FOOD HABITS OF THE CARP, *CYPRINUS CARPIO* L., IN FIVE OKLAHOMA RESERVOIRS[1]

by

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ABSTRACT

Alimentary tracts were examined of 1010 carp collected with gill and trammel nets by commercial fishermen from four riverine reservoirs, and 211 adult and 45 young carp from Lake Carl Blackwell, a headwaters reservoir. The alimentary tract contents of carp in five Oklahoma reservoirs contained algae, plant fragments, seeds, entomostraca, chironomids, *Chaoborus*, pelecypods, caddisflies, Ceratopogonidae, animal fragments, and organic and inorganic matter. Terrestrial insects were of rare occurrence. The major volumetric constituents in the alimentary tracts of carp from the riverine reservoirs Grand, Fort Gibson, Eufaula, and Texoma Reservoirs were: unidentified organic matter (65.5%), animal fragments (12.5%), plant fragments (10.1%), entomostraca (3.8%), algae (1.9%), pupae (1.1%). Adult carp collected by electrofishing from Lake Carl Blackwell, a headwaters impoundment, contained on a volumetric basis, 41.7% organic detritus, 35.9% plant matter (18.8% plant fragments, 11.8% seeds, 5.3% algae), 5.0% entomostraca, 3.1% chironomids, 0.2% *Chaoborus*, 8.9% animal fragments. Organic detritus was also the major volumetric constituent (49.8%) of the 45 young carp (<9 inches total length) examined from Lake Carl Blackwell. Stomachs of young carp contained no algae, and fewer seeds and plant fragments than the adults, and a considerably larger volume of entomostraca (19.2% of the total volume). Carp seem to feed on the unconsolidated portion of the substrate. Organisms like tubificids, and burrowing mayflies and odonates, requiring consolidated substrate, were not present. The Cladoceran genus *Chydorus* which lives in the flocculent material at the substrate-water interface, predominated over limnetic genera like *Bosmina* and *Daphnia*. Seeds were very abundant in Carl Blackwell carp following a spring flooding of marginal vegetation. No fish eggs, fish fry, dragonflies, mayflies or oligochaetes were found in carp tracts, and only two tracts contained fish. There was considerable monthly and inter-reservoir variation in abundance of most items. In Lake Texoma, peak abundance of Cladocera and Copepoda in carp tracts coincided with the maximum inflow of water.

In the Oklahoma reservoirs studied, carp probably have little effect on water quality or availability of aquatic plants. Food competition by carp is probably greatest with young game fishes, young and adult river carpsucker and smallmouth buffalo. The high relative abundance of carp, carpsucker and smallmouth buffalo is attributable to their consumption of particulate organic matter, and the community of decomposer organisms and the invertebrates which feed on the organic detritus. Direct competition with game fish would

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occur among larval game fish when food scarcity during the critical period could limit year class strength. Indirect food competition occurs between carp and larger invertebrate life which are utilized by juvenile game fishes.

INTRODUCTION

The contents of 5074 stomachs or intestinal tracts of 8 species of fishes occurring in the commercial gill and trammel net catch from four Oklahoma reservoirs were examined. The purpose of the food habits study was to determine the biological basis for productivity of these fishes and interspecies relationships. Collections were made between August 1967 and July 1968, coinciding with the period of field collection for the "Commercial Fisheries Statistics Survey" of the annual harvest of commercial fish (Parrack, Brown, and Mensinger, In press). Live weight-dressed weight relationships for 7 of the 8 commercial species were presented by Mensinger and Brown (1969).

The eight species included in the food habits study were the flathead catfish *(Pylodictis olivaris)*, smallmouth buffalo *(Ictiobus bubalus)*, bigmouth buffalo *(Ictiobus cyprinellus)*, river carpsucker *(Carpiodes carpio)*, drum *(Aplodinotus grunniens)*, longnose gar *(Lepisosteus osseus)*, shortnose gar *(L. platostomus)*, and the carp. This paper presents the findings on the intestinal tract contents of carp. Elsewhere in these proceedings, Tafanelli, Mensinger and Mauck have described the food habits of two species of buffalo, and Turner and Summerfelt described the stomach contents of the flathead catfish. Manuscripts on the two species of gar, the drum and river carpsucker are in preparation.

Carp comprised 15.8% of the 1,126,537 pounds of fish harvested by commercial fishermen from four Oklahoma reservoirs between July 1967 and June 1968. Carp ranked second to buffalo *(Ictiobus* spp.*)* in total pounds harvested by commercial fishermen. The average weight of adult carp in the commercial catch was 5.0 pounds, and the harvest of carp averaged 0.9 pounds per surface acre.

Food habits of 1011 adult carp are described from 4 riverine reservoirs where carp were commercially harvested, and of 211 adult carp from a reservoir where commercial fishing was not permitted. Observations were also made on alimentary tract contents of 45 juvenile carp from the latter reservoir. This report describes the types of tract contents, and numerical and volumetric composition; differences between diet of carp collected from four larger riverine reservoirs compared with those from a smaller headwaters reservoir; differences between young and adult carp; and monthly variation.

DESCRIPTION OF THE RESERVOIRS

Grand and Fort Gibson Reservoirs are located in the northeastern section of Oklahoma (Figure 1). Grand Lake had the highest standing crop of fish, perhaps related to high fertility of the Neosho and Spring Rivers which receive enrichment from feedlots (Kansas) and poultry production (Missouri), respectively. Fort Gibson, an impoundment of Grand (Neosho) River located downstream from Grand Lake and Lake Hudson (Markham Ferry Project), had a smaller standing crop of fish than the upper two reservoirs. Fort Gibson in 1967 had the lowest estimated commercial harvest (55,468 pounds) compared with the other reservoirs; Eufaula 141,258 pounds; Grand 94,895 pounds; and Texoma 834,915 pounds.

Lake Carl Blackwell is located in north-central Oklahoma 10 miles west of Stillwater. It is a headwater impoundment of Stillwater Creek, a tributary of the Cimarron River. During the study its surface area was 2400 acres. It is highly turbid because of wind-induced turbulence. Gizzard shad comprised 75% of the estimated biomass in a June 1968 cove rotenone sample. The last commercial fishery harvest on this reservoir was in 1957.

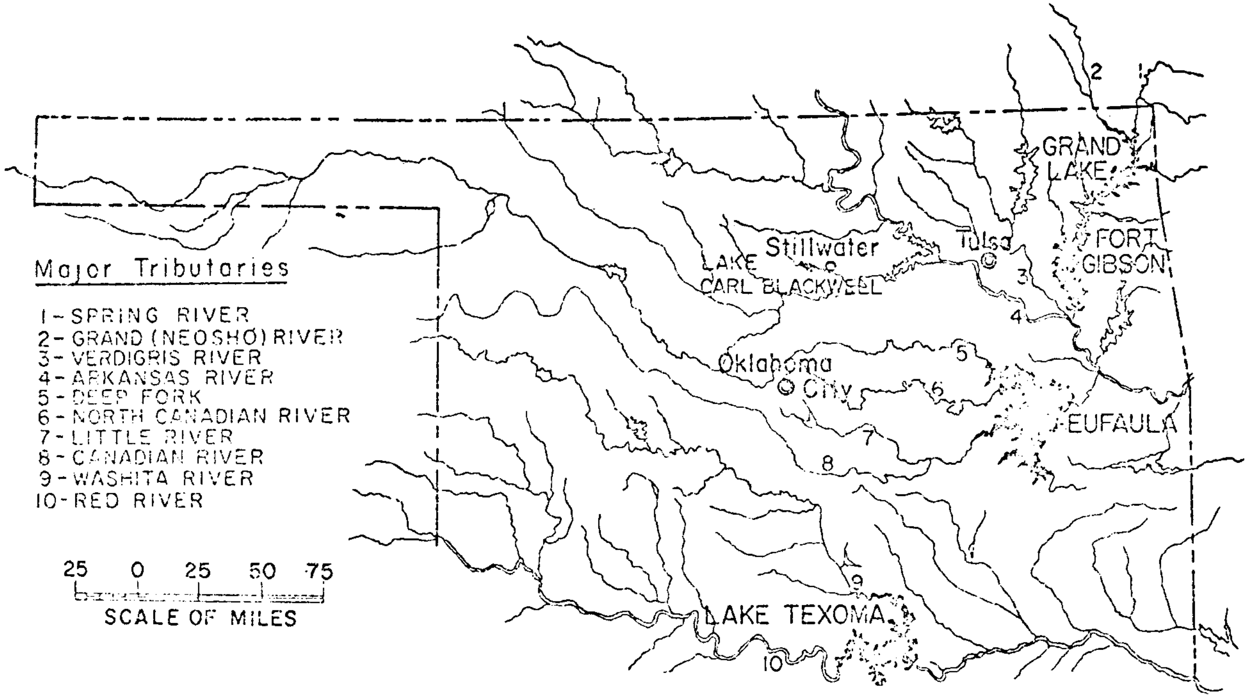

FIGURE 1. Location of the five Oklahoma reservoirs where carp were collected for food habits analysis.

Eufaula Reservoir, located in east central Oklahoma, ranks as the 15th largest impoundment in the U. S. Its total storage capacity is 3.8 million acre-feet. Three major rivers, the North Canadian, the Canadian River, and the Deep Fork River, contribute to its inflow. Lake Texoma, the second largest Oklahoma reservoir in surface area, is a riverine reservoir formed by impounding the Washita and Red Rivers on the Oklahoma-Texas border. Its storage capacity of 5.3 million acre-feet exceeds that of Eufaula Reservoir.

Certain morphometric data, productivity indices, and comparisons of standing crop (Jenkins, 1957) and commercial catch of carp are given in Table 1. Age shown is the years since impoundment. Surface area is at top of power pool; surface area for Lake Carl Blackwell was the spillway level. The shoreline development index is the ratio of the actual length of shoreline of a lake to the circumference of a circle which would be equal to the surface area of the reservoir; the morphoedaphic index equals the total dissolved solids (ppm) divided by mean depth in feet. Grand Lake has the greatest shoreline development, but Texoma and Blackwell have the highest total dissolved solids-mean depth ratio. Standing crop of fish in these reservoirs seems more closely related to the shoreline development index than the morphoedaphic index.

PROCEDURES

Fish Collections

The entire alimentary tracts of adult carp from Grand Lake, Fort Gibson, Lake Texoma and Eufaula reservoirs were purchased from commercial fishermen who generally fished on a fulltime basis and attended their nets regularly. These fish were collected in gill or trammel nets of 3-inch bar mesh or larger, but most fishing was done with nets of 3-inch to 3½-inch mesh. Cooperating fishermen were provided containers with 10% formalin solution in the summer months and a 5% solution in the winter, and cotton soil sample bags (4.5 x 6 inches, or 7 x 12.5 inches) with draw strings, in which they placed the alimentary tracts of individual carp. Air bladders and ovaries were not included with the alimentary tract. Collectors were encouraged to use precaution in dressing the fish to prevent loss of the contents. These containers were collected monthly between September 1967 and August 1968.

Samples of lengths and weights of individual carp were collected by Department of Wildlife Conservation biologists. Most carp in the Oklahoma commercial catch weighed between 3 and 8 pounds. The weighted mean weight of carp in the four riverine reservoirs was 5.0 pounds (sample size of 1219). The average length of carp was 20.2 inches (sample size of 751). The average weight of carp in the Oklahoma commercial fishery is larger than many other reservoir fisheries (Parrack, 1970). Carp collected by electrofishing in Lake Carl Blackwell averaged only 1.0 pound. Length-weight data for carp from the riverine reservoir were reported by Parrack, Mensinger and Brown (In press).

Fish collected by the commercial fishermen were largely from the sublittoral and profundal zones, because commercial fishermen were required by statute to locate their nets 100 yards from the bank and at least 4 feet below the surface. Time between net raises for Lake Texoma fishermen was 1.1 to 1.2 days June through August and 1.7 to 2.2 days October through March (Parrack, Mensinger and Brown, In press). However, fishermen providing tracts were encouraged to raise the nets more often and they probably raised their nets more frequently than these averages.

The 256 carp from Lake Carl Blackwell were collected by electrofishing in all months (except January) for comparison to tract contents of fish net-caught by commercial fishermen. Electrofishing was generally within 80-100 feet of the bank in water $<$ 10 feet in depth. The sample was composed of 211 adult ($<$ 9 inches) and 45 young ($<$ 9 inches). Alimentary tracts were removed as soon as fish were transported from the field to the laboratory, a matter of a few hours.

TABLE 1

CHARACTERISTICS OF FIVE OKLAHOMA RESERVOIRS FROM WHICH CARP WERE COLLECTED FOR FOOD HABITS ANALYSES.

Reservoir	Age in 1967	Surface area (acres)	Length shoreline (miles)	Shoreline development index	TDS	Morphoedaphic index	Standing crop of fish (lbs/acre)	Avg. wt. carp (lbs) commercial catch	Carp as % total wt. commercial catch
Grand (Grand R.)	26	59,000	1300	38.2	178	7.1	236	4.3	15.9
Ft. Gibson (Grand R.)	14	19,100	225	11.6	165	8.7	124	3.8	16.1
Eufaula (Canadian R.)	2	102,500	600	13.4	225	10.0	220[2]	2.8	3.6
Texoma (Red R.)	23	93,080	580	12.8	840	28.0	145	6.7	17.9
Carl Blackwell (tributary of Cimarron R.)	30	3,700	45	5.2	337	19.0	137	1.0[1]	—

[1]Avg. wt. of fish collected by electrofishing.
[2]Estimated from morphoedaphic index (Jenkins, 1967: Figure 3).

Analysis of Alimentary Tracts

The entire contents of alimentary tracts ("tracts"), i.e., espophagus to anus, were emptied into a jar, the contents of all tracts collected from a reservoir for a month being pooled and stored in a single container. Group analyses procedures similar to those described by Borgeson (1963) were used. The contents of each jar were concentrated on filter paper in a Buchner funnel with a vacuum. Contents were lightly blotted to remove excess moisture and total volume of the contents was measured by water displacement. Contents were placed in a white porcelain pan and diluted with one or two liters of water to facilitate sampling. Successively, ten, 1-cc samples were withdrawn with a wide orifice pipette and placed in a 1-cc Sedgwich-Rafter counting cell. The entire contents were enumerated on a dissecting microscope (40 X). Percentage total volume of each item was visually estimated in each of the 10 samples. The average number of organisms in the samples was related to number per stomach by use of the appropriate dilution factor and the number of stomachs in the pooled sample. The mean of the ten samples was used to characterize the abundance of food items on a numerical and volumetric basis.

RESULTS

The Lake Carl Blackwell Carp

Average tract contents of the 211 large carp ($>$ 230 mm) were 14 times larger than the 45 small carp ($<$230 mm). Detritus was the major volumetric tract constituent of both young (76.2% of the volume) and adult (73.2%) carp in Lake Carl Blackwell (Table 2). Three categories of detritus were recognized: plant and animal fragments, inorganic particles, and unidentifiable organic matter. Plant fragments were composed of triturated stems and leaves, mostly of terrestrial plants. Animal fragments were composed of pieces of chitinized exoskeleton of insects and entomostraca.

Organic detritus was generally the most important category, comprising 49.8% of the tract contents of young carp and 41.7% in tracts of adult carp. Absolute amounts of organic matter varied directly with the total volume of tract contents. Correlations between twelve monthly means of average volumes of total tract contents and organic matter was highly significient (r= .87; P 10 d.f.$<$.01). The linear regression, using the monthly average volume or organic matter as the dependent variable (Y), and total volume of tract contents (X) was: $Y = 0.61 + 0.33X$. In young carp, the volume of organic matter was highly variable (.088 to .469 cc per tract), but total volume, except for June, ranged from 0.1 to 0.6 cc. Thus, in adult carp organic matter was apparently consumed, or produced from digestion, in direct proportion to the total contents of each tract. Occurrence of organic matter in small carp was independent of total volume of tract contents.

On a volumetric basis plant matter comprised 35.9% of the volumetric composition of tract contents of adult carp but made up only 15.5% of the contents of tracts of young carp. Algae did not occur in the tracts of young carp and comprised only 5.3% of the mean total volume in tracts of adult carp. The number of plant seeds averaged 2669 per tract in adult carp compared with 61 in young carp. Average volume of plant fragments as a percentage of total volume was greater in adult than young carp. Monthly variation in volume of plant fragments in adult carp was positively correlated with total tract contents (r=.46). Although this correlation was non-significant (P 10 d.f.$<$.05), due to small sample size, the correlation suggests that occurrence of plant fragments in carp tracts is, like organic matter, generally dependent upon total tract contents.

Animals assignable to a taxonomic category made up 9.7% of the tract volume in adult carp and 20.9% in young carp. The largest portion of the animal matter in young carp was entomostraca. The tracts of adult carp had a greater diversity of species.

Entomostraca comprised 19.2% of the volumetric composition of the tracts of young carp compared with only 5.0% of the tracts of the adult carp. The average number of Cladocera and Ostracoda per stomach was much higher in young carp, but the adults had a larger number of Copepoda. Tracts of young carp contained no *Chaoborus*, pelecypods, or algae. These items were common in tracts of adult carp.

Inter-Reservoir Comparisons

The composition of alimentary tract contents of 1010 carp collected from Grand, Fort Gibson, Eufaula and Texoma Reservoirs is presented for comparison with tract contents of 211 adult carp from Lake Carl Blackwell (Table 3).

The average volume of food per tract was similar in Grand, Fort Gibson, and Texoma (1.9 to 2.2 cc). The volume of the tracts of larger carp was less than one-third the volume of the smaller carp from Lake Carl Blackwell (7.1 cc). Effendie (1968) showed that at 20 C, all but 8% of the tract contents of carp would be digested in 12 hours. The smaller volume of the contents and the larger percentage of organic detritus in tracts of carp from riverine reservoirs probably resulted from digestion prior to removal from the nets. Organic detritus averaged 65.5% in the four riverine reservoirs, 24% higher than comparable data on Carl Blackwell carp. Similarity in qualitative composition in tract contents among the reservoirs indicates that contents of tracts of carp caught by fishermen would still provide useful relative comparisons.

Organic Detritus.—This category comprised 55 to 76% of the total volume of food in the 1010 carp tracts examined from four riverine reservoirs and 41.7% of total volume in carp tracts from Lake Carl Blackwell. The abundance of organic detritus in carp tracts from Grand Lake on a large volumetric basis and an apparent abundance of entomostraca, chironomids and Chaoborus suggests that the environment in Grand Lake is favorable to production of both macrobenthos and fish. Standing crop of fish in Grand Lake is higher than the other reservoirs (Table 1).

Plant Matter.—Material consisting of algae, seeds, and plant fragments made up 6.6 to 25.2% and 35.9% of the total volume of tract contents of carp from four riverine reservoirs and Lake Carl Blackwell, respectively. The large volume of plant matter, especially seeds, in carp tracts from Carl Blackwell seems related to inundation of marginal plants during the study. Seeds were more abundant in Lake Carl Blackwell carp than most reservoirs. The volumetric contribution by algae was highly variable and relatively large only in carp tracts from Eufaula Reservoir. The large contribution of plant fragments in Fort Gibson was mostly of terrestrial origin and predominantly cellulose fragments of low nutritional value.

Animal Matter.—Collectively, all categories of animals, excluding animal fragments, comprised 3.0 to 13.4% and 8.4% of the volumetric composition in the four riverine reservoirs and Lake Carl Blackwell, respectively. The diversity of categories of animal food was relatively small, Eufaula carp tracts had the smallest and Texoma the largest diversity. Animal fragments were most abundant in tracts of carp from Fort Gibson suggesting extensive digestion prior to removal from the nets. Collectively, the total contribution of animal fragments and identifiable animals was 11.5 to 25.5% of the carp diet in four riverine reservoirs compared with 17.3% in Carl Blackwell. In Lake Carl Blackwell and Eufaula Reservoirs, plant matter made up a larger relative contribution to the diet than animal matter.

Entomostraca were more abundant in carp tracts from Texoma than all other reservoirs, but this situation was also true of carp from Lake Carl Blackwell. Ostracods were always less numerous than other entomostraca, copepoda were usually most abundant. Abundance of entomostraca does not classify carp as pelagic plantivore, because it is more probable that the density

TABLE 2

ALIMENTARY TRACT CONTENTS OF YOUNG (<230 mm) AND ADULT (>230 mm) CARP *(CYPRINUS CARPIO)* IN LAKE CARL BLACKWELL, DECEMBER 1967 THROUGH NOVEMBER 1968.

Food items	Young Number avg.	Young Number %	Young Volume %	Adult Number avg.	Adult Number %	Adult Volume %
Plant						
Algae	-	-	-	-	-	5.3
Seeds	61	4.6	2.9	2669	56.0	11.8
Fragments	-	-	12.6	-	-	18.8
Animal						
Copepoda	352	26.8	6.4	1011	21.2	3.5
Cladocera	748	56.9	10.1	507	10.6	1.2
Ostracoda	97	7.4	2.7	82	1.7	0.3
Chironomidae	46	3.5	1.4	444	9.3	3.1
Chironomidae cases	3	0.3	0.1	-	-	-
Chaoborinae	-	-	-	25	0.5	0.2
Ceratopogonidae	6	0.5	0.2	34	0.7	0.3
Mollusca	-	-	-	-	-	1.1
Fish remains	-	-	-	-	-	Tr.*
Fragments	-	-	11.0	-	-	8.9
Detritus						
Organic	-	-	49.8	-	-	41.7
Inorganic	-	-	2.8	-	-	3.8
No. tracts	45			211		
Avg. vol. (cc)/ Alimentary tract	0.5			7.1		

*Trace (Tr.) represents volume less than .05 percent.

-*Indicates none were observed.*

TABLE 3

PERCENTAGE COMPOSITION OF TOTAL VOLUME OF CARP ALIMENTARY TRACTS IN FOUR RIVERINE RESERVOIRS (EUFAULA, GRAND, TEXOMA AND FORT GIBSON, SEPTEMBER 1967 THROUGH AUGUST 1968) COMPARED WITH THE DIET OF ADULT CARP FROM LAKE CARL BLACKWELL (DECEMBER 1967 THROUGH NOVEMBER 1968), AN UPSTREAM RESERVOIR

Item	The Riverine Reservoirs				Lake Carl
	Grand	Gibson	Eufaula	Texoma	Blackwell[1]
Plant					
Algae	0.12	0.29	25.24	3.11	5.3
Seeds	0.22	1.29	-	0.03	11.8
Fragments	6.19	18.50	-	8.35	18.8
Animal					
Pelecypods	-	1.33	-	0.02	1.1
Copepoda	0.46	0.36	0.32	5.42	3.5
Cladocera	0.82	0.33	0.16	3.33	1.2
Ostracoda	0.06	0.12	-	1.14	0.3
Chironomidae	3.50	3.96	2.52	2.80	3.1
Chaoborinae	2.76	0.02	-	0.06	0.2
Trichoptera (cases)	-	-	-	0.62	-
Fragments	9.41	17.43	8.52	12.07	8.9
Detritus					
Organic	76.00	55.34	62.14	62.09	41.7
Inorganic	0.46	1.03	1.10	0.96	3.8
No. tracts examined	420	287	13	290	211
Avg. vol. (cc)/tract	1.9	2.0	4.9	2.2	7.1

[1]The tract contents of Lake Carl Blackwell also contained a few fish remains (<0.1%) and some Ceratopogonidae which comprised 0.3% of the total.

of entomostraca is very great near the mud-water interface where carp feed. This hypothesis is supported by the predominance of the genera *Chydorus* and *Pleuroxus* over the more pelagic *Bosmina* and *Daphnia*. Chironomids were common in carp tracts from all reservoirs, but the migratory *Chaoborus* was relatively unimportant except in Grand Lake where they made up 2.7% of the volumetric composition.

Pelecypods occurred in tracts of carp from Carl Blackwell and Fort Gibson Reservoirs,but were absent in the other reservoirs. Specimens were always broken and fragmented pieces of *Pisidium*.

Monthly Variation

Young Carp (Lake Carl Blackwell). Variation was observed in the contents of carp tracts in the seven monthly collections of 45 young carp (primarily young-of-the-year and yearling fish) ranging in length from 92 to 230 mm (Table 4). Average monthly volumes of food in the tracts ranged from 0.1 to 1.2 cc, largest monthly volumes occurring in May, June and July. Plant fragments (avg. 12.6%) occurred in the tracts of carp between July and October. Seed consumption was higher than normal during the year of this study because of the influence of inundation of marginal plants in the spring. Seeds of the common smartweed, *Polygonum persicaria,* occurred most frequently, and grass seeds, family Gramineae, were common but present in small numbers. The relative contribution of seeds was greatest in September but the largest number occurred in October.

Entomostraca (Copepoda, Cladocera, and Ostracoda) were volumetrically important in tracts of young carp in all months but January and November. Two young carp collected in June contained an average of 12,000 Cladocera per tract which made up 94% of the total number of all organisms and 59.9% of the total volume of food in these two tracts. The bulk of entomostraca utilized by young carp were *Cyclops* and *Chydorus. The cladoceran genus Pleuroxus* was less common. Organic detritus was less abundant in months when Cladocera were volumetrically abundant, i.e., over 10%. This suggests selective feeding for Cladocera rather than consumption related to level of feeding on an organic substrate.

Young carp had larger numbers of *Chironomus* than the larger *Palpomyia* larvae. The sclerotized head capsules were often the only recognizable feature of many chironomid larvae due to mastication and digestive processes. Chironomids were numerically most abundant in June and October. Norton (1968) observed densities of chironomids in macrobenthos of Lake Carl Blackwell were about equal in these two months which suggests that temporal variability in occurrence of a good item is influenced by variability in abundance of the other items in the food complex.

Adult carp. Monthly average total volume of alimentary tract contents of adult carp in Carl Blackwell varied from 2.4 to 11.3 cc per fish (Table 5). The smallest monthly average volume coincided with the lowest average monthly water temperature (3 C) and the two largest monthly averages coincided with spring and fall periods when water temperatures were 7 to 9 C (Figure 2). Presumably, the lowest average tract contents occur in January because of inactivity due to low water temperatures, but the large volume of food in March and November may not coincide with periods of maximum intake because relationships between intake and digestive rates increase directly with temperature up to some maximum amount. Maximum intake probably occurs in August when tract contents averaged 8.2 cc per fish and water temperatures were 25-28 C. Surface water temperatures were 27 C in August and 23 C in September. Average volumes of organic matter in carp tracts July through September were 2.2 to 2.1 cc, i.e., showed little variation. Poor food supplies rather than rapid digestion seem to be the cause for decline in average volumes of food in tracts in July and September.

TABLE 4

MONTHLY VARIATION IN THE CONTENTS OF ALIMENTARY TRACTS OF YOUNG CARP (CYPRINUS CARPIO) FROM LAKE CARL BLACKWELL, OKLAHOMA, JANUARY THROUGH NOVEMBER 1969; VALUES ARE PERCENTAGES OF THE TOTAL VOLUME FOR EACH MONTH AND (IN PARENTHESIS) THE AVERAGE NUMBER OF EACH ORGANISMS PER TRACT.

Month	No. of fish	Avg. Vol. (cc) food per fish	Plant: Seeds[1]	Plant: Plant fragments	Animal: Copepoda[2]	Animal: Cladocera[3]	Animal: Ostacoda	Animal: Chironomidae	Animal: Animal fragments	Detritus: organic	Detritus: Inorganic	Detritus: All detritus[5]
Jan.	1	0.1	-	-	4.2	0.4	0.4	-	50.0	45.0	-	95.0
			-	-	(105)	(15)	(10)	-	-	-	-	
May	1	0.6	-	-	45.0	20.0	-	-	20.0	14.6	0.4	35.0
			-	-	(3640)	(1720)	-	-	-	-	-	
Jun.	2	1.2	-	-	1.8	59.9	-	5.0	11.4	21.7	0.2	33.3
			-	-	(380)	(12,000)	-	(420)	-	-	-	
Jul.	11	0.6	1.0	16.0	3.0	4.2	5.2	0.8	11.4	58.4	-	69.8
			(45)	-	(245)	(391)	(218)	(45)	-	-	-	
Aug.	19	0.4	4.2	15.0	2.8	2.4	3.2	1.2	10.0	60.6	0.6	86.2
			(63)	-	(105)	(79)	(89)	(26)	-	-	-	
Sep.	7	0.4	9.2	17.0	9.4	-	0.4	0.2	10.4	53.2	0.2	80.8
			(97)	-	(326)	-	(11)	(6)	-	-	-	
Oct.[6]	3	0.4	2.6	11.0	21.8	10.2	0.6	2.8	12.0	36.4	0.6	60.0
			(130)	-	(1420)	(700)	(60)	(110)	-	-	-	
Nov.	1	0.5	-	-	6.0	0.2	-	-	-	93.8	-	93.8
			-	-	(110)	(5)	-	-	-	-	-	

[1]*Polygonum persicaria, Amaranthaceae, Graminae, Helianthus;* [2]*Cyclops;* [3]*Pleuroxus, Chydorus, Bosmina* and *Daphnia;* [4]*Palpomyia;* [5]The sum of the percentage of plant fragments, animal fragments, unidentified organic matter and inorganic detritus; [6]Carp tracts from October included an average of 90 Ceratopogonidae which made up 2.0% of the volume.

TABLE 5

MONTHLY VARIATION IN ALIMENTARY TRACT CONTENTS OF ADULT CARP (>230 mm) IN LAKE CARL BLACKWELL FROM DECEMBER 1967 THROUGH NOVEMBER 1968; VALUES ARE PERCENTAGES OF TOTAL VOLUME FOR EACH MONTH AND (IN PARENTHESIS) THE AVERAGE NUMBER OF ORGANISMS PER TRACT.

	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
Plant												
Seeds	-	-	-	0.2	23.0	36.0	15.6	16.0	2.4	8.0	21.4	0.8
				(22)	(3090)	(7779)	(3171)	(933)	(2080)	(5053)	(327)	
Algae	-	-	-	2.0	-	-	-	-	21.5	5.0	2.2	29.8
Fragments	-	-	-	29.0	15.0	15.0	6.0	12.0	34.8	13.0	14.0	10.6
Animal												
Copepoda	10.8	10.4	8.8	3.8	7.0	1.6	3.0	2.0	1.9	1.8	2.6	2.8
	(3550)	(911)	(1567)	(689)	(1590)	(310)	(714)	(400)	(817)	(520)	(695)	(982)
Cladocera	6.6	3.6	0.4	0.2	-	0.4	3.2	2.2	2.9	0.6	0.6	0.4
	(2250)	(222)	(67)	(44)		(41)	(829)	(571)	(1206)	(160)	(158)	(109)
Ostracoda	-	-	-	-	0.2	-	-	0.2	1.9	1.0	0.2	-
					(30)			(29)	(583)	(320)	(32)	
Chironomidae	2.0	5.0	3.2	2.4	1.6	6.6	9.4	2.2	1.4	0.6	0.2	0.4
	(250)	(200)	(233)	(267)	(210)	(848)	(1514)	(257)	(467)	(120)	(32)	(109)
Chaoborinae	0.2	-	0.4	0.4	0.4	-	-	-	-	0.6	-	0.2
	(50)		(33)	(44)	(60)					(120)		(55)
Ceratopogonidae	-	-	2.4	0.8	0.6	-	-	0.2	-	-	0.2	-
			(200)	(67)	(120)			(29)			(32)	
Pelecypoda	-	-	1.8	1.6	1.6	0.2	-	-	-	-	2.0	0.5
Fragments	29.0	26.0	31.0	11.0	5.0	5.0	7.0	10.0	3.9	12.0	7.4	9.6
Detritua												
Organic	48.2	49.8	47.6	38.6	43.6	33.2	54.8	54.2	28.5	56.4	47.8	39.7
Inorganic	3.2	5.2	4.4	10.0	2.0	2.0	1.0	1.0	0.8	1.0	1.4	1.0
No. fish	8	9	6	36	20	29	21	21	21	10	19	11
Ave. cc/fish	3.6	2.4	3.8	11.3	6.8	6.6	7.6	4.1	8.2	3.7	7.4	9.0

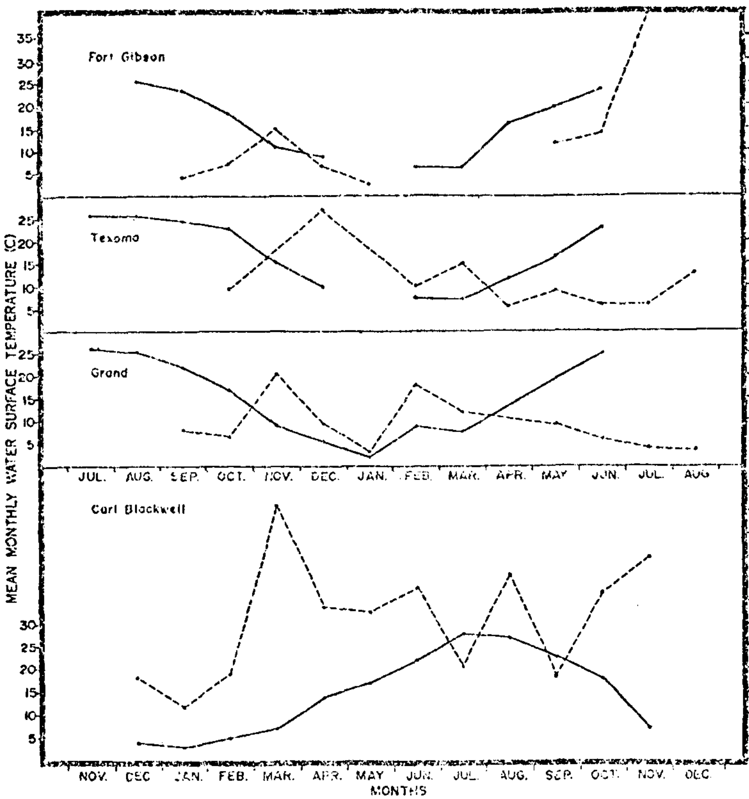

FIGURE 2. Monthly average volume of alimentary tract contents of carp (broken line) and surface water temperature (solid line) of four Oklahoma reservoirs.

Relative contribution of plant matter (seeds, algae, plant fragments) varied from 0 to 58.7%. Availability of seeds or fragments of terrestrial plants probably varied in relationship to rainfall and flooding of marginal plants. Algae was most abundant in the lake in August. Large numbers of seeds in tracts of adult carp in Lake Carl Blackwell occurred in May and October (Figure 3) when rainfall was common and inflow large. The lake level rose 1.6 meters in May inundating marginal vegetation. Plant seeds occurring most frequently in the diet of adult carp were: *Polygonum* (smartweed), *Ameranthaceae* (pigweed family), *Gramineae* (grass family), and *Helianthus* (sunflower).

Filamentous algae was a main constituent in the diet of carp during August and November (Table 5) contributing 21.5% and 29.8%, respectively, of the total food volume. Algae contributed only 5.3% of the total volume eaten by adult carp in Lake Carl Blackwell (Table 2). Large amounts of algae occasionally occurred in carp tracts containing pelecypod shells.

The majority of entomostraca utilized by adult carp in Carl Blackwell belonged to the genera *Cyclops, Pleuroxus, Chydorus, Bosmina* and *Daphina*. *Cyclops* was the only genus of copepods eaten by adult carp. Large numbers of *Cyclops* were present during all months but maximum abundance was during December through February (Figure 3). *Pleuroxus* and *Chydorus* were consumed in large numbers and were found in tracts of carp in all months but April. *Bosmina* and *Dapnia,* more pelagic in habitat than *Chydorus,*. appeared sporadically and in small numbers. Being numerous but small in size, the Cladocera contributed only 1.2% of the total volume of food. The largest average numbber of Copepoda per carp tract was 3550 in December; the lowest monthly average was 310 in May. Large numbers of Cladocera also occurred in December, declined sharply between December and April, were again abundant in June, July, and August, and then declined in autumn. Ostracoda were the least abundant entomostracans, never contributing more than 1.9% of total tract volume, and occurring in only five months. Ostracoda were most abundant in tracts of carp from Lakes Carl Blackwell and Texoma in late summer, and in tracts of carp from Fort Gibson in November, respectively (Figure 5).

All identifiable insect larvae were Diptera, the most numerous and important dipteran larvae being Chironomus, which occurred in tracts of adult carp in all months. Average number of Chironomus was 444 per tract and they comprised 3.1% of the total volume. The largest average numbers of Chironomus were observed in tracts collected in May and June. Norton (1968), in 1967, found an average of $194/m^2$ and $180/m^2$ Chironomids in June and October samples, respectively. Assuming the density of chironomids during June and October 1968 was about the same as in 1967, the large difference in consumption of chironomids between June and October apparently was not due to a variation in the absolute abundance of chironomids but related to intensive utilization of seeds which apparently were exceptionally abundant. *Chaoborus* and *Palpomyia* (Ceratopogonidae) were less important as a food source and accounted for less than 1% of tract contents of adult carp. In Lake Carl Blackwell, and nearby Boomer Lake (Craven and Brown, 1969), *Chaoborus* was much more numerous in October than June. *Chaoborus* did not occur in carp tracts in June but averaged 120 per tract in October.

Piscidium was the only mollusk consumed by adult carp in Lake Carl Blackwell during this study. These small clams were usually crushed into small pieces by the pharyngeal teeth. They were most common in early spring but, contributed only 1.1% of the average total food volume.

Organic detritus ranged from 28.5%, in August, to 56.4% of the total volume in September. The smallest quantity occurrrd in August when large quantities of seeds and plant fragments were consumed. Average volume of organic matter ranged from 1.19 cc per tract in January to 4.16 cc per tract in June. The seasonal pattern was irregular and lacked an obvious seasonal trend.

Carp in the Riverine Reservoirs

Volumes of tract contents of carp collected in several months were grouped to provide a synoptic view of tract composition for each reservoir (Table 5). In this section, monthly variation in carp tract contents in three of the large riverine reservoirs (Grand, Fort Gibson, and Texoma) is presented, and fluctuations in numbers or volume of certain more common categories of tract contents are compared with volume (acre-feet) of inflowing water and surface water temperature (Figures 4, 5 and 6). Two few carp were collected from Eufaula to examine monthly variation.

Average volume of carp tract contents in three riverine reservoirs were examined in relationship to surface water temperature (Figure 2). Many inter-reservoir differences occurred which may be related to variations in degree of digestion, but average volumes generally were maximum in November or December when water temperatures were 9 to 11 C. In Carl Blackwell, the largest average volume occurred in March (7 C) and the second largest average volume in November when the temperature was also 7 C. Large volumes of carp tract contents occurred in the fall or spring, when reservoir water temperatures were 7 to 11 C. Smallest average volume of tract contents occurred in January in all reservoirs. Water temperature in January ranged from 3 to

5 C (water temperature was not taken in Texoma in January). Volumes of tracts were quite variable in summer months when reservoir water temperatures were 21 to 28 C.

Grand Lake. Copepoda occurred in tract contents in 6 of 11 monthly samples, Cladocera in 5 of 11 monthly samples. Number of entomostraca was relatively small in most months but the maximum number per tract occurred in May when numbers of Copepoda and Cladocera per fish were 105 and 1020, respectively (Figure 4). Inflow of water in Grand Reservoir was relatively large in all months except August and September. The pattern of inflow in Grand was similar to Fort Gibson which is downstream from Grand Lake (Figure 1). but maximum numbers of Cladocera and Copepoda in carp tracts from Fort Gibson occurred in November (Figure 5). In Lake Texoma, in southern Oklahoma, maximum numbers of Copepoda and Cladocera in carp tracts occurred in March (Figure 6). Ostracods rarely occurred in carp tracts in Grand Lake, and comprised only 0.06% of total tract volume for the entire series of collections. Ostracods occurred in smaller numbers in Grand Lake Carp than any other reservoir.

Chironomids occurred in tract contents in very monthly collection. Generally, chironomids averaged less than 50 specimens per fish, but in October collection the average was 160 per fish. A cause and effect relationship is not implied, but monthly variation in numbers of chironomids in carp tracts generally coincided with the pattern of variation of inflow. A similar relationship occurred in carp in Fort Gibson but not Texoma.

Chaoborus was more common in carp in Grand Lake than other reservoirs. The maximum average number of *Chaoborus* was 180 per tract in February when water levels were rising. Monthly fluctuations in numbers of *Chaoborus* were not obviously related to monthly fluctuations of the volume of inflow.

Average volume of animal matter in Grand Lake carp tracts fluctuated greatly, but, with the exception of the March collection, the basic pattern of fluctuation generally coincided with monthly fluctuations of inflow. Largest average volumes of organic matter occurred in November which coincided with the largest average volume of organic matter occurring in carp tracts from Fort Gibson Reservoir. The amount of organic matter declined from February through August which was a period of generally declining inflows.

Algae occurred in carp tracts in Septembter and October; seeds only in November; plant fragments occurred in small quantities in several months but comprised 6% of the volume of tract contents in June. A few terrestrial beetles were found in carp tracts in September; pelecypods were observed only in December and May when they comprosed 1% and 6% of the total tract volume.

Fort Gibson. Copepoda occurred in carp tracts in 4 of 9 monthly collections; 196 per tract was the largest monthly average which occurred in November, coinciding with the largest numerical occurrence of Cladocera, and largest average volume of plant matter (Figure 5). Monthly inflow in Fort Gibson fluctuated less than Texoma. In the latter reservoir, maximum numbers of Cladocera and Copepoda occurred in March coinciding with the month of maximum inflow. Ostracods occurred in Fort Gibson carp in 4 of 9 months, but they were most abundant in November and December; 24 and 29 per tract, respectively, rather than June, July and August as in Lake Texoma, or August and September as in Carl Blackwell. Numbers of chironomids varied from 3 to 189 in tracts containing them. They occurred in 8 of 9 carp tracts in 8 of 9 collections. The general pattern of their variation coincided with the pattern of inlow of water. The major portion of plant matter occurred in October, when it contributed 17% of the total volume of carp tracts. Fluctuation of the total volume of food in carp tracts was irregular and not obviously related to inflow.

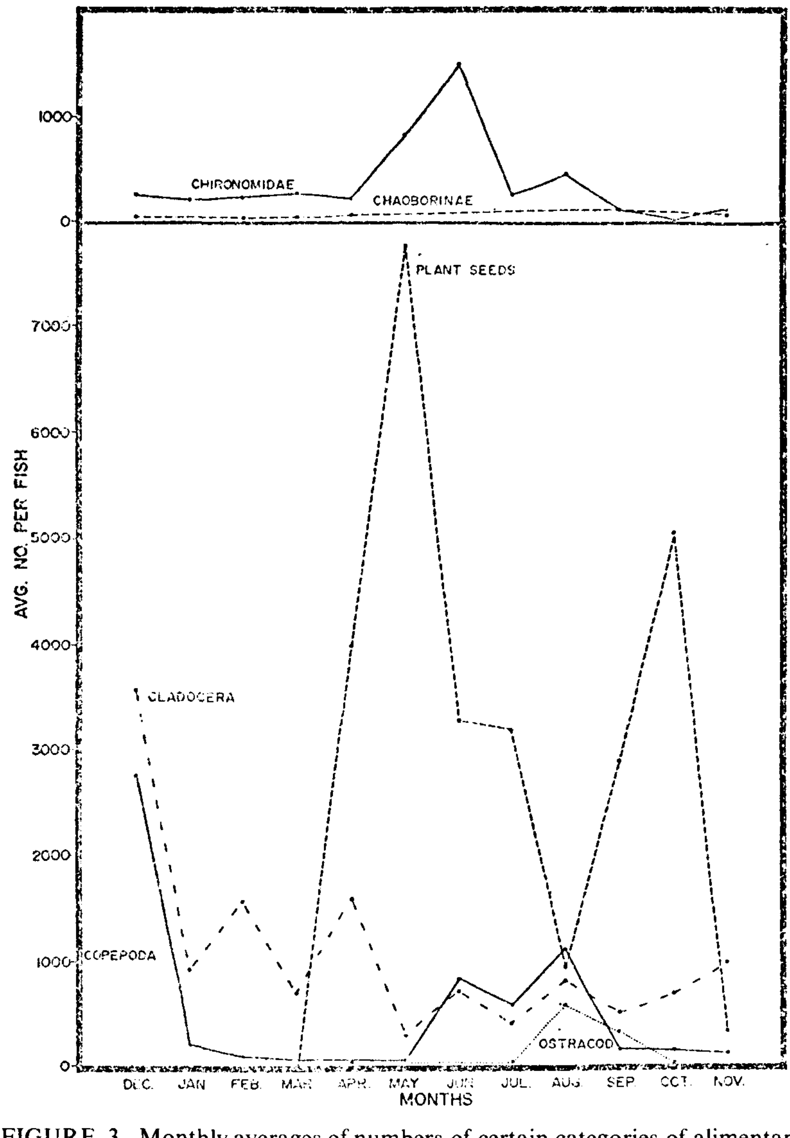

FIGURE 3. Monthly averages of numbers of certain categories of alimentary tract contents of carp from Lake Carl Blackwell.

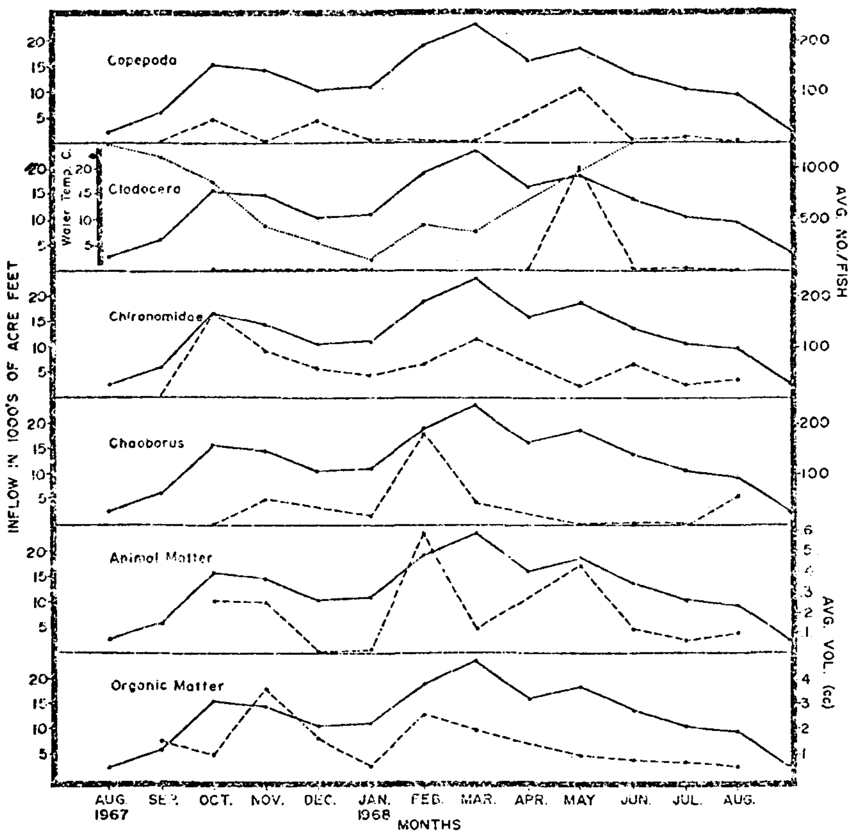

FIGURE 4. Monthly averages, numbers or volumes of certain categories of alimentary tract contents (broken line) of carp in Grand Lake compared with volume (acre-feet) of inflow of water (solid line) and surface water temperatures (dotted line).

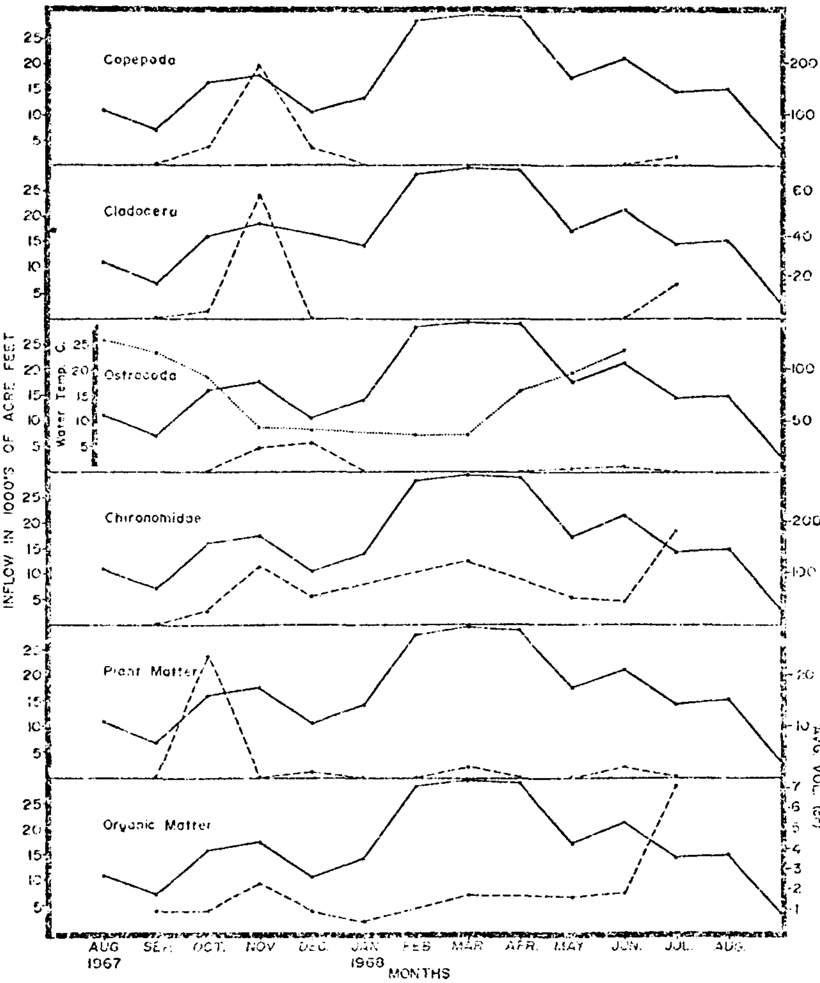

FIGURE 5. Monthly averages, numbers or volumes of certain categories of alimentary tract contents of carp (broken line) in Fort Gibson Reservoir compared with volume (acre-feet) of inflow of water (solid line) and surface water temperatures (dotted line).

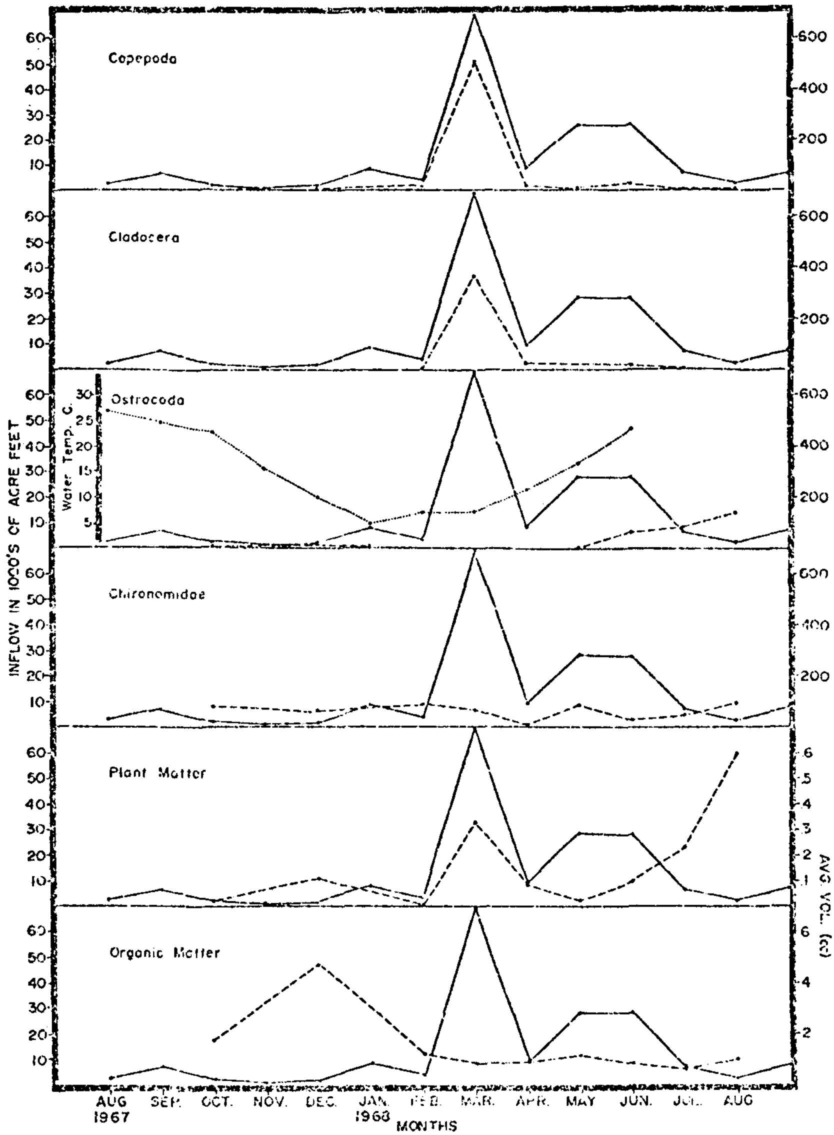

FIGURE 6. Monthly averages of numbers or volumes of certain categories of alimentary tract contents of carp (broken line) in Lake Texoma compared with volume (acre-feet) of inflow of water (solid line) and surface water temperature (dotted line).

Seasonal variation in surface water temperature was similar in the three reservoirs, with peak temperature occurring in August, minimum temperatures in January. Monthly fluctuation or seasonal trends in numbers or volumes of the several categories of carp tract contents are not easily related to monthly variations or seasonal trends in surface water temperatures.

Algae occurred in tracts only in March but comprised only 1% of the bolumetric composition of carp tracts in the month; seeds occurred in October, making up 11% of the volumetric composition of tract contents in the month; plant fragments occurred in October (17%) and June (6%). A few terrestrial Ceoloptera occurred in 9 of 31 carp collected in September.

Lake Texoma. Average numbers of Copepoda in carp tracts from Lake Texoma ranged from 0 in October, to 506 in March (Figure 6). Maximum numbers of Cladocera in carp tracts occurred in March which was the month of maximum inflow of water. Ostracods in carp tracts were least abundant in the spring, reaching maximum abundance June through August. Numbers of chironomids in carp tracts was relatively small, and their variation could not be associated with inflow of water. Average volume of plant matter in carp tracts fluctuated between 0.19 and 0.60 cc. A large average volume was observed in March (0.33 cc). This volume decreased in May, but increased to the maximum monthly average in Aguust. Presumably, March levels resulted from inflow of stems and leaves of terrestrial plants, and August levels resulted from consumption of aquatic macrophytes. Monthly average volumes of organic matter were greatest in December and least in March when inflow was greatest. If organic matter, as we believe, is derived from the substrate, the maximum amount occurs in winter because bacterial decomposition of the substrate is slower then because of low temperatures and accumulation would be relatively greater. The low average volume of food at times of maximum inflow would result if turbulence caused suspension of the matter or if sedimentation of inflowing particulate matter blankted the substrate. Monthly variation in numbers of Copepoda, Cladocera, Ostracoda, Chironomidae, and volume of plant and organic matter could not be associated with seasonal trends in water temperature.

Algae occurred in carp tracts in February, March, April, July and August. Algae comprised a relatively large percentage of the average tract volume in February (24%), July (13%) and August (7%). These were months when volume of inflow was very small (Figure 6), but inflow was also low in several other months when algae was absent in carp tracts. Seeds occurred in July when they made up 1% of the total volume; pelecypods occurred in trace quantities in July and August; Trichoptera made up 9% of the volume in the August collection.

DISCUSSION

Qualitative Composition

The qualitative composition of carp tracts in the five Oklahoma reservoirs was very similar. The diet was classified as being either: (1) detritus, principally unidentified organic matter, (2) plant material, algae, seeds and plant fragments, or (3) animal material, consisting of pelecypods, entomostraca, dipteran larvae, trichoptera cases, and animal fragments. The organisms are mainly those which live in or near the substrate and expected of a fish with tactile, maxillary barbels, and an imbibbing mouth. Polyphagy was less diverse than the channel catfish (Jearld, 1970). There were no oligochaetes, gastropopods or odonates, and pelecypods comprised only a small volume of carp tracts. Mayflies occurred only in the form of pieces of mandibles or gills. Caddisflies occurred only in Lake Texoma carp, and the Ceratopogonidae only in Lake Carl Blackwell. Fish remains were found only in three carp in Lake Carl Blackwell. Terrestrial insects, consisting of a few beetles, were very limited, even in carp collected in shallow littoral areas of protected coves in Lake Carl Blackwell.

Characterization of carp as omnivorous scavengers was made by Cole (1905), and Forbes and Richardson (1909) because the dietary spectrum contains both animal and vegetable matter. McCrimmon (1968) gives a thorough review of the qualitative composition of carp food habits from the North American literature. Although the diversity is great, evidence from tract analysis (Struthers, 1931; Sigler, 1958; Mackay, 1963) supported by experimental studies by Ivlev (1961) indicates deliberate and selective feeding. Most quantitative field studies show less diversity than expected. The bulk of the carp's diet is composed of small chironomids, in some cases caddisfly larvae, entomostraca, organic detritus, composed of triturated and digested food, and finely divided organic matter, and vegetable matter. Mayflies and caddisflies comprised most of the volume on certain collection dates in Clear Lake, Iowa (Effendie, 1968).

Sigler (1958) reported amphipods, mayflies, the Odonata and Hemiptera in Utah carp tracts, but in that study they comprised less than 1% of the total volume of carp tract contents which did not include volume of organic detritus. Moore (1952) also reported some Hemiptera *(Corixidae).* Effendie (1968) reported in addition to the usual items, trace amounts of water mites and rotifers. Effendie (1968) found a large diversity of algae species with a rather limited volumetric contribution.

Detritus Versus Plant and Animal Food

Forbes and Richardson (1920: 106) characterized the carp as an omnivorous feeder which principally took vegetable matter. Quantitative observations published in 1950's indicated that the carp's diet was mainly of animal origin (Moore, 1952; Moen, 1953; Sigler, 1958; Rehder, 1958). Moen (1953), for example, stated that under normal lake conditions, the diet of carp was predominantly of insect larvae, crustaceans and mollusks. Research published in the 1960's emphasized the percentage contribution by detritus when there was more emphasis on biomass as determined by volumetric analysis rather than counts of identifiable animal and plant organisms (Walburg and Nelson, 1966; Dalquest and Peters, 1966; Effendie, 1968). In these studies, composition of the animal matter of adult carp was 30, 17 and 23 percent, respectively, and plant matter 9, 43, and 13 percent; whereas, detritus made up 61, 40 and 66% of the tract contents, respectively.

Percentage of animal material was higher in young carp than adult carp in Lewis and Clark Lake (Walburg and Nelson, 1966). Young carp in Lake Carl Blackwell were more selective than adult carp for animal components, especially smaller entomostraca, and young carp consume far less plant matter than adult carp.

Detritus including animal and plant fragments, was a major constituent in the diet of both young (76.2%) and adult carp (73.2%) in Lake Carl Blackwell. Young carp consumed large numbers of animal organisms which comprised 95.4% of the total number of food items but only 20.9% of the total volume of food. In the riverine reservoirs, plant matter compromed 12.4%, animal matter 21.3%, and organic detritus 65.5% of the volume of tract contents. A large portion of the plant matter was cellulose fragments which would not be of nutritional value except as roughage. A large portion of the animal fragments were of indigestible chitin. This reduces the diversity of nutritionally significant food items to the microflora and fauna of the organic substrate and entomostraca which supports Darnell's (1961, 1964) stress on organic detritus as a major source of imput to secondary production in aquatic communities.

Food Selectivity

Carp are polyphagous but their omnivorous characteristics are limited in larger degrees than generally appreciated. They apparently feed on the unconsolidated (flocculent) portion of the substrate, which contributes the larger portion of the volumetric composition of carp tract contents. Few organisms which dwell in the consolidated substrate, such as borrowing mayflies *(Hexagenia)*, crawling odonates, or oligochaetes were consumed. The diversity of food items in carp tracts was limited suggesting selective feeding or a habitat dominated by organisms like *Chydorus, Cladocera,* Chironomids, *Chaoborus,* organic matter, plant fragments, and seeds. Both food selectivity and availability apparently account for the composition. No tubificids or mayflies were found in carp tracts collected from any reservoir although tubificids were abundant in the macrobenthos in the central pool area of Eufaula Reservoir (Margaret Ewing, personal communication), and tubificids and mayflies were major components of the macrobenthos in Texoma (Sublette, 1957) and Carl Blackwell (Norton, 1968). Norton (1968) found maximum tubificid and mayfly *(Hexagenia)* densities of 301 and 266 per m^2, respectively. Lack of tubificids in carp tracts from Carl Blackwell is probably not a result of very rapid digestion because the interval between collection and fixation was short. Moreover, Windell (1967) found that the rate of digestion of hard-bodied and soft-bodied organisms (chironomids, oligochaetes and dragonfly naiads) in bluegill *(Lepomis macrochirus)* is about the same. Mandibles and gills of mayflies found in carp tracts may indicate either consumption of these fragments from the substrate, or mastication of the softer parts prior to swallowing. Absence of mayflies and odonates in tracts of adults could also have been due to negative electivity, or due to the absence of these organisms at the depths where the fish were collected because fishermen were required to set their nets at least 100 yards from the bank. Small items like oligochaetes, being abundant in dredge samples of the profundal substrate, were not found in the carp tracts examined from any Oklahoma reservoir. Sigler (1958) and Effendie (1968) did not find oligochaetes, and Moore (1952), and Dalquest and Peters (1966) found very few.

In Lake Carl Blackwell, numbers of chironomids in the dredge samples were very similar in June and October; yet, carp tract contained 1514 and 32 chironomids per tract in June and October, respectively. Although monthly variation in availability apparently accounts for variation in consumption of certain items, especially the entomostraca, monthly variation in consumption of certain items is dependent on availability of other items (seeds or algae) in the food complex. Seeds seem to be the result of deliberate selection and possibly are of nutritive value for their starch and protein.

The large average size and abundance of carp in the commercial fishery indicates the adaptability of the carp to the food resources available in reservoirs. The basis for productivity of carp, carpsucker and smallmouth buffalo seems to be related to the heterotrophic nature of the food web in these reservoirs. Most biomass, and probably a great percentage of energy and protein intake, is probably derived from organic detritus, entomostraca, and chironomids. Vegetable matter is probably less important in the diet of carp than usually assumed since carp lack cellulase and an intestinal microflora capable of digesting a significant quantity of cellulose. Lefevre (1940) found that numerous species of algae remain viable after passage through the alimentary tract of carp indicating little digestion of the algae in the tracts; Darnell (1961) assumed the same. Several investigators concluded that aquatic plants were of a low order of preference for the carp (Cole, 1905; Mottley, 1938). Plant fragments may have some value as roughage.

Inter-Relationships Among Carp and Other Fishes

Carp are alledged to have undesirable effects on game fishes related to food competition, predation on eggs, larvae, or juvenile game fishes, effects on spawning, effects on aquatic plants, turbidity, and primary productivity. The latter is related to destruction of aquatic plants and roiling of the water.

Detrimental relationships of carp on game fishes are categorized into effects of three types: (1) primary productivity, (2) reproduction, (3) direct food competition.

McCrimmon (1968: 69) states that there is ample evidence for the Great Lakes region that carp have a detrimental effect on the aquatic environment including destructive effect on certain aquatic plants. Under certain circumstances carp are very destructive to aquatic vegetation (Cahn, 1929: Threinen and Helm, 1954). They uproot plants in search of invertebrate food which seems most abundant in the substrate under aquatic plants (Townes, 1937). Environments where carp have been a managment problem were usually those where plant production was of importance for waterfowl, or where destruction of limited beds of aquatic macrophytes was undesirable.

The environment of turbid mainstream impoundments of the southern Great Plains is totally different from those environments where carp historically have been a problem. The detrimental influence of carp on valuable but sparse aquatic plant communities, characteristic of riverine lakes is probably trival compared with influences of hydrological, watershed conditions, climatological and reservoir management on the development of communities of aquatic macrophytes. The latter result from the operating regime of the reservoir for flood control, power production and navigation. Under these conditions, environmental influences are more improtant in shaping the nature of plant communities and the carp probably has little impact on the quality of the physical environment.

Larger carp rarely consume fish and it is generally assumed that the fish which are occasionally found were probably dead when eaten. The assumption that carp consume fish eggs or fry of fingerling game fish is based on reports by Cole (1905) and Meeham (1904). Sigler (1958) found only Utah chub and small carp in 9 of 603 carp intestinal tracts from four Utah lakes. Sigler regarded fish as a starvation food for carp and postulated that the fish were probably dead when consumed. Moore (1952) observed a few fry of yellow perch in 3 of 104 carp tracts in two Colorado reservoirs. Harlan and Speaker (1956) also reported some fish in intestines of carp, and Dyche (1914) saw carp eat dead minnows. However, the occurrence of fish in carp tracts in these studies was infrequent, and in several stuidies, no fish or fish eggs were found (Pearse, 1918; Struthers, 1931; Dalquest and Peters, 1966; Effendie, 1968).

Disturbance by carp of largemouth bass or sunfish nets has not been observed in certain Arkansas reservoirs by SCUBA divers, although sunfish predation on bass nets is intense (Ron Boyer, personal communication). Moore (1952) believed nest building species would have little trouble defending their nests against carp.

Food competition during the critical period may limit year class strength. Year class strength is established shortly after spawning in most stocks, sometimes by the availability of food during the critical period when the yolk sac is absorbed and the larvae must find an exogenous source of food. Almost all larval fishes feed on entomostraca (Toetz, 1966). In practical fish culture, fingerling production depends upon a readily available food supply, usually entomostraca, when the yolk sac is absorbed.

Do adult or young carp graze sufficient quantities of entomostraca of affect survival of young fish during the critical period? Adult and young carp are in direct competition with young game fish for entomostraca but they may not consume entomostraca of the same size. Also, at the time of hatching of most reservoir game fishes, entomostraca are usually very abundant. Abundance of entomostraca in reservoirs is more likely controlled by a flushing or environmental variables other than carp predation. It does not seem likely that, if carp were dense, they could reduce the density of entromostraca to the level that young game fishes could not capture food to pass the critical period. Toetz (1966) demonstrated that the quantity of food needed to pass the critical period can be very small and consumption of a single cladoceran can provide sufficient energy to insure survival for 10 days.

Brooks and Dodson (1965) presented convincing evidence for a size dependent zooplankton predation by alewife *(Alosa pseudoharengus)* which indicated that the alewife determine the size, i.e., species composition of the zooplankton community, and since the larger zooplanktons were more effective filter feeders than the species of smaller size, the size-selective feeding by the alewife actually changed the productivity of the ecosystem. A similar study is urgently needed to evaluate influence of carp on species composition of reservoirs.

Aside from competition with the young of piscivorous species, carp probably compete most intensively with carpsucker and smallmouth buffalo for food. The latter are indigenous river fishes with the most similarity in dietary composition to the carp of the fishes studied in Oklahoma reservoirs.

ACKNOWLEDGEMENTS

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FOOD HABITS AND FEEDING CHRONOLOGY OF CHANNEL CATFISH *ICTALURUS PUNCTATUS* (RAFINESQUE), IN CONOWINGO RESERVOIR

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The single 24-hour feeding chronology study indicated that subadult and adult catfish fed heavily during the daylight hours although some feeding also occurred in the night. The major foods eaten by subadults and adults differed over the 24-hour period. Fishes formed the bulk of the diet at 0600 and 0900 hours and insects at 0400 and 2400 hours; whereas the zooplankton was the principal food at other periods. The presence of large amounts of detritus (sand and mud) during the times of heavy feeding indicated near-bottom feeding habits.

Stomach contents of 798 subadult and adult channel catfish (122 to 270 mm fork length) collected from July to November, 1966 in Conowingo Reservoir were examined. Stomachs of 183 young catfish (35 to 83 mm) collected in August and September were also analyzed. By weight and on the basis of percentage frequency of occurrence zooplankton was the principal food of catfish of all sizes. Fishes were important in the diet of subadults and adults only in August and October. Amphipods comprised an important segment of the diet of subadults and adults only in November. Insects and algae were less important.

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