# FOOD HABITS OF THE FLATHEAD CATFISH, *PYLODICTIS OLIVARIS* RAFINESQUE, IN SIX OKLAHOMA RESERVOIRS

By

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## PREFACE

The major objective of this study was to collect food habits information on the flathead catfish useful in evaluating and developing management techniques designed to improve commercial and sport fishing. Seasonal variation in food habits of flathead catfish > 480 mm was described for fish from Carl Blackwell, Eufaula, Ft. Gibson, Grand, Hudson, and Texoma Reservoirs. Food habits of flathead catfish < 400 mm was described in Lake Carl Blackwell.

I would like to express my gratitude to Dr. R. C. Summerfelt, Leader of the Oklahoma Cooperative Fishery Unit, who served as committee chairman and adviser. His helpful suggestions and encouragement throughout this study and during the writing of the text gave need inspiration. I also wish to thank Drs. R. J. Miller and D. W. Toetz for serving on my advisory committee and for their constructive criticism during the preparation of this text.

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# CHAPTER I

## INTRODUCTION

The flathead catfish, Pylodictis olivaris, occurs in large rivers and reservoirs from South Dakota through Michigan to Pennsylvania and southward in the Mississippi Valley to the Gulf Coast states and westward to the Rio Grande River in northeastern Mexico (Hubbs and Lagler, 1947; Moore, 1957). It is found in New Mexico (Koster, 1957), and Tennessee River and Mobile Bay drainages in Alabama (Smith-Vaniz, 1968). It has been introduced into the state of Colorado (Beckman, 1953) and Arizona from where it has entered southern California (Bottroff, St. Amant, and Parker, 1968).

Jordan and Evermann (1902) report the flathead catfish "is most abundant in large streams, bayous, and overflow ponds of the lower Mississippi Valley". It is primarily a species of large rivers (Harlan and Speaker, 1956; Hubbs and Lagler, 1947; and others), but has adapted well to reservoirs, particularly the more turbid ones (Buck, 1956; and Cross, 1967).

Flathead catfish feed primarily on fishes, although frogs, aquatic insects, crayfish, molluscs, worms, and other terrestrial animals are also utilized (Forbes and Richardson, 1920; Luce, 1933; Berner, 1947; Koster, 1957; Trautman, 1957; Clay, 1962; and others). Minckly and Deacon (1959) and Langemeier (1965) found that young-of-the-year flathead catfish in rivers fed on Ephemeroptera, Trichoptera, and Diptera, while intermediate-sized fish fed on aquatic invertebrates and fishes in varying proportions. Brown and Dendy (1961) found that flathead catfish change from an invertebrate to a fish diet at about 280 mm. However, pond experiments by Hackney (1966) and Swingle (1967) in Alabama showed that all sizes of flathead catfish should be considered piscivorous and indicated that fish > 250 mm select for the larger bluegill (*Lepomis macrochirus*) and *Tilapia* spp. available in pond populations.

Minckley and Deacon (1959) found that the food habits of flathead catfish > 250 mm was determined mainly by availability of prey in two Kansas rivers. Flathead catfish from a turbid river were found to have consumed mostly fishes, while those from a clearer, more gravel-bottomed river fed on crayfish, fishes, and aquatic insects. Langemeier (1965) reported that stomachs from flathead catfish > 360 mm contained 80.8% and 98.5% fishes by weight, respectively, from unchanneled and channeled sections of the Missouri River. Clemens (1954) examined six flathead catfish from two Oklahoma reservoirs. He found fish remains in flathead catfish from Ft. Gibson Reservoir and midges and mayflies in those from Tenkiller Reservoir.

The piscivorous food habits of flathead catfish in rivers has been reported to vary with the size of the flathead catfish (Brown and Dendy, 1961), with availability of forage fish (Langemeier, 1965), or relative abundance of forage fish and invertebrates (Minckley and Deacon, 1959). Swingle (1954) tentatively included only 406 mm (16-inch) and larger flathead catfish in the piscivorous "C" classification, but subsequent pond experiments (Swingle, 1967) indicated all flathead catfish should be included in the "C" group for population analysis.

Because of their piscivorous food habits, flathead catfish have been used experimentally for thinning stunted forage fish in small Texas lakes and hatchery ponds (Dietz, 1962). The results of these experiments were inconclusive. When stocked with pond populations of stunted black bullheads (Ictalurus melas) in Nebraska, flathead catfish preyed on bullheads of all sizes (Kendle, 1970). Experiments by Hackney (1966) and Swingle (1967) indicated that flathead catfish were not well suited for introduction into Alabama ponds.

Knowledge of flathead catfish food habits in reservoirs is limited to observations by Clemens (1954) on six flathead catfish. The absence of information on the food habits of flathead catfish in reservoirs stimulated the initiation of this study.

The objectives of the study were to describe the seasonal food habits of mainly adult fish (> 480 mm) from six Oklahoma reservoirs (Carl Blackwell, Eufaula, Ft. Gibson, Grand, Hudson, and Texoma) and to describe the food habits of juvenile flathead catfish (< 400 mm) from Lake Carl Blackwell. It was hoped that the information gained during this study would help answer a number of management questions pertinent to the flathead catfish and the waters it inhabits. These questions include: (1) whether the flathead catfish feeds heavily on game fishes, (2) whether the flathead catfish is a predator on mainly rough fishes, and (3) whether it is valuable for management of reservoir fisheries to classify the flathead catfish as a game or commercial species.

# CHAPTER II

# DESCRIPTION OF THE STUDY AREA

## Lake Carl Blackwell

Lake Carl Blackwell (Figure 1) has a surface area of approximately 1,486 hectares (3,670 acres) and a shoreline length of 71.6 kilometers (42.5 miles) at spillway elevation (Norton, 1968). The earth-and-rockfill dam is located 11 kilometers (7 miles) west of Stillwater, Oklahoma in Section 10, Township 19N, Range 1E of Payne County. The reservoir extends westward approximately 8.5 kilometers (5.3 miles) to U.S. Highway 86. The dam on Stillwater Creek was completed in 1937. The reservoir reached maximum storage capacity of 80 million cubic meters (65,000 acre-feet) in 1945 (Norton, 1968) at the spillway elevation of 287.7 m (944.0 feet), M.S.L.

An average rainfall deficit of about 5 inches per year from 1962 through 1968 resulted in steadily decreasing water levels from 1961 to 1968 (Jearld, 1970). The average elevation of the water level during the 1967 portion of this study was about 284 m, M.S.L. By 1967 the surface area and shoreline length had been reduced by about 40% of the potential at the level of the spillway. Extensive areas of barren mud flats were exposed. The lowest water level since filling in 1945 occurred in March, 1968 at an estimated elevation of 283.4 m, M.S.L. Heavy spring runoffs in 1968 increased the lake level 1.5 m (5 ft) to 284.9 m, M.S.L. by June 1. The extensive terrestrial and semi-aquatic

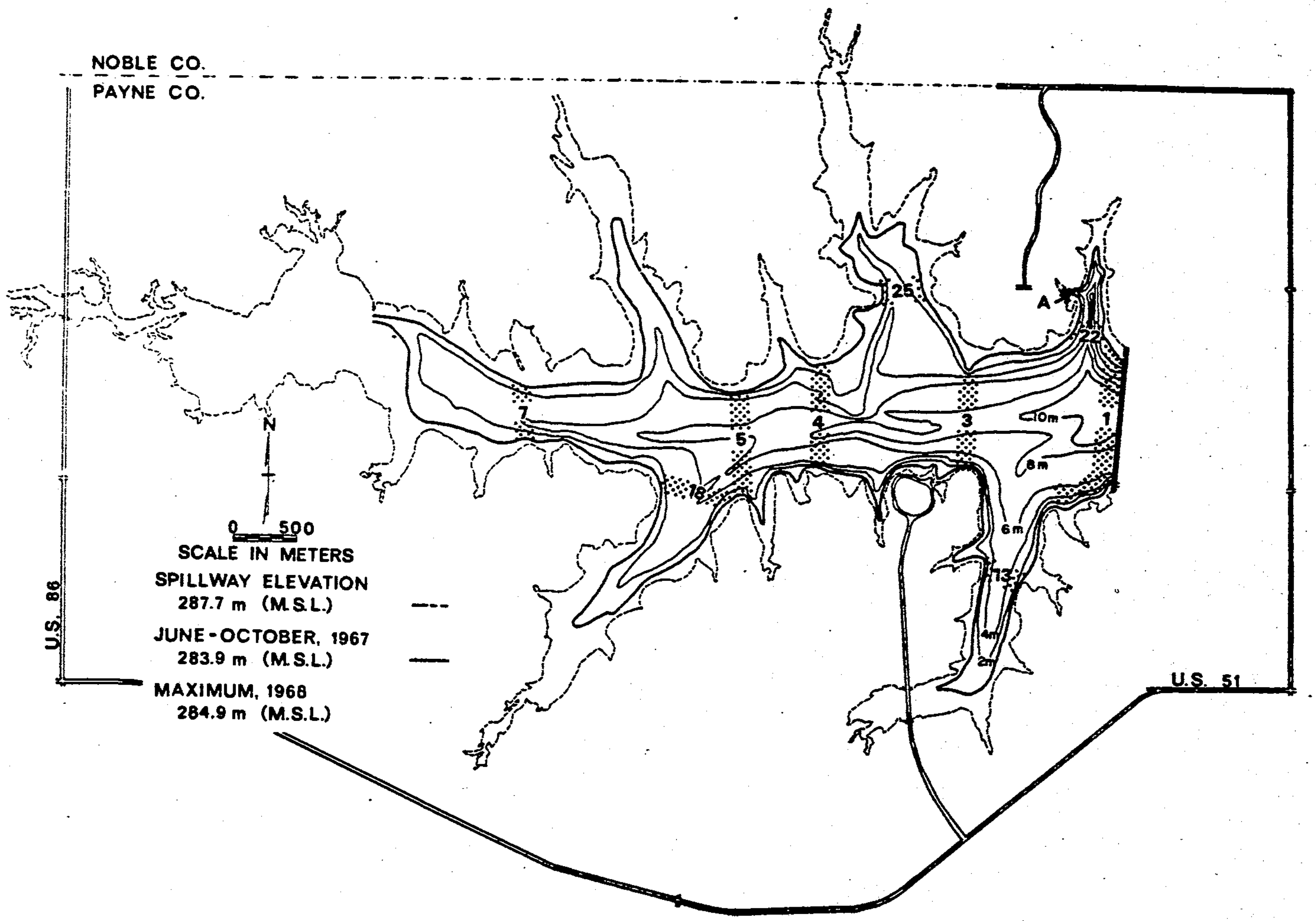


Figure 1. Lake Carl Blackwell Showing Depth Contours, Netting Areas, and a Rotenone Cove (A)

vegetation which had developed on the exposed mud flats of the western area of the reservoir and shallower coves was inundated by the rising water. As a response to the rise, the growth of young-of-the-year carp showed a definite increase in growth rate (Mauck, 1970).

The reservoir watershed is contained within the Redbeds Plains physiographic region and has soils derived from Permian clays and shale. The gently rolling hills surrounding Lake Carl Blackwell are partially wooded and have well-developed pastures of native grasses. The majority of the land in the vicinity of the reservoir is owned and operated by Oklahoma State University. The university maintains the land between the two major southern coves of the lake as a recreational facility, catering mainly to fishing and other water-based activities. Much of the remaining university land is leased for grazing. The privately-owned land in the watershed is also used mainly for grazing with a small amount of wheat and sorgum farming. Despite the lack of extensive farming in the watershed, the runoff of the intermittent Stillwater Creek and its tributaries is highly turbid. Following any major runoff, the western portions of the lake become quite turbid and water transparency often decreases to 10 cm or less. A maximum Secchi disc transparency of 117 cm was observed, but transparencies seldom exceeded 50 cm except for areas near the dam. Turbidity measurements in Jackson units ranged from a minimum of 20 during calm periods to a maximum of 180 in western end of the reservoir during periods of high wave action (Norton, 1968).

The relatively low, unprotected shoreline, shallow depth, and orientation of the main reservoir and its southern coves allow extensive vertical and horizontal water circulation due to wind-driven wave action. When wind intensity is sufficient, the wave-generated circulation causes relatively uniform vertical water temperature and dissolved oxygen over most of the reservoir. Thermal stratification and its associated oxygen depletion occurs only during irregular periods during the summer months when conditions of high ambient temperature and decreased wind velocity coincide. Stratification is mainly restricted to the main pool near the dam and to the original stream channels of the middle reservoir and major coves.

Average depth of the reservoir at spillway elevation is 5.4 m (17.7 ft). The two meter depth contours in Figure 1 give an indication of the relative depth of the sampling areas. However, these contours are drawn with respect to the low water levels in 1967 and represent the minimum depths observed during this study. In addition, water depths in the original stream channels of the upper reservoir and major coves are up to one meter deeper in some locations than indicated by Figure 1. The 1.5 m rise in water level during the spring of 1968 increased the surface area and shoreline length of the reservoir by a substantial but unknown amount. The reservoir had a maximum water depth of about 12 m near the dam during the summer of 1968.

Sampling area 1 (Figure 1) has a gradually sloping bottom composed of fine silt and clays in deeper water and sands and coarse silts in shallower areas (Norton, 1968). This distribution of bottom particles is characteristic of the entire reservoir. The southern part of area 1 has an extremely rocky shoreline with many large submerged boulders. The protected places beneath and between these boulders are probably used as spawning sites by flathead catfish. Hand fishing in these places was an effective method of taking adult flathead catfish from late June into August.

Area 22 was situated across the mouth of a relatively small, narrow cove which was bisected by a deep channel. The sandy bottom of the gently sloping western shore was in contrast to the rockier bottom and steeper slope of the eastern shore. Area 13 did not have a noticeable stream channel, but the water depth dropped off abruptly near the very rocky shores. Areas 3, 4, 5, and 7 were characterized by gently sloping mud or sand flats near their northern shores. In contrast, their southern shores were steeper and sandier with some areas of gravel and broken sandstone shelf rock.

The bottom of sampling areas 7, 13, 22, and 25 had a few small submerged trees and stumps. Areas 4 and 5 were in or near a large forest of partially submerged trees. Netting was restricted to the borders or clearer areas of this submerged forest. Sampling areas 18 and 25 were across portions of two relatively shallow coves. Area 18 had a number of partially submerged trees near the stream channel which bordered its southern extremity. By contrast, area 25 had no discernible channel and only a few submerged snags.

Periodic rotenone cove-samples were made on a 1.3 acre portion of Area A (Figure 1) having an average depth of about 2 m. The cove is narrow and steep-sided with rock outcroppings in the upper end. Because of the cove's orientation and morphology, it is well-protected from wave action which affects much of the lake.

The following ecological studies of Lake Carl Blackwell have been concerned with: limnological features and successional changes (Leonard, 1950); depth distribution of fish populations as related to temperature (Loomis, 1951); effects of water fluctuations on higher plants (DeGruchy, 1952); effects of turbidity on bottom fauna (Hambric, 1953); causes of stunting of the crappies, *Pomoxis nigromaculatus* and *P. annularis* (Crawley, 1954); productivity as related to turbidity, light penetration, and plankton populations (Claffey, 1955); abundance and number of algal species (Cooper, 1965); sediment characteristics and macroinvertebrate-substrate relationships (Norton, 1968); occurrence and distribution of helminth parasites of fishes (Spall, 1968); and the life histories of the channel catfish (Jearld, 1970) and carp (Mauck, 1970).

## Riverine Reservoirs

Grand, Hudson, and Ft. Gibson Reservoirs are multi-purpose reservoirs located in northeastern Oklahoma on the Grand (Neosho) River (Figure 2). Grand Lake, the uppermost, has a surface area of 59,000 acres. Lake Hudson (Markham Ferry) is a 10,400-acre main stream reservoir directly below Grand Lake. Ft. Gibson Reservoir is a 19,100-acre mainstream reservoir below Lake Hudson.

Lake Eufaula, a 102,500-acre multi-purpose reservoir, was formed by impounding the Deep Fork, North Canadian, and Canadian Rivers in east-central Oklahoma. It has the largest surface acreage of Oklahoma reservoirs. Lake Texoma is a 93,080-acre multi-purpose reservoir located on the Red River.

Additional morphometric data are given in Table I. Age, surface area, and total dissolved solids are from Summerfelt, Mauck, and Mensinger (1971). These authors also give shoreline development index, morphoedaphic index, and total standing crop of fish. The percentage

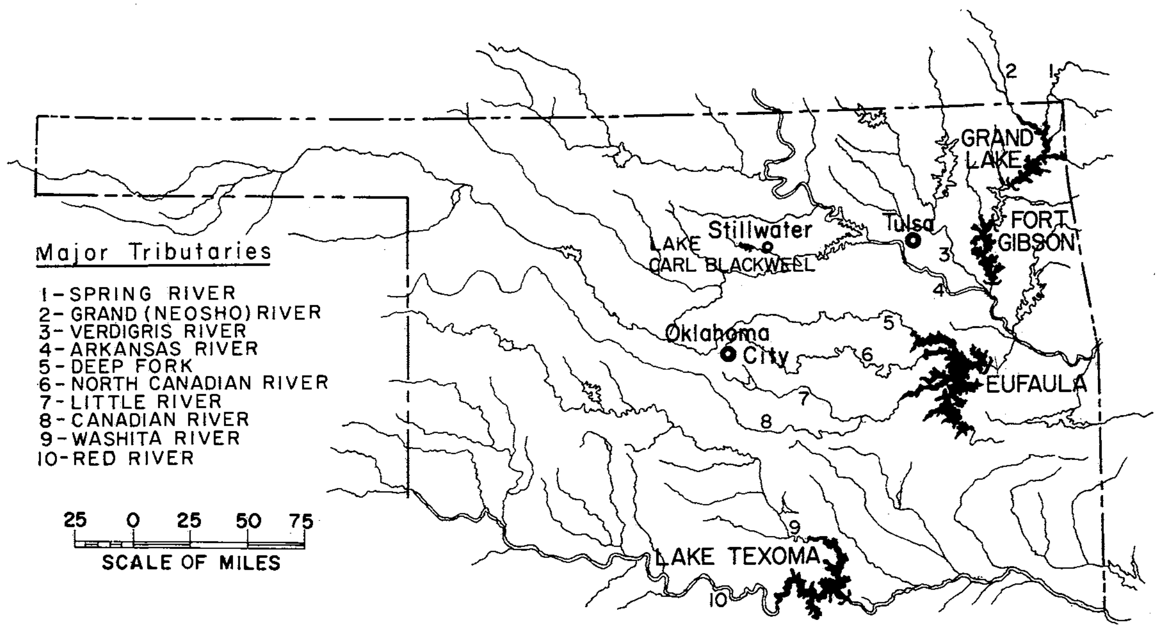


Figure 2. Location of Oklahoma Reservoirs where Flathead Catfish Were Collected for Food Habits Analysis

TABLE I

CHARACTERISTICS OF THE OKALHOMA RESERVOIRS WHERE FLATHEAD CATFISH WERE COLLECTED

| Reservoir | Age in 1967 | Surface area (acres) | Shoreline length (miles) | Normal storage (acre-ft) | Maximum storage (acre-ft) | Total dissolved solids | Flathead catfish as percentage of commercial catch |
|---|---|---|---|---|---|---|---|
| Carl Blackwell | 30 | 3,670 | 42.5 | -- | 65,000 | 337 | -- |
| Eufaula | 2 | 102,500 | 600 | 2,378,000 | 3,848,000 | 225 | 50.8 |
| Ft. Gibson | 14 | 19,100 | 225 | 365,200 | 1,284,400 | 165 | 13.9 |
| Grand | 26 | 59,000 | 1300 | 1,653,000 | 2,175,000 | 178 | 13.3 |
| Texoma | 30 | 93,080 | 580 | 2,722,000 | 5,382,000 | 840 | 2.4 |

of the commercial catch contributed by flathead catfish in the different reservoirs was reported by Parrack, Brown, and Mensinger (1970). Other morphometric data in Table I was listed by Oklahoma Water Resources Board (1965).

## CHAPTER III

## METHODS AND MATERIALS

### Lake Carl Blackwell Collection Methods

Flathead catfish from Lake Carl Blackwell were collected from July, 1967 through August, 1968. Specimens $>$ 400 mm were collected by experimental gill nets fished in the netting areas indicated in Figure 1, but a few were obtained by the use of electrofishing gear, barrel traps, snag lines, and rotenone cove samples. Flathead catfish less than 400 mm were collected exclusively by electrofishing and rotenone.

Collection gear was very selective as to size of fish obtained. Mesh size of the gill nets strongly influenced the range and average length of the flathead catfish collected. Although less selective than gill nets, electrofishing and rotenone were definitely more selective for fish $<$ 400 mm. This selectivity could probably be attributed to distributional and behaviorial differences between size classes rather than the failure of a specific gear to capture all sizes present.

#### Gill Netting

Approximately one-sixth of the flathead catfish caught in gill nets were captured in 45.7 m (150 ft), gill nets containing one 15.2 m (50 ft) by 1.2 m (4 ft) section each of 25 mm (1-inch), 51 mm (2-inch), and 76 mm (3-inch) square mesh. The latter mesh was the most effective in collecting flathead catfish as only a few were taken in the 51 mm mesh. All gill nets were anchored to the bottom and were normally set at a right angle to the shoreline or submerged stream channels.

Starting in August, 1967 gill nets similar to nets described by Heard (1959) were used to collect flathead catfish of larger sizes. These nets were 45.7 m in length and contained three sections each 15.2 m by 2.4 m (8 ft) tied down to 1.8 m (6 ft). There were three sections composed either of 76 mm (3-inch), 89 mm (3½-inch), or 101 mm (4-inch) square mesh in each net. In addition, 61.0 m (200 ft) and 91.4 m (300 ft) gill nets of only one mesh size (either 89, 101, or 127 mm square mesh) were used. These nets were fished 268.5 net-days (91.4 m of net fished 24 hours) and collected 352 flathead catfish. The overall catch rate was 1.31 flathead catfish per net-day. The average total length of flathead catfish caught in 51, 76, 89, 101, and 127 mm square mesh was 491, 606, 672, 740, and 847 mm, respectively. The average total length and weight of the 352 flathead catfish collected by the larger mesh (76 to 127 mm) gill nets was 697 mm (27.5 inches) and 5.24 kg (10.6 lb).

## Electrofishing

Twenty flathead catfish were collected by the use of electric fishing gear. All but four fish were within the 200-400 mm size range. Most fish collected by electrofishing were obtained during the course of other investigations. Although no systematic effort was made to capture flathead catfish by shoreline electrofishing, only 15 flathead catfish were obtained in 1968 by intensive electrofishing around the entire shoreline of Lake Carl Blackwell by Paul Zweiacher for the purpose of mark-and-recapture of largemouth bass.

### Rotenone Samples

Periodic rotenone cove-samples were made on a 1.3 acre portion of Area A (Figure 1) having an average depth of over 2 m. Samples were taken in July and October of 1967 and in January, March, May, June, and August of 1968. Ten flathead catfish ranging from 37 to 591 mm were collected in the summer and fall samples. Only two of the ten fish were greater than 200 mm in length.

### Other Collection Methods

Flathead catfish were also collected by collapsible barrel traps, wire traps, and snag lines. On only one occasion were flathead catfish collected in the barrel traps; however, six fish ranging from 458 to 826 mm were taken at this time. One flathead catfish was collected by wire traps 92 cm in length by 42 cm in diameter. Nine flathead catfish alimentary tracts were obtained from a local snag line fisherman.

## Collection Methods in Riverine Reservoirs

The food of flathead catfish living in riverine reservoirs was examined as one segment of a larger study on food habits of eight commercial fish species. A discussion of methods used in collecting fish stomachs from commercial fishermen and descriptions of the sampled reservoirs has been given by Summerfelt, Mauck, and Mensinger (1971). A survey of seasonal characteristics and annual harvest of Oklahoma's commercial fishery was made during the food habits study (Parrack, Brown and Mensinger, 1970). Fish utilized in the present study were collected by commercial fishermen who used gill and trammel nets. Flathead catfish were collected from July, 1967 through August, 1968.

Changes in the time interval between net raises was examined for the commercial fishermen of Lake Texoma (Parrack, Brown, and Mensinger, 1970). The time interval between net raises averaged 1.1 to 1.2 days for July, August, and September of 1967. The interval between raises increased during the autumn months and was 2.1 to 2.2 days from December, 1967 through March, 1968. The interval between net raises was 1.5 days in April and had decreased to 1.2 days by June. The time interval between net raises seemed to be related to water temperature and was probably related to greater mortalities of netted fish at greater water temperatures. Water temperatures in the riverine reservoirs averaged 20 to 25 C from June through September of 1967 and 5 to 10 C from November, 1967 through March, 1968.

Numbers of flathead catfish alimentary tracts collected in a month from a single reservoir varied from 0 to 100 (Table II). Very few flathead catfish were caught during the winter months. Commercial fishermen at Lake Hudson (Markham Ferry), a 10,400-acre mainstream reservoir between Grand and Fort Gibson Reservoirs, stopped collecting alimentary tracts after October. A total of 1,181 alimentary tracts were purchased from commercial fishermen and subsequently examined.

Mean total lengths of flathead catfish collected by commercial fishermen were 647 mm (25.5 inches) Lake Texoma; 597 mm (23.5 inches) Grand Lake; 647 mm (25.5 inches) Eufaula Reservoir; 595 mm (23.4 inches) Ft. Gibson Reservoir. There was no significant differences in mean size of flathead catfish caught in different quarters of the year

TABLE II

NUMBER OF FLATHEAD CATFISH STOMACHS EXAMINED JULY, 1967-AUGUST, 1968 FROM SIX OKLAHOMA RESERVOIRS

| Month | Carl Blackwell | Eufaula | Ft. Gibson | Grand | Hudson | Texoma | Total |
|---|---|---|---|---|---|---|---|
| 1967 | | | | | | | |
| July | 4 | 18 | 14 | - | - | 7 | 39 |
| Aug. | 4 | - | 17 | - | - | - | 17 |
| Sep. | 1 | 17 | 49 | 30 | 25 | 7 | 128 |
| Oct. | 2 | 13 | 53 | 104 | 16 | 16 | 202 |
| Nov. | - | 21 | 34 | 27 | - | 20 | 102 |
| Dec. | 2 | 5 | 25 | 4 | - | - | 34 |
| 1968 | | | | | | | |
| Jan. | - | 15 | - | 9 | - | - | 24 |
| Feb. | 3 | 6 | - | 16 | - | 1 | 23 |
| Mar. | 11 | 25 | 6 | 3 | - | 1 | 46 |
| Apr. | 18 | 28 | - | - | - | 3 | 49 |
| May | 42 | 100 | 50 | 32 | - | 12 | 236 |
| June | 26 | 64 | 7 | 23 | - | 10 | 130 |
| July | 17 | 67 | - | 50 | - | 2 | 136 |
| Aug. | 18 | 53 | - | 40 | - | 15 | 126 |
| Total | 148 | 453[1] | 255 | 338 | 41 | 94 | 1,329 |

[1]This total includes one sample of 21 stomachs for which the month was unknown.

from these four riverine reservoirs. Oklahoma's commercial fishermen were restricted by law to mesh sizes of not less than 76 mm square which maintained a uniform lower limit to mesh size. In Lake Carl Blackwell 84 of 85 flathead catfish collected in 76 mm mesh were greater than 500 mm in length. The smallest flathead catfish caught by commercial fishermen was probably about 480 mm. Assuming that flathead catfish in the riverine reservoirs mature at similar sizes as those in Lake Carl Blackwell, all males and the majority of females examined were sexually mature.

## Laboratory Methods

### Lake Carl Blackwell

The total length and the weight of the flathead catfish from Lake Carl Blackwell were usually determined immediately after capture. The fish was measured on its side. The maximum distance from the anterior part of the lower jaw to the posterior tip of the caudal fin (generally in the dorsal half) was measured to the nearest millimeter with a measuring board. Depending on size, each fish was weighed to the nearest ounce, gram, or 0.1 gram.

Stomachs of flathead catfish collected by gill netting, electrofishing, and rotenone were examined for food. Stomachs of fish captured by gill nets were examined only if the nets had been checked within 24 hours. All 148 flathead catfish (> 480 mm) used for food habits analysis were collected by gill nets.

The fish were brought back to the laboratory for processing as soon as possible. If the fish could not be autopsied within two to three hours, they were frozen or refrigerated until examined. The stomach contents of most fish were identified and tabulated immediately after removal. The stomachs requiring examination under a dissecting microscope, mainly fish $<$ 400 mm, were placed in jars containing 20% formalin. The intestinal contents were also examined to aid in identification of deteriorated food items found in the stomachs, but were not included in the tabulations. For example, the otoliths of freshwater drum (*Aplodinotus grunniens*) or gizzards of shad (*Dorosoma* sp.) were used occasionally to identify fish remains in the stomach.

After identification, the number and total volume of each type of food item was determined. Total volume of each type of food was estimated by water displacement to the nearest milliliter or 0.1 ml in graduated cylinders for most items. The volume was determined to the nearest 0.01 ml in graduated centrifuge tubes for smaller items. The standard length of undigested forage fish was estimated to the nearest millimeter.

In Lake Carl Blackwell flathead catfish were grouped into three size groups for food habits analysis. The groups were fish $<$ 110 mm, fish 170-400 mm, and fish $>$ 480 mm. Fish from the latter category were further divided into monthly samples for fish collected from March through August, 1968. The per cent frequency of occurrence, percentage of numerical occurrence, and percentage of the total food volume were calculated for each type of food item following the methods of Lagler (1956). All three methods of describing food habits were calculated for the samples of fish in the three size groups and for each monthly sample of fish $>$ 480 mm. The average standard length of each species of forage fish was calculated for flathead catfish $>$ 480 mm.

Riverine Reservoirs

Commercial fishermen placed entire alimentary tracts into cotton soil-sample bags (178 by 267 mm or 254 by 432 mm). The bags were placed in a 5-gallon can containing 5 or 10% formalin. The commercial fishermen were given 20 cents for each alimentary tract collected. Samples were collected monthly from commercial fishermen by personnel of the Oklahoma Department of Wildlife Conservation. Analyses were made of individual stomach contents which were identified, counted, and recorded as described for Lake Carl Blackwell. Intestinal contents were examined to aid in the identification of partially digested forage fish in the stomachs. Items found in the intestines were not used in the numerical or volumetric analyses.

Percentage frequency of occurrence, percentage numerical occurrence and percentage total volume were calculated for each monthly sample from each reservoir. Standard lengths (S.L.) of undigested forage fish were measured to the nearest millimeter. Standard lengths of gizzard shad (Dorosoma cepedianum) in which the skull had disarticulated were derived from measurements on length of the vertebral column. The length of vertebral column was measured from the first vertera to the posterior tip of the hypurals. Gizzard shad vertebral lengths (V.L.) were converted to standard length from the empirical equation: S.L. = 1.2 V.L. This conversion factor was determined by measuring both S.L. and V.L. on 53 intact gizzard shad which were 71 to 193 mm (S.L.).

## CHAPTER IV

## RESULTS

### Food Habits of Fish > 480 MM

Organic and inorganic debris, fish, and invertebrates were found in the stomachs of 50.8% (675) of 1,329 flathead catfish > 480 mm. Forty-seven per cent of all flathead stomachs contained fish or invertebrates. An additional 3.8% of the stomachs contained various types of debris (mud, sand, gravel, and pieces of wood and leaves), and 49.2% were empty except for a few scales. The percentage of stomachs with fish or invertebrates (47.0%) was less than percentages reported for river populations of flathead catfish collected with electric fishing gear in Kansas (Minckley and Deacon, 1959) and Nebraska (Langemeier, 1965), but exceeded that reported in Alabama (Brown and Dendy, 1961). The majority of the fish examined in these earlier studies were less than 480 mm.

#### Inter-Reservoir Comparisons

Food habit characteristics were compared for flathead catfish (> 480 mm) collected from Carl Blackwell, Eufaula, Ft. Gibson, Grand, Hudson, and Texoma Reservoirs (Table III). Percentages of flathead catfish stomachs containing food items ranged from 33.8% at Lake Carl Blackwell to 56.1% at Lake Hudson (Markham Ferry). Flathead catfish stomachs from Lake Carl Blackwell were examined only if the net had

TABLE III

VARIATION IN COMPOSITION OF STOMACH CONTENTS OF FLATHEAD CATFISH COLLECTED IN SIX OKLAHOMA RESERVOIRS

| Item | Percentages of Total Volume | | | | | |
|---|---|---|---|---|---|---|
| | Carl Blackwell | Eufaula | Ft. Gibson | Grand | Hudson | Texoma |
| Gizzard shad | 49.5 | 50.7 | 60.7 | 91.7 | 50.4 | 55.1[1] |
| Freshwater drum | 38.2 | 12.9 | 20.4 | 4.9 | 3.3 | 33.6 |
| Carp | - | 23.2 | - | - | 42.0 | - |
| Channel catfish | 4.7 | - | 13.8 | 1.8 | 1.6 | - |
| Bullhead (Ictalurus spp.) | - | Tr[2] | Tr | - | - | - |
| Flathead catfish | - | - | - | 0.1 | - | - |
| Largemouth bass | - | - | - | - | - | 2.1 |
| Bluegill | 5.1 | 1.4 | - | - | - | - |
| Sunfish (Lepomis spp.) | - | 3.1 | - | - | - | 3.9 |
| White crappie | - | 5.1 | - | - | - | - |
| Unidentified Centrarchidae | 0.3 | 0.4 | - | - | - | 0.1 |
| White bass | 0.4 | - | - | - | - | - |
| Darter (Percina spp.) | - | - | - | - | - | 0.5 |
| Unidentified fish remains | 1.0 | 2.6 | 3.5 | 1.3 | 2.3 | 3.5 |
| Total of all fish | 99.2 | 99.4 | 98.4 | 99.8 | 99.6 | 98.7 |
| Decapoda | - | 0.3 | 0.6 | Tr | - | - |
| Ephemeroptera (Hexagenia spp.) | - | - | Tr | Tr | - | - |
| Detritus | 0.7 | 0.2 | 0.6 | 0.2 | 0.4 | 1.3 |
| Plant remains | 0.1 | Tr | 0.2 | - | - | Tr |
| No. stomachs examined | 148 | 453 | 255 | 338 | 41 | 94 |
| Percentage of stomachs with $\geq$ 0.1 ml of contents | 33.8 | 46.6 | 44.3 | 54.7 | 56.1 | 45.7 |
| Avg. vol. (ml)[3] | 29.7 | 23.9 | 11.3 | 37.4 | 25.4 | 34.2 |
| Avg. no. of items[3] | 2.0 | 1.7 | 1.4 | 1.4 | 1.3 | 1.6 |

[1]Sixteen of twenty shad were identified as D. cepedianum.

[2]Trace (Tr) indicates volumes less than 0.1 per cent.

[3]In stomachs containing food.

been previously raised within 24 hours. If increasing time interval between net raises would increase the percentage of empty stomachs, as expected, the cooperating commercial fishermen apparently raised their nets on a similar frequency as in Lake Carl Blackwell. Commercial fishermen seem to be a desirable source for obtaining large numbers of flathead catfish stomachs for food habits analysis.

Average volume of food in stomachs containing $\geq$ .1 ml food ranged from 23.9 to 37.4 ml, with the exception of the samples from Ft. Gibson Reservoir (Table III). The 11.3 ml average volume per stomach in Ft. Gibson Reservoir may have resulted from a greater time interval between net raises or smaller average size of the forage. Unidentified fish remains in flathead catfish stomachs had greatest volumetric and numerical importance in Ft. Gibson and Texoma Reservoirs. Average volumes of flathead catfish stomach contents from Grand Lake (37.4 ml) and Lake Texoma (34.2 ml) were three times greater than those found in Ft. Gibson Reservoir, suggesting greater time intervals between net raises in Ft. Gibson Reservoir. This confirms the conclusion by Summerfelt, Mauck, and Mensinger (1971) regarding the condition of carp alimentary tract contents from Ft. Gibson.

Average number of food items found in stomachs with food ranged from 1.3 (Lake Hudson) to 2.0 (Lake Carl Blackwell). Only one item was found in the stomachs of most flathead catfish. The maximum number of food items per stomach was observed in a flathead catfish stomach collected in December from Lake Eufaula which contained 12 small gizzard shad. Eleven gizzard shad were found in a single stomach collected in December from Grand Lake. Stomachs with more than five forage fish always contained small or young-of-the-year gizzard shad.

Types of Food Organisms

Fish comprised from 98.4 to 99.8% of the total volume of stomach contents (Table III) and 95.5 to 100.0% of the total number of food items in stomachs of flathead catfish in the six reservoirs. Crayfish (Decapoda) were found in flathead catfish stomachs from Eufaula, Fort Gibson, and Grand Reservoirs, but contributed $< 1.0\%$ of the total volume or $<1.0\%$ of the total number of items in flathead catfish stomachs in these reservoirs. Ephemeroptera (Hexagenia spp.) comprised 0.6 and 4.2% of the total number of food items in Ft. Gibson and Grand Reservoirs, respectively, although on a volume basis they constituted $< 0.1\%$. Percentages of total food volume and percentages of numerical occurrence of the major forage fish species were compared for the six reservoirs (Figure 3). Per cent frequency of occurrence differed only slightly from percentages of numerical occurrence. Percentages of numerical occurrence for gizzard shad and Hexagenia sp. were usually greater or about equal to per cent frequency of occurrence. Most other food organisms had slightly greater per cent frequency of occurrence than percentage of numerical occurrence.

Gizzard Shad. Gizzard shad were the most important forage species in all six reservoirs in both percentage of total food volume and percentage of the total number of food items (Figure 3). Although threadfin shad (Dorosoma petenense) were common in Lake Texoma, only gizzard shad were identified to species in flathead catfish stomachs. The four shad identified only to genus may have been threadfin shad, but based on the stomachs examined from Lake Texoma with only gizzard shad, the threadfin shad was not an important forage species. Threadfin shad are

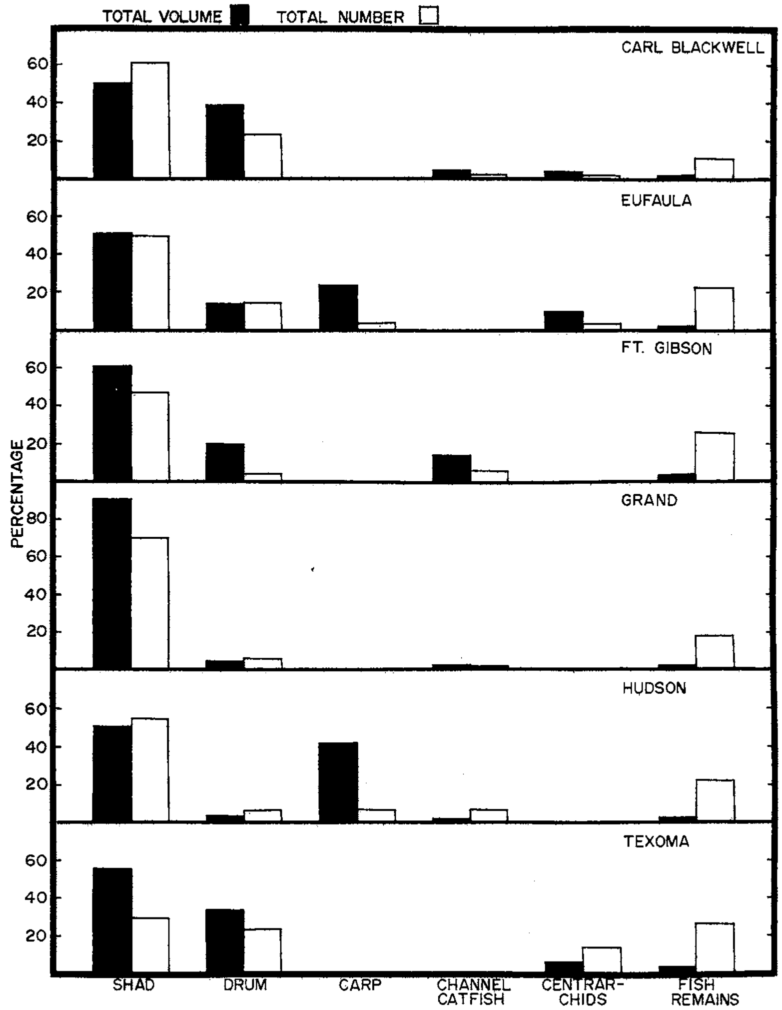


Figure 3. Percentages of Stomach Volume and Number of Food Items Which Forage Fish Comprised of the Total Volume and Number of Food Items in Flathead Catfish Stomachs From Six Oklahoma Reservoirs

apparently epipelagic in distribution and are much less common near the reservoir bottom than gizzard shad. This difference in the distribution of the two prey species probably accounts for the abundance of gizzard shad and scarcity of threadfin shad in stomachs from Lake Texoma where both shad species are abundant. Also, gizzard shad are reported to feed more extensively on bottom organisms as they grow older (Cross, 1967). This would apparently make older gizzard shad more available to the bottom-dwelling flathead catfish.

Gizzard shad comprised at least 49.5% by volume of the total stomach contents of flathead catfish in all six reservoirs. In Grand Lake gizzard shad comprised 91.7% of the total food volume and 70.1% of the total number of food items. Numerical occurrence (60.4%) of gizzard shad exceeded percentage of total food volume (49.5%) only in flathead catfish stomachs from Lake Carl Blackwell.

Freshwater Drum. The freshwater drum ranked second in percentage of total food volume in flathead catfish stomachs from Ft. Gibson (20.4%), Texoma (33.6%), and Carl Blackwell (38.2%). In Lake Eufaula, freshwater drum ranked third in percentage of total food volume (12.9%), but second in numerical occurrence (14.3%). Percentage of numerical occurrence was less for freshwater drum than percentage of total food volume in all reservoirs. Generally, only a single drum occurred in an individual flathead catfish stomach, but on a few occasions two or three specimens were found. The bottom-feeding characteristics of yearling and adult drum (Swedberg, 1968) probably accounted for their abundance in the stomachs of the bottom-dwelling flathead catfish.

Importance of the freshwater drum in stomachs of flathead catfish from Lake Carl Blackwell coincided with the abundance of freshwater drum in the 25 mm (1-inch) mesh of experimental gill nets which caught gizzard shad and freshwater drum of the same size as those found in flathead catfish stomachs. The distribution of freshwater drum and gizzard shad in gill net catches in Lake Carl Blackwell was positively correlated with catch rates of flathead catfish (Summerfelt, 1971).

Carp. Carp (*Cyprinus carpio*) were found in flathead catfish from Eufaula and Hudson Reservoirs where they made up 23.2 and 42.0% of the total food volume, respectively. The numerical occurrence of carp was less than 7% in both reservoirs because of their large average size.

Channel Catfish. Channel catfish (*Ictalurus punctatus*) comprised 4.7 and 13.8% of total food volume in Carl Blackwell and Ft. Gibson Reservoirs, respectively. They contributed less than 2% to the total volume of stomach contents in Grand and Hudson Reservoirs. The abundance of channel catfish in flathead catfish stomachs from Carl Blackwell and Ft. Gibson Reservoirs compared to the other reservoirs was apparently related to a dense population of channel catfish. Channel catfish composed 18.1% of the gill net catch by commercial fishermen in Ft. Gibson Reservoir (Parrack, Brown, and Mensinger, 1970) and extensive gill netting indicated a large population of small channel catfish in Lake Carl Blackwell.

Centrarchids. Centrarchids comprised 5.4, 10.0, and 6.1% of the total stomach volumes in flathead catfish from Carl Blackwell, Eufaula, and Texoma Reservoirs, respectively. Percentage numerical occurrences in Lake Carl Blackwell (3.0%) and Eufaula Reservoir (3.9%) were less than percentage total volume. Young-of-the-year largemouth bass and sunfish (*Lepomis* sp.) found in flathead stomachs in Lake Texoma contributed to a greater numerical occurrence (13.2%) of centrarchids than found in other reservoirs. Two white crappie (Pomoxis annularis) from Lake Eufaula samples were the only harvestable centrarchids found in flathead catfish stomachs during this study.

Although commercial netting in the five riverine reservoirs was restricted to water at least 100 yards from shore, netting in Lake Carl Blackwell was limited only to water depths of at least ten feet to avoid conflicts with boaters. This allowed netting much closer to shore and may have accounted for the larger number of bluegill (Lepomis macrochirus) found in flathead catfish stomachs in this reservoir. Bluegill were found to be more common in cove samples than open water samples in an evaluation of rotenone sampling at Douglas Reservoir, Tennessee (Hayne, Hall, and Nichols, 1967). The 100 yard limit on commercial netting would eliminate many smaller coves from being fished by commercial fishing, therefore, the bluegill would probably be consumed less frequently by flathead catfish caught in open water areas.

Miscellaneous Species. Other forage fish found in flathead stomachs included a single flathead catfish from Grand Lake and six Percina sp. from Texoma Reservoir. Several bullhead (Ictalurus spp.) and channel catfish spines, identified according to techniques described by Paloumpis (1963), were found imbedded in the stomach wall or mesenteries of flathead catfish. An adult river carpsucker (Carpiodes carpio) was observed in a flathead catfish stomach from Lake Carl Blackwell after the defined collection period for this study.

Size of Forage Fish

Average standard length and range in length of each taxon of forage fish was determined for the combined samples (Table IV). Gizzard shad were classified as either young-of-the-year (considered age I after December 31) or older. Young-of-the-year gizzard shad averaged 66 mm, while older gizzard shad had an average standard length of 147 mm. Although young-of-the-year freshwater drum, channel catfish, and sunfish (Lepomis sp.) were found in stomachs of flathead catfish, they occurred in small numbers and were not classified separately.

Average standard lengths of freshwater drum, carp, and channel catfish were 142, 231, and 134 mm, respectively (Table IV). Three bluegills and two white crappies averaged 119 and 188 mm, respectively. The only largemouth bass identified were young-of-the-year from Lake Texoma (average length 84 mm).

Two white crappie from Lake Eufaula and a partially digested channel catfish from Grand Lake were the only game fish of harvestable size found among 718 fish identified during this study. Several specimens of partially digested carp found in stomachs from Lake Eufaula probably exceeded 360 mm (S.L.).

Ranges in average standard length for young-of-the-year and age I and older gizzard shad occurring in flathead catfish stomachs were 58 to 76 mm and 132 to 165 mm, respectively (Table V). Adult shad in stomachs of flathead catfish from the two older riverine reservoirs, Grand and Texoma, averaged 165 mm. Adult shad in stomachs from the 2-year-old Lake Eufaula and Lake Carl Blackwell averaged 132 mm. Average lengths of freshwater drum in stomachs of flathead catfish were generally similar for the reservoirs with sample sizes > 5 fish

TABLE IV

STANDARD LENGTH (MM) OF MEASURABLE FORAGE FISH CONSUMED BY FLATHEAD CATFISH FROM SIX OKLAHOMA RESERVOIRS

| Forage Fish | Number Measured | Average S.L. | Range in S.L. |
|---|---|---|---|
| Gizzard shad (*Dorosoma cepedianum*) | | | |
| Age I and older | 276 | 147 | 63-249 |
| Young-of-the-year | 107 | 66 | 35- 96 |
| Freshwater drum (*Aplodinotus grunniens*) | 53 | 142 | 35-322 |
| Carp (*Cyprinus carpio*) | 5 | 231 | 211-266 |
| Channel catfish (*Ictalurus punctatus*) | 7 | 134 | 35-193 |
| White crappie (*Pomoxis annularis*) | 2 | 188 | 165-208 |
| Bluegill sunfish (*Lepomis macrochirus*) | 3 | 119 | 101-134 |
| Sunfish (*Lepomis* spp.) | 5 | 79 | 23-139 |
| Largemouth bass (*Micropterus salmoides*) | 4 | 84 | 45-147 |
| White bass (*Morone chrysops*) | 1 | 94 | 94 |
| Darter (*Percina* spp.) | 4 | 61 | 51- 68 |
| All species combined | 467 | 127 | 23-322 |

## TABLE V

COMPARISON OF THE AVERAGE STANDARD LENGTHS (MM) OF MEASURABLE GIZZARD SHAD AND FRESHWATER DRUM CONSUMED BY FLATHEAD CATFISH > 480 MM FROM SIX OKLAHOMA RESERVOIRS

| | Gizzard shad | | | | | | Freshwater drum | | |
|---|---|---|---|---|---|---|---|---|---|
| | Young-of-the-year | | | Age I and older | | | All fish | | |
| Reservoir | No. | Avg. S.L. | Range | No. | Avg. S.L. | Range | No. | Avg. S.L. | Range |
| Carl Blackwell | 15 | 63 | 51-73 | 35 | 132 | 73-188 | 12 | 152 | 76-264 |
| Eufaula | 24 | 58 | 38-84 | 96 | 132 | 91-190 | 22 | 127 | 35-206 |
| Ft. Gibson | 21 | 76 | 35-96 | 19 | 145 | 76-183 | 3 | 165 | 114-203 |
| Grand | 40 | 68 | 51-84 | 105 | 165 | 63-203 | 8 | 132 | 58-322 |
| Hudson | 6 | 61 | 40-66 | 6 | 157 | 101-193 | 2 | 81 | 51-109 |
| Texoma | 1 | 40 | 40 | 15 | 165 | 119-249 | 8 | 150 | 68-208 |

(ranging from 127 to 152 mm). Other species occurred in stomachs in too few numbers to make meaningful comparisons between reservoirs.

## Seasonal Variation in Food Consumption

Monthly trends in feeding activity were studied by examining monthly variation in percentage of flathead catfish stomachs containing food and average food volume per stomach.

Spring and Summer Feeding Activity. In Lake Carl Blackwell, the time interval between net raises was less than 24 hours for the flathead catfish collected for food habits analysis during March through August (Table II). The average volume of food per stomach and percentage of stomachs containing food were low in March, but increased in April to their highest monthly levels (Figure 4). Percentage of stomachs with food remained high in May although average food volume per stomach decreased. The low percentage of stomachs with food and low average food volume during June and July in Lake Carl Blackwell were probably related to spawning which occurred in late July and early August. Langemeier (1965) also noted a decrease in flathead catfish feeding prior to and during the spawning period. Spawning in the riverine reservoirs occurred in June and early July (Gary Mensinger, personal communication). Therefore, the decrease in feeding activity in June observed in all reservoirs but Lake Texoma was probably related to the spawning period. Feeding activity increased in August following spawning in Lakes Carl Blackwell, Eufaula, and Grand (Figure 4). In Lake Texoma the percentage of stomachs containing food was the highest in July. However, Lake Texoma is the southernmost of the reservoirs in Oklahoma and spawning was probably over by late June.

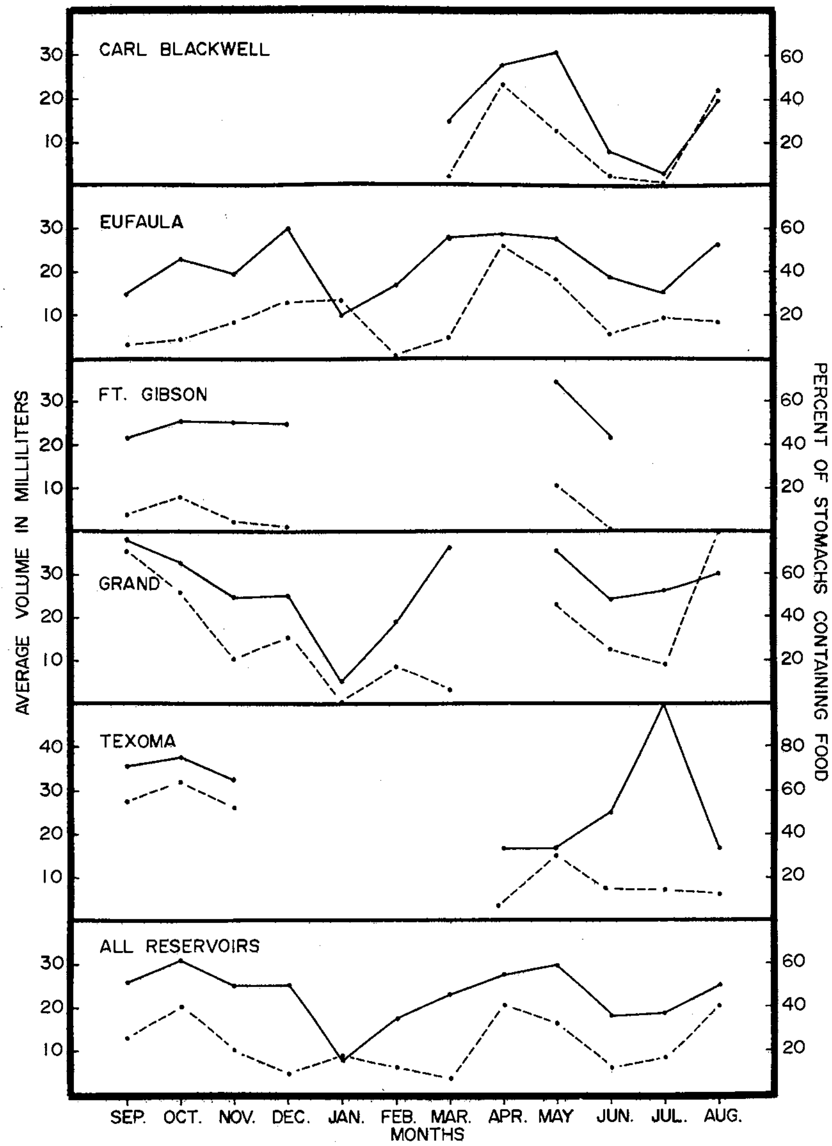


Figure 4. Monthly Variation in Average Food Volume Per Stomach (------) and Percentage of Stomachs Containing Food (———) of Flathead Catfish From Five Oklahoma Reservoirs

Fall and Winter Feeding Activity. Feeding activity in the fall and winter is known only for the riverine reservoirs as few fish were collected from Lake Carl Blackwell during these months. Average food volume per stomach and percentage of stomachs with food decreased from September, 1967 through March, 1968 in flathead catfish collected in Grand Lake (Figure 4). In Grand Lake, average food volume per stomach remained low during February and March although two of three stomachs available for examination in March contained food.

Monthly changes in the pattern of feeding activity for Lake Eufaula flathead catfish contrasted sharply with those of Grand Lake. Average food volumes and percentages of stomachs with food increased September through December, 1967. The increased average volume per stomach during December and January, 1968 was caused by large food volumes found in three of five and three of 15 stomachs, respectively. The increasing average food volume per stomach in these two months may be related more to a decrease in digestive rate than to an increase in feeding activity.

Average food volumes per stomach in Ft. Gibson Reservoir indicated a decrease in feeding activity in November and December although the percentages of stomachs with food was similar. The six stomachs examined in March were empty. Average food volumes per stomach and percentages of stomachs with food were uniformly high for flathead catfish collected in September, October, and November from Lake Texoma. However, the uniformity probably indicates a decrease in feeding activity as water temperature decreased during this period.

Seasonal Variation in Forage

Seasonal variation in composition of forage species was evaluated for all reservoirs. Lake Eufaula and Grand Lake have been emphasized in this study because samples were available for all months with the exception of April, 1968 when commercial fishing was not allowed on Grand Lake. Unfortunately, samples from winter months were usually small (Table II).

Grand Lake. There was little monthly variation in relative abundance of the various forage species in flathead catfish stomachs from Grand Lake (Table VI). Gizzard shad always contributed $> 75\%$ of total stomach volume. The freshwater drum was the only other forage species of importance, comprising from 3.0 to 20.6% of total stomach volumes in six of the 11 monthly samples. Most freshwater drum were found in stomachs collected in autumn months. *Hexagenia* spp. were found only in June and July.

The large numbers of gizzard shad found in stomachs from Grand Lake were analyzed for monthly variation in average size of both young-of-the-year and age I and older fish. Average standard lengths of age I and older gizzard shad increased from 155 to 177 mm (September through November) and from 142 to 177 mm (May through August). Young-of-the-year gizzard shad increased in size (from 56 to 75 mm) and in numeric and volumetric importance during fall months.

Lake Eufaula. Flathead catfish stomach contents from Lake Eufaula (Table VII) differed from Grand Lake stomach contents in both composition and seasonal trends. A major change in food habits occurred in the spring of 1968. Gizzard shad had been the major forage fish during the

TABLE VI

MONTHLY VARIATION IN PERCENTAGES OF TOTAL VOLUME OF STOMACH CONTENTS OF FLATHEAD CATFISH COLLECTED FROM GRAND LAKE

| Food Item | 1967 | | | | 1968 | | | | | | | Total Volume (Per Cent) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sept | Oct | Nov | Dec | Jan | Feb | Mar | May | June | July | Aug | |
| Dorosoma cepedianum | 95.4 | 87.2 | 81.8 | 100.0 | - | 75.5 | 30.6 | 90.3 | 98.5 | 89.6 | 99.9 | 91.7 |
| Aplodinotus grunniens | 3.0 | 6.1 | 16.9 | - | - | 20.6 | - | 6.2 | - | 9.4 | - | 4.9 |
| Ictalurus punctatus | - | 4.8 | - | - | - | - | - | - | - | - | - | 1.8 |
| Pylodictis olivaris | 0.5 | - | - | - | - | - | - | - | - | - | - | 0.1 |
| Unidentified fish remains | 0.7 | 1.8 | 0.9 | - | - | 1.5 | 25.5 | 3.5 | 1.0 | 0.9 | 0.1 | 1.3 |
| Fish (total) | 99.6 | 99.9 | 99.6 | 100.0 | - | 97.6 | 56.1 | 100.0 | 99.5 | 99.9 | 100.0 | 99.8 |
| Decapoda | Tr[1] | - | - | - | - | - | - | - | - | - | - | Tr |
| Ephemeroptera (Hexagenia spp.) | - | - | - | - | - | - | - | - | 0.3 | Tr | - | Tr |
| Detritus | 0.3 | 0.1 | 0.3 | - | 100.0 | 2.4 | 43.9 | - | 0.2 | - | - | 0.2 |
| No. of stomachs examined | 30 | 104 | 27 | 4 | 9 | 16 | 3 | 32 | 23 | 50 | 40 | 338 |
| Per cent empty | 23.3 | 34.6 | 51.9 | 50.0 | 88.9 | 62.5 | 33.3 | 34.4 | 52.2 | 48.0 | 40.0 | 41.7 |
| Total volume (ml) | 1059.0 | 2697.0 | 286.3 | 62.2 | 0.5 | 141.7 | 9.8 | 735.0 | 296.6 | 466.4 | 1620.5 | 7374.7 |

[1] Trace (Tr) indicates volumes less than 0.1 per cent.

TABLE VII

MONTHLY VARIATION IN PERCENTAGES OF TOTAL VOLUME OF STOMACH CONTENTS OF FLATHEAD CATFISH COLLECTED FROM LAKE EUFAULA

| Food Item | 1967 | | | | | 1968 | | | | | | | | Total Volume (Per Cent)[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July | Sept | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | June | July | Aug | |
| <u>Dorosoma cepedianum</u> | 98.7 | 92.6 | 71.9 | 99.0 | 78.0 | 99.5 | 80.0 | 34.4 | 75.3 | 40.1 | 6.4 | 35.4 | 36.9 | 50.7 |
| <u>Aplodinotus grunniens</u> | - | - | - | - | - | - | - | 46.9 | 7.2 | 7.3 | 58.5 | 1.9 | 37.7 | 12.9 |
| <u>Cyprinus carpio</u> | - | - | - | - | - | - | - | - | 11.8 | 37.5 | 4.0 | 61.6 | 9.6 | 23.2 |
| <u>Ictalurus</u> spp. (bullhead) | - | - | - | - | - | - | - | - | - | - | - | - | 0.4 | Tr[2] |
| <u>Lepomis macrochirus</u> | - | - | - | - | - | - | - | 2.3 | - | - | - | - | - | 1.4 |
| <u>Lepomis</u> spp. | - | - | - | - | - | - | - | 8.5 | - | 1.0 | 24.1 | - | 4.6 | 3.1 |
| <u>Pomoxis annularis</u> | - | - | - | - | - | - | - | - | - | 12.1 | - | - | 8.9 | 5.1 |
| Unidentified Centrarchidae | - | 3.6 | 23.3 | - | - | - | - | - | - | Tr | 1.2 | - | - | 0.4 |
| Centrarchidae (total) | - | 3.6 | 23.3 | - | - | - | - | 10.8 | - | 13.1 | 25.3 | - | 13.5 | 10.0 |
| Unidentified fish remains | 1.3 | 3.3 | 3.6 | 1.0 | 21.5 | 0.5 | - | 7.4 | 5.8 | 1.8 | 0.5 | 1.0 | 1.1 | 2.6 |
| Fish (total) | 100.0 | 99.5 | 97.8 | 100.0 | 99.5 | 100.0 | 80.0 | 99.5 | 100.0 | 99.8 | 94.7 | 99.9 | 99.2 | 99.4 |
| Decapoda | - | - | - | - | - | - | - | - | - | - | 4.9 | - | - | 0.3 |
| Plant remains | - | 0.5 | - | - | - | Tr | - | - | - | Tr | Tr | Tr | Tr | Tr |
| Detritus | - | - | 1.2 | - | 0.5 | - | 20.0 | 0.5 | - | 0.1 | 0.3 | Tr | 0.7 | 0.2 |
| No. stomachs examined | 18 | 17 | 13 | 21 | 5 | 15 | 6 | 25 | 28 | 100 | 64 | 67 | 53 | 453 |
| Percentage empty | 38.7 | 70.6 | 53.8 | 61.9 | 40.0 | 80.0 | 66.7 | 44.0 | 42.8 | 45.0 | 62.5 | 68.6 | 47.2 | 52.3 |
| Total volume (ml) | 291.2 | 55.2 | 60.5 | 175.6 | 64.1 | 202.8 | 4.0 | 126.1 | 576.1 | 1,842.7 | 357.7 | 618.1 | 449.0 | 5,166.0 |

[1] The totals include a sample of 21 fish for which the month label was lost.

[2] Trace (Tr) indicates volumes less than 0.1 per cent.

period July, 1967 through February, 1968 as only two centrarchids were found in stomachs collected in September and October. Beginning in March, the percentage of the total food volume contributed by freshwater drum, carp, and centrarchids began to increase. These species comprised 83.8% of total stomach volume compared with only 6.4% for gizzard shad in June.

Other Reservoirs. Samples from Lake Carl Blackwell, Ft. Gibson Reservoir, and Lake Texoma, although not available for all months (Table II), still showed trends similar to those observed in Lake Eufaula (Appendix). Gizzard shad were numerically the most abundant fish found in flathead catfish stomachs from Ft. Gibson Reservoir July through December, 1967, but freshwater drum comprised a greater percentage of total food volume in August and October. Channel catfish were found in six of the seven larger samples and were most abundant in summer months.

Gizzard shad were found only in late summer and autumn in Lake Texoma. Freshwater drum and centrarchids were the most important forage species found in flathead catfish stomachs in May, June, and both July samples. *Percina* spp. were found only in stomachs collected during July and August.

The decreasing percentages of total food volume of gizzard shad during the period March through July in Lake Carl Blackwell was paralleled by an increasing contribution by freshwater drum. Centrarchids and channel catfish were found in stomachs only in May and June.

## Food Habits of Fish < 110 MM

Food of flathead catfish < 110 mm was described for six fish, 37 to 105 mm, collected by electrofishing and rotenone during the periods from June through October in 1967 and 1968. Diptera (unidentified dipterans and Chironomidae) constituted 70% of the total number of food organisms and 39% of the total stomach contents. Organic detritus comprised 55% of the total food volume.

Minckley and Deacon (1959) found Ephemeroptera and Trichoptera more important by volume than Diptera in flathead catfish < 108 mm from two Kansas rivers. Although Diptera ranked second in importance at one station, Ephemeroptera and Trichoptera were the most important food by volume of young-of-the-year flathead catfish from the Missouri River, Nebraska (Langemeier, 1965). The absence of Ephemeroptera and Trichoptera found in this study is directly related to their scarcity in Lake Carl Blackwell. Norton (1968) found Ephemeridae (Ephemeroptera), Chironomidae and Culicidae (Diptera), and Tubificidae (Annelida) comprised 99.35% of the total number of macroinvertebrates found in benthic samples from Lake Carl Blackwell. Chironomidae contributed 47.9% of the total number in June samples while Culicidae comprised 60.5% in October samples. However, Culicidae were found mainly in deeper water and small flathead catfish were collected only in shallow water. Ephemeridae were not an important food item of young-of-the-year flathead catfish in the Missouri River (Langemeier, 1965).

## Food Habits of Fish 170-400 MM

A total of 16 flathead catfish, 177-387 mm, were collected by electrofishing and rotenone during the months of June through September in 1967 and 1968. Although only two fish were collected by rotenone, one of these contained three young-of-the-year gizzard shad (average 52 mm S.L.). These gizzard shad were probably ingested after being killed by the rotenone, and were not included in Table VIII. If the shad were added, the percentages of total volume would be 61, 26, and 9% for decapoda, gizzard shad, and Notropis lutrensis, respectively. When gizzard shad were not included, Decapoda and Notropis lutrensis comprised 83 and 17%, respectively, of the total food volume.

In Kansas decapods comprised 12 and 17% of the total food volumes of flathead catfish, 108-254 mm, collected in Neosho and Big Blue Rivers, respectively (Minckley and Deacon, 1959). Fishes and decapods accounted for 37 and 43%, respectively, of the stomach contents of flathead catfish, > 254 mm, from the Neosho River. Fishes comprised 79% of the food volume of flathead catfish, > 254 mm, from the Big Blue River; decapods were not found. Langemeier (1965) reported 29.8 and 10.9% decapods compared to 62.9 and 78.7% fishes in yearling and adult flathead catfish < 360 mm from unchanneled and channeled sections of the Missouri River, Nebraska.

The greater importance of decapods in the stomach contents of flathead catfish, 170-400 mm, from Lake Carl Blackwell may be related to the scarcity of small ictalurids and cyprinids, which were the main forage fishes of flathead catfish from rivers (Minckley and Deacon, 1959; Langemeier, 1965). Decapods are probably more vulnerable to capture by predatory fish than small forage fishes (Lewis, 1967). In Lake Carl Blackwell, young-of-the-year gizzard shad, freshwater drum, and centrarchids are probably utilized while they are in size classes which can be consumed by juvenile flathead catfish.

TABLE VIII

FOOD HABITS OF FLATHEAD CATFISH (< 400 MM) FROM LAKE CARL BLACKWELL

| Food Item | Frequency of Occurrence (Per Cent) | Numerical Occurrence (Per Cent) | Total Volume (Per Cent) |
|---|---|---|---|
| Fish < 110 mm | | | |
| Copepoda | 25 | 10 | Tr[1] |
| Unidentified Diptera | 50 | 30 | 17 |
| Chironomidae | 75 | 40 | 22 |
| Insect remains | 50 | 20 | 6 |
| Detritus | 50 | - | 55 |
| Fish 170-400 mm | | | |
| Decapoda | 66 | 72 | 83 |
| *Notropis lutrensis* | 17 | 14 | 12 |
| Unidentified minnow | 17 | 14 | 5 |

[1]Tr indicates a value less than one per cent.

## Selectivity and Competition

Selectivity by a predator for specific kinds of forage fish can be measured by computation of an electivity index (E) which is the comparison of per cent composition of specific forage species in the environment relative to their composition in the diet (Ivlev, 1961). In the present study, per cent composition of the stomach contents can be compared with per cent composition of gizzard shad from cove rotenone samples reported by Jenkins (1967) for Ft. Gibson, Grand, and Texoma Reservoirs, and per cent composition of gizzard shad and drum from cove rotenone samples in Lake Carl Blackwell. Per cent composition of total standing crop of clupeids in Ft. Gibson, Grand, and Texoma Reservoirs was 38, 53, and 17%, respectively. In a July, 1967 cove rotenone sample in Lake Carl Blackwell, gizzard shad and freshwater drum comprised 75.7 and 3.5% of total standing crop, respectively. Gizzard shad may be less abundant and drum may be more abundant than indicated by cove rotenone samples because they have been shown to overestimate the biomass of gizzard shad by 216% and underestimate the biomass of freshwater drum by 250% (Hayne, Hall, and Nichols, 1967).

After adjusting the estimated population data as indicated to be necessary by Hayne, Hall, and Nichols (1967), electivity index (E) for freshwater drum in Lake Carl Blackwell was +.63. E values for gizzard shad ranged from +.17 (Lake Carl Blackwell) to +.75 (Lake Texoma). The high positive electivity index for freshwater drum and generally high E values for gizzard shad indicates consumption of these species by flathead catfish in greater proportion than their relative abundance. In river studies on the flathead catfish, occurrence of the most important items in the stomach varied closely with the relative abundance of the forage in the habitat (Minckley and Deacon, 1959; Langemeier, 1965). Relating the present findings with other studies seems to indicate that, in the reservoirs from which flathead catfish were collected, the horizontal and vertical distribution of the flathead catfish makes gizzard shad and freshwater drum more available than other forage species. The greatest diversity in species of forage fish occurred in the stomach contents of flathead catfish in the spring and summer when flathead catfish were more commonly found in shallower water.

Reliance of flathead catfish on gizzard shad as forage places them in competition with other game fish. Gizzard shad were the major forage of largemouth bass (Schneidermeyer and Lewis, 1956) and large channel catfish (Busbee, 1968) in Illinois and Georgia reservoirs, respectively. Dendy (1946) reported gizzard shad were the major food of eight game species in Norris Reservoir, Tennessee. However, Dendy deduced that competition among the predators was lessened because of the great range in depth distribution of the shad and various game species during the growing season. Differences in vertical and horizontal distribution probably also occurs between predators in Oklahoma reservoirs. However, this would not strongly reduce competition for gizzard shad unless there was a tendency for the gizzard shad to segregate into subpopulations which remained in the different habitat types. This type of segregation of gizzard shad may possibly occur between different size groups. Cross (1967) indicated gizzard shad tended to feed more extensively on bottom organisms at older ages. A similar segregation of forage fish probably occurs in reservoirs where both gizzard and threadfin shad are abundant. Threadfin shad were six times more important by volume than gizzard shad in the stomach contents of six centrarchids in Bull Shoals Reservoir, Arkansas (Applegate, Mullan, and Morais, 1967). Considering the apparent absence of threadfin shad in stomachs of flathead catfish from Lake Texoma, competition between flathead catfish and other reservoir predators may be less when both shad species are abundant.

Differences in the preferred size of forage fish between flathead catfish and other predators might also tend to reduce competition.

Adult flathead catfish probably consume a larger average size of forage than other predators because of the flathead catfish's greater average size. The average length of flathead catfish collected by gill and trammel nets ranged from 595 to 697 mm in the six Oklahoma reservoirs. Therefore, flathead catfish collected in this study were capable of swallowing larger forage fishes than other common predators which are smaller in average size (i.e., largemouth bass, channel catfish, white crappie, and white bass).

Lawrence's (1958) tabulation of the size ranges of several forage species which can be swallowed by largemouth bass of various sizes shows that only largemouth bass greater than 406 mm could have consumed the average age I and older gizzard shad (147 mm S.L.) found in flathead catfish stomachs in the present study. Lawrence (1958) noted that largemouth bass preferred forage fish smaller than those approaching the estimated maximum size. The same type of tabulation for the spotted bass, Micropterus punctulatus, (Lawrence, 1961) indicates spotted bass would also be unable to swallow a 147 mm (S.L.) gizzard shad until reaching a length of about 400 mm.

In Lake Carl Blackwell, a largemouth bass would have had to be about 380 mm (T.L.) before it could have swallowed the average age I and older gizzard shad (132 mm S.L.) found in flathead catfish stomachs.

During the period of this study, the average length of largemouth bass at age III was 374 mm in Lake Carl Blackwell (Zweiacker and Brown, 1971). Therefore, about 50% of the age III and all older largemouth bass could have swallowed a 132 mm S.L. gizzard shad. Data given by Zweiacker and Brown (1971) indicate that about 40% of the estimated number of largemouth bass, age I and older, were capable of ingesting a 132 mm S.L. gizzard shad. This information indicates flathead catfish, > 480 mm, probably compete with largemouth bass for age I and older gizzard shad in Lake Carl Blackwell.

Consumption of young-of-the-year gizzard shad by flathead catfish, > 480 mm, occurred mainly in late autumn when feeding activity of flathead catfish is reduced. However, flathead catfish, < 480 mm, probably compete with game species for young-of-the-year gizzard shad throughout the year. Although somewhat limited by its preference for larger forage fish, the flathead catfish must be considered a competitor of game species in Oklahoma reservoirs because of its reliance on gizzard shad as forage. However, the flathead catfish does consume other forage species such as carp and freshwater drum which are not utilized extensively by Oklahoma game species.

# CHAPTER VI

## SUMMARY

The food habits of flathead catfish $>$ 480 mm was determined by the examination of stomach contents of 1,329 fish collected from six Oklahoma reservoirs by gill and trammel nets. Food habits of fish $<$ 400 mm was determined by examination of fish collected from Lake Carl Blackwell by rotenone and electric fishing gear. The major findings are as follows:

1. Food items, such as fish, fish remains, and invertebrates, were found in 47.0% of the stomachs of flathead catfish ($>$ 480 mm). The average number of food items and average food volume per stomach with food ranged from 1.3 to 2.0, and 11.3 to 37.4 ml, respectively.
2. Fish comprised more than 95% of total food volume and total number of food items in all six reservoirs. Gizzard shad contributed from 49.5 to 91.7% of total stomach volumes. Although common in Lake Texoma, threadfin shad were not identified in stomachs from that reservoir.
3. Freshwater drum were second in importance as forage, accounting for 3.3 to 38.2% of total food volumes.
4. Carp contributed 23.2 and 42.0% of total stomach volumes on Lakes Eufaula and Hudson, respectively,

but were not found elsewhere.

5. The channel catfish comprised 13.8% of the total food volume in flathead catfish from Ft. Gibson Reservoir where channel catfish were very abundant.

6. All species of centrarchids comprised only 5.4 to 10.0% of total stomach volumes in three reservoirs.

7. The average standard length of 467 measurable forage fish was 127 mm. The average lengths of age I+ gizzard shad, freshwater drum, and channel catfish were similar, ranging from 134 to 147 mm (S.L.).

8. Of 718 identifiable fish, only two white crappie and one channel catfish were of harvestable size for fishermen. Apparently flathead catfish do not compete with sport fishermen in the reservoirs studied.

9. Flathead catfish feeding activity was greatest in September through October and April through May. Feeding activity was less during the winter months and in June and July when spawning occurred. Feeding activity increased in August following spawning.

10. Gizzard shad decreased in importance as forage during spring and summer months in most reservoirs when centrarchids and channel catfish were increasing in importance. This shift may be related to the movement of flathead catfish into shallower water during this period.

11. The food habits of flathead catfish less than 110 mm from Lake Carl Blackwell was dominated by aquatic

dipterans, mainly Chironomidae.

12. Decapods were the most important food item found in fish 170-400 mm total length. Gizzard shad and Nortopis lutrensis were also found.

13. Flathead catfish predation in reservoirs is probably determined by the availability of suitable-sized forage species near the reservoir bottom in water depths inhabited by flathead catfish.

14. The desirability of flathead catfish as a predator in Oklahoma reservoirs is related to their predation on carp, freshwater drum, and larger gizzard shad. Flathead catfish compete with other reservoir predators for young-of-the-year and intermediate-sized gizzard shad.

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# APPENDIX

## SEASONAL VARIATION IN FOOD HABITS OF FISH > 480 MM

TABLE IX

MONTHLY VARIATION IN PERCENTAGES OF TOTAL VOLUME OF STOMACH CONTENTS OF FIFTY-SIX FLATHEAD CATFISH (> 480 MM) FROM LAKE CARL BLACKWELL

| | 1967 | 1968 | | | | | | Total Volume |
|---|---|---|---|---|---|---|---|---|
| Food Item | Total | March | April | May | June | July | August | (Per Cent) |
| *Dorosoma cepedianum* | 80.0 | 100.0 | 77.3 | 38.4 | 12.4 | - | 21.2 | 49.5 |
| *Aplodinotus grunniens* | 18.6 | - | 22.0 | 28.2 | 60.8 | 100.0 | 78.6 | 38.2 |
| *Ictalurus punctatus* | - | - | - | 12.3 | 20.7 | - | - | 4.7 |
| *Lepomis macrochirus* | - | - | - | 15.3 | - | - | - | 5.1 |
| Unidentified Centrarchidae | - | - | - | 1.0 | - | - | - | 0.3 |
| *Morone chrysops* | - | - | - | 1.2 | - | - | - | 0.4 |
| Unidentified fish remains | 1.4 | - | 0.6 | 1.8 | - | - | 0.2 | 1.0 |
| Detritus | - | - | - | 1.4 | 5.5 | - | - | 0.7 |
| Plant remains | - | - | - | 0.4 | 0.5 | - | - | 0.1 |
| No. stomachs examined | 16 | 11 | 18 | 42 | 26 | 17 | 18 | 148 |
| Per cent empty | 62.5 | 72.7 | 44.4 | 40.5 | 84.6 | 94.1 | 61.1 | 62.2 |
| Total volume (ml) | 225.4 | 22.6 | 423.3 | 554.0 | 54.6 | 7.0 | 396.9 | 1683.8 |

TABLE X

MONTHLY VARIATION IN PER CENT FREQUENCY OF OCCURRENCE OF STOMACH CONTENTS OF FIFTY-SIX FLATHEAD CATFISH (> 480 MM) FROM LAKE CARL BLACKWELL WHICH CONTAINED FOOD

| Food Item | 1967 | 1968 | | | | | | Total Frequency of Occurrence |
|---|---|---|---|---|---|---|---|---|
| | Total | March | April | May | June | July | August | |
| Dorosoma cepedianum | 83.3 | 100.0 | 80.0 | 42.3 | 25.0 | - | 57.1 | 57.1 |
| Aplodinotus grunniens | 16.7 | - | 50.0 | 30.8 | 50.0 | 100.0 | 42.8 | 35.7 |
| Ictalurus punctatus | - | - | - | 3.8 | 25.0 | - | - | 3.6 |
| Lepomis macrochirus | - | - | - | 7.6 | - | - | - | 3.6 |
| Unidentified Centrarchidae | - | - | - | 3.8 | - | - | - | 1.8 |
| Morone chrysops | - | - | - | 3.8 | - | - | - | 1.8 |
| Unidentified fish remains | 33.3 | - | 30.0 | 11.5 | - | - | 28.6 | 17.8 |
| Detritus | - | - | - | 15.4 | 50.0 | - | - | 10.7 |
| Plant remains | - | - | - | 7.7 | 25.0 | - | - | 5.4 |
| No. stomachs examined | 16 | 11 | 18 | 42 | 26 | 17 | 18 | 148 |
| No. with food items | 6 | 3 | 10 | 26 | 4 | 1 | 6 | 56 |

TABLE XI

MONTHLY VARIATION IN THE PER CENT NUMERICAL OCCURRENCE OF STOMACH CONTENTS OF FIFTY-SIX FLATHEAD CATFISH (>480 MM) FROM LAKE CARL BLACKWELL WHICH CONTAINED FOOD

| Food Item | 1967 Total | 1968 March | 1968 April | 1968 May | 1968 June | 1968 July | 1968 August | Total Volume (Per Cent) |
|---|---|---|---|---|---|---|---|---|
| *Dorosoma cepedianum* | 80.0 | 100.0 | 77.3 | 38.4 | 12.4 | - | 21.2 | 49.5 |
| *Aplodinotus grunniens* | 18.6 | - | 22.0 | 28.2 | 60.8 | 100.0 | 78.6 | 38.2 |
| *Ictalurus punctatus* | - | - | - | 12.3 | 20.7 | - | - | 4.7 |
| *Lepomis macrochirus* | - | - | - | 15.3 | - | - | - | 5.1 |
| Unidentified Centrarchidae | - | - | - | 1.0 | - | - | - | 0.3 |
| *Morone chrysops* | - | - | - | 1.2 | - | - | - | 0.4 |
| Unidentified fish remains | 1.4 | - | 0.6 | 1.8 | - | - | 0.2 | 1.0 |
| Detritus | - | - | - | 1.4 | 5.5 | - | - | 0.7 |
| Plant remains | - | - | - | 0.4 | 0.5 | - | - | 0.1 |
| No. stomachs examined | 16 | 11 | 18 | 42 | 26 | 17 | 18 | 148 |
| Per cent empty | 62.5 | 72.7 | 44.4 | 40.5 | 84.6 | 94.1 | 61.1 | 62.2 |
| Total volume (ml) | 225.4 | 22.6 | 423.3 | 554.0 | 54.6 | 7.0 | 396.9 | 1683.8 |

TABLE XII

MONTHLY VARIATION IN PER CENT FREQUENCY OF OCCURRENCE OF STOMACH CONTENTS OF TWO HUNDRED SIXTEEN FLATHEAD CATFISH FROM LAKE EUFAULA WHICH CONTAINED FOOD

| Food Item | 1967 | | | | | 1968 | | | | | | | | Total Frequency of Occurrence[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July | Sept | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | June | July | Aug | |
| Dorosoma cepedianum | 72.7 | 40.0 | 66.7 | 75.0 | 33.3 | 66.7 | 50.0 | 50.0 | 75.0 | 43.6 | 25.0 | 47.6 | 36.7 | 45.8 |
| Aplodinotus grunniens | - | - | - | - | - | - | - | 21.4 | 12.5 | 18.2 | 29.2 | 19.0 | 26.7 | 17.6 |
| Cyprinus carpio | - | - | - | - | - | - | - | - | 6.2 | 14.5 | 8.3 | 4.8 | 3.6 | 6.0 |
| Lepomis macrochirus | - | - | - | - | - | - | - | 7.1 | - | - | - | - | - | .9 |
| Lepomis spp. | - | - | - | - | - | - | - | 7.1 | - | 1.8 | 8.3 | - | 3.6 | 2.8 |
| Pomoxis annularis | - | - | - | - | - | - | - | - | - | 1.8 | - | - | 3.6 | .9 |
| Unidentified Centrarchidae | - | 20.0 | 16.7 | - | - | - | - | - | - | 1.8 | 4.2 | - | - | 1.8 |
| Centrarchidae (total) | - | 20.0 | 16.7 | - | - | - | - | 7.1 | - | 5.4 | 8.3 | - | 7.1 | 5.1 |
| Ictalurus spp. (bullhead) | - | - | - | - | - | - | - | - | - | - | - | - | 3.6 | .5 |
| Unidentified small fish remains | 27.3 | 20.0 | 33.3 | 37.5 | 66.7 | 33.3 | - | 35.7 | 43.8 | 27.3 | 12.5 | 33.3 | 25.0 | 28.7 |
| Unidentified large scales | - | - | - | - | - | - | - | 7.1 | - | 16.4 | 8.3 | 9.5 | 7.1 | 7.9 |
| Fish (total) | 100.0 | 80.0 | 83.3 | 100.0 | 66.7 | 66.7 | 50.0 | 92.9 | 100.0 | 96.4 | 79.2 | 90.5 | 92.9 | 82.9 |
| Decapoda | - | - | - | - | - | - | - | - | - | - | 12.5 | - | - | 1.4 |
| Plant remains | - | 20.0 | - | - | - | - | - | - | - | 3.6 | 8.3 | 4.8 | 3.6 | 4.2 |
| Detritus | - | - | 16.7 | - | 33.3 | 33.3 | 50.0 | 7.1 | - | 1.8 | 8.3 | 4.8 | 3.6 | 5.1 |
| No. stomachs examined | 18 | 17 | 13 | 21 | 5 | 15 | 6 | 25 | 28 | 100 | 64 | 67 | 53 | 453 |
| No. with food items | 11 | 5 | 6 | 8 | 3 | 3 | 2 | 14 | 16 | 55 | 24 | 21 | 28 | 216 |

[1]The totals include a sample of 21 fish for which the month label was lost.

TABLE XIII

MONTHLY VARIATION IN PER CENT NUMERICAL OCCURRENCE OF STOMACH CONTENTS OF TWO HUNDRED ELEVEN FLATHEAD CATFISH FROM LAKE EUFAULA WHICH CONTAINED FOOD ITEMS

| Food Item | 1967 | | | | | 1968 | | | | | | | | Total Number (Per Cent)[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July | Sept | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | June | July | Aug | |
| Dorosoma cepedianum | 78.6 | 60.0 | 70.6 | 78.6 | 64.7 | 75.0 | 100.0 | 33.3 | 65.7 | 40.9 | 27.3 | 63.2 | 42.8 | 49.6 |
| Aplodinotus grunniens | - | - | - | - | - | - | - | 22.2 | 5.7 | 14.8 | 27.3 | 10.5 | 24.5 | 14.3 |
| Cyprinus carpio | - | - | - | - | - | - | - | - | 2.8 | 10.2 | 6.1 | 2.6 | 2.0 | 3.9 |
| Lepomis macrochirus | - | - | - | - | - | - | - | 3.7 | - | - | - | - | - | 0.6 |
| Lepomis spp. | - | - | - | - | - | - | - | 3.7 | - | 1.1 | 6.1 | - | 2.0 | 1.7 |
| Pomoxis annularis | - | - | - | - | - | - | - | - | - | 1.1 | - | - | 2.0 | 0.6 |
| Unidentified Centrarchidae | - | 20.0 | 5.9 | - | - | - | - | - | - | 1.1 | 3.0 | - | - | 1.1 |
| Centrarchidae (total) | - | 20.0 | 5.9 | - | - | - | - | 7.4 | - | 3.4 | 9.1 | - | 4.1 | 3.9 |
| Ictalurus spp. (bullhead) | - | - | - | - | - | - | - | - | - | - | - | - | 2.0 | 0.3 |
| Unidentified small fish remains | 21.4 | 20.0 | 23.5 | 21.4 | 35.3 | 25.0 | - | 33.3 | 25.7 | 20.4 | 15.2 | 18.1 | 20.4 | 22.6 |
| Unidentified large scales | - | - | - | - | - | - | - | 3.7 | - | 10.2 | 6.1 | 5.3 | 4.1 | 4.7 |
| Fish (total) | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 99.2 |
| Decapoda | - | - | - | - | - | - | - | - | - | - | 9.1 | - | - | 0.8 |
| No. of stomachs examined | 18 | 17 | 13 | 21 | 5 | 15 | 6 | 25 | 28 | 100 | 64 | 67 | 53 | 453 |
| No. of food items | 14 | 5 | 17 | 14 | 17 | 4 | 1 | 27 | 35 | 88 | 33 | 38 | 49 | 363 |

[1]The totals include a sample of 21 fish for which the month label was lost.

TABLE XIV

MONTHLY VARIATION IN PERCENTAGES OF TOTAL VOLUME OF STOMACH CONTENTS OF FLATHEAD CATFISH FROM FT. GIBSON RESERVOIR

| Food Item | 1967 | | | | | | 1968 | | | Total Volume (Per Cent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | July | Aug | Sept | Oct | Nov | Dec | Mar | May | June | |
| *Dorosoma cepedianum* | 21.5 | 38.5 | 76.8 | 42.5 | 91.4 | 72.0 | - | 75.1 | - | 60.7 |
| *Aplodinotus grunniens* | - | 40.7 | - | 55.1 | - | - | - | 4.4 | - | 20.4 |
| *Ictalurus punctatus* | 78.1 | 18.6 | 15.8 | Tr | 1.0 | - | - | 14.7 | - | 13.8 |
| Ictalurus spp. (not *I. punctatus*) | - | - | - | - | - | - | - | Tr | - | Tr[1] |
| Unidentified minnow | - | - | - | Tr | - | - | - | - | - | Tr |
| Unidentified fish remains | 0.2 | 1.4 | 1.7 | 2.2 | 6.4 | 11.4 | 12.5 | 5.2 | 50.0 | 3.5 |
| Fish (total) | 99.6 | 99.2 | 94.3 | 99.8 | 98.8 | 83.4 | 12.5 | 99.4 | 50.0 | 98.4 |
| Decapoda | - | - | 4.3 | - | - | - | - | - | - | 0.6 |
| Ephemeroptera (*Hexagenia* spp.) | - | - | - | - | - | - | - | - | 50.0 | Tr |
| Detritus | 0.2 | - | 0.8 | - | 1.2 | 16.5 | - | 0.3 | - | 0.6 |
| Plant remains | - | 0.8 | 0.3 | Tr | - | Tr | 88.5 | Tr | - | 0.2 |
| No. of stomachs examined | 14 | 17 | 49 | 53 | 34 | 25 | 6 | 50 | 7 | 255 |
| Per cent empty | 50.0 | 58.8 | 57.1 | 49.0 | 50.0 | 52.0 | 66.7 | 32.0 | 57.1 | 49.0 |
| Total volume (ml) | 91.2 | 99.7 | 202.4 | 425.5 | 71.7 | 25.4 | 0.8 | 545.4 | 0.4 | 1462.5 |

[1] Trace (Tr) indicates volumes less than 0.1 per cent.

TABLE XV

MONTHLY VARIATION IN PER CENT FREQUENCY OF OCCURRENCE OF STOMACH CONTENTS OF ONE HUNDRED THIRTY FLATHEAD CATFISH FROM FT. GIBSON RESERVOIR WHICH CONTAINED FOOD

| Food Item | 1967 | | | | | | 1968 | | | Total Frequency of Occurrence |
|---|---|---|---|---|---|---|---|---|---|---|
| | July | Aug | Sept | Oct | Nov | Dec | Mar | May | June | |
| *Dorosoma cepedianum* | 57.1 | 28.6 | 38.1 | 51.8 | 41.2 | 25.0 | - | 50.0 | - | 42.3 |
| *Aplodinotus grunniens* | - | 28.6 | - | 11.1 | - | - | - | 2.9 | - | 4.6 |
| *Ictalurus punctatus* | 28.6 | 14.3 | 9.5 | 3.7 | 5.9 | - | - | 8.8 | - | 7.7 |
| *Ictalurus* spp. (not *I. punctatus*) | - | - | - | - | - | - | - | 2.9 | - | 0.8 |
| Unidentified minnow | - | - | - | 3.7 | - | - | - | - | - | 0.8 |
| Unidentified small fish remains | 14.3 | 42.8 | 9.5 | 25.9 | 29.4 | 41.6 | 50.0 | 20.6 | 33.3 | 24.6 |
| Unidentified large scales | - | - | 19.1 | 14.8 | 5.9 | 16.7 | - | 14.7 | 33.3 | 13.1 |
| Fish (total) | 100.0 | 71.4 | 66.7 | 92.6 | 82.4 | 75.0 | 50.0 | 91.2 | 66.7 | 83.1 |
| Decapoda | - | - | 4.8 | - | - | - | - | - | - | 0.8 |
| Ephemeroptera (*Hexagenia* spp.) | - | - | - | - | - | - | - | - | 33.3 | 0.8 |
| Detritus | 14.3 | - | 19.5 | 3.7 | 17.6 | 8.3 | - | 5.9 | 33.3 | 10.0 |
| Plant remains | - | 14.3 | 14.3 | 3.7 | - | 16.7 | 50.0 | 8.8 | - | 8.5 |
| No. of stomachs examined | 14 | 17 | 49 | 53 | 34 | 25 | 6 | 50 | 7 | 255 |
| No. with food items | 7 | 7 | 21 | 27 | 17 | 12 | 2 | 34 | 3 | 130 |

TABLE XVI

MONTHLY VARIATION IN PER CENT NUMERICAL OCCURRENCE OF STOMACH CONTENTS OF ONE HUNDRED THIRTY FLATHEAD CATFISH FROM FT. GIBSON RESERVOIR WHICH CONTAINED FOOD

| Food Item | 1967 | | | | | | 1968 | | | Total Number |
|---|---|---|---|---|---|---|---|---|---|---|
| | July | Aug | Sept | Oct | Nov | Dec | Mar | May | June | (Per Cent) |
| *Dorosoma cepedianum* | 57.1 | 33.3 | 47.1 | 55.0 | 66.7 | 46.2 | - | 53.6 | - | 52.0 |
| *Aplodinotus grunniens* | - | 22.2 | - | 7.5 | - | - | - | 2.4 | - | 3.9 |
| *Ictalurus punctatus* | 28.6 | 11.1 | 11.8 | 2.5 | 4.8 | - | - | 7.3 | - | 6.6 |
| *Ictalurus* spp. (not *I. punctatus*) | - | - | - | - | - | - | - | 2.4 | - | 0.6 |
| Unidentified minnow | - | - | - | 2.5 | - | - | - | - | - | 0.6 |
| Unidentified small fish remains | 14.3 | 33.3 | 17.6 | 22.5 | 23.8 | 53.8 | 100.0 | 22.0 | 33.3 | 25.7 |
| Unidentified large fish remains | - | - | 17.6 | 10.0 | 4.8 | - | - | 12.2 | 33.3 | 9.2 |
| Fish (total) | 100.0 | 99.9 | 94.1 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 66.7 | 98.7 |
| Decapoda | - | - | 5.9 | - | - | - | - | - | - | 0.6 |
| Ephemeroptera (*Hexagenia* spp.) | - | - | - | - | - | - | - | - | 33.3 | 0.6 |
| No. of stomachs examined | 14 | 17 | 49 | 53 | 34 | 25 | 6 | 50 | 7 | 255 |
| No. of food items | 7 | 9 | 17 | 40 | 21 | 13 | 1 | 41 | 3 | 152 |

TABLE XVII

MONTHLY VARIATION IN PER CENT FREQUENCY OF OCCURRENCE OF STOMACH CONTENTS OF ONE HUNDRED NINETY-SEVEN FLATHEAD CATFISH FROM GRAND LAKE WHICH CONTAINED FOOD

| Food Item | 1967 | | | | 1968 | | | | | | | Total Frequency of Occurrence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sept | Oct | Nov | Dec | Jan | Feb | Mar | May | June | July | Aug | |
| *Dorosoma cepedianum* | 56.5 | 76.5 | 76.9 | 100.0 | - | 16.7 | 50.0 | 66.7 | 45.4 | 76.9 | 84.0 | 70.6 |
| *Aplodinotus grunniens* | 21.7 | 5.9 | 7.7 | - | - | 33.3 | - | 4.8 | - | 3.8 | - | 6.6 |
| *Ictalurus punctatus* | - | 1.5 | - | - | - | - | - | - | - | - | - | 0.5 |
| *Pylodictis olivaris* | 4.3 | - | - | - | - | - | - | - | - | - | - | 0.5 |
| Unidentified small fish remains | 21.7 | 20.6 | 23.1 | - | - | 16.7 | 50.0 | 38.1 | 27.3 | 15.4 | 16.0 | 21.8 |
| Unidentified large scales | - | - | - | - | - | - | - | - | - | 3.8 | - | 0.5 |
| Fish (total) | 91.3 | 97.0 | 92.3 | 100.0 | 0.0 | 66.7 | 50.0 | 100.0 | 72.7 | 96.2 | 100.0 | 93.4 |
| Decapoda | 4.3 | - | - | - | - | - | - | - | - | - | - | 0.5 |
| Ephemeroptera (*Hexagenia* spp.) | - | - | - | - | - | - | - | - | 18.2 | 7.7 | - | 2.0 |
| Detritus | 8.7 | 4.4 | 7.7 | - | 100.0 | 50.0 | 50.0 | - | 9.1 | - | - | 6.1 |
| No. of stomachs examined | 30 | 104 | 27 | 4 | 9 | 16 | 3 | 32 | 23 | 50 | 40 | 338 |
| No. with food items | 23 | 68 | 13 | 2 | 1 | 6 | 2 | 21 | 11 | 26 | 24 | 197 |

TABLE XVIII

MONTHLY VARIATION IN PER CENT NUMERICAL OCCURRENCE OF STOMACH CONTENTS OF ONE HUNDRED EIGHTY-FIVE FLATHEAD CATFISH FROM GRAND LAKE WHICH CONTAINED FOOD

| Food Item | 1967 | | | | 1968 | | | | | | | Total Number (Per Cent) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sept | Oct | Nov | Dec | Jan | Feb | Mar | May | June | July | Aug | |
| *Dorosoma cepedianum* | 56.7 | 75.3 | 84.0 | 100.0 | - | 25.0 | 50.0 | 66.7 | 27.8 | 71.4 | 84.0 | 70.1 |
| *Aplodinotus grunniens* | 20.0 | 5.4 | 4.0 | - | - | 50.0 | - | 3.7 | - | 3.6 | - | 6.1 |
| *Ictalurus punctatus* | - | 1.1 | - | - | - | - | - | - | - | - | - | 0.4 |
| *Pylodictis olivaris* | 3.3 | - | - | - | - | - | - | - | - | - | - | 0.4 |
| Unidentified small fish remains | 16.7 | 18.3 | 12.0 | - | - | 25.0 | 50.0 | 29.6 | 22.2 | 14.3 | 16.0 | 17.8 |
| Unidentified large scales | - | - | - | - | - | - | - | - | - | 3.6 | - | 0.4 |
| Fish (total) | 96.7 | 100.0 | 100.0 | 100.0 | - | 100.0 | 100.0 | 100.0 | 50.0 | 92.9 | 100.0 | 95.5 |
| Decapoda | 3.3 | - | - | - | - | - | - | - | - | - | - | 0.4 |
| Ephemeroptera (*Hexagenia* spp.) | - | - | - | - | - | - | - | - | 50.0 | 7.1 | - | 4.2 |
| No. of stomachs examined | 30 | 104 | 27 | 4 | 9 | 16 | 3 | 32 | 23 | 50 | 40 | 338 |
| No. of food items | 30 | 93 | 25 | 12 | 0 | 4 | 2 | 27 | 18 | 28 | 25 | 264 |

TABLE XIX

MONTHLY VARIATION IN PERCENTAGES OF THE TOTAL VOLUME OF STOMACH CONTENTS OF FLATHEAD CATFISH COLLECTED FROM LAKE TEXOMA

| Food Item | 1967 | | | | 1968 | | | | | | | Total Volume |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July | Sept | Oct | Nov | Feb | Mar | Apr | May | June | July | Aug | (Per Cent) |
| *Dorosoma* spp. | - | 85.1 | 84.0 | 50.9 | - | - | - | - | - | - | 85.0 | 55.1 |
| *Aplodinotus grunniens* | 93.8 | 14.3 | 15.2 | 41.9 | - | - | - | 55.5 | 59.8 | - | 5.7 | 33.6 |
| *Micropterus* spp. | 5.1 | - | - | - | - | - | - | - | 27.8 | 72.1 | - | 2.1 |
| *Lepomis* spp. | 0.6 | - | - | - | - | - | - | 36.4 | - | - | - | 3.9 |
| Unidentified Centrarchidae | - | - | - | - | - | - | - | - | 1.5 | - | - | 0.1 |
| Centrarchidae (total) | 5.7 | - | - | - | - | - | - | 36.4 | 29.3 | 72.1 | - | 6.1 |
| *Percina* spp. | - | - | - | - | - | - | - | - | - | 12.1 | 7.1 | 0.5 |
| Unidentified fish remains | 0.6 | 0.5 | 0.4 | 7.0 | - | - | - | 6.8 | 2.5 | 4.3 | 2.2 | 3.4 |
| Fish (total) | 100.0 | 99.9 | 99.6 | 100.0 | - | - | - | 98.7 | 91.6 | 88.5 | 97.0 | 98.7 |
| Detritus | - | 0.1 | 0.4 | - | - | - | 100.0 | 1.3 | 8.5 | 7.8 | - | 1.4 |
| Plant remains | - | - | - | - | - | - | - | - | - | 3.6 | - | Tr[1] |
| No. of stomachs examined | 7 | 7 | 16 | 20 | 1 | 1 | 3 | 12 | 10 | 2 | 15 | 94 |
| Per cent empty | 57.1 | 28.6 | 25.0 | 35.0 | 100.0 | 100.0 | 66.7 | 66.7 | 50.0 | 0.0 | 66.7 | 46.8 |
| Total volume (ml) | 102.4 | 191.6 | 513.8 | 531.0 | - | - | 10.0 | 180.2 | 75.3 | 14.0 | 91.6 | 1709.9 |

[1]Trace (Tr) indicates volumes less than 0.1 per cent.

TABLE XX

MONTHLY VARIATION IN PER CENT FREQUENCY OF OCCURRENCE OF STOMACH CONTENTS OF FIFTY FLATHEAD CATFISH FROM LAKE TEXOMA WHICH CONTAINED FOOD

| Food Item | 1967 | | | | 1968 | | | | | | | Total Frequency of Occurrence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July | Sept | Oct | Nov | Feb | Mar | Apr | May | June | July | Aug | |
| *Dorosoma* spp.[1] | - | 20.0 | 66.7 | 30.8 | - | - | - | - | - | | 60.0 | 32.0 |
| *Aplodinotus grunniens* | 66.7 | 40.0 | 8.3 | 38.5 | - | - | - | 25.0 | 40.0 | - | 20.0 | 28.0 |
| *Micropterus* spp. | 33.3 | - | - | - | - | - | - | - | 20.0 | 50.0 | - | 6.0 |
| *Lepomis* spp. | 33.3 | - | - | - | - | - | - | 25.0 | - | - | - | 4.0 |
| Unidentified Centrarchidae | - | - | - | - | - | - | - | - | 20.0 | - | - | 2.0 |
| Centrarchidae (total) | 33.3 | - | - | - | - | - | - | 25.0 | 20.0 | 50.0 | - | 8.0 |
| *Percina* spp. | - | - | - | - | - | - | - | - | - | 50.0 | 20.0 | 4.0 |
| Unidentified fish remains | 33.3 | 20.0 | 16.7 | 23.1 | - | - | - | 50.0 | 40.0 | 50.0 | 20.0 | 26.0 |
| Fish (total) | 100.0 | 80.0 | 83.3 | 84.6 | - | - | - | 100.0 | 100.0 | 50.0 | 100.0 | 86.0 |
| Detritus | - | 20.0 | 16.7 | 15.4 | - | - | 100.0 | 25.0 | 40.0 | 50.0 | - | 20.0 |
| Plant remains | - | - | - | - | - | - | - | - | - | 50.0 | - | 2.0 |
| No. of stomachs examined | 7 | 7 | 16 | 20 | 1 | 1 | 3 | 12 | 10 | 2 | 15 | 94 |
| No. with food items | 3 | 5 | 12 | 13 | 0 | 0 | 1 | 4 | 5 | 2 | 5 | 50 |

[1]Sixteen of twenty shad were identified as D. cepedianum.

TABLE XXI

MONTHLY VARIATION IN PER CENT NUMERICAL OCCURRENCE OF STOMACH CONTENTS OF FORTY-THREE FLATHEAD CATFISH FROM LAKE TEXOMA WHICH CONTAINED FOOD

| Food Item | 1967 | | | | 1968 | | | | | | | Total Number (Per Cent) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July | Sept | Oct | Nov | Feb | Mar | Apr | May | June | July | Aug | |
| Dorosoma spp.[1] | - | 16.7 | 80.0 | 30.8 | - | - | - | - | - | - | 30.0 | 29.4 |
| Aplodinotus grunniens | 30.0 | 50.0 | 6.7 | 38.5 | - | - | - | 25.0 | 28.6 | - | 10.0 | 23.5 |
| Micropterus spp. | 30.0 | - | - | - | - | - | - | - | 14.3 | 33.3 | - | 7.4 |
| Lepomis spp. | 20.0 | - | - | - | - | - | - | 25.0 | - | - | - | 4.4 |
| Unidentified Centrarchidae | - | - | - | - | - | - | - | - | 14.3 | - | - | 1.5 |
| Centrarchidae (total) | 50.0 | - | - | - | - | - | - | 25.0 | 28.6 | 33.3 | - | 13.2 |
| Percina spp. | - | - | - | - | - | - | - | - | - | 33.3 | 40.0 | 7.4 |
| Unidentified fish remains | 20.0 | 33.3 | 13.3 | 30.8 | - | - | - | 50.0 | 42.8 | 33.3 | 20.0 | 26.5 |
| Fish (total) | 100.0 | 100.0 | 100.0 | 100.0 | - | - | - | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| No. of stomachs examined | 7 | 7 | 16 | 20 | 1 | 1 | 3 | 12 | 10 | 2 | 15 | 94 |
| No. of food items | 10 | 6 | 15 | 13 | 0 | 0 | 0 | 4 | 7 | 3 | 10 | 68 |

[1]Sixteen of twenty shad were identified as D. cepedianum.

# VITA

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Master of Science

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