1964

Food Habits of Bigmouth and Smallmouth Buffalo in Lewis and Clark Lake and the Missouri River

Thomas S. McComish

FOOD HABITS OF BIGMOUTH AND SMALLMOUTH BUFFALO

IN LEWIS AND CLARK LAKE AND THE

MISSOURI RIVER

BY

THOMAS S. McCOMISH

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Department of
Wildlife Management, South Dakota State
College of Agriculture
and Mechanic Arts

1964

FOOD HABITS OF BIGMOUTH AND SMALLMOUTH BUFFALO IN LEWIS AND CLARK LAKE AND THE MISSOURI RIVER

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

ACKNOWLEDGEMENTS

I wish to express sincere appreciation to Norman D. Schoenthal and Marvin O. Allum for their suggestions, personal interest and constructive criticisms offered during the course of this study. I also wish to thank Dr. Donald R. Progulske for his suggestions during the preparation of the manuscript. Thanks are also due Dr. Norman G. Benson, Head of North Central Reservoir Investigations, who supplied stomach samples, data on fish collections and critically reviewed the manuscript.

I also wish to extend thanks to friends and colleagues who offered advice during the study.

T.S.M.

TABLE OF CONTENTS

	Page
ABSTRACT	vi
INTRODUCTION	1
METHODS	3
RESULTS	7
Young-of-the-year bigmouth buffalo	7
Adult bigmouth buffalo	9
Young-of-the-year smallmouth buffalo	13
Adult smallmouth buffalo	13
SUMMARY AND CONCLUSIONS	17
LITERATURE CITED	20

LIST OF FIGURES AND TABLES

Figures Page

1. Study Area 2

Tables

1. Calculated volumes of food organisms 6
2. Food of young-of-the-year bigmouth buffalo . . . 8
3. Food of adult bigmouth buffalo in 1962 10
4. Food of adult bigmouth buffalo in 1963 11
5. Food of adult smallmouth buffalo in 1962 14
6. Food of adult smallmouth buffalo in 1963 15

ABSTRACT

Food habits were determined for 386 bigmouth buffalo and 277 smallmouth buffalo collected in 1962 and 1963 from Lewis and Clark Lake and the Missouri River. Young-of-the-year bigmouth buffalo stomachs contained 100 percent zooplankton. Bigmouth buffalo (330 to 530 millimeters) stomachs contained 99 percent zooplankton in 1962 and 95 percent in 1963. Digestive tracts of young-of-the-year smallmouth buffalo contained 99 percent copepods and one percent sand. Smallmouth buffalo (250 to 400 millimeters) contained about 65 percent zooplankton, 30 percent phytoplankton and the remaining five percent consisted of chironomid larvae, plant detritus, and sand.

INTRODUCTION

North Central Reservoir Investigations of the Bureau of Sport Fisheries and Wildlife initiated a study in 1962 to determine the food habits of fish in Lewis and Clark Lake near Yankton, South Dakota. Food habits of bigmouth buffalo, Ictiobus cyprinellus and smallmouth buffalo, Ictiobus bubalus are reported in this paper.

Studies concerning food habits of bigmouth and smallmouth buffalo are limited. Recent studies on the feeding of bigmouth buffalo were conducted by Moen (1954) in Iowa, Scidmore and Woods (1959) in Minnesota, and Johnson (1963) in Saskatchewan. Food habits of smallmouth buffalo are described by Forbes and Richardson (1920) in Illinois, Gowanloch (1933) in Louisiana, and Lagler and Ricker (1943) in Indiana.

DESCRIPTION OF STUDY AREA

The Lewis and Clark Lake portion of the study area was formed in 1955 by Gavins Point Dam on the Missouri River (Figure 1). The impoundment has 33,000 surface acres, a length of 37 miles, an average width of two miles, and approximately 100 miles of shoreline. The depth of the lake ranges from two to three feet in the upper end to a maximum of 55 feet near the dam. A complete turnover of the 54,000 acre feet of water in the lake occurs every eight to ten days during the months of navigation. Water levels in the reservoir fluctuate as much as six feet during a normal year. The impoundment is described in detail by Shields (1957).

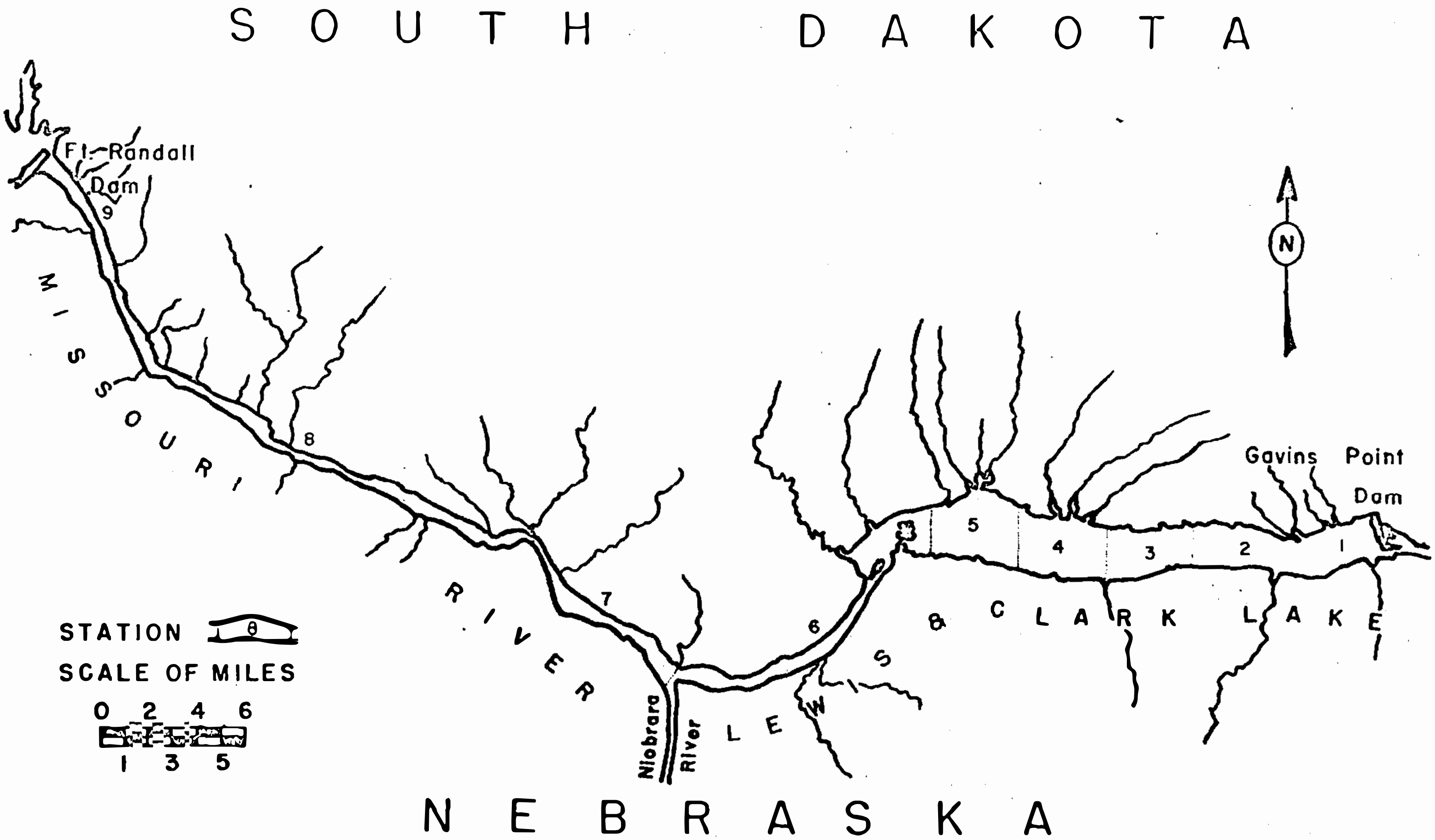

Figure 1. Lewis and Clark Lake and Missouri River study area showing collecting stations.

Shorelines of the lake vary from steep cut banks to gentle slopes with a narrow flood plain. The Niobrara River enters the lake near its upper limits and is the only permanent tributary. A few intermittent streams form small bays where they enter the lake. Large concentrations of flooded trees and scattered small islands are common in the upper lake.

The Missouri River portion of the study area was 41 miles long. The maximum flow rate of the river is about 25,000 cubic feet per second. Fluctuations in the rate of flow are caused by changes in power requirements at Ft. Randall Dam. The shorelines are similar to those found along the reservoir.

METHODS

Lewis and Clark Lake and the Missouri River were divided into nine sampling stations (Figure 1). Six of the stations were in the lake and three in the river. Fish were collected at least once every three weeks from each station by electrofishing, gill netting, seining, and trawling. Five fish stomachs were collected at each sampling station and period when available.

Data relative to the length, weight, sex, and maturity of each fish was recorded. Scale samples were removed from each fish and a collection number assigned. Digestive tracts were removed intact by cutting at the esophagus and anus. The stomachs were then labeled, wrapped in gauze sheets, secured, and preserved in 10 percent formalin.

In the laboratory the anterior portion of the digestive tract, from the esophagus to the first major curve of the small intestine, was removed. This procedure was followed for adult fish only. Henceforth, the term adult denotes fish other than young-of-the-year which are not necessarily sexually mature. The validity of using this portion of the tract was tested. Ten entire digestive tracts were sectioned at various intervals and their contents were examined. It was found that a representative sample of food organisms with the least amount of digestion could be obtained by using this section.

The stomachs of adult fish were opened with a scissors and the contents flushed into a gridded petri dish. The stomach contents were examined with a binocular microscope and all macroorganisms and pieces of debris were measured, recorded, and removed. The remaining portion of the stomach sample was washed into a 25-milliliter graduated cylinder, diluted to 25 milliliters, corked, and inverted several times until thoroughly mixed. A one milliliter sample was quickly removed from the center of the graduated cylinder with a pipette and transferred to a Sedgwick Rafter counting cell. The aperature of the pipette used for transferring a sample was enlarged to allow easy entrance and exit of microorganisms. All microorganisms in the counting cell were enumerated by the survey method as described by the American Public Health Association et al. (1960). The microscope used for counts had a 15-power wide-angle ocular lens and a 10-power objective lens.

The entire digestive tracts of young-of-the-year fish were removed, macerated, and then diluted to 10 milliliters in a graduated cylinder. One milliliter was removed and a count of microorganisms made using the same procedure as described for adults.

Phytoplankton in the stomach samples were identified to genus with the aid of taxonomic keys by Palmer (1962), Prescott (1954), Smith (1933), and Ward and Whipple (1945). Keys used to identify zooplankton were those by Needham and Needham (1963), Pennak (1953), and Ward and Whipple (1945).

Each essentially whole organism in the count was recorded. Parts of organisms were not recorded except to note their presence as partially digested material. Total organisms in the stomach samples were determined by multiplying the organisms in the counting cell by the dilution factor (25 for adults and 10 for young-of-the-year).

The average volumes of microorganisms found in stomach samples were calculated (Table 1). Average dimensions for 100 microorganisms were found by measuring each species with a calibrated ocular micrometer in a 645-power microscope. The formula used to calculate the volume was determined by the shape (cube, cylinder, rectangular parallelepiped, sphere) of the organism. Calculated volumes of stomach samples where little digestion had taken place closely approximated the centrifuge volume of the same sample. The volume of unidentified digested material and fragments of organisms in each sample were found by subtracting the calculated volume for identified whole organisms from the centrifuged volume.

Table 1. Calculated volumes of organisms found in bigmouth and smallmouth buffalo stomach samples in 1962 and 1963 from Lewis and Clark Lake and the Missouri River.

Animals

Classification of organisms		Volume in milliliters	Classification of organisms		Volume in milliliters
Protozoa			*Diaptomus*	(small)	2×10^{-4}
Codonella		39×10^{-8}		(medium)	7×10^{-4}
				(large)	14×10^{-4}
Rotifera			*Eucyclops*		5×10^{-4}
Brachionus		3×10^{-5}	Copepod eggs		2×10^{-6}
Keratella		74×10^{-8}	Nauplii		43×10^{-6}
Rotifer eggs		55×10^{-8}			
			Insecta		
Crustacea			Diptera		
Cladocera			*Chironomus*	(1 mm)	5×10^{-6}
Bosmina		4×10^{-5}		(2 mm)	16×10^{-6}
Chydorus		4×10^{-5}		(3 mm)	94×10^{-6}
Daphnia	(small)	25×10^{-5}		(4 mm)	18×10^{-5}
	(medium)	58×10^{-5}		(5 mm)	35×10^{-5}
	(large)	88×10^{-4}		(6 mm)	45×10^{-5}
Daphnia eggs		56×10^{-7}		(7 mm)	88×10^{-5}
Leptodora		14×10^{-4}	*Probezzia*		1×10^{-3}
Moina		58×10^{-6}			
			Ephemeroptera		
Copepoda			*Caenis*		3×10^{-3}
Cyclops	(small)	73×10^{-6}			
	(medium)	15×10^{-5}	Hemiptera		
	(large)	5×10^{-4}	*Sigara*		23×10^{-4}

Plants

Classification of organisms		Volume in milliliters	Classification of organisms		Volume in milliliters
[illegible]			Chrysophyta		
[illegible]		[illegible]	[illegible]		[illegible]
	(strand)	[illegible]	[illegible]		$38 \times 10^{-[illegible]}$
[illegible]		2×10^{-7}	*Cyclotella*		97×10^{-8}
Microspora		38×10^{-9}	*Cymbella*		9×10^{-7}
Mougeotia		24×10^{-8}		(sheath)	15×10^{-6}
Oedogonium	(small)	19×10^{-9}	*Fragilaria*		3×10^{-8}
	(large)	75×10^{-9}	*Gyrosigma*		5×10^{-8}
Pediastrum		38×10^{-8}	*Navicula*		25×10^{-9}
Rhizoclonium		24×10^{-8}			
Scenedesmus		14×10^{-9}	Cyanophyta		
Ulothrix		2×10^{-7}	*Oscillatoria*	(strand)	23×10^{-8}

* All volumes are for a cell unless otherwise stated.

Reliability of the technique was determined by counting 10 samples from a 25-milliliter graduated cylinder containing 100 *Daphnia* and 1000 *Diaptomus*. The number of *Daphnia* calculated from the counts ranged from 75 to 225 organisms with the mean at 157. The calculated number of *Diaptomus* ranged from 700 to 1175 organisms with the mean at 995. Due to the wide ranges in the numbers of both organisms, no satisfactory confidence interval could be established. Since the stomach samples involved in the study were numerous, proportionate numbers and volumes of food organisms indicate the general food habits of these fish.

RESULTS

Young-of-the-year bigmouth buffalo. Stomach analysis was conducted on 261 fish ranging from 16 to 47 millimeters in length captured during the summer of 1963. Nineteen fish collections were made in shallow bays and terminal ends of intermittent streams in the lake where depths were less than three feet. These areas were sampled by small mesh seining (191 fish) and electrofishing (66 fish) which accounted for 98 percent of all fish captured. Two collections by trawling were made in five to six feet of water and accounted for only four fish.

Zooplankton made up 100 percent of the stomach volume and occurred in all samples (Table 2). Crustacea accounted for 91 percent of the stomach volumes. Copepods (principally *Cyclops*, *Diaptomus*, and *Eucyclops*) contributed 80 percent to the volume while cladocerans

Table 2. Stomach contents of young-of-the-year bigmouth buffalo taken from Lewis and Clark Lake during June, July, and August, 1963--expressed as percent volume and percent frequency of occurrence (parentheses).

Item	Fish length intervals (millimeters)						
	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Phytoplankton	T* (4)		T (4)				
Chlorophyta	T (4)		T (4)				
Zooplankton	100 (100)	100 (100)	100 (100)	100 (100)	100 (100)	100 (100)	100 (100)
Rotifera	6 (25)	4 (41)	9 (83)	25 (99)	6 (87)	13 (100)	T (100)
Crustacea	94 (100)	96 (100)	91 (73)	75 (40)	94 (90)	87 (100)	100 (100)
Cladocera	43 (68)	21 (64)	1 (27)	1 (12)	1 (37)	10 (100)	1 (100)
Copepoda	51 (68)	73 (75)	90 (65)	74 (35)	93 (90)	77 (100)	99 (100)
Fragments**		2 (2)					
Insecta	T (4)	T (2)	T (4)	T (2)			
Diptera	T (4)	T (2)	T (4)	T (2)			
Stomachs with food	25	61	52	85	30	4	2
Stomachs empty	1	0	1	0	0	0	0

* Trace amounts less than one percent.

** Fragments of Crustacea.

(represented by *Chydorus* and *Daphnia*) accounted for 11 percent. Cladocera were more important to the smaller fish (15 to 24 millimeters) and averaged 32 percent of their stomach volumes. The rotifers, *Branchionus* and *Keratella*, made up nine percent of the volume in all stomachs. Johnson (1963) found copepods and cladocerans to be the most important food organisms of young bigmouth buffalo in Pasqua Lake, Saskatchewan.

Insects (*Chironomus* larvae) and phytoplankton (*Pediastrum*) were found in trace amounts and contributed little to the stomach volumes.

Adult bigmouth buffalo. During collection periods in 1962 and 1963, 125 bigmouth buffalo ranging in size from 330 to 530 millimeters were collected for stomach analysis. Because of poor recruitment, no bigmouth buffalo from 50 to 330 millimeters were collected. Thirty-two collections which accounted for 65 percent of the catch were made by electrofishing along shorelines in less than four feet of water. Sixteen collections representing 35 percent of the fish captured were made in water eight to ten feet deep by trawling and gill netting. These fish were members of the 1955 through 1958 year classes.

Copepods (*Cyclops, Diaptomus, Eucyclops*) and cladocerans (*Bosmina, Daphnia*) made up 99 percent of the stomach contents in 1962 and 95 percent in 1963 (Tables 3 and 4). Microcrustaceans occurred in all stomach samples examined for the two year period. Unidentified material consisting of fragments of copepods and cladocerans constituted 42 percent of the stomach volumes. Calculation of the percentage

Table 3. Stomach contents of bigmouth buffalo (330 to 530 millimeters) taken from all stations on Lewis and Clark Lake and the Missouri River in 1962--expressed as percent volume and percent frequency of occurrence (parentheses).

Item	Date				
	June	July	August	September	October
Phytoplankton			T* (10)		4 (100)
Chlorophyta			T (10)		T (100)
Chrysophyta					4 (100)
Zooplankton	100 (100)	100 (100)	100 (100)	100 (100)	96 (100)
Rotifera			T (10)		
Crustacea	100 (100)	100 (100)	100 (100)	100 (100)	96 (100)
Cladocera	10 (60)	3 (50)	7 (30)	4 (58)	
Copepoda	13 (50)	38 (56)	37 (55)	88 (100)	96 (100)
Fragments**	77 (90)	59 (78)	56 (65)	8 (33)	
Insecta***	T (10)				
Sand		T (5)	T (5)		
Stomachs with food	10	18	20	12	1
Stomachs empty	1	1	2	0	0

* Trace amounts less than one percent.
** Fragments of Crustacea.
*** Unidentified insect fragments.

Table 4. Stomach contents of bigmouth buffalo (330 to 530 millimeters) taken from all stations on Lewis and Clark Lake and the Missouri River in 1963--expressed as percent volume and percent occurrence (parentheses).

Item	Date				
	May	June	July	August	September
Phytoplankton					4 (25)
Chlorophyta					4 (25)
Zooplankton	100 (100)	100 (100)	99 (100)	100 (100)	80 (100)
Rotifera	2 (17)	T* (10)	T (5)	T (50)	
Crustacea	98 (100)	100 (100)	99 (100)	100 (100)	80 (100)
Cladocera	14 (75)	49 (65)	1 (29)	4 (100)	
Copepoda	72 (92)	19 (95)	T (19)	96 (100)	6 (50)
Fragments**	12 (33)	32 (85)	98 (95)		74 (50)
Sand	T (8)	T (5)	1 (5)		16 (25)
Stomachs with food	12	20	21	2	4
Stomachs empty	1	0	0	0	0

* Trace amounts less than one percent.
** Fragments of Crustacea.

of cladocera and copepods from observed fragments in digested material was impossible. A ratio of one cladoceran to four copepods based on whole organisms counted was established. On this basis, digested Crustacea is assumed to be 20 percent cladocerans and 80 percent copepods. The results of this study are similar to the findings of Moen (1954) in northwest Iowa lakes. He examined 259 bigmouth buffalo stomachs and found that they were feeding principally on small crustaceans (Entomostraca).

Chironomus larvae were found in five stomach samples examined and accounted for only a trace of the volume. Moen (1954) states insect larvae (most commonly Tendipedidae) were taken frequently but seldom made up more than one percent of the total food volume in any one stomach. Studies on bigmouth buffalo in Clear Lake, Minnesota by Scidmore and Woods (1959) revealed only trace amounts of insects taken in 1955 and 10 percent of the volume in 10 fish captured in 1957.

Phytoplankton was found in four stomach samples and with the exception of one stomach which contained four percent it was present in trace amounts. Moen (1954) states plant material seldom contributed more than 10 percent of the volume of food organisms. Plant material, mainly diatoms, was negligible in the intestines of bigmouth buffalo studied by Johnson (1963). Plankton algae in trace amounts was noted by Scidmore and Woods (1959).

The grouping of fish according to size, collection method, and collection station revealed no change in the feeding habits.

Young-of-the-year smallmouth buffalo. In 1962 and 1963, six smallmouth buffalo from 35 to 64 millimeters in length were captured. Copepods and cladocerans made up 99 percent of the stomach contents while sand constituted the remainder. According to Forbes (1888), Forbes and Richardson (1920) and Gowanloch (1933) the food of young smallmouth buffalo consists of 80 percent algae and duckweed. The animal food as reported by these authors includes protozoa, rotifers, insect eggs and larvae.

Adult smallmouth buffalo. In 1962 and 1963, 271 fish from 250 to 400 millimeters in length were captured. No smallmouth buffalo in the 65 to 250 millimeter size range were collected. Thirty-nine collections, made by electrofishing, accounted for 70 percent of the catch. Gill netting and trawling constituted 30 percent of the fish captured in 35 individual collections. Smallmouth buffalo were collected in the same areas and water depths as bigmouth buffalo. Fish captured in 1962 represented the 1956 through 1958 year classes. Primary year classes for 1963 fish sampled were the 1957 through 1960 groups.

Zooplankton was found in 78 percent of the stomach samples and accounted for 81 percent of the total volume (Tables 5 and 6). Copepods (*Cyclops*, *Diaptomus*, *Eucyclops*) contributed 74 percent to the total volume of zooplankters while cladocerans (*Bosmina*, *Chydorus*, *Daphnia*) constituted the remaining 26 percent. Forbes (1888) states that animal matter taken by smallmouth buffalo is composed principally of

Table 5. Stomach contents of smallmouth buffalo (250 to 400 millimeters) taken from all stations on Lewis and Clark Lake and the Missouri River in 1962--expressed as percent volume and percent occurrence (parentheses).

Item	Date				
	June	July	August	September	October
Phytoplankton	T* (38)	6 (53)	18 (28)	22 (40)	17 (34)
Chlorophyta	T (38)	4 (22)	10 (21)	18 (40)	3 (34)
Chrysophyta		2 (19)	8 (24)	4 (40)	14 (25)
Zooplankton	71 (88)	30 (72)	33 (92)	20 (52)	27 (75)
Rotifera	T (13)	T (17)	2 (25)	T (12)	T (9)
Crustacea	71 (88)	30 (72)	31 (9[illegible])	20 (44)	26 (69)
Cladocera	28 (63)	13 (53)	4 (46)	2 (44)	5 (44)
Copepoda	43 (88)	17 (69)	27 (88)	18 (40)	21 (56)
Hydracarina		T (8)	T (4)		1 (6)
Insecta	T (25)	3 (67)	1 (47)	T (20)	T (34)
Diptera	T (13)	3 (67)	1 (39)	T (20)	T (28)
Other	T (13)	T (6)	T (8)	T (4)	T (6)
Digested**	29 (63)	58 (83)	46 (60)	58 (84)	56 (69)
Debris***		2 (31)	1 (29)	T (24)	T (16)
Sand	T (25)	1 (50)	1 (68)		T (50)
Stomachs with food	8	36	72	25	32
Stomachs empty	5	6	3	2	0

* Trace amounts less than one percent.
** Unidentified digested material and mucous.
*** Woody and herbaceous plant fragments.

Table 6. Stomach contents of smallmouth buffalo (250 to 400 millimeters) taken from all stations on Lewis and Clark Lake and the Missouri River in 1963--expressed as percent volume and percent occurrence (parentheses).

Item	Date		
	April	May	June
Phytoplankton	9 (25)	25 (38)	5 (46)
Chlorophyta	9 (25)	1 (32)	4 (27)
Chrysophyta		24 (30)	1 (34)
Zooplankton	16 (100)	19 (68)	37 (85)
Rotifera		T* (3)	T (24)
Crustacea	16 (100)	19 (68)	37 (83)
Cladocera		7 (43)	7 (56)
Copepoda	16 (100)	12 (65)	30 (83)
Insecta	27 (75)	2 (49)	11 (85)
Diptera	27 (50)	2 (43)	10 (83)
Other	T (25)	T (8)	1 (10)
Digested**	43 (75)	51 (81)	40 (73)
Debris***		1 (11)	2 (27)
Sand	5 (50)	2 (38)	5 (66)
Stomachs with food	4	37	41
Stomachs empty	0	0	0

* Trace amounts less than one percent.
** Unidentified digested material and mucous.
*** Woody and herbaceous plant fragments.

Mollusca, Entomostraca, Planaria and Polyzoa. Gowenloch (1933) in his report on Louisiana fishes states that food of the smallmouth buffalo consists of molluscs, insects, and freshwater crustaceans in about equal amounts.

The 1962 stomachs showed a general increase in the percent volume of phytoplankton during the summer months (Table 5). Phytoplankton constituted 13 percent of the total stomach volume in both years. Chlorophyta (Cladophora, Mougeotia, Oedogonium, Ulothrix) accounted for 48 percent of the phytoplankton in all stomachs. The Chrysophyta (Cymbella, Fragilaria, Gyrosigma, Navicula) made up 52 percent of the total phytoplankton. The vegetable food of smallmouth buffalo examined by Forbes and Richardson (1920) consisted largely of duckweeds (Wolffia and Lemna) and the remainder was made up of algae and larger aquatic plants.

Insects (primarily Chironomus) constituted trace amounts of the stomach volumes during June, September, and October of 1962. The months of July and August showed a slight increase to one and three percent of the volume respectively. In the 1963 samples, chironomid larvae made up 27 percent of the volume in April, two percent in May, and 10 percent in June. Insects accounted for larger percentages of volume in the earlier 1963 sampling period. Lagler and Ricker (1943) in studies of Foots Pond, Indiana found that the stomach contents of smallmouth buffalo were entirely filled with chironomid pupae.

Stomach analyses from both years revealed debris (herbaceous plant detritus and fragments of woody material) in 33 percent of the stomachs and sand in 54 percent. This material represented volumes ranging from a trace to five percent of the stomach contents.

Analysis of smallmouth buffalo stomach samples was difficult due to the large amounts of digested material encountered. Stomachs from 1962 and 1963 contained 49 and 45 percent digested material respectively.

No change in the constituents of stomach samples was noted between sampling stations, size of fish or sampling methods.

SUMMARY AND CONCLUSIONS

Food habits of bigmouth and smallmouth buffalo in Lewis and Clark Lake and the Missouri River in 1962 and 1963 are described from the analysis of 663 stomach samples.

1. The method of subsampling used, counting the microorganisms in a milliliter sample and multiplying by a dilution factor, did not prove to be satisfactory. No confidence limits were established due to the sampling error.

2. Young-of-the-year bigmouth buffalo food habits were determined from 261 fish collected by small mesh seining, electrofishing, and trawling. Zooplankton made up 100 percent of the stomach volumes of which crustacea constituted 91 percent and rotifers the remainder. Copepods made up 80 percent of the stomach volumes and were the most important group of organisms in the diet.

3. Adult bigmouth buffalo (125 stomach samples) were collected by electrofishing, trawling, and gill netting. Copepods and cladocerans were the primary food organisms taken by the fish and comprised 99 percent of the volume in 1962 and 95 percent in 1963. The pattern of feeding extensively on crustacea is apparently established in the post-larval fishes and continues through adulthood. The findings of this study are concurrent with those of Moen (1954) and Scidmore and Woods (1959). The contents of stomachs examined indicate that these fish are not an extensive bottom forager in this ecosystem but generally feed in a niche removed from the bottom.

4. Young-of-the-year smallmouth buffalo were not abundant during the periods of collection and only six fish were captured. The analysis of their digestive tracts revealed 99 percent copepods and one percent sand.

5. Adult smallmouth buffalo were easily captured by all collecting methods. The analysis of 271 stomach samples indicates that zooplankton contribute about 65 percent to the total food volume. Phytoplankton make up about 30 percent of the stomach volume. The remaining five percent is composed of equal amounts of chironomid larvae, plant detritus and sand. These figures are based on identified organisms and do not take into account unidentified digested material or possible differences in digestion rate. Computation of exact amounts for total stomach volumes was impossible because of the large amounts of digested material.

The presence of sand and plant detritus in 54 and 33 percent respectively of the stomach samples indicates these fish are feeding at the bottom.

LITERATURE CITED

American Public Health Association, American Water Works Association and Sewage and Industrial Water Association. 1960. Standard methods for the examination of water and wastewater, 11th ed. Waverly Press Inc., Baltimore. 626 pp.

Forbes, S. A. 1888. On the food relations of fresh-water fishes: a summary and discussion. Ill. Lib. Nat. Hist., II(8): 475-538.

Forbes, S. A. and R. E. Richardson. 1920. The fishes of Illinois. Nat. Hist. Surv. Ill., III: 66-73.

Gowanloch, James Nelson. 1933. Fishes and fishing in Louisiana. La. Dept. Cons. Bull., 23: 431-434.

Johnson, R. P. 1963. Studies on the life history and ecology of the bigmouth buffalo. Jour. Fish. Res. Bd. Canada, 20(6): 1397-1429.

Lagler, Karl F. and William E. Ricker. 1943. Biological fisheries investigations of Foots Pond, Gibson County, Indiana. Invest. Ind. Lakes and Streams, 2(3): 47-72.

Moen, Tom. 1954. Food of the bigmouth buffalo in northwest Iowa lakes. Proc. Ia. Acad. Sci., 61: 561-569.

Needham, James G. and Paul R. Needham. 1963. A guide to the study of fresh-water biology. Holden-Day, Inc., San Francisco. 108 pp.

Palmer, C. Mervin. 1962. Algae in water supplies. U. S. Dept. Health, Ed. and Welfare Pub. Health Serv., Wash., D. C. 88 pp.

Pennak, Robert W. 1953. Fresh-water invertebrates of the United States. Ronald Press Co., N. Y. 769 pp.

Prescott, G. W. 1954. How to know the fresh-water algae. Wm. C. Brown Co., Dubuque, Ia. 211 pp.

Scidmore, W. J. and Donald E. Woods. 1959. Some observations on competition between several species of fish for summer foods in four southern Minnesota lakes in 1955, 1956 and 1957. Minn. Fish and Game Invest., Fish Series, 2: 13-24.

Shields, James T. 1957. Report of fisheries investigations during the second year of impoundment of Gavins Point Reservoir, South Dakota, 1956. Dingell-Johnson Proj. F-1-R-6, Mimeo. 34 pp.

Smith, Gilbert M. 1933. The fresh-water algae of the United States, 1st ed. McGraw Hill Co., N. Y. 716 pp.

Ward, Henry Baldwin and George Chandler Whipple. 1945. Fresh-water biology. John Wiley and Sons, Inc., N. Y. 1111 pp.