DISTRIBUTION OF ROTIFERA AND CLADOCERA IN A REGULATED RIVER SYSTEM

by

Larry Gene Western

Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Zoology

APPROVED:

Dr. G. M. Simmons, Jr.
Chairman

Dr. A. L. Buikema, Jr.

Dr. J. R. Voshell

July, 1984

Blacksburg, Virginia

DISTRIBUTION OF ROTIFERA AND CLADOCERA
IN A REGULATED RIVER SYSTEM

by

Larry Gene Western

(ABSTRACT)

The purpose of this study was to determine distributions of Rotifera and Cladocera in the Kanawha River in West Virginia. Rotifera were sampled monthly for twelve months with a Juday trap in the more lotic upstream end of Winfield pool (UW), and the more lentic downstream end of Winfield pool (LW) to determine seasonal distribution. During the period of peak rotifer abundance, rotifers were sampled along a longitudinal transect of Winfield pool and lower Marmet pool to determine longitudinal distribution. Cladocera were sampled with funnel traps at Marmet and Winfield Locks and Dams from lock wall, midchannel, and near shore sites.

The seasonal study showed that both UW and LW total rotifer densities were characterized by a single summer population peak. The same physical and/or chemical parameters did not account for equivalent variation in rotifer densities at the two stations. The longitudinal profile showed that a shift in species composition occured from bacteriophageous and detritivorous species upstream to herbivorous species downstream. A new species of the genus *Lecane* Nitzsch 1827 (Lecanidae: Rotifera) was discovered, namely *Lecane arietii* n. sp. This species was found to have fungal parasites which apparently effect its distribution. The Cladocera study showed shore and lock wall areas had greater numbers of Cladocera from mud and vegetative habitats than midchannel areas, apparently due to differences in periphyton between the sites. Cladocera from mud and vegetative habitats in lotic systems may be useful organisms to study tow boat perturbations.

Dedicated to my wife Tracy, without whose moral support
this work would not have been possible.

ACKNOWLEDGMENTS

I earnestly thank my advisor, Dr. George Simmons, for his supportive and helpful guidance, constructive criticism, and sage counsel. I also sincerely thank my graduate committee. Dr. Art Buikema and Dr. Reese Voshell were always ready to discuss any research problems; their availability and advice are greatly appreciated. The field aid given by Drs. Simmons and Voshell will long be remembered--and appreciated.

The time and efforts of Mike Lizotte, Chuck Roadley, Steve Hiner, and Ray Layton, who regularly traversed the West Virginia Turnpike to help with field work, are greatly appreciated. The assistance of Jim Chadduck, Gay Bowen, and Andy Wones are also greatly appreciated.

I also thank Dr. Mel Whiteside of the University of Tennessee and University of Minnesota for instruction in Cladoceran taxonomy and ecology, and Dr. Rama Chengalath of the National Museum of Natural Sciences of Canada for training in rotifer taxonomy.

The helpful suggestions and moral support of Dr. Penny Kontratieff and Mike Lizotte were genuinely appreciated.

I acknowledge the Department of Biology for use of the laboratory and facilities. I also thank and acknowledge the Hungtinton West Virginia Army Corps of Engineers by whom the research was funded.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

page

CHAPTER 1.

CHAPTER 2.

CHAPTER 3.

GENERAL INTRODUCTION

The Kanawha River is regulated for navigation and flood control purposes and runs through a populated and highly industrialized area of West Virginia. The lower reaches of the river have a recent history of exceptionally poor water water quality. Zooplankton populations, comprised predominantly of rotifers, were greatly reduced by poor water quality in the early 1960's. Since the Water Pollution Control Act of 1972, water quality in the Kanawha River has improved. No comprehensive taxonomic, seasonal, or longitudinal distribution study of the zooplankton has been carried out on the lower reaches of the Kanawha River since the recovery of the river began, and an extensive literature review revealed that no such study has been conducted on any recovering river system like the Kanawha. In 1982-83 a seasonal study was conducted on the zooplankton of the Winfield pool on the Kanawha River. It was noticed that rotifers constitute the majority of the zooplankton, and also that rotifers in the upstream end of the pool were generally species with characteristically different feeding habits than the species in the downstream end of the pool. Consequently, a longitudinal distribution study was conducted during the period of peak rotifer abundance. Pertinent literature references and the details and results of this seasonal and longitudinal distribution study are given in Chapter 1:

Seasonal and Longitudinal Distribution of Rotifers in the Kanawha River, WV.

During a preliminary study in 1982, a previously undescribed species of Lecane Nitzsch 1827 (Lecanidae: Rotifera) was discovered in Marmet pool (See map, fig. 1., Chapter 2 of this thesis). This species was present in lower Marmet pool in quantities ten times greater than in lower Winfield pool. Later, in 1983, a fungal parasite was found to be infesting this species of Lecane. Samples were taken along a longitudinal transect of the river during the time period this Lecane species was present and parasitized. Pertinent literature references, a description of the new species, and details of its longitudinal distribution and parasite problem are given in Chapter 2: A New Species of the Genus Lecane Nitzsch 1827 (Lecanidae: Rotifera) With Notes on Its Longitudinal Distribution and Fungal Parasitism.

Crustacea are generally considered to be unimportant in lotic systems. The occurance of crustacea in large river systems and in impounded rivers has been recorded. It was noticed that many of the species from larger rivers recorded in the literature are characteristically from mud or mud and vegetative habitats. A large percentage of the Cladocera found in the seasonal study samples in the Kanawha River were species which characteristically occur in mud or mud and vegetative habitats. Using a better sampling design (funnel traps during night hours),a study was conducted in 1983 to determine the composition and abundance of Cladocera in the Kanawha, and also to determine what locations (mud and vegetation or plankton) within the river these Cladocera inhabit. Pertinent literature references and the details and results of this study are given in Chapter 3: Cladocera from Mud and Vegetative Habitats in a Regulated River.

CHAPTER 1.

Seasonal and Longitudinal Distribution of Rotifers in the Kanawha River, WV.

INTRODUCTION

The Kanawha River is regulated for navigation and flood control purposes, and runs through a populated and highly industrialized area of West Virginia to its confluence with the Ohio River. Water quality in the lower reaches of the river in the early 1960's greatly reduced rotifer populations (Williams, 1966). Average rotifer concentrations in the Winfield Pool were $6 \cdot l^{-1}$ in 1959-61 (Palmer, 1967) and $34 \cdot l^{-1}$ in 1961-62 (Williams, 1966). Water quality in the upper reaches was apparently less affected: the 1975 ten year average of dissolved oxygen was > 7 $mg \cdot l^{-1}$ at Marmet pool, but < 2 $mg \cdot l^{-1}$ at Winfield pool during low flow (Dames and Moore, 1975). Greater numbers of rotifers and higher dissolved oxygen concentrations found during a 1982 study (Voshell et al., 1983) suggest this river system is recovering. The objectives of this study were 1.) to determine the current seasonal composition and distribution of rotifers in the Winfield Pool on the Kanawha River at the Winfield dam, and just below Marmet dam, and 2.) to determine the longitudinal distribution and composition of rotifers in this section of the Kanawha River (see fig. 1).

Numerous studies have been conducted on seasonal distribution of rotifers in river systems (e.g. Kofoid, 1908; Carlin, 1943; Beach, 1960; Green, 1960; Holden and Green, 1960). Fewer studies have been done on the longitudinal distribution of rotifers in river systems (e.g. Hutchison, 1939; Beach, 1960; and Rai, 1974). An extensive literature review revealed that a seasonal and longitudinal study has not been carried out on a recovering river system like the Kanawha.

METHODS

Seasonal samples were collected monthly, October 1982 to September 1983, from two stations on the Kanawha River in WV. Lower Winfield station (LW), river mile 32, immediately upstream of Winfield locks and Dam is somewhat lentic. Upper Winfield station (UW), river mile 67, immediately downstream of Marmet Locks and Dam is more lotic. Longitudinal samples were collected monthly during peak rotifer abundance, July 1983 to October 1983, from eight stations. Stations 1 through 8 are each six river miles apart, with station 1 at river mile 32 (LW) and station 8 at river mile 74 (see fig. 1).

Seasonal and longitudinal samples were collected from midchannel only, because a preliminary study conducted in June 1982, established that samples obtained from mid-channel were representative of sites left and right of mid-channel when sampled at the same depth (Voshell, et al., 1983). Samples were collected in duplicate October 1982 to February 1983, and in triplicate March 1983 to October 1983 (Green, 1977). Seasonal samples were collected 1 m below surface and 1 m above the sediment-water interface (refered to as "top" and "bottom" samples, respectively). Longitudinal samples were collected from 1 m, 4 m, and (where depth permitted) 8 m below surface. Rotifers were collected with a 5 liter Juday trap (Lind, 1979) equipped with 35 μm mesh net on the Wisconsin bucket (Likens and Gilbert, 1970). Trap avoidance by rotifers was assumed negligible (Green, 1977). Rotifers were narcotized with carbonated water and preserved with 10% formalin in the field (Gannon and Gannon, 1975). Each rotifer sample was then concentrated to a known volume and a 1 ml subsample was placed in a Sedgewick-Rafter cell, and the entire cell was counted under 100x (A.P.H.A. et al., 1981).

All physical and chemical data were collected concurrently with rotifer samples, with the exception of river discharge. Daily river discharge data for the duration of the study were provided by the Huntington District U.S. Army Corps of Engineers. Temperature and specific conductance were measured with a Hydrolab (T-C2) conductivity meter. Vertical light intensity was measured with a Montedero-Whitney LMD 8A Light meter (Oct. 1982-Feb. 1983) and a Li-Cor L.I. 185B photometer (Mar. 1983-Oct. 1983). Alkalinity and pH samples were returned to the laboratory in Nalgene screwcap bottles on ice. Alkalinity was measured by titration with methyl purple (A.P.H.A., 1981), and a and pH was measured with a pH meter-(ChemMate). Dissolved oxygen was measured according to the azide modification of the Winkler method (A.P.H.A., et al., 1981). Chlorophyll *a* (chl *a*) for the longitudinal study was measured according to the fluorometric method (A.P.H.A., et al., 1981) using a Turner Designs fluorometer (model 10). Chlorophyll *a* samples for the seasonal study were fractioned through 1000 μm, 243 μm, 105 μm, 43 μm, and 25 μm, mesh screens. Each fraction was then analyzed for chl *a* as in the longitudinal study. The resulting chl *a* values were then summed for total chl *a* in the seasonal study.

Statistical analyses (Duncans Multiple Range test, Multivariate Analysis of Variance, and Pearson Correlation) were conducted ysis using a Statistical Analysis System (SAS) package. Pinkham-Pearson similarity index cluster analysis was performed using a fortran program described by Pinkham and Pearson (1976).

RESULTS

Seasonal: Total rotifer concentrations were characterized by a single summer population peak (July-Aug.), with total rotifer concentration at UW and LW approaching or exceeding 1×10^6 individuals m^{-3} (fig. 2). Spring concentrations (Apr.-June) were significantly lower than summer populations (Duncans Multiple Range Test, $\alpha = .05$) and significantly higher than winter and fall populations. Winter and fall concentrations were not significantly different from each other. Total rotifer concentrations were significantly higher in July than in August, and were significantly higher in August than in all remaining months. All remaining months (Oct. 1982-June 1983, and Sept. 1983) were not significantly different from each other.

Total rotifer concentrations showed significant positive correlations with chl a and temperature at UW and LW, and negative correlations with dissolved oxygen and discharge. Specific conductance correlated positively at UW only. Other parameters showed no significant correlation (Table 1).

Analysis of the seasonal data by Multivariate Analysis of Variance statistics showed that there was a month effect on species composition at both UW and LW. Correlations of species with physical, chemical, and biological parameters (results of which are grouped by family) are given in Table 2. Species composition clustered by season (Pinkham & Pearson similarity index cluster analysis,[Pinkham and Pearson, 1976]) showed that winter and fall were most similar to each other. Spring and summer were dissimilar to each other and both were dissimilar to fall and winter, summer more so than spring.

Longitudinal: Total rotifer concentrations showed significant differences between stations in longitudinal transect (Table 3). Longitudinal total rotifer concentration at 1 m showed significant positive correlation with pH (mean $r = .53$; $\alpha \leq .05$) on all sampling dates. (It should be noted that data analyzed for the longitudinal study included the last three sampling dates only ; the July 28 samples were collected after a spate which temporarily eliminated the rotifer population.) No significant correlation was found between longitudinal total rotifer concentration and chl *a* sampled at 1 m when all eight stations were analyzed ($r = .28$). Stations 1-6 were significantly correlated ($r = .82$) with chlorophyll *a*.

Total rotifer concentrations at 1 m were significantly higher than at 4 m, with the exception of station 8 where there was no significant difference. Stations 1, 2, and 7 had 8 m samples which were not significantly different from the respective 4 m samples (with the exception of station 2 where the 8 m sample concentration was significantly lower than that of the 4 m sample).

Analysis of the longitudinal data by Multivariate Analysis of Variance statistics showed that there was a station effect on species composition. Correlation of species composition with physical, chemical and biological parameters showed that Branchionidae, Conochilidae and

Hexarthridae showed no significant correlation with light or temperature. They did show significant positive correlations with specific conductance (except Hexarthridae) and significant negative correlations with chl a and dissolved oxygen. Some Branchionidae showed positive correlations with pH. The Synchaetidae showed significant negative correlations with alkalinity and specific conductance, and either no trend or no significant correlation with temperature, vertical light intensity, and chl a. The Trichocerchidae showed no trend or correlation with any parameter measured.

Analysis of the veritical profifle data showed that species composition did not change with depth in 96% of the profiles taken.

DISCUSSION

Seasonal: Seasonal trends of total rotifer concentration in the Kanawha River were characterized by a single summer population pulse which is similar to trends shown in other rivers, e.g. the Ocqueoc River System in Michigan, U.S.A., (Beach, 1960) and the Sokoto River in Nigeria (Holden and Green, 1960). Studies on the Illinois river, Illinois, U.S.A., (Kofoid, 1908) and Motala river in Sweden (Carlin, 1943) showed an early spring pulse in addition to a summer pulse. Pulses have been noted in winter months in the Yamuna River in India

(Rai, 1974) in addition to a vernal-early summer pulse. Lack of a winter or spring rotifer bloom at UW may be attributed to low temperature, high river discharge, and indirectly to low specific conductance. Low temperature decreases reproductive rates of planktonic rotifers (Edmondson, 1964). High discharge lowers rotifer populations by dilution and by physically removing the rotifers (Williams, 1966; Hutchison, 1939; Kofoid, 1908; Rai, 1974). Specific conductance decreased during high water probably as a result of reduced mineralization at low water temperatures (Holland, et al., 1983) and dilution. Lack of winter or spring rotifer blooms at LW may be attributed to low phytoplankton concentration, since LW species are primarily herbivores or carnivores of herbivores, and low temperature. Although some species found in the Kanawha in winter are recorded elsewhere as cold stenotherms, such as _Filinia terminalis_ (Hutchinson, 1967), none of these or any other rotifer exhibited a winter population peak. Even though cold stenotherms have shorter egg development time at low temperatures than do warm stenotherms (Hofmann, 1977), high flow rates throughout the winter and spring may not allow these cold adapted species to remain present long enough to capitalize on their developmental advantage and attain large densities.

Seasonal trends of rotifer densities at UW did not correlate well with chl _a_ but did correlate with specific conductance. Specific conductance in freshwater systems shows a relationship with total dissolved solids (TDS); total dissolved solids is a measure of inorganic salts and dissolved organics (Cole, 1979). Direct utilization of dissolved organic substances by rotifers has not been demonstrated, but the possibility cannot be excluded (Pourriot, 1977). More likely, however, high concentrations of dissolved organics benefits bacterial growth, evident from UW bacterial counts (Simmons, unpublished, 1984). Bacteria are an important food source in the absence of phytoplankton (Pedros-Allio and Brock, 1983). Seston ash free dry weight (AFDW), a measure of particulate organics (often bacterial ladened), increases with fall leaf input and also when flood waters pick up detritus (Simmons, unpublished, 1984). In both fall and spring, rotifer concentrations increased marginally, positively correlated with seston AFDW. Lack of a greater rotifer density increase in fall was apparently due to falling temperatures; whereas lack of greater rotifer density increase in spring was apparently due to high flow conditions. Many of the rotifers present at UW are listed by Pourriot (1977) as exclusively or frequently bacteriophageous and/or detritvores. These include *Hexarthra mira*, *Keratella cochlearis* var. *cochlearis*, and *Lecane* sp. *H. mira* and *Lecane* sp. were found in appreciable quantities (up to 1.48 x 10^5 m^{-3}) at UW only. *Polyarthra remata* and *Synchaeta stylata*, which can feed on bacteria (Pourriot, 1977; Gliwicz, 1969), were found at UW in quantities up to 2.33 x 10^5 m^{-3} and 7.37 x 10^5 m^{-3}, respectively. At UW, however, neither species showed significant correlation with chl *a* while both showed significant correlation with specific conductance (r = .462 and .486, α .01 respectively). At LW both *P. remata* and *S. stylata* showed significant correlation (r = .523 and .567, α .01 respectively) with chl a, but no significant correlation with conductivity. It should be noted that the majority of chl a was found in the < 25 µm size class at UW; thus the rotifers had a choice of food items in an edible size range. These data indicate that bacteria, detritus and/or dissolved organics were playing a significant role in the nutrition of some rotifers at UW. Similar phenomena have been reported by Johansson (1983) who noted Synchaeta spp. correlated with chl a one season, but not another season even though the phytoplankton biomass and species present were the same.

Longitudinal: Plankton densities in general are expected to increase downstream (Cushing, 1964; Greenberg, 1964) due to the river becoming more lentic with increased watershed. Dams creating impounded areas have been shown to increase rotifer densities, but rotifer density quickly drops when lotic conditions recur below a dam (Beach, 1960; Cushing, 1964; Reif, 1939; Whitton, 1975). While a general downstream increase in rotifer concentration was evident from station 8 to station 1, the downstream and dam effects were overshadowed by what appeared to be increased nutrient loading from municipal and/or industrial wastewater (fig. 3).

Total rotifer concentrations at stations 1 to 8 did not correlate well with chl a concentrations at stations 1 to 8 (r^2 = .08), however, when stations 7 and 8 were excluded from the analysis then total rotifer concentrations at stations 1 - 6 did correlate well with chl a (r^2 = .67). Lack of a strong positive correlation when all stations were analyzed may be attributed to the lower concentrations of the bacteriophageous and detritivorous species at stations 7 and 8. Correlations of species with physical, chemical and biological parameters showed the herbivorous Brachionus calyciflorus, B. havanaensis, B. quadridentata and Polyarthra vulgaris were negatively correlated with chl a (i.e. as the number of herbivores increased, the amount of chl a decreased), This may be attributable to the tremendous filtering and feeding rates of species such as B. calyciflorus -- on the average 40 to 50 cells animal^{-1} hr^{-1} but up to 4000 cells animal^{-1} hr^{-1} (Starkweather and Gilbert, 1977; Pourriot, 1977).

Total rotifer concentrations in the longitudinal profile correlated well with pH and alkalinity. It should be noted that the range of alkalinity was 36 to 52 mg $CaCo_3$ l^{-1} and the pH range was 6.1 to 7.5. Species such as B. calyciflorus normally associated with alkaline waters were found in circumnuetral water (pH 6.7 to 7.3). Although total rotifer concentration correlated with pH and alkalinity, no particular species showed the same correlation trend on all sampling dates. Thus, total rotifer concentrations may not be directly associated with pH and alkalinity.

In the longitudinal profile, lack of correlation of species composition with temperature was attributed to the homogenous nature of the temperatures. The greatest temperature range on any sampling date was 1.5°C.

There is a gradual shift in the number of species indicative of eutrophy, mestrophy, and oligotrophy (indicator species according to Sladecek (1983) and Pawlowski (1973)) along the longitudinal transect sampled. The shift is from more oligotrophic upstream to more eutrophic downstream. A coefficient of association cluster analysis showed that when stations are clustered by species composition, stations in the lower reaches (1-3) were similar to each other and stations in the upper reaches (5-8) were more similar to each other on the majority of sampling dates (fig. 4).

Significantly higher concentrations of rotifers at 1 m than at 4 m in the lower reaches of the Kanawha may be attributable to the dominance of herbivorous species. Herbivorous rotifers would be expected to be concentrated in the photic zone (0 to 3 m) where their food is concentrated. No significant difference in concentrations of rotifers at 1 m and 4 m at station 8 was probably due to the bacteriophageous species present there. Bacterial counts showed that bacterial densities were similar throughout the water column in this season. Because vertical variation in physical and chemical parameters was slight in the longitudinal profile (with the exception of chl *a* and vertical light intensity), it is reasonable that species composition was very rarely affected by depth. In the few instances species composition was statistically different between depths it could be attributed to species such as *Trichocerca agnata* staying in the top of the water column near their food source.

AUTECOLOGY OF DOMINANT AND IMPORTANT SPECIES

Fifty-four species of rotifers were found in plankton samples from the Kanawha River. Notes on species comprising > 40% of the rotifer population or > 200 individuals per liter are given below.

Brachionus calyciflorus.

Brachionus calyiciflorus is a commonly encountered planktonic species of ponds and lakes throughout the world (Ahlstrom, 1940; Gilbert and Starkweather, 1977). It is also a common constituent of the plankton in rivers: Sokoto River, Nigeria (Green, 1960); Atchafalaya River, Louisianna, USA (Holland, et. al. , 1983); Grabia River, Poland (Pawlowski, 1973); Ohio River, USA (Ohio River Valley Sanitation Commission, 1962); and the Yamuna River, India (Rai, 1974). *B. calyciflorus* was found in the Kanawha River at station 1 (LW) on 7/21/83 and 10/8/83 in quantities > 200 individuals per liter, and also at station 2 on 8/16/83. It is a summer form.

B. calyciflorus is commonly found in alkaline and eutrophic habitats. This species is generally recognized as an indicator of eutrophy (Pawlowski, 1973; Sladacek, 1983; Stemberger, 1979). *B. calyciflorus* is primarily an herbivore, although it can ingest detritus and bacteria (Gilbert and Starkweather, 1977; Pourriot, 1977).

Brachionus quadridentatus.

Brachionus quadridentatus is a cosmopolitan species, common to ponds and rivers (Ahlstrom, 1940). It has been found in the Sokoto River, Nigeria (Green, 1960); the Canard River, Canada (Hodgkinson, 1970); the Illinois River, USA (Kofoid, 1908); the Ohio River, USA (Ohio

River Valley Sanitation Commission, 1962); and the Yamuna River,India (Rai, 1974). *B. quadridentatus* was found in the Kanawha River at stations 1 and 2 in quantities > 200 indivuals per liter on 10/8/83. It is a summer form (Kofoid, 1908). *B. quadridentatus* is commonly found in alkaline habitats (Ahlstrom, 1940). This species is generally recognized as an indicator of eutrophy (Pawlowski, 1973; Sladacek, 1983; Stemberger, 1979).

Cephalodella gibba.

Cephalodella gibba is common to littoral areas and is normally epiphytic or benthic although it occasionally occurs in the plankton (Edmondson, 1959; Stemberger, 1979). Generally the genus *Cephalodella* is considered an acid water species (Edmondson, 1959).

It has been found in activated sludge plants in Europe (Sladacek, 1983), as well as in the Grabia River, Poland (Pawlowski, 1973), and in the Yamuna River, India (Rai, 1974). *C. gibba* was found in the Kanawha River at station 1 on 4/21/83, comprising > 40% of the rotifer population. *C. gibba* is considered an indicator of eutrophy (Pawlowski, 1973 Sladacek, 1983). It is an omnivore which feeds on other rotifers, diatoms, and green algae (Stemberger, 1979).

Colurella gastrocantha.

Colurella gastrocantha is a littoral species, although it occasionally occurs in the plankton (Edmondson, 1959). *Colurella* species have been found in the plankton of the Ocqueoc River, Michigan USA (Beach, 1960); the Atchafalaya River, Louisianna (Holland, 1977); the Illinois River, USA (Kofoid, 1908); and the Grabia River, Poland

(Pawlowski, 1973). *C. gastrocantha* was found in the Kanawha River plankton at UW on 3/25/83 and at LW on 5/20/83. *Colurella* species, although considered littoral often become abundant in the limnetic zone of eutrophic waters (Gannon and Stemberger, 1978). *Colurella* species are often found in eutrophic waters, although they have been recorded in oligotrophic waters (Sladacek, 1983). *Colurella* species feed by scraping up small organisms with their head sheild (Edmondson, 1959).

Euchlanis sp.

Euchlanis species are littoral rotifers (Stemberger, 1979). They have been noted in the Sokoto River, Nigeria (Green, 1960); the Atchafalaya River, Louisianna, USA (Holland, 1977); the Illinois River, USA (Kofoid, 1908); and the Yamuna River, India (Rai, 1974). *Euchlanis* species are eutrophic to mesotrophic species (Pawlowski, 1973; Sladacek, 1983). us. Euchlanis$ species may eat green algae, diatoms, or bacteria (Pourriot, 1977; Stemberger, 1979).

Keratella cochlearis var. *cochlearis*.

K. cochlearis is cosmopolitan, and is probably the worlds most common rotifer (Edmondson, 1959). It is perennial and lives in a wide range of conditions: cold Bare Lake in Alaska to temperate South Africa (Hutchinson, 1967). It has been found in rivers world-wide: e.g. the Ocqueoc River, Michigan, USA (Beach, 1960) to the Motala River, Sweden (Carlin, 1943). *K. cochlearis* constituted 40% or more of the population in the Kanawha River at LW on 10/18/82, 11/18/82, and 3/24/83, and 40% or more of the population at UW on 11/19/82, 2/18/83, and 6/22/83. It is found in a wide range of trophic conditions (Sladacek, 1983).

K. cochlearis consumes particles of detritus (with associated bacteria) up to 12 microns in diameter (Edmondson, 1964). It can eat larger items such as cryptomonads and chrysomonads (Pourriot, 1977).

Lecane arietii n. sp.

Lecane arietii n. sp. had a very limited distribution, known only from the upper reaches of the Kanawha River, particularly UW station (See chapter 2). It appeared in small quantities on occasions throughout the year in the Kanawha, however, it is a summer form. Large populations were noted on 6/28/82 and 9/13/83 (see Chapter 2 for details of densities and longitudinal distribution). Other *Lecane* species are known to be microphageous and feed on bacteria and detritus (Stemberger, 1979). This *Lecane* species apparently feeds on bacteria and detritus because its populations did not correlate with chl *a*.

Lepadella sp.

Lepadella sp. are littoral rotifers, common in hard waters worldwide (Harring, 1916). They have been found in river systems: the Ocqueoc River, Michigan, USA (Beach, 1960); the Illinois River, USA (Kofoid, 1908); the Ohio River, USA (Ohio River Valley Sanitation Commission, 1962); the Grabia River, Poland (Pawlowski, 1973); and the Yamuna River, India (Rai, 1974). *Lepadella* species were relatively abundant in the Kanawha River on 3/25/83.

Polyarthra dolichoptera

Polyarthra dolichoptera is a widely distributed planktonic species. Records of the distribution of this species are confusing and incomplete due to the synonomy of *P. platyptera* and *P. trigla* with *P. dolichoptera* and with *P. vulgaris* (Bartos, 1959). *P. dolichoptera* is generally considered to be a cold stenotherm (but not a winter form), although it can live in temperatures up to 19ºC (Chengalath, 1982.unpublished; Hutchinson, 1967). It is often found near or in the hypolimnion at low dissolved oxygen levels, apparently excluded from the epilimnion by the competition of other *Polyarthra*. *P. dolichoptera* is found in large numbers in the great lakes in late spring (Hutchinson, 1967). It is found in the Motala River, Sweden, in late spring (Carlin, 1943). It was found in the Kanawha River on 8/16/83.

Polyarthra dolichoptera is found in oligotrophic and eutrophic waters (Sladacek, 1983). It is exclusively algae eating (Pourriot, 1977).

Polyarthra remata

Polyarthra remata is an epilimnetic species (Hutchinson, 1967) and is the smallest *Polyarthra* species (Stemberger, 1979). Much synonomy exists for this *Polyarthra* species (Bartos, 1959).

P. remata is a late summer species (Hutchinson, 1967). It occurs only at high summer temperatures in Lake Ösbysjön, Sweden (Pejler, 1961). it also occurs in river systems, e.g. in the Motala River, Sweden (Carlin, 1943), and the Yamuna River, India (Rai, 1974). *P. remata* may prefer oligotrophic lakes (Maemets, 1983), but it is found in oligotrophic to eutrophic lakes (Sladecek, 1983). It was abundant in the Kanawha River 8/25/83.

Polyarthra vulgaris.

Polyarthra vulgaris is a widely distributed perennial form that inhabits the epilimnion (Carlin, 1943; Hutchinson, 1967). It usually shows a population pulse in late spring or early summer when the water temperature is 15-20° C (Carlin,1943), and may be a temperature dependent species (Edmondson, 1964). Extensive synonomy exists for this species (Bartos, 1959).

P. vulgaris has been found in other river systems, e.g. the Atchafalaya River, Louisianna, USA (Holland. 1977). It was found in the Kanawha River 8/24/83 at UW. This species may be a useful indicator of eutrophy (Sladacek, 1983).

Polyarthra vulgaris eats algae (almost exclusively) and probably no algae smaller than 15 microns (Pourriot, 1977; Edmondson, 1964). *P. vulgaris* also eats flagelated protozoans of the genus *Bodo* in culture (Buikema *et. al.*, 1977). In nature, *P. vulgaris* may feed primarily on cryptomonads (Edmondson, 1964).

Synchaeta stylata.

Synchaeta stylata occurs during late spring through the fall, usually with maximum populations in late spring and summer, particularly in August (Stemberger, 1979; Carlin, 1943). It has been noted in river systems such as the Motala River, Sweden (Carlin, 1943), and the Atchafalaya River, Louisianna (Holland, 1977). It was found in the Kanawha River at UW on 7/20/83 and 8/24/83.

S. stylata is considered an indicator of oligotrophic conditions (Hutchinson, 1967). *Synchaeta* species, however, have been noted in eutrophic systems (Sladacek, 1983). *S. stylata* is a grasping species and is considered by Pourriot (1977) to be an obligate herbivore.

However, it should be noted that some species may feed on bacteria in eutrophic systems.(Gliwicz, 1969; Johansen, 1983).

SUMMARY AND CONCLUSIONS

Water quality in the Kanawha River has greatly improved since the reports made by Palmer (1967) and Williams (1966) regarding water quality in the early 1960's. Mean rotifer concentration at LW was 354 individuals 1^{-1}, and 233 individuals 1^{-1} at UW for the 12 months sampled. Dissolved oxygen was not observed to fall below 5.0 mg O_2 1^{-1}, and was below 6.0 mg O_2 1^{-1} in only one month (Aug.). Nevertheless, downstream and dam effects (which increase rotifer density) were overshadowed apparently by municipal and/or industrial wastewater effects (which also increase rotifer density).

The longitudinal profile showed that a shift in species composition from bacteriophageous and detritus-eating species to herbivorous species occured from the upper reaches to the lower reaches of the river. The seasonal study showed that while both UW and LW total rotifer concentrations were characterized by a single summer population peak, the same physical or chemical parameters did not account for the same amount of variation in rotifer concentration at the two stations. This may be due in part to the lentic nature of LW and to the lotic nature of UW, as well as to the difference in species compostion of the upper and lower reaches of the river.

Rotifers were able to maintain an overall heterogeneous distribution in the water column in this river system, even in the most lotic region sampled, where all physical and chemical parameters measured showed no stratification with the exception of chl *a* (phytoplankton) and vertical light intensity. Where there was no stratification of the rotifer's food source, there was no stratification of the water column with respect to rotifers.

LITERATURE CITED

Ahlstrom, E. 1949. A revision of the rotatorian genera *Brachionus* and *Platyias* with descriptions of one new species and two new varieties. *Bull. Am. Mus. Nat. Hist.* 77: 143-184.

American Public Health Association (A.P.H.A.), American Water Works Association, and Water Pollution Control Federation. 1980. *Standard Methods for the Examination of Water and Wastewater*. 15th ed. Washington D.C., USA.

Bartos, E. 1959. Virnici-Rotatoria. *Fauna* CSR 15: 1-965.

Beach, N. W. 1960. A study of the planktonic rotifers of the Ocqueoc River system, Presque Isle County Michigan. *Ecol. Monogr.* 30(4):339-357.

Carlin, B. 1943. Die Planktonrotatorien des Motalastrom. *Medd. Lunds Univ Limn. Inst.* 5:1-255.

Cole, G. A., 1979. *Textbook of Limnology, 2nd ed.* The C.V. Mosby Co., St. Louis, Mo. 426 pp.

Cushing, C.E. 1964. Plankton and Water chemistry in the Montreal river-lake stream system, Saskatchewan. *Ecology* 45:306-313.

Dames and Moore. 1975. *Assessment of the Impacts of PL 92-500 on the Kanawha River Basin for the Natinal Commission on Water Quality.*

Water Pollution Control Act of 1972 - Regional Impacts. N.T.I.S. U.S. Dept. of Commerce. Springfield, VA.

Edmondson, W.T. 1959. ed. Freshwater Biology, 2nd. ed. New York, John Wiley & Sons, Inc. 248 pp.

______________. 1964. Reproductive rate of planktonic rotifers as related to food and temperature in nature. Ecol. Monogr. 35(1):61-111.

Gannon, J.E., and S. A. Gannon. 1975. Observations on the narcotization of crustacean Zooplankton. Crustaceana 28(2):220-224.

________.,and R.S. Stemberger, 1978. Zooplankton (especially crustaceans and rotifers) as indicators of water quality. Trans. Amer. Microsc. Soc. 97: 16-35.

Gilbert, J. and P. Starkweather. 1977. Feeding in the rotifer *Brachionus calyciflorus*. I. Regulatory mechanisms. Oecologia (Berl.) 28: 133-135.

Gliwicz, Z. M. 1969. The share of algae, bacteria and trypton in the food of zooplankton of lakes with various trophic characteristics. Bull. Acad. Sci. 3:159-165.

Green, J. 1960. The zooplankton of the river Sokoto. The Rotifera. Proc. Zool. Soc. Land. 135:491-523.

_______. 1977. Sampling Rotifers. Arch. Hydrobiol. Beih. Ergebn. Limnol. 8:9-12.

Greenberg, A. E. 1964. Plankton of the Sacramento River. Ecology 45(1):40-49.

Harring, H.K. 1916. A revision of the rotatorian genera Lepadella and Lophocharis with descriptions of five new species. Proc. U.S. Nat. Museum. 51: 527-568.

Hodgkinson, E.A. 1970. A study of the planktonic Rotifera of the River Canard, Essex County, Ontario. M.Sc. Thesis. Univ. of Windsor, Ontario.

Hofmann, W. 1977. The influence of abiotic environmental factors on population dynamics in plankton rotifers. Arch. Hydrobiol. Beih. Ergebn. Limnol. 8:77-83.

Holden, M.J. and J. Green. 1960. The hydrology and plankton of the river Sokoto. J. Anim. Ecol. 29:65-84.

Holland, L.E. 1977. Distribution and ecology of plankton Rotifera in the Atchafalaya River Basin, Louisianna. M.S. Thesis. Louisianna St. Univ.

___________., C. F. Bryan, and J. P. Newman, Jr. 1983. Water quality and the rotifer population in the Atchafalaya River Basin, LA. Hydrobiologia 98(1):55-70.

Hutchinson, G.E. 1967. A Treatise on Limnology, Vol. II. Introduction to Lake Biology and the Limnoplankton. John Wiley & Sons, Inc., New York. 1115 pp.

Hutchison, L. 1939. Some factors influencing zooplankton distribution in the Hocking River. Ohio J. Sci. 39:259-273.

Johansson, S. 1983. Annual dynamics and production of rotifers in an eutrophic gradient in the Baltic Sea. Hydrobiologia 104:335-340.

Kofoid, C.A. 1908. The plankton of the Illinois River 1894 - 1899, II. Constituent organisms and their seasonal distribution. Bull. Ill. State Lab. Nat. Hist. 8:3-361.

Likens, G. and J. Gilbert. 1970. Notes on quantitative sampling of natural populations of planktonic rotifers. Limnology and Oceanogr. 15:816-820.

Lind, O.T. 1979. Handbook of Common Methods in Limnology, 2nd ed. The C.V. Mosbey Co., St. Louis, Mo. 199 pp.

Maemets, A. 1983. Rotifers as indicators of lake types in Estonia. Hydrobiologia 104: 357-361.

Ohio River Valley Water Sanitation Commission. 1962. Aquatic Life Resources of the Ohio River. Ohio River Valley Water Sanitation Commission, Cincinnati, OH.

Palmer, C. M. 1967. Algae and associated organisms in W.VA waters. Castanea. 32 (3):123-133.

Pawlowski, L. K. 1973. Les Rotiferes De La Rivere Grabia Dans Le Profil Longitudinal. Pr. Wydz. Mat. - Przyr. Lodz. Nr. 116.

Pedros-Allio, C. and T. D. Brock. 1983. The impact of zooplankton feeding on the epilimetic bacteria of a eutrophic lake. Freshwater Biol. 13:227-239.

Pejler, B. 1961. The zooplankton of Ösbysjön, Djursholm. I. Seasonal and vertical distribution of species. Oikos. 12: 225-248.

Pinkham, C. F. and J. G. Pearson. 1976. Application of a new coefficient of similarity to pollution surveys. J. Water Poll. Contr. Fed. 48(4):717-723.

Pourriot, R. 1977. Food and feeding habits of Rotifera. Arch Hydrobiol. Beih. Ergebn. Limnol. 8:243-260.

Rai, H. 1974. Limnologcial studies on the River Yanuna at Delhi, India. Part II. The dynamics of potamoplankton populations in the River Yamuna. Arch. Hydrobiol. 73(4):492-517.

Reif, C. B. 1939. The effect on stream conditions on lake plankton. Trans. Amer. Micros. Soc. 58(4):398-403.

Simmons, G.M. Jr. 1984. unpublished report. Dept. of Biology, VPI & SU Blacksburg, VA.

Sladacek, V. 1983. Rotifers as indicators of water quality. *Hydrobiologia* 100:169-201.

Starkweather, P.L. and J. Gilbert. 1977. Feeding in the rotifer *Brachionus calyciflorus*. II. Effect of food density on feeding rates. *Oecologia* (Berl.) 28:133-139.

Stemberger, R. 1979. *A Guide to the Rotifers of the Laurentian Great Lakes*. Environmental Monitoring and Support Lab. Office of R & D. U.S. E.P.A., Cincinnati, OH. EPA-600/4-79-021.

Voshell, J.R.; G.M. Simmons, Jr.; L.A. Nielson; and D.J. Orth. 1983. *Summer Reconnaisance of the Kanawha River*. Final Report submitted to Huntington District U.S. Army Corps of Engineers, Huntington, WV by J.R. Voshell, Dept. of Entomology, VPI & SU, Blacksburg, VA.

Whitton, B. A. (ed.). 1975. *River Ecology*. *Studies in Ecology Vol. II*. Univ. Calif. Press, Berkely and L.A. pp. 155-179.

Williams, L. G. 1966. Dominant planktonic rotifers of Major waterways of the United States. *Limnology and Oceanogr*. 11:83-91.

Table 1. Total rotifer concentrations from upper Winfield (UW) and lower Winfield (LW) sampled at a depth of 1m correlated with physical, chemical, and biological parameters.

Parameter	Station	r^2
Chlorophyll a	UW	14.4
Chlorophyll a	LW	73.6
Temperature	UW	44.8
Temperature	LW	25.2
Discharge	UW	20.8
Discharge	LW	12.6
Dissolved O_2	UW	38.1
Dissolved O_2	LW	8.4
Conductivity	UW	35.6
Conductivity	LW	4.1*
pH	UW	*
pH	LW	*
Light	UW	*
Light	LW	*

* r^2 not significant at α .05

Table 2. Concentrations of species (grouped by family) correlated with chemical, physical, and biological parameters. The range of r values is given. NS = not significant at α .05.

Parameter	Family (& Station)		
	Synchaetidae Trichocercidae (UW & LW)	Asplanchnidae Brachionidae Hexarthridae (UW & LW)	Dicraniphoridae (UW)
Temperature	.47 to .68	.38 to .49	-.36
Conductivity	.45 to .69[a]	-.37 to .65[b] -.53[c]	NS
Dissolved O_2	-.41 to -.70	.44 to .51	.38
Alkalinity	.78 to .87	.44 to .81	NS
Discharged	-.38 to -.50	NS[d]	NS
Chlorophyll _a_	.50 to .57[e]	NS[f]	NS

[a] Not significant at LW
[b] Values for LW
[c] Values for UW
[d] Exception: _Euchlanis alata_, .53
[e] Not significant at UW
[f] Exception: _Brachionus calyciflorus_, .56

Table 3. Mean total rotifer concentration per liter from 1m at each station in the longitudinal transect. Concentrations at stations preceded by the same group letter are not significantly different (Duncans Multiple Range analysis).

Group	Station	no. l^{-1}
A	5	1634.0
B	4	1244.0
B	3	1242.9
B	2	1203.1
C	1	878.2
C	6	809.3
D	7	437.8
E	8	49.6

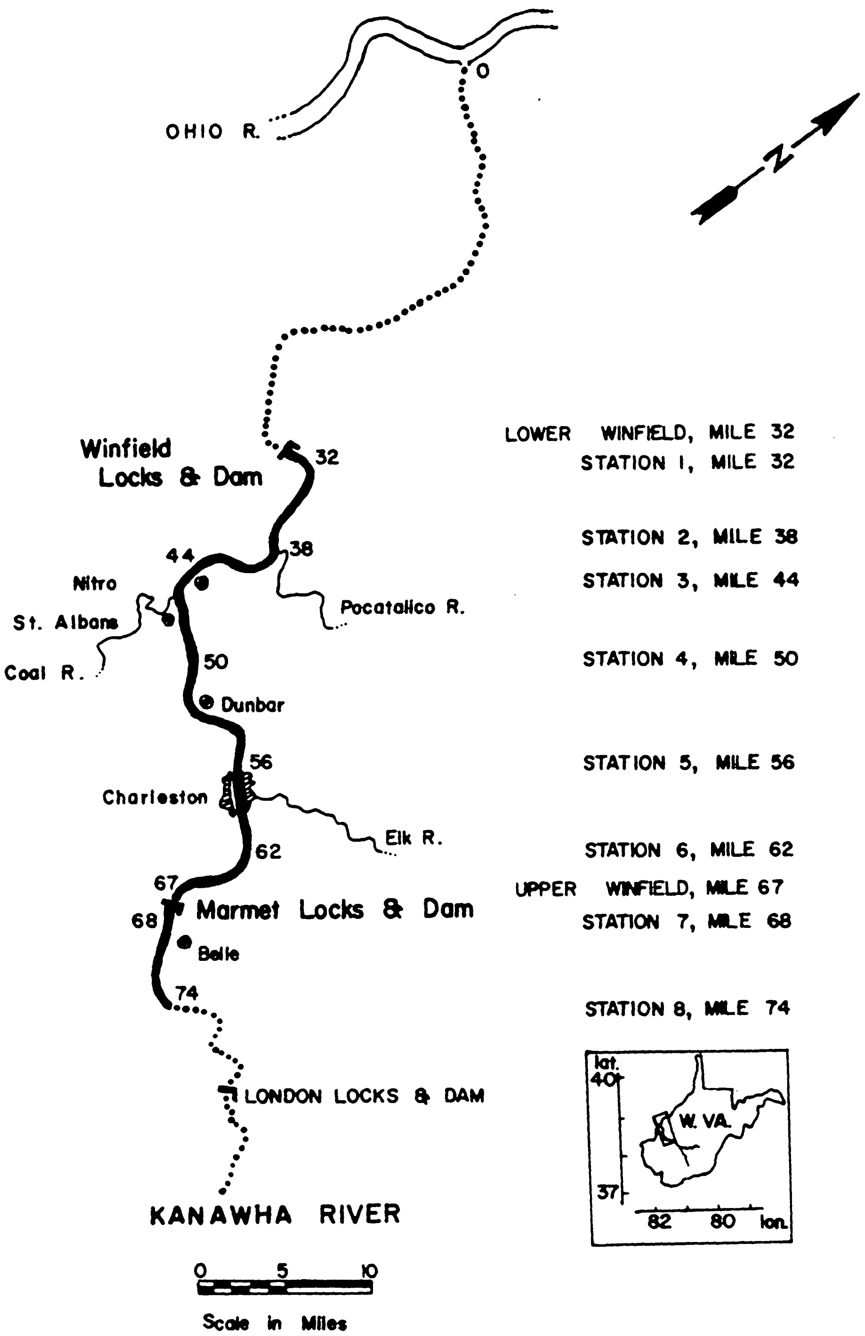

Figure 1. Map of the Kanawha River showing the stations sampled, and the location in WV of the section of the Kanawha River studied.

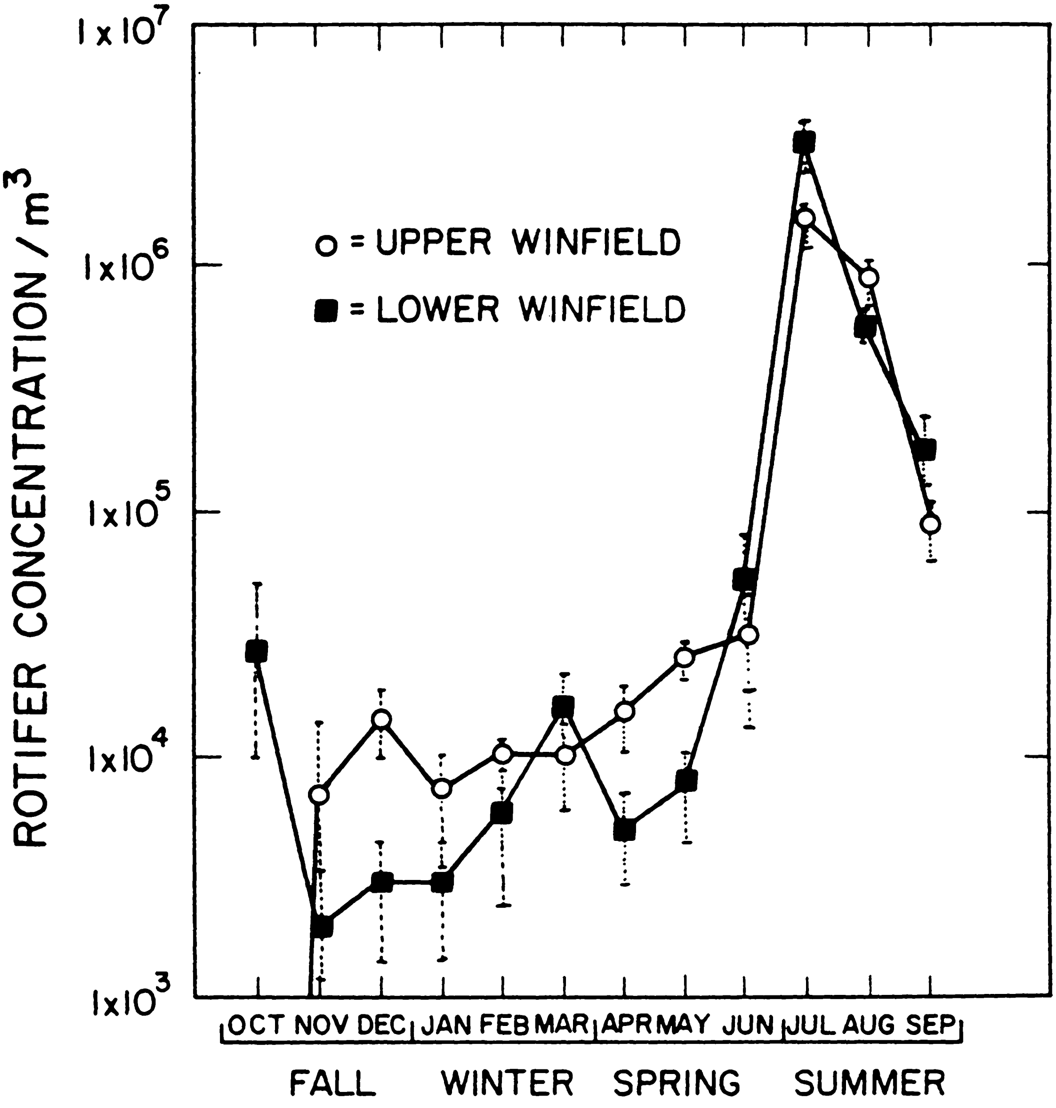

Figure 2. Mean total rotifer population densities (number per cubic meter) sampled at one meter below surface in lower Winfield pool and upper Winfield pool from October 1982 to September 1983.

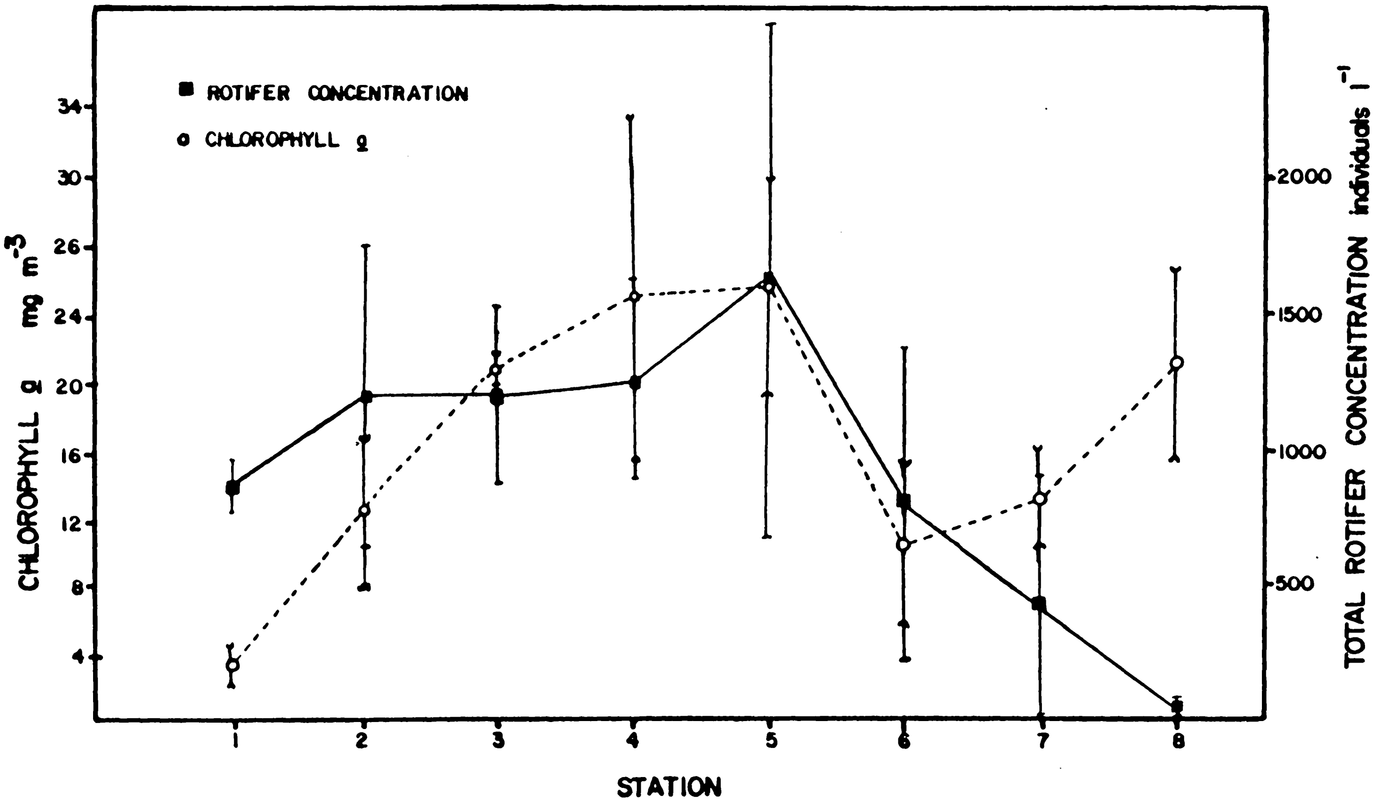

Figure 3. Mean total rotifer concentration (individuals per liter) and mean chlorophyll a concentration (mg. per cubic meter) from three sampling dates, sampled at one meter below surface.

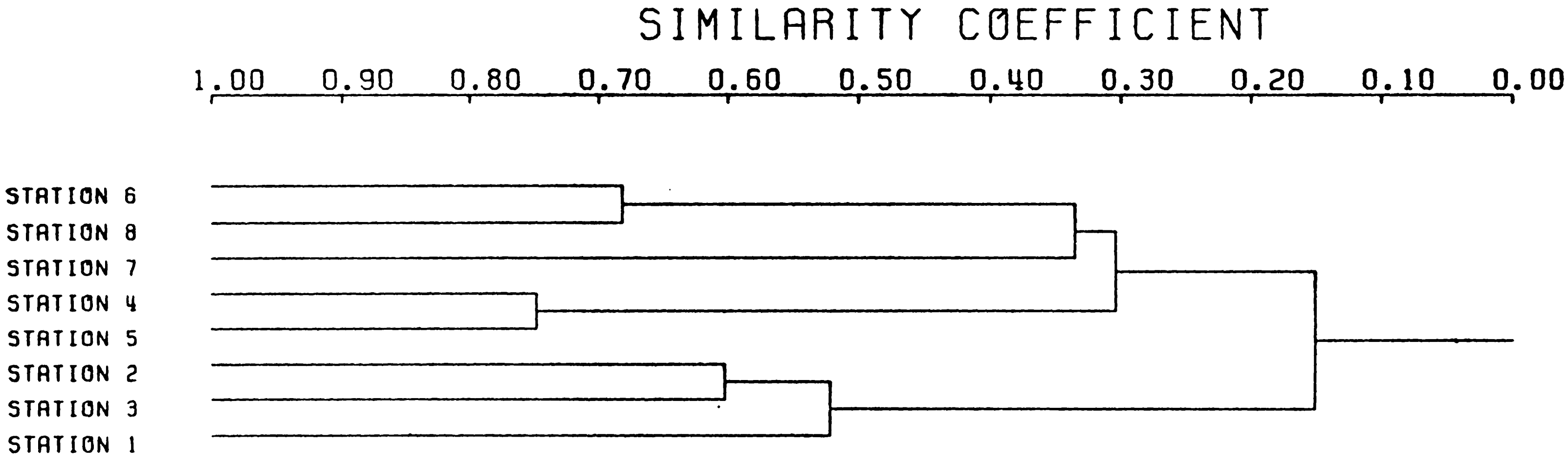

Figure 4. Dendrogram plot of Pinkham-Pearson similarity coefficients of stations clustered by species composition.

CHAPTER 2.

A New Species of the Genus Lecane Nitzsch 1827 (Lecanidae: Rotifera) With Notes on Its Distribution and Fungal Parasitism.

Introduction

Since the early 1970's the lower Kanawha River has been a system recovering from excessive pollution (See Chapter 1, this thesis). Williams (1966) noted that industrial chemicals had greatly reduced rotifer populations in the lower Kanawha River. A thorough literature search revealed that an extensive study of the Rotifera of the lower Kanawha River has not been carried out since the study completed by Williams (1966) in 1961-62. The present study is part of a distribution study on the Lower Kanawha River. A new species of the genus Lecane Nitzsch 1827 is described.

An insular distribution of the new species of Lecane was noted, as well as the occurance of fungal parasites of this species of Lecane. The possibility that these parasites are affecting the distribution of Lecane cannot be excluded. Fungal and sporozoan parasites of rotifers are not unknown. The rotifers Branchionus calyciflorus, B. caudatus, Filinia longiseta, Platyias patulua and Synchaeta pectinata have been reported to be parasitized (Whitton, 1975), as well as *Polyarthra vulgaris* (Beach, 1960; Buikema et al., 1977; Kofoid, 1908; Pejler, 1961), *Nothloca longispina* (Patterson, 1958), *Synchaeta stylata* (Beach, 1960 *Epiphanes sentor* (Hollowday, 1947), *Keratella cochlearis* and *Kellicotia longispina* (Edmondson, 1965), and *Lecane* sp. (*Distyla* sp.) (Karling, 1944). Parasites of rotifers could have a dramatic effect on species composition and succession in a river system (Whitton, 1975). The objective of this investigation on parasitized *Lecane* was to determine whether or not the incidence of parasitism was related to its longitudinal distribution in the river.

Materials and Methods

Initial samples for taxonomic work were collected 28-29 June 1982 from the Kanawha River in West Virginia, U.S.A., above and below Marmet Locks and Dam (L & D) as well as above and below Winfield L & D (fig. 1). Samples for a longitudinal distribution study were collected 13 September 1983 from eight stations, six miles apart--a total of 42 river miles (fig. 1). Samples were collected monthly October 1982 to September 1983 above Winfield L & D and below Marmet L & D for a seasonal distribution determination. Samples for the seasonal study were collected 1 meter below surface and 1 meter above the sediment-water interface. Samples for the longitudinal study were collected from 1, 4, and where depth permitted (stations 1, 2, and 7) 8 meters.

Samples were collected with a 5 liter Juday trap with 35 μm mesh net on the Wisconsin bucket (Likens and Gilbert, 1970). Rotifers were then narcotized with carbonated water, preserved with 10% formalin, and stained with Rose Bengal (Gannon and Gannon, 1975). Some rotifers were not preserved and were observed live. A total of 123 Lecane were measured for the description of the new species.

Lecane arietii n. sp.

Description of the female (fig. 2)

The lorica is exceedingly pliable and membranous, nevertheless the general outline of the contracted animal is fairly constant and diagnostic. The outline of the lorica is broadly ovate with a distinct constriction 1/4 of the distance from the anterior margin to the posterior margin. The anterior margins are slightly convex and the lorica is open in front even when fully contracted. The dorsal plate is broadly ovate and rounded posteriorly; the constriction of the dorsal plate is distinct, but is less evident than that of the ventral plate. The ventral plate is ovate and smaller than the dorsal plate.

Neither plate has distinguishing markings. The first foot segment is bluntly wedge-shaped and is often indistinct. The second foot segment has a convex anterior margin and is parallel-sided anteriorly; posteriorly it has the shape of a truncated "V". The second foot segment extends to the edge of the dorsal lorica, very rarely beyond. The toes are approximately 20% of lorica length, straight, with a slight taper distally, each terminating with a straight lanceolate claw approximately 50% the length of the toe.

Measurements

Total Length, 81 to 97 μm;
Length of dorsal plate, 63 to 71 μm;
Width of dorsal plate, 40 to 50 μm;
Length of toes without claw, 13-14 μm;
Length of claw, 5 to 8 μm;

Male

Unknown.

Type Locality

United States; West Virginia; Kanawha River in Marmet pool, Marmet Locks and Dam (38° 15' N, 81° 34' W), 28 June, 1982, and 13 September 1983. Known only from one locality (see section on parasitism and distribution).

Remarks

At first glance *Lecane arietii* n. sp. resembles *Lecane tenuiseta* Harring 1914, primarily because of the general lorica shape and the shape of the foot and toes. *L. arietii* is distinctly different from *L. tenuiseta* and all other *Lecane* species because of the distinct constriction of both dorsal and ventral plates. *L. arietii* does not have the markings on the ventral plate which are characteristic of *L. tenuiseta*. The ratio of toe length (without claw) to lorica length in *L. tenuiseta* is .27 to .30, but only .20 to .21 in *L. arietii*. *L. arietii* (mean total length 89 m) is generally smaller than *L. tenuiseta* (mean total length 106 m).

At first glance *L. arietii* may also resemble *Lecane inermis* (Bryce, 1892), primarily because of the general lorica shape. However, *L. inermis* does not have the distinct constriction in the lorica of *L. arietii*. The posterior of the lorica is more lobate in *L. inermis* than in *L. arietii*, and the ventral plate of *L. arietii* is larger, whereas the dorsal plate of *L. arietii is* larger. *L. inermis* usually has a straight anterior margin whereas that of *L. arietii* is convex. Finally the foot segment normally does not extend beyond the lorica on *L. arietii* whereas it does on *L. inermis*. *L. arietii* (mean total length 89 m) is generally smaller than *L. inermis* (mean total length 115 m).

L. tenuiseta and *L. inermis* are the only rotifers known to even remotely resemble *L. arietii* n. sp.

Parasitism and Distribution

Lecane arietii is sporadically present year round, however it is a late summer form showing blooms at low flow conditions when water temperature is near 25° C. *Lecane arietii* was first discovered 28 June 1982, but it was not until 13 September in 1983 that the initial incidence of a *L. arietii* population was observed. This latter population was infected with a fungal parasite (fig. 3) which resembles the lagenidiaceous parasites of *Lecane sp.* (*Distyla sp.*) from Brazil as described by Karling (1944). Biflagelated zoospores, such as those described for *Legenidium sp.* by Karling (1944) also occurred in these samples. Only adults of *Lecane arietii* were infected. No other species of *Lecane* or any other genus were infected.

An insular distribution of *L. arietii* was noticed. The June 1982 population of *L. arietii* was present at Marmet pool in concentrations up to 1.86×10^5 individuals per cubic meter, but was present in concentrations of only 1.1×10^4 individuals per cubic meter at Lower Winfield pool. The September 1983 population was present at Marmet pool in concentrations of 5.2×10^4 individuals per cubic meter, but only 8.0

x 10^2 individuals per cubic meter at Lower Winfield pool. Sampling a longitudinal transect of the river showed that total L. arietii number generally decreased downstream, with upstream stations 4, 5, 7 and 8 significantly higher in concentration than stations 1 and 2 (Table 1). The percent of L. arietii parasitized increased downstream (Table 2).

It is not clear why L. arietii was not surviving downstream, but of the many possibilities two stand out. One possibility is that biological or physical stresses suchas a shift in food type or abundance, or the hydrostatic pressure of passing under the dam, or predation, etc., were decimating the population. The rotifer population thus would have been perishing (not due to parasitism) and the parasites were capitalizing on the weakened condition of the population infesting a higher percentage. Another possibility is that parasites were introduced at a point above Marmet pool and they eliminated the population as it drifted downstream. Because discharge for September 13 was 3000 cfs and drift rate was approximately 4 miles per day, rotifers would drift from Marmet dam to Winfield dam in 9 days (Dames and Moore, 1975). Parasites have been known to eliminate entire rotifer populations in several days (Edmondson, 1965). A combination of these two possibilities cannot be excluded.

Literature Cited

Beach, N. W. 1960. A study of the planktonic rotifers of the Ocqueoc River System, Presque Isle County, Michigan. Ecol. Monogr. 30(4):339-357.

Buikema, A. L., Jr., J. Cairns, Jr., P. C. Edmunds, and T. H. Krakauer. 1977. Culturing and ecology studies of the rotifer *Polyarthra vulgaris*. U.S. Environmental Protection Agency, Duluth, Minnesota. EPA-600/3-77-051

Dames and Moore. 1975. Assessment of the Impacts of PL 92-500 on the Kanawha River Basin for the National Commission on Water Quality. Water Pollution Control Act of 1972-Regional Impacts. N.T.I.S. U.S. Dept. of Commerce, Springfield, VA.

Gannon, J. E., and S. A. Gannon. 1975. Observations on the narcotization of crustacean zooplankton. Crustaceana 28(2):220-224.

Hollowday, E. D. 1947. Internal fungoid and sporozoan parasites of rotifera. J. Quekett Microsp. Cl. (Series 4) 11(4):222-224.

Karling, J. S. 1944. New lagenidiaceous parasites of rotifers from Brazil. Lloydia 7(4):328-342.

Kofoid, C. A. 1908. The plankton of the Illinois River 1894-1899, II. constituent organisms and their seasonal distribution. Bull. Ill. State Lab. Nat. Hist. 8:3-361.

Likens, G. and J. Gilbert. 1970. Notes on quantitative sampling of natural populations of planktonic rotifers. *Limnology and Oceanogr*. 15:816-820.

Patterson, R. A. 1958. Parasitic and saprophytic phycomycetes which invade planktonic organisms II. A new species of *Dangeardia* with notes on other lacustrine fungi. *Mycologia* 50:453-468.

Pejler, B. 1961. The zooplankton of Ösbysjön, Djursholm. I. Seasonal and vertical distribution of the species. *Oikos* 12(2):226-248.

Whitton, B. A. (ed.). 1975. *River Ecology*. *Studies in Ecology* Vol. 2. Univ. of Calif. Press. Berkeley and L.A. pp. 155-169.

Williams, L. G. 1966. Dominant planktonic rotifers of major water ways of the United States. *Limnology and Oceangr*. 11:83-91.

Table 1. Mean concentration per cubic meter of *Lecane arietii* n. sp. at each station. Stations with the same group letter are not significantly different (Duncans Multiple Range).

Mean no. m^{-3}	Station	Group		
52333	7	A		
		A		
39000	8		C	
		A		
			C	D
34000	4	A		
			C	D
		A		
28667	5		C	D
		A		
			C	D
22000	6	B		
			C	D
		B		
10000	3			D
		B		
800	1	B		
		B		
0	2	B		

Table 2. Mean percent of *Lecane arietii* n. sp. parasitized by fungi at each station. Stations with the same group letter are not significantly different (Duncans Multiple Range). Station 2 had no *L. arietii* n. sp.

Mean %	Station	Group	
75.0	3	A	
58.2	6	A	B
53.0	4	A	B
40.1	5		B
35.1	8		B
28.5	7		B

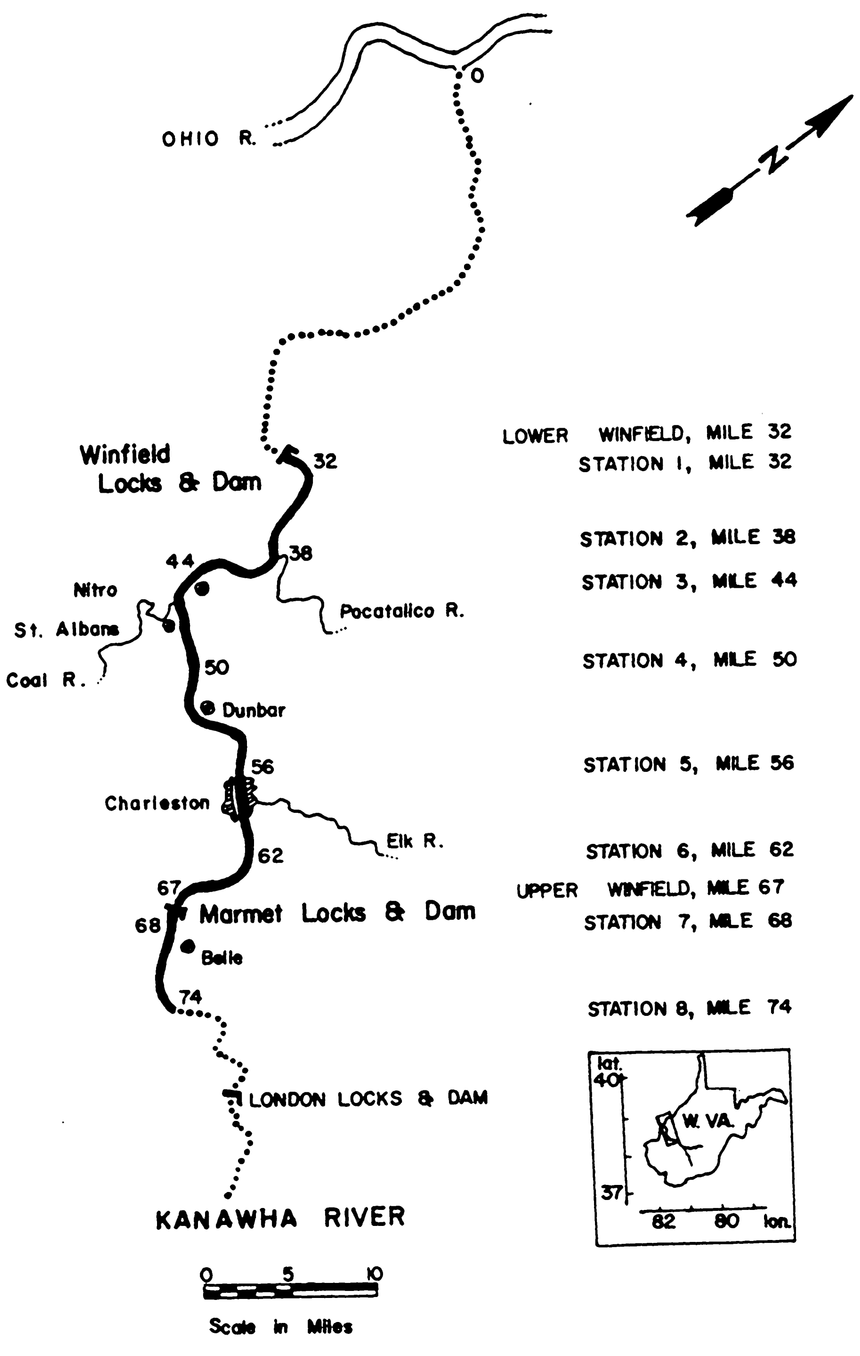

Figure 1. Map of the Kanawha River showing the stations sampled, and the location in WV of the section of the Kanawha River studied.

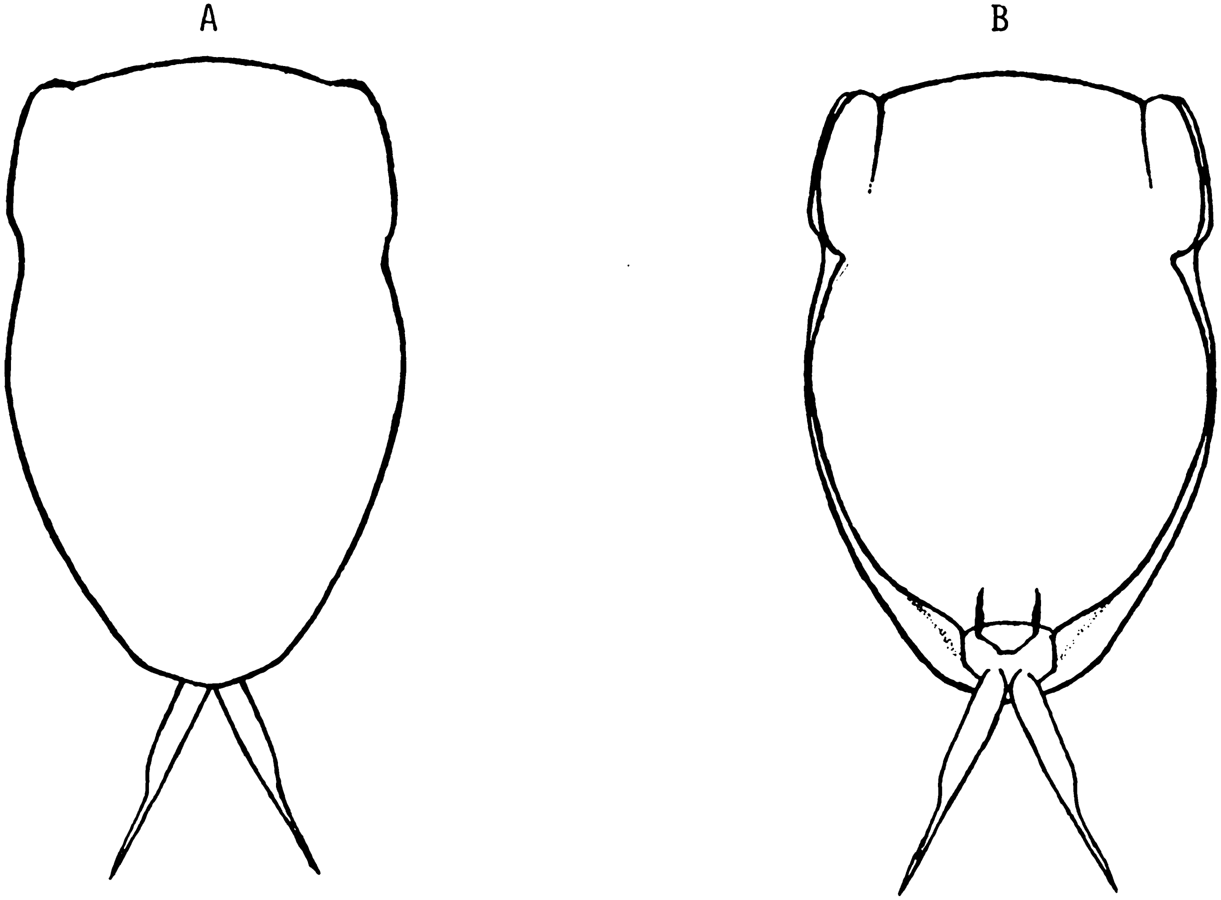

Figure 2. Lecane arietii n. sp. A. Dorsal view. B. Ventral View.

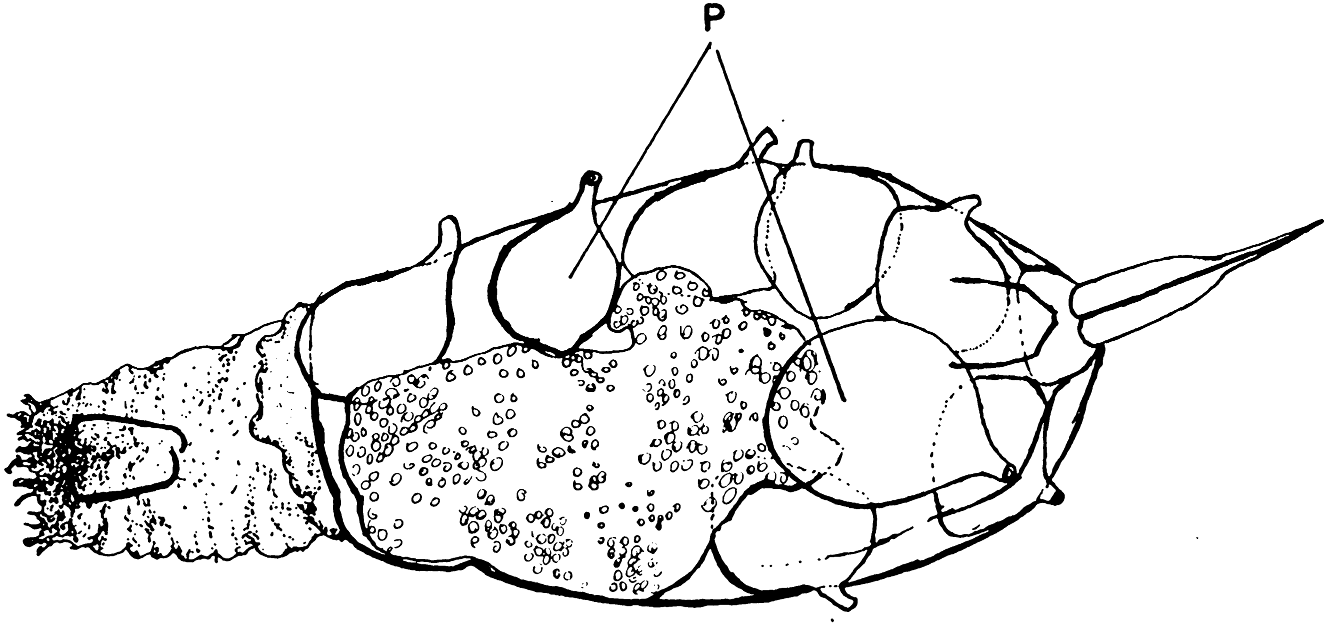

Figure 3. Lecane arietii n. sp. (extended) parasitized by fungi (P).

CHAPTER 3.

Cladocera from Mud and Vegetative Habitats in a Regulated River

INTRODUCTION

Previous thought on the importance of Cladocera in lotic systems is summarized well by Hynes (1970): "In great contrast to the condition in lakes crustaceans are always unimportant (in rivers) and the animals are represented mainly by rotifers." Hynes (1970) also states that Cladocera in rivers are generally considered to be strays from other bodies of water. However, when dams reduce the rate of flow as in an impoundment, crustacean numbers and importance increase. It has been demonstrated that Cladocera can be present in large quantities in the plankton of lotic systems. Kofoid (1908) showed this in the Illinois River, U.S.A. and Green, (1961) showed the same phenomenon in the Sokoto River, Nigeria. Many of the Cladocera present in these systems were characteristically from mud or mud and vegetative habitats. The system chosen for study, the Kanawha River, is a tributary of the Ohio River, and is regulated for navigation and flood control. The Kanawha, however, in no way resembles a reservoir due to exceedingly short retention times behind dams. The objectives of this study were to determine composition and abundance of Cladocera in the Kanawha River and to determine what locations (mud and vegetation or plankton) within the river these Cladocera inhabit.

METHODS

Cladocera were collected using funnel traps which consist of three 10 cm diameter glass funnels arrayed equidistant (19 cm) in a 30 by 32 cm sheet of plexiglass. The three funnels lead upward into 300 ml clear plastic bottles. Procedures for collection were similar to those of Whiteside and Williams (1975) except where noted. Two stations were sampled -- Marmet Locks and Dam, river mile 68, and Winfield Locks and Dam, mile 32, on the Kanawha River in West Virginia. Three sites were sampled at each station: the lock wall, midchannel, and nearshore. These were chosen because they were representative of somewhat different habitats. The lock wall was a large artificial substrate for periphyton. In midchannel the sediments were at a depth of 10 m, well below the photic zone. Near shore areas had allochthonous sticks and structures as well as mud providing substrate for periphyton. The portion of the Kanawha River sampled for this study was devoid of aquatic macrophytes; vegetation was exclusively periphyton. Funnel traps were suspended 1 m below surface (9 m above sediment-water interface) adjacent to the lock wall and in mid-channel.

Funnel traps were also suspended within 1 m of the sediment-water interface in nearshore areas. Because the samplers are most efficient when positioned in the evening and retrieved the next morning (Whiteside and Williams, 1975) funnel traps were put into position at 2100 hrs and retrieved at 0900 hrs. After retrieval, 5-10 ml ethanol was added to each bottle (Whiteside et al., 1978) in the field, and within 30 minutes an equal amount of formalin was added. Samples for this study were collected on five occasions at both pools: July 20-21, July 28, August 16, August 23-24, and September 15, 1983. Lock wall samples were collected on every occasion; midchannel samples were collected on all occasions but the first; shore samples were collected at one pool on all occasions but the first and fourth. Samples were returned to the laboratory and concentrated with 35 µm mesh plankton net and counted using a dissecting scope. Identifications were made using a compound microscope.

RESULTS

A total of 18 species of Cladocera were found in the Kanawha River (Table 1). Of these, 61% (designated by an asterisk and referenced in Table 1) are characteristically from mud or mud and vegetative habitats.

Because there were few aquatic macrophytes within the study area of our sampling sites, and since vegetation at these sites consisted of periphyton only, these species designated by an asterisk will hereafter be referred to as benthic.

Midchannel funnel trap collections showed a range from 0 to 2038 total Cladocera per m^2 and from 0 to 801 benthic Cladocera per m^2 at Winfield pool. Midchannel funnel trap collections showed a range from 0 to 7601 total Cladocera per m^2 and from 0 to 4714 benthic Cladocera per m^2 at Marmet pool (figure 1).

Lock wall funnel trap collections showed a range from 764 to 8110 total Cladocera per m^2 and from 467 to 2803 benthic Cladocera per m^2 at Winfield pool. Lock wall funnel trap collections showed a range from 637 to 7983 total Cladocera per m^2 and from 212 to 5605 benthic Cladocera per m^2 at Marmet pool (figure 2).

Shore funnel trap samples at Winfield pool showed a range from 0 to 8705 total Cladocera per m^2 and from 0 to 1953 benthic Cladocera. The shore funnel trap samples at Marmet pool showed a mean of 11762 (±6985) total Cladocera and a mean of 1996 (± 1516) benthic Cladocera (figure 3). Results of the midchannel vertical profile are given in figure 4.

Some funnel traps were found to have larval fish trapped in them. Stomach contents of these fish were analyzed and were found to contain Cladocera.

DISCUSSION

Lock wall samples had greater total numbers of Cladocera and greater numbers of benthic Cladocera than did the midchannel samples on the same night (with but one exception). This may be attributed to the cover and protection provided by the periphyton along lock walls. Dredge samples showed no periphyton occurred on the sediments at 10 m in midchannel. Periphyton not only provides refuge from predators and substrate on which to attach and filter, but also provides a place to avoid direct current. Midchannel Cladocera numbers may have been reduced due to normal stream flow. The additional possibility that midchannel cladoceran numbers may have been reduced by propeller jet currents from barge traffic cannot be excluded. Samples taken July 28, 1983 demonstrated the importance of current on these organisms. An increase in discharge from 76 m^3 $sec.^{-1}$ to 1501 m^3 $sec.^{-1}$ occured July 22, 1983 to July 24, 1983. Midchannel samples were completely devoid of Cladocera after the spate. Lock wall samples showed Cladocera present, although reduced in number. These cladoceran communities are thus apparently sensitive to current disturbances.

Shore funnel trap samples taken over allochthonous sticks showed total shore cladoceran concentrations greater than midchannel or lock wall samples. This was primarily due to the planktonic forms which comprised an average of 79% of the samples. Shore benthos areas were apparently a daytime refuge for planktonic Cladocera; it is highly unlikely that these forms were trapped while positioning the sampler (Whiteside and Lindegaard, 1980). Shore samples taken over exclusively mud habitats after a spate showed no Cladocera were present. These observations, along with observations that Cladocera were present in areas with periphyton, support the claim that periphyton aids Cladocera in maintaining their position in the river, in much the same manner as the macrophytes do in the Ocqueoc River System described by Beach (1960).

Ichthyoplankton caught in funnel traps were found to have Cladocera in their stomachs. It is not known whether these Cladocera were ingested before or after the fish entered the trap, nor is it known why a larval fish would enter a funnel trap (unless perhaps in pursuit of zooplankton). Because it is known that freshwater plantivorous fish actively seek and visually select zooplankton to ingest (Brooks, 1968; Vinyard and O'Brien, 1975; Zaret, 1980; Zaret and Kerfoot, 1975.), the importance of this zooplankton community thus becomes more apparent. When the total number of Cladocera (and the number of benthic Cladocera) was calculated for the area under a 1 m wide span of the river by extrapolating the densities per m^2 from shore, lock wall, and midchannel areas, it was found that 7.91×10^5 total Cladocera and 3.11×10^5 benthic Cladocera would be in this 1 m wide strip. According to a longitudinal depth profile of the river (Chapter 1), there are at least 10,000 meters of pool similiar in depth to the sites sampled. Cladocera may therefore be significant in terms of biomass as a prefered food item. These Cladoceran numbers are an underestimate. Funnel traps when in direct contact with vegetation have been shown by Whiteside and Williams (1975), to trap migrating chydorid Cladocera with 90 to 94% efficiency. Our funnel traps were not in direct contact with thesubstrate sampled and in addition, one of the species recovered, Ilyocryptus spinifer, does not normally leave the sediment unless it is dislodged. Benthic (and total) Cladocera numbers are thus underestimated by at least 6 to 10%, and most likely more.

SUMMARY AND CONCLUSIONS

Shore and lock wall areas have greater total numbers of Cladocera than midchannel areas, apparently due to cover afforded by periphyton on various substrates such as sticks and the lock wall. For the same reasons lock wall areas have greater numbers of benthic Cladocera than midchannel areas. Post-flood samples show that periphyton aids Cladocera in maintaining their position in the river.

Benthic Cladocera in a system like the Kanawha River are sensitive to current disturbances. Due to the tremendous velocity of water generated behind a tow boat propellor, benthic Cladocera may be useful organisms to study barge traffic perturbations.

Because cladocera are selected as food by fish larvae, cladoceran biomass is large enough to be of considerable ecological importance.

LITERATURE CITED

Beach, N. W. 1960. A study of the planktonic rotifers of the Ocqueoc River system. Presque Isle County, Michigan. *Ecol. Monogr.* 30(4):339-357.

Brooks, J. L. 1968. The effects of prey size selection by lake planktivores. *Syst. Zool.* 17:273-291.

Edmondson, W. T. ed. 1959. *Fresh Water Biology* 2nd edition. John Wiley and Sons, Inc. New York. 1248 pp.

Goulden, C. E. 1968. The systematics and evolution of the *Moinidae*. *Transactions of the American Philosophical Society*. 58(6):1-101.

Green, J. 1962. Zooplankton of the river Sokoto. The Crustacea. *Proc. Zool. Soc. Lond.* 136:415-453.

Hutchinson, G. E. 1967. *A. Treatise on Limnology, Vol. II. Introduction to Lake Biology and Limnoplankton.* John Wiley and Sons, Inc. New York. 1115 pp.

Kofoid, C. A. 1908. The plankton of the Illinois River, 1894-1899, with introductory notes upon the hydrography of the Illinois River and its basin. Part II. constituent organisms and their seasonal distribution. *Bull. Ill. Lab. Nat. Hist.* 8:1-361.

Vinyard, G. and W. O'Brien. 1975. Dorsal light response as an index of prey preference in Bluegill (*Lepomis macrochirus*) *J. Fish Res. Bd.*

Canada. 32: 1860-63.

Whiteside, M.C. 1974. Chydorid (Cladocera) Ecology: Seasonal patterns and abundance of populations in Elk Lake, Minnesota. *Ecology*: 55: 538-550.

________. and J.B. Williams. 1975. A new sampling technique for aquatic ecologists. *Verh. Internat. Verein. Limnol.* 19: 1534-1539.

________, ________, and C.P. White. Seasomal Abundance and pattern of chydorid Cladocera in mud and vegetative habitats. *Ecology* 59(6): 1177-1188.

Zaret, T. 1980. *Predation in Freshwater Communities*. Yale Univ. Edwards Brothers, Inc. 187 p.

________, and C. Kerfoot. 1975. Fish predation on *Bosmina longirostris*: Body size selection versus visibility selection. *Ecology* 56: 232-237.

Table 1. Species list of Cladocera found in the Kanawha River designating sampling sites where the species was found, and the relative frequency of occurange at the sites. Asterisk indicates species characteristic of mud or mud and vegetative habitats. Site: W = lock wall; M = midchannel; S = shore. Frequency: C = common; LC = less common; R = rare.

Taxa	Marmet			Winfield		
Bosminidae	W	M	S	W	M	S
Bosmina coregoni (Baird, 1857)	—	R	—	—	—	—
B. longirostris (O. F. Muller, 1785)	C	C	C	—	C	C
Bosminopsis deitersi (Richard, 1895)	C	C	C	C	C	—
Chydoridae						
*Alona guttata (Sars, 1862)	—	—	—	R	—	—
*A. intermedia (Sars, 1862)	—	—	—	LC	LC	—
*A. quadrangularis (O.F. Muller, 1785)	LC	R	—	LC	—	—
*A. rectangula (Sars, 1861)	C	—	—	C	C	—
*Chydorus sphaericus (O.F. Muller, 1785)	—	LC	—	LC	—	—
*Plueroxus uncinatus (Baird, 1850)	R	—	—	—	—	—
Daphnidae						
Ceriodaphnia sp.	—	LC	R	—	—	—
C. reticulata (Jurine, 1820)	—	—	—	—	LC	—
Daphnia sp.	—	—	—	—	LC	LC
Scapholeberis kingi (Sars, 1903)	LC	—	—	LC	—	—
*Simocephalus expinosus (Koch, 1841)						
Macrothricidae						
*Ilyocryptus spinifer (Herrick, 1884)	LC	—	—	—	LC	—
Moinidae						
*Moina affinis (Birge, 1893)	LC	LC	LC	C	C	C
*M. micrura (Kurz, 1874)	—	—	—	—	R	—
Sididae						
*Sida crystallina (O.F. Muller, 1785)	C	C	LC	C	C	LC

References (characteristic habitats):

Edmondson, W.T. 1959; Goulden, 1968; Hutchinson, 1967; Whiteside, 1974; Whiteside, *et al.*, 1978.

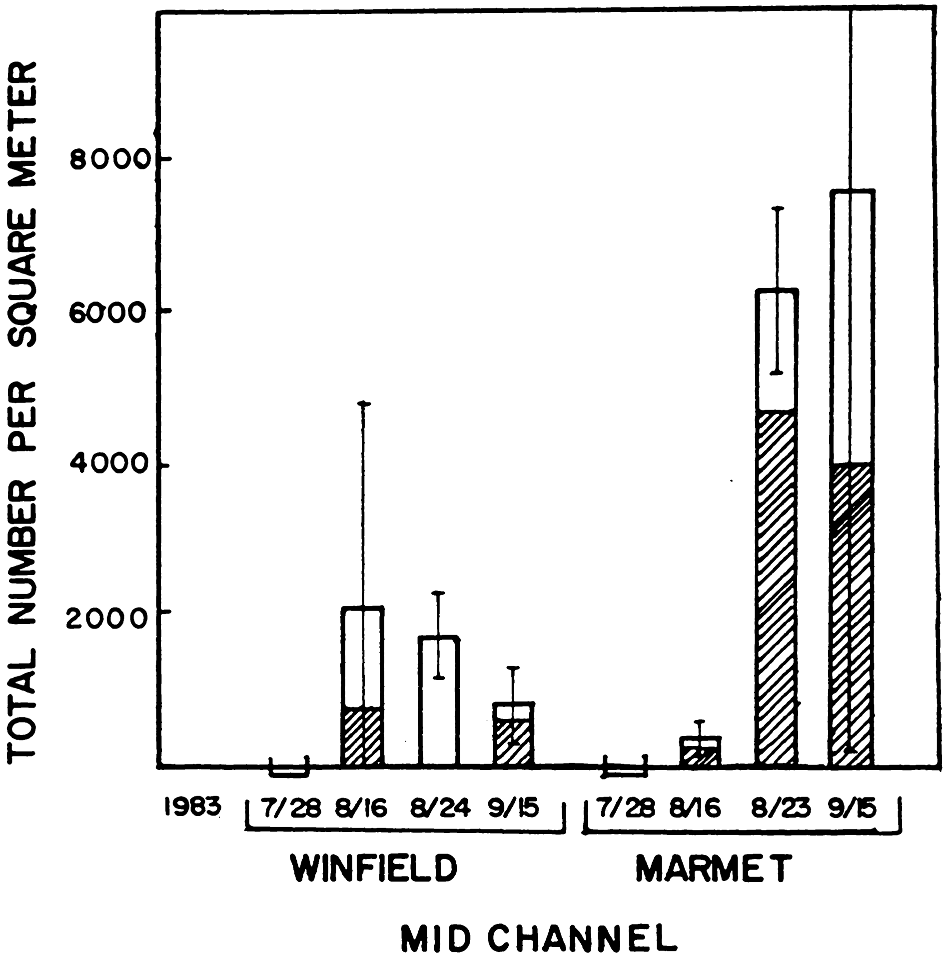

Figure 1. Mean numbers of Cladocera per square meter in midchannel areas of lower Marmet pool and lower Winfield pool. Hatched areas indicate the benthic portion of total Cladocera.

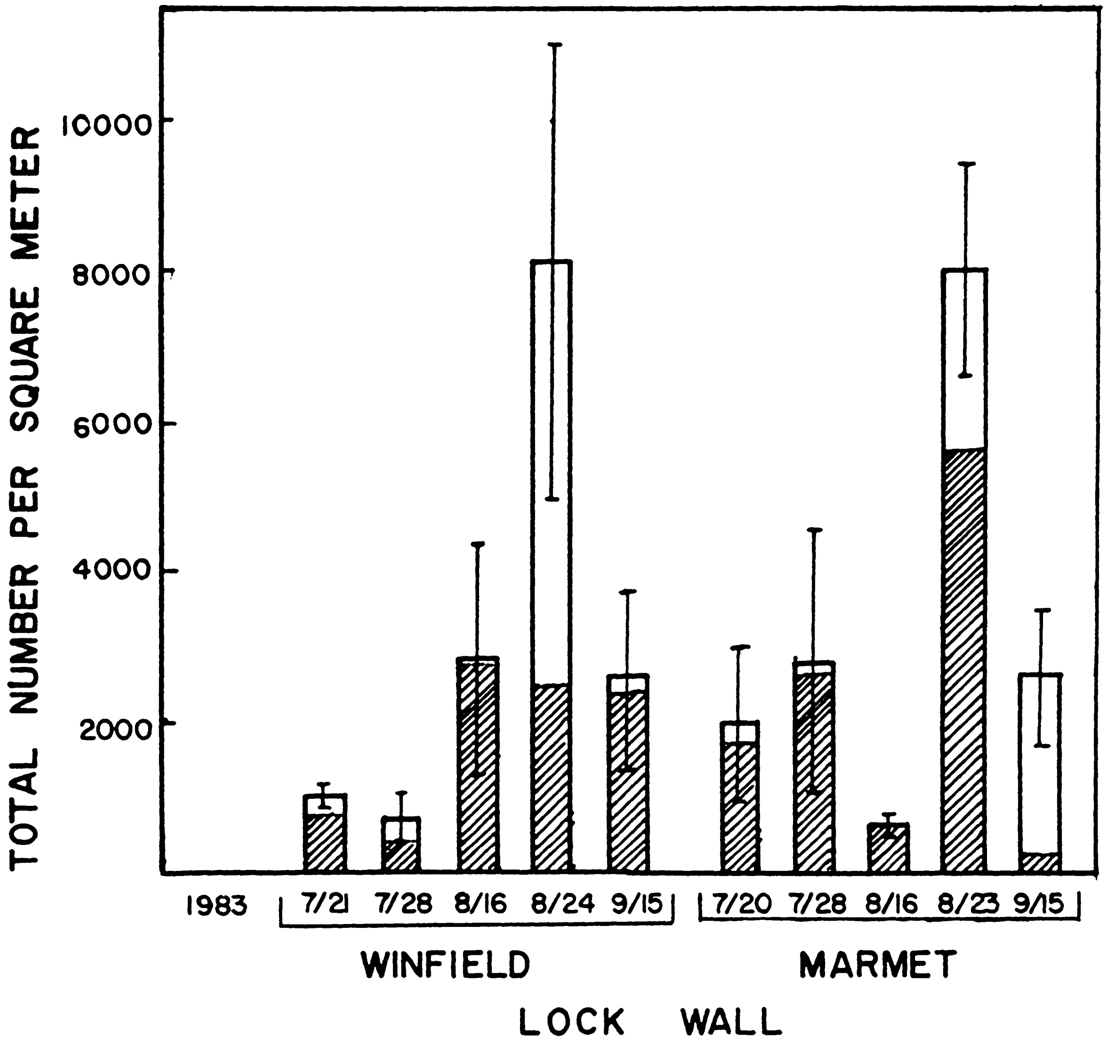

Figure 2. Mean numbers of Cladocera per square meter near lock walls at Marmet and Winfield Lock and Dams. Hatched areas indicate the benthic portion of total Cladocera.

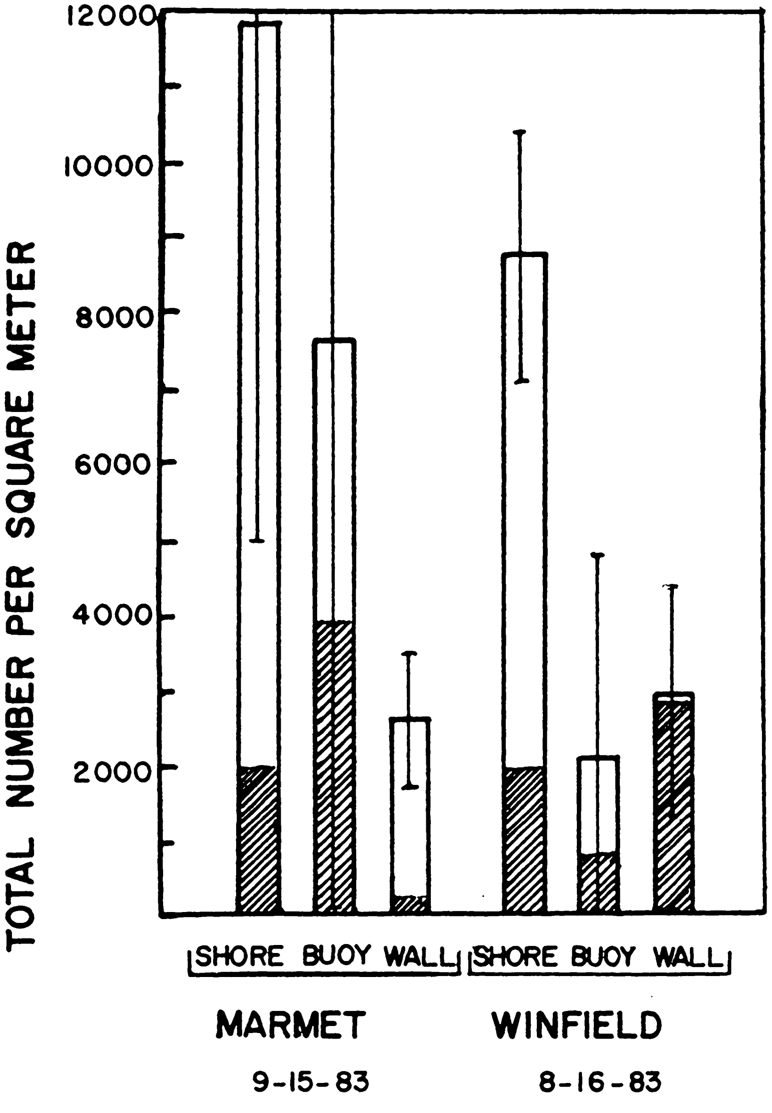

Figure 3. Mean numbers of Cladocera per square meter in near shore areas of lower Marmet and lower Winfield pools compared with mid-channel (bouy) and lock wall (wall) samples collected on the same night. Hatched areas indicate the benthic portion of total Cladocera.

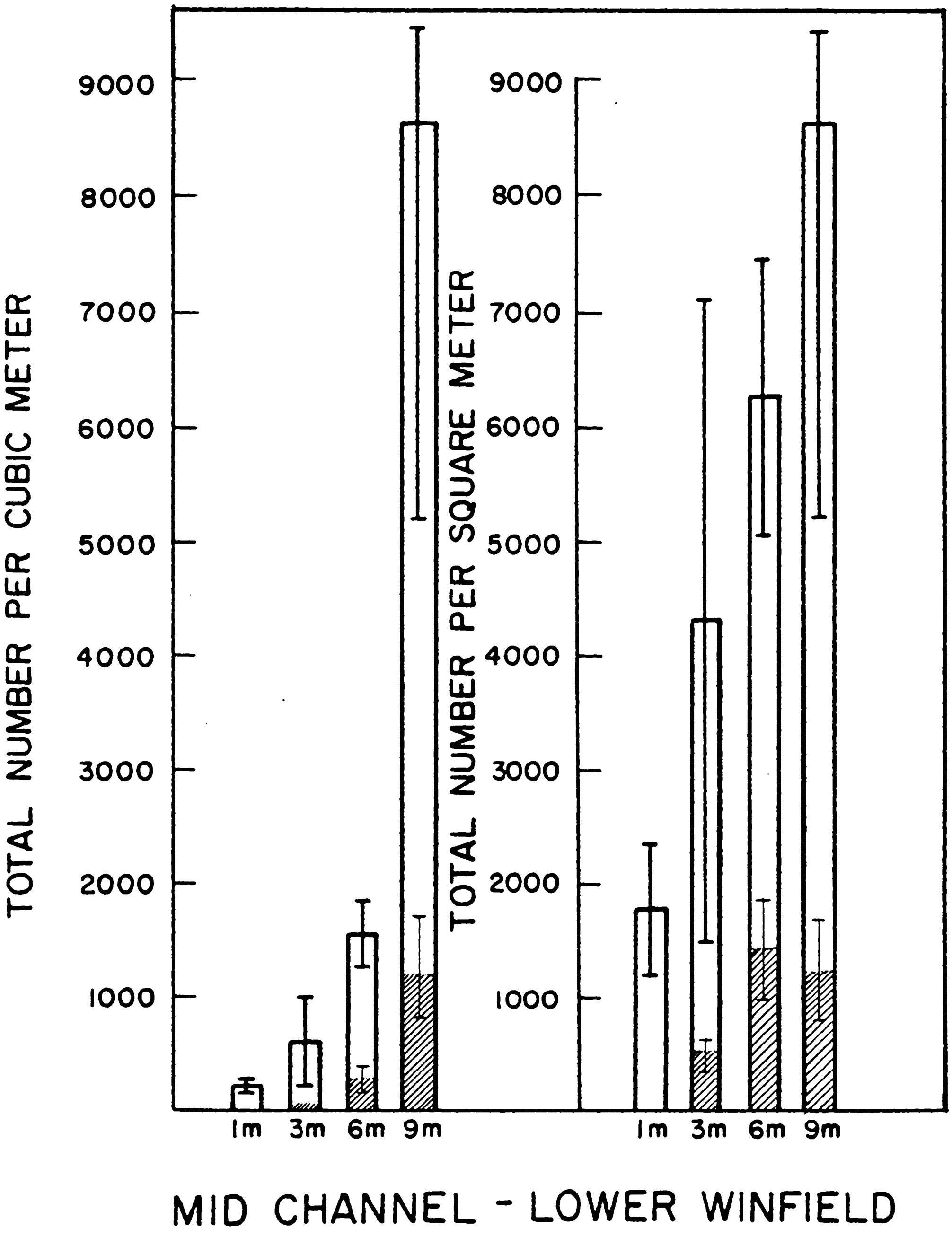

Figure 4. Mean numbers of Cladocera per cubic meter (left) and per square meter (right) in midchannel at lower Winfield pool. 1m, 3m, 6m, 9m indicate depths below surface at which funnel traps were suspended.

GENERAL SUMMARY

In Winfield pool and lower Marmet pool both Rotifera and Cladocera were important constituents of the microfauna. Rotifera comprised 76% of the plankton microfauna in spring, 94% in the summer, 79% in the fall, and 84% in the winter (sampling during the day and excluding the Protozoa). Rotifera were represented by a diverse group of species. A total of 54 species were recognized, one of which was previously undescribed. A species list is given in Appendix I. Monthly composition of plankton for the seasonal study is given in Appendix II. Cladocera constituted up to 5.6% of the microfauna during summer months when plankton abundances were at their highest point. A total of 18 species were recognized. A species list is given in Chapter 3, Table 1. During the summer Cladocera were present in mean quantities up to 11762 per m2 in near shore areas, up to 8110 per m2 in lock wall areas, and up to 4714 per m2 in midchannel areas. Because Cladocera are actively selected for by ichthyoplankton (Chapter 3), and were observed in larval fish gut contents, it appears that the cladoceran component of the microfauna is significant. It was observed that cladoceran populations were completely eliminated by increased current in areas where no periphyton was present, but Cladocera populations were not eliminated (although they were reduced) by increased current in areas with periphyton. When river currents are minimal (during the summer at low flow) these Cladocera maybe useful organisms to study perturbation caused by currents from towboat propeller jets.

There was a shift in species composition from lower Marmet pool and upper Winfield pool to lower Winfield pool. Species in lower Marmet pool and upper Winfield pool tended to be bacteriophageous and/or detritivorous, while those in lower Winfield tended to be herbivorous. Rotifer density correlated well with chl a from lower Winfield pool up to six river miles below Marmet Locks and Dam, but not beyond that point.

It was expected that rotifer density would increase in the vicinity of the dams due to more lentic conditions there. It was also expected that rotifer density would increase downstream with increased watershed. However, chl a concentration and hence herbivorous rotifer density increased near river mile 56 , apparently from municipal and/or industrial wastewater, overshadowing dam and downstream effects. Rotifers are good indicators of municipal and/or industrial wastewater perturbation (Chapter 1) and are thus important.

Rotifers, however, were not the only important zooplankton in this system. Species of Cladocera were found in the Kanawha River which are known to inhabit mud and vegetative habitats in other systems (Chapter 3), and were apparently inhabiting the the same narrow niche in the Kanawha River. These cladocerans could be useful organisms to study towboat perturbation. This study has shown that Cladocera biomass is large enough in this type of river system to be of great ecological and trophic significance.

TAXONOMIC REFERENCES

Ahlstrom, E. 1938. Plankton Rotatoria from North Carolina. J. Elisha Mitchell Soc. 54: 88-110.

__________. 1940. A. revision of the rotatorian genera Brachionus and Platyias with descriptions of one new species and two new varieties. Bull. Am. Mus. Nat. Hist. 77: 143-184.

__________. 1983. A revision of the genus Keratella with descriptions of three new species and five new varieties. Bull. Am. Mus. Nat. Hist. 80: 411-457.

Bartos, E. 1948. On the Bohemian species of the genus Pedalia, Barrois. Hydrobiologia 1: 63-77.

_________. 1959. Virnici-Rotatoria. Fauna CSR 15: 1-965.

Berzins, B. 1951. On the Collotheceacean Rotatoria. Ark. Zool. Ser. 2 1(37): 565-592.

Chengalath, R. Rotifers of Canada. unpublished. 171 pp.

__________, and C. Fernando. 1973. The planktonic Rotifera of Ontario with records of distributionn and notes on some morphological variation. Canadian Field Naturalist. 87: 267-277.

__________, ____________, and M. George. 1971. Planktonic Rotifera of Ontario. Univ. of Waterloo Biol. Ser. (2) 1-40.

Edmondson, W.T. ed. 1959. Freshwater Biology 2nd ed. New York, John Wiley & Sons, Inc. 248 pp.

Harring, H.K. 1916. A revision of the rotatorian genera Lepadella and Lophocharis with descriptions of five new species. Proc. U.S. Nat. Museum 51: 527-568.

________. 1926. The rotifer fauna of Wisconsin III. A revision of the genus Lecane and Monostyla. Trans. Wisconsin Acad. Sci., Arts, Lett. 22: 315-423.

Jennings, H. S. 1903. Rotatoria of the United States, II. A monograph of the Rattulidae. Bull. U.S. Fish Comm. (1902) 22: 273-352.

Rousselet, C.F. 1902. The genus Synchaeta: a monographic study with descriptions of five new species. J. Roy. Micro. Soc. 1902: 269-290
393-411.

Ruttner-Kolisko, A. 1974. Plankton rotifers: biology and taxonomy. Die Binnengewasser 26(1), Suppl. 146 pp.

Stemberger, R. 1979. A guide of Rotifers of the Laurentian Great Lakes. Environmental Monitoring and Support Lab. Office of R & D. U.S. EPA, Cincinnati, OH. EPA - 600/4-79-021.

Voigt, M. 1957. Rotatoria. Die Radertiere Mitteleuropas. 2 Vols. Borntraeger, Berlin. 508 pp.

Wulfert, K. 1936. Beitrage zur Kenntnis der Radertierfauna Deutschlands III. Arch. Hydrobiol. 31: 592-635.

________. 1939. Beitrage zur Kenntnis der Radertierfauna Deutschlands IV. Arch. Hydrobiol. 35: 563-624.

________. 1956. Die Radertier des Teufelssees bei Friedrichshagen. Arch. Hydrobiol. 51: 457-495.

APPENDIX I

SPECIES LIST: ROTIFERA

Class Bdelloidea (Digononta)
Order Bdelloida
- Family Philodinidae
  - *Philodina* sp.
  - *P. tranquilla* (Wulfert, 1942)

Class Monogononta
Order Collthecaceae
- Family Collothecidae
  - *Collotheca mutabilis* (Hudson, 1885)
  - *C. pelagica* (Rousselet, 1893)

Order Flosculariaceae
- Family Conochilidae
  - *Conochiloides dossuarius* (Hudson, 1885)
  - *C. unicornis* (Rousselet, 1892)
- Family Hexarthridae
  - *Hexarthra mira* (Hudson, 1871)
- Family Testudinellidae
  - *Filinia longiseta* (Ehrbg., 1834)
  - *F. terminalis* (Plate, 1886)

Order Ploima
- Family Asplanchnidae
  - *Asplanchna priodonta* (Gosse, 1850)
  - *A. sieboldi* (Leydig, 1854)
- Family Brachionidae
  - Subfamily Brachionidae
    - *Brachionus angularis* (Gosse, 1851)
    - *B. bidentata* (Anderson, 1899)
    - *B. budapestinensis* (Daday, 1894)
    - *B. calyciflorus* (Palas, 1766)
    - *B. caudatus* (Barrois and Daday, 1894)
    - *B. caudatus* var. *personatus* (Ahlstrom, 1940)
    - *B. havanaensis* (Rousselet, 1911)
    - *B. quadridentatus* (Hermann, 1783)
    - *B. rubens* (Ehrbg., 1838)
    - *Euchlanis* sp.
    - *E. alata* (Voronkov, 1911)
    - *Kellicottia bostoniensis* (Rousselet, 1908)

Keratella americana (Carlin, 1943)
K. cochlearis cochlearis (Gosse, 1851)
K. cochlearis f. tecta (Gosse, 1851)
K. earlinae (Ahlstrom, 1943)
K. valga (Ehrbg., 1834)
Notholca sp.
Platyias patulus (Muller, 1786)
Subfamily Colurinae
Colurella gastrocantha (Hauer, 1924)
Lepadella sp.
L. ovalis (Muller, 1786)
L. patella (Muller, 1773)
Family Dicranophoridae
Dicranophorus sp.
Family Lecanidae
Lecane arietii n. sp.
L. flexilis (Gosse, 1886)
Monostyla sp.
M. bulla (Gosse, 1886)
M. copeis (Harring and Myers, 1926)
M. lunaris (Ehrbg., 1832)
Family Notommatidae
Cephalodella gibba (Ehrbg., 1832)
C. minera (Myers, 1926)
Family Synchaetidae
Ploesoma truncatum (Levander, 1894)
Polyarthra dolichoptera (Idelson, 1925)
P. major (Burckhardt, 1900)
P. remata (Skorikov, 1896)
P. vulgaris (Carlin, 1943)
Synchaeta sp.
S. stylata (Wierzejski, 1893)
Family Trichocercidae
Trichocerca agnata (Wulfert, 1939)
T. cylindrica (Imhof, 1891)
T. similis (Wierzejski, 1893)

APPENDIX II

OCTOBER

Species list of zooplankton with mean number of individuals per liter given for top and bottom samples.

Lower Winfield pool. October 18, 1982.

Taxa	Top (1m)	Bottom (9m)
Rotifera		
Keratella cochlearis cochlearis	16	21
Lecane arietii n. sp.	0	1
Lepadella sp.	4	1
Polyarthra major	0	3
Synchaeta sp.	2	0
S. stylata	4	1
Cladocera		
Ilyocryptus spinifer	2	0
Copepoda		
nauplii	4	0

Upper Winfield pool. October 19, 1982.

Taxa	Top (1m)	Bottom (3m)
Cladocera		
Alona quadrangularis	0	1
Bosmina coregoni	1	0

APPENDIX II (cont.)

NOVEMBER

Species list of zooplankton with mean number of individuals per liter given for top and bottom samples.

Lower Winfield pool. November 18, 1982.

Taxa	Top (1m)	Bottom (8m)
Rotifera		
Keratella cochlearis cochlearis	1	5
Lecane arietii n. sp.	0	1
Monostyla lunaris	0	1
Philodina sp.	1	15
Trichocerca agnata	0	3

Upper Winfield pool. November 19, 1982

Taxa	Top (1m)	Bottom (3.5m)
Rotifera		
Cephalodella sp.	1	1
Keratella cochlearis cochlearis	6	0
Philodina sp.	0	1

APPENDIX II (cont.)

DECEMBER

Species list of zooplankton with mean number of individuals per liter given for top and bottom samples.

Lower Winfield pool. December 16, 1982.

Taxa	Top (1m)	Bottom (9m)
Rotifera		
Keratella cochlearis cochlearis	0	1
Lecane arietii n. sp.	0	1
Lepadella sp.	1	1
Notholca sp.	1	0
Philodina sp.	0	1
Synchaeta stylata	1	0

Upper Winfield pool. December 17, 1982.

Taxa	Top (1m)	Bottom (5m)
Rotifera		
Cephalodella sp.	5	0
Lecane arietii n. sp.	9	9
Lepadella sp.	5	0
Notholca sp.	0	5
Ostracoda	0	5

APPENDIX II (cont.)

JANUARY

Species list of zooplankton with mean number of individuals per liter given for top and bottom samples.

Lower Winfield pool. January 20, 1983.

Taxa	Top (1m)	Bottom (10m)
Rotifera		
Keratella cochlearis cochlearis	1	0
Philodina sp.	1	0
Synchaeta stylata	1	0

Upper Winfield pool. January 21, 1983.

Taxa	Top (1m)	Bottom (2m)
Rotifera		
Dicranophorus sp.	2	0
Monostyla sp.	0	2
Notholca sp.	3	0
Philodina sp.	0	5

APPENDIX II (cont.)

FEBRUARY

Species list of zooplankton with mean number of individuals per liter given for top and bottom samples.

Lower Winfield pool. February 17, 1983.

Taxa	Top (1m)	Bottom (9m)
Rotifera		
Euchlanis alata	2	0
Keratella cochlearis cochlearis	2	0
Philodina sp.	0	10
Polyarthra vulgaris	0	4
Synchaeta stylata	2	0
Nemata	3	2
Tardigrada	2	0

Upper Winfield pool. February 18, 1983

Taxa	Top (1m)	Bottom (4m)
Rotifera		
Asplanchna sp.	0	2
Dicranophorus sp.	7	0
Keratella cochlearis cochlearis	4	6
Lepadella sp.	4	2
Notholca sp.	0	2
Philodina sp.	4	0
Copepoda		
nauplii	2	2

APPENDIX II (cont.)

MARCH

Species list of zooplankton with mean number of individuals per liter given for top and bottom samples.

Lower Winfield pool. March 24, 1983.

Taxa	Top (1m)	Bottom (9m)
Rotifera		
Cephalodella sp.	0	3
C. gibba	0	1
Euchlanis sp.	10	0
E. alata	0	1
Keratella cochlearis cochlearis	6	7
Lepadella sp.	0	3
Tardigrada	0	4
Nemata	2	7

Upper Winfield pool. March 25, 1983.

Taxa	Top (1m)	Bottom (4m)
Rotifera		
Asplanchna sp.	1	0
Cephalodella gibba	8	3
Colurella gastrocantha	0	4
Keratella cochlearis cochlearis	3	2
K. earinae	0	1
Lepadella sp.	13	0
Philodina sp.	1	0
Nemata	6	3
Tardigrada	1	1

APPENDIX II (cont.)

APRIL

Species list of zooplankton with mean numbers of individuals per liter given for top and bottom samples.

Lower Winfield pool. April 21, 1983.

Taxa	Top (1m)	Bottom (9m)
Rotifera		
Cephalodella gibba	2	0
Colurella gastrocantha	1	1
Lecane arietii n. sp.	1	0
Philodina sp.	1	5
Polyarthra remata	0	1
Nemata	2	3
Tardigrada	1	0

Upper Winfield pool. April 22, 1983.

Taxa	Top (1m)	Bottom (9m)
Rotifera		
Cephalodella sp.	0	1
Colurella gastrocantha	0	3
Lepadella sp.	0	1
L. ovalis	1	0
Monostyla lunaris	0	1
Philodina sp.	4	7
Synchaeta sp.	0	2
S. stylata	1	0
Copepoda		
Harpacticoida	0	1
Nemata	1	3
Tardigrada	0	1

APPENDIX II (cont.)

MAY

Species list of zooplankton with mean numbers of individuals per liter given for top and bottom samples.

Lower Winfield pool. May 20, 1983.

Taxa	Top (1m)	Bottom (9m)
Rotifera		
Cephalodella gibba	0	5
Colurella gastrocantha	4	3
Euchlanis alata	1	0
Keratella cochlearis cochlearis	1	1
Lecane arietii n. sp.	1	1
Philodina sp.	0	10
Copepoda		
Cyclopoida	1	0
Nemata	6	8

Upper Winfield pool. May 19, 1983.

Taxa	Top (1m)	Bottom (3m)
Rotifera		
Cephalodella gibba	3	3
C. mineri	3	6
Colurella gastrocantha	5	7
Keratella cochlearis cochlearis	2	3
Lepadella ovalis	1	0
L. patella	1	0
Philodina sp.	4	3
Polyarthra remata	1	2
Synchaeta stylata	0	1
Nemata	8	7
Tardigrada	0	1

APPENDIX II (cont.)

JUNE

Species list of zooplankton with mean numbers of individuals per liter given for top and bottom samples.

Lower Winfield pool. June 23, 1983.

Taxa	Top (1m)	Bottom (8m)
Rotifera		
Brachionus calyciflorus	0	1
B. rubens	2	0
Cephalodella gibba	2	0
Colurella gastrocantha	0	1
Hexarthra mira	4	0
Lecane arietii n. sp.	0	1
Monostyla lunaris	4	0
Philodina sp.	0	2
P. tranquila	2	1
Ploesoma truncatum	2	0
Polyarthra remata	10	5
Synchaeta stylata	8	2
Trichocerca agnata	18	2
Copepoda		
nauplii	0	1
Nemata	2	0

Upper Winfield pool. June 22, 1983.

Taxa	Top (1m)	Bottom (3m)
Rotifera		
Cephalodella sp.	0	1
Keratella cochlearis cochlearis	3	0
Lecane arietii n. sp.	0	25
Philodina sp.	0	3
Synchaeta stylata	2	0
Nemata		

APPENDIX II (cont.)

JULY

Species list of zooplankton with mean numbers of individuals per liter given for top and bottom samples.

Lower Winfield pool. July 21, 1983.

Taxa	Top (1m)	Bottom (9m)
Rotifera		
Asplanchna sp.	13	4
Brachionus budapestinensis	15	17
B. calyciflorus	284	153
B. caudatus	111	43
B. rubens	99	35
Cephalodella gibba	1	1
Colotheca pelagica	39	49
Euchlanis alata	0	1
Filinia longiseta	1	1
Hexarthra mira	4	1
Keratella cochlearis cochlearis	5	33
Philodina sp.	5	12
Platyias patula	85	40
Ploesoma truncatum	111	3
Polyarthra dolichoptera	0	7
P. major	75	20
P. remata	1091	408
P. vulgaris	2	3
Synchaeta stylata	737	216
Trichocerca agnata	768	388
T. similis	15	15
Cladocera		
Alona rectangularis	0	1
Moina micrura	6	4
Sida crystalina	3	0
Copepoda		
copepodid	0	3
Cyclopoida	0	4

APPENDIX II (cont.)

JULY

Species list of zooplankton with mean numbers of individuals per liter given for top and bottom samples.

Upper Winfield pool. July 20, 1983.

Taxa	Top (1m)	Bottom (3m)
Rotifera		
Asplanchna sp.	1	1
Brachionus calyciflorus	8	4
B. caudatus	7	3
Colotheca pelagica	9	0
Colurella gastrocantha	0	3
Hexarthra mira	81	148
Keratella cochlearis cochlearis	7	11
Lecane flexilis	1	0
Monostyla lunaris	0	1
Philodina sp.	3	17
Platyias patula	1	7
Ploesoma truncatum	33	13
Polyarthra dolichoptera	9	0
P. major	13	15
P. remata	233	291
Synchaeta stylata	769	968
Trichocerca agnata	185	187
Cladocera		
Sida crystalina	1	3
Nemata	0	1

APPENDIX II (cont.)

AUGUST

Species list of zooplankton with mean numbers of individuals per liter given for top and bottom samples.

Lower Winfield pool. August 25, 1983.

Taxa	Top (1m)	Bottom (9m)
Rotifera		
Asplanchna priodonta	83	0
A. sieboldi	0	17
Brachionus budapestinensis	65	23
B. calyciflorus	1	1
Collotheca pelagica	5	1
Filinia terminalis	3	5
Keratella cochlearis cochlearis	8	13
Lecane arietii n. sp.	16	0
Polyarthra major	22	0
P. remata	267	84
P. vulgaris	50	11
Synchaeta stylata	5	2
Trichocerca agnata	67	20
Cladocera		
Bosmina longirostris	3	0
Bosminopsis deitersi	17	3
Daphnia sp.	0	2
Moina affinis	21	8
Sida crystalina	2	3

APPENDIX II (cont.)

AUGUST

Species list of zooplankton with mean numbers of individuals per liter given for top and bottom samples.

Upper Winfield pool. August 24, 1983.

Taxa	Top (1m)	Bottom (3m)
Rotifera		
Asplanchna sieboldi	0	1
Brachionus urceolaris	38	13
Collotheca pelagica	1	1
Filinia terminalis	5	6
Hexarthra mira	3	4
Keratella cochlearis cochlearis	3	1
K. cochlearis f. *tecta*	0	2
Ploesoma truncatum	1	1
Polyarthra major	1	2
P. remata	172	137
P. vulgaris	24	19
Synchaeta stylata	784	662
Trichocerca agnata	87	75
T. similis	1	0
Cladocera		
Bosminopsis deitersi	18	16
Sida crystalina	7	7

APPENDIX II (cont.)

SEPTEMBER

Species list of zooplankton with mean number of individuals per liter given for top and bottom samples.

Lower Winfield pool. September 15, 1983.

Taxa	Top (1m)	Bottom (10m)
Rotifera		
Asplanchna sieboldi	10	11
Brachionus calyciflorus	4	0
B. caudatus	2	1
B. caudatus var. *personatus*	1	0
B. quadridentatus	6	15
Colletheca pelagica	14	15
Filinia terminalis	0	1
Hexarthra mira	1	1
Keratella cochlearis cochlearis	0	1
Lecane arietii n. sp.	0	1
Ploesoma truncatum	3	1
Polyarthra vulgaris	76	46
Synchaeta stylata	7	4
Trichocerca cylindrica	51	17
Cladocera		
Bosmina longirostris	0	1
Bosminopsis deitersi	30	11
Daphnia sp.	1	1
Moina affinis	15	0
Sida crystalina	1	0
Copepoda		
nauplii	6	15
copepodid	0	3
Cyclopoida	0	1

APPENDIX (cont.)

SEPTEMBER

Species list of zooplankton with mean number of individuals per liter give for top and bottom samples.

Upper Winfield pool. September 14, 1983.

Taxa	Top (1m)	Bottom (3m)
Rotifera		
Brachionus calyciflorus	0	1
B. quadridentatus	4	4
Cephalodella gibba	0	2
Collotheca pelagica	4	2
Conochiloides dossuarius	3	1
Hexarthra mira	3	0
Keratella cochlearis cochlearis	2	0
Lecane arietii n. sp.	3	0
Platyias patula	0	1
Polyarthra vulgaris	49	47
Synchaeta stylata	18	20
Trichocerca agnata	8	8
Cladocera		
Bosminopsis deitersi	2	1
Moina affinis	1	1
Sida crystalina	0	1
Copepoda		
pauplii	0	1
copepodid	1	2

The two page vita has been removed from the scanned document. Page 1 of 2

The two page vita has been removed from the scanned document. Page 2 of 2