskett (1963) compared the foods of impoundment and stream-dwelling bullfrogs in

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Missouri. Examination of 408 bullfrogs showed the general feeding habits to be similar and both resembled those of farm-pond bullfrogs. Crayfish were a major item during June in all three habitats but gorging on locally abundant foods occurred; examples being meadow mice, cicadas, and grasshoppers. A study of 425 bullfrog and pig frog (*Rana grylio*) stomachs from the coastal marshes of Louisiana by Reggio (1967) showed that crustaceans accounted for more than 50 percent by volume of the spring and summer foods.

Baker (1942) found that crayfish were the principal food of bullfrogs in eastern Texas. However, sample size and collection dates were not mentioned. The purpose of this study was to determine not only the seasonal food habits of bullfrogs in eastern Texas but also the influence of habitat upon their diet.

METHODS

Bullfrogs of all ages were collected in Nacogdoches County, Texas from March through October 1969. Collections were made at night using a headlight and gig. Hand-grabbing, frog graspers, and a .22 calibre rifle were used sparingly and a 12-foot flat bottom boat was used where necessary. Approximately 40 frogs were collected each month; 20 from open habitat and 20 from wooded habitat. Open habitat collecting areas consisted of farm ponds and lakes located in pastures, fields and sites generally void of trees. Collecting sites in wooded habitat were those ponds, lakes and river bottoms located in a heavily forested area. A detailed account of the woody and herbaceous plants which were generally found in or adjacent to water in both habitat types is given in Taylor (1970).

Frogs were tagged when captured and pertinent collection data were recorded. They were frozen immediately after each collecting trip and for analysis were thawed, sexed and weighed. Stomach contents were removed, washed under a tap in petri dishes, and partially dried on absorbent paper. Semi-dry food items, including miscellaneous material, were measured volumetrically using graduated cylinders. A Bausch and Lomb binocular microscope was used to aid identification when necessary.

Nacogdoches County, Texas represents a segment of the shortleaf-loblolly pine-hardwood timber lands of East Texas. The topography varies from nearly level to rolling. Low ridges are dissected by intermittent streams and draws that drain southward to the Angelina River. Soils are usually sandy, acid and low in plant nutrients and organic matter. The average frost-free growing season is 234 days. The last killing frost in the spring is usually around March 22 whereas the first in the fall is around November 13.

RESULTS

The results of this study are based on 307 bullfrog stomachs, 158 from open habitat and 149 from wooded habitat. Open habitat frogs were collected from 12 areas and wooded habitat specimens from 11 areas. There were 55 animal groups represented in open habitat stomachs and 65 in wooded habitat. Open habitat stomachs had 12 plant groups represented, while wooded had 20. Total volume of food consumed was greater for frogs from open habitat; however, volume of plant material consumed was greater in wooded habitat. Average monthly food consumption by volume per frog was greater in open habitat than in wooded habitat during March, April, June, August, and October, but was greater in wooded habitat in July and September. The months of greatest food consumption by volume in open habitat were March, April, May and October whereas in wooded habitat they were April, May, July and September (Fig. 1).

Items found in stomachs are categorized into seven major groups and discussed in descending order by volume.

Crayfish. Crayfish (Decapoda) comprised the most common food item in both open and wooded habitats. They occurred in 40.5 percent

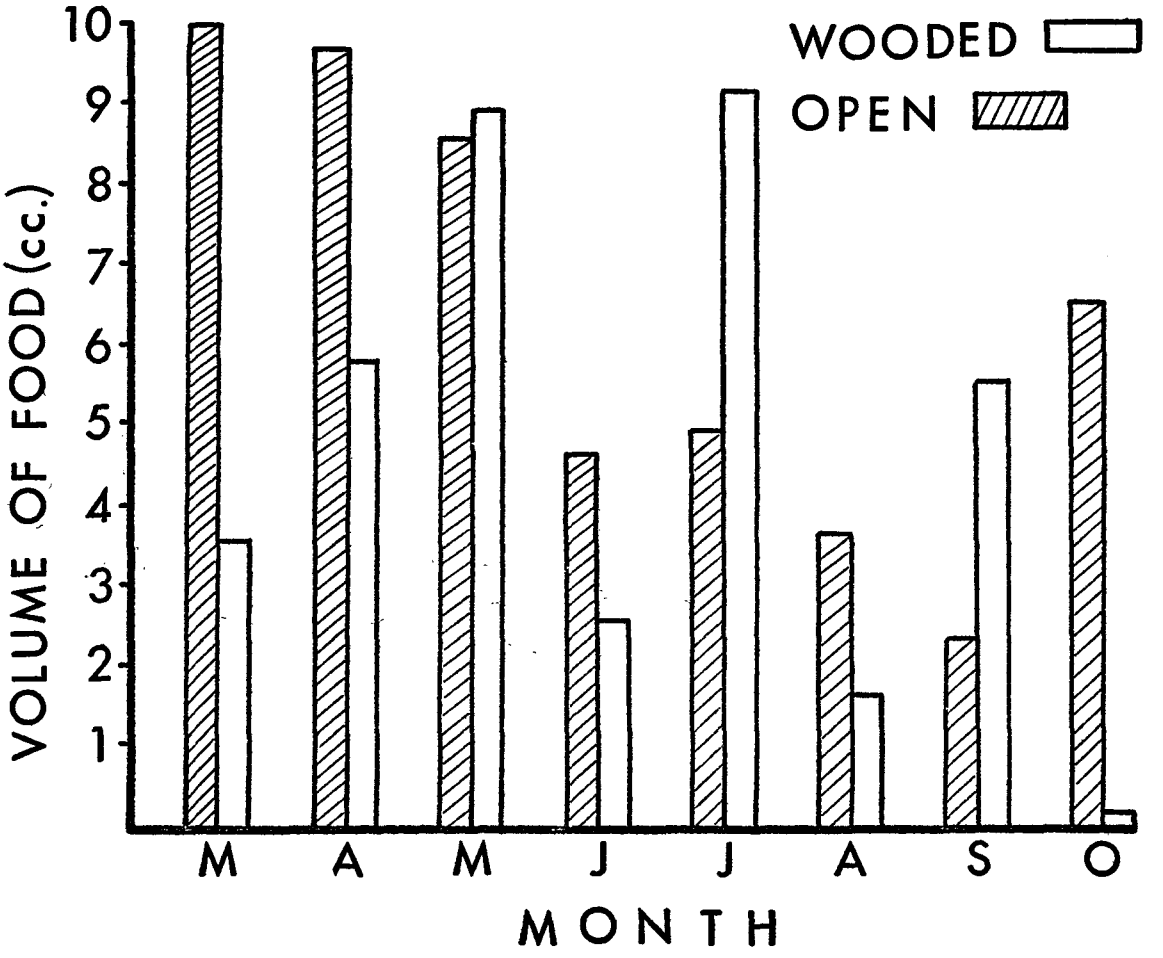

FIG. 1. Average monthly (March-October) food consumption per frog by habitat.

of the samples from open habitat and 26.8 percent from wooded habitat. Crayfish were frequently consumed from March through July in open habitat, while March, May and July were the main months in wooded habitat. There were no crayfish consumed by the frogs examined after July in wooded habitat and only insignificant amounts in open habitat (Figs. 2, 3). Crayfish also comprised the greatest percent by volume in both habitats. This item comprised 61.4 percent of all foods consumed in open habitat and 44.4 percent in wooded habitat (Table 1).

TABLE 1. Comparison of bullfrog foods from open (158 frogs) versus wooded (149 frogs) habitats in Nacogdoches County, Texas.

Prey Item	Percent of Total Volume	
	Open	Wooded
Crayfish	61.4	44.4
Spiders	1.8	2.2
Giant Water Bugs	2.0	1.2
Dragonflies and Damselflies	0.9	1.4
Ground Beetles	1.0	1.5
Predaceous Diving Beetles	1.4	0.6
May and Dung Beetles	2.9	2.0
Horned Passalus	0	1.7
Frogs	7.1	16.1
Toads	4.7	6.8
Turtles	0.1	1.1
Snakes	1.3	2.1
Birds	3.8	0
Miscellaneous Animals	6.9	7.9
Plant Material	4.7	11.0

Amphibians and Reptiles. Amphibians and reptiles ranked second in total food volume in both open and wooded habitats, but were more common in wooded habitat. These items were eaten in all months in open habitat, but taken more frequently during March, June, August and September. In wooded habitat these items were eaten in all months except July, with April, May, June and September being the main months (Figs. 2, 3). Amphibians and reptiles composed 14.5 percent by volume of the diet in open habitat and 26.2 percent in wooded habitat. Frogs (Ranidae) were consumed in greatest volumes during June, August and September in open habitat. Toads (Bufonidae) were consumed only during March. In wooded habitat frogs were most common as food items in bullfrog stomachs during June and September, while toads were eaten only during April and May.

Insects. Insects, as a group, comprised the third most commonly eaten food. Open habitat frogs' diet was composed of 12.4 percent by volume of insects, while wooded habitat had 13.8 percent. Insects were consumed each month of collection in both habitats. March, June, August and September were the months of greatest insect consumption in both open and wooded habitats (Figs. 2, 3).

Birds. One adult female house sparrow, (*Passer domesticus*), was consumed in an open habitat pond in August. This single occurrence comprised 3.8 percent and ranked fourth in total volume of animal foods.

Miscellaneous Invertebrates. Other invertebrate prey items ranked fourth and fifth in wooded and open habitats respectively and comprised 4.2 percent by volume of total foods consumed in wooded and 2.0 percent in open habitat. In open habitat, spiders (Arachnida) composed 1.8 percent by volume and were the most abundant food item in this group. June and August were the months of greatest intake of spiders. Other invertebrate food items in open habitat were pillbugs (Isopoda) and snails (Gastropoda).

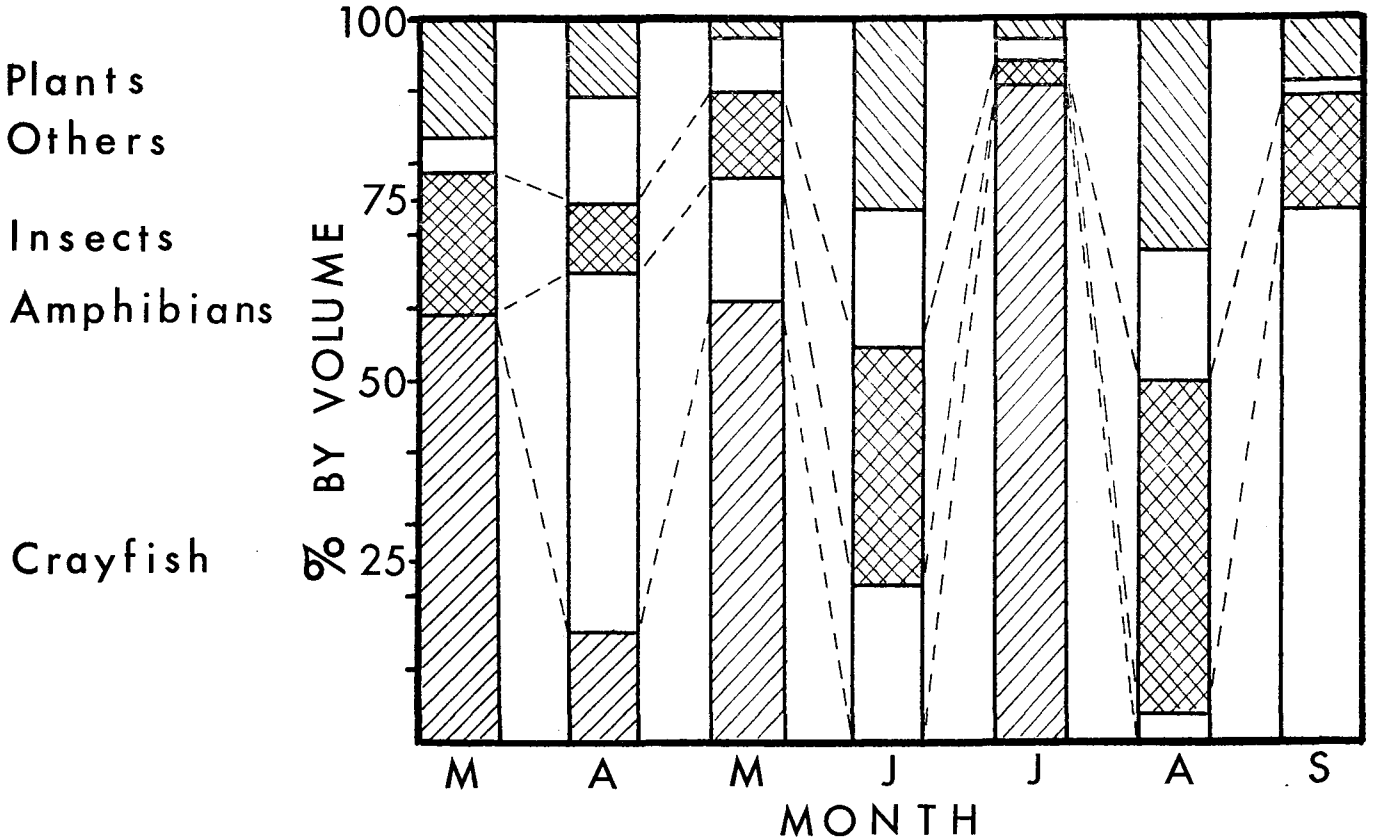

FIG. 2. Major foods of bullfrogs from wooded habitat by month. (TAYLOR AND MICHAEL—BULLFROG FOODS)

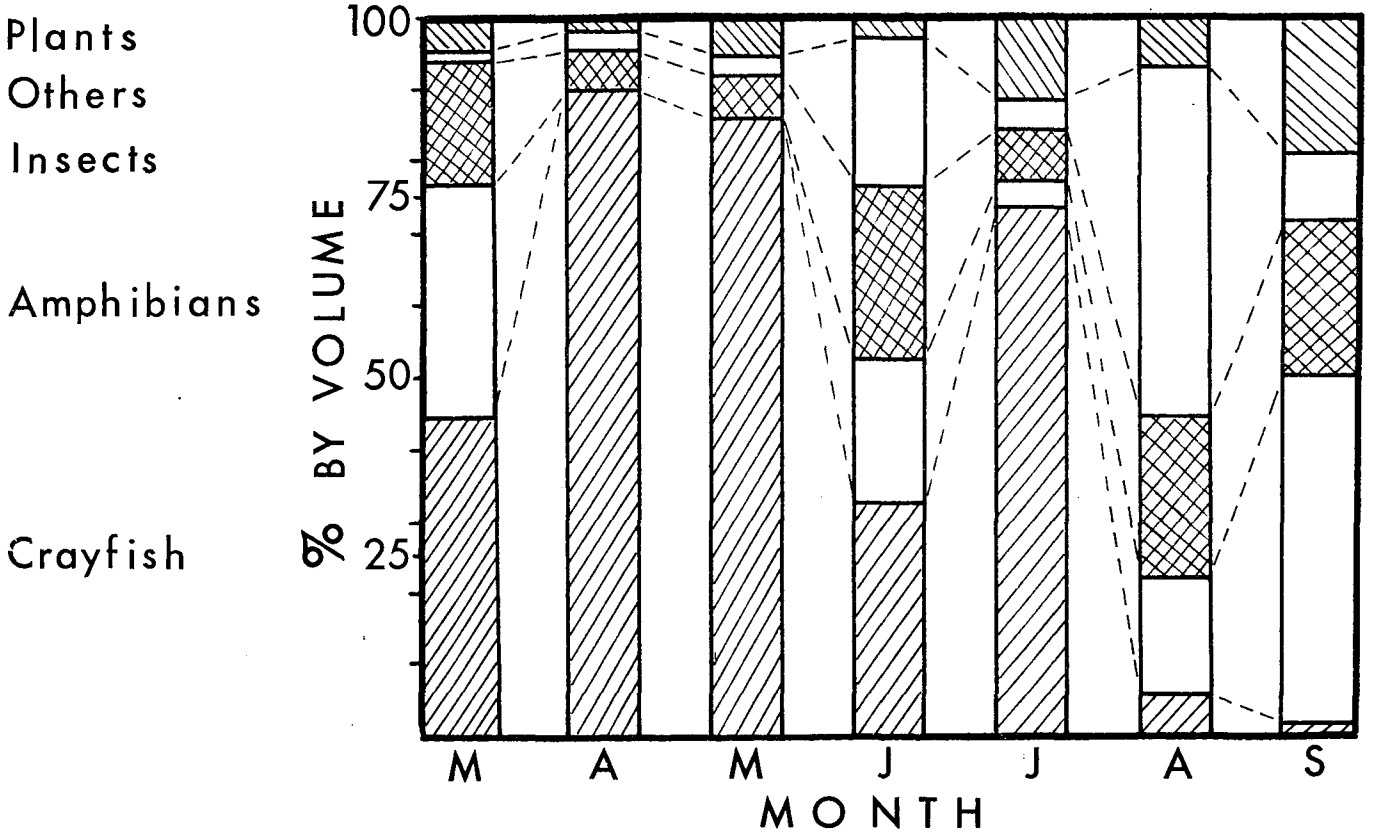

FIG. 3. Major foods of bullfrogs from open habitat by month. (TAYLOR AND MICHAEL—BULLFROG FOODS)

In wooded habitat, spiders again were the most abundant food of the invertebrate group and formed 2.2 percent by volume of all foods consumed. Spiders were consumed in greatest quantities during June and August, the same months as in open habitat. Other invertebrate foods taken in wooded habitat consisted of one mussel, Pelecypoda, two horse leeches (Gnathobdellida) and two unidentified leeches. Leeches did not occur in bullfrog stomachs from open habitat. Minor prey items in wooded habitat were snails, pillbugs, sowbugs and millipedes (Diplopoda).

Others. In open habitat, these consisted of 1 sunfish (*Lepomis* sp.), 6 mosquito fish (*Gambusia affinis*), 1 golden shiner (*Notemigonus chrysoleucas*), 1 unidentified fish, 1 unidentified vertebrate, pebbles and feathers. Fishes accounted for 0.8 percent by volume of all foods, while pebbles comprised 0.4 percent. In wooded habitat, 1 unidentified vertebrate constituted 0.2 percent, 1 mosquito fish and several pebbles each comprised 0.1 percent by volume.

Plant Materials. Plant material occurred in 30.2 percent of the bullfrog stomachs from open habitat and comprised 4.7 percent by volume of all foods. In wooded habitat, plant material occurred in 53.8 percent of the stomachs and formed 11.1 percent of the total volume (Table 1). The months of greatest plant intake in open habitat were July and September. In wooded habitat, plant material was engulfed more frequently and in greater quantities than in open habitats. March, April, June, August and September were the months of greatest consumption by volume in wooded habitat.

For a complete listing of all food items identified in captured bullfrogs with the percent occurrence and percent volume of each, see Taylor (1970).

DISCUSSION

Food habit studies are usually successful in regard to quantity of data obtained but are much less successful in regard to interpretation and application of data for management purposes. One parameter which is difficult to assess, but necessary in understanding the ecology of bullfrogs, is the relative importance of each food item consumed. We have attempted to evaluate the importance of major food items to bullfrogs, realizing that several additional years of intensive study are necessary before accurate evaluations can be made. Our findings indicate that crayfish were the most important food item to bullfrogs in eastern Texas, followed in order of importance by amphibians, insects, plant materials, and miscellaneous invertebrates.

Crayfish were consistently an important food from March until July in open habitat but were consumed more sporadically in wooded habitat (Figs. 2, 3). The conspicuous reduction of crayfish in the diet following an almost total dependency upon them in July is difficult to explain. The large intake in July, when crayfish comprised 96.8 percent by volume of food in wooded habitat, occurred when summer drought was causing water levels to recede drastically. Crayfish were possibly more exposed during this period and thus captured more easily. The lesser consumption of crayfish during August and September was probably due to a combination of the following two factors: (1) predator pressure decreasing the crayfish population and (2) a change in crayfish behavior causing them to become unavailable to bullfrogs. Crayfish commonly form a large percentage of the diet of raccoons, mink, and water birds such as little blue herons, yellow-crowned night herons, and little green herons (Martin, Zim and Nelson 1961). These predators, as well as many reptiles, and fish were numerous in all areas where frogs were collected and they must have significantly reduced the crayfish population. As water levels changed, behavior and microhabitat of bullfrogs also changed. During periods of drought, crayfish may construct mounds to conserve water or dig into gravel and mud to reach the water table, thus further reducing their availability.

These same two factors, unstable water levels and predation, may have also contributed to the lesser consumption of crayfish in wooded habitat as compared to open habitat. Predators were thought to be more numerous and water levels seemed to fluctuate more in wooded habitat.

There is some question whether amphibians or insects should be ranked second in importance. Toads were consumed in large quantities during March and April, months when they migrate to small bodies of water for reproduction. Frogs, especially leopard frogs (*Rana pipiens*) and recently metamorphosed bullfrogs, were common foods during June, August, and September. Insects were important food supplements in both habitats throughout the study, but no gorging on locally abundant species of insects occurred as was witnessed with crayfish and amphibians. Instead, very little month-to-month variation in insect consumption occurred. The consistency with which a prey item is consumed may be more important in evaluating importance than total amount consumed. Thus, insects (a staple item) may be more important to bullfrogs than are amphibians, even though insects comprise a smaller portions of the diet.

Plant materials are generally regarded as accidental food items but the frequent consumption in our study possibly questions this assumption. A large amount of plant material is probably mistaken for animal food by bullfrogs and therefore preyed upon intentionally. However, plant material is also taken in accidentally with animal foods. The significantly greater volume of plant materials consumed in wooded than in open areas was probably due to the dense vegetation which was characteristic of wooded habitat. Red maple (*Acer rubrum*) seeds, for example, were consumed in early spring when maple trees were fruiting. When the fruit, a samara, twirls down to the water it probably resembles a flying insect. Accidental foods, which were taken in with prey items, consisted of algae, grass, water lilies (*Nymphaea* sp.), wood materials (bark, twigs, etc.) and seeds (Table 1). Grasses and algae, which usually occur more often in open areas, were consumed in greater quantities in open habitat than in wooded areas, as was expected due to their abundance. The derived caloric value of plant materials to bullfrogs was not determined but we feel they must benefit from ingesting these plant materials. No literature could be found to support or refute this hypothesis.

Regression analyses were calculated to determine if the quantity of plant matter ingested varied with type of animal matter consumed. The only statistically significant correlation (.05 level) which occurred was a positive one between percent plants and percent insects in the diet of open habitat frogs. The regression equation was $Y = 2.1121 + 0.7151 (X)$. Thus, as insects increased in the diet so did plant matter. The similarity of falling seeds and leaves to insects may partially explain the positive correlation. When flying insects are being eaten there is an increased chance that falling or floating plant matter will be mistaken for insects and thus ingested. Another possibility is that insects are more commonly found in close proximity to aquatic plants than are either crayfish or amphibians and thus plant matter is incidentally ingested when insects are intentionally eaten. Further work is necessary to explain the reasons for plant matter being ingested and its ultimate value to bullfrogs.

Volume of food consumed per frog varied significantly from month-to-month but did not appear to be directly correlated with season-of-year. Frogs in open habitat seemed to consume a greater volume during the two periods following and prior to hibernation. By comparison, monthly variation by wooded habitat frogs followed no such pattern but instead was very erratic in month-to-month variation. We gained the impression that volume of food eaten may be determined by availability of certain foods rather than by season *per se*. To test this hypothesis, regression analyses were calculated for average volume of food consumed per frog and percent of each food item in the total diet. There was a positive correlation (statistically significant at .05 level) between

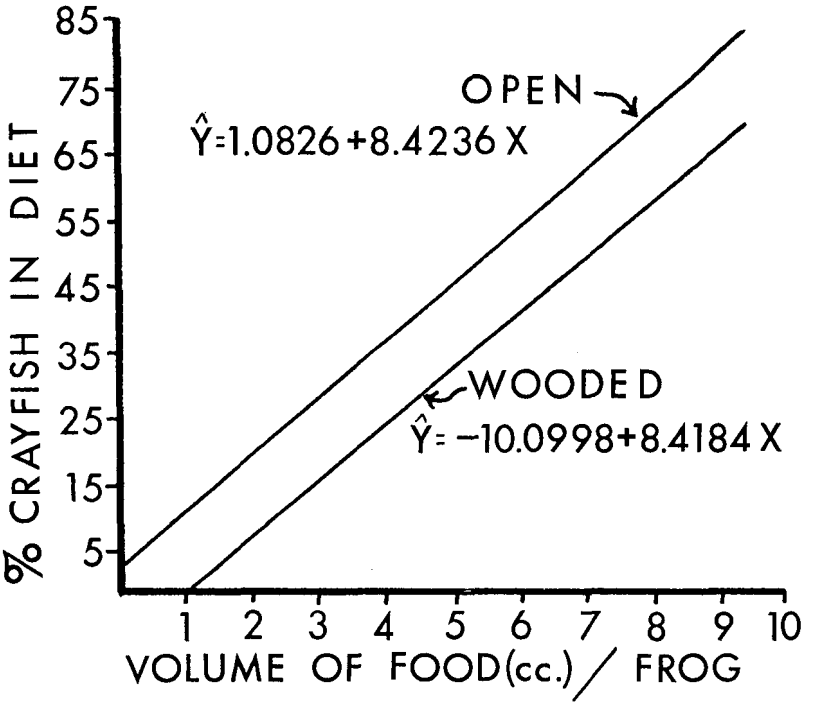

FIG. 4. Regression analyses of percent crayfish in diet with average volume of food per frog from open and wooded habitats. (TAYLOR AND MICHAEL—BULLFROG FOODS)

average volume of food consumed and percent crayfish in the diet of both wooded and open habitat frogs (Fig. 4). In contrast, there was a negative correlation (statistically significant at .05 level) between percent insects in the diet and average volume of food consumed by open habitat frogs. The regression equation was: $Y = 24.3595 + (-1.8813)X$. No correlation occurred between average volume of food consumed and the following: (1) percent insects—wooded habitat, (2) percent plants—open, (3) percent plants—wooded, (4) percent amphibians—open, and (5) percent amphibians—wooded.

Thus, it seems that volume of food eaten is determined mainly by crayfish availability. Bullfrogs will gorge on crayfish but not on insects. If crayfish are not available then volume of food consumed will be significantly reduced. We were unable to obtain data on monthly availabilities of each individual food item and thus cannot substantiate our ideas regarding effects of food items upon total volume consumed. Controlled experimentation is needed before month-to-month variations in composition and volume of food eaten can be explained.

A comparison of food habits of bullfrogs from eastern Texas with those from different states and habitats shows several major differences (Table 2). Some of these variations in diet may be actual but others are probably due to the specific conditions under which frogs were collected. In all studies compared, crustaceans were consumed in larger volume than were any other food item, with the exception of frogs from Missouri ponds. Crayfish constituted the bulk of crustaceans consumed in all studies except that in Louisiana coastal marshes where blue crabs and fiddler crabs formed the bulk of frog foods.

TABLE 2. Comparison of bullfrog foods from different states and habitats.

State and Habitat	Number of Stomachs	Months of Collection	Percent by volume *						References
			Crustaceans	Insects	Fish	Reptiles and Amphibians	Plant	Others [1]	
Texas Open Habitat	158	Mar.-Oct.	61.0	12.0	0.7	15.0	5.0	6.0	Taylor, 1970
Texas Wooded Habitat	149	Mar.-Oct.	44.0	14.0	0.1	26.0	11.0	5.0	Taylor, 1970
Louisiana Coastal Marshes	425[3]	Jan.-Aug.	67.0	7.0	13.0	2.0	8.0	2.0	Reggio, 1967
Missouri Farm Ponds	455	Apr.-Oct.	26.0	33.0	3.0	24.0	3.0	11.0	Korschgen & Moyle, 1955
Missouri Impoundments	278	May-Sept.	32.0	26.0	3.0	14.0	6.0	19.0	Korschgen & Baskett, 1963
Florida Everglades	1,049[4]	May-May	75.0	16.0	3.0	2.0	. .[2]	4.0	Ligas, 1963

* All percentages were rounded off to whole numbers, except when less than one.
1 Includes snails, mussels, spiders, birds, mammals and unclassified material.
2 Plant material was excluded from food calculations.
3 Pigfrogs and bullfrogs combined.
4 Pigfrogs only.

The value of insects as compared to amphibians is somewhat questionable. Insects composed a greater volume of the diet of bullfrogs than did amphibians in all studies compared except ours in eastern Texas. In none of these studies, however, was the difference very great. Amphibians, and especially frogs, are commonly consumed by bullfrogs in all geographic areas compared. By comparison, the acceptability of toads as bullfrog foods has been questioned. Our study indicates that toads are preferred food when available.

Fish appear to be an unimportant food item for bullfrogs, although the study in Louisiana showed they composed 13 percent of the diet. There appeared to be an adequate supply of small fish in both habitats in eastern Texas and they were probably also present in most other areas where pertinent studies were conducted. Possibly, fish were more available in Louisiana coastal marshes as compared to other areas, or there were a limited amount of other prey items present.

Plant material composed a greater percentage of bullfrog foods in wooded habitat in eastern Texas and Louisiana coastal marshes than in any other area. In eastern Texas, deciduous twigs and leaves composed the bulk of plant material while in Louisiana burned stubble and sensitive-joint vetch were the major plant foods (Reggio 1967). We have no explanation for these variations from region to region, but they are probably associated with food availability.

In summary, our study supports the findings of other workers that bullfrogs are opportunistic feeders but raises several new questions regarding the influence of time and place on food habits. Hopefully, later studies will provide answers for these questions.

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