A SYSTEMATIC SURVEY OF THE LARGER AQUATIC INVERTEBRATES OF PAYNE COUNTY (OKLAHOMA) AND THE CHEMICAL COMPOSITION OF SOME OF THE MORE ABUNDANT FORMS

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CHAPTER I

INTRODUCTION

The work upon which this report is based is the first in a proposed series of studies on fish nutrition at the Oklahoma Agricultural and Mechanical College. The writer has (1) reviewed the literature on fish nutrition and on the nutritional value of artificial foods, (2) collected and identified representatives of the larger aquatic invertebrates of Payne County which potentially were available as fish food, and (3) accumulated representatives of 21 families of aquatic invertebrates and of four families of vertebrates in quantities sufficient for proximate chemical analysis. The report consists of a presentation of the results of a taxonomic study of the organisms collected over a 23-month period and an interpretation of data on 62 samples of specimens for which the results of chemical analysis were available.

Food studies on fishes consistently have stressed the importance of insects and related arthropods in the diet of fishes. Leonard and Leonard (1949) reported that the two most important groups of food organisms for Michigan trout were aquatic insects and fishes. Lachner (1950) found that aquatic insects, crayfishes, and fishes formed the bulk of food eaten by fingerling northern smallmouth bass in western New York. A study of the food habits of a sculpin and of two species of trout showed that amphipods and the immature stages of mayflies, caddisflies, stoneflies, and aquatic diptera were the five major food items (Dineen, 1951). Arthropods constituted 70 percent by volume of the food of a population of brown trout from central New York (Evans, 1952). Bonn (1953) studied the food and growth rate of young white bass in Lake Texoma. He reported three major food organisms: crustaceans (chiefly cladocerans and copepods), insects (chiefly midges), and gizzard shad. Benson (1954) found that the most common organisms eaten during the period of most rapid growth and best condition of brook trout in Michigan were mayflies, caddisflies, and crayfish. Pre-impoundment studies of the summer food of three species of fishes in Tenkiller and Fort Gibson reservoirs in Oklahoma were made by Clemens (1954). He concluded that arthropods were of almost universal occurrence and that insects made up the bulk of the diet.

Ball (1948) studied the relationships between the food available for fishes, the feeding habits of the fishes, and the total production of fishes in a Michigan lake. He found evidence for a relationship between the production of aquatic invertebrates and the total production of fishes. A low volume of invertebrates per unit area of the littoral zone indicated that the consumption of food by the fishes exceeded the rate at which the food organisms could maintain themselves. In another study (Ball, 1949), it was shown that the production of invertebrate organisms was 1.42 times greater in fertilized ponds than in unfertilized ponds, and that the production of plankton organisms was 3.3 times as great. Similar results on an analysis of the bottom fauna production in fertilized and unfertilized ponds were reported by Patriarche and Ball (1949).

The importance in the diet of fishes of specific chemical constituents of natural food has been reported in the literature. Natural foods and fresh raw meats were known for a long time to contain some unknown dietary factor essential for growth in trout. McCay and Dilley (1927) discussed the attributes of this constituent and designated it as factor "H". Other studies of the factor were reported by McCay, Bing, and Dilley (1927), McCay et al. (1928, 1929, 1931), McCay and Tunison (1934), and Tunison et al. (1939?, 1940?). Hewitt (1937a) identified factor "H" as lecithin, the use of which, he claimed, would make it possible to displace greater amounts of fresh food in the diet of hatchery fishes with less expensive dry materials. Anemia in trout frequently was linked with factor "H" deficiency. Phillips (1940) produced anemia in trout through the use of a meatless synthetic diet. The effectiveness of a diet of fly maggots in restoring normal levels of erythrocytes was noted by Phillips et al. (1941?), Phillips and McCay (1941), and Tunison et al. (1942?). Simmons and Norris (1941) found the chemical properties of the fish anemia factor very similar to those of xanthopterin. A bacterial disease whose progress was checked merely by the substitution of natural for artificial food was observed in trout (Hayford, 1921). The reason for the lack of vitality and stamina in liver-fed trout was attributed by Hewitt (1937b) to the high fat content of liver (28 percent on a dry-weight basis) and to its high cholesterol content. Cooke et al. (1949) reported on an unidentified growth factor for young trout and salmon that was concentrated in the roe and the milt. The high degree of brilliance in color of trout on a diet rich in <u>Gammarus</u> was reported (André, 1926; Surber, 1935). Steven (1947) noted the lack of pigmentation in trout fed chopped meat and earthworms, in contrast to that of fish fed solely on natural foods. Experiments were directed toward finding an inexpensive food to reproduce wild coloration in hatchery trout

(Tunison et al., 1947).

The ability to maintain normal growth and reproduction for an indefinite period on a diet compounded from chemically-pure ingredients has been one of the goals of nutrition studies (L. A. Maynard, 1951). As emphasized by Davis and Lord (1929), by Davis (1932), and in nearly all other reports dealing with their use, dry trout foods always had to be used in combination with fresh meat or natural food. Any attempt to rear trout for any great length of time on dry products alone was doomed to failure. Wolf (1951a), however, developed a synthetic diet of chemically-pure substances which conformed as closely as possible to the proportions of the various food categories found either in the food of wild trout or in a food (liver) known to give good growth in hatchery experience. Growth rates of rainbow trout on the synthetic diet and of a control group on a diet of beef liver did not differ significantly after 26 weeks. Rucker et al. (1952) found Wolf's diet adequate for the rearing of chinook salmon fingerlings. It was reported as producing a slow rate of growth in trout, but with low mortality, by Phillips et al. (1953?).

The problem of world malnutrition is one of the most crucial tasks facing mankind today (Cruickshank, 1946). Because of the pressure of increasing population we may depend more and more upon fishes as the primary source of human dietary protein. Fish protein is unexcelled in quality among proteins of animal origin (Dunn et al., 1949; Neilands et al., 1949; Ingalls et al., 1950). Fishes can be used for many things other than human food, such as for fertilizers, oils, vitamins, glue, livestock and poultry meals, and pet food (Riggs and Sneed, 1951).

Sport fishing has become an industry in Oklahoma (Riggs and Clemens, 1951). King (1955) estimated that the 500,000 surface acres of water which Oklahoma had at that time could grow an average of 200 pounds of game fishes per acre, and that 70 percent of the game fishes could be harvested and still maintain themselves. Houser (1952) placed the commercial catch of fishes from the Denison Reservoir over a three-month period in the summer of 1952 at 136,634 pounds. Commercial fishing is one means for the control of rough fishes, which is recognized as the basic problem in restoring sport fishing in many impoundments of Oklahoma (Aldrich, 1949). Other advantages could come to the state from an extension of commercial fishery activities (Riggs and Sneed, 1951). Oklahoma eventually will have one million surface acres of water which may be expected to produce an annual fish crop of 25 million dollars (Thompson, 1948). Food and the feeding habits of fishes are one area in a coordinated program of basic research in limnology and fishery biology needed in Oklahoma (Riggs and Clemens, 1951). It is hoped that the proposed series of studies initiated by this report will contribute to the further development of Oklahoma's fishery resources.

One study comparable to a portion of this report has been published (Phillips et al., 1954). In addition to reviewing the literature on the analysis of natural food of trout, the authors presented the results of proximate and mineral analyses for representatives of four orders of insects, an amphipod, and an oligochaete. Results of vitamin assays (riboflavin, biotin, pantothenic acid, and niacin) on representatives of five orders of insects were given. Averages of the values obtained from their study were compared with the chemical content of a standard hatchery diet. Although hatchery foods appeared to be nutritionally superior to natural foods on the basis of chemical content alone, the authors concluded that any such assumption had to be re-evaluated in terms of the conversion of natural food into fish flesh.

CHAPTER II

METHODS AND MATERIALS

Collection Methods

Plankton

Samples of plankton were taken by means of a tow net made of number 25 silk bolting cloth. The net, attached to the end of a rope approximately 20 feet long, was first thrown into the water and then pulled slowly toward the operator, its depth in the water being regulated by the rate at which it was thus returned. Samples obtained in this manner were taken to the laboratory and kept at approximately 4^{o} Centigrade until identifications of the organisms could be made. Because of the difficulties involved in the identification of most plankters and because of the great variety of species in most samples, the number of plankton samples collected and studied in this manner was small. Limitations of time restricted identifications to the more abundant forms.

Bottom Fauna

Bottom samples from deeper waters were collected by the use of a Petersen dredge. Material obtained in this way was emptied into a large tub, from which successive small portions were then washed relatively free of mud in sieves. The sieves were of a graded series, 15 inches in diameter and five inches deep. The largest mesh openings of the series were 5/16 of an inch; the mesh of the finest sieve had openings of

1/30 of an inch.

The remaining mixture of organisms and debris was taken into the laboratory, where several rinses in tap water removed any remaining mud and silt. The material was then spread over about one-half of the bottom of a large shallow rectangular pan, enough water added barely to cover the bottom of the pan, and a small portion of the debris examined carefully at a time. The organisms disclosed in this way (mainly Chaoborus, midge larvae, water mites, copepods, ostracods, and annelids) were placed either in finger bowls or in Syracuse watch glasses, in which they could be refrigerated, if necessary, until identifications could be made.

The sieves previously referred to were used to scoop up muck or other organic debris that harbored organisms. Mud was separated from the other components of the sample by a series of short reciprocal movements in a vertical or horizontal plane with the sieve partially submerged. After the removal of the coarser debris by hand, the remaining mixture of organisms and fine particles was taken to the laboratory for sorting and processing.

An ordinary garden rake was found to be effective for pulling bottom materials in shallow areas from the water, and spreading the mud and debris in a relatively-thin layer on shore. Larger organisms in such material were located readily and removed.

A large amount of time was required to collect, rinse, sort, and identify most of the organisms comprising the bottom fauna of ponds. The small size of the organisms prevented the accumulation of a sufficient quantity for chemical analysis. Complete collections of plankton, bottom fauna, and organisms inhabiting external surfaces were attempted for only four stations.

Macroscopic Organisms Living on External Surfaces

In general, the bulk of the living material which was collected represented organisms that were attached to the surface of plants or other objects in the water. Such organisms were collected either by a direct examination of the surfaces involved or by the use of a collecting net of some kind. A water dip net having a strong canvas bag with a coarse mesh sieve and a 5-foot handle was used most frequently. Organisms were taken from the surface of plants and from the bottom, as well as when they were swimming free in water, or as they moved about on the surface of water. The capture of small specimens from a net or directly from other surfaces was facilitated by the use of a suction collector (Peterson, 1953).

As the specimens were collected, they were sorted on the basis of size into several containers for transporting to the laboratory. Fragments of plants or debris of various kinds placed in the containers with the specimens provided surfaces for attachment and places of concealment, minimizing losses due to overcrowding and predation. Covered containers frequently were necessary to prevent the escape of adult insects through flight.

No attempt was made to follow an organized plan of random sampling, nor were all specimens which were encountered saved for eventual processing. The kinds of organisms collected at any one station had no qualitative significance. The frequency of collections was governed primarily by the amount of time available to the writer for such purposes and to a lesser extent by weather conditions. While the writer always was alert to the possibility of collecting additional forms for the first time in the study, the nature of the problem practically necessitated a concentration of effort on organisms that could be obtained in considerable quantity.

Processing of Specimens

Procedure

Live specimens were taken into the laboratory, washed several times in tap water, and sorted into containers in which they were kept for a minimum of 24 hours before identification and further processing. This allowed time for the contents of the alimentary tract to be expelled. It was necessary to refrigerate the adults of some types of insects to suppress predatory tendencies and to minimize activity. Large predaceous species were separated from other forms. In some cases, e.g., water tigers, *Tropisternus* larvae, and gyrinid larvae, the isolation of each specimen was necessary.

The specimens were identified (with one exception mentioned later), rinsed in distilled water, placed on several layers of paper towel in open containers, and air dried. Difficulty was encountered in distinguishing between the completion of drying of the external surfaces and desiccation of the animals from the loss of internal fluids for delicate forms like mosquito larvae and pupae, midge larvae, *Chaoborus*, and annelids. Satisfactory results in such cases were obtained by drying the specimens on several layers of moist cloth. Most of the aquatic organisms, however, were resistant to desiccation.

Specimens dried in this manner were placed in a glass vial and weighed on an analytical balance to the nearest tenth of a milligram.

The difference in the weight of the vial before and after the addition of the specimens represented the live weight of the organisms. The organisms were then transferred to a second vial and killed by placing the specimens temporarily in an oven at a temperature of about 102° Centigrade.

Data concerning the specimens were recorded in a notebook. As soon as an identification was made, the name of the organism was recorded and the sample given a collection number. This collection number consisted of two parts separated by a hyphen. The digits before the hyphen, ranging from "1" to "1217", represent the numerical order in which the samples were entered in the notebook, while the digits following the hyphen identify the field collection, or station, from which the specimens were obtained. A list of the collecting stations is given as Appendix B. Specimens contributed to the study by various individuals and specimens from eight incidental collections (i.e., not a part of a regular field collection) by the writer were recorded in each instance under a simple number representing the numerical order in which the specimens were processed. Collection data in all such cases appear as footnotes in Table I. The date of entry and all calculations involved in determining live weight and dry weight of the samples were recorded in the notebook.

Samples were dried at a temperature of 102° to 106° Centigrade in a thermostatically-controlled, 300-watt electric oven manufactured by the Precision Scientific Company. During the drying process, samples were exposed in the oven on Pyrex watch glasses of from 25 to 100 millimeters diameter, depending upon the number and size of the specimens. The collection number of the sample was written on the under surface of the watch glass for identification. After removal from the oven the samples were placed in a desiccator and allowed to cool to room temperature before being weighed. All samples were dried until equal values were obtained from two successive weighings. The weight of the watch glass and dried specimens less the weight of the watch glass represented the dry weight of the sample. Watch glasses were washed thoroughly and dried after each use.

The oven-dried material was stored in tightly-stoppered vials or jars, each labeled with the name of the organism and the collection number of each sample of the organism processed. The dried material upon which analyses were made thus represented, in most cases, a composite sample. Analysis of the beetle *Laccophilus fasciatus* Aubé, for example, was based upon specimens obtained from 31 different field collections.

Two time-saving practices were followed. The approximate weight was painted on each watch glass or other container used in weighing samples. (Precise weighings always were made each time the items identified in this manner were used.) It became apparent early in the study that one or a few individuals of small organisms dried to a constant weight in about three or four days. Samples of this kind thereafter were oven-dried for six or seven days, the single weight obtained at the end of this period being taken as the constant one. All samples of larger specimens, however, and all samples composed of many small specimens were dried to a constant weight in the manner already described.

Two Chainomatic analytical balances, manufactured by Christian Becker Incorporated, were used successively during the study. All weighings were made with the same set of balance weights, of class S-1 quality.

Processing of Mixtures of Species

During the summer of 1955 as many as 4000 individuals of several kinds of insects (predaceous diving beetles, water scavenger beetles, water boatmen, and backswimmers) were obtained from a single field collection. The size of the specimens made it difficult to recognize some of the forms directly; furthermore, the number and the activity of the specimens made the usual processing method already described impractical. A special technique was used for handling small insects in quantity with a minimum of time and effort.

The mixture of specimens was placed in water in a one-gallon, wide-mouth pickle jar. A fine-mesh household strainer, 110 millimeters in diameter, which fitted snugly into the mouth of the jar, made repeated washings of the specimens with tap water possible without removal of the specimens from the jar. A final rinse in distilled water was given before the insects were dried.

The specimens were air-dried in a second jar of the same type, the bottom of which was covered with paper toweling and in which a number of crumpled pieces of the towel were placed for absorbing any water remaining on the specimens and to provide surfaces upon which the insects could crawl. Water from the rinse jar containing the specimens was poured through the sieve a little at a time, the specimens obtained in this manner then being dislodged after the sieve was inverted over the mouth of the second jar. When the transfer of specimens was complete, the sieve was placed in the mouth of the second jar to prevent the escape of specimens and the jar itself left near a source of mild heat for from four to six hours to complete the process of drying.

When the contents of the jar were completely dry the pieces of toweling were taken out one at a time. The dry mass of insects now remaining in the otherwise-empty jar was quickly poured through a funnel into a previously-weighed container of appropriate size. The container and specimens were then weighed, after which the container was placed in the oven and left there until movement of the specimens ceased.

The dead insects were then sorted under a dissecting microscope into containers that were kept covered to prevent the loss of additional moisture. After the sorting process was completed the sample of each species was weighed, giving what in effect was a "dead" weight for the sample, and the number of individuals in the sample was determined.

Since moisture was lost during the killing of the insects, the sum of the "dead" weights of the samples always was less than the weight of the mixture of living specimens. This difference had to be distributed in some way among the samples in order to approximate what must have been their actual live weight. In the absence of any experimental evidence as to the exact manner in which this should be done, the writer arbitrarily distributed half of the difference in weight on the basis of the relative number of specimens in each sample, the other half being distributed on the basis of the relative weight of each sample. The values obtained in this way were designated as "calculated" live weights to differentiate them from the values obtained from actually weighing a number of living specimens of one kind.

Preparation of the Samples for Analysis

Samples were prepared for analysis by being ground in a mortar with a pestle until the particle size of the material was fine enough to pass through a sieve having openings 0.84 of a millimeter in diameter. Samples varied greatly in the ease with which this desired particle size could be attained, being influenced by the presence of calcareous shells and heavily-sclerotized structures, and apparently by the chemical composition of the sample. The pulverized material obtained in this manner was placed in vials or bottles, tightly stoppered, and numbered for later identification.

Analytical Procedures

Chemical analyses of 62 samples were made by the Department of Agricultural Chemistry of the Oklahoma Agricultural and Mechanical College. Analytical procedures used were those described in the seventh edition of "Official Methods of Analysis of the Association of Official Agricultural Chemists" (1950), except that phosphorus was determined by the method of Koenig and Johnson (1942).

CHAPTER III

ORGANISMS COLLECTED IN THE SURVEY

Introduction

The organisms collected from October 20, 1953, to September 8, 1955, are listed in the first column of Table I. The second column contains the collection number of each sample of the organisms that was processed. The figures in the remaining portion of the table (other than percentages) are the sums of the respective values (i.e., number of specimens, live weight, dry weight, and moisture) for each sample of the organism. Except as previously acknowledged, the writer assumes full responsibility for the identifications; none have been verified.

While some groups in Table I (adult Dytiscidae and Hydrophilidae, for example) are thought to represent the local fauna fairly completely, others (such as flatworms, annelids, cladocerans, copepods, ostracods, and springtails) are represented only by some of their more abundant forms. Few of the smaller organisms conveniently could be collected in quantities sufficient for weighing; for this reason data other than the number identifying the date and place of the field collection are lacking for some or all representatives of two phyla (Bryozoa and Annelida) and of five arthropod orders (Cladocera, Eucopepoda, Podocopa, Hydracarina, and Collembola). Although generally restricted to aquatic invertebrates, data have been presented on collections of seven species of spiders, a slug (Philomycus), three species of fishes, and three species of amphibians. Collections outside of Payne County, specimens taken by individuals other than the writer, and eight incidental collections are indicated. A total of 1217 samples, consisting of over 48,000 specimens, was processed in the study. The 286 items in Table I represent eight phyla and 92 families of animals. One hundred and eighty-two genera are listed. The distribution of the genera among the major taxonomic categories is as follows.

Porifera			2
Coelenterata			1
Platyhelminthes			1
Bryozoa			2
Annelida			7
Arthropoda			152
Crustacea		23	
Arachnoidea		15	
Insecta		114	
Collembola	3		
Ephemerida	5		
Odonata	20		
Hemiptera	20		
Megaloptera	2		
Trichoptera	3		
Lepidoptera	1		
Coleoptera	32		
Diptera	28		
Mollusca			11
Gastropoda		6	
Pelecypoda		5	
Chordata			6

Publications upon which the author relied for most of the work of identification were those of Blatchley (1920, 1926), Comstock (1948), Hungerford (1933, 1948), Needham and Westfall (1955), Pennack (1953), and Ward and Whipple (1918). Occasional use was made of the following: Bertrand (1928), Bishop (1924), Blackwelder (1939), Blatchley and Leng (1916), Böving and Craighead (1953), Bradley (1930), Chamberlin (1908), Dunlap (1951), Fall (1922, 1923), Hoff (1942), Johannsen (1934, 1935, 1937a, 1937b), Leng (1920), Leng and Mutchler (1927, 1933), Matheson

(1929), E. A. Maynard (1951), Needham, Traver, and Hsu (1935), Peterson (1951), Pratt (1935), Roberts (1913), Ross (1944), Sanderson (1938), Seeley (1928), Thomsen (1937), and Wilson (1932).

The terminology and arrangement of families of the invertebrates in Table I is largely that of Pennack (1953).

TABLE I.

A Phylogenetic Arrangement of the Organisms Collected in the Survey and Summaries of Data from the Processing of 1217 Samples of Specimens

Name	Collection Numbers[1]	Total of Corresponding Values for Each Sample					
		No. Specimens	Live Weight (grams)	Dry Weight		Moisture	
				grams	percent	grams	percent
SPONGILLIDAE							
Heteromeyenia baileyi (Bowerbank)	662-56	-	1.2277	0.3041	(24.77)	0.9236	(75.23)
Meyenia crateriformis Potts	(73) 1208-100 (101)[2]	-	1.4123	0.3269	(23.15)	1.0854	(76.85)
HYDRIDAE							
Hydra sp.	96-14	73	0.0037	0.0016	(43.24)	0.0021	(56.76)
TURBELLARIA	94-14	39	0.0426	0.0121	(28.40)	0.0305	(71.60)
PLANARIIDAE							
Dugesia tigrina (Girard)	391-43	5	0.0040	0.0006	(15.00)	0.0034	(85.00)
LOPHOPODIDAE							
Pectinatella magnifica Leidy	(99)						

[1] a field collection number enclosed in parentheses indicates that no specimens of the organism from that collection were processed; the localities of the collections are given as Appendix B

[2] also collected by the author from the Cushing Reservoir, August 31, 1955

TABLE I. (Continued)

PLUMATELLIDAE					
Plumatella sp.	(48)				
LUMBRICIDAE					
Eisenia foetida (Savigny)	14-4	-	69.4443	9.3414 (13.45)	60.1029 (86.55)
ENCHYTRAEIDAE					
ENCHYTRAEIDAE gen. et sp.	183-30, 198-31, 376-42, 465-45	34	1.0240	0.1881 (18.37)	0.8359 (81.63)
BRANCHIOBDELLIDAE					
Bdellodrilus illuminatus (Moore)	(2)				
LUMBRICULIDAE					
Lumbriculus inconstans Smith	404-43	3	0.0042	0.0012 (28.57)	0.0030 (71.43)
GLOSSIPHONIIDAE					
Helobdella sp.	(15) (16)				
Placobdella sp.	109-15	6	0.0580	0.0130 (22.41)	0.0450 (77.59)
P. parasitica (Say)	172-28[3]	4	3.9199	0.6796 (17.34)	3.2403 (82.66)
P. rugosa (Verrill)	29-6, 45-8, 124-16, 145-20	35	37.4880	7.6928 (20.52)	29.7952 (79.48)
ERPOBDELLIDAE					
Erpobdella punctata (Leidy)	93-13, 95-14, 107-15, 126-16, 452-44, 561-50, 1043-83, 1163-96	20	2.1305	0.4423 (20.76)	1.6882 (79.24)

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[3] Delaware County, Oklahoma

TABLE I. (Continued)

HIRUDIDAE					
Haemopsis sp.	531[4]	2	2.1280	0.3360 (15.79)	1.7920 (84.21)
STREPTOCEPHALIDAE					
Streptocephalus seali Ryder (adult)	767-64[5], 774-65, 784-66, 866-72, 1078-87, 1139-94, 1159-96	260	13.5220	1.0716 (7.92)	12.4504 (92.08)
APODIDAE					
Apus longicaudatus LeConte (adult)	766-64	3	0.9084	0.0696 (7.66)	0.8388 (92.34)
CAENESTHERIIDAE					
Caenestheriella morsei (Packard) (adult)	711-59, 741-62, 749-63, 765-64, 775-65, 793-66, 817-67, 841-69, 857-70, 879-73, 889-74, 911-75, 925-76, 965-79, 1085-88, 1105-90, 1119-91, 1140-94, 1160-96	430	58.3782	12.7040 (21.76)	45.6742 (78.24)
DAPHNIDAE					
Daphnia longispina (O.F.Müller)	(42) (44)				
D. pulex (de Geer)	(44)				
Moina macrocopa Straus	(43)				
Simocephalus serrulatus (Koch)	(43)				

[4]collected by Morgan Collins at Yost Lake, March 15, 1955

[5]first collected in Payne County by B. A. Branson and W. C. Greer, June 29, 1955

TABLE I. (Continued)

BOSMINIDAE					
Bosmina longirostris cornuta (O.F.Müller)	(42) (44)				
CHYDORIDAE					
Acroperus harpae Baird	(42)				
Alona costata Sars	(44)				
Alonella globulosa Daday	(43)				
Eurycercus lamellatus (O.F.Müller)	(42)				
Pleuroxus denticulatus Birge	(43)				
P. striatus Schödler	(42)				
CYCLOPIDAE					
Eucyclops prasinus (Fischer)	(42)				
Macrocyclops albidus (Jurine)	(43) (44)				
M. ater (Herrick)	(43)				
CYPRIDAE					
Candona sp.	(43)				
Chlamydotheca herricki Turner	798-66	72	0.2846	0.0369 (12.97)	0.2477 (87.03)
Cypridopsis vidua O.F.M.	(43)				

TABLE I. (Continued)

Potamocypris smaragdina (Vavra)	(43)				
ASELLIDAE					
Lirceus hoppinae (Faxon)	609-53	180	0.9887	0.2303 (23.29)	0.7584 (76.71)
TALITRIDAE					
Hyalella azteca (Saussure)	71-11, 80-13, 204-31, 228-33, 402-43, 435-44, 558-50, 586-52	307	0.3253	0.0922 (28.34)	0.2331 (71.66)
ASTACIDAE					
Orconectes nais (Faxon) (adult)	42-7, 120-15	3	53.2173	18.6230 (34.99)	34.5943 (65.01)
O. neglectus (Faxon) (immature)	165[6]	8	59.0230	17.0676 (28.92)	41.9554 (71.08)
O. neglectus (Faxon) (adult)	164[6]	1	15.3246	4.6935 (30.63)	10.6311 (69.37)
Procambarus blandingi (Girard) (adult)	135-17, 163[7]	2	38.8116	9.7584 (25.14)	29.0532 (74.86)
P. simulans (Faxon) (immature, 20-35 mm)	9-2, 10-2, 118-15, 127-16	69	35.6352	6.5477 (18.37)	29.0875 (81.63)
P. simulans (Faxon) (immature, 50-60 mm)	119-15	18	39.1486	8.3095 (21.23)	30.8391 (78.77)
P. simulans (Faxon) (adult)	8-2, 11-2	2	27.6068	7.4739 (27.07)	20.1329 (72.93)

[6] collected by the author at the Logan Fish Hatchery, Siloam Springs, Arkansas, May 8, 1954

[7] collected by the author from the Mill Pond, Stillwater, May 4, 1954

TABLE I. (Continued)

PALAEMONIDAE						
Palaemonetes kadiakensis Rathbun (adult)	168-26[8]	16	2.8871	0.5984 (20.73)	2.2887 (79.27)
P. paludosus (Gibbes) (adult)	169-26[8]	8	3.7605	0.8248 (21.93)	2.9357 (78.07)
ARGIOPIDAE					
Tetragnatha sp. (adult)	1013-81	1	0.0268	0.0064 (23.88)	0.0204 (76.12)
T. elongata Walckenaer (adult)	808-66, 924-75, 1030-83, 1051-85	8	0.4560	0.1318 (28.90)	0.3242 (71.10)
T. pallescens Cambridge (adult)	851-69, 894-74	7	0.2091	0.0582 (27.83)	0.1509 (72.17)
T. straminea Emerton (adult)	1014-81	2	0.0474	0.0122 (25.74)	0.0352 (74.26)
PISAURIDAE					
Dolomedes triton (Walckenaer) (adult)	1027-82, 1092-89, 1137-93	12	3.8650	0.9696 (25.09)	2.8954 (74.91)
D. triton sexpunctatus Hentz (adult)	620-54, 638-55, 695-59, 1044-83	8	1.8568	0.4793 (25.81)	1.3775 (74.19)
D. urinator Hentz (adult)	1062-85	1	0.5038	0.1153 (22.89)	0.3885 (77.11)
LYCOSIDAE					
Lycosa helluo Walckenaer (adult)	680-57, 759-63, 1028-82	3	1.0086	0.2426 (24.05)	0.7660 (75.95)

[8] Rogers County, Oklahoma

TABLE I. (Continued)

HYDRACHNIDAE						
Hydrachna sp.	(adult)	260-36, 305-39	13	0.0101	0.0017 (16.83)	0.0084 (83.17)
EYLAIDAE						
Eylais sp.	(adult)	306-39, 333-40, 363-41, 785-66, 971-79	11	0.0578	0.0109 (19.89)	0.0439 (80.11)
ARRENURIDAE						
Arrenurus sp.	(adult)	227-33, 307-39, 335-40, 361-41, 387-42 (43)	27	0.0109	0.0023 (21.10)	0.0086 (78.90)
ATHIENEMANNIIDAE						
Krendowskia similis Viets	(adult)	(43)				
LIBERTIIDAE						
Frontipoda sp.	(adult)	389-42	8	0.0010	0.0002 (20.00)	0.0008 (80.00)
Gnaphiscus sp.	(adult)	(43)				
Oxus sp.	(adult)	203-31, 386-42 (43)	18	0.0034	0.0008 (23.53)	0.0026 (76.47)
HYGROBATIDAE						
Megapus sp.	(adult)	(43)				
UNIONICOLIDAE						
Koenikea sp.	(adult)	384-42 (43)	24	0.0012	0.0002 (16.67)	0.0010 (83.33)
Neumania sp.	(adult)	360-41, 388-42 (43)	7	0.0028	0.0007 (25.00)	0.0021 (75.00)
Unionicola sp.	(adult)	362-41, 385-42 (44)	5	0.0007	0.0002 (28.57)	0.0005 (71.43)
LIMNESIIDAE						
Limnesia sp.	(adult)	334-40, 359-41 (43)	84	0.0526	0.0170 (32.32)	0.0356 (67.68)

TABLE I. (Continued)

SMINTHURIDAE							
Sminthurides aquaticus (Bourlet)	(adult)	(57)					
PODURIDAE							
Hypogastrura (Achorutes) armata Nicolet	(adult)	(6) (8)					
Podura aquatica L.	(adult)	(13)					
EPHEMERIDAE							
Hexagenia sp.	(naiad)	20-5, 24-6, 44-8, 56-9, 82-13, 148-21, 186-31, 375-42, 437-44, 537-49, 650-56, 762-64, 1058-85	129	3.6605	0.5892 (16.10)	3.0713 (83.90)	
BAETIDAE							
Caenis sp.	(naiad)	72-11, 81-13, 200-31, 374-42, 403-43, 429-44, 720-60	366	0.2927	0.0741 (25.32)	0.2186 (74.68)	
Callibaetis sp.	(naiad)	76-11	1	0.0031	0.0002 (6.45)	0.0029 (93.55)	
Siphlonurus sp.	(naiad)	252-36, 262-37, 345-41, 425-44, 603-52, 651-56, 664-57, 708-59, 721-60, 763-64, 800-66, 972-79	76	0.3453	0.0921 (26.67)	0.2532 (73.33)	
HEPTAGENIIDAE							
Stenonema sp.	(naiad)	535-48, 648-56, 1063-85	62	1.1901	0.2853 (23.97)	0.9048 (76.03)	
GOMPHIDAE							
Gomphus sp.	(naiad)	21-6, 50-8, 57-9, 150-21, 179-29, 188-31, 315-39, 380-42, 420-43, 455-44, 480-46, 500-47, 540-49, 887-73, 1130-93	171	18.8118	3.6703 (19.51)	15.1415 (80.49)	

TABLE I. (Continued)

Progomphus obscurus Rambur (naiad)	1052-85 (97)	7	1.2516	0.2801 (22.38)	0.9715 (77.62)
AESCHNIDAE					
Anax sp. (naiad)	108-15, 128-16, 133-17, 144-20	55	32.0293	6.4441 (20.12)	25.5852 (79.88)
Nasiaeschna pentacantha (Rambur) (naiad)	58-9, 110-15, 125-16, 134-17, 184-30, 544-50, 1103-90, 1168-97	11	3.3098	0.7588 (22.93)	2.5510 (77.07)
LIBELLULIDAE					
Epicordulia sp. (naiad)	36-6	3	0.3462	0.0737 (21.29)	0.2725 (78.71)
Erythemis sp. (naiad)	54-8, 66-9, 74-11, 88-13, 208-32, 235-33, 247-36, 274-38, 311-39, 323-40, 418-43, 457-44, 478-46, 498-47, 590-52, 633-55, 716-60, 1006-81, 1127-93	235	16.4849	3.1619 (19.18)	13.3230 (80.82)
Libellula sp. (26a) (naiad)	16-5, 33-6, 51-8, 68-9, 78-11, 87-13, 141-19, 178-29, 192-31, 234-33, 310-39, 413-43, 456-44, 476-46, 497-47, 557-50, 577-51, 589-52, 614-54, 715-60	414	32.1348	5.4451 (16.94)	26.6897 (83.06)
Libellula sp. (32a) (naiad)	19-5, 34-6, 53-8, 67-9, 77-11, 86-13, 111-15, 191-31, 415-43, 477-46, 499-47, 578-51, 1129-93	164	14.3363	2.8473 (19.86)	11.4890 (80.14)
Macromia sp. (naiad)	37-6, 177-29	2	0.6516	0.1769 (27.15)	0.4747 (72.85)
Pachydiplax longipennis (Burm.) (naiad)	64-9, 85-13, 190-31, 479-46, 556-50, 579-51, 850-69, 885-73, 1020-82, 1031-83, 1091-89	158	18.3877	3.0040 (16.34)	15.3837 (83.66)

TABLE I. (Continued)

<u>Pantala</u> sp.	(naiad)	417-43, 459-44, 731,[9] 764-64, 794-66, 811-67, 895-74, 910-75	101	35.7699	6.5419 (18.29)	29.2280 (81.71)
<u>Perithemis</u> <u>domitia</u> Drury	(naiad)	38-6, 180-29, 189-31, 381-42, 419-43, 458-44, 907-75, 1084-88, 1104-90	25	1.0194	0.2181 (21.39)	0.8013 (78.61)
<u>Plathemis</u> <u>lydia</u> Drury	(naiad)	52-8, 155-22, 263-37, 312-39, 347-41, 379-42, 412-43, 475-46, 496-47, 541-49, 576-51, 591-52, 795-66, 886-73, 890-74, 908-75, 959-78, 987-80, 1033-83, 1045-84, 1120-91, 1128-93, 1161-96	409	56.9713	10.7764 (18.92)	46.1949 (81.08)
<u>Tetragoneuria</u> sp.	(naiad)	18-5, 35-6, 65-9, 84-13, 151-21, 314-39, 529,[10] 532-48	100	14.2677	3.2940 (23.09)	10.9737 (76.91)
<u>Trapezostigma</u> sp.	(naiad)	17-5, 217-34, 239-35, 246-36, 313-39, 416-43, 501-47, 628-55, 812-67, 891-74, 909-75, 1007-81	180	53.8028	7.8902 (14.67)	45.9126 (85.33)
AGRIONIDAE						
<u>Agrion</u> sp.	(naiad)	511-47	4	0.0847	0.0138 (16.29)	0.0709 (83.71)
COENAGRIONIDAE						
<u>Anomalagrion</u> sp.	(naiad)	48-8, 62-9	5	0.0409	0.0109 (26.65)	0.0300 (73.35)
<u>A.</u> <u>hastatum</u> Say	(naiad)	27-6, 421-43, 434-44	19	0.1525	0.0302 (19.80)	0.1223 (80.20)

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[9] collected by the author at Boomer Lake, June 27, 1955

[10] collected by John Preston at Lake Carl Blackwell, March 20, 1955

TABLE I. (Continued)

Argia sp. (naiad)	25-6, 49-8, 61-9, 101-14, 112-15, 176-29, 187-31, 495-46, 503-47, 530,[11] 533-48, 539-49, 647-56, 1065-85, 1121-92, 1131-93	548	17.4848	3.7899 (21.68)	13.6949 (78.32)
Enallagma sp. (naiad)	26-6, 47-8, 63-9, 73-11, 102-14, 114-15, 308-39, 422-43, 432-44, 570-51, 592-52, 615-54, 631-55, 707-59	200	2.2560	0.4585 (20.32)	1.7975 (79.68)
Ischnura sp. (naiad)	46-8, 103-14, 113-15, 433-44, 502-47, 564-50, 571-51, 593-52, 616-54, 663-57, 714-60, 746-62, 751-63, 796-66, 818-67, 888-73, 1019-82	442	7.9941	1.6564 (20.72)	6.3377 (79.28)
Lestes sp. (naiad)	713-60, 747-62, 750-63, 797-66, 856-70, 892-74, 973-79, 1141-94	82	4.5424	0.7847 (17.28)	3.7577 (82.72)
HYDROMETRIDAE					
Hydrometra australis Say (adult)	241-35, 623-54, 729-60, 1009-81	7	0.0101	0.0046 (45.54)	0.0055 (54.46)
H. martini Kirkaldy (adult)	213-33, 474-46, 513-47, 574-51, 1010-81	16	0.0142	0.0095 (66.90)	0.0047 (33.10)
MESOVELIIDAE					
Mesovelia mulsanti White (adult)	823-67, 842-69, 934-76, 999-81, 1017-82, 1199-99	95	0.1037	0.0445 (42.91)	0.0592 (57.09)

[11] collected by John Preston at Lake Carl Blackwell, March 20, 1955

TABLE I. (Continued)

GERRIDAE						
Gerris sp. (adult)	625-54	2	0.0507	0.0083 (16.37)	0.0424 (83.63)
G. marginatus Say (adult)	277-38, 642-55, 693-58, 730-60, 740-61, 787-66, 820-67, 961-78, 983-80	23	0.2967	0.1204 (40.58)	0.1763 (59.42)
G. remigis Say (adult)	652-56, 1067-85	261	12.9941	5.2717 (40.57)	7.7224 (59.43)
Limnogonus sp. (adult)	821-67, 845-69	10	0.0633	0.0182 (28.75)	0.0451 (71.25)
L. hesione (Kirkaldy) (adult)	278-38, 282-39, 984-80, 1018-82	48	0.3834	0.1213 (31.64)	0.2621 (68.36)
Rheumatobates rileyi palosi Blatchley (adult)	899-74, 936-76, 946-77, 1076-86	24	0.0123	0.0058 (47.15)	0.0065 (52.85)
Trepobates pictus (Herrich-Schaeffer) (adult)	699-59, 882-73, 947-77, 985-80, 1066-85, 1077-86	26	0.0722	0.0265 (36.70)	0.0457 (63.30)
VELIIDAE					
Microvelia americana (Uhler) (adult)	739-61, 935-76, 948-77, 964-78, 986-80, 1175-97	148	0.1248	0.0741 (59.38)	0.0507 (40.62)
M. borealis Bueno (adult)	930-76	7	0.0014	0.0006 (42.86)	0.0008 (57.14)
Velia brachialis Stal (adult)	1133-93	1	0.0077	0.0034 (44.16)	0.0043 (55.84)
SALDIDAE					
Saldula interstitialis (Say) (adult)	1198-99	1	0.0017	0.0009 (52.94)	0.0008 (47.06)
NERTHRIDAE					
Gelastocoris oculatus (Fabricius) (adult)	30-6, 174-29, 542-49, 588-52, 1053-85	61	1.5104	0.8065 (53.40)	0.7039 (46.60)

TABLE I. (Continued)

NOTONECTIDAE						
Buenoa sp.	(nymph)	901-74, 913-75, 940-77, 954-78, 967-79, 1108-91	1867	12.8706	2.9869 (23.21)	9.8837 (76.79)
B. margaritacea Torre-Bueno	(adult)	780-65, 858-70, 867-72, 902-74, 912-75, 938-77, 953-78, 966-79	2975	37.5207	10.4714 (27.91)	27.0493 (72.09)
Notonecta sp.	(nymph)	724-60, 822-67, 897-74, 905-75, 926-76, 968-79, 1079-87, 1109-91, 1122-92, 1157-96	497	13.5255	3.4491 (25.50)	10.0764 (74.50)
N. howardi Bueno	(adult)	789-66, 1080-87, 1116-91, 1158-96	280	13.3894	4.3969 (32.84)	8.9925 (67.16)
N. irrorata Uhler	(adult)	944-77, 1132-93, 1143-95, 1171-97	7	0.7382	0.3069 (41.57)	0.4313 (58.43)
N. undulata Say	(adult)	12-3, 39-6a	507	26.5403	10.0380 (37.82)	16.5023 (62.18)
PLEIDAE						
Plea striola Fieber	(adult)	242-35, 253-36, 273-38, 280-39, 325-40, 354-41, 401-43, 423-44, 585-52, 674-57, 1200-99	4127	4.4297	1.8224 (41.14)	2.6073 (58.86)
NEPIDAE						
Ranatra sp.	(nymph)	224-34, 846-69, 884-73, 1041-83, 1095-89	33	1.1663	0.4443 (38.09)	0.7220 (61.91)
R. australis Hungerford	(adult)	276-38, 309-39, 318-40, 357-41, 568-51, 613-54, 637-55, 883-73, 1011-81, 1039-83, 1097-89, 1216-101	38	4.7774	1.9468 (40.75)	2.8306 (59.25)
R. buenoi Hungerford	(adult)	1040-83, 1096-89	17	2.1341	0.8179 (38.33)	1.3162 (61.67)

TABLE I. (Continued)

R. fusca Palisot de Beauvois (adult)	117-15, 132-17, 222-34, 271-37, 1215-101	39	4.2593	1.7318 (40.66)	2.5275 (59.34)
R. kirkaldyi Bueno (adult)	317-40, 1000-81	2	0.1168	0.0313 (26.80)	0.0855 (73.20)
R. nigra Herrich-Schaeffer (adult)	215,[12] 223-34, 270-37, 567-51, 612-54, 646-55, 1012-81	101	8.8737	3.1923 (35.97)	5.6814 (64.03)
BELOSTOMATIDAE					
Belostoma fluminea Say (adult)	41-7, 89-13, 97-14, 212-32, 214,[12] 219-34, 238-35, 249-36, 269-37, 275-38, 284-39, 321-40, 358-41, 466-46, 546-50, 566-51, 610-54, 636-55, 697-59, 742-62, 790-66, 878-73, 923-75, 960-78, 1002-81, 1025-82	175	49.6558	14.9212 (30.05)	34.7346 (69.95)
Lethocerus americanus (Leidy) (adult)	221-34, 712[13]	2	6.8874	2.5066 (36.39)	4.3808 (63.61)
CORIXIDAE					
Corisella sp. (adult)	781-65	6	0.0614	0.0209 (34.04)	0.0405 (65.96)
C. edulis (Champion) (adult)	870-72, 903-74, 916-75, 942-77, 949-78	1474	19.1192	5.6599 (29.60)	13.4593 (70.40)
CORIXIDAE gen. et sp. (nymph)	698-59, 718-60	21	0.0509	0.0096 (18.86)	0.0413 (81.14)

[12]collected by I. E. Wallen and W. C. Greer at the Village Pond, June 21, 1954

[13]collected by the author under lights at 6th and Main, Stillwater, June 20, 1955

TABLE I. (Continued)

Ramphocorixa acuminata (Uhler) (adult)	783-65, 854-70, 863-71, 868-72, 900-74, 914-75, 939-77, 951-78, 969-79, 977-80	4526	23.1228	6.5092 (28.15)	16.6136 (71.85)
Sigara sp. (adult)	13-3, 453-44, 554-50, 627-54, 717-60, 777-65, 855-70, 864-71, 871-72, 904-74, 915-75, 941-77, 950-78, 970-79, 1016-82	2891	16.0283	6.3315 (39.50)	9.6968 (60.50)
Trichocorixa sp. (adult)	454-44, 555-50, 626-54, 700-59, 719-60, 748-62, 782-65, 853-70, 862-71, 869-72, 917-75, 937-77, 952-78, 978-80, 1015-82, 1050-84, 1086-88, 1099-90	5642	17.0916	5.1818 (30.32)	11.9098 (69.68)
SIALIDAE					
Sialis sp. (larva)	59-9, 146-21, 462-45	61	1.8117	0.4093 (22.59)	1.4024 (77.41)
CORYDALIDAE					
Corydalus cornutus L. (larva)	170-27,[14] 649-56, 1061-85	13	7.1104	1.9011 (26.74)	5.2093 (73.26)
HELICOPSYCHIDAE					
Helicopsyche borealis Hagen (larva)	605-53, 657-56, 1059-85	24	0.0787	0.0242 (30.75)	0.0545 (69.25)
H. borealis Hagen (pupa)	658-56, 1060-85	3	0.0115	0.0029 (25.22)	0.0086 (74.78)
LEPTOCERIDAE					
Oecetis sp. (larva)	405-43, 424-44, 470-46	22	0.0097	0.0023 (23.71)	0.0074 (76.29)

[14] Cherokee County, Oklahoma

TABLE I. (Continued)

LIMNEPHILIDAE					
Hesperophylax designatus (Walker) (larva)	467,[15] 471-46, 504-47	16	0.9006	0.1899 (21.09)	0.7107 (78.91)
PYRALIDIDAE					
Nymphula sp. (larva)	427-44	4	0.0389	0.0083 (21.34)	0.0306 (78.66)
OMOPHRONIDAE					
Omophron americanum Dej. (adult)	205-31	2	0.0410	0.0175 (42.68)	0.0235 (57.32)
HALIPLIDAE					
Haliplus sp. (larva)	377-42	5	0.1609	0.0194 (12.06)	0.1415 (87.94)
H. triopsis Say (adult)	267-37, 298-39, 327-40, 351-41, 410-43, 446-44, 493-46, 525-47, 553-50, 645-55, 669-57, 1083-87, 1110-91, 1185-98	568	2.2585	0.9811 (43.44)	1.2774 (56.56)
Peltodytes (Cnemidotus) sp. (larva)	296-39	10	0.0287	0.0106 (36.93)	0.0181 (63.07)
P. sexmaculatus Rbts. (adult)	329-40, 353-41, 414-43, 447-44, 494-46, 527-47, 552-50, 643-55, 1026-82, 1187-98	224	0.9354	0.4265 (45.60)	0.5089 (54.40)
P. 12-punctatus (Say) (adult)	211-32, 229-33, 266-37, 297-39, 328-40, 352-41, 411-43, 492-46, 526-47, 644-55, 807-66, 828-67, 1186-98	283	1.1826	0.6037 (51.05)	0.5789 (48.95)

[15] collected by John Preston from Stillwater Creek near the Lake Carl Blackwell dam, Febr. 13, 1955

TABLE I. (Continued)

DYTISCIDAE						
Agabus sp.	(larva)	512-47, 560-50, 606-53	6	0.0581	0.0126 (21.69)	0.0455 (78.31)
A. disintegratus (Cr.)	(adult)	608-53	3	0.0544	0.0124 (22.79)	0.0420 (77.21)
A. semivittatus (Lec.)	(adult)	367-42, 522-47, 607-53, 656-56	25	1.1011	0.3437 (31.21)	0.7574 (68.79)
Bidessus sp.	(adult)	272-38	1	0.0003	(lost)	
B. flavicollis (Lec.)	(adult)	295-39, 336-40, 340-41, 679-57	34	0.0120	0.0066 (55.00)	0.0054 (45.00)
B. lacustris (Say)	(adult)	294-39, 451-44, 677-57, 706-59, 754-63, 835-67, 932-76, 989-81, 1123-92	26	0.0101	0.0047 (46.53)	0.0054 (53.47)
Canthydrus bicolor (Say)	(adult)	286-39, 582-51	3	0.0039	0.0020 (51.28)	0.0019 (48.72)
Coelambus sp. (a)	(adult)	293-39	3	0.0190	0.0056 (29.47)	0.0134 (70.53)
Coelambus sp. (b)	(adult)	303-39	5	0.0169	0.0154 (91.12)	0.0015 (8.88)
Coelambus sp. (c)	(adult)	326-40	38	0.1840	0.1032 (56.09)	0.0808 (43.91)
C. acaroides (Lec.)	(adult)	617-54, 920-75, 931-76, 1173-97, 1204-100	6	0.0072	0.0034 (47.22)	0.0038 (52.78)
C. nubilus (Lec.)	(adult)	518-47, 632-55, 703-59, 753-63, 770-64, 778-65, 802-66, 833-67, 1071-86, 1081-87, 1087-88, 1107-91, 1149-95, 1165-96, 1203-100, 1210-101	606	3.3754	1.3435 (39.80)	2.0319 (60.20)

TABLE I. (Continued)

Colymbetinae gen. et sp. (larva)	199-31	1	0.0033	0.0006 (18.18)	0.0027 (81.82)
Copelatus sp. (a) (adult)	287-39, 482-46, 687-58, 788-66, 829-67, 963-78, 996-81, 1134-93, 1145-95	94	1.2196	0.4905 (40.22)	0.7291 (59.78)
C. glyphicus (Say) (adult)	690-58	3	0.0148	0.0077 (52.03)	0.0071 (47.97)
Coptotomus interrogatus (Fab.) (adult)	152-21, 232-34, 244-35, 257-36, 292-39, 324-40, 337-41, 408-43, 769-64, 791-66, 831-67, 1117-91, 1125-92, 1142-94	25	0.7149	0.2768 (38.72)	0.4381 (61.28)
Cybister sp. (larva)	209-32, 226-34, 240-35, 725-60, 745-62, 834-67, 1005-81	9	3.6287	0.5982 (16.49)	3.0305 (83.51)
C. fimbriolatus (Say) (adult)	250-36, 635-55, 1217-101	5	7.5952	3.1504 (41.48)	4.4448 (58.52)
Desmopachria dispersa (Cr.) (adult)	1114-91, 1146-95, 1166-96, 1211-101	11	0.0174	0.0067 (38.51)	0.0107 (61.49)
Dytiscinae gen. et sp. (larva)	773-65	3	0.2898	0.0776 (26.78)	0.2122 (73.22)
Eretes sticticus (L.) (adult)	980-80, 1046-84 (94)	3	0.3538	0.0958 (27.08)	0.2580 (72.92)
Hydrocanthus iricolor Say (adult)	259-36, 264-37, 304-39, 551-50, 584-51, 598-52, 624-54, 755-63, 997-81, 1022-82, 1036-83, 1183-98, 1191-99	81	0.3921	0.1842 (46.98)	0.2079 (53.02)

TABLE I. (Continued)

Hydroporinae gen. et sp.	(larva)	461-45	1	0.0018	0.0008 (44.44)	0.0010 (55.56)
Hydroporus sp. (a)	(adult)	289-39	1	0.0058	0.0027 (46.55)	0.0031 (53.45)
Hydroporus sp. (b)	(adult)	1147-95	4	0.0076	0.0038 (50.00)	0.0038 (50.00)
H. niger Say	(adult)	1193-99	1	0.0042	0.0029 (69.05)	0.0013 (30.95)
H. semirufus (Lec.)	(adult)	206-31, 365-42, 407-43, 464-45, 484-46, 517-47, 594-52, 659-56, 660-56, 1056-85, 1135-93, 1148-95	66	0.3945	0.1760 (44.61)	0.2185 (55.39)
H. sericeus Lec.	(adult)	515-47	1	0.0057	0.0025 (43.86)	0.0032 (56.14)
H. undulatus Say	(adult)	338-41	14	0.0832	0.0369 (44.35)	0.0463 (55.65)
Hydrovatus cuspidatus (Kunze)	(adult)	243-35, 290-39, 449-44, 597-52, 998-81, 1023-82, 1190-99	21	0.0434	0.0164 (37.79)	0.0270 (62.21)
Laccophilus sp.	(larva)	799-66, 881-73	7	0.0280	0.0067 (23.93)	0.0213 (76.07)
L. fasciatus Aubé	(adult)	140-19, 233-34, 255-36, 258-36, 291-39, 302-39, 339-41, 364-42, 366-42, 450-44, 481-46, 483-46, 514-47, 516-47, 583-51, 622-54, 661-56, 670-57, 671-57, 686-58, 688-58, 689-58, 705-59, 728-60, 736-61, 737-61, 771-64, 772-64, 779-65, 803-66, 804-66, 962-78, 1069-86, 1082-87, 1088-88, 1106-91, 1144-95, 1164-96, 1184-98, 1189-99, 1202-100, 1209-101	3733	30.4017	11.2038 (36.85)	19.1979 (63.15)

TABLE I. (Continued)

Laccophilus sp. (a)	(adult)	265-37	1	0.0055	0.0027 (49.09)	0.0028 (50.91)
L. quadrilineatus Horn	(adult)	830-67, 919-75, 945-77, 958-78, 974-79, 979-80, 1070-86	38	0.5551	0.2123 (38.25)	0.3428 (61.75)
Thermonectes sp.	(larva)	734-61, 761-64, 957-78	13	0.6526	0.1465 (22.45)	0.5061 (77.55)
T. basilaris (Harr.)	(adult)	752-63, 859-70, 1047-84, 1124-92	4	0.2719	0.1087 (39.98)	0.1632 (60.02)
T. ornaticollis (Aubé)	(adult)	138-17, 231-34, 237-35, 251-36, 281-39, 320-40, 355-41, 406-43, 528,[16] 726-60, 735-61, 756-63, 810-67, 922-75, 928-76, 943-77, 955-78, 976-79, 981-80, 1003-81, 1048-84, 1073-86, 1115-91	247	28.1064	11.9252 (42.43)	16.1812 (57.57)
GYRINIDAE						
Dineutes sp.	(larva)	849-69, 861-70, 873-73, 1118-91, 1162-96	11	0.2788	0.0563 (20.19)	0.2225 (79.81)
Dineutes sp.	(adult)	654-56, 1064-85	10	1.2871	0.5403 (41.98)	0.7468 (58.02)
D. americanus Say	(adult)	319-40, 569-51, 587-52, 618-54, 675-57, 743-62, 758-63, 792-66, 848-69, 852-70, 872-73	526	21.9567	8.4970 (38.70)	13.4597 (61.30)
Gyrinus analis Say	(adult)	580-51, 744-62, 757-63, 776-65, 847-69, 880-73, 906-75	151	1.3395	0.6808 (50.82)	0.6587 (49.18)

[16] collected by Morgan Collins in the Lake Carl Blackwell area, March 20, 1955

TABLE I. (Continued)

HYDROPHILIDAE						
Berosus sp.	(larva)	506-47, 722-60, 801-66	3	0.0136	0.0039 (28.68)	0.0097 (71.32)
B. exiguus (Say)	(adult)	1179-98, 1192-99	14	0.0177	0.0074 (41.81)	0.0103 (58.19)
B. pantherinus Lec.	(adult)	300-39, 330-40, 348-41, 549-50, 573-51, 621-54, 640-55, 768-64, 805-66, 1037-83, 1089-88, 1101-90, 1113-91, 1181-98, 1207-100, 1214-101	242	1.0085	0.4469 (44.31)	0.5616 (55.69)
B. peregrinus (Hbst.)	(adult)	301-39, 331-40, 349-41, 409-43, 489-46, 519-47, 534-48, 548-50, 600-52, 667-57, 824-67, 921-75, 1024-82, 1102-90, 1126-92, 1174-97, 1178-98, 1194-99	100	0.4137	0.1792 (43.32)	0.2345 (56.68)
B. pugnax Lec.	(adult)	341-41, 827-67, 893-74, 1111-91, 1212-101	6	0.1018	0.0373 (36.64)	0.0645 (63.36)
B. striatus (Say)	(adult)	285-39, 350-41, 521-47, 572-51, 826-67, 865-71, 875-73, 898-74, 929-76, 1072-86, 1090-88, 1100-90, 1112-91, 1167-96, 1180-98, 1213-101	87	1.0245	0.4098 (40.00)	0.6147 (60.00)
Cymbiodyta fimbriata (Melsh.)	(adult)	485-46, 550-50	3	0.0191	0.0080 (41.88)	0.0111 (58.12)
Enochrus (Philhydrus) hamiltoni (Horn)	(adult)	1182-98	2	0.0119	0.0058 (48.74)	0.0061 (51.26)
E. nebulosus (Say)	(adult)	299-39, 368-42, 448-44, 490-46, 520-47, 599-52, 641-55, 702-59, 825-67, 933-76, 988-81, 1152-95, 1177-98, 1195-99	58	0.1587	0.0718 (45.24)	0.0869 (54.76)

TABLE I. (Continued)

E. ochraceus (Melsh.) (adult)	837-67, 992-81	3	0.0053	0.0019 (35.85)	0.0034 (64.15)
E. perplexus (Lec.) (adult)	668-57, 1055-85	4	0.0297	0.0083 (27.95)	0.0214 (72.05)
Helochares maculicollis Muls. (adult)	536-49, 596-52, 786-66, 874-73, 975-79, 993-81, 1151-95, 1206-100	32	0.1930	0.0962 (49.84)	0.0968 (50.16)
Helophorus lacustris Lec. (adult)	332-40, 343-41, 524-47, 666-57, 701-59, 727-60, 738-61, 806-66, 990-81	40	0.0454	0.0178 (39.21)	0.0276 (60.79)
Hydrophilus (Hydrocharis) obtusatus Say (adult)	860-70, 876-73, 994-81	3	0.6111	0.1773 (29.01)	0.4338 (70.99)
Hydrochus sp. (adult)	1197-99	4	0.0040	0.0025 (62.50)	0.0015 (37.50)
H. callosus Lec. (adult)	1205-100	1	0.0053	0.0031 (58.49)	0.0022 (41.51)
H. excavatus Lec. (adult)	595-52	18	0.0265	0.0125 (47.17)	0.0140 (52.83)
H. inaequalis Lec. (adult)	991-81	3	0.0017	0.0009 (52.94)	0.0008 (47.06)
H. squamifer Lec. (adult)	1150-95, 1196-99	3	0.0040	0.0026 (65.00)	0.0014 (35.00)
Hydrous (Hydrophilus) triangularis (Say) (larva)	1004-81	4	0.0442	0.0033 (7.47)	0.0409 (92.53)

TABLE I. (Continued)

H. triangularis (Say) (adult)	162,[17] 220-34, 236-35, 248-36, 545-50, 634-55, 696-59, 809-67, 1001-81, 1038-83, 1068,[18] 1094-89, 1176-98, 1201-99	24	37.2290	15.0560 (40.44)	22.1730 (59.56)
Laccobius sp. (a) (adult)	832-67	34	0.2028	0.0680 (33.53)	0.1348 (66.47)
L. agilis Rand. (adult)	460-45, 1156,[19] 1172-97	3	0.0028	0.0014 (50.00)	0.0014 (50.00)
Paracymus (Creniphilus) digestus (Lec.) (adult)	288-39, 639-55	2	0.0041	0.0022 (53.66)	0.0019 (46.34)
P. subcupreus (Say) (adult)	486-46, 581-51, 678-57, 704-59, 836-67, 844-69	19	0.0116	0.0043 (37.07)	0.0073 (62.93)
P. suturalis (Lec.) (adult)	342-41, 843-69, 995-81, 1075-86	33	0.0192	0.0088 (45.83)	0.0104 (54.17)
Tropisternus sp. (larva)	166-25, 261-37, 279-39, 344-41, 619-54, 665-57, 691-58, 694-59, 760-64, 956-78	60	1.4295	0.3024 (21.15)	1.1271 (78.85)
T. glaber (Hbst.) (adult)	488-46, 1035-83	2	0.1177	0.0464 (39.42)	0.0713 (60.58)
T. lateralis (Fabr.) (adult)	15-5, 40-6a	452	17.7848	6.9004 (38.80)	10.8844 (61.20)

[17] collected by the author under lights near the Life Science building, Stillwater, April 26, 1954

[18] collected by Richard Darlington at 8th and Main, Stillwater, August 18, 1955

[19] collected by the author from the Cimarron River near the State Highway 33 bridge, August 31, 1955

TABLE I. (Continued)

T. striolatus (Lec.)	(adult)	256-36, 268-37, 283-39, 322-40, 356-41, 491-46, 547-50, 565-51, 611-54, 629-55, 896-74, 918-75, 927-76, 982-80, 1021-82, 1032-83, 1049-84, 1074-86	276	15.4727	5.9336 (38.35)	9.5391 (61.65)
T. sublaevis (Lec.)	(adult)	487-46, 523-47, 1093-89, 1153-95	26	1.4994	0.6113 (40.77)	0.8881 (59.23)
ELMIDAE						
Stenelmis crenata (Say)	(adult)	655-56, 1057-85	5	0.0104	0.0055 (52.88)	0.0049 (47.12)
HELODIDAE						
HELODIDAE gen. et sp.	(larva)	201-31, 468-46, 559-50, 1169-97	7	0.0150	0.0045 (30.00)	0.0105 (70.00)
CURCULIONIDAE						
Bagous sp.	(adult)	1188-98	2	0.0050	0.0022 (44.00)	0.0028 (56.00)
TIPULIDAE						
Hexatoma sp.	(larva)	676-57	8	0.0942	0.0126 (13.38)	0.0816 (86.62)
Tipula sp.	(larva)	60-9, 167-25, 473-46, 672-57	23	9.8187	0.9539 (9.72)	8.8648 (90.28)
CULICIDAE						
Anopheles sp.	(larva)	505-47, 815-67, 839-68	21	0.0792	0.0149 (18.81)	0.0643 (81.19)
Chaoborus sp.	(larva)	210-32, 393-43, 428-44	553	0.7319	0.0756 (10.33)	0.6563 (89.67)
Culex sp.	(larva)	681-57, 685-58	276	0.9492	0.1744 (18.37)	0.7748 (81.63)
Culex sp.	(pupa)	682-58	251	1.1216	0.2109 (18.80)	0.9107 (81.20)
Culiseta sp.	(larva)	70-10, 79-12, 143-19	1932	9.6505	1.6302 (16.89)	8.0203 (83.11)

TABLE I. (Continued)

Psorophora sp.	(larva)	732-61, 838-68	575	1.0634	0.1747 (16.43)	0.8887 (83.57)
Psorophora sp.	(pupa)	733-61, 840-68	145	0.3295	0.0561 (17.03)	0.2734 (82.97)
TENDIPEDIDAE						
Anatopynia sp.	(larva)	369-42	37	0.0929	0.0161 (17.33)	0.0768 (82.67)
Calopsectra sp.	(larva)	373-42, 444-44	15	0.0061	0.0008 (13.11)	0.0053 (86.89)
Clinotanypus sp.	(larva)	90-13, 195-31, 370-42, 399-43, 440-44	88	0.2320	0.0390 (16.81)	0.1930 (83.19)
Coelotanypus sp.	(larva)	438-44	30	0.0745	0.0127 (17.05)	0.0618 (82.95)
Cryptochironomus sp.	(larva)	400-43, 445-44	4	0.0084	0.0017 (20.24)	0.0067 (79.76)
Metriocnemus sp.	(larva)	442-44	60	0.0841	0.0111 (13.20)	0.0730 (86.80)
Pentaneura sp.	(larva)	439-44	6	0.0184	0.0032 (17.39)	0.0152 (82.61)
Procladius sp.	(larva)	398-43	6	0.0060	0.0010 (16.67)	0.0050 (83.33)
Spaniotoma sp.	(larva)	372-42	1	0.0013	0.0001 (7.69)	0.0012 (92.31)
Stenochironomus sp.	(larva)	441-44	75	0.6735	0.0560 (8.31)	0.6175 (91.69)
Tanypus sp.	(larva)	371-42, 397-43	9	0.0112	0.0012 (10.71)	0.0100 (89.29)
TENDIPEDIDAE gen. et sp.	(larva)	91-13, 684-58	161	0.5491	0.0639 (11.64)	0.4852 (88.36)
TENDIPEDIDAE gen. et sp.	(pupa)	507-47, 683-58	10	0.0286	0.0044 (15.38)	0.0242 (84.62)

TABLE I. (Continued)

Tendipes (*Chironomus*) sp. (larva)	182-30, 194-31, 395-43, 443-44, 562-50	202	0.4526	0.0682 (15.07)	0.3844 (84.93)
CERATOPOGONIDAE					
Atrichopogon websteri (Coquillett) (larva)	710-59	2	0.0007	0.0003 (42.86)	0.0004 (57.14)
CERATOPOGONIDAE gen. et sp. (larva)	202-31	11	0.0113	0.0030 (26.55)	0.0083 (73.45)
Palpomyia/*Bezzia*/*Probezzia* (larva)	431-44	11	0.0078	0.0022 (28.21)	0.0056 (71.79)
Stilobezzia sp. (larva)	378-42, 394-43, 430-44, 604-52	107	0.1494	0.0351 (23.49)	0.1143 (76.51)
STRATIOMYIIDAE					
Odontomyia sp. (larva)	139-17, 225-34, 230-33, 245-35, 469-46, 508-47, 673-57, 723-60, 814-67, 1008-81	88	2.6579	0.7170 (26.98)	1.9409 (73.02)
Stratiomyia sp. (larva)	509-47, 813-67, 1042-83, 1054-85, 1154-95	60	5.1122	1.2538 (24.53)	3.8584 (75.47)
STRATIOMYIIDAE gen. et sp. (larva)	(46) (50) 630-55	1	0.0006	0.0004 (66.67)	0.0002 (33.33)
TABANIDAE					
Chrysops sp. (larva)	92-13, 158-23, 396-43, 426-44, 463-45, 472-46, 602-52, 819-67, 1029-82	75	1.7649	0.3797 (21.51)	1.3852 (78.49)

TABLE I. (Continued)

Tabanus sp. (larva)	28-6, 157-23, 193-31, 346-41, 538-49, 653-56, 816-67, 1098,[20] 1138,[21] 1155,[22] 1170-97	14	8.3346	1.3695 (16.43)	6.9651 (83.57)
SYRPHIDAE					
Tubifera (Eristalis) sp. (larva)	181-30	1	0.0652	0.0126 (19.33)	0.0526 (80.67)
TETANOCERIDAE					
Dictya pictipes Loew (larva)	392-43	1	0.0006	0.0002 (33.33)	0.0004 (66.67)
ANTHOMYIIDAE					
Limnophora sp. (larva)	692-58, 709-59	4	0.0060	0.0009 (15.00)	0.0051 (85.00)
PHYSIDAE					
Physa anatina (Lea) (entire animal)	55[23]	1479	51.1390	16.3680 (32.01)	34.7710 (67.99)
P. hawnii (Lea) (entire animal)	98-14, 130-16, 142-19	155	24.8394	8.7811 (35.35)	16.0583 (64.65)
P. hawnii (Lea) (body only)	106-15	68	13.1579	1.7235 (13.10)	11.4344 (86.90)
PLANORBIDAE					
Gyraulus parvus (Say) (entire animal)	601-52	33	0.1179	0.0607 (51.48)	0.0572 (48.52)

[20] collected by R. M. Sutton from Stillwater Creek, August 22, 1955

[21] collected by R. M. Sutton from Stillwater Creek, August 26, 1955

[22] collected by the author from the Cimarron River near the State Highway 33 bridge, August 31, 1955

[23] collected by A. W. Hill at the State Fish Hatchery, Durant, Oklahoma; December, 1953

TABLE I. (Continued)

Helisoma trivolvis (Say) (entire animal)	99-14, 129-16, 154-22	101	43.6709	21.0024 (48.09)	22.6685 (51.91)
H. trivolvis (Say) (body only)	105-15, 131-17, 153-22	132	53.3761	8.2415 (15.44)	45.1346 (84.56)
ANCYLIDAE					
Ferrissia shimekii (Pilsbry) (entire animal)	436-44	22	0.0148	0.0061 (41.22)	0.0087 (58.78)
PHILOMYCIDAE					
Philomycus sp.	316[24]	32	155.3554	(discarded)	
PLEUROCERIDAE					
Goniobiasis potosensis plebius (Anthony) (entire animal)	171-27[25]	54	10.0739	7.6058 (75.50)	2.4681 (24.50)
UNIONIDAE					
Anodonta corpulenta Cooper (entire animal)	7-1	1	112.7334	22.5132 (19.97)	90.2202 (80.03)
A. corpulenta Cooper (boiled to remove body)	4-1, 6-1, 32-6	5	695.3501	19.1898 (2.76) (body) 130.9328 (18.83) (valves)	545.2275 (78.41)
A. corpulenta Cooper (placed alive in oven)	5-1, 31-6	4	564.6601	14.9324 (2.64) (body) 134.4041 (23.80) (valves)	415.3236 (73.55)

[24] collected by the author at the Village, Stillwater, October 1, 1954

[25] Cherokee County, Oklahoma

TABLE I. (Continued)

Carunculina parva (Barnes) (entire animal)	43-8, 137-18, 149-21	9	22.1769	13.0512 (58.85)	9.1257 (41.15)
C. parva (Barnes) (placed alive in oven)	22-6, 160-24, 175-29, 185-30, 197-31, 382-42, 543-49	75	263.3499	9.8093 (3.72) (body) 124.1726 (47.15) (valves)	129.3680 (49.12)
C. parva (Barnes) (boiled to remove body)	1-1, 2-1, 383-42	59	45.2414	8.2485 (18.23) (body) 16.3141 (36.06) (valves)	20.6788 (45.71)
Uniomerus tetralasmus Say (placed alive in oven)	23-6, 136-18	15	546.2889	20.3539 (3.73) (body) 213.5728 (39.09) (valves)	312.3622 (57.18)
U. tetralasmus Say (boiled to remove body)	3-1, 161-24	15	589.7849	21.7083 (3.68) (body) 238.1364 (40.38) (valves)	329.9402 (55.94)
SPHAERIIDAE					
Musculium sp. (entire animal)	69-9, 75-11, 83-13, 100-14, 116-15, 159-23, 196-31, 563-50, 575-51, 877-73, 1034-83	188	23.8045	7.6137 (31.98)	16.1908 (68.02)
Pisidium sp. (entire animal)	510-47, 1136-93	46	0.7289	0.4549 (62.41)	0.2740 (37.59)
CYPRINIDAE					
Pimephales promelas Rafinesque	207[26]	26	28.0148	6.5598 (23.42)	21.4550 (76.58)

[26] collected by I. E. Wallen from the Mill Pond, Stillwater, June 10, 1954

TABLE I. (Continued)

POECILLIIDAE					
Gambusia affinis affinis (Baird and Girard)	104-15, 121-16	80	21.1977	4.7997 (22.64)	16.3980 (77.36)
CENTRARCHIDAE					
Lepomis sp.	147-21	9	11.3689	2.5494 (22.42)	8.8195 (77.58)
PLETHODONTIDAE					
Eurycea longicauda melanopleura Cope (larva)	173-28[27]	37	1.7026	0.2761 (16.22)	1.4265 (83.78)
HYLIDAE					
Acris gryllus crepitans Baird (larva)	216-34	138	38.2157	4.4110 (11.54)	33.8047 (88.46)
A. gryllus crepitans Baird (adult)	156-22, 218-34, 254-36	30	10.9362	2.0281 (18.54)	8.9081 (81.46)
RANIDAE					
Rana catesbeiana Shaw (larva, 40-60 mm)	115-15, 122-16	29	76.7816	8.1486 (10.61)	68.6330 (89.39)
R. catesbeiana Shaw (larva, 90-110 mm)	123-16	11	114.7896	13.2814 (11.57)	101.5082 (88.43)
R. catesbeiana Shaw (adult)	390-41	1	21.1429	3.6735 (17.37)	17.4694 (82.63)

[27] Delaware County, Oklahoma

Discussion

Special Observations

A number of observations pertaining to certain field collections may be of interest. Since the gathering of evidence in support of the observations was not within the scope of the study, they are presented here for whatever value they may have in themselves. Foremost in this connection was the extreme variation in abundance of many aquatic invertebrates during the two-year period in which collections were made. Literally thousands of pigmy backswimmers (Plea striola Fieber), for example, were in one small impoundment (Yost golf course) in the fall of 1954, with considerable numbers of three species of crawling water beetles, Haliplus triopsis Say, Peltodytes sexmaculatus Rbts., and P. 12-punctatus (Say). During the summer and fall of 1955, however, the four insects that during the previous year had been so abundant were extremely rare.

Probably less than a dozen individual whirligig beetles (Dineutes americanus Say) were observed during 1954, yet this species was numerous and widespread in 1955, sometimes congregated as large black masses on the surface of a pond. Although field collections were begun in October of 1953, the first clam shrimps [Caenestheriella morsei (Packard)] were not taken until June 18, 1955 (Village pond). A fairy shrimp, Streptocephalus seali Ryder, and the tadpole shrimp, Apus longicaudatus Lec., likewise were first obtained during the summer of 1955 about twelve miles south of Stillwater. The writer did not collect in areas along the Cimarron River in 1954, but conditions were so arid that in all probability the two crustaceans did not occur there the preceeding year. A small dytiscid, Coelambus nubilus (Lec.), was found in fairly large numbers in an impoundment ten miles south of Stillwater in the early summer of 1955; at no other time or place was more than a relatively-small number of specimens of this beetle ever obtained. Because of this tendency for fluctuations in the kinds of aquatic organisms from year to year, attempts to establish a complete faunal list for this or any similar area must extend over a number of years.

The writer was impressed also by the rapidity with which conditions in aquatic environments changed, sometimes within the course of a few weeks. This especially was true of temporary ponds into which water drained in the spring but from which the water later evaporated. In the absence of predators--both vertebrate and invertebrate--that tend to inhabit most permanent ponds, large populations of insects and crustaceans with life cycles that can be completed in a short time tended to build up in the spring and early summer. Because large populations build up quickly, very intense competition must have arisen among the inhabitants of such ponds as the ponds became smaller and smaller. Small shallow-water areas often had extremely-concentrated populations of invertebrates. Sometimes one or only a few species predominated, but usually a greater variety of organisms was found. The only occasion on which the writer easily obtained an ostracod in quantity was from a small pool in which only an inch or two of water remained and where, for some reason, the ostracods (Chlamydotheca herricki Turner) were virtually the only form of animal life remaining. Thermonectes ornaticollis (Aubé) is a fairly-large dytiscid of which ordinarily the writer obtained not more than eight or ten specimens in an afternoon of collecting; yet on one occasion 50 of the beetles were captured in less than five minutes from a small body of water with an area of not more than four square feet and a maximum depth of only about two inches. The same body of water also yielded several hundred small dytiscids (*Laccophilus fasciatus* Aubé) and a number of large hydrophilids [*Hydrous triangularis* (Say)]. Concentrations of backswimmers and water boatmen were common in middle and late summer in some such pools.

Beetles, bugs, and other insects (in their adult stages at least) can migrate to more favorable surroundings as the ponds become dry. Some aquatic organisms survive unfavorable conditions as a quiescent or dormant form, or in the egg stage. A somewhat catastrophic effect of changing conditions on invertebrates occasionally was observed. *Uniomerus tetralasmus* Say was seldom readily collected. Large numbers of the mussel, however, were found in a relatively-shallow impoundment on the Oklahoma Agricultural and Mechanical College golf course in the spring of 1954. The water eventually evaporated from the pond during the summer. The next year water again was impounded in the pool, but there were no living *Uniomerus*.

Spiders were surprisingly numerous around ponds, at least where there was debris for concealment or plants for the attachment of webs. The Araneida were thought to be strictly terrestrial, yet *Tetragnatha* and *Dolomedes* were observed many times running on the surface of water when disturbed and when pursued they submerged completely by crawling along the under-water portions of objects. One *Tetragnatha* in a container half-filled with water was observed making swimming motions with its legs while submerged, by which means it progressed through the water. Spiders that are characteristic of the littoral areas of ponds and lakes seemed to be practically amphibious in habits.

An observation that may have applications to fisheries management is that most aquatic insects occurred only where there was cover of some kind. For certain species (e.g., damselfly and mayfly naiads) rocks and similar objects may have provided places for attachment and for concealment. Sometimes dead leaves or other plant residues on the bottom supplied cover. The presence of higher aquatic plants in a pond tended to indicate a variety of aquatic invertebrates and the lack of plants either a paucity of individuals, or, at best, very limited kinds of organisms. Portions of the same impoundment that differed in the amount of vegetation present usually differed correspondingly in the abundance of aquatic invertebrates. There were a few exceptions. Large populations of certain dytiscids (especially Laccophilus fasciatus Aubé), water boatmen, and backswimmers were found in waters where no cover of any kind seemed to exist.

There were other factors that probably influenced the density of insect populations in ponds. Two of the ponds (Sanborn Lake and the deepest one of several impoundments on the college golf course) seemed to be ideal collecting sites, since both were fairly large permanent bodies of water with an abundance of submerged and emergent vegetation for cover. Yet collections at Sanborn Lake consistently yielded only meagre results and the other pond was a veritable desert. Fish populations of the ponds may have been responsible for the phenomenon. The density of insect populations in ponds probably was inversely proportional to the density of population of fishes.

Turbidity also seemed to be a factor in the distribution of aquatic organisms. Although none of the ponds were entirely free of suspended matter, the writer soon learned to avoid markedly turbid ponds. Whether the effect of the turbidity on the paucity of aquatic invertebrates was due directly to the suspended particles themselves or indirectly through other effects was not known. Occasionally a considerable number of water boatmen and backswimmers was found in small bodies of water that were fairly turbid.

The nature of the bottom of a pond seemed to affect the abundance of organisms. The bottom fauna of ponds that had deposits of silt was practically non-existant. If an abundance of organic debris was present on the bottom, larger numbers and a greater variety of organisms tended to occur.

Atypical Aquatic Forms

A number of species listed in the table actually are not aquatic in the sense that they live continuously--or even intermittently--in water. Eisenia foetida (Savigny), for example, lives where there is an abundance of putrefying organic matter, yet apparently it is almost as incapable of surviving under truly aquatic conditions as the common earthworm. Springtails (Collembola) frequent open water surfaces; they are not, however, actually aquatic. Marsh-treaders (Hydrometra australis Say, H. martini Kirkaldy) are found on vegetation, on mud, and on the surface of water; similar types of surfaces are inhabited by the water treader, Mesovelia mulsanti White. Water striders (Gerridae, Veliidae) are predaceous bugs living on the surface of, but not in, water. Among predaceous insects that frequent damp or marshy soils is the shore bug, Saldula interstitialis (Say). The toad bug, Gelastocoris oculatus (Fabr.), likewise is littoral in habits; it takes to water readily when pursued but quickly returns to muddy or mucky areas.

Beetles of the genus Omophron occupy holes in wet areas along the margins of lakes and ponds, or are found under stones and other objects in such areas. Although the long-toed water beetle, Stenelmis crenata (Say), crawls on submerged surfaces, it is incapable of swimming freely in water. Bagous similarly represents a subtribe of snout beetles (Hydronomi) whose members, while living upon semiaquatic plants, seem to lack the usual structural types of adaptations for living in water.

Additional Forms Known to Occur

The occurrence in Payne County of a number of aquatic insects not among those listed in Table I is known from records of the Department of Entomology. The imago of the mayfly Ephemerella infrequens McDunnough, for example, has been collected locally, indicating the likelihood of naiads of this genus in our fauna. Adults of four species of dragonflies (Dromogomphus spoliatus Hagen, Brechmorhoga mendax Hagen, Didymops transversa Say, and Tarnetrum /Sympetrum/ corruptum Hagen) represent genera that were not encountered as naiads. Imagines of Hetaerina americana (Fab.) and Telebasis salva Hagen, and naiads of Hesperagrion sp. and Teleallagma sp. likewise represent genera of Zygoptera that have been reported for the county.

Two members of the family Saldidae, Pentacora sphacelata (Uhler) and Saldula reperta (Uhler), the gerrid Trepobates knighti Dehl, and the belostomatid Benacus griseus (Say) are recorded. The caddice fly Potamyia flava (Hagen) has been collected locally.

A number of additional representatives of families of beetles are known to occur. For the family Haliplidae, they are Haliplus punctatus Aubé and Peltodytes litoralis Math.; for the family Dytiscidae, Acilius mediatus (Say), A. semisulcatus Aubé, Agabus lugens (Lec.), Coptotomus longulus Lec., Dytiscus verticallis Say, Hydroporus dichrous Melsh., and Laccophilus proximus Say; for the family Gyrinidae, Dineutes emarginatus Say, D. vittatus (Germ.), Gyrinus aeneolus Lec., G. borealis Aubé, and G. parcus Say; and for the family Hydrophilidae, Berosus infuscatus Lec., Sphaeridium scarabaeoides (L.), Tropisternus mexicanus Cast., and T. mixtus (Lec.).

Adults of a number of Diptera, whose genera are not among the larval forms listed in Table I, have been collected in or near Stillwater. Craneflies of the genera Empedomorpha, Gonomyia, and Helobia are known to occur, as are the culicid genera Aedes and Theobaldia. Adults of Culicoides, Forcipomyia, and Palpomyia represent additional genera of Ceratopogonidae; the stratiomyid genera Hermetia, Hoplitimyia, Labostigmina, Oxycera, Pedicella, and Ptecticus also are recorded. Two additional genera of horse flies, Esenbeckia and Silvius, are represented by specimens from Payne County.

Suggested Areas for Future Taxonomic Study

The writer was impressed with the need for research in two particular taxonomic categories. For a problem in intraspecific variation and for a critical study of the limits of speciation, the dytiscid considered here as a single species (Laccophilus fasciatus Aubé) appeared to be ideal. It was one of the most abundant aquatic beetles. The elytral color pattern of L. fasciatus was extremely variable. Limited collections of the beetle originally were sorted into two groups, for neither of which was the specific status certain. Only after additional collecting and study did it become apparent that the two "species" into which the beetles were divided were variations of the same species. Comparison with specimens determined by Frost in the collection of the Department of Entomology confirmed the identification as fasciatus.

The naiads of damselflies are another challenging group for the taxonomist. Specimens belonging to the genus Ischnura and those of the genus Enallagma were seldom distinguished with any degree of certainty. Key characteristics for the genera were relative and overlapping, and specimens themselves were variable. Some specimens had a different number of labial setae on one side than on the other. This difficulty apparently was one that had been recognized for some time. Walker (1953) wrote of the group:

> "The main difficulty in constructing a key to the genera of this family [Coenagriidae], based on nymphal characters, is that the characters that appear to be generic do not always correspond to those based on adult features. This is the case in the related genera Enallagma, Coenagrion, and Ischnura. Considering the Canadian species of Enallagma alone, there are four well-defined groups of nymphs apparently deserving of generic rank. One of these groups...is inseparable from Coenagrion and Ischnura and, if we knew these forms only as nymphs, we would certainly class them as one genus.... Hence a key to the recognized genera based on nymphal characters becomes highly artificial and, in some places, breaks down altogether."

While monographic treatments of any genus or larger unit always are worthwhile, no taxonomic work in aquatic biology is more needed than one on the Zygoptera comparable to the manual of the Anisoptera of Needham and Westfall (1955).

CHAPTER IV

CHEMICAL COMPOSITION

Introduction

The general composition (moisture, protein, fat, nitrogen-free extract, fiber, and ash) and percentages of two minerals (calcium and phosphorus) for representatives of 21 families of aquatic invertebrates and of four vertebrate families is presented in Table II. The number of analyses upon which the averages were based is given in the second column from the left of the table. Detailed analyses of the 62 individual samples on a moisture-free basis are given as Table IV of Appendix A; corresponding values for each sample on a live-weight basis are given as Table V of Appendix A. All percentages on a dry-weight basis are values determined by the Department of Agricultural Chemistry of the Oklahoma Agricultural and Mechanical College; conversions to live weight were made by the writer on the basis of moisture determinations described in Chapter II.

In heterotrophic nutrition, energy can be derived only from the protein, fat, and digestible carbohydrate components of food. From the values in Table II, therefore, it is possible to calculate the number of calories capable of being supplied by each of the three food components. Since the values in Table II are on a percentage basis, they can be interpreted as grams of protein, of fat, and of nitrogen-free extract (N.F.E.) per 100 grams live weight. Grams of protein and of N.F.E. (carbohydrate) are multiplied by four to convert to calories; grams of fat are multiplied by nine to convert to calories (L. A. Maynard, 1944). The results of such calculations are given in Table III. It was assumed for calculational purposes that the N.F.E. values in Table II represented digestible carbohydrate (Dutcher et al., 1951).

TABLE II.

The Average Composition (Live Weight Basis) of Representatives of Twenty-one Families of Aquatic Invertebrates and of Four Families of Vertebrates

Family	Number of Analyses	Percentage Composition							
		Moisture	Protein	Fat	N.F.E.	Fiber	Ash	Calcium	Phosphorus
LUMBRICIDAE	1	86.55	8.83	1.61	1.97	0.30	0.73	0.03	0.11
GLOSSIPHONIIDAE	1	79.48	17.52	0.56	1.24	0.42	0.78	0.37	0.09
CAENESTHERIIDAE	1	78.24	10.52	0.57	0.78	3.31	6.58	2.14	0.86
ASTACIDAE (mature)	4	70.02	13.22	1.14	2.22	2.87	10.53	3.30	0.34
ASTACIDAE (immature) . . .	3	77.16	11.31	0.61	1.43	2.07	7.43	2.30	0.30
GOMPHIDAE	1	80.49	12.76	0.95	0.13	2.81	2.86	0.07	0.15
AESCHNIDAE	1	79.88	14.49	1.53	0.08	2.82	1.21	0.01	0.12
LIBELLULIDAE	7	81.80	12.56	0.86	1.01	2.44	1.33	0.04	0.17
COENAGRIONIDAE	1	78.32	14.75	1.40	1.08	2.68	1.78	0.03	0.23
GERRIDAE	1	59.43	27.34	4.70	1.04	6.21	1.28	0.08	0.30
NOTONECTIDAE (adult) . . .	3	67.14	20.23	4.29	3.28	3.69	1.36	0.08	0.29
NOTONECTIDAE (nymph) . . .	2	75.64	18.86	1.68	0.12*	2.16	1.25*	0.04*	0.29*
NEPIDAE	1	64.03	25.51	1.69	0.51	7.03	1.23	0.09	1.20
BELOSTOMATIDAE	1	69.95	20.37	1.86	1.82	4.56	1.43	0.08	0.28
CORIXIDAE	4	68.11	21.35	3.78	1.81	3.76	1.19	0.04	0.30

*based on one sample only

TABLE II. (Continued)

DYTISCIDAE	3	59.75	22.91	9.27	0.87	5.79	1.42	0.05	0.26
GYRINIDAE	1	61.30	23.41	7.22	0.33	6.44	1.30	0.06	0.30
HYDROPHILIDAE	3	60.80	25.77	5.84	0.80	5.16	1.63	0.04	0.21
PHYSIDAE (entire)	2	66.32	7.74	0.37	1.94	1.62	22.02	7.82	0.12
PLANORBIDAE (entire) . . .	1	51.91	6.43	0.33	4.25	0.42	36.66	12.85	1.34
PLANORBIDAE (body only) . .	1	84.56	8.55	0.50	3.05	0.47	2.88	0.74	0.11
PLEUROCERIDAE (entire) . .	1	24.50	33.46	0.54	3.81	8.65	29.04	25.29	0.08
UNIONIDAE[1]	4	83.36	8.17	0.40	4.14	0.66	3.26	0.66	0.39
UNIONIDAE[2]	3	78.82	10.57	0.33	5.25	0.82	4.21	0.84	0.19
UNIONIDAE (entire)	2	61.44	2.44	0.44	0.46	0.62	34.59	11.27	0.57
UNIONIDAE[3]	1	95.62	1.87	0.13	1.04	0.05	1.29	0.38	0.08
UNIONIDAE[4]	1	96.14	1.76	0.12	0.41	0.05	1.51	0.49	0.07
SPHAERIIDAE (entire) . . .	1	68.02	1.22	0.47	2.41	0.18	27.71	10.95	0.04
CYPRINIDAE	1	76.58	13.80	2.08	3.03	0.40	4.11	1.10	1.05
POECILIIDAE	1	77.36	14.36	1.38	1.60	0.36	4.94	1.46	0.69
HYLIDAE	1	88.46	3.69	0.14	3.88	0.18	3.64	0.13	0.21
RANIDAE (larva)	2	88.91	6.98	0.48	0.45	0.66	2.52	0.16	0.13
RANIDAE (adult)	1	82.63	13.44	0.80	0.48	0.10	2.54	0.70	0.28

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[1] body only; animal killed by being placed in oven

[2] body only; removed from valves by boiling

[3] body only (with glochidia); removed from valves by boiling

[4] body only (with glochidia); animal killed by being placed in oven

TABLE III.

The Number and Percentage of Calories Supplied by the Protein, Fat, and N.F.E. of, and the Total Number of Calories in, an Average 100-gram Sample (Live Weight) of Representatives of Twenty-one Families of Aquatic Invertebrates and Four Families of Vertebrates

Family	Calories Supplied By						Total Number of Calories	
	Protein		Fat		N.F.E.		Actual	Number on the Basis of 178.55 = 100
	number	percent	number	percent	number	percent	Number	
LUMBRICIDAE	35.32	(61.22)	14.49	(25.12)	7.88	(13.66)	57.69	32.31
GLOSSIPHONIIDAE	70.08	(87.51)	5.04	(6.29)	4.96	(6.19)	80.08	44.85
CAENESTHERIIDAE	42.08	(83.61)	5.13	(10.19)	3.12	(6.20)	50.33	28.19
ASTACIDAE (mature)	52.88	(73.42)	10.26	(14.25)	8.88	(12.33)	72.02	40.34
ASTACIDAE (immature) . . .	45.24	(80.14)	5.49	(9.72)	5.72	(10.13)	56.45	31.62
GOMPHIDAE	51.04	(84.91)	8.55	(14.22)	0.52	(0.87)	60.11	33.67
AESCHNIDAE	57.96	(80.44)	13.77	(19.11)	0.32	(0.44)	72.05	40.35
LIBELLULIDAE	50.24	(81.01)	7.74	(12.48)	4.04	(6.51)	62.02	34.74
COENAGRIONIDAE	59.00	(77.71)	12.60	(16.60)	4.32	(5.69)	75.92	42.52
GERRIDAE	109.36	(70.18)	42.30	(27.15)	4.16	(2.67)	155.82	87.27
NOTONECTIDAE (adult) . . .	80.92	(61.00)	38.61	(29.11)	13.12	(9.89)	132.65	74.29
NOTONECTIDAE (nymph) . . .	75.44	(82.86)	15.12	(16.61)	0.48	(0.53)	91.04	50.99
NEPIDAE	102.04	(85.54)	15.21	(12.75)	2.04	(1.71)	119.29	66.81
BELOSTOMATIDAE	81.48	(77.23)	16.74	(15.87)	7.28	(6.90)	105.50	59.09
CORIXIDAE	85.40	(67.42)	34.02	(26.86)	7.24	(5.72)	126.66	70.94

TABLE III. (Continued)

DYTISCIDAE	91.64 (51.32)	83.43 (46.73)	3.48 (1.95)	178.55	100.00
GYRINIDAE	93.64 (58.55)	64.98 (40.63)	1.32 (0.82)	159.94	89.58
HYDROPHILIDAE	103.08 (64.90)	52.56 (33.09)	3.20 (2.01)	158.84	88.96
PHYSIDAE (entire)	30.96 (73.63)	3.33 (7.92)	7.76 (18.45)	42.05	23.55
PLANORBIDAE (entire) . . .	25.72 (56.29)	2.97 (6.50)	17.00 (37.21)	45.69	25.59
PLANORBIDAE (body only) .	34.20 (67.19)	4.50 (8.84)	12.20 (23.97)	50.90	28.51
PLEUROCERIDAE (entire) . .	133.84 (86.94)	4.86 (3.16)	15.24 (9.90)	153.94	86.22
UNIONIDAE[1]	32.68 (61.85)	3.60 (6.81)	16.56 (31.34)	52.84	29.59
UNIONIDAE[2]	42.28 (63.82)	2.97 (4.48)	21.00 (31.70)	66.25	37.10
UNIONIDAE (entire)	9.76 (62.72)	3.96 (25.45)	1.84 (11.83)	15.56	8.71
UNIONIDAE[3]	7.48 (58.39)	1.17 (9.13)	4.16 (32.47)	12.81	7.17
UNIONIDAE[4]	7.04 (72.13)	1.08 (11.07)	1.64 (16.80)	9.76	5.47
SPHAERIIDAE (entire) . . .	4.88 (26.03)	4.23 (22.56)	9.64 (51.41)	18.75	10.50
CYPRINIDAE	55.20 (64.16)	18.72 (21.76)	12.12 (14.09)	86.04	48.19
POECILLIIDAE	57.44 (75.32)	12.42 (16.29)	6.40 (8.39)	76.26	42.71
HYLIDAE	14.76 (46.80)	1.26 (3.99)	15.52 (49.21)	31.54	17.66
RANIDAE (larva)	27.92 (82.02)	4.32 (12.69)	1.80 (5.29)	34.04	19.06
RANIDAE (adult)	53.76 (85.50)	7.20 (11.45)	1.92 (3.05)	62.88	35.22
(Average)	55.30 (70.88)	15.84 (20.30)	6.88 (8.82)	78.02	43.70

[1]body only; animal killed by being placed in oven

[2]body only; removed from valves by boiling

[3]body only (with glochidia); removed from valves by boiling

[4]body only (with glochidia); animal killed by being placed in oven

Discussion

Protein

The data presented in Table II tend to confirm the variation in chemical composition of aquatic organisms that was reported in the literature (Embody and Gordon, 1924; Schaeperclaus, 1933; Phillips et al., 1954). The protein content on a live-weight basis varied from 1.22 to 33.46 percent, both extremes being represented in the Mollusca. On a dry-weight basis the leech *Placobdella rugosa* (Verrill) contained over 85 percent protein (Appendix A, Table IV). Because of the rather high moisture content (79 percent), its protein content on a live-weight basis was about median in position. All of the families of the orders Coleoptera and Hemiptera were relatively high in protein, while the Odonata averaged slightly below the median. The range of protein content among the gastropods and pelecypods was rather striking. The high protein content of *Goniobiasis* (Appendix A) may have been associated with the facts that, unlike *Physa* and *Helisoma*, it was an operculate snail, was a stream inhabitant, and had a shell composed almost entirely of relatively low-density calcium compounds. Potentially at least, *Goniobiasis* represented a more concentrated food for fishes than the other species of snails analyzed.

The apparent difference in protein content among the pelecypod species (Appendix A, Table V) was due largely to differences in moisture content. Analyses of the body of *Anodonta corpulenta* Cooper and *Uniomerus tetralasmus* Say showed a moisture content of approximately 96 percent, while the body of the smaller *Carunculina parva* (Barnes) averaged less than 50 percent moisture. In converting from a dry-weight to a live-weight basis, the protein content of the first two species was reduced to about one twenty-fifth of its dry-weight value (56-62 percent), while the protein content on a dry-weight basis (46-48 percent) of the last-named species was reduced only to one half.

Tunison et al. (1943?) presented methods for the determination of values for digestion and utilization of protein, and listed digestion coefficients and biological values for several proteins in brook trout. McCay et al. (1931) placed the minimum protein requirement for optimum growth of trout above 14 percent of the total calories, the 15 percent level being almost optimum. If we accept this value as being applicable to fishes in general, then proteins should constitute a certain minimal proportion of the combined energy-yielding components of the diet. The percentage of calories derived from protein, from fat, and from the N.F.E. in the various food organisms is shown in Table III. Protein supplied from 26.03 to 87.51 percent of the calories, the average of all the families represented being 70.88 percent. Fats supplied from 3.16 to 46.73 percent of the calories, with an average of 20.30 percent. Carbohydrates (N.F.E.) supplied from 0.44 to 21.00 percent of the calories, the average being 8.82 percent. The data show that the percentage of calories capable of being supplied by protein was well above the assumed minimum level (15 percent) in all the natural foods analyzed, in most instances actually being from four to five times this value. There was, then, clearly no lack of quantity of protein in natural food in comparison to the proportion of digestible carbohydrate and fat.

As might have been expected from the variance in chemical composition indicated in Table II, food organisms differed widely in the number of calories they supplied on an equivalent live-weight basis. The actual number of calories in an average 100-gram sample (live weight) is given in the second column from the right of Table III. The number varied from 9.76 to 178.55, with an average of 78.02 calories per 100 grams for all the families. The last column of the table shows the energy content on a purely relative basis, i.e., on the basis of 100 as the value for the family (Dytiscidae) having the highest actual caloric content per unit of weight.

Beetles were the most energy-rich food, various Hemiptera as a group were the next highest in calories, while dragonfly and damselfly naiads were third. The crustaceans, annelids, molluscs, and vertebrates represented the lowest average energy-producing sources. Caloric content is not in itself a complete measure of the nutritional value of food: vitamins and bulk or roughage have been shown to be essential for maximum rates of growth, for vigor, and for reproduction in trout (Haempel and Peter, 1927; Titcomb et al., 1929; Halver, 1954). Halver (1954) indicated the possibility of deficiency conditions for certain amino acids and for fatty acids. Still other factors which may be important in estimating the potential usefulness of an organism as food for fishes are digestibility, the natural abundance of the organism, its size, the amount of protective cover in the habitat, and possible food preferences and feeding habits of the fishes themselves.

Fat

The amount of fat in food organisms showed considerable variation, the range in percentage being from 0.14 to 9.27 percent. The three families of beetles in Table II had the highest average fat content, which may have accounted for the fact that it was impossible to reduce the specimens to the finely-divided homogeneous state desired in preparing them for analysis. The families of Hemiptera seemed to fall into two distinct groups: one with a fat content ranging from 3.78 to 4.70 percent (Gerridae, adult Notonectidae, and Corixidae), and one with a fat content ranging from 1.68 to 1.86 percent (immature Notonectidae, Nepidae, and Belostomatidae). The level of fat in the annelid Eisena foetida (Savigny) was nearly median in position (12 percent) on a dry-weight basis, but the high moisture content of the animal reduced the value on a live-weight basis (1.61 percent) to a point well below the median. The fat content of the remaining families generally was less than one percent.

Reports in the literature were somewhat contradictory on the role of fat in the diet of fishes and on its optimum level. McCay, Bing, and Dilley (1927) reported no detrimental action of relatively large amounts of fat. McCay and Tunison (1935) found the same utilization of fats whether fed at high or low levels to either small or large trout. Hewitt (1937b) claimed that diets high in fats should be avoided, a fat content of five to eight percent being as high as trout should have. Preliminary data (Tunison et al., 1945?) indicated that the level of fat in a spleen diet influenced the biological value of the protein.

Carbohydrate

Any form of carbohydrate in organic matter other than fiber is referred to for general analytical purposes as nitrogen-free extract (N.F.E.) (Triebold, 1946). It is a category not determined directly in proximate analysis but calculated as the difference between 100 and the sum of the percentages of all other measurable values (Triebold, 1946). For purposes of this discussion it was assumed that the nitrogen-free extract represented carbohydrate capable of being digested, absorbed, and metabolized by fishes, although in reality this would not necessarily have been true (Dutcher et al., 1951; Knowles and Watkin, 1947). The N.F.E. level of the samples (Table II) varied from 0.08 to 5.25 percent, but generally tended to be below one or two percent. The highest levels of N.F.E. seemed to occur in forms that predominantly were vegetarian, i.e., in the larva of the cricket frog (Acris gryllus crepitans Baird), in the fathead minnow (Pimephales promelas Rafinesque), and in the body of the mussels and snails. A high level of N.F.E. was determined for one of three analyses made on adult Notonectidae.

After a study of natural trout foods, Embody and Gordon (1924) estimated that carbohydrates should form about 18 percent of the diet on a dry-weight basis. The effect of feeding high levels of carbohydrate over long periods of time in developing "high-glycogen" livers in trout was discussed by Tunison et al. (1940?, 1942?, 1943?), McLaren et al. (1946), and Phillips et al. (1948). The latter authors found no evidence of carbohydrate excretion and concluded that trout were unable to eliminate over-doses of carbohydrate material through the urinary system. If we assume that the desirable level of carbohydrate in the diet of trout also is the desired level in the diet of pond fishes, then the carbohydrate levels (dry-weight basis) of the organisms listed in Table IV of Appendix A were, with one exception, well below this theoretical limit.

Fiber

Fiber is important in the diet of fishes as a source of bulk. Toleration of relatively-high levels of cellulose in the diet of trout was mentioned by Titcomb et al. (1929), McCay et al. (1930), Tunison et al. (1940?), and Furukawa and Ogasawara (1952). Moderate amounts of cellulose had a positive action in promotion of physical well being (Titcomb et al., 1929). Addition of bulk to artificial diets containing concentrated meals diluted the food to a proper proportion and minimized the danger of overfeeding with its resulting degeneration of the pancreas and liver (Hagen, 1940; Foster et al., 1939; Davis, 1953). Analyses of natural food of trout (Embody and Gordon, 1924) established a tentative optimum fiber content on a dry-weight basis of eight percent. With the exception of two groups, molluscs and annelids, this level was maintained or exceeded in the animals that were analyzed (Appendix A, Table IV). On a live-weight basis the fiber content varied from 0.05 to 8.65 percent. Most of the food organisms, including those probably of greatest importance in the natural food of most pond fishes, seemed to supply an adequate intake of fiber.

Ash

Embody and Gordon (1924) reported that minerals appeared to constitute about 9.9 percent of the dry matter in the natural food of trout and that artificial foods tended to be deficient in this respect. Later studies (McCay et al., 1936; Lovelace and Podoliak, 1952; Phillips et al., 1952?, 1954?, 1955?) indicated that at least a portion of the mineral needs of trout were supplied by direct absorption from the surrounding water. Wolf (1951b) studied the effect of the addition of two mineral supplements to a mineral-free synthetic diet and concluded, after a 23-week experiment, that no need for any mineral addition had been shown, the mineral requirement of the trout apparently having been met entirely from solutes in the water. Even if we apply the original standard of Embody and Gordon (1924), many of the organisms for which analyses were available closely approached or actually exceeded the ten percent mineral level on a dry-weight basis (Appendix A, Table IV). The molluscs, on the basis of the composition either of the entire animal or of the body alone, supplied a minimum of 15 percent ash, as did the bony fishes and amphibians. Representatives of the Crustacea analyzed were about one-third ash on a dry-weight basis. Many of the insect families, especially those of the orders Hemiptera and Coleoptera, were somewhat below this ten percent theoretical standard in mineral content. On a live-weight basis the percentage of ash ranged from 0.73 to 36.66 in the families represented.

The proportion of calcium and phosphorus in food may have been significant. Natural food was shown to have a narrow calcium-phosphorus ratio (one part CaO to 0.86 part P_2O_5), while fresh meat products were deficient in lime and too rich in phosphate (a 1:11 ratio) (Embody and Gordon, 1924). This ratio was but an average, and individual analyses of the insects (Zygoptera, *Sialis*, and *Chironomus*) and crustaceans (*Cambarus* and *Hyalella*) from which Embody and Gordon derived their ratio tended to show extremes of variation in the proportion of calcium to phosphorus like that reported more recently in the literature (Phillips et al., 1954). In the present study the percentage of calcium varied from 0.03 to 25.29 and that of phosphorus from 0.04 to 1.34. The calcium-phosphorus ratio was extremely variable (Table II).

Miscellaneous

Analyses for some of the molluscs were run on two types of samples. In one series the entire animal, including calcareous material, was utilized in preparing the samples. In another series only the body, or soft portion, of the animal was used.

Analyses of the entire body of the molluscs showed fairly high percentages of ash, although considerable variation was found (Appendix A, Table V). The range on a live-weight basis was from 17.79 percent for Anodonta corpulenta Cooper to 51.39 percent for Carunculina parva (Barnes), the average of seven analyses being 29.52 percent. The ratio of calcium to total ash was fairly uniform for six of the analyses (from 0.30:1 to 0.40:1, with an average of 0.35:1), but for Goniobiasis potosensis plebius (Anthony) the corresponding ratio was 0.87:1. This was interpreted as an indication of the presence of relatively little organic matter in the shell of the latter species. The ratio of phosphorus to total ash ranged from 0.0014:1 in Musculium sp. to 0.0070:1 for Physa anatina (Lea), the average being 0.0033:1. The relatively-low percentage of water (24.50 percent in contrast to an average of 62.58 percent for the other six analyses) and the relatively-high protein content (33.46 percent in comparison with an average of 4.67 percent for the six other analyses) of Goniobiasis potosensis plebius (Anthony) has been referred to previously. The gastropods as a group had a higher protein content on a live-weight basis (varying from 6.43 to 33.46 percent with an average of 13.84 percent) than the pelecypods (from 1.22 to 3.29 percent, averaging 2.03 percent). With respect to other factors the differences between the two groups were very slight.

Two different procedures were used in removing the body of mussels from the valves. In some cases the animals were immersed in boiling water for about 10 seconds, after which the body easily was lifted out. In other cases the live mussels were merely placed in the oven, the body eventually shrinking within, and pulling away from, the valves as drying took place. A comparison of the data for the three mussels /Anodonta corpulenta Cooper, Uniomerus tetralasmus Say, and Carunculina parva (Barnes)/ for which both types of samples were analyzed showed very similar results (Appendix A, Table IV), any differences in composition probably having been within the limits of experimental error. Since the method of removing the body from the valves seemed to have no measurable influence upon the subsequent analysis, it was disregarded for discussional purposes.

On the basis of the chemical composition of the body of the mussels, Anodonta corpulenta Cooper and Uniomerus tetralasmus Say seemed to have decidedly less food value than Carunculina parva (Barnes) (Appendix A, Table V). The average of two analyses (on a live-weight basis) of the body of the latter species showed eight times as much protein, four times as much fat, thirteen times as much carbohydrate, fifteen times as much fiber, and nineteen times as much mineral matter as the average of five analyses of the body of the larger unionids. This difference was apparent to a certain extent in analyses of the entire animal. The presence of glochidia in the body of Anodonta corpulenta Cooper seemed to reduce the percentages of protein and fat slightly, and approximately to double the percentages of ash and calcium; other values virtually were unchanged (Appendix A, Table V).

One sample composed of the bodies of a snail /Helisoma trivolvis (Say)/ was analyzed (Appendix A, Table V). The composition was intermediate in all respects between the values for the body of Carunculina parva (Barnes) and those of Anodonta corpulenta Cooper and Uniomerus tetralasmus Say.

In the two instances (Astacidae and Notonectidae) in which samples of both the immature and adult stages of an invertebrate were analyzed, the immature forms showed a higher moisture content and had slightly lower values for protein, fat, nitrogen-free extract, fiber, ash, and calcium (Appendix A, Table V).

CHAPTER V

SUMMARY

1. The work upon which this report is based represents the first of a proposed series of studies on fish nutrition at the Oklahoma Agricultural and Mechanical College.

2. A taxonomic study was made of the larger aquatic invertebrates of Payne County which potentially were available as food for fishes. The results of the collection and processing of more than 48,000 specimens over a 23-month period are summarized. A faunal list including 92 families and 182 genera is presented. Arthropods are the predominating group.

3. A number of special observations of an ecological nature are presented. Variation in the abundance of many invertebrates and the rapidity with which conditions in many impoundments change are discussed. The importance of protective cover, possible effects of overpopulations of fishes, and other factors influencing the distribution and abundance of aquatic invertebrates are presented.

4. A number of additional genera and/or species of aquatic insects known to occur in Payne County but not encountered in the present study are listed.

5. Variation in the dytiscid *Laccophilus fasciatus* Aubé and the taxonomy of the immature stages of the Zygoptera are suggested as areas

for future study.

6. Proximate and mineral analyses are given for 62 samples of specimens representing 21 families of aquatic invertebrates and four families of vertebrates.

7. Considerable variation in the average chemical composition for the 25 families represented by the samples is shown. The range in percentages (on a live-weight basis) of the components determined in the analyses were: protein, 1.22 to 33.46 percent; fat, 0.14 to 9.27 percent; nitrogen-free extract, 0.08 to 5.25 percent; fiber, 0.05 to 8.65 percent; ash, 0.73 to 36.66 percent; calcium, 0.03 to 25.29 percent; and phosphorus, 0.04 to 1.34 percent. This variation in general is in agreement with reports of similar studies in the literature.

8. Calculations were made of the number and percentage of calories supplied by the protein, fat, and nitrogen-free extract of average 100-gram (live weight) samples. Protein supplied from 26.03 to 87.51 percent of the calories, the average of all the families represented being 70.88 percent. Fats supplied from 3.16 to 46.73 percent of the calories, with an average of 20.30 percent. Carbohydrates (nitrogen-free extract) supplied from 0.44 to 21.00 percent of the calories, the average being 8.82 percent.

9. The total caloric content of 100-gram samples of representatives of the families varied from 9.76 to 178.55, the average of all the families being 78.02.

10. The data on chemical composition are discussed in relation to the literature on fish nutrition.

11. Attempts to evaluate the nutritional qualities of natural food for fishes on the basis of general chemical composition alone have been limited to a comparison with standards that have been established for trout. Comparable standards for pond fishes were not found in the literature.

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Appendix A

TABLE IV.

Percentage Composition of the 62 Individual Samples on a Dry-weight Basis

Name	Analysis Number	Percentage Composition: Protein	Fat	N.F.E.	Fiber	Ash	Calcium	Phosphorus
LUMBRICIDAE								
Eisena foetida	7	65.68	11.99	14.67	2.25	5.41	0.26	0.80
GLOSSIPHONIIDAE								
Placobdella rugosa	20	85.37	2.74	6.05	2.03	3.81	1.80	0.42
CAENESTHERIIDAE								
Caenestheriella morsei	57	48.35	2.61	3.57	15.23	30.24	9.84	3.94
ASTACIDAE								
Orconectes nais (immature)	53	38.11	2.79	5.71	11.24	42.15	14.02	1.71
Procambarus simulans (immature) .	22	58.00	2.39	4.00	7.76	27.85	7.72	1.09
P. simulans (immature)	23	57.69	2.77	8.94	7.16	23.44	6.72	0.94
(Average)		51.27	2.65	6.22	8.72	31.15	9.49	1.25
Orconectes nais (mature)	17	42.34	1.93	4.68	11.95	39.10	12.36	1.12
O. neglectus (mature)	54	41.24	3.72	6.40	10.04	38.60	12.90	1.45
Procambarus blandingi (mature) . .	21	49.31	4.73	3.12	12.29	30.55	8.92	1.10
P. simulans (mature)	8	44.31	5.44	16.32	3.25	30.68	9.28	0.87
(Average)		44.30	3.96	7.63	9.38	34.73	10.86	1.14
GOMPHIDAE								
Gomphus sp. (naiad)	35	65.42	4.86	0.68	14.40	14.64	0.38	0.78
AESCHNIDAE								
Anax sp. (naiad)	11	72.00	7.59	0.40	14.01	6.00	0.05	0.60

TABLE IV. (Continued)

LIBELLULIDAE								
Erythemis sp. (naiad)	37	68.55	3.13	8.26	12.86	7.20	0.74	1.00
Libellula sp. (naiad) (26a). . . .	33	68.27	2.39	7.35	12.62	9.37	0.10	1.06
Pachydiplax longipennis (naiad) .	31	67.17	6.04	5.76	11.77	9.26	0.18	0.96
Pantala sp. (naiad)	49	69.18	8.44	4.62	11.29	6.47	0.15	1.04
Plathemis lydia (naiad)	29	65.86	4.73	5.06	16.94	7.41	0.13	0.91
Tetragoneuria sp. (naiad)	42	72.05	5.62	2.82	14.24	5.27	0.15	0.62
Trapezostigma sp. (naiad)	28	71.57	2.11	5.61	13.72	6.99	0.16	1.21
(Average)		68.95	4.64	5.64	13.35	7.42	0.23	0.97
COENAGRIONIDAE								
Argia sp. (naiad)	40	68.05	6.44	4.96	12.35	8.20	0.15	1.05
GERRIDAE								
Gerris remigis (adult)	50	67.38	11.59	2.56	15.31	3.16	0.19	0.74
NOTONECTIDAE								
Buenoa sp. (nymph)	45	79.13	4.82	--	7.72	--	--	--
Notonecta sp. (nymph)	61	75.88	8.81	0.46	9.95	4.90	0.17	1.14
(Average)		77.50	6.82		8.84			
Buenoa margaritacea (adult) . . .	44	73.95	10.68	3.09	6.97	5.31	0.36	1.30
Notonecta howardi (adult)	58	43.99	14.58	25.90	11.72	3.81	0.16	0.76
N. undulata (adult)	9	67.68	13.51	1.25	13.98	3.58	0.20	0.66
(Average)		61.78	12.92	10.08	10.89	4.23	0.24	0.91
NEPIDAE								
Ranatra nigra (adult)	59	70.93	4.69	1.42	19.54	3.42	0.25	3.35
BELOSTOMATIDAE								
Belostoma fluminea (adult)	39	67.80	6.20	6.06	15.17	4.77	0.26	0.93

TABLE IV. (Continued)

CORIXIDAE								
Corisella edulis (adult)	60	67.89	8.47	6.24	13.24	4.16	0.15	1.08
Ramphocorixa acuminata (adult) . .	46	69.80	10.39	6.61	11.38	1.82	0.09	0.42
Sigara sp. (adult)	27	60.67	18.66	4.96	11.49	4.22	0.13	1.01
Trichocorixa sp. (adult)	48	71.50	7.66	5.23	11.12	4.49	0.14	1.14
(Average)		67.46	11.30	5.76	11.81	3.67	0.13	0.91
DYTISCIDAE								
Cybister fimbriolatus (adult) . .	62	56.05	21.59	3.46	16.16	2.74	0.12	0.40
Laccophilus fasciatus (adult) . .	34	63.52	16.29	1.38	15.27	3.54	0.13	0.83
Thermonectes ornaticollis (adult)	30	52.00	30.30	1.53	11.90	4.27	0.10	0.73
(Average)		57.19	22.73	2.12	14.44	3.52	0.12	0.65
GYRINIDAE								
Dineutes americanus (adult) . . .	52	60.50	18.65	0.86	16.63	3.36	0.15	0.78
HYDROPHILIDAE								
Hydrous triangularis (adult) . . .	47	60.75	23.87	2.42	10.45	2.51	0.07	0.38
Tropisternus lateralis (adult) . .	10	67.03	14.45	1.10	14.82	2.60	0.18	0.40
T. striolatus (adult)	26	69.67	5.87	2.61	14.34	7.51	0.08	0.81
(Average)		65.82	14.73	2.04	13.20	4.21	0.11	0.53
PHYSIDAE								
Physa anatina (entire)	18	24.59	1.18	7.51	4.26	62.46	22.44	0.43
P. hawnii (entire)	19	21.50	1.00	4.17	5.32	68.01	23.92	0.27
(Average)		23.05	1.09	5.84	4.79	65.24	23.18	0.35
PLANORBIDAE								
Helisoma trivolvis (entire) . . .	16	13.38	0.69	8.83	0.87	76.23	26.72	2.78
H. trivolvis (body only)	15	55.38	3.23	19.73	3.02	18.64	4.80	0.69
PLEUROCERIDAE								
Goniobiasis potosensis plebius (entire)	55	44.32	0.71	5.05	11.46	38.46	33.50	0.11

TABLE IV. (Continued)

UNIONIDAE								
Anodonta corpulenta[1]	4	60.78	5.41	9.81	6.43	17.57	4.28	1.65
Carunculina parva[1]	38	45.92	1.93	25.63	4.33	22.19	4.40	2.62
Uniomerus tetralasmus[1]	25	62.45	3.24	22.53	2.63	9.15	2.14	1.46
U. tetralasmus[1]	6	55.81	4.16	29.06	1.36	9.61	1.68	1.43
(Average)		56.24	3.68	21.76	3.69	14.63	3.12	1.79
Anodonta corpulenta[2]	2	60.34	5.55	13.70	1.57	18.84	4.92	1.87
Carunculina parva[2]	43	47.96	1.14	25.86	4.08	20.96	4.21	0.76
Uniomerus tetralasmus[2]	24	61.90	3.35	20.73	3.08	10.94	1.32	1.78
(Average)		56.73	3.35	20.10	2.91	16.91	3.48	1.47
Anodonta corpulenta (entire) . . .	1	7.97	1.51	0.13	1.30	89.09	26.60	0.21
Carunculina parva (entire)	12	5.75	1.01	1.59	1.71	89.94	30.16	1.92
(Average)		6.86	1.26	0.86	1.50	89.52	28.38	1.06
Anodonta corpulenta[3]	3	42.66	3.03	23.68	1.12	29.51	8.80	1.82
Anodonta corpulenta[4]	5	45.56	3.20	10.66	1.36	39.22	12.64	1.80
SPHAERIIDAE								
Musculium sp. (entire)	32	3.80	1.47	7.53	0.56	86.64	34.25	0.12
CYPRINIDAE								
Pimephales promelas	56	58.93	8.88	12.95	1.69	17.55	4.68	4.48
POECILLIIDAE								
Gambusia affinis affinis	36	63.42	6.11	7.09	1.58	21.80	6.44	3.04

[1]body only; killed by being placed in oven

[2]body only; removed from valves by boiling

[3]body only (with glochidia); removed from valves by boiling

[4]body only (with glochidia); killed by being placed in oven

TABLE IV. (Continued)

HYLIDAE								
Acris gryllus crepitans (larva) .	41	31.99	1.25	33.65	1.61	31.50	1.10	1.83
RANIDAE								
Rana catesbeiana (larva, 40-60 mm)	14	60.69	2.39	1.36	7.61	27.95	1.32	1.18
R. catesbeiana (larva, 90-110 mm)	13	64.90	6.07	6.53	4.49	18.01	1.48	1.22
(Average)		62.80	4.23	3.95	6.05	22.98	1.40	1.20
R. catesbeiana (adult)	51	77.38	4.60	2.78	0.60	14.64	4.04	1.62

TABLE V.

Percentage Composition of the 62 Individual Samples on a Live-weight Basis

Name	Analysis Number	Percentage Composition: Moisture	Protein	Fat	N.F.E.	Fiber	Ash	Calcium	Phosphorus
LUMBRICIDAE									
Eisena foetida	7	86.55	8.83	1.61	1.97	0.30	0.73	0.03	0.11
GLOSSIPHONIIDAE									
Placobdella rugosa	20	79.48	17.52	0.56	1.24	0.42	0.78	0.37	0.09
CAENESTHERIIDAE									
Caenestheriella morsei	57	78.24	10.52	0.57	0.78	3.31	6.58	2.14	0.86
ASTACIDAE									
Orconectes neglectus (immature) .	53	71.08	11.02	0.81	1.65	3.25	12.19	4.05	0.49
Procambarus simulans (immature) .	22	81.63	10.65	0.44	0.73	1.43	5.12	1.42	0.20
P. simulans (immature)	23	78.77	12.25	0.59	1.90	1.52	4.98	1.43	0.20
Orconectes nais (mature)	17	64.97	14.83	0.68	1.64	4.19	13.70	4.33	0.39
O. neglectus (mature)	54	69.37	12.63	1.14	1.96	3.08	11.82	3.95	0.44
Procambarus blandingi (mature) .	21	72.79	13.42	1.29	0.85	3.34	8.31	2.43	0.30
P. simulans (mature)	8	72.93	11.99	1.47	4.42	0.88	8.30	2.51	0.24
GOMPHIDAE									
Gomphus sp. (naiad)	35	80.49	12.76	0.95	0.13	2.81	2.86	0.07	0.15
AESCHNIDAE									
Anax sp. (naiad)	11	79.88	14.49	1.53	0.08	2.82	1.21	0.01	0.12
LIBELLULIDAE									
Erythemis sp. (naiad)	37	80.82	13.15	0.60	1.58	2.47	1.38	0.14	0.19
Libellula sp. (naiad) (26a) . . .	33	83.06	11.56	0.40	1.24	2.14	1.59	0.02	0.18

TABLE V. (Continued)

Pachydiplax longipennis (naiad) .	31	83.66	10.98	0.99	0.94	1.92	1.51	0.03	0.16
Pantala sp. (naiad)	49	81.71	12.65	1.54	0.85	2.07	1.18	0.03	0.19
Plathemis lydia (naiad)	29	81.08	12.46	0.89	0.96	3.20	1.40	0.02	0.17
Tetragoneuria sp. (naiad)	42	76.91	16.64	1.30	0.65	3.29	1.22	0.03	0.14
Trapezostigma sp. (naiad)	28	85.33	10.50	0.31	0.82	2.01	1.03	0.02	0.18
COENAGRIONIDAE									
Argia sp. (naiad)	40	78.32	14.75	1.40	1.08	2.68	1.78	0.03	0.23
GERRIDAE									
Gerris remigis (adult)	50	59.43	27.34	4.70	1.04	6.21	1.28	0.08	0.30
NOTONECTIDAE									
Buenoa sp. (nymph)	45	76.79	18.37	1.12	--	1.79	--	--	--
Notonecta sp. (nymph)	61	74.50	19.35	2.25	0.12	2.54	1.25	0.04	0.29
Buenoa margaritacea (adult) . . .	44	72.09	20.64	2.98	0.86	1.94	1.48	0.10	0.36
Notonecta howardi (adult)	58	67.16	14.45	4.79	8.50	3.85	1.25	0.05	0.25
N. undulata (adult)	9	62.18	25.60	5.11	0.47	5.29	1.35	0.08	0.25
NEPIDAE									
Ranatra nigra (adult)	59	64.03	25.51	1.69	0.51	7.03	1.23	0.09	1.20
BELOSTOMATIDAE									
Belostoma fluminea (adult) . . .	39	69.95	20.37	1.86	1.82	4.56	1.43	0.08	0.28
CORIXIDAE									
Corisella edulis (adult)	60	70.40	20.10	2.51	1.85	3.92	1.23	0.04	0.32
Ramphocorixa acuminata (adult) .	46	71.85	19.65	2.92	1.86	3.20	0.51	0.02	0.12
Sigara sp. (adult)	27	60.50	23.96	7.37	1.96	4.54	1.67	0.05	0.40
Trichocorixa sp. (adult)	48	69.68	21.68	2.32	1.58	3.37	1.36	0.04	0.34

TABLE V. (Continued)

DYTISCIDAE									
Cybister fimbriolatus (adult) . .	62	58.52	23.25	8.96	1.44	6.70	1.14	0.05	0.16
Laccophilus fasciatus (adult) . .	34	63.15	23.41	6.00	0.51	5.63	1.30	0.05	0.30
Thermonectes ornaticollis (adult)	30	57.57	22.06	12.86	0.65	5.05	1.81	0.04	0.31
GYRINIDAE									
Dineutes americanus (adult) . . .	52	61.30	23.41	7.22	0.33	6.44	1.30	0.06	0.30
HYDROPHILIDAE									
Hydrous triangularis (adult) . .	47	59.56	24.57	9.65	0.98	4.22	1.02	0.03	0.15
Tropisternus lateralis (adult) .	10	61.20	26.01	5.61	0.43	5.75	1.01	0.07	0.16
T. striolatus (adult)	26	61.65	26.72	2.25	1.00	5.50	2.88	0.03	0.31
PHYSIDAE									
Physa anatina (entire)	18	67.99	7.87	0.38	2.40	1.36	19.99	7.18	0.14
P. hawnii (entire)	19	64.65	7.60	0.35	1.47	1.88	24.04	8.46	0.09
PLANORBIDAE									
Helisoma trivolvis (entire) . . .	16	51.91	6.43	0.33	4.25	0.42	36.66	12.85	1.34
H. trivolvis (body only)	15	84.56	8.55	0.50	3.05	0.47	2.88	0.74	0.11
PLEUROCERIDAE									
Goniobiasis potosensis plebius (entire)	55	24.50	33.46	0.54	3.81	8.65	29.04	25.29	0.08
UNIONIDAE									
Anodonta corpulenta[1]	4	96.71	2.00	0.18	0.32	0.21	0.58	0.14	0.05
Carunculina parva[1]	38	49.12	23.36	0.98	13.04	2.20	11.29	2.24	1.33
Uniomerus tetralasmus[1]	25	94.06	3.71	0.19	1.34	0.16	0.54	0.13	0.09
U. tetralasmus[1]	6	93.55	3.60	0.27	1.87	0.09	0.62	0.11	0.09

[1] body only; killed by being placed in oven

TABLE V. (Continued)

Anodonta corpulenta[2]	2	96.93	1.85	0.17	0.42	0.05	0.58	0.15	0.06
Carunculina parva[2]	43	45.71	26.04	0.62	14.04	2.22	11.38	2.28	0.41
Uniomerus tetralasmus[2]	24	93.83	3.82	0.21	1.28	0.19	0.68	0.08	0.11
Anodonta corpulenta (entire) . .	1	80.03	1.59	0.30	0.02	0.26	17.79	5.31	0.04
Carunculina parva (entire) . . .	12	42.86	3.29	0.58	0.91	0.98	51.39	17.23	1.10
Anodonta corpulenta[3]	3	95.62	1.87	0.13	1.04	0.05	1.29	0.38	0.08
Anodonta corpulenta[4]	5	96.14	1.76	0.12	0.41	0.05	1.51	0.49	0.07
SPHAERIIDAE									
Musculium sp. (entire)	32	68.02	1.22	0.47	2.41	0.18	27.71	10.95	0.04
CYPRINIDAE									
Pimephales promelas	56	76.58	13.80	2.08	3.03	0.40	4.11	1.10	1.05
POECILLIIDAE									
Gambusia affinis affinis	36	77.36	14.36	1.38	1.60	0.36	4.94	1.46	0.69
HYLIDAE									
Acris gryllus crepitans (larva) .	41	88.46	3.69	0.14	3.88	0.18	3.64	0.13	0.21
RANIDAE									
Rana catesbeiana (larva, 40-60mm)	14	89.39	6.44	0.25	0.14	0.81	2.96	0.14	0.12
R. catesbeiana (larva, 90-110mm)	13	88.43	7.51	0.70	0.76	0.52	2.08	0.17	0.14
R. catesbeiana (adult)	51	82.63	13.44	0.80	0.48	0.10	2.54	0.70	0.28

[2]body only; removed from valves by boiling

[3]body only (with glochidia); removed from valves by boiling

[4]body only (with glochidia); killed by being placed in oven

Appendix B

TABLE VI.

Dates and Localities of Field Collections

Number	Date	Station	Location
1	Oct. 20, 1953	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E
2	Nov. 2, 1953	muddy pools in ditch	SW1/4, SW1/4, NW1/4, S15, T-19-N, R-2-E
3	Nov. 5, 1953	muddy pools in ditch	SW1/4, SW1/4, NW1/4, S15, T-19-N, R-2-E
4	Nov. 12, 1953	disposal plant	NE1/4, SW1/4, SW1/4, S23, T-19-N, R-2-E
5	Nov. 16, 1953	Carberry stock tank	SE1/4, SW1/4, NE1/4, S24, T-19-N, R-1-E
6	Nov. 24, 1953	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E
6a	Nov. 24, 1953	Carberry stock tank	SE1/4, SW1/4, NE1/4, S24, T-19-N, R-1-E
7	Nov. 27, 1953	spillway, Lake Carl Blackwell	NE1/4, NW1/4, NW1/4, S15, T-19-N, R-1-E
8	Dec. 11, 1953	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E
9	Dec. 21, 1953	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E
10	Dec. 26, 1953	pools south of Boomer Lake dam	SE1/4, NW1/4, NW1/4, S11, T-19-N, R-2-E
11	Dec. 26, 1953	Sanborn Lake	SW1/4, NE1/4, S 3, T-19-N, R-2-E
12	Dec. 29, 1953	pools south of Boomer Lake dam	SE1/4, NW1/4, NW1/4, S11, T-19-N, R-2-E
13	Jan. 2, 1954	Sanborn Lake	SW1/4, NE1/4, S 3, T-19-N, R-2-E

TABLE VI. (Continued)

14	Febr. 12, 1954	Mill pond	SE1/4, SE1/4, SE1/4, S14, T-19-N, R-2-E
15	Febr. 19, 1954	Mill pond	SE1/4, SE1/4, SE1/4, S14, T-19-N, R-2-E
16	Febr. 26, 1954	Mill pond	SE1/4, SE1/4, SE1/4, S14, T-19-N, R-2-E
17	March 9, 1954	Mill pond	SE1/4, SE1/4, SE1/4, S14, T-19-N, R-2-E
18	March 9, 1954	College golf course	W1/2, NW1/4, SE1/4, NE1/4, S10, T-19-N, R-2-E
19	March 12, 1954	College golf course	NW1/4, NW1/4, SE1/4, S10, T-19-N, R-2-E
20	March 12, 1954	West Boomer Creek	NE1/4, SE1/4, SE1/4, S14, T-19-N, R-2-E
21	March 19, 1954	College golf course	W1/2, NW1/4, SE1/4, NE1/4, S10, T-19-N, R-2-E
22	March 21, 1954	Reding Pond No. 3	SW1/4, NW1/4, NW1/4, S31, T-19-N, R-3-E
23	March 27, 1954	Sanborn Lake	SW1/4, NE1/4, S 3, T-19-N, R-2-E
24	March 27, 1954	College golf course	W1/2, NW1/4, SE1/4, NE1/4, S10, T-19-N, R-2-E
25	May 15, 1954	cement tank	NE1/4, NW1/4, NW1/4, S15, T-19-N, R-2-E
26	May 29, 1954	Claremore Lake	(Rogers County) S 3, T-12-N, R-16-E
27	May 30, 1954	Illinois River	(Cherokee County) S12, T-18-N, R-22-E
28	May 31, 1954	spring along S.H. 33	(Delaware County) S23, T-20-N, R-22-E
29	June 6, 1954	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E
30	June 9, 1954	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E

TABLE VI. (Continued)

31	June 11, 1954	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E
32	June 18, 1954	Village pond	SE1/4, NW1/4, NE1/4, S15, T-19-N, R-2-E
33	June 20, 1954	Yost Lake	NE1/4, NW1/4, S20, T-20-N, R-3-E
34	June 30, 1954	Village pond	SE1/4, NW1/4, NE1/4, S15, T-19-N, R-2-E
35	July 18, 1954	Village pond	SE1/4, NW1/4, NE1/4, S15, T-19-N, R-2-E
36	Sept. 5, 1954	Village pond	SE1/4, NW1/4, NE1/4, S15, T-19-N, R-2-E
37	Sept. 11, 1954	Mill pond	SE1/4, SE1/4, SE1/4, S14, T-19-N, R-2-E
38	Sept. 14, 1954	Sanborn Lake	SW1/4, NE1/4, S 3, T-19-N, R-2-E
39	Sept. 14, 1954	Yost Lake	SW1/4, SE1/4, SW1/4, S17, T-20-N, R-3-E NE1/4, NW1/4, S20, T-20-N, R-3-E
		pond on Yost golf course	NE1/4, NW1/4, NW1/4, NW1/4, S20, T-20-N, R-3-E
40	Oct. 16, 1954	pond on Yost golf course	NE1/4, NW1/4, NW1/4, NW1/4, S20, T-20-N, R-3-E
41	Oct. 23, 1954	pond on Yost golf course	NE1/4, NW1/4, NW1/4, NW1/4, S20, T-20-N, R-3-E
42	Nov. 13, 1954	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E
43	Nov. 20, 1954	Berry ponds	SE1/4, SE1/4, SW1/4, NE1/4, S 4, T-18-N, R-3-E N1/2, NE1/4, SE1/4, S 4, T-18-N, R-3-E
44	Dec. 19, 1954	Sanborn Lake	SW1/4, NE1/4, S 3, T-19-N, R-2-E

TABLE VI. (Continued)

45	Febr. 9, 1955	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E
46	March 11, 1955	Stillwater Creek near Lake Carl Blackwell dam	SE1/4, NW1/4, SW1/4, S10, T-19-N, R-1-E
47	March 17, 1955	Stillwater Creek near Lake Carl Blackwell dam	SE1/4, NW1/4, SW1/4, S10, T-19-N, R-1-E
48	March 30, 1955	Lake Carl Blackwell	NE1/4, NW1/4, NW1/4, S15, T-19-N, R-1-E
49	April 2, 1955	Country Club pond	SE1/4, NE1/4, SE1/4, S19, T-19-N, R-2-E
50	April 5, 1955	West Boomer Creek	E1/2, SE1/4, SE1/4, S14, T-19-N, R-2-E
51	April 7, 1955	West Boomer Creek	E1/2, SE1/4, SE1/4, S14, T-19-N, R-2-E
52	April 8, 1955	Carberry pond	N1/2, SW1/4, NE1/4, S24, T-19-N, R-1-E
53	April 29, 1955	Ghost Glen	E1/2, E1/2, NE1/4, S17, T-18-N, R-4-E
54	May 5, 1955	West Boomer Creek	E1/2, SE1/4, SE1/4, S14, T-19-N, R-2-E
55	May 11, 1955	Village pond	SE1/4, NW1/4, NE1/4, S15, T-19-N, R-2-E
56	June 11, 1955	Ghost Glen	E1/2, E1/2, NE1/4, S17, T-18-N, R-4-E
57	June 15, 1955	Yost Lake	SW1/4, SE1/4, SW1/4, S17, T-20-N, R-3-E NE1/4, NW1/4, S20, T-20-N, R-3-E
58	June 17, 1955	unused fish pool north of NHE building	NW1/4, NE1/4, SE1/4, S15, T-19-N, R-2-E
59	June 18, 1955	Village pond	SE1/4, NW1/4, NE1/4, S15, T-19-N, R-2-E

TABLE VI. (Continued)

60	June 22, 1955	College golf course	SE1/4, NW1/4, NW1/4, SE1/4, S10, T-19-N, R-2-E
61	June 27, 1955	ditch along railroad tracks	NE1/4, NE1/4, NE1/4, S11, T-19-N, R-2-E
62	June 27, 1955	College golf course	W1/2, NW1/4, SE1/4, NE1/4, S10, T-19-N, R-2-E
63	June 29, 1955	College golf course	W1/2, NW1/4, SE1/4, NE1/4, S10, T-19-N, R-2-E
64	July 2, 1955	roadside ditch and farm ponds	E1/2, E1/2, SE1/4, S11, T-17-N, R-2-E N1/2, N1/2, NE1/4, S14, T-17-N, R-2-E
65	July 5, 1955	excavation	SW1/4, SW1/4, SW1/4, SW1/4, S31, T-18-N, R-3-E
66	July 5, 1955	impoundment and adjoining low area	SW1/4, SW1/4, NW1/4, NW1/4, S 1, T-17-N, R-2-E NW1/4, NW1/4, SW1/4, NW1/4, S 1, T-17-N, R-2-E
67	July 8, 1955	flooded area	SE1/4, SE1/4, NE1/4, S 4, T-17-N, R-2-E
68	July 12, 1955	water-filled receptacle near spring	NE1/4, NW1/4, NW1/4, S15, T-19-N, R-2-E
69	July 16, 1955	College golf course	W1/2, NW1/4, SE1/4, NE1/4, S10, T-19-N, R-2-E
70	July 18, 1955	College golf course	SE1/4, NW1/4, NW1/4, SE1/4, S10, T-19-N, R-2-E
71	July 20, 1955	Reding Pond No. 2	NE1/4, NW1/4, NW1/4, S31, T-19-N, R-3-E
72	July 26, 1955	excavation	SW1/4, SW1/4, SW1/4, SW1/4, S31, T-18-N, R-3-E
73	July 26, 1955	impoundment	SW1/4, SW1/4, NW1/4, NW1/4, S 1, T-17-N, R-2-E
74	July 28, 1955	College golf course	SE1/4, NW1/4, NW1/4, SE1/4, S10, T-19-N, R-2-E

TABLE VI. (Continued)

75	July 30, 1955	College golf course	SE1/4, NW1/4, NW1/4, SE1/4, S10, T-19-N, R-2-E
76	July 31, 1955	College golf course	SE1/4, NW1/4, NW1/4, SE1/4, S10, T-19-N, R-2-E
77	Aug. 2, 1955	drainage ditch	SW1/4, SW1/4, NW1/4, S15, T-19-N, R-2-E
78	Aug. 4, 1955	drainage ditch	SW1/4, SW1/4, NW1/4, S15, T-19-N, R-2-E
79	Aug. 7, 1955	farm pond	NE1/4, SE1/4, SE1/4, S 3, T-18-N, R-2-E
80	Aug. 9, 1955	Reding Pond No. 3	SW1/4, NW1/4, NW1/4, S31, T-19-N, R-3-E
81	Aug. 11, 1955	Village pond	SE1/4, NW1/4, NE1/4, S15, T-19-N, R-2-E
82	Aug. 13, 1955	Mill pond	SE1/4, SE1/4, SE1/4, S14, T-19-N, R-2-E
83	Aug. 15, 1955	West Boomer Creek	NE1/4, SE1/4, SE1/4, S14, T-19-N, R-2-E
84	Aug. 16, 1955	Reding Pond No. 3	SW1/4, NW1/4, NW1/4, S31, T-19-N, R-3-E
85	Aug. 18, 1955	Ghost Glen	E1/2, E1/2, NE1/4, S17, T-18-N, R-4-E
86	Aug. 18, 1955	drainage ditch	SW1/4, SW1/4, NW1/4, S15, T-19-N, R-2-E
87	Aug. 20, 1955	low area in field	SE1/4, SE1/4, SE1/4, SW1/4, S36, T-18-N, R-2-E
88	Aug. 20, 1955	shallow impoundment	SW1/4, SW1/4, NW1/4, S 3, T-17-N, R-2-E
89	Aug. 22, 1955	West Boomer Creek	NE1/4, SE1/4, SE1/4, S14, T-19-N, R-2-E
90	Aug. 23, 1955	shallow impoundment	SW1/4, SW1/4, NW1/4, S 3, T-17-N, R-2-E
91	Aug. 23, 1955	low area in field	SE1/4, SE1/4, SE1/4, SW1/4, S36, T-18-N, R-2-E

TABLE VI. (Continued)

92	Aug. 26, 1955	spillway, Lake Carl Blackwell	NE1/4, NW1/4, NW1/4, S15, T-19-N, R-1-E
93	Aug. 26, 1955	Stillwater Creek near Lake Carl Blackwell dam	SE1/4, NW1/4, SW1/4, S10, T-19-N, R-1-E
94	Aug. 29, 1955	farm pond	SW1/4, SW1/4, SW1/4, SW1/4, S20, T-19-N, R-2-E
95	Aug. 29, 1955	drainage ditch	NE1/4, NW1/4, NE1/4, S11, T-19-N, R-1-E
96	Aug. 31, 1955	low area in field	SE1/4, SE1/4, SE1/4, SW1/4, S36, T-18-N, R-2-E
97	Aug. 31, 1955	Wildhorse creek	E1/2, NW1/4, NW1/4, S 5, T-17-N, R-2-E
98	Sept. 2, 1955	farm pond	SW1/4, NW1/4, NW1/4, S 1, T-18-N, R-2-E
99	Sept. 5, 1955	Yost Lake	SW1/4, SE1/4, SW1/4, S17, T-20-N, R-3-E NE1/4, NW1/4, S20, T-20-N, R-3-E
100	Sept. 8, 1955	farm pond	SW1/4, NW1/4, NW1/4, S 2, T-19-N, R-2-E
101	Sept. 8, 1955	impoundment	SW1/4, SW1/4, NW1/4, NW1/4, S 1, T-17-N, R-2-E

VITA

Winthrop William Darlington

Candidate for the Degree of

Doctor of Philosophy

Thesis: A SYSTEMATIC SURVEY OF THE LARGER AQUATIC INVERTEBRATES OF PAYNE COUNTY (OKLAHOMA) AND THE CHEMICAL COMPOSITION OF SOME OF THE MORE ABUNDANT FORMS

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Biographical:

Personal data: Born at Madison, Nebraska, June 21, 1916, the son of William M. and Mabel F. Darlington.

Education: Elementary and secondary education in the public schools at Neligh, Nebraska; received a Bachelor of Science degree in Agriculture from the University of Nebraska in January, 1939, with a major in Entomology; received a Master of Science degree from the University of Nebraska in January, 1942, with a major in Entomology; attended Iowa State College part time from 1942 to 1946, working in Entomology and Zoology; completed requirements for the Doctor of Philosophy degree from the Oklahoma Agricultural and Mechanical College in August, 1956, with a major in Zoology.

Professional experience: Graduate teaching assistant in Entomology, University of Nebraska, 1939-1941; Field Assistant, Office of the State Entomologist, Iowa State College, 1941-1946; Professor, Science Department, State Teachers College, Mayville, North Dakota, 1946-1953; Graduate teaching assistant in Zoology, Oklahoma Agricultural and Mechanical College, 1953-1955; Research Fellow, Oklahoma Cooperative Wildlife Research Unit, Oklahoma Agricultural and Mechanical College, 1955-1956.

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Professional: National Science Teachers Association; National Association of Biology Teachers; Department of Audio-Visual Instruction, NEA; American Association for the Advancement of Science.