THE FOOD HABITS OF THE SHOVELNOSE STURGEON, SCAPHIRHYNCHUS PLATORYNCHUS (RAFINESQUE), IN THE MISSOURI RIVER

by

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INTRODUCTION

The shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), is a member of the family Acipenseridae and is commonly referred to by laymen as the sand sturgeon, hackleback, switchtail, or flathead sturgeon. In North America the shovelnose sturgeon is found principally in the Mississippi-Missouri-Ohio River drainage and their tributaries, but it ranges from the Hudson Bay drainage of the Canadian plains southward to New Mexico, Arkansas, and Kentucky (Eddy and Surber, 1947). The species has been reported in other areas of the south such as the Tombigbee River of Alabama (Chermock, 1955), from Texas by Bonn and Kemp (1952), and also from Oklahoma by Riggs and Moore (1951).

The pallid sturgeon, *Scaphirhynchus album* (Forbes and Richardson), a closely related species, is also found in the Missouri River. The pallid reaches a length of 5.5 feet and a weight of 38 pounds (Brown, 1955). The shovelnose is the smaller of the two species, rarely exceeding a length of 3 feet or a weight of 5 to 6 pounds (Eddy and Surber, 1947). The shovelnose can also be distinguished from the pallid in that the bases of the outer barbels of the shovelnose lie in a line parallel with the inner barbels, and are heavily fringed and longer than the inner barbels. The bases of the outer barbels in the pallid lie posterior to the inner barbels (Bailey and Cross, 1954).

The color of the shovelnose is a uniform pale yellowish olive, without spots or blotches. Except for a few rhomboid scales on the caudal peduncle, the body is armored with heavy bony bucklers arranged in five longitudinal rows. The upper lobe of the heterocercal tail is much longer than the lower lobe.

According to Eddy and Surber (1947), the shovelnose is commercially exploited and marketed either as steaks or as smoked sturgeon. Being of small size, most of them are smoked. In recent years the roe has been made into caviar.

After the impoundment of Lewis and Clark Lake in 1955, the catch and condition of shovelnose sturgeon declined over a five-year period (Sprague, 1960). Recently, the capture of sturgeon in the reservoir has been uncommon except in the upstream portion (Walburg, personal communication). There is no data available concerning the sturgeon population in the Missouri River itself and, therefore, it is difficult to tell whether the population is declining. However, the construction of dams across the Missouri River probably has been detrimental to the sturgeon by prohibiting them from reaching traditional spawning areas. It has also been suggested that the reduction in current caused by impounding the water may have some effect upon the sturgeon's growth, ponderal index, and distribution within the reservoirs.

The shovelnose sturgeon is restricted to a lotic environment. More specifically, except at times of spawning when they may enter some of the tributaries, they are confined to the larger rivers. In the upper reaches of Lewis and Clark Lake sturgeon have been collected primarily from the old river channel (Nelson, 1961). The reason for their apparent preference for a lotic environment is not clear. Perhaps it relates to their mode of feeding, as will be suggested later.

Existing reports of food habits of the Mississippi River shovelnose sturgeon indicated that aquatic insect larvae were important (Eddy and Surber, 1947; Barnickol and Starrett, 1951; Hoopes, 1960). Eddy and Surber found dragonfly naiads included in the stomach contents. Stomachs examined from specimens taken at Andalusia, Illinois, by Barnickol and Starrett contained mayfly naiads of the Genus *Hexagenia*. Hoopes examined specimens taken from the tailwaters of dams near Keokuk, Iowa, and reported that they depended largely on caddis fly larvae throughout the year. Reports on other species of sturgeon from Russian rivers also have emphasized the importance of caddis fly larvae as food for the sturgeon (Cherneva, 1944; Yukhimenko, 1963; Nikolsky, 1963).

Karzinkin (1942), working on sturgeon fry of Russian species, stated that light does not increase feeding activity or food consumption in the sturgeon. Sturgeon are guided to their food principally by olfaction which makes them well adapted to feeding in turbid waters. However, more research is needed in regard to the feeding behavior of the sturgeon.

The objective of this study was to determine the food habits of the shovelnose sturgeon in the Missouri River. It is recognized that interpretations of the results are limited by the method of sampling (gill nets), length of the sampling period (two weeks), and season of the year (mid-June) when the sampling was accomplished. However, it is hoped that the following report will provide more information on the life history of this interesting species. Perhaps this study will aid in evaluating the status of the shovelnose sturgeon in an environment already altered by mankind and promulgate management practices beneficial to the species.

METHODS AND MATERIALS

The shovelnose sturgeon used in this study were taken from two areas of the Missouri River. Area I was located approximately 21 miles upstream from Gavins Point Dam and essentially represented a river environment, even though it fell within the confines of Lewis and Clark Lake. The exact location of Area I was T 92 N, R 60 W, Sec. 15, Bon Homme County, South Dakota. Area II was approximately 23 miles downstream from the dam; T 92 N, R 53 W, Sec. 17, Clay County, South Dakota. The latter was located in one of the few remaining stretches of the river relatively unaltered by man's activities. A total of 75 sturgeon stomachs were examined; 64 from Area I and 11 from Area II.

Sturgeon from Area I were provided by the North Central Reservoir Investigations Division of the U.S. Fish and Wildlife Service. These fish were collected in mid-June, 1962, by means of gill nets, set at depths of 10 to 20 feet. Sturgeon from Area II were collected by fisheries personnel of the University of South Dakota in late June of the same year, also by means of gill nets in water 6 to 15 feet deep.

The fish were weighed to the nearest gram and measured to the nearest millimeter. Standard, total, and fork lengths were recorded. Sex was determined by internal examination and the anterior pectoral ray was removed for future age and growth studies. An incision of the mid-ventral surface of the fish from the gular region to the anus permitted the removal of the stomach. The stomachs were then placed in vials containing 10% formalin and stored.

The six methods which are often used in stomach analyses are (1) numerical count, (2) frequency of occurrence, (3) estimating percentage of bulk, (4) gravimetric, (5) volumetric, and (6) restoration of original properties methods (Lagler, 1964). Any of the methods used separately usually prove inadequate; therefore, a combination of two or three of the methods provides a more accurate assessment of the food habits of the species. Those methods employed in the present study were the numerical, volumetric, and frequency of occurrence.

The numerical method involves identifying and counting each food item in the stomach and totaling these counts at the conclusion of the analyses. An obvious objection to this method is that small food items may appear important numerically, and yet be insignificant volumetrically.

The volumetric method involves determining the total volume of each food item and expressing it as a percentage of the total volume of all items encountered. Infrequently taken large food items often appear very important with this method of assessment.

Due to the sturgeon's method of feeding, much organic and inorganic debris was found in the stomachs. Highly sclerotized organisms or parts of organisms are retained in the stomach and macerated by this muscularised, gizzard-like organ. Perhaps inorganic matter is voluntarily ingested to aid in the grinding process. In the present study, therefore, the total volume of each food item was expressed as a percentage of the total volume of all identifiable food organisms as well as a percentage of the total volume of all the stomach contents. The former ratio excludes the organic and inorganic debris. It was hoped that this additional computation would aid the investigator in evaluating the importance of each food item.

The frequency of occurrence method expresses the food item as a percentage of the total number of stomachs in which the item was found. This index indicates how widespread the item was utilized. Small food items taken frequently but not in large numbers would appear very important using this method.

One objection common to the methods used in this study concerns the rate of decomposition for each food item. A highly chitinized organism may appear to be more important than one less resistant to digestion only because it resists digestion longer and identification of that organism is more easily made.

The sturgeon stomach is modified into a grinding organ and the lumen is made very small because of the thickened, muscularised walls (Lagler, Bardach, and Miller, 1962). Therefore, approximately 50 millimeters of the esophagus, in addition to the stomach itself, was included in the analysis.

This area of the esophagus was often found to be distended with food material while the stomach was nearly empty. In the discussion the term "stomach" will include the esophageal portion also.

The stomachs were opened and the contents flushed into a Syracuse watch glass with 70% ethanol. Identification was made with a binocular microscope and a 2X auxillary lens using magnification from 7 to 30 diameters.

Food organisms were identified to the lowest taxon possible, usually to the family level. Occasionally, when an item was intact and well preserved, it was possible to identify the item to a lower taxon. Identification was often possible when only a part of an organism was present, such as a mandible (Ephemeridae), hemelytra (Corixidae), or head capsule (Ceratopogonidae).

A cylinder graduated to 0.05 milliliter was used to measure volume by water displacement. A commercial anti-wetting agent, desicote (Beckman Industries), helped to flatten the meniscus and aided in obtaining accurate readings to 0.005 milliliter. In cases where the volume of an organism was less than 0.005 milliliter, a known number of organisms was used to displace the water and an average volume was then computed for each organism.

Identification of food items was made using the following keys: An Introduction to the Study of Insects, Borror and DeLong (1959); Aquatic Insects of California, Usinger (1956); Freshwater Invertebrates of the United States, Pennak

(1953); Larvae of Insects: Part II, Peterson (1960).

RESULTS AND DISCUSSION

Aquatic insect larvae were the most important food of the [illegible] collected in June (Table [illegible]). They were found in [illegible] 97% of the stomachs, [illegible] [illegible] and numerically 89.1% of all the organisms found. [illegible] ranked second in importance by [illegible], and [illegible] occurrence, and the terrestrial [illegible] were the third most important [illegible].

[illegible] families of aquatic [illegible] represented in [illegible] stomachs (Appendix, Table [illegible]) [illegible], comprising [illegible] organisms. Mayfly [illegible], constituting [illegible]. Of [illegible] which constituted [illegible] respectively.

[illegible] families [illegible] [illegible] (Table [illegible]) [illegible] [illegible] [illegible] were 97.3 [illegible] [illegible] [illegible]

RESULTS AND DISCUSSION

Aquatic insect larvae were the most important food of the shovelnose sturgeon collected in June (Table 1). They were found in more than 97% of the stomachs, numerically comprised 92.9% and volumetrically 89.1% of all the organisms found. Crustaceans ranked second in importance by number, volume, and frequency of occurrence, and the terrestrial insects volumetrically were the third most important food item.

Seven orders and 29 families of aquatic insects were represented in the stomachs (Appendix, Table 3). The Order Diptera was the most important, comprising 88.2% by number and 53.9% by volume of all organisms. Mayfly naiads, Order Ephemeroptera, were also important, constituting 19.8% of the total volume of all organisms. Of less importance were the Orders Coleoptera and Odonata which constituted 6.9% and 5.5% by volume of all organisms respectively.

Aquatic dipteran larvae from 11 families were found in the stomachs. The Family Chironomidae (Tendipedidae), or the "nonbiting midges," was the most important family represented. The frequency of occurrence, numerical, and volumetric percentages of this family were 97.3, 62.8, and 26.8 of all organisms respectively. The author did not attempt to identify the chironomids beyond family; however, the following are some of the common chironomids that have been

Table 1 (cont.)

	Digestive Tracts with Food Item (Freq. occur.)		Total Organisms		Total Volume of Food Item	% of Total Volume	
	No.	%	No.	%	Ml.	Of All Contents	Of All Organisms
TERRESTRIAL ORGANISMS							
INSECTA							
Coleoptera	13	17.3	34	.1	.70	.9	1.5
Hymenoptera	14	18.7	25	T	.18	.2	.4
Orthoptera	3	4.0	3	T	.17	.2	.4
Homoptera	12	16.0	31	.1	.14	.2	.3
Diptera	9	12.0	25	T	.10	.1	.2
Collembola	7	9.3	22	T	.04	.1	.1
Thysanoptera	1	1.3	1	T	T	T	T
TOTAL TERR. INSECTA	29	37.7	141	.2	1.32	1.7	2.9
OTHER							
ARACHNIDA	7	9.3	21	T	[illegible]	1.0	1.6
CHILOPODA	9	12.0	43	[illegible]	[illegible]	[illegible]	1.8
TOTAL TERR. ORGANISMS	30	40.0	205	[illegible]	[illegible]	[illegible]	6.3

*T= less than .05% of the numerical or volumetric percentages, or less than .01 milliliter.

Table 1. Summary of frequency of occurrence, numbers, numerical percentages, volumes, and volume percentages of food items taken from the stomachs of 75 shovelnose sturgeon collected from the Missouri River, June 1962.

	Digestive Tracts with Food Item (Freq. occur.) No.	Digestive Tracts with Food Item (Freq. occur.) %	Total Organisms No.	Total Organisms %	Total Volume of Food Item Ml.	% of Total Volume Of All Contents	% of Total Volume Of All Organisms
EMPTY	2	2.7					
AQUATIC ORGANISMS							
INSECTA							
Diptera	73	97.3	51,594	88.2	24.99	32.0	53.9
Ephemeroptera	64	85.3	2,396	4.1	9.20	11.8	19.8
Coleoptera	22	29.3	129	.2	3.21	4.1	6.9
Odonata	28	37.3	97	.2	2.54	3.3	5.5
Trichoptera	32	42.7	154	.3	1.07	1.4	2.3
Plecoptera	8	10.7	9	T*	.19	.3	.4
Hemiptera	7	9.3	9	T	.11	.1	.2
TOTAL AQUATIC INSECTA	73	97.3	54,388	92.9	41.31	52.9	89.1
CRUSTACEA							
Cladocera	32	42.7	2,393	4.1	1.66	2.1	3.6
Eucopepoda	42	56.0	1,088	1.9	.11	.1	.2
Decapoda	7	9.3	7	T	.14	.2	.3
Amphipoda	4	5.3	4	T	.04	T	.1
TOTAL CRUSTACEA	55	73.3	3,492	6.0	1.94	2.5	4.2
OTHER							
NEMATODA	51	68.0	430	.7	.10	.1	.2
MOLLUSCA	1	1.3	1	T	.07	.1	.2
OLIGOCHAETA	1	1.3	1	T	.01	T	T
TOTAL AQUATIC ORGANISMS	73	97.3	58,312	99.7	43.42	55.6	93.7

* T, .05% of the numerical volume/percentages, less than .01 milliliter.

identified in Lewis and Clark Lake: *Coelotanypus* sp., *Pentaneura flavifrons*, *Cryptochironomus fulvus*, *Tendipes riparius*, and *Tendipes tentans*.

Another dipteran family, Ceratopogonidae (Heleidae), or the "biting midges," was the second most abundant dipteran family. These were found in over 95% of the stomachs and comprised 22.1% of the total number and 20.9% of the total volume of all organisms. The majority of the ceratopogonids were of the Genus *Palpomyia*.

Dipteran pupae were often macerated by the action of the stomach and consequently were difficult to identify to family. Most pupae were midges belonging to the Families Chironomidae and Ceratopogonidae. The pupae were combined in the results (Appendix, Table 3) and made up 8.4% of the total number and 2.9% of the total volume of all organisms. Pupae were taken commonly and occurred in nearly 90% of the stomachs. The only other dipteran family of significant importance was the Family Dolichopodidae, which was found in more than 41% of the stomachs but made up only 1.3% of the total volume and 0.4% of the total number of all organisms.

Mayflies were second in importance only to the dipterans, occurring in over 85% of the stomachs and comprising 19.8% of the total volume and 4.1% of the total number of all organisms. Except for the dipteran Families Chironomidae and Ceratopogonidae, mayfly naiads of the Family Baetidae were volumetrically (8.1%) the third most important family of organisms ingested by the sturgeon. Naiads of this family [illegible] occurrence of more than 77%. [illegible] Baetidae, the genus *Baetis* comprised 81% of the volume, the remaining 19% belonging to the Genus *Ameletus*.

Aquatic coleopterans, the third most important order, were found in 29% of the stomachs and made up 6.9% of the total volume of the organisms. Numerically, however, they were unimportant, comprising only 0.2% of the total number of the organisms. The most important coleopteran family was the family Dytiscidae. The most common genus of those which were identifiable was the Genus *Laccophilus*.

The only other insect order of major importance was [illegible] which occurred in more than 37% of the [illegible] the total volume [illegible] was represented [illegible] the [illegible]

[illegible]

arthropod, was not very high (18%), their volume was greater than the terrestrial coleopterans.

Hoopes (1960) reported that shovelnose from the tail-waters of dams on the Mississippi River (Iowa) depended largely on caddis fly larvae (Order Trichoptera). In his study, larvae of the Family Hydropsychidae (mostly *Potamyia*) composed 75% of the total content and mayfly naids (*Hexagenia*) composed 17%. Barnickol and Starrett (1951) also reported that stomachs of shovelnose from the Mississippi (Illinois) contained mayfly naiads of the Genus *Hexagenia*. In the present study, *Hexagenia* comprised only 1.2% by volume. However, the mayfly naiads as a group totaled approximately 20% by volume. The reported differences in utilization of mayflies as food for sturgeon may be due in part to seasonal fluctuations in their populations or at least in their availability to fish. A large standing crop of *Hexagenia* naiads exists in Lewis and Clark Reservoir (Swanson, in press), but they are abundant in areas infrequently visited by sturgeon.

Russian reports on the sterlet (*Acipenser ruthenus*), Amur sturgeon (*Acipenser schrencki*), and other sturgeons of the central Asian Rivers also indicated that caddis fly larvae were the most important food item of the sturgeon, while crustaceans and dipteran larvae were of secondary importance (Chernova, 1944; Yukhimenko, 1963; Nikolsky, 1963). In these rivers the caddis fly larvae were abundant on the substrate, mostly objects which had fallen into the water. In the present investigation, trichopteran larvae comprised only 2.3% of the total volume of all organisms. The most important species represented were *Hydropsyche orris* and *Hydropsyche frisoni*. In the habitats of the Missouri River from which the author received specimens, caddis flies probably were not as abundant as in Russian rivers. Studies of the benthos of Lewis and Clark Lake have shown trichopterans to be relatively unimportant (Schmulbach and Sandholm, 1960).

Investigations conducted on the lake sturgeon (*Acipenser fulvescens*) in Lake Winnebago, Wisconsin, indicated that chironomid larvae were the most important food item (Schneberger and Woodbury, 1944; Probst and Cooper, 1955).

The composition of the sturgeon stomach contents differs considerably depending upon the habitat from which the sturgeon were taken, as evidenced by the previous studies. In the present study, differences between the two sampling areas were noticed, although the small number of stomachs taken from Area II limits the accuracy of the comparison. However, it is interesting to note that an average of 18.5 families of food organisms were identified in each of the stomachs from Area II, while the average number of families in stomachs from Area I (in Lewis and Clark Reservoir) was only 9.2 (Table 2). The greater diversity of organisms utilized in Area II is reflected in the frequency of occurrence of terrestrial organisms, such as the centipedes and collembolans, which was 90.9%. Only 10.5% of the stomachs from Area I contained terrestrial organisms. Perhaps the

Table 2: Comparison of some of the stomach contents from 75 shovelnose sturgeon collected from two areas of the Missouri River, June, 1962.

	Area I	Area II
Number of Stomachs	64	11
Chironomidae		
Average no./stomach	439	448
% total no. of organisms	56.3%	57.0%
% total vol. of organisms	30.7%	14.9%
Ceratopogonidae		
Average no./stomach	182	59
% total no. of organisms	24.0%	7.5%
% total vol. of organisms	26.0%	37.2%
Collembolla		
Frequency of occurrence	0.0%	63.6%
Chilopoda		
Frequency of occurrence	3.1%	63.6%
Average no. families found in each stomach	9.2	18.5
Frequency of occurrence of terrestrial organisms	10.3%	90.9%

greater current in Area II caused a more diverse fauna to be carried in the water mass along the bottom, whereas in Area I much of the fauna was deposited upstream from the collecting site. The numerical importance of chironomids was nearly equal in the two areas. Ceratopogonids, however, appeared to be a more important food item in Area I.

The feeding habits, or the behavioral aspects of feeding, were not the principal intent of this investigation. However, certain inferences concerning feeding habits are suggested from knowledge of the food habits.

The method of feeding by sturgeon in general has been described as suctorial on benthic organisms, but in some cases the food items suggest a grazing phenomenon. The sturgeon is well adapted for suctorial feeding with an inferior mouth and fleshy modification of lips. The lips are protrusible and described as plicate, having folds, or papillose, having small tufts of skin or papillae (Lagler, Bardach, and Miller, 1962). The inferior mouth and modified lips aid the sturgeon in picking food organisms from the bottom. This manner of feeding is suggested by the fact that the majority of food items found in the present study were bottom-dwelling insect larvae. Nevertheless, the author was surprised at the number and diversity of terrestrial organisms ingested by sturgeon, particularly from the downstream location.

The sturgeon is a species that possesses taste buds outside of the mouth, concentrated on the barbels. These barbels have many olfactory and gustatory endorgans to help locate food in the soft bottom materials. When food is located, the protrusible mouth drops down and the food is siphoned into the mouth. In comparison with other fishes, the sturgeon is a very slow feeder. Moreover, the food items it eats are small when compared to its own size, so that it must devote a great deal of time to foraging. The finding of only two empty stomachs in this study would tend to support this hypothesis.

It was previously mentioned that the sturgeon's feeding habits could on some occasions be of a grazing nature. The frequency of occurrence of zooplankters, principally cladocerans, was 67%. Other zooplankton forms were present in small numbers in most stomachs and their ingestion may have been accidental. However, great numbers of these organisms occasionally were found in a single stomach. This indicated that upon locating a swarm of these microcrustaceans, the sturgeon, an opportunist, would readily feed upon them.

Ivlev (1961) stated that for an inactive type of fish silt on the bottom was more likely to reduce the accessibility of chironomid larvae than for a more active fish. Perhaps this suggests why the sturgeon is restricted to a lotic environment in Lewis and Clark Reservoir, the old river channel, a habitat where current would reduce sedimentation of silt and would therefore render the chironomid larvae more accessible to a feeding sturgeon.

Accompanying data regarding available benthic organisms and detritus was lacking, and because of this void little can be said about selectivity, palatibility, etc. However, the present work, as well as those previously mentioned, indicate that the shovelnose sturgeon are opportunistic feeders. Using the variety of organisms found in the stomachs as an indicator, the sturgeon will apparently utilize whatever organisms (usually benthic) are readily available.

SUMMARY AND CONCLUSION

A food habits study of the shovelnose sturgeon was conducted on 75 specimens collected from two areas of the Missouri River. These fish were collected in June of 1962 by gill-netting operations.

The three methods of analysis employed in the present study were the numerical, volumetric, and frequency of occurrence. Identification of organisms was made to the lowest taxon possible.

Aquatic insect larvae from seven orders and 29 families comprised 92.9% of the total number and 89.1% of the total volume of all organisms found and occurred in over 97% of the stomachs. In previous food habits studies of the shovelnose, immature aquatic insects were also reported to be important as food items, including naiads of dragonflies and mayflies, and caddis fly larvae.

In the present study, two dipteran families, Chironomidae and Ceratopogonidae, comprised numerically 42.8% and 22.1% and volumetrically 26.8% and 20.3% of all organisms respectively. Mayfly naiads were also important food items, constituting 19.8% of the total volume and 4.1% of the total number of all organisms. Naiads of the Family Baetidae were the most important of the mayflies represented. Aquatic coleopterans, mainly of the Family Dytiscidae, made up 6.9%

of the total volume of all organisms, but comprised only 0.2% numerically. Naiads of the Order Odonata constituted 5.5% of the total volume of all organisms.

Microcrustaceans, mostly *Daphnia*, represented over 4% of the total number and 3.6% of the total volume of all organisms. Occasionally, large numbers of these zooplankters were found in a single stomach, suggesting that sturgeon will graze on zooplankton.

Terrestrial arthropods occurred in 40% of the stomachs and as a group comprised 6.3% of the total volume of all organisms. This fact, as well as the utilization of zooplankton, indicates the opportunistic feeding habits of the sturgeon.

Comparison of results from the two sampling areas shows that Area II, a location characterized by a stronger current, provided a greater diversity of organisms for the sturgeon. Also, the frequency of occurrence of terrestrial organisms in Area II was nearly 91%, while only 10.5% of the stomachs from Area I contained terrestrial organisms.

The shovelnose apparently prefers a lotic environment. This may in part be due to the fact that a habitat such as a river channel is less disturbed by siltation, making benthic organisms more accessible to the feeding sturgeon. The present investigation, as well as those previously mentioned, indicates that the shovelnose will utilize available food items in an opportunistic manner.

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APPENDIX

Table 3. Frequency of occurrence, numbers and numerical percentages, volumes and volumetric percentages of all food items identified from stomachs of 75 shovelnose sturgeon collected from the Missouri River, June, 1962. (N= naiads, L= larva, P= pupae, A= adult).

	Digestive Tract with Food Item (Freq. occur.)		Total Organisms		Total Volume of Food Item	% of Total Volume	
	No.	%	No.	%	Ml.	Of All Contents	Of All Organisms
EMPTY	2	2.7					
AQUATIC ORGANISMS							
INSECTA							
Diptera							
Chironomidae-L	73	97.3	36,743	62.8	12.42	15.9	26.8
Ceratopogonidae-L	70	93.3	12,915	22.1	9.49	12.2	20.5
Dipteran pupae	67	89.3	1,402	2.4	1.33	1.7	2.9
Dolichopodidae-L	31	41.3	252	.4	.61	.8	1.3
Muscidae-L	26	34.7	125	.2	.31	.4	.7
Ephydridae-L	13	17.3	27	.1	.18	.3	.4
Culicidae-L	19	25.3	33	[illegible]	[illegible]	[illegible]	.2
Simuliidae-L	19	25.3	84	.1	[illegible]	[illegible]	[illegible]
Syrphidae-L	2	2.7	5	T	[illegible]	[illegible]	.4
Tabanidae-L	6	8.0	11	T	.09	.1	.2
Stratiomyidae-L	6	8.0	11	T	.10	.1	.2
Tipulidae-L	1	1.3	2	T	.08	[illegible]	[illegible]
Unid. dipteran-L	3	4.0	4	T	[illegible]	[illegible]	[illegible]
Total Diptera	73	97.3	51,584	88.2	[illegible]	33.0	53.9
Ephemeroptera							
Baetidae-N	58	77.3	1,057	1.8	3.76	4.8	8.1
Caenis-N	57	76.0	930	1.6	3.07	3.9	6.6
Ameletus-N	31	41.3	127	.2	.70	.9	1.5
Heptageniidae-N	31	41.3	70	.1	.92	1.2	2.0
Ephemeridae-N	21	28.0	95	.2	.54	.7	1.2
Unk. mayfly-A	13	17.3	117	.2	.23	.3	.5
Total Ephemeropt.	64	85.3	2,396	4.1	9.20	11.8	19.8

	Digestive Tract with Food Item (Freq. occur.) No.	%	Total Organisms No.	%	Total Volume of Food Item Ml.	% of Total Volume: Of All Contents	% of Total Volume: Of All Organisms
Coleoptera							
Dytiscidae-L	13	17.3	68	.1	1.90	2.4	4.1
Hydrophilidae-L	11	14.7	31	.1	.88	1.1	1.9
Cincindelidae-L	7	9.3	13	T	.20	.3	.4
Gyrinidae-L	3	4.0	3	T	.10	.1	.2
Haliplidae-L	5	6.7	9	T	.09	.1	.2
Helodidae-L	2	2.7	2	T	.02	T	T
Elmidae-L	1	1.3	1	T	.01	T	T
Chrysomelidae-L	1	1.3	1	T	.01	T	T
Unk. Coleoptera-L	1	1.3	1	T	.01	T	T
Total Coleoptera	22	29.3	129	.2	3.21	4.1	6.9
Odonata							
Gomphidae-N	23	30.7	51	.1	1.80	2.3	3.9
Coenagrionidae-N	17	22.7	46	.1	.74	1.0	[illegible]
Total Odonata	28	37.3	97	.2	2.54	3.3	5.5
Trichoptera							
Hydropsychidae-L	29	38.7	123	.2	.83	1.1	1.8
Hydropsychidae-P	6	8.0	9	T	.13	.2	.3
Psychomyiidae-L	5	6.7	7	T	.05	.1	.1
Leptoceridae-L	2	2.7	2	T	.02	T	.1
Unk. Trichoptera	4	5.3	13	T	.05	.1	.1
Total Trichoptera	32	42.7	154	.3	1.07	1.4	2.3
Plecoptera							
[illegible]-N	7	9.3	8	T	.19	.2	.4
Unk. Plecoptera-N	1	1.3	1	T	.01	.1	T
Total Plecoptera	8	10.7	9	T	.19	.3	.4

Table 3 (cont.)

	Digestive Tract with Food Item (Freq. occur.) No.	%	Total Organisms No.	%	Total Volume of Food Item Ml.	% of Total Volume Of All Contents	Of All Organisms
Hemiptera							
Corixidae-A	7	9.3	9	T	.11	.1	.2
TOTAL AQUATIC INSECTA	73	97.3	54,388	92.9	41.30	52.9	89.1
OTHER							
CRUSTACEA							
Cladocera							
Daphnia	31	41.3	2,376	4.1	1.66	2.1	3.6
Bosmina	7	9.3	17	T	T	T	T
Total Cladocera	32	42.7	2,393	4.1	1.68	2.1	3.6
Decapoda							
Astacidae	7	9.3	7	T	.14	.2	.3
Eucopopoda							
Diaptomus	28	37.3	356	.6	.07	.1	.2
Cyclops	41	54.7	732	1.3	.04	[illegible]	[illegible]
Total Eucopopoda	42	56.0	1,088	1.9	.11	.2	.2
Amphipoda							
Orchestiidae	4	5.3	4	T	.04	T	.1
TOTAL CRUSTACEA	54	72.0	3,492	6.0	1.94	2.5	4.2
NEMATODA	51	68.0	430	.7	.10	.1	.2
MOLLUSCA							
Sphaeriidae	1	1.3	1	T	.07	.1	.2
OLIGOCHAETA	1	1.3	1	T	.01	T	T
TOTAL AQUATIC ORGANISMS	73	97.3	58,312	99.7	43.42	55.6	93.7

Table 3 (cont.)

	Digestive Tract with Food Item (Freq. occur.)		Total Organisms		Total Volume of Food Item	% of Total Volume	
	No.	%	No.	%	Ml.	Of All Contents	Of All Organisms
TERRESTRIAL ORGANISMS							
INSECTA							
Coleoptera							
Histeridae-A	2	2.7	3	T	.02	T	T
Curculionidae-A	2	2.7	3	T	.02	T	T
Elmidae-L	2	2.7	2	T	.02	T	T
Scarabeidae-A	1	1.3	1	T	.01	T	T
Cincindelidae-A	1	1.3	2	T	.03	T	.1
Carabeidae-A	1	1.3	1	T	.03	T	.1
Elateridae-L	1	1.3	1	T	.01	T	T
Helodidae-L	1	1.3	1	T	.01	T	T
Staphlinidae-L	1	1.3	1	T	.01	T	T
Chrysomelidae-L	1	1.3	1	T	.01	T	T
Unk. Coleoptera-A	7	9.3	16	T	.25	.3	.5
Unk. Coleoptera-L	2	2.7	2	T	.31	.4	.6
Total Coleoptera	13	17.3	34	.1	.70	.9	1.5
Hymenoptera							
Formicidae	14	18.7	25	T	.18	.2	.4
Orthoptera							
Acridae	1	1.3	1	T	.05	.1	.1
Tridactylidae	2	2.7	2	T	.12	.1	.3
Total Orthoptera	3	4.0	3	T	.17	.2	.4
Homoptera							
Cicadellidae	12	16.0	31	.1	.14	.2	.3

	Digestive Tract with Food Item (Freq. Occur.)		Total Organisms		Total Volume of Food Item	% of Total Volume	
	No.	%	No.	%	ml.	Of All Contents	Of All Organisms
[illegible]		[illegible]			8.17	10.5	
[illegible]		[illegible]			.09	.1	
	[illegible]	[illegible]			23.45	30.0	
Total No. of Organisms			[illegible]				
Total Vol. of Organisms					46.36		
Total Vol. of all Contents					78.06		

* less than .0[illegible] of the numerical or volumetric percentages, or less than .01 milliliter.