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Spring and Summer Foods of Bullfrogs in Louisiana Coastal Marshes

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SPRING AND SUMMER FOODS OF BULLFROGS
IN LOUISIANA COASTAL MARSHES

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
Master of Science.

in

The School of Forestry and Wildlife Management

by

Villere Caliste Reggio, Jr.

B.S., University of Southwestern Louisiana, 1965
May, 1967

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ABSTRACT

The spring and summer foods of bullfrogs (Rana catesbeiana and R. grylio) were determined from examination of stomachs of 425 specimens collected in three coastal areas of Louisiana.

Bullfrogs from the coastal marshes are omnivorous although chiefly carnivorous. Crustaceans make up over 50 per cent of their spring and summer diet. Their major food is crabs which occurred in 55 per cent of the stomachs and formed 51 per cent of the total volume of consumed food. This is in marked contrast to findings in more northern states, where crawfish and insects form the principal foods. Other major foods consumed by coastal bullfrogs are crawfish, fish, and insects.

INTRODUCTION

The bullfrog is a valuable natural resource. Frog legs are considered a delicacy and command a price equal, on a pound-for-pound basis, to the finest beef.

Unlike many game species, isolation is not a major necessity for this nocturnal animal. Being an amphibian, food and water are its major requirements. It can be found in drainage ditches in the largest metropolis as well as in the most isolated swamps and marshes.

The time required for larval bullfrogs to transform from tadpoles to frogs depends on factors such as water temperature and food abundance. According to Viosca (1892), Louisiana tadpoles develop into frogs in as short an interval as 4 months. In New York, however, it takes as long as 3 years for a bullfrog tadpole to transform (Wright, 1914).

South Louisiana has 4 million acres of waterways and marshes (St. Amant, 1959). This abundance of wetlands, together with a sub-tropical climate, provides what may be ideal habitat for two sympatric species of bullfrogs, Rana catesbeiana, the common bullfrog, and R. grylio, the southern bullfrog or pig frog.

Knowledge of food habits of an animal is essential in order to utilize it effectively as a renewable resource. Little is known concerning foods consumed by bullfrogs in

coastal areas of Louisiana. This study, therefore, was conducted to fill the gap in our knowledge of the ecology of bullfrogs in this important state.

REVIEW OF LITERATURE

Bullfrog Tadpoles

Ligas (1963) first observed tadpole feeding activities 6.5 days after hatching. The tadpoles fed on green unicellular algae. Other reports (Louisiana Department of Conservation, 1933 and U.S. Fish and Wildlife Service, 1944) state that tadpoles are scavengers and will feed on dead and decaying animal or vegetable material. They also report tadpoles to be cannibalistic.

Dickerson (1931) noted that during transformation the tadpole receives nourishment through the absorption of its tail. During this absorption period no other food is taken. If a tadpole's tail is severed it will grow back.

Most references dealing with foods of post-larval bullfrogs are general in context or result from small sample sizes. Several reports are mere notes of interest concerning the feeding of a single frog.

Common Bullfrog

Early authors indicated crawfish, insects, fish, spiders, and snails are stable bullfrog prey, regardless of geographical location (Needham, 1905; Surface, 1913; Dyche, 1914; Baker, 1942; Penn, 1950 and Perez, 1951). Frost (1935) stated that insects formed the chief food of smaller bullfrogs, but that spiders and snails formed the greatest

proportion of food of the larger ones.

Several writers have recorded the taking of seemingly unusual prey items by individual bullfrogs. These include ducklings (McAtee, 1921), a 17-inch coral snake (Minton, 1949), remains of a full-grown field mouse and two downy black ducks in a single stomach (Hewitt, 1950), and a young alligator (Wright, 1920).

Korschgen and Moyle (1955) made a detailed study of the stomach contents of 455 Missouri bullfrogs taken throughout the time they were out of hibernation. Principal foods, in order of abundance, were: insects, crawfish, frogs, and tadpoles. The stomachs contained a few small rodents, fish, and birds. Plant materials, consisting mainly of vegetative parts and filamentous algae, were found in 53.8 per cent of the stomachs and comprised 3.0 per cent of the total volume of stomach contents. They concluded that plant materials were eaten accidentally with animal prey.

A more recent report (Cohen and Howard, 1958) summarized the food contents from 300 bullfrog stomachs taken at the San Joaquin Experimental Range, California. Foods reported by frequency of occurrence for small to medium-sized frogs showed an omnivorous diet, with insects, particularly beetles, being the chief fare.

Korschgen and Baskett (1963) examined 278 bullfrog stomachs collected during the months of May-September, inclusive, from a large impoundment, and 130 stomach samples

from stream-inhabiting bullfrogs during June. This was done to show the general food habits of bullfrogs in contrasting environments. Principal foods, in general categories, included: crawfish, insects, mice, frogs, and tadpoles, snakes, turtles, fish, and spiders. Plant material was recorded frequently, but this was believed to have been ingested incidentally. General patterns of feeding are similar in impoundments and rivers, and resemble those of farm-pond bullfrogs. Crawfish were a major item during June in all three habitats, comprising from 39 to 55 per cent of the foods on a volume basis. Gorging by the frogs on locally abundant foods was evident; consumption of meadow mice, cicadas, and grasshoppers were examples.

Pig Frog

The range of the southern bullfrog is limited in comparison with the common bullfrog. The pig frog's natural range extends from southern South Carolina, along the Atlantic and Gulf Coast, to extreme southeastern Texas (Conant, 1958). Rarely does its range extend more than 100 miles inland. Ligas (1963) stated that the common bullfrog is absent south of central Florida, but the pig frog occurs throughout this region. He examined 1,049 pig frogs of all ages and from all types of habitat for food analysis. Bullfrogs were sampled in every month of the year. His findings indicate crawfish were the main food of Everglades pig frogs (75 per cent by

volume). Insects, fish, spiders, frogs, snakes, birds, snails and miscellaneous items accounted for the remaining 25 per cent. Carr's study (1940) revealed similar results. Crawfish, aquatic insects, fish and small frogs were found to be stable pig frog food.

DESCRIPTION OF COLLECTION AREAS

All collections were made in coastal marsh areas. Each area however, is a different type of marsh, and each marsh contains several types of habitat.

Mouth of Mississippi River

Location. All bullfrogs taken in the delta were from an area east of the main channel of the Mississippi River which extends into South Pass. The area is bounded on the south and east by the Gulf of Mexico, and on the north by Delta National Wildlife Refuge. Delta Refuge is located approximately 75 miles southeast of New Orleans in Plaquemine Parish, Louisiana (Figure 1).

Topography and Soils. The delta marsh as a whole is a fresh marsh composed of passes, shallow ponds, bayous, canals, floats and impoundments. The marsh lies between 2 feet below and above sea level and is subject to frequent water fluctuations as a result of tidal action and river overflow.

Soils of the area are rich in organic matter and mineral plant nutrients. Harris soils, slightly acid to alkaline, composed of dark gray clay and covered by peats and mucks, are predominant (Lytle and Sturgis, 1962).

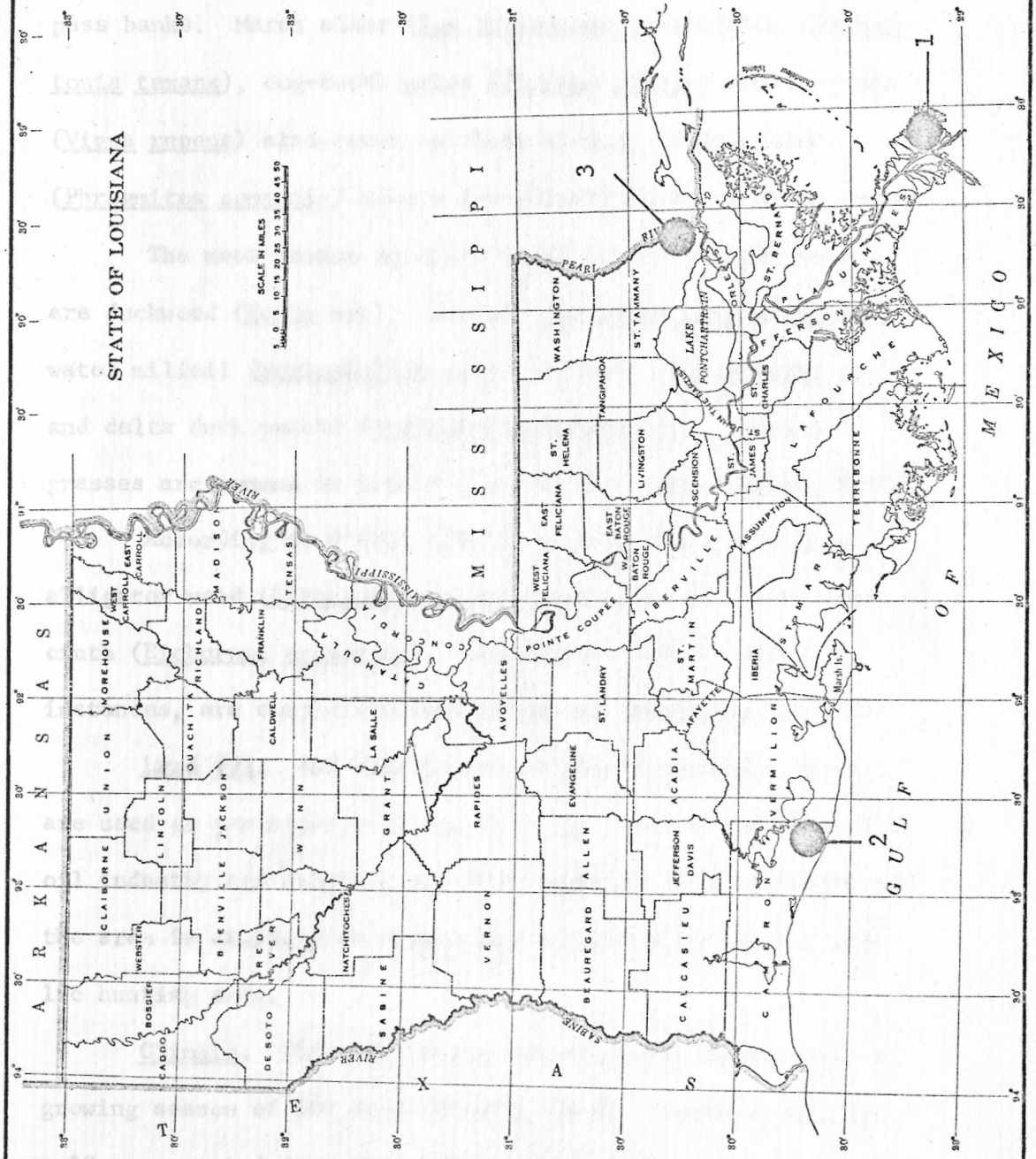
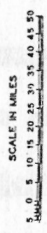
Vegetation. Very little plant succession is possible in the marsh because of constant inundations, occasional fires

8

Figure 1. Location of Collection Areas

- 1 - Mouth of Mississippi River
- 2 - Rockefeller Refuge
- 3 - Pearl River Delta

STATE OF LOUISIANA



and eatouts by furbearers and geese, and periodic hurricanes.

Black willow (Salix nigra) reflects the highest stage of plant succession in the area and occurs only on canal and pass banks. Marsh elder (Iva frutescens), rattlebox (Daubentonia texana), dog-tooth grass (Panicum repens) and deer pea (Vigna repens) also occur on these ridges. Roseau cane (Phragmites communis) occurs irregularly throughout the marsh.

The most common aquatics found in the shallow ponds are duckweed (Lemna sp.), coontail (Ceratophyllum demersum), water milfoil (Myriophyllum sp.), pondweed (Potamogeton sp.), and delta duck potato (Sagittaria platyphylla). Annual grasses are common in summer when water is low (Carver, 1965).

According to O'Neil (1949), two introduced exotics, alligator weed (Alternanthera philoxeroides) and water hyacinth (Eichornia crassipes), considered pests in most instances, are completely dominating the indigenous species.

Land Use. The main passes of the Mississippi River are used as passageways to and from the Gulf of Mexico by the oil industry and seagoing merchant vessels. The remainder of the area is utilized as a game and waterfowl refuge and public hunting area.

Climate. The delta has a sub-tropical climate with a growing season of 300 days (O'Neil, 1949). Weather data for a 10-year period from 1951-1960 indicates the average annual temperature is 69.6°F. August is the warmest month with an

average of 82.3°F, and January the coldest with an average of 56.0°F. Average annual precipitation is 61.78 inches with August, the wettest month, averaging 11.04 inches (Roberson, 1967).

Rockefeller Refuge

Location. Rockefeller Refuge, owned and operated by the Louisiana Wild Life and Fisheries Commission, is located in southwestern Louisiana in Cameron and Vermilion parishes (Figure 1). It is bounded on the north by the Grand Chenier-Pecan Island stranded beach ridge complex and extends southward to the Gulf of Mexico (Joanen, 1964).

Topography and Soils. Rockefeller Refuge consists of fresh, brackish and salt marshes, levees and ridges, tidal channels and lakes, and impoundments.

St. Amant (1958) classifies the marshes of Cameron and Vermilion parishes as Prairie Marshes. These marshes have a clearly-defined beach line, and the marsh floor is relatively firm with a shallow layer of peat overlying a clay pan. Throughout this marsh, there is a series of high ridges, called chenieres, running parallel to the coast. They support higher land types and tend to separate the fresh, brackish, and salt-water parts of the prairie marsh.

Vegetation. The following plants are typical of the salt marsh: sea-myrtle (Baccharis halimifolia), hogcane (Spartina cynosuroides), and oystergrass (Spartina alterniflora).

Bullfrogs do not occur in the salt marsh.

The vegetation of the brackish marsh is dominated by wiregrass (Spartina patens). In association with wiregrass are saltmarsh grass (Distichlis spicata), coco (Scirpus robustus), three-cornered grass (Scirpus olneyi), widgeon-grass (Ruppia maritima), and dwarf spike-rush (Eleocharis parvula).

Typical plants of the fresh marsh, which harbor the largest bullfrog populations, are bullwhip (Scirpus californicus), roseau cane, bulltongue (Sagittaria latifolia), and wiregrass. Also present are free-floating aquatics such as mosquito fern (Azolla caroliniana), and duckweed (Lemna minor). Waterhyssop (Bacopa monniera), an emergent to submergent aquatic, is abundant in this area (Babcock, 1967). Many of the frogs from the Rockefeller area came from the shallow ditches separating the fresh marsh from access roads to oil fields.

Land Use. Rockefeller serves mainly as a refuge for wintering waterfowl. Oil field operations and wildlife research occur throughout the area.

Adjacent areas are used for cattle grazing, fur trapping and duck hunting. Controlled burning is practiced both on and off the refuge.

Climate. The geographic position of Rockefeller Refuge puts it in a semi-tropical climate. The average annual rainfall and temperature for the years 1956 to 1965 were 52.26 inches

and 66.3°F, respectively (Babcock, 1967).

Pearl River Marsh and Swamp

Location. Bullfrogs from the Pearl River area were collected in two locations near the town of Pearl River, Louisiana which is located in St. Tammany Parish (Figure 1). The Pearl River divides the states of Louisiana and Mississippi. Its waters flow into the Rigolets which is a pass between Lake Borgne, a highly saline lake, and Lake Pontchartrain, a less saline lake.

Black Bayou, where one group of frogs was collected, is a tributary of the Pearl River and is located approximately 3 miles north of the Rigolets pass.

Old River, the other collection site, is another tributary located approximately 4 miles north of Pearl River, Louisiana.

Topography and Soils. The Black Bayou area is freshwater marshland with canals and levees. The soil of this area is the typical marsh soil of clays covered by peat and muck.

The Old River area could best be described as swamp-land. The soil in this area is the recent alluvium type which comprises silty sediments from loessial areas and sandy and clay sediment from Coastal Plain areas (Lytle and Sturgis, 1962).

Vegetation. According to Penfound and Hataway (1938), the nearly fresh marsh, typical of the Black Bayou area, is

characterized by an almost pure stand of sawgrass (Mariscus jamaicensis) associated with broadleaf cattail (Typha latifolia), narrowleaf cattail (T. angustifolia), and bullwhip in the deeper water, and waterlily (Castalia sp.) and bladderwort (Utricularia sp.) in shallower areas. Also present are sea-myrtle, marsh elder, palmetto (Sabal minor), feather grass (Panicum virgatum) and wiregrass.

Penfound and Hathaway further described swampland, typical of the Old River area, as abounding in a considerable number of large trees, mainly bald cypress (Taxodium distichum) and tupelo gum (Nyssa aquatica). Other trees present are water ash (Fraxinus profunda) and swamp maple (Acer drummondii). Also present are buttonbushes (Cephalanthus occidentalis), sea-myrtle and palmetto.

Land Use. Commercial fishing and crawfishing occur extensively in the Pearl River and its tributaries, as well as sport fishing and hunting.

Climate. This area is essentially semi-tropical with a growing season of approximately 300 days. Annual temperature averages 68°F, with extreme lows ranging from 20° to 25°F and extreme highs from 100° to 102°F. Annual rainfall averages approximately 60 inches (Lambou, 1952).

METHODS AND PROCEDURES

Collections

Most of the stomachs were collected during sporting and commercial operations before I initiated my study. This resulted in inequal sampling, and no distinction was made between the common and pig bullfrog or between immature and adult post-larval bullfrogs.

A total of 493 stomachs was collected between January, 1965, and March, 1967. Of this number, 425 or 86.2 per cent contained food and were analyzed, as indicated below.

<u>Location</u>	<u>Stomachs</u>	<u>Dates Collected</u>
Mouth of Mississippi River	262	January-May, 1965-1967
Rockefeller Refuge	99	July, 1965 and March, 1967
Pearl River Delta	64	August, 1965

Each collection site consists of a vast marsh area. More specific descriptions of location of collections are given for each area in the footnotes of Tables 4-6 in the Appendix.

All collections were made at night with the use of headlights. Frogs were either caught bare-handed or with "frog grabs". Most frogs were taken from an airboat, but some were captured while walking.

Frogs were cleaned soon after capture. The stomachs

from the Mississippi Delta and Rockefeller were stored in 10 per cent formalin. Those from the Pearl River area were frozen and later transferred to 10 per cent formalin.

Analysis

In the analysis, the contents of each stomach were emptied into a 40-mesh-per-inch sieve and washed under tap water. Contents were separated and identified. The type and number of food items in each particular stomach were recorded in a data book from which per cent occurrences were derived. Food items were stored in 10 per cent formalin until volumes were calculated.

Volumes were measured by water displacement and calculated in cubic-centimeters. Food items were removed from the preservative and left on absorbent paper. After excess moisture was removed, the larger items were measured in either a 1,000 ml., 500 ml., or 50 ml. graduated cylinder. The small items were measured in a 10 ml. graduated cylinder. Only stomachs which contained a measurable quantity of identifiable (relatively undigested) food were included.

Per cent volume and per cent occurrence were determined for each collection area for each collection date (Appendix, Tables 7-16). These tables were combined to form a composite table for each area (Appendix, Tables 4-6). Table 1 resulted from the combination of the composite tables. Any calculations which rounded off to less than 0.1 per cent were recorded as trace amounts.

Quantitative measurements of occurrence and volume were used together to assure a reliable analysis. Hydrocotyle seeds, for example, occurred in 17.6 per cent of all stomachs from the mouth of the Mississippi River (Appendix, Table 4) yet constituted only a trace amount by volume.

RESULTS AND DISCUSSION

Upon its metamorphosis from a tadpole to a frog, the bullfrog experiences a change in body form and breathing apparatus. It also undergoes a drastic transformation in food habits. Table 1 presents the combined foods of 425 bullfrogs collected at three different areas of coastal Louisiana. Scientific names are listed beside food items. Table 2 compares the foods of bullfrogs from the three different marsh types. There are obvious problems in comparing foods of such voracious feeders as bullfrogs collected in different months and from different habitats, and these problems will be discussed later.

Principal Foods

The principal foods of coastal bullfrogs in the spring and summer were placed into six major groups. These groups will be discussed in their order of importance.

Crustaceans. Crustaceans comprised the most important food of coastal bullfrogs, 66.9 per cent by volume. Blue crabs, the most favored of this group, occurred in 40.7 per cent of all frogs analyzed and comprised 43.6 per cent by volume. Crustaceans formed approximately three-fourths of the volume of food from the Mississippi and Pearl River Delta's, yet accounted for only 36 per cent of the food from Rockefeller (Table 2). Blue crabs, which made up 63.7 per

Table 1. Combined foods of 425 bullfrogs collected at three different areas of coastal Louisiana

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs (<u>Callinectes</u> <u>sapidus</u>)	40.7	43.6
Crawfish (<u>Procambarus</u> sp.)	15.3	15.9
Fiddler crabs (<u>Uca</u> <u>pugnax</u>)	13.9	7.3
Shrimp (<u>Palaemonetes</u> sp.)	1.2	.1
Fish		
Killifishes (Cyprinodontidae) and unclassified	29.4	13.2
Sailfin molly (<u>Mollienisia</u> <u>latipinna</u>)	1.2	.1
Amphibians and Reptiles		
Snakes (<u>Natrix</u> sp.)	1.2	1.4
Frogs (Anura)	.9	.8
Miscellaneous Invertebrates		
Snails (Gastropoda)	12.2	1.4
Spiders (Arachnida)	7.5	.4
Insects		
Immature		
Horsefly larvae (Tabanidae)	.9	.1
Dragonfly naiads (Libellulidae)	.9	Trace
Miller moth larvae (Phalaenidae)	1.4	Trace
Soldierfly larvae (Stratiomyidae)	1.2	Trace
Damselfly naiads (Coenagrionidae)	.5	Trace
Water scavenger beetle larvae (Hydrophilidae)	1.2	Trace
Tiger moth larvae (Arctiidae)	.2	Trace
Diptera larvae	.2	Trace
Unidentifiable larvae	.5	Trace
Adults		
Grasshoppers (Acrididae)	4.2	2.8
Waterbugs (Belostomatidae)	21.4	2.0
Insect fragments (Hemiptera, Coleoptera, Odonata)	16.2	.7
Dragonflies (Libellulidae)	1.2	.3
Predaceous diving beetles (Dytiscidae)	1.6	.2

Table 1. (Continued)

Food Item	Per cent by	
	Occurrence	Volume
Adults (Continued)		
Water scavenger beetles (Hydrophilidae)	5.4	.2
Ground beetles (Carabidae)	3.1	.1
Lamellicorn beetles (Scarabaeidae)	1.5	Trace
Wood roach (Blattidae)	.2	Trace
Typical weevile (Curculionidae)	.2	Trace
Damselfly (Coenagrionidae)	.2	Trace
Unidentifiable insect	.2	Trace
Birds and Mammals		
Myrtle warbler (<u>Dendroica coronata</u>)	.2	.4
Hair unclassified	.2	Trace
PLANT		
Miscellaneous vegetation	62.1	6.8
Sensitive-joint-vetch seed pods (<u>Aeschynomene</u> sp.)	15.1	.5
Hydrocotyle seeds (<u>Hydrocotyle</u> sp.)	10.8	Trace
Burned stubble, Roseau cane (<u>Phragmites communis</u>)	3.8	1.1
OTHER		
Mud lumps	2.1	.2
Stomach parasites (Nematoda)	3.8	

1/ 292 stomachs, Mississippi River Delta, spring and early summer, 1965-1967.

99 stomachs, Rockefeller Refuge, spring and summer, 1965 and 1967.

64 stomachs, Pearl River Delta, late summer, 1965.

Table 2. Comparison of spring and summer foods of bullfrogs from three coastal areas in Louisiana

Area	Stomachs	Crustaceans	Insects	Fish	Per cent by volume ^{1/}					Plants	Birds	Mud
					Reptiles and amphibians	Snails and spiders						
Mississippi River Delta	262	74.0	6.0	8.0	3.0	3.0				7.0	1.0	0.0
Rockefeller Refuge	99	36.0	1.0	43.0	1.0	0.0				18.0	0.0	1.0
Pearl River Delta	64	78.0	17.0	1.0	0.0	1.0				3.0	0.0	0.0

^{1/} All per cents were rounded off to the nearest whole number.

cent from the Mississippi Delta (Appendix, Table 4) and 28.8 per cent of the food by volume from the Pearl River Delta (Appendix, Table 6), were completely absent from the 99 stomachs taken at Rockefeller. Crawfish, on the other hand, composed 34.8 per cent by volume of all the foods at Rockefeller (Appendix, Table 5) yet only .4 per cent in the Mississippi Delta. Availability is apparently the key to the shifting of major food emphasis in coastal areas. Crawfish are not abundant in the open marsh of the Mississippi Delta but are found in large numbers in the fresh marsh at Rockefeller during the spring. Crawfish also comprised the major portion of food by volume from the Pearl River Delta, accounting for 47.3 per cent.

Fiddler crabs occurred in all three coastal areas and comprised 7.3 per cent of the total food volume. Freshwater shrimp, the only other crustacean consumed, contributed only .1 per cent of the total food volume. The largest blue crab eaten was 8.2 cm. in diameter.

Fish. Fish, as a group, are the second most important food. They appeared in approximately 30 per cent of the stomachs making up 13.5 per cent by volume. Stomachs collected from Rockefeller in July, 1965 (Appendix, Table 5) contained an exceptionally large number of fish (42.5 per cent by volume). Ted Joanen, who collected these frogs, told me water conditions were low causing the minnows to be

vulnerable. Fish from the killifish family occurred most often. The sheepshead minnow (Cyprinodon variegatus) was the most abundant species in the stomachs. One frog consumed 20 of these minnows. Other killifishes eaten were rainwater killifish (Lucania parva), gulf killifish (Fundulus similis) and mud killifish (Fundulus grandis).

Plants. Plant matter appeared in more than 50 per cent of the stomachs and constituted 8.4 per cent by volume. The greatest volume of plant foods, miscellaneous vegetation (6.8 per cent by volume) consisted of decaying vegetation, leaves, stems, algae and herbaceous material. Roseau cane, alligator weed, spanish moss (Tillandsia usneoides), rattle box seed pod, and an acorn were some of the recognizable items in this category. Korschgen and Baskett (1963) stated that plant matter was probably ingested incidentally or accidentally because of close proximity to a desired food object. My research bears this out in part because much of the vegetation encountered was in association with the larger food items, such as crabs, which probably grabbed vegetation with its claws while being eaten. Some plant food items, however, were taken consistently, and I believe they were purposely taken for food. The most notable was sensitive-joint-vetch seed pod pieces which occurred in 24.4 per cent of the stomachs from the Mississippi Delta accounting for .8 per cent by volume (Appendix, Table 4). Vetch seed pods

split into several rectangular pieces approximately 1 by .5 cm. These pieces float and appear much like insects in the water. Only one individual insect, waterbugs, appeared more often from this area. Vetch occurred frequently enough to be considered stable fare. One bullfrog stomach contained 70 segments of sensitive-joint-vetch, 12 pieces of miscellaneous vegetation, 4 hydrocotyle seeds and one tiny insect head indicating almost an entire plant diet. Another instance of high occurrence of a plant article is burned stubble of roseau cane from the Rockefeller area (Appendix, Table 13). Controlled burning of this marsh is a common practice. Many pieces of burned stubble remain after a fire and will float and resemble an insect. Pieces of stubble occurred in 16.2 per cent of the stomachs at Rockefeller and accounted for 5.3 per cent by volume (Appendix, Table 5).

I believe some plant food is taken incidentally. However, some evidently is deliberately eaten.

Insects. Insects, the next most important group, comprised 6.6 per cent by volume. Insect larvae formed .3 per cent and adult insects 6.4 per cent of this total.

The grasshopper formed 2.8 per cent of the food volume because the large lubber grasshopper (Romalea microntera) was abundant in the Black Bayou area at the time of collection (Appendix, Table 15). This grasshopper is a seasonal food and would account for much less food volume if more collections were made throughout a longer period of time. Stomachs

from Rockefeller and the Mississippi Delta contained only a trace amount of grasshoppers. Waterbugs showed the greatest incidence in samples from the mouth of the Mississippi River. They occurred in 32.4 per cent of the stomachs and accounted for 3.1 per cent of all food eaten from that area. Waterbugs were rare in stomachs from the other two areas. Water scavenger beetles occurred in 5.4 per cent of all stomachs but, because of their small size, accounted for only .2 per cent of all food by volume. Other insects appearing in greater than trace amounts by volume were horsefly larvae, dragonflies, predaceous diving beetles, and ground beetles.

Amphibians and Reptiles. This group accounted for 2.2 per cent by volume and consisted of five snakes and four unclassified frogs. A water snake (Natrix sp.) was 15.5 inches long.

Miscellaneous Invertebrates. Snails and spiders comprise this category and accounted for 1.8 per cent of all foods by volume. Snails, mainly of the family Viviparidae were present in 12.2 per cent of the stomachs and accounted for 1.4 per cent by volume. Wolf and water spiders appeared in 7.5 per cent of the stomachs and constituted .4 per cent by volume.

Other. Mud lumps occurred in nine stomachs and comprised .2 per cent by volume. Stomachs from Rockefeller (Appendix, Table 5) accounted for most of the mud lumps.

These lumps were very hard and did not dissolve after remaining in formalin for over a year. One mammal hair located in a stomach could not be identified. Small mammals such as mice and bats are occasional foods of bullfrogs (Korschgen and Baskett, 1963).

Parasites. There was a high incidence of stomach parasites in the group from Rockefeller (Appendix, Table 5). These parasites occurred in 22.4 per cent of the stomachs collected in July of 1965 (Appendix, Table 13). Parasites were excluded from volumetric computations because they were not considered food.

Comparison with Other Studies

Table 3 compares bullfrog foods from different areas and habitats. Crustaceans compose a greater percentage of bullfrog food in the more southern marsh areas of Louisiana and Florida; whereas, insects, reptiles and amphibians, along with crustaceans (crawfish), contribute to the largest portion of the bullfrog's diet in Missouri ponds and impoundments.

All comprehensive bullfrog food habits studies found in the literature report crawfish is the most preferred food item (Ligas, 1963; Korschgen and Baskett, 1963; Korschgen and Moyle, 1955). Bullfrog food studies were never reported previously from a marine coastal area; consequently, the importance of crabs in their diet was not known.

Table 3. Comparison of bullfrog foods from different states and habitats

State and habitat	Number of stomachs	Month of collection	Per cent by volume ^{1/}						References
			Crustaceans	Insects	Fish	amphibians	Plants	Other	
Louisiana coastal marshes	425	January - August	67.0	7.0	13.0	2.0	8.0	2.0	
Missouri farm ponds	455	April - October	26.0	33.0	3.0	25.0	3.0	7.0	Korschgen & Moyle, 1955
Missouri impoundments	278	May - September	32.0	26.0	3.0	14.0	6.0	19.0	Korschgen & Baskett, 1963
Florida Everglades ^{3/}	1,049	May - May	75.0	16.0	3.0	2.0	-	4.0	Ligas, 1963

^{1/} All percentages were rounded to the nearest whole number.

^{2/} Includes snails, spiders, birds, mammals and unclassified material.

^{3/} Plant material was excluded from food calculations.

SUMMARY AND CONCLUSIONS

This study was made to determine the spring and summer foods of bullfrogs in the coastal marshes of Louisiana.

Information was gathered from the examination of 425 stomachs.

An analysis of 262 stomachs from the mouth of the Mississippi River indicated blue crabs are the main food in the delta marshes and account for more than 50 per cent by volume. An examination of 99 stomachs from Rockefeller Refuge indicated fish and crawfish are preferred foods in the Prairie Marsh. Analysis of 64 stomachs from the Pearl River Delta shows bullfrogs prefer crawfish, blue crabs and grasshoppers as their main diet in this area.

Crustaceans, especially blue crabs, crawfish and fiddler crabs, account for more than 50 per cent by volume of the spring and summer foods of coastal Louisiana bullfrogs. Fish, insects, amphibians, reptiles, and miscellaneous invertebrates make up the remainder of the diet depending on availability. Most plant items are probably eaten incidentally; however, some are taken as regular fare.

Consumption of an extraordinary number of fish and burned stubble from Rockefeller, lubber grasshoppers from the Pearl River area and sensitive-joint-vetch from the Mississippi River Delta indicated bullfrogs will eat any locally abundant foods which are alive or appear to be alive.

Crustaceans are the most important bullfrog food in

Louisiana and Florida marshes. In Missouri ponds and impoundments, however, insects contribute as much food as crustaceans. The year-round availability of crustaceans probably accounts for their importance in southern marshes.

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APPENDIX

Table 4. Foods of 262 bullfrogs from the mouth of the Mississippi River ^{2/}

Food Item ^{1/}	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs	56.9	63.7
Fiddler crabs	14.9	9.5
Crawfish	1.5	.4
Shrimp	.8	Trace
Fish		
Killifishes and unclassified	24.4	7.5
Sailfin molly	1.1	.3
Amphibians and Reptiles		
Snakes	1.1	2.0
Frogs	1.1	1.2
Miscellaneous Invertebrates		
Snails	17.2	2.0
Spiders, wolf and water	9.2	.5
Insects		
Immature		
Horsefly larvae	1.5	.1
Dragonfly naiads	.8	.1
Unidentifiable larvae	.8	.1
Damselfly naiads	.8	Trace
Soldierfly larvae	1.9	Trace
Water scavenger beetle larvae	1.9	Trace
Miller moth larvae	1.1	Trace
Diptera larvae	.4	Trace
Adults		
Waterbugs	32.4	3.1
Water scavenger beetles	8.8	.3
Ground beetles	4.2	.1
Lamellicorn beetles	.8	.1
Predaceous diving beetles	.8	.1
Dragonflies	1.1	.1
Insect fragments	23.0	1.0
Typical weevils	.4	Trace
Wood roach	.4	Trace
Grasshopper	.4	Trace

Table 4. (Continued)

Food Item <u>1/</u>	Per cent by	
	Occurrence	Volume
Birds and Mammals		
Myrtle warbler	.4	.7
Hair	.4	Trace
PLANT		
Miscellaneous vegetation	61.8	5.9
Sensitive-joint-vetch	24.4	.8
Hydrocotyle seeds	17.6	Trace
OTHER		
Mud	.4	.2
Parasite	.4	

- 1/ Scientific names of food items listed in Table 1.
 13 stomachs collected January 26, 1965.
 44 stomachs from Pass-a-Loutre collected April 9, 1965.
 112 stomachs from Delta National Refuge collected May 20, 1965.
 51 stomachs from Mud Bay collected May 20, 1965.
 8 stomachs from Pass-a-Loutre collected March 31, 1966.
 44 stomachs from Pass-a-Loutre collected April 8, 1967.

Table 5. Foods of 99 bullfrogs from Rockefeller Refuge ^{1/}

Food Item ^{2/}	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Fiddler crabs	12.1	1.2
Crawfish	30.3	34.8
Shrimp	3.0	.2
Fish		
Killifishes	56.6	42.3
Sailfin molly	2.0	.2
Amphibians and Reptiles		
Snakes	2.0	.9
Frogs	1.0	.3
Miscellaneous Invertebrates		
Snails	2.0	.2
Insects		
Immature		
Miller moth larvae	1.0	Trace
Tiger moth larvae	1.0	Trace
Adults		
Predaceous diving beetles	5.1	.4
Waterbugs	4.0	.2
Ground beetles	1.0	Trace
Grasshopper	1.0	Trace
Damselfly	1.0	Trace
Unclassified beetles	1.0	Trace
Insect fragments	3.0	Trace
PLANT		
Miscellaneous vegetation	67.7	12.9
Burned stubble, roseau cane	16.2	5.3
OTHER		
Mud lumps	8.1	.6
Stomach parasites	15.2	

^{1/} 67 stomachs collected July 7, 1965.

32 stomachs collected in February and March, 1967.

^{2/} Scientific names of food items listed in Table 1.

Table 6. Foods of 64 bullfrogs from the Pearl River Delta ^{1/}

Food Item ^{2/}	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs	37.5	23.8
Fiddler crabs	12.5	6.6
Crawfish	48.4	47.3
Fish		
Unclassified	7.8	.5
Miscellaneous Invertebrates		
Spiders, wolf and water	12.5	.8
Snails	7.8	.6
Insects		
Immature		
Dragonfly naiads	3.1	.1
Miller moth larvae	3.1	.1
Adults		
Grasshoppers	25.0	15.3
Dragonflies	3.1	1.1
Insect fragments	9.4	.3
Waterbugs	3.1	.1
Ground beetles	1.6	.1
PLANT		
Miscellaneous vegetation	54.7	3.3

^{1/} 22 stomachs from Old River collected August, 1965.
 42 stomachs from Black Bayou collected August, 1965.

^{2/} Scientific names of food items listed in Table 1.

Table 7. Foods of 13 bullfrogs from the mouth of the Mississippi River, January 26, 1965

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs (<u>Callinectes sapidus</u>)	23.1	27.8
Amphibians and Reptiles		
Frog (<u>Rana</u> sp.)	7.7	26.5
Miscellaneous Invertebrates		
Spiders, wolf and water (Lycosidae and Pisauridae)	61.5	3.7
Insects		
Immature		
Horsefly larvae (Tabanidae)	7.7	.4
Water scavenger beetle larvae (Hydrophilidae)	7.7	Trace
Adults		
Insect fragments (Hemiptera and Coleoptera)	46.2	1.6
Water scavenger beetles (Hydrophilidae)	7.7	1.1
Ground beetles (Carabidae)	15.4	.6
Waterbugs (Belostomatidae)	15.4	.4
Predaceous diving beetles (Dytiscidae)	7.7	Trace
Typical weevils (Curculionidae)	7.7	Trace
Birds		
Myrtle warbler (<u>Dendroica coronata</u>)	7.7	15.2
PLANT		
Miscellaneous vegetation, alligator weed, hydrocotyle leaf and herbaceous matter	76.9	10.1
Sensitive-joint-vetch (<u>Aeschynomene virginica</u>)	84.6	12.6
Hydrocotyle seeds (<u>Hydrocotyle</u> sp.)	46.2	Trace

Table 8. Foods of 44 bullfrogs from Pass-a-Loutre collected April 9, 1965

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs (<u>Callinectes</u> <u>sapidus</u>)	34.1	28.2
Fiddler crabs (<u>Uca</u> <u>pugnax</u>)	38.6	34.0
Shrimp (<u>Palaemonetes</u> sp.)	2.3	.1
Fish		
Sheepshead minnow (<u>Cyprinodon</u> <u>variegatus</u>)	6.8	7.6
Sailfin molly (<u>Mollienisia</u> <u>latipinna</u>)	4.5	1.3
Unclassified	18.2	3.8
Amphibians and Reptiles		
Snake (<u>Natrix</u> sp.)	2.3	11.0
Miscellaneous Invertebrates		
Snails (Viviparidae)	18.2	1.4
Spiders, wolf and water (Lycosidae and Pisauridae)	6.8	.2
Insects		
Immature		
Horsefly larvae (Tabanidae)	6.8	1.0
Soliderfly larvae (Stratiomyidae)	4.5	.1
Damselfly naiads (Coenagrionidae)	2.3	Trace
Water scavenger beetle larvae (Hydrophilidae)	2.3	Trace
Adults		
Water scavenger beetles (Hydrophilidae)	27.3	1.3
Waterbugs (Belostomatidae)	6.8	.6
Ground beetles (Carabidae)	6.8	.2
Insect fragments	18.3	.1
PLANT		
Miscellaneous vegetation, roseau cane, hydrocotyle, duckweed, algae, herbaceous material		
	68.2	8.0
Sensitive-joint-vetch (<u>Aeschynomene</u> <u>virginica</u>)	47.7	1.2
Hydrocotyle seeds (<u>Hydrocotyle</u> sp.)	31.8	Trace

Table 9. Foods of 112 bullfrogs from Delta National Wildlife Refuge collected May 20, 1965

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs (<u>Callinectes sapidus</u>)	71.5	77.9
Fiddler crabs (<u>Uca pugnax</u>)	.9	.6
Fish		
Killifishes (Cyprinodontidae)	34.3	8.9
Miscellaneous Invertebrates		
Snails (Viviparidae and unclassified)	11.7	.7
Spiders, wolf (Lycosidae)	2.0	.1
Insects		
Immature		
Dragonfly naiad (Libellulidae)	1.0	.1
Unclassified larvae	1.0	.1
Solidierfly larvae (Stratiomyidae)	2.0	Trace
Water scavenger beetle larvae (Hydrophilidae)	1.0	.1
Diptera larvae	1.0	Trace
Damselfly naiads (Coenagrionidae)	1.0	Trace
Miller moth larvae (Phalaenidae)	1.0	Trace
Adults		
Waterbugs (Belostomatidae)	43.1	4.2
Insect fragments	38.2	2.2
Dragonflies (Libellulidae)	2.0	.2
Lamellicorn beetles (Scarabaeidae)	2.0	.2
Water scavenger beetles (Hydrophilidae)	2.9	.1
Ground beetles (Carabidae)	2.9	.1
Grasshopper (Acrididae)	1.0	Trace
Wood roach (Blattidae)	1.0	Trace
PLANT		
Miscellaneous vegetation, alligator weed, roseau cane, duckweed, algae, hydrocotyle leaves		
	55.0	4.4
Sensitive-joint-vetch (<u>Aeschynomene virginica</u>)	7.8	.1
Hydrocotyle seeds (<u>Hydrocotyle</u> sp.)	7.8	Trace

Table 10. Foods of 51 bullfrogs from Mud Bay collected May 20, 1965

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs (<u>Callinectes</u> <u>sapidus</u>)	76.5	67.4
Fiddler crabs (<u>Uca</u> <u>pugnax</u>)	15.7	6.6
Fish		
Unclassified	13.7	5.3
Sheepshead minnows (<u>Cyprinodon</u> <u>variegatus</u>)	3.9	.5
Sailfin molly (<u>Mollienisia</u> <u>latipinna</u>)	2.0	.6
Amphibians		
Frog, unclassified	3.9	.4
Miscellaneous Invertebrates		
Snails (Viviparidae)	35.3	5.8
Spiders, wolf (Lycosidae)	.1	Trace
Insects		
Immature		
Unclassified larvae	2.0	.2
Dragonfly naiad (Libellulidae)	2.0	.1
Miller moth larvae (Phalaenidae)	2.0	.1
Soldierfly larvae (Stratiomyiidae)	2.0	Trace
Adults		
Waterbugs (Belostomatidae)	47.1	3.8
Dragonfly (Libellulidae)	2.0	.3
Insect fragments	13.7	.2
Ground beetles (Carabidae)	3.9	.1
Water scavenger beetles (Hydrophilidae)	7.8	Trace
PLANT		
Miscellaneous vegetation, roseau cane, woody stems, hydrocotyle leaves, herbaceous material		
	70.6	8.5
Sensitive-joint-vetch (<u>Aeschynomene</u> <u>virginica</u>)	37.3	.2
Hydrocotyle seeds (<u>Hydrocotyle</u> sp.)	21.6	Trace

Table 11. Foods of eight bullfrogs from Pass-a-Loutre collected March 3, 1966

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs (<u>Callinectes sapidus</u>)	75.0	93.1
Fiddler crabs (<u>Uca pugnax</u>)	37.5	1.8
Miscellaneous Invertebrates		
Snails (<u>Viviparidae</u>)	12.5	1.2
Insects		
Immature		
Miller moth larvae (<u>Phalaenidae</u>)	12.5	.4
Adults		
Water bugs (<u>Belostomidae</u>)	25.0	.7
Water scavenger beetles (<u>Hydrophilidae</u>)	12.5	.1
PLANT		
Miscellaneous vegetation, roseau cane, herbaceous material	62.5	2.4
Sensitive-joint-vetch (<u>Aeschynomene virginica</u>)	12.5	.1

Table 12. Foods of 44 bullfrogs from Pass-a-Loutre collected April 8, 1967

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs (<u>Callinectes</u> <u>sapidus</u>)	29.5	49.2
Fiddler crabs (<u>Uca</u> <u>pugnax</u>)	22.7	22.3
Crawfish (<u>Procambarus</u> sp.)	9.1	3.1
Shrimp (<u>Palaemonetes</u> sp.)	2.3	.2
Fish		
Killifishes (Cyprinodontidae)	20.5	8.1
Reptiles		
Snakes (<u>Natrix</u> sp.)	4.5	3.8
Miscellaneous Invertebrates		
Snails (Viviparidae)	13.6	1.7
Spiders, wolf and water (Lycosidae and Pisauridae)	22.7	1.7
Insects		
Adults		
Waterbugs (Belostomatidae)	22.7	3.1
Predaceous diving beetles (Dytiscidae)	2.3	.8
Ground beetles (Carabidae)	2.3	.1
Water scavenger beetles (Hydrophilidae)	4.5	Trace
PLANT		
Miscellaneous vegetation, alligator weed, hydrocotyle leaves, algae	54.5	4.6
Sensitive-joint-vetch (<u>Aeschynomene</u> <u>virginica</u>)	9.1	.2
Hydrocotyle seeds (<u>Hydrocotyle</u> sp.)	6.8	Trace
OTHER		
Mud	2.3	1.2
Hair, unclassified	2.3	Trace

Table 13. Foods of 67 bullfrogs from Rockefeller Refuge collected July 7, 1965

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Fiddler crabs (<u>Uca pugnax</u>)	17.9	1.9
Shrimp (<u>Palaemonetes</u> sp.)	4.5	.2
Fish		
Killifishes and unclassified (Cyprinodontidae)	82.0	65.8
Sailfin molly (<u>Mollienisia latipinna</u>)	3.0	1.0
Amphibians and Reptiles		
Snakes (<u>Natrix</u> sp.)	3.0	1.4
Frog, unclassified	1.5	.4
Insects		
Immature		
Tiger moth larvae (Arctiidae)	1.5	.1
Adults		
Predaceous diving beetles (Dytiscidae)	3.0	.4
Waterbugs (Belostomatidae)	6.0	.3
Ground beetles (Carabidae)	1.5	Trace
Grasshoppers, longhorned (Acrididae)	1.5	Trace
Damselfly (Coenagrionidae)	1.5	Trace
Insect fragments (Hemiptera)	4.5	Trace
PLANT		
Miscellaneous vegetation, herbaceous and woody material	71.6	19.1
Burned stubble, roseau cane (<u>Phragmites communis</u>)	23.9	8.5
OTHER		
Mud lumps	12.0	1.0
Stomach parasites (Nematoda)	22.4	

Table 14. Foods of 32 bullfrogs from Rockefeller Refuge collected in February and March, 1967

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Crawfish (<u>Procambarus</u> sp.)	93.8	94.9
Fish		
Unclassified	3.1	1.9
Miscellaneous Invertebrates		
Snails (<u>Viviparidae</u>)	6.3	.5
Insects		
Immature		
Zebra caterpillar (<u>Phalaenidae</u>)	3.1	.1
Adults		
Predaceous diving beetle (<u>Dytiscidae</u>)	6.3	.6
Unclassified beetle (<u>Coleoptera</u>)	3.1	Trace
PLANT		
Miscellaneous vegetation, alligator weed, rattle box seed pod, grassy vegetation, herbaceous material		
	59.4	2.1

Table 15. Foods of 42 bullfrogs from Black Bayou collected August, 1965

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Blue crabs (<u>Callinectes</u> <u>sapidus</u>)	57.1	42.8
Fiddler crabs (<u>Uca</u> <u>pugnax</u>)	19.0	11.8
Crawfish (<u>Procambarus</u> sp.)	21.4	9.1
Fish		
Unclassified	11.9	.9
Miscellaneous Invertebrates		
Snails (<u>Viviparidae</u>)	11.9	1.1
Spiders, wolf and water (<u>Lycosidae</u> and <u>Pisauridae</u>)	19.0	1.4
Insects		
Immature		
Dragonfly naiads (<u>Libellulidae</u>)	4.8	.2
Adults		
Grasshoppers, lubber (<u>Romalea</u> <u>microptera</u>)	35.7	27.0
Dragonflies (<u>Libellulidae</u>)	4.8	2.0
Insect fragments (<u>Hemiptera</u> and <u>Odonata</u>)	7.1	.5
PLANT		
Miscellaneous vegetation, algae, spanish moss, broad leaves, acorn	50.0	3.2

Table 16. Foods of 22 bullfrogs from Old River collected August, 1965

Food Item	Per cent by	
	Occurrence	Volume
ANIMAL		
Crustacea		
Crawfish (<u>Procambarus</u> sp.)	100.0	95.3
Insects		
Immature		
Miller moth larvae (Phalaenidae)	9.1	.1
Adults		
Grasshopper, broadwinged katydid (Acrididae)	4.5	.7
Ground beetle (Carabidae)	4.5	.2
Insect fragments (Coleoptera and Odonata)	13.6	.2
Waterbugs (Belostomatidae)	9.1	.1
PLANT		
Miscellaneous vegetation, woody vegetation, spanish moss, broad leaves, 2 large seeds	63.6	3.4

VITA

I was born on June 16, 1942, at New Orleans, Louisiana. I attended catholic primary and secondary schools in New Orleans and graduated from De La Salle High School in May, 1960.

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EXAMINATION AND THESIS REPORT

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Major Field: Game Management

Title of Thesis: Spring and Summer Foods of Bullfrogs in Louisiana Coastal Marshes

Approved:

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May 9, 1967