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Food Habits of Snakes in an East Texas State Fish Hatchery

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Dean of the Graduate School

ACCEPTED BY DEAN OF GRADUATE SCHOOL
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FOOD HABITS OF SNAKES
IN AN EAST TEXAS STATE FISH HATCHERY

by

JOHN L. MALLOY, B. S. Ed.

THESIS

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To my parents, Lawrence and Betsy Malloy, I dedicate this manuscript.

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INTRODUCTION

Snakes which live and thrive in aquatic or semiaquatic habitats are often piscivorous. The western cottonmouth (Agkistrodon piscivorous leucostoma), broad-banded water snake (Natrix fasciata confluens), yellow-bellied water snake (Natrix erythrogaster flavigaster), diamond-backed water snake (Natrix rhombifera rhombifera), and black-backed ribbon snake (Thamnophis proximus proximus) are known to be piscivorous and are found in abundance around East Texas catfish farms and hatcheries. It is conceivable that the depredation of these snakes on fish could be detrimental to the successful operation of fish farms and hatcheries. This is of particular importance at the present time because commercial catfish production, a relatively new industry, is fast gaining interest in Texas and especially in eastern Texas. There is very little information available on many of the hazards which might be encountered in a catfish farming operation. This new business is still in the developmental stage, and, thus, their techniques and methods are not perfected. The commercial catfish operations are being improved through trial and error methods and by obtaining information from state fish hatcheries. To determine the degree of predation by snakes on fish in such a highly fish populated environment as a fish farm, a field study was performed. A state fish hatchery was an excellent location in which to conduct such a study for not only did it have catfish ponds but also ponds containing various other game fishes. In addition to obtaining predation data, an attempt was made to determine the food preferences of each species of snake in the hatchery.

The general objectives of this study were to contribute additional information to the knowledge of the food habits of the various snakes found in fish hatcheries and to determine the economical importance of these snakes to state fish hatcheries and commercial fish farms. The specific objectives were to determine the amount of predation of snakes on fishes in the Jasper State Fish Hatchery at Jasper, Texas, and to determine the food preferences of these snakes within the fish hatchery. The general public will benefit from this study by having better informed catfish farmers and state fish hatchery managers. Scientific knowledge will also be advanced since only a few studies have been concerned with the impact of snake predation on the fishes in fish hatcheries.

LITERATURE REVIEW

There are relatively few comprehensive food habit studies reported concerning the particular species of snakes which frequent the Jasper State Fish Hatchery. Information is especially lacking on the diet of the broad-banded water snake Natrix fasciata confluens. Most reports on this species have been based on a small number of specimens and were not the object of the study being conducted. Accounts of food habits of other natricine snakes are included in this literature review because of this scarcity of information and because these snakes presumably possess similar food habits. Species names are presented here as written in the original works cited.

Lagler and Salyer (1947) investigated the food habits of the common water snake Natrix sipedon sipedon in Michigan and attempted to determine the snakes' effect on game-fish production both at rearing stations and in natural waters. Their data were based on the analyses of the stomach contents of 188 snakes. They reported that the size of fish eaten varied greatly. Usually, the fish were small, but in rare cases one was taken which was extremely large in relation to the size of the snake. Single large organisms found in the digestive tracts were a 7.75 inch as well as an 8.5 inch brown trout (Salmo trutta fario), a 7.38 inch brown bullhead (Ameriurus nebulosus nebulosus), and a lamprey (Icthyomyzon castaneus) more than 8 inches long. Many small fish were found in a stomach at one time. One snake stomach contained 20 brook trout ranging from 1.25 to 1.50 inches in length. Lagler and Salyer reported that common water snakes from fish-rearing stations often contained several to many fish, whereas, those from natural waters contained on the average only a little more than one organism. In their data they categorized the fish extracted from the snakes' stomachs into three groups. These groups consisted of trout, forage fishes, and fish remains. Lagler and Salyer stated that trout comprised 19 % of the total food volume and had a 6.6 % frequency of occurrence, while forage fishes comprised 55.8 % by volume and had 72.6 % frequency of occurrence. The fish remains occupied 0.2 % by volume and had a 4.7 % frequency of occurrence.

Raney and Roecker (1947) stated that 95.8 % of the total volume of stomach contents of 59 Natrix sipedon which they examined in western New York was fishes. The frequency of occurrence of fishes was 89.8 %. Most species of fish eaten by the common water snake were species that generally live on or near the bottom. By volume suckers (Catostomidae) occupied 39.9 % and minnows (Cyprinidae) 29.0 %. However, minnows exhibited a higher frequency of occurrence than suckers.

In a study performed in central New York and northern Michigan (Brown, 1958), it was determined from the examination of the contents of the stomachs of 207 water snakes (Natrix sipedon) that fishes comprised about 80 % of the food items taken (68 % of the total volume). The remaining 20 % (32 % by volume) of the water snakes' diet was amphibians. This snake species appeared to be well suited for either diurnal or nocturnal feeding activity, apparently more diurnal in cooler habitats and more nocturnal in warmer ones. Food amounting to 40 % of the weight of the snake could be taken at one time, but a meal was generally much smaller. Moderate meals required about two days for gastric digestion to be completed at mid-summer temperatures. Post-gastric digestions required somewhat less time. June, July, and August were months of heaviest feeding with moderate food consumption during late April, May, and September. Food was secured from specimens by dissection, by voluntary regurgitation, and by manually induced regurgitation.

It was reported in a study conducted in parts of Arkansas, Kansas, Missouri, Oklahoma, and Texas that Natrix erythrogaster was first observed in mid-March

(Diener, 1957). The study included the two subspecies Natrix erythrogaster flavigaster and Natrix erythrogaster transversa. In early spring these basked from 8:00 AM to 5:00 PM, but at night they foraged for food. The snakes were always found in early evening foraging in isolated ponds and in some areas were active until 3:00 AM. In late summer and autumn the nights were cooler while the days remained warm. At that time Natrix erythrogaster was either basking or foraging during the morning. Natrix sipedon differed in that it foraged in early evening and disappeared into protective cover after midnight. Food items consumed by the two species of Natrix expressed in percentages of food items represented were the following: Natrix erythrogaster, fishes 5.5 %, frogs 91.8 %, and unidentified items 2.7 %; Natrix sipedon, fishes 76.5 % and unidentified items 23.5 %.

Bowers (1962, 1966) studied the food habits of Natrix in a small lake in Red River County, Texas, as well as in 104 commercial minnow ponds in Bowie County, Texas. The food items of 112 water snakes belonging to the three species Natrix rhombifera rhombifera, Natrix erythrogaster flavigaster, and Natrix sipedon confluens were primarily anurans (52.87 % by volume) and secondarily fish (40.39 % by volume). In the five broad-banded water snakes (Natrix sipedon confluens) which contained food, anurans were greater than fish in both predominance and volume. Anurans and fish were taken in equal numbers by the yellow-bellied water snakes (Natrix erythrogaster flavigaster), but anurans comprised the greater volume. Approximately 50 % of the food volume of the diamond-backed water snakes (Natrix rhombifera rhombifera) consisted of fish, but the frequency of occurrence of anurans was greater than that of fish. The three major food items of this snake species in per cent of total volume were the following: Yellow bullhead (Ictalurus natalis), 22.8 %; bullheads (Ictalurus) not identified to species, 17.2 %; and bullfrogs (Rana catesbeiana), 18.1 %. Bowers indicated that water snakes were not harmful to the minnow population in commercial minnow ponds and suggested that this might be due to the construction or depth of the ponds. He found that snakes caught in the ponds with low water level contained more fish than anurans in both numbers and volume.

Between 1 June 1926 and 1 June 1927, Clark (1949) conducted a study of snakes found in swamps, streams, and rivers in the hill parishes of Louisiana. He collected a total of 2,083 snakes. Of this number 186 were Natrix erythrogaster erythrogaster. Fish (unidentified) were the predominant food in this snake species. Fish were found in 120 of the 186 snakes. Crayfish occurred in 50 snakes, while frogs (Rana pipiens sphenocephala) were found in 16. Two hundred fifty Natrix rhombifera rhombifera were captured. Fish (unidentified) were found in 97; frogs, Rana pipiens sphenocephala in 85 and Rana clamitans in 57; and birds (unidentified) in 11. Clark further commented that a captive Natrix rhombifera rhombifera was observed swallowing nine catfish in quick succession. The destructiveness of this snake to the fish supply is evidenced by the facts that the snake had fed the previous day, and that the rapidly ingested fish were from 4 to 5 inches in length. Natrix sipedon confluens was represented in the total catch by 150 snakes. Fish (unidentified) were consumed by 60 of these snakes; frogs, Rana pipiens sphenocephala by 47 of them and Rana clamitans by 38; and birds (unidentified) by 5. Thirty-seven Thamnophis sirtalis proximus (Say) were collected. Fish (unidentified) had been eaten by 15 snakes and frogs (Rana pipiens sphenocephala) by 22. Captured Agkistrodon piscivorus leucostomus totaled 180 specimens. Based on the stomach contents of 100 specimens, 34 contained fish (unidentified); 25 had Rana pipiens sphenocephala, 16 had Rana clamitans, and 7 had Acris sp.; 4 contained snakes (Natrix sipedon confluens); 8 contained birds (unidentified); and 5 contained squirrels (unidentified). In one cottonmouth (Agkistrodon piscivorus leucostomus) a partially digested 13.5 inch catfish was found. A few days later while Clark was fishing, a cottonmouth swallowed an 11 inch smallmouth black bass which Clark had caught and tied to a string. Clark mentioned that these incidents may denote this species destructiveness to fish in fresh water streams and ponds.

Allen and Swindell (1948) recorded that there was an extreme diversity of food items found in cottonmouth stomachs including rodents, rabbits, bats, birds, frogs, fish and numerous species of reptiles. The most common food items found were frogs and fish (catfish included).

Upon analyzation of the food items of 46 cottonmouths collected in Arkansas, Louisiana, and Texas, Burkett (1966) found that fish (primarily Esox sp. and Lepomis sp.), amphibians, and reptiles made up approximately 70 % of the diet by bulk (weight).

In a study by Carpenter (1952) the diet of the ribbon snake (Thamnophis sauritus sauritus) was found to be 90 % amphibians. The remainder of the identified food items consisted of two fish (2 %) and two caterpillars (2 %). Carpenter further stated that his evidence indicated that there were no apparent individual food preferences, and that any available food will be eaten that is within the range of food of the species.

Foquette (1954) reported on the stomach contents of 49 *Thamnophis sauritus* which were obtained from the Texas Natural History Collection at the University of Texas. Forty (82 %) of the snakes had eaten amphibians; seven (14 %) had eaten fishes; two (4 %) had eaten water beetles; and two (4 %) had eaten unidentifiable vertebrates. Of the seven stomachs which contained fishes, two had *Gambusia affinis*; one had *Lepomis megalotis*; one had *Herichthys cyanoguttatus*; and three had unidentifiable fishes.

According to Fontaine (1944), a 50 inch *Natrix* captured and consumed two 2.5 pound channel catfish *Ictalurus lacustris punctatus* (Raf.) from a brood pen at the City of Dallas (Texas) Fish Hatchery. The pectoral spines of the second catfish being consumed had been erected and pierced the cheeks of the snake, thus making it impossible for the snake to swallow or to regurgitate the fish. Fontaine also mentioned an incident of a 15.5 inch *Natrix* feeding on a 4.5 inch fingerling catfish.

Four *Natrix erythrogaster flavigaster* were captured in Hunt County, Texas, and all contained fish (Greding, 1964). Also caught were five *Natrix rhombifera rhombifera* containing fish.

Limited collections of snakes were made by Guidry (1953) in the following counties in eastern Texas: Orange, Newton, Hardin, and Jefferson. The first three counties listed adjoined Jasper County (in which my research was performed), while the fourth, a non-contiguous county, is nearby. In these counties several cottonmouths fed on frogs and one contained a large catfish. Broad-banded, diamond-backed, and yellow-bellied water snakes were observed eating fish and frogs. Western ribbon snakes (Thamnophis sauritus proximus) were seen eating frogs. All five species of snakes fed readily on fish and frogs in captivity.

Fish and tadpoles seemed to be the favorite food items of Natrix sipedon (Stebbins, 1954). In the diet of Natrix erythrogaster fish, crayfish, frogs, tadpoles, and salamander larvae were important food items. Stebbins also stated that Thamnophis sauritus will feed on frogs and, perhaps, fish, salamanders, insects, and earthworms.

A catfish was taken from the gut of a Natrix erythrogaster which was caught in Pecos County, Texas (Marr, 1944).

Of three Natrix erythrogaster transversa taken in Oklahoma, one fed on a small fish; the second regurgitated a 1 inch and a 6 inch fish; and the third regurgitated a crayfish (Carpenter, 1958). A group of Natrix rhombifera rhombifera taken in July of 1958 fed on carp (Cyprinus carpio). Carpenter also reported that one had eaten a large leopard frog (Rana pipiens), and another had consumed a 6 inch Lepomis sp. A Natrix sipedon confluens had regurgitated five green tree frogs (Hyla cinerea). In three Agkistrodon piscivorous leucostoma the following food items were found: a juvenile wood thrush (Hylocichla mustelina); seven cicadas (Cicadidae); and a young cottontail rabbit (Sylvilagus floridanus).

The food habits of the genus Natrix, according to Conant (1958), included frogs, salamanders, fish, and crayfish. Conant also stated that ribbon snakes (Thamnophis sauritus) eat salamanders, frogs, and small fishes. Agkistrodon piscivorous will eat a variety of organisms, including any of the following: Fish, frogs, salamanders, snakes, lizards, turtles, baby alligators, birds, and mammals.

Research carried out by Laughlin (1959) in Oklahoma revealed that some species of the genus Natrix fed on golden shiners (Notemigonus crysoleucas), spotted sunfish (Lepomis punctatus), the black bullhead (Ictalurus melas), and bullfrogs (Rana catesbeiana).

Also in Oklahoma several cottonmouths were captured and their stomach contents analyzed (Trowbridge, 1937). One snake contained sun perch (Apomotis cyanellus), while another had consumed six catfish (Ameiurus sp.) 6 to 10 inches long. Another specimen had eaten a water snake

(*Natrix sipedon transversa*) about 18 inches long. Others had been feeding on frogs. Two *Thamnophis sauritus proximus* that contained food items were collected along the eastern border of Oklahoma. Only the leopard frog (*Rana sphenocephala*) was found in their stomachs.

Yerger (1953) related the capture of a cottonmouth (*Agkistrodon piscivorus*) in Wakulla County, Florida which measured 63 inches in length. Dissection revealed that an adult yellow bullhead (*Ameiurus natalis*) nearly 12 inches long had been consumed. Schmidt and Davis (1941) stated that *Agkistrodon piscivorus* fed largely on fish, frogs, and other aquatic or semiaquatic vertebrates. Small mammals, birds, and lizards were eaten when available.

STUDY AREA DESCRIPTION

This study was conducted in the Jasper State Fish Hatchery, which is located in eastern Texas approximately 7 miles northwest of Jasper, in Jasper County on U.S. Highway 63. This hatchery specialized in the production of channel catfish (Ictalurus punctatus), blue catfish (Ictalurus furcatus), white crappie (Pomoxis annularis), black crappie (Pomoxis nigromaculatus), and largemouth bass (Micropterus salmoides). Also raised were flathead catfish (Pylodictis olivaris), yellow bullhead catfish (Ictalurus natalis), green sunfish (Lepomis cyanellus), redear sunfish (Lepomis microlophus), hybrid sunfish (green x redear), golden shiner (Notemigonus crysoleucas), and fathead minnows (Pimephales promelas). Largemouth bass were raised from late February through May; crappie from late February through September; blue catfish from the last of April through August; channel catfish from the last of May through August. These fishes are used primarily to stock public waters and secondarily to stock private lakes and ponds.

The hatchery consisted of 63 earthen ponds ranging in size from 0.17 to 4.54 acres of surface water, with a mean pond size of 1.24 acres. The average pond depth was

2.5 feet. These ponds were aligned in four rows in the midst of a large clearing (Fig. 1). The grassy marginal areas surrounding the ponds were mowed periodically. There was also a lack of extensive aquatic vegetation due to intermittent pond drainage. The group of ponds is surrounded on all four sides by a forest. Ninety per cent of the county consists of a pine-hardwood forest blanketing rolling hills.

Jasper County ranges in altitude from 30 to 200 feet. The annual rainfall in the area is 52.40 inches. The average temperature in January is 40 F, while the average temperature in July is 93 F. The average number of growing days per year is 229. The county is drained by the Neches and Angelina Rivers. The water supply for the hatchery is a gravity flow system and comes from Indian Creek which flows along the southern border of the hatchery. The Angelina River passes by the hatchery about 2 miles to the west.

PROCEDURE

From one to four nights per month were spent collecting the various snakes. The number of collecting trips each month was determined by collecting success of trips made earlier in the month. Trips were made each month until the quota for that month was met. The quota was 20 snakes per month from 1 August 1969 to 1 August 1970 excepting the months December, January, and February when the snakes were inactive.

Lagler and Salyer (1947) stated that the best way to capture water snakes was by walking or wading along the banks of the stream or pond because too many snakes were not seen from a boat and thereby avoided capture. The wading method was utilized in this study. Wire funnel traps (6 x 6 x 22 inches) were also employed to capture snakes. One was placed near the flood gate of each pond. These traps were checked and emptied daily by hatchery personnel.

A headlight was used when collecting at night. With such a light water snakes can be approached easily without being disturbed (Clark, 1949). It was powered by a 6-volt lantern battery which was easily attached to one's belt. Chest-high rubber waders were worn for protection against poisonous snakes which were known to frequent the study area.

The snakes were flushed from their hiding places in the weeds at the edges of each pond either by stepping into these areas or by prodding them with the snake stick. The snake stick was a pair of modified Pillstrom snake tongs 7 feet in length. The stick was extremely effective in catching snakes in an aquatic environment. A .22 caliber pistol loaded with bird shot was used to kill all snakes found on the land and all removed from the water by the snake stick. The stick could not be used effectively on land because it tended to grasp more grass than snake.

After each snake was caught and killed, a tag was attached to it containing the date, time of capture, and the pond number in which it was caught or to which it was nearest. Then the snake was placed in a portable ice chest to arrest or retard enzymatic activity associated with digestion. Salyer and Lagler (1940) stated that the predator (snake) should be refrigerated as soon as possible after it is killed so that losses of food materials by prolonged digestion and decomposition will be reduced to a minimum. The snakes were then taken back to Stephen F. Austin State University in Nacogdoches, Texas where they were transferred to a freezer to await analyzation. When time allowed, the snakes were thawed and head-body length, tail length, total length, body mass, and sex were recorded. The stomachs were opened by dissection,and the volume of the stomach contents was measured by the water displacement method using graduated cylinders. These cylinders had maximum capacities of 10 ml, 50 ml, 100 ml, 500 ml, and 1,000 ml. The smallest one possible was used in each instance. The food items were hardened and preserved in 10 % formalin. Later, when time permitted, the food items were identified to the lowest taxa possible. A binocular zoom lens (7x - 30x) dissecting microscope was used when needed for the identification of small food items.

Frequency of occurrence, volume, and per cent of total volume of food items in each specimen was calculated and recorded. Per cent frequency of occurrence of a given item in stomachs appears to indicate food preference or food availability, while the volume appears to emphasize the predation impact of the study sample on the total available food mass (Brown, 1958).

RESULTS

A total of 373 snakes was captured and examined for food contents. Of these 167 (45 %) contained no food. Therefore, the data presented in this paper are based on the stomach content analyses of 206 (55 %) snakes. Any mention hereafter of "all snakes" refers only to the 206 snakes containing food. Seven different species of snakes were represented in this number. Of all snakes containing food there were 89 Natrix fasciata confluens, 86 Agkistrodon piscivorous leucostoma, 9 Natrix rhombifera rhombifera, 9 Thamnophis proximus proximus, 7 Natrix erythrogaster flavigaster, 5 Farancia abacura reinwardti, and 1 Micrurus fulvius tenere (Fig. 2).

Amphibians of the family Ranidae (primarily bullfrogs and leopard frogs) were found in more snakes (95) than any other food item group (Fig. 3). The amphibian family Hylidae (tree frogs) was second most important in its frequency of occurrence as a food item. One or more hylids were found in 64 snakes. The presence of the fish families Ictaluridae (catfish), Cyprinidae (minnows and shiners), and Centrarchidae (sunfish) were noted in snakes six times. Unidentifiable frog matter was recorded in 33 snakes, while unidentifiable fish was in 14.

Since two species of snakes represented 85 % of all snakes, they were considered to be of greater importance than the other species and, thus, were dealt with accordingly in this report. One of these species, Agkistrodon piscivorous leucostoma, had a comparatively high degree of occurrence of ranids in its diet (Fig. 4). The number of snakes in which this food item group appeared (47) was more than twice the number in which hylids appeared (22). The ictalurids were represented in four snakes, while the centrarchids were in three snakes. Unidentifiable frog matter was in five snakes, and unidentifiable fish matter in 10 snakes.

The presence of ranids and hylids in Natrix fasciata confluens was observed in snakes 38 times (Fig. 5). Cyprinids were noted in four snakes of this species, while centrarchids and poeciliids (Poeciliidae, live-bearers) were in three. Ictalurids were found in only one snake. Unidentifiable frog matter was in 19 snake stomachs, while unidentifiable fish was in four.

The minimal volumetric values of the food groups were minute (0.1 cm^3 - 1.0 cm^3); whereas, the maximal volumetric values showed a wide variation (0.3 cm^3 - 112.0 cm^3). In most instances the maximal value of a range is indicative of the volume of a complete intact undigested food item. Individual food items exhibited a greater volumetric range in Ranidae than any other food group during all three seasons. Only the autumn ictalurid mean rivalled any of the ranid seasonal means. It exceeded both of the ranid means for the spring and autumn. However, the ictalurid autumn mean was calculated from only eight food items, while the ranid spring and autumn means were calculated from 52 and 79 items, respectively. Fish taken were relatively small. They had an average volume of 1.5 cm^3. The largest fish consumed was a flathead catfish Pylodictis olivaris which possessed a volume of 10.0 cm^3. It was eaten by an Agkistrodon piscivorous leucostoma. Other individual catfish of slightly less volume (Ictalurus natalis, 8.5 cm^3, and Pylodictis olivaris, 9.5 cm^3) were also taken by this same snake species. All of the larger catfish were eaten during the month of October. No snakes were captured during the winter months (December, January, and February) due to their inactivity during cold weather, and, consequently, food habits were not recorded for this period. (Fig. 6).

Examination of the esophagus and stomach in each snake yielded a yearly total food volume of 1,197.1 cm^3. The largest seasonal food volume (554.2 cm^3) was taken during the spring (Fig. 7); the second, during the autumn (395.3 cm^3); and the third, during the summer season (247.6 cm^3). Seasonal intake of all fish in descending order of volume was as follows: autumn, 74.0 cm^3, spring, 73.9 cm^3; and summer, 11.8 cm^3. Ictalurid intake in descending order of volume for the three seasons (Fig. 8) was as follows: autumn, 43.3 cm^3; summer, 3.5 cm^3; and spring, 0.0 cm^3.

Monthly food volume and per cent of fish versus non-fish food is presented in Table 1. The high consumption months of fish were April and October. April and October were also the prime months for non-fish consumption. Relatively heavy predation on non-fish food items extended from April through June with no fish consumption during June.

Of the total food volume of all snakes (1197.1 cm^3), Agkistrodon piscivorous leucostoma consumed 635.0 cm^3; Natrix fasciata confluens, 393.1 cm^3; Natrix erythrogaster flavigaster, 114.9 cm^3; and Natrix rhombifera rhombifera, 39.9 cm^3. The food eaten by these four species comprised 99 % of the total food volume of all snakes (Fig. 9).

The major species of snakes did not feed heavily simultaneously (Fig. 10). The food consumption of Agkistrodon piscivorous leucostoma increased steadily and decidedly from spring through autumn. Natrix fasciata confluens fed comparatively heavy in the spring and light in the summer and autumn. Natrix fasciata confluens consumed the most food in the spring, while Agkistrodon piscivorous leucostoma consumed the most in the summer and autumn. In addition to the seasonal food volume per snake species, consideration was given to the seasonal food intake average per snake for the two major snake species (Table 2). Agkistrodon piscivorous leucostoma fed almost twice as heavily (per snake) in the summer and autumn as it did in the spring. Natrix fasciata confluens fed almost twice as heavily (per snake) in the spring and autumn as it did in the summer.

The sample size of Natrix erythrogaster flavigaster was small, but this species deserves special mention. Of this species seven snakes (3.4 % of all snakes) consumed 9.0 % of the total food volume. Also, this prodigious food intake per snake occurred almost exclusively during one season, the spring.

Members of the family Ranidae comprised 65 % (by volume) of the diet of Agkistrodon piscivorous leucostoma. Fish were of secondary importance comprising 15 % (Fig. 11). Ranidae also composed 48 % (by volume) of the diet of Natrix fasciata confluens, while Hylidae comprised 37 % and fish only 11 % (Fig. 12).

The snake species of limited sample size and their food habits for the year in decreasing order of food volume ingested were as follows: Natrix erythrogaster flavigaster, 114.9 cm^3 (99 % by volume was amphibian, and 1 % was fish); Natrix rhombifera rhombifera, 39.9 cm^3

(52 % was amphibian, and 46 % was fish); Farancia abacura reinwardti, 14.4 cm^3 (100 % amphibian); Thamnophis proximus proximus, 11.3 cm^3 (100 % amphibian); Micrurus fulvius tenere, 0.5 cm^3 (100 % reptilian).

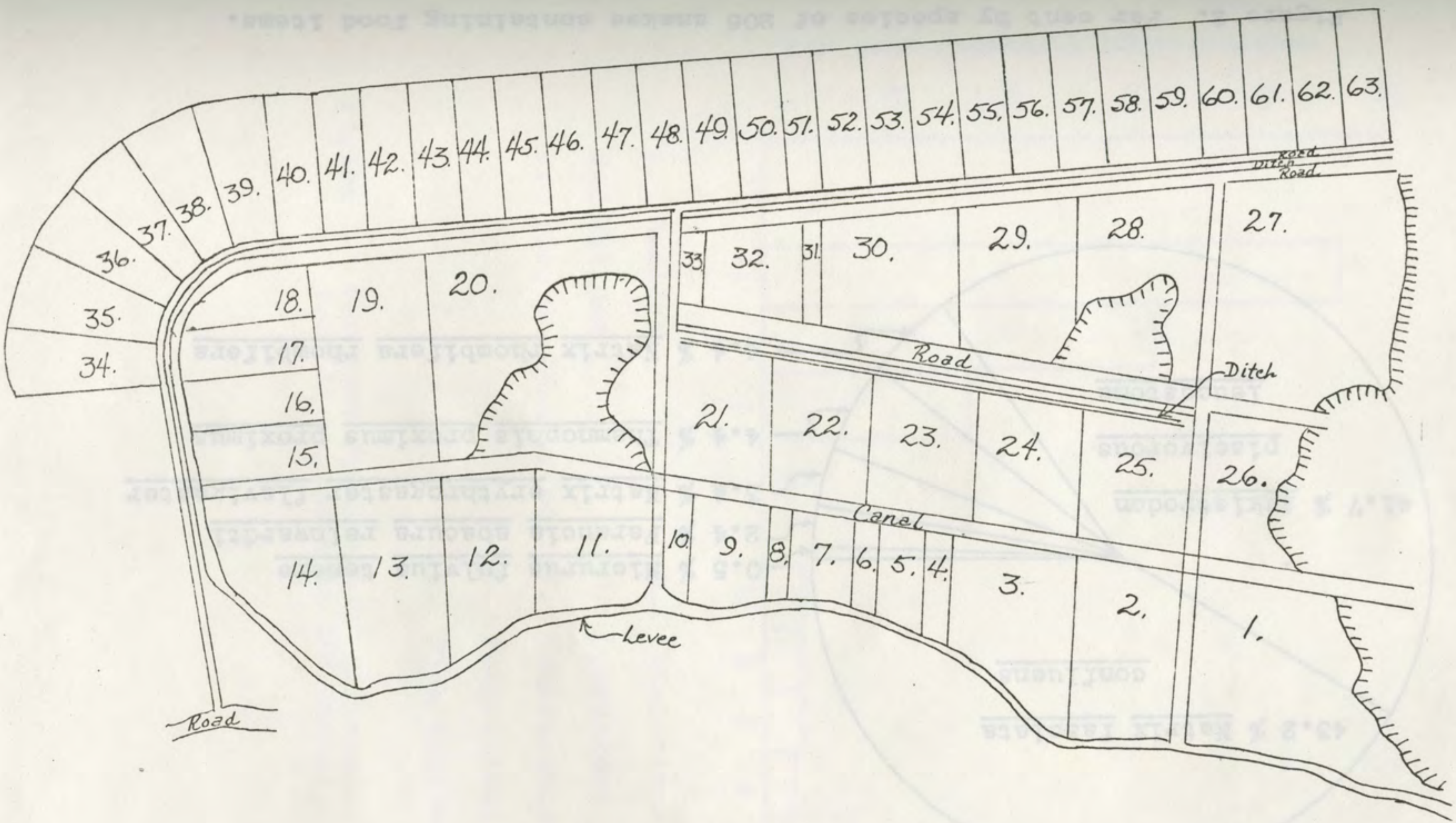


Figure 1. Jasper State Fish Hatchery

Scale 1" = 360'

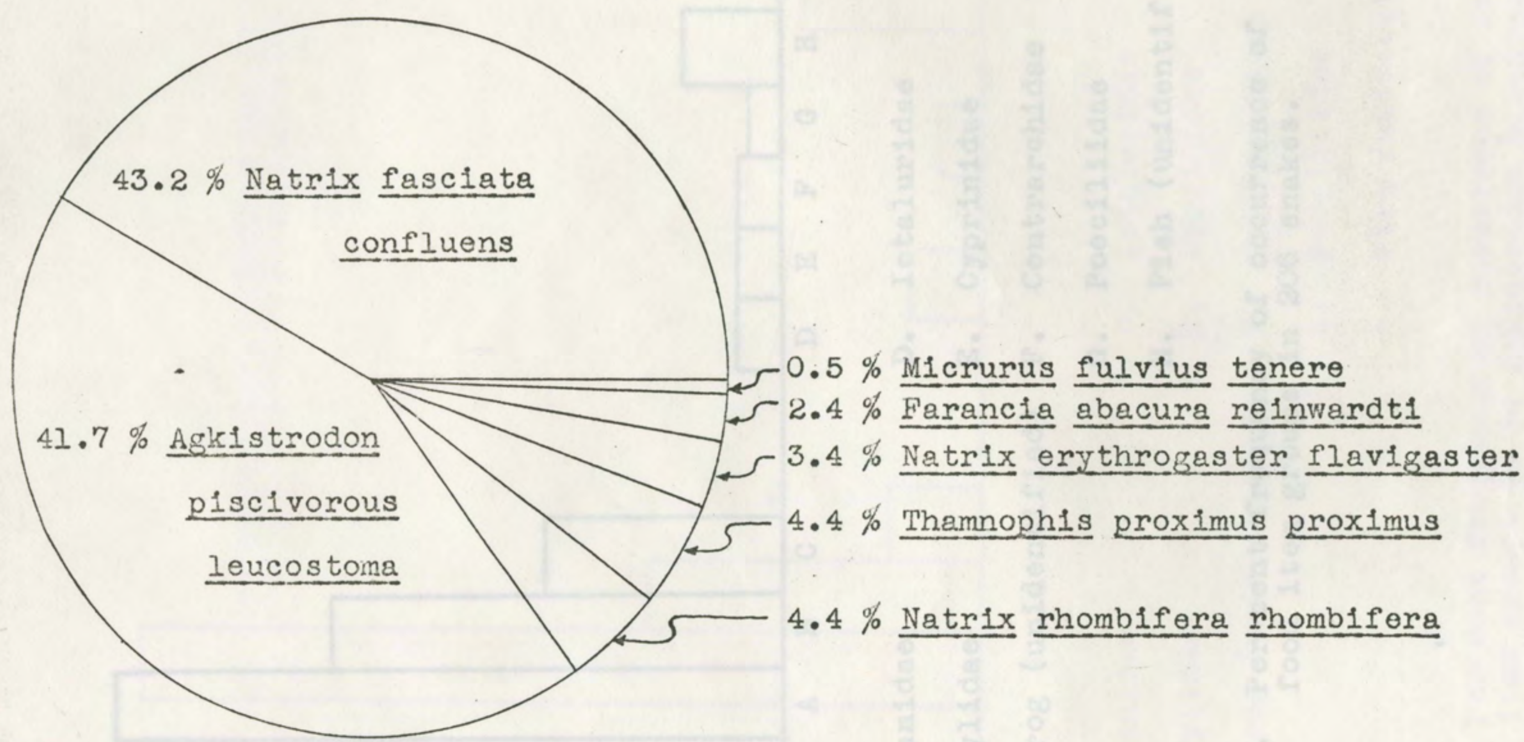
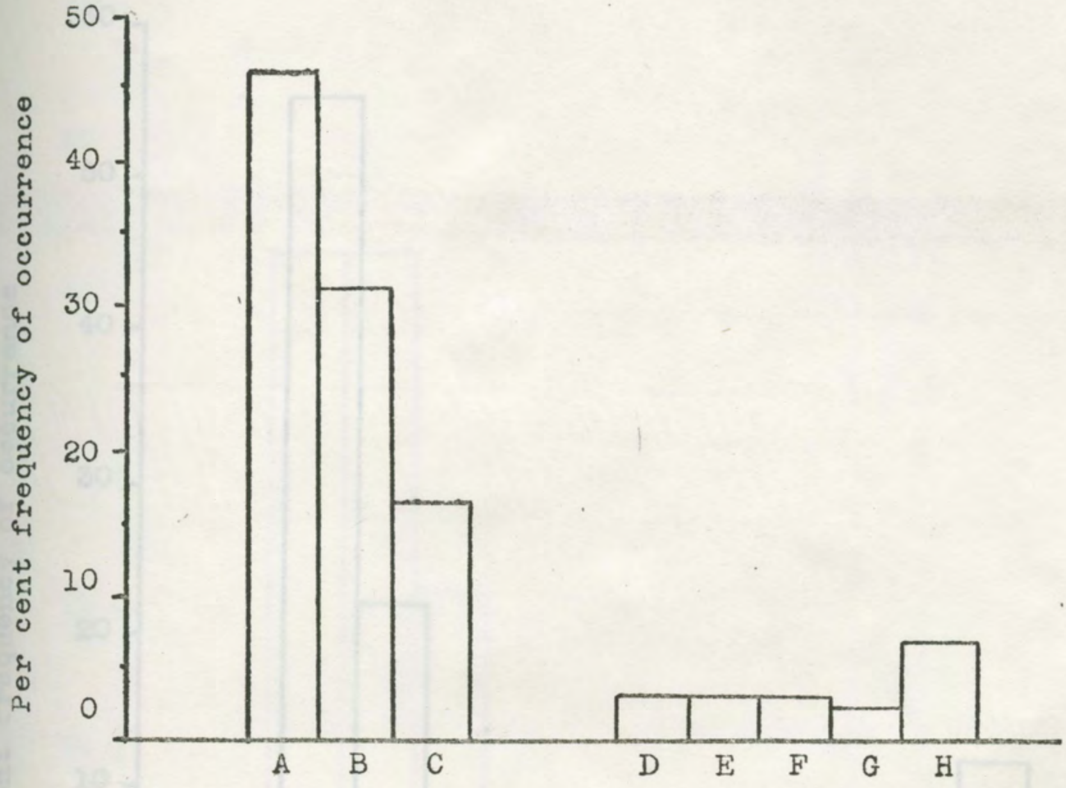


Figure 2. Per cent by species of 206 snakes containing food items.



A. Ranidae
B. Hylidae
C. Frog (unidentified)
D. Ictaluridae
E. Cyprinidae
F. Centrarchidae
G. Poeciliidae
H. Fish (unidentified)

Figure 3. Per cent frequency of occurrence of food item groups in 206 snakes.

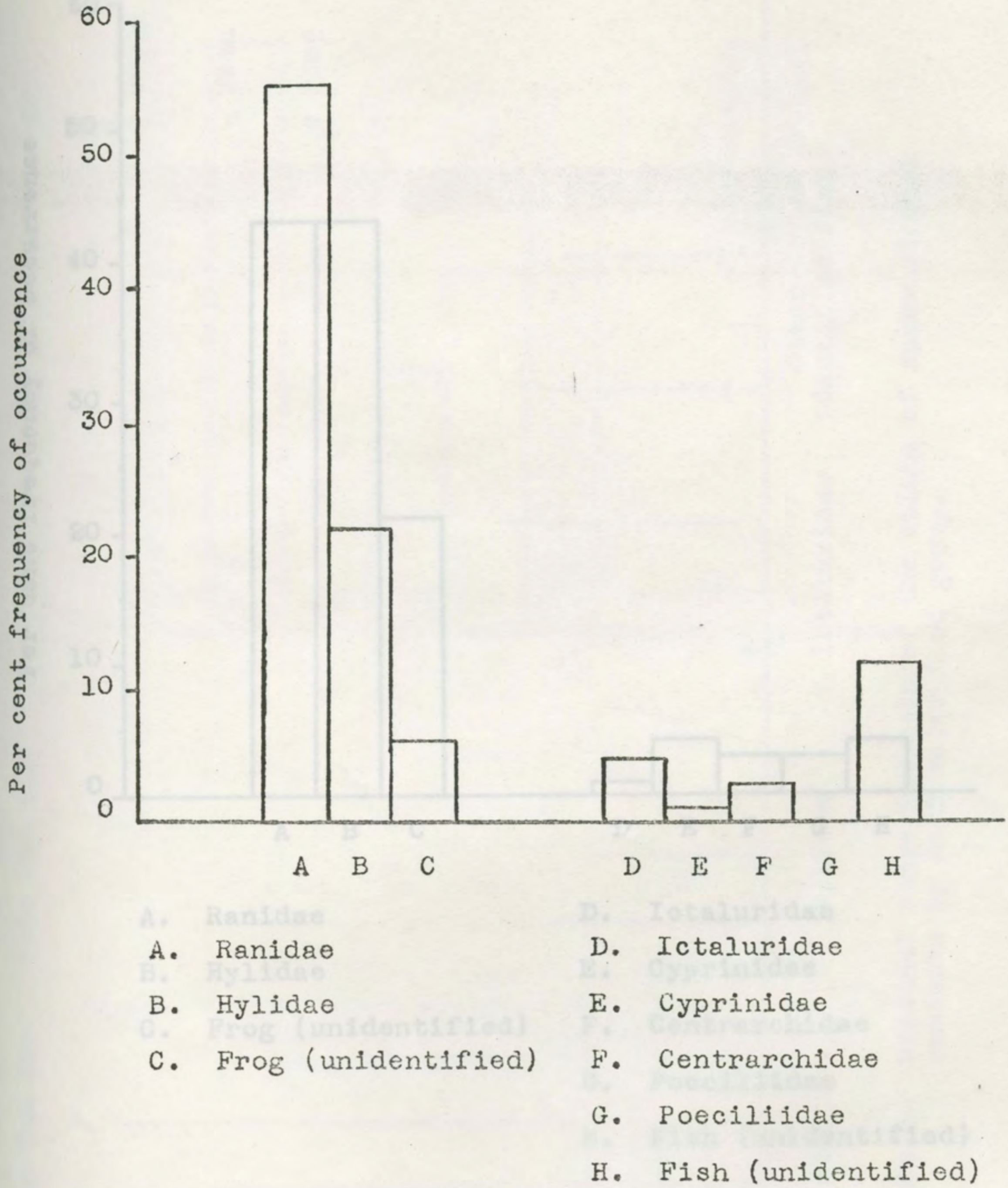


Figure 4. Per cent frequency of occurrence of food item groups in 86 Agkistrodon piscivorous leucostoma.

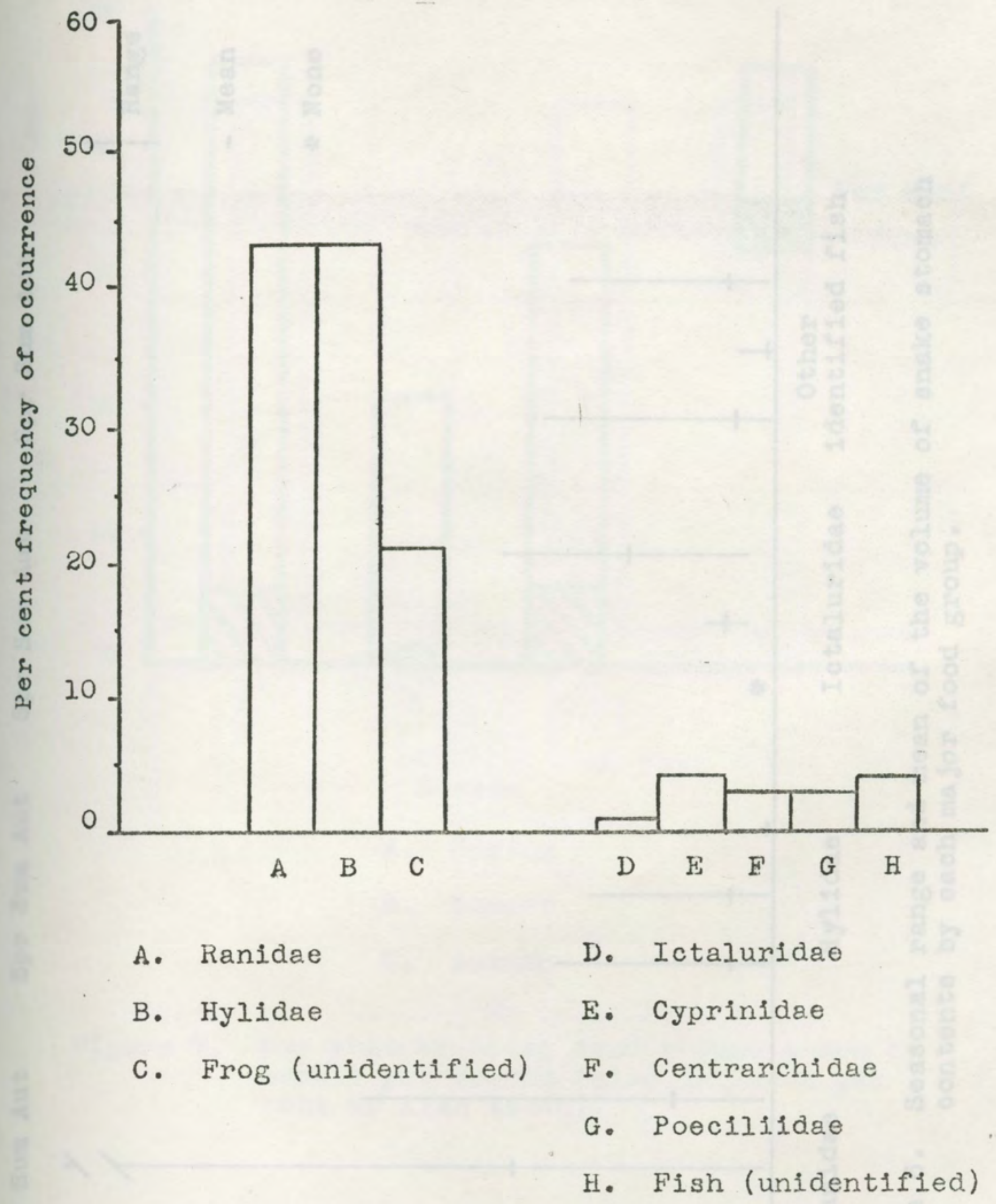


Figure 5. Per cent frequency of occurrence of food item groups in 89 *Natrix fasciata confluens*.

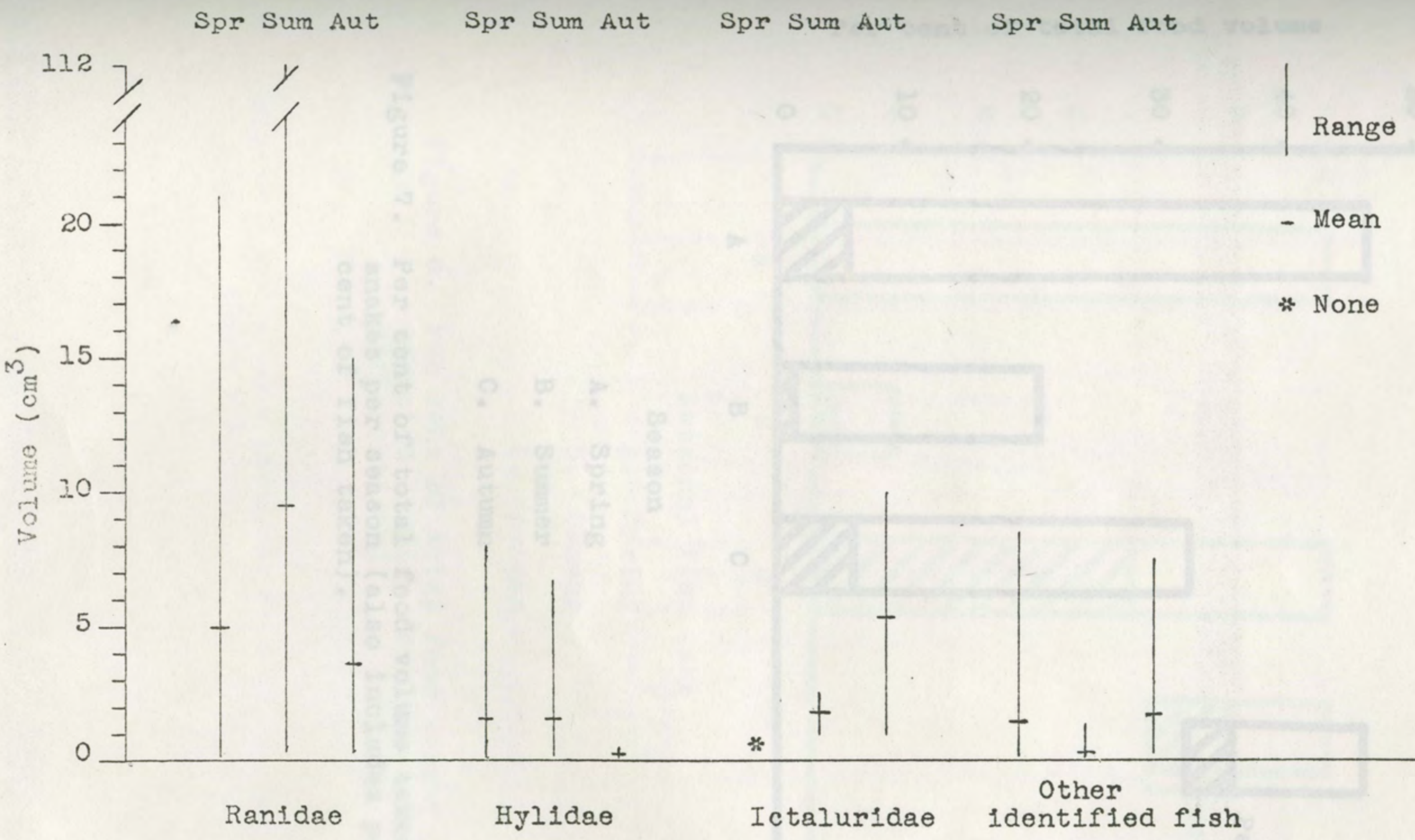
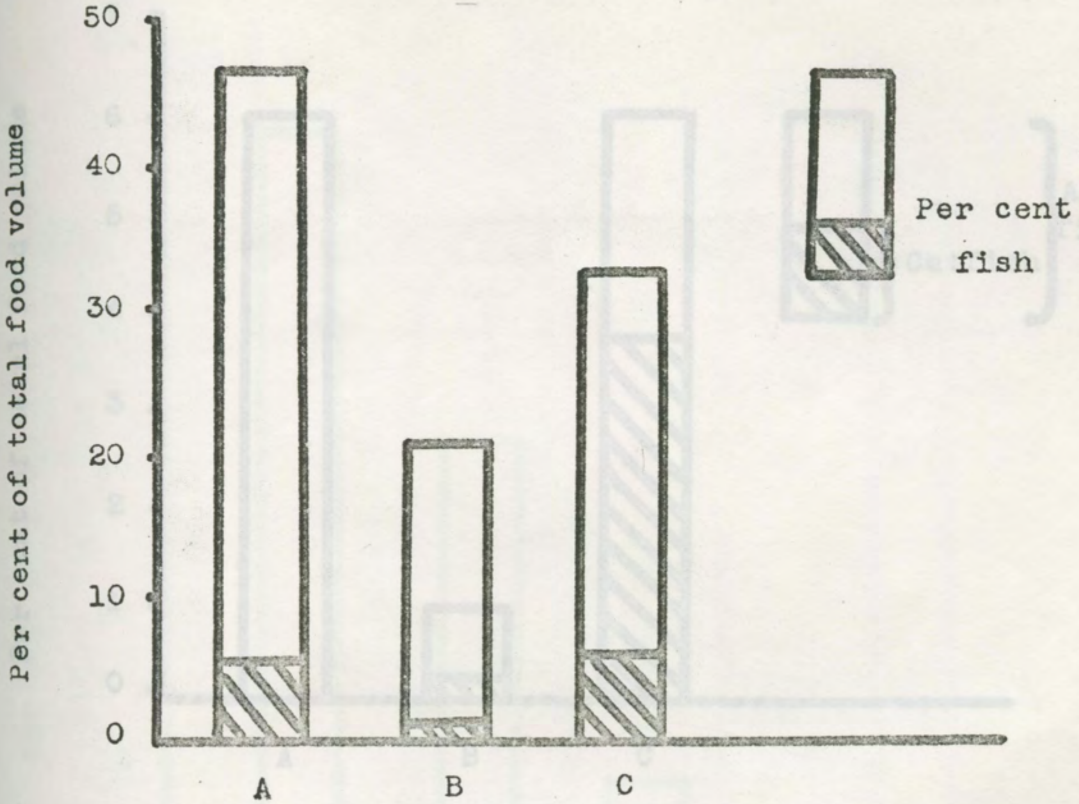


Figure 6. Seasonal range and mean of the volume of snake stomach contents by each major food group.



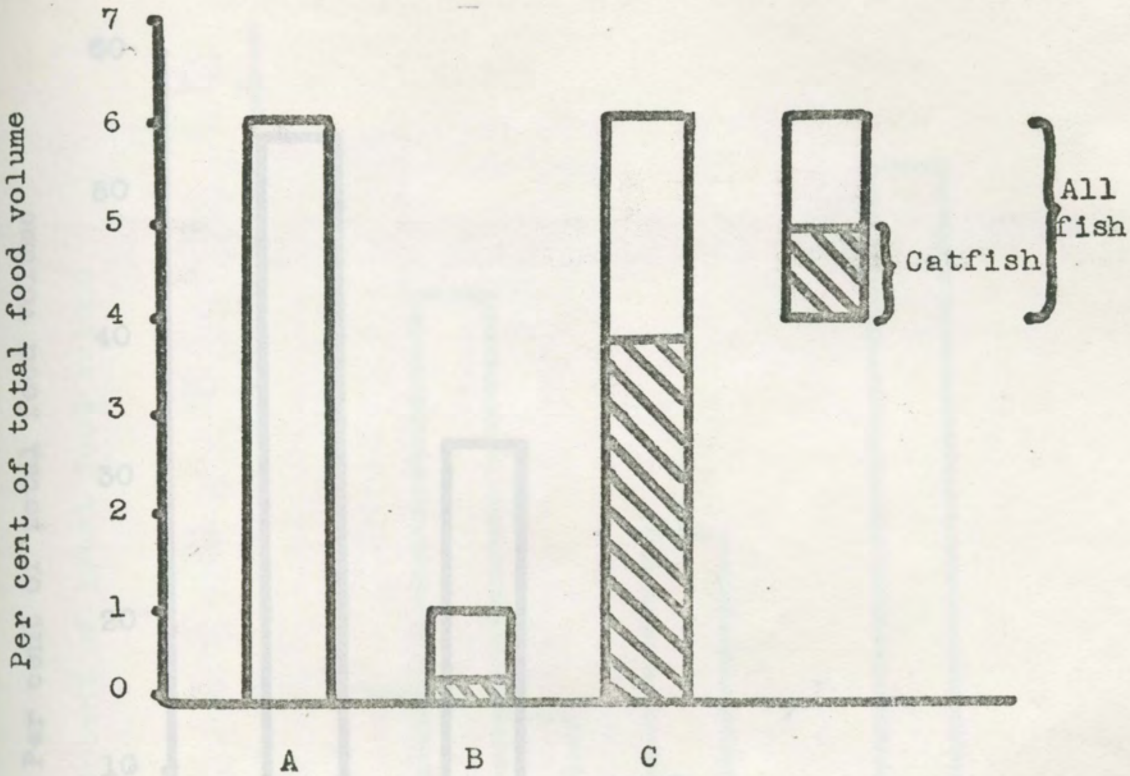
Season

A. Spring

B. Summer

C. Autumn

Figure 7. Per cent of total food volume taken by snakes per season (also includes per cent of fish taken).



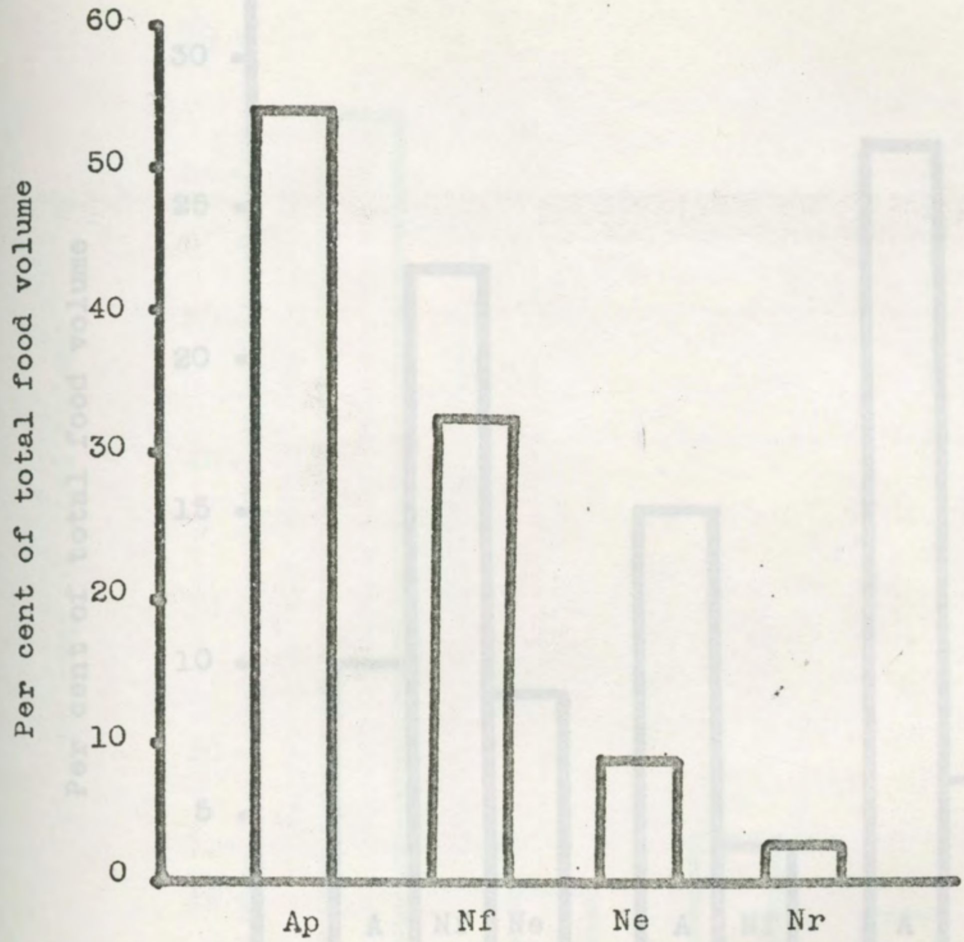
Seasonal fish take

A. Spring

B. Summer

C. Autumn

Figure 8. Per cent of total food volume occupied by fish (catfish differentiated).



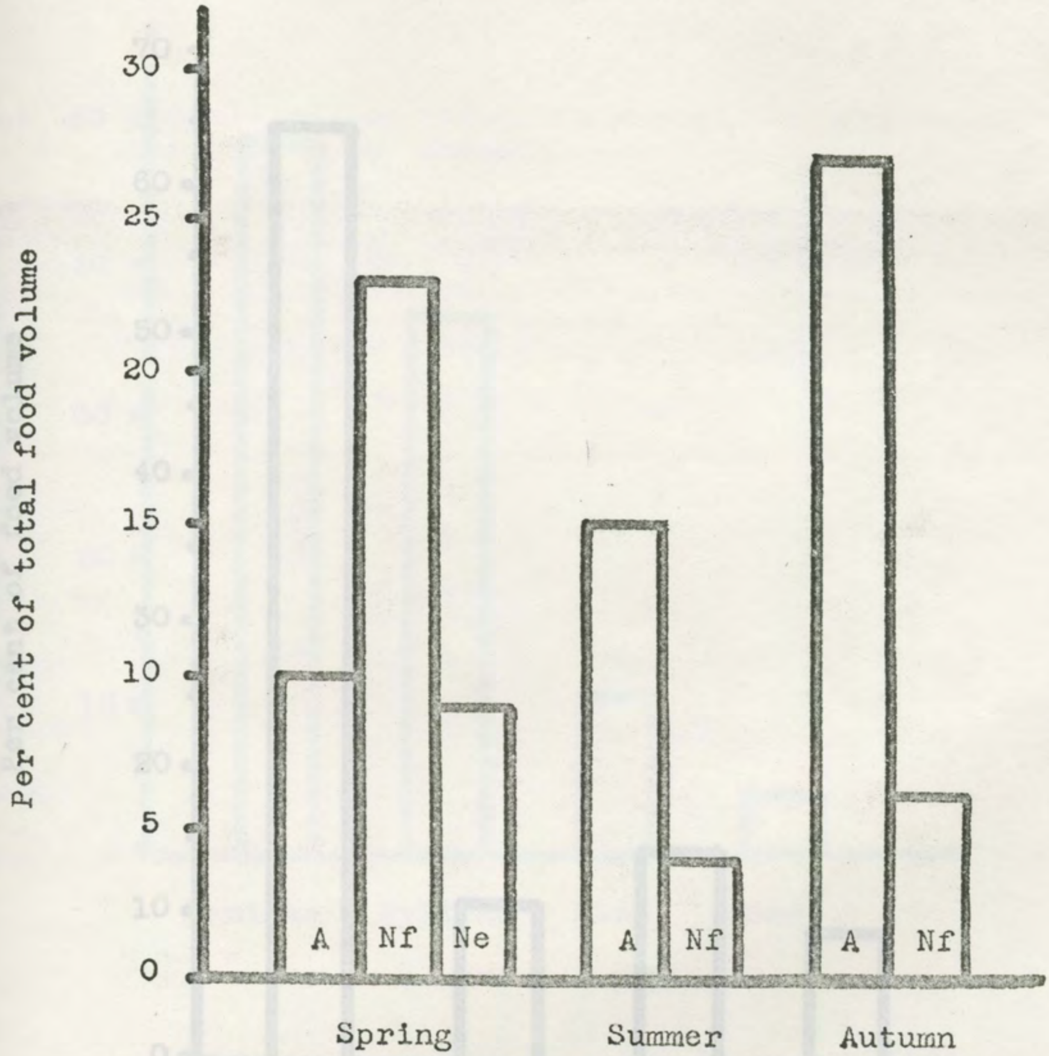
Ap. Agkistrodon piscivorous leucostoma

Nf. Natrix fasciata confluens

Ne. Natrix erythrogaster flavigaster

Nr. Natrix rhombifera rhombifera

Figure 9. Per cent of total food volume per snake species.



A. Agkistrodon piscivorous leucostoma

Nf. Natrix fasciata confluens

Ne. Natrix erythrogaster flavigaster

Figure 10. Per cent of total food volume per snake species by seasons.

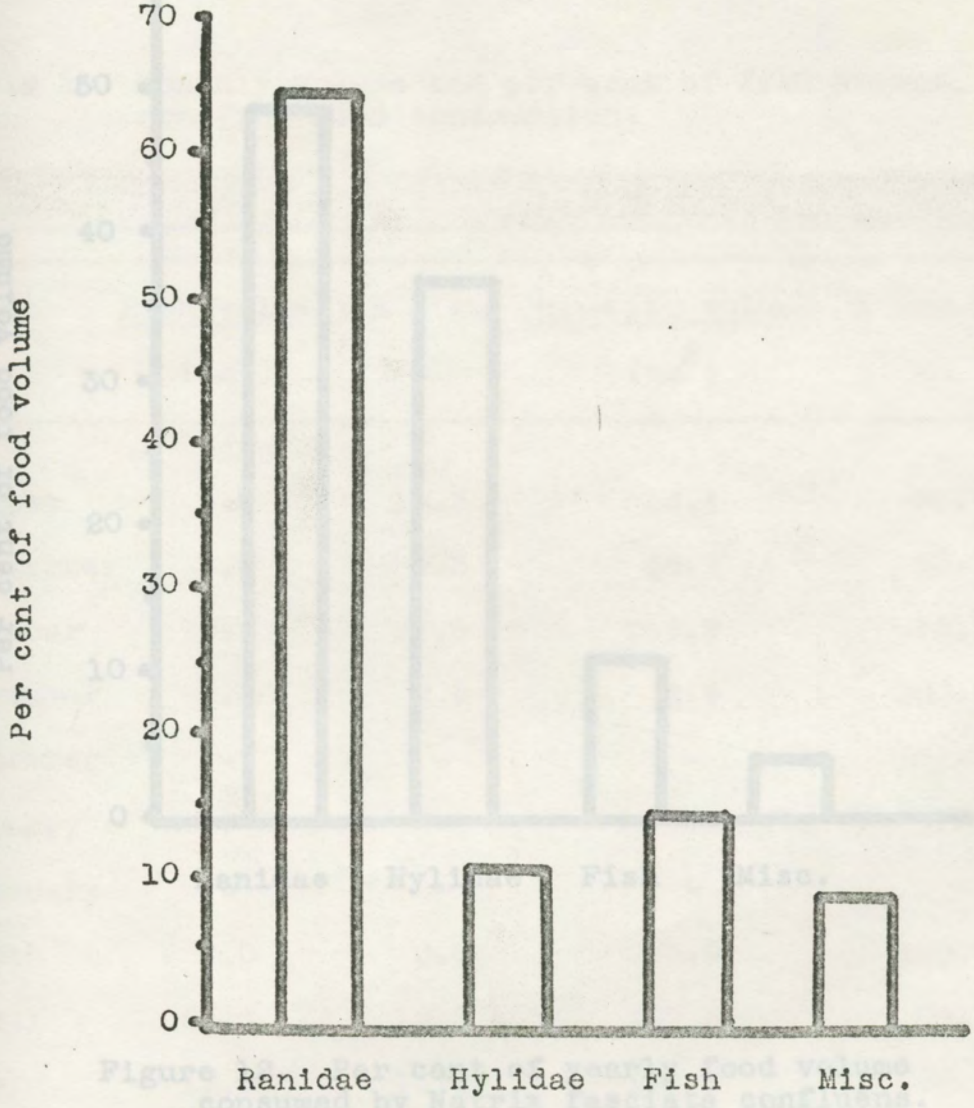


Figure 11. Per cent of yearly food volume consumed by Agkistrodon piscivorous leucostoma.

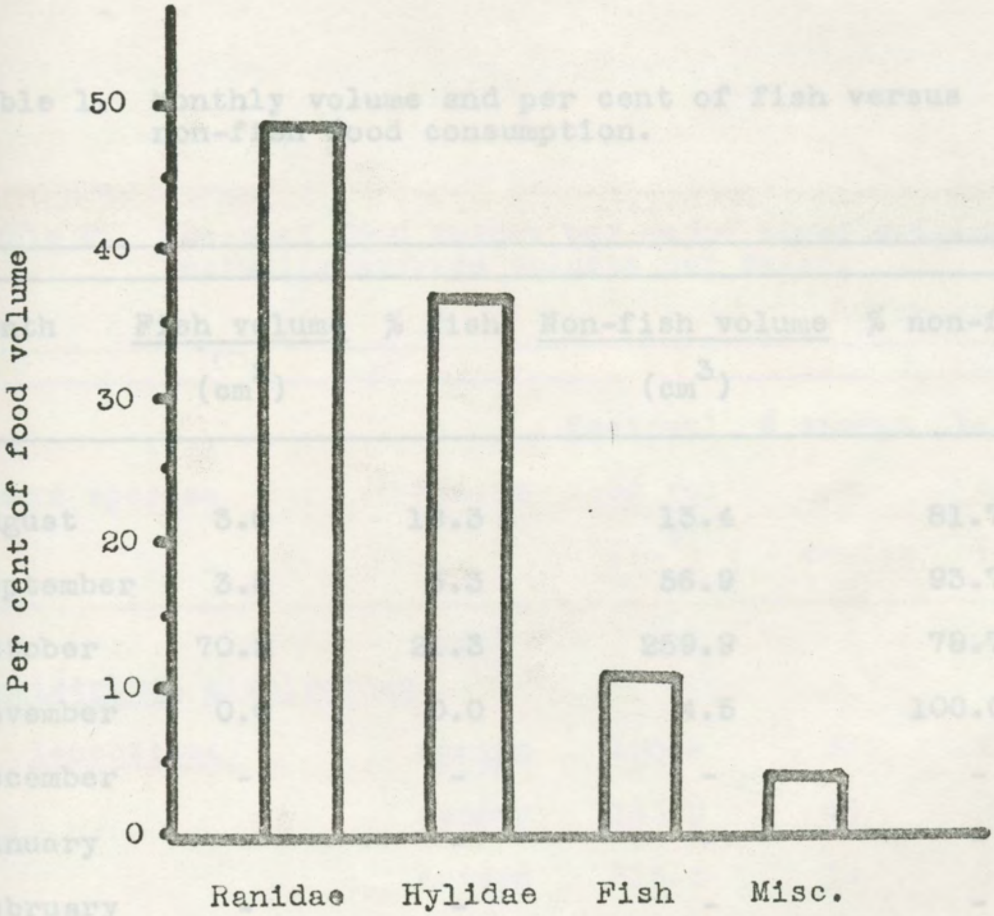


Figure 12. Per cent of yearly food volume consumed by _Natrix fasciata confluens_.

Table 1. Monthly volume and per cent of fish versus non-fish food consumption.

Month	Fish volume (cm^3)	% fish	Non-fish volume (cm^3)	% non-fish
August	3.0	18.3	13.4	81.7
September	3.8	6.3	56.9	93.7
October	70.2	21.3	259.9	78.7
November	0.0	0.0	4.5	100.0
December	-	-	-	-
January	-	-	-	-
February	-	-	-	-
March	0.0	0.0	33.9	100.0
April	54.4	15.5	297.6	84.5
May	19.5	11.6	148.8	88.4
June	0.0	0.0	163.5	100.0
July	8.8	13.0	58.9	87.0
Year total	159.7	13.3	1037.4	86.7

Table 2. Seasonal food volume per major snake species including average volumes per snake.

Snake species	Season	Seasonal food vol (cm^3)	# snakes per season	Vol per snake (cm^3)
Agkistrodon piscivorous				
leucostoma	spring	125.2	28	4.47
	summer	183.2	20	9.16
	autumn	315.5	38	8.30
Natrix fasciata				
confluens	spring	280.3	56	5.01
	summer	36.4	15	2.43
	autumn	76.4	18	4.24

DISCUSSION

The primary concern of this investigation was to determine if the predation of fish by snakes in a fish hatchery was sufficient to warrant control. In the process of determining the importance of predation two major criteria were examined. These criteria were the frequency of occurrence of food items and the per cent of volume occupied by these food items in the diets of predators. Frequency of occurrence concerns the number of stomachs in which a particular food item type occurs and is an indication of food preference. The volumetric percentages of food items are generally utilized to indicate the impact of the predator study sample on prey populations, (Brown, 1958).

Preference, in the author's opinion, is expressed by a choice that is made under any given set of circumstances. The choice is generally affected by the set of circumstances that surround it. Because of this, availability (accessibility) plays an important role in food preference. The ease in obtaining a food item that is palatable would definitely be a factor in determining the food preference of a predator. Availability of a prey species includes not only ease of capture but population density.

Capture ease and population density may or may not be related, depending on the prey and predator species. In this study these two factors were not interdependent. The fish were present in large numbers, in high concentrations, and in accessible locations. The predator species (snakes) were known to be piscivorous. However, the snakes did not prefer (choose) fish as their major food item. This indicates the involvement of the ease of capture. When conditions are such that capture of a prey organism can be accomplished easily, then population density would have a direct affect on the selection of the prey species in the diet of the predator. The reverse is possible also: That a population is so dense or concentrated that it affects the ease of capture. An example could be the isolation and concentration of fish in a small pond or ditch due to water evaporation. In this study the population density of fish had minor effect on the snakes' food preference because of the inaccessibility of the fish.

The per cent frequencies of occurrence as food items were extremely low (2 % - 3 %) for each of the fish families (Ictaluridae, Cyprinidae, Centrarchidae, and Poeciliidae) represented in the study. Unidentifiable fish appeared more frequently than specimens identifiable to any one of the fish families. Unidentifiable fish, however, were found in only 7 % of all snakes. These data indicated a low degree of preference exhibited by snakes for fish. This appeared to be somewhat unusual due to the aquatic nature of the predominent species of snakes and their supposedly piscivorous habits. Amphibians, frogs specifically, were found quite frequently in the snakes (ranids in 46 % and hylids in 31 %). Evidently both the fish and the frogs were palatable to the snakes since they were both eaten with some degree of regularity. However, frogs definitely were preferred over fish as food items as is evidenced by their higher frequency of occurrence. High concentrations of both fish and frogs were present so population density alone did not determine the food preference of the snakes. If one of the two prey populations had been significantly lower, then the population densities might have played a more important role in food preference determination. Since both prey populations were high and palatability for both groups was evident (from the literature and this study), then availability must be of importance in selecting food items. According to Lagler and Salyer (1945) availability is an important factor in determining food habits of snakes. The availability of a prey species is determined by the ease of capture of the prey. Ease of capture is dependent on several factors. One of these is the habitat of the prey. If the prey is fish, then water is a necessary part of the habitat. If the water is but a few inches in depth rather than a few feet, the chances of a predator, such as a snake, successfully capturing a fish are probably enhanced since the fish's escape movements would be restricted only to a horizontal plane. A low sloping pond bank would create a shoreline area of shallow water that could aid a snake in its "fishing" endeavors. However, if the slope of the bank is steep, and the pond is deep along the shore, then there will be no shallow water along the shoreline thus making fish capturing difficult. Aquatic vegetation perhaps is an aid to a hungry aquatic or semiaquatic snake since it would tend to conceal the snake from the prey and, thus, provide the snake with the element of surprise. It also may restrict the velocity and directional movements of the prey.

Pond depth in the fish hatchery was an average of 2.5 feet. The slope of the bank was steep. Aquatic vegetation was scarce. These factors probably made it difficult for a snake to catch a fish, thus making the fish relatively unavailable or unaccessible to a snake. Frogs on the contrary were relatively available,for they were found along the edge of the ponds in the grass or near the edge in the water. Some factors which contribute to the ease with which a snake captures a frog are the silent movements of a snake, the habitual periodic immobility of a frog, the frequent habit of a frog's returning quickly to the bank once frightened into the water, and the nocturnal habits of both frogs and water snakes. Therefore, because of the physical properties of the study area and the innate behavioral characteristics of both predator and prey, frogs had a much higher degree of availability to snakes than did fish.

The greatest impact of predation by snakes on the available food mass of this study occurred during the spring months. The volume of food ingested during the spring was 554.2 cm^3. However, this was not due to a greater food intake per snake (average intake of all snakes) but to more snakes actively feeding. This spring feeding allowed the snakes to regain mass that previously had been lost during hibernation.

Fewer snakes were actively feeding during the summer, but the intake per snake (average intake of all snakes) increased. Although Natrix fasciata confluens decreased in the amount of food intake per snake during summer, Agkistrodon piscivorous leucostoma more than doubled its intake per snake. This increase was sufficient to counterbalance the decrease per snake of Natrix fasciata confluens and then even to raise the total average food intake per snake for all snakes over that of the spring months.

However, both species were less active during the summer, probably due to higher temperatures, since fewer snakes were captured during this time. Because there were fewer snakes active and feeding, the total food volume intake of all snakes was lowest, and consequent impact on food groups was least during the summer season (247.6 cm^3).

In the autumn the total volume ingested by all snakes increased over that of the summer but did not rival that of the spring. The autumn intake was 395.3 cm^3. The number of snakes active and feeding increased during this season. The amount of food intake per snake (considering all snakes) was at its maximum in the autumn. A large amount of food per snake ingested during this season would provide sufficient body mass to withstand loss of body mass associated with the succeeding winter hibernation. The food intake per snake of *Agkistrodon piscivorous leucostoma* decreased only slightly from its peak during the summer, while the food intake per snake of *Natrix fasciata confluens* more than doubled its summer habits. Lower temperatures in the autumn may be more favorable for *Natrix* activity. The number of snakes active and feeding in this season did not approach the number that were active and feeding in the spring, thus, the total volume of food groups consumed in the autumn was far less than the total consumed in the spring.

Fish consumption by all snakes actually reached its peak in the autumn (74.0 cm^3) but was of equal magnitude in the spring (73.9 cm^3). The spring intake of fish coincided with the raising time for largemouth bass and crappie, but no bass and relatively few crappie were eaten. Fish occupied only about 14 % of the total food volume in the spring. During the summer when the catfish program was being conducted, less fish was taken (11.8 cm^3). Ninety-seven per cent of this volume was taken by the minor species Natrix rhombifera rhombifera.

Starting in September, fish were shipped out of the hatchery. By the end of the month almost all were gone with the exception of the brood fish which were kept throughout the winter. In spite of this, more fish were taken during this season than during any other season. However, there was also an increase in the frog intake perhaps due to the preparation necessary for hibernation. Fish occupied slightly over one-fifth of the total diet of all snakes in the autumn and slightly under one-sixth of the diet in the spring. Accounting for this difference could be that fewer frogs were active in the autumn than in the spring, thus, allowing fish to occupy a slightly higher percentage of the total food intake.

Essentially, no catfish were taken during the spring. Catfish were eaten during the summer and autumn with the summer intake being especially small (less than 0.5 % of the total yearly food volume). Almost all catfish taken during the year were taken in the autumn after the hatchery's catfish season had been terminated. The catfish populations fed upon during this season (primarily Pylodictis olivaris) were not one of the main species being raised, and, therefore, their numbers had not been reduced to only brooders in September.

The volume of the largest catfish taken (Pylodictis olivaris) was 10.0 cm^3, while the largest non-ictalurid fish was 8.5 cm^3 (Lepomis sp.). The most predominant size catfish taken was fingerling size and about 2 inches in length. Two inches was also the approximate average size of all fish consumed. The average length of 154 fish taken from snake stomachs in a Michigan study was 1.9 inches (Lagler and Salyer, 1947).

The largest ranid taken was 112.0 cm^3. Generally, ranids eaten were much larger in volume than individuals eaten of any other food group. Therefore, relatively few ranids could account for a sizeable volume intake.

Both fish and frogs were occasionally taken in great numbers by individual snakes. As many as 25 fish were ingested for one meal. These were mostly mosquito fish (Gambusia affinis) slightly less than 1 inch in length. Meals consisting of multiple food items were quite common in all species of snakes. This indicates that snakes could be a problem in a hatchery situation if the fish were the most available food species. Other researchers such as Netting (1938) and Lagler and Salyer (1947), agree that the reduction or control of snakes at fish hatcheries is justified.

Agkistrodon piscivorous leucostoma (Cottonmouth). The cottonmouth comprised 42 % of all snakes yet consumed 53 % of the yearly total food volume of all snakes. This snake species is quite heavy for its body length in comparison to the lengths of the other snakes in the hatchery. According to Brown (1958) water snakes may generally consume up to 40 % of their body mass. If this is true for the cottonmouths, they should be able to eat more than the other snake species in the hatchery of equal length. This was borne out by the following information. For the year each cottonmouth, which was captured and contained food, averaged 7.4 cm^3 of stomach contents as compared to 4.4 cm^3 of stomach contents for Natrix fasciata confluens.

Ranid frogs occurred in 55 % of the cottonmouths. This preference could be because of the ranids' abundance, accessibility, and large body size. The frequency of occurrence of ranids was over twice that of any other food item in its diet. Because of the body size, ranids occupied 65 % of the food volume of this snake species.

Hylids were the second choice as a food item (22 % frequency of occurrence) but were third in per cent volume (11 %). Their diminutive body mass, rather than lack of availability, was the cause of this third place position, for their availability was greater than that of fish. Hylids spent much of their time in the grassy areas both in and out of the water near the edge of the bank. This location is proximal to the area most frequented by cottonmouths. This frog family has the same behavioral characteristics as mentioned previously for frogs in general, which contribute to its availability to aquatic or semiaquatic snakes. On the basis of frequency of occurrence of identifiable food items, third choice of food was ictalurids (5 %), fourth was centrarchids (3 %), and last was cyprinids (1 %). Combined all of these fish plus unidentifiable fish had a 17.4 % frequency of occurrence and comprised almost 15 % by volume of this snake species total food consumption.

Natrix fasciata confluens (Broad-banded Water Snake). The broad-banded water snake comprised 43 % of all snakes and consumed 33 % of the yearly total food volume of all snakes. Ranids and hylids occurred in the diet of this water snake with the same high frequency (43 % for each). Thus, neither is preferred over the other, but both are preferred over any other food items. They may be taken with equal frequency, but ranids were more important in the broad-banded water snakes' diet because they comprised almost 50 % (by volume) of this snake species total food intake for the year. Hylids composed slightly less than 40 % (by volume) of the species total food ingested. On the basis of frequency of occurrence of identifiable food items, second choice was cyprinids (4 %), third choice was centrarchids or poeciliids (each 3 %), and last was ictalurids (1%). The total of these fish plus unidentifiable fish had a 14.6 % frequency of occurrence and comprised 10 % by volume of this snake species total food consumption.

Minor Species of Snakes. Five other food-containing species of snakes were captured, but because of their limited sample size, any conclusions which might be drawn from the results recorded could not be considered valid. However, as a group, these snakes expressed the same food habit tendencies as the two predominant snake species. Amphibians occupied 88 % of their total food volume, while fish occupied 12 %.

SUMMARY AND CONCLUSIONS

The objectives of this research were to determine if snake control is justifiable in the Jasper State Fish Hatchery near Jasper, Texas, and to resolve the feeding habits of the major species of snakes found there.

Stomach contents of 206 snakes captured in the hatchery were recorded according to frequencies of occurrence and per cent of food volume. Amphibians, particularly frogs of the family Ranidae, occurred more frequently and occupied more volume than any other food group in the total food volume that was compiled from all snakes. Only 159.7 cm^3 (13.3 %) of the total food volume (1,197.1 cm^3) consisted of fish. The greater preponderance of the fish taken (per cent volume) was not the major game fish being propagated in the hatchery. The fish taken in largest volumetric quantities were Lepomis sp. (49.3 cm^3), Pylodictis olivaris (31.5 cm^3), Gambusia affinis (25.8 cm^3), and Notemigonus crysoleucas (20.8 cm^3). The two most abundant snake species present in the hatchery were the broad-banded water snake (Natrix fasciata confluens) and the cottonmouth (Agkistrodon piscivorous leucostoma) which consumed a yearly total food volume of 393.1 cm^3 and 635.0 cm^3, respectively. The diet of

Natrix fasciata confluens was comprised of 85 % frogs (by volume) and 11 % fish (by volume), while that of Agkistrodon piscivorous leucostoma was comprised of 76 % frogs and 14% fish.

In such an area as the state fish hatchery at Jasper where the frog population is high, it would not appear to warrant control of snakes as predators on fish. If for any reasons the fish are at least as available as the frogs as prey for snakes, then a control program is perhaps justifiable. Some reasons which might increase the availability of fish are extremely shallow ponds, low sloping shorelines, or extensive aquatic vegetation. Decreasing the frog population, thus decreasing frog availability, might influence or cause an increase in fish predation. It was realized from this study that wire traps could be used effectively in the capture of aquatic snakes, especially during early spring (March and April in this locale) just as the snakes were emerging from hibernation. If any such snake eradication program is initiated it would probably not be necessary to keep it in force continually. After intensive eradication the snake population will be lowered and will build up again only slowly over the next several years (Brown, 1958).

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FOOD HABITS OF SNAKES

IN AN EAST TEXAS STATE FISH HATCHERY

(ABSTRACT)

APPROVED:

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Dean of the Graduate School

FOOD HABITS OF SNAKES

IN AN EAST TEXAS STATE FISH HATCHERY

by

JOHN L. MALLOY, B. S. Ed.

THESIS ABSTRACT

Presented to the Faculty of the Graduate School of

Stephen F. Austin State University

In Partial Fulfillment

of the Requirements

For the Degree of

Master of Science

Stephen F. Austin State University
August, 1971

ABSTRACT

A study was conducted from 1 August 1969 to 1 August 1970 in the Jasper State Fish Hatchery near Jasper, Texas to determine the amount of predation by snakes on fish being propagated. The hatchery consisted of 63 earthen ponds. A total of 373 snakes were captured. Results of stomach contents analyses of the 206 snakes containing food were calculated in per cent frequency of occurrence and per cent volume. Frogs, primarily Ranidae, were found to be the major food item. Fish were taken far less frequently, representing only 13.3 % (by volume) and 15.5 % frequency of occurrence. The two predominant snake species were Natrix fasciata confluens and Agkistrodon piscivorous leucostoma. From this study it was concluded that snakes did not pose a major fish predation problem. Thus, snake control in this hatchery is not necessary at the present time.

VITA

John Lawrence Malloy, the son of Lyda Bess Atkins Malloy and Lawrence Milton Malloy, was born in Paris, Texas on August 5, 1942. After completing his work at Bryan Adams High School, Dallas, Texas, in 1960, he served 6 months active duty in the U. S. Army Reserve. In 1961 he entered North Texas State University. After one year of attendance he transferred to the University of Arkansas from which he was graduated in 1966. He then taught biology and physical science in the public school system of Dallas, Texas, from September 1966, to January, 1969. He then entered the Graduate School of Stephen F. Austin State University as a graduate assistant in biology. After completing his course work in the summer of 1970, he taught life science during the school year 1970 - 1971 in the public school system of LaMarque, Texas. He then returned to Stephen F. Austin State University to complete his thesis work.

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