Community development and seasonal succession of aquatic macroinvertebrates in the Canyon Ferry Wildlife Management Area ponds

by Daniel Lee McGuire

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Biological Sciences
Montana State University

Abstract:
Macroinvertebrates constitute a major energy pathway between trophic levels in aquatic and riparian ecosystems. They are especially important to waterfowl, providing essential protein and influencing the selection of breeding sites and survival of young. Knowledge of macroinvertebrate abundance and the factors which regulate it are, therefore, of considerable importance in waterfowl management.

The Canyon Ferry ponds provided an unusual opportunity to study the development and factors regulating macroinvertebrate communities. Between June 1979 and August 1980, organisms on plants and in the water column were sampled at 14 locations with a sweepnet and benthic organisms were obtained with an Ekman dredge at 21 sites in the four ponds.

Despite many similar environmental factors, the density and composition of macroinvertebrates were significantly different among ponds. The mean density of benthic macroinvertebrates was 5,438, 3,195, 9,794 and 2,512 per square meter and the mean density of organisms in sweepnet samples was 77.5, 36.3, 99.8 and 17.2 in Ponds 1 through 4, respectively. Diversity exhibited a similar pattern and the dominant taxa varied among ponds. The observed disparities were attributed, primarily, to differences in water clarity, amount of submerged vegetation and extent of water level fluctuation. The high density and diversity of macroinvertebrates in Pond 3 was associated with profuse stands of vegetation while the high turbidity of Pond 4 resulted in an impoverished flora and fauna. Relatively clear water in Pond 1 had a positive effect on macroinvertebrate populations; however, extensive water level fluctuations in Ponds 1 and 2 were detrimental to macroinvertebrates.

The macroinvertebrate community consisted of four assemblages of organisms. Benthic organisms formed two groups. Tubificids dominated at deeper, more turbid stations while chironomids were dominant in shallow areas. Chironomids and oligochaetes comprised 98% of the benthic fauna and were predominant on plants while corixids were the most abundant nekton. The abundance of each community was highest during the summer and lowest in the spring. Overwintering populations were adversely affected by reduced water levels. Maintaining higher water levels until the ponds freeze would increase winter survival and result in larger macroinvertebrate populations available for consumption by waterfowl during the spring.

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Daniel Lee McGuire

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

Macroinvertebrates constitute a major energy pathway between trophic levels in aquatic and riparian ecosystems. They are especially important to waterfowl, providing essential protein and influencing the selection of breeding sites and survival of young. Knowledge of macroinvertebrate abundance and the factors which regulate it are, therefore, of considerable importance in waterfowl management.

The Canyon Ferry ponds provided an unusual opportunity to study the development and factors regulating macroinvertebrate communities. Between June 1979 and August 1980, organisms on plants and in the water column were sampled at 14 locations with a sweepnet and benthic organisms were obtained with an Ekman dredge at 21 sites in the four ponds.

Despite many similar environmental factors, the density and composition of macroinvertebrates were significantly different among ponds. The mean density of benthic macroinvertebrates was 5,438, 3,195, 9,794 and 2,512 per square meter and the mean density of organisms in sweepnet samples was 77.5, 36.3, 99.8 and 17.2 in Ponds 1 through 4, respectively. Diversity exhibited a similar pattern and the dominant taxa varied among ponds. The observed disparities were attributed, primarily, to differences in water clarity, amount of submerged vegetation and extent of water level fluctuation. The high density and diversity of macroinvertebrates in Pond 3 was associated with profuse stands of vegetation while the high turbidity of Pond 4 resulted in an impoverished flora and fauna. Relatively clear water in Pond 1 had a positive effect on macroinvertebrate populations; however, extensive water level fluctuations in Ponds 1 and 2 were detrimental to macroinvertebrates.

The macroinvertebrate community consisted of four assemblages of organisms. Benthic organisms formed two groups. Tubificids dominated at deeper, more turbid stations while chironomids were dominant in shallow areas. Chironomids and oligochaetes comprised 98% of the benthic fauna and were predominant on plants while corixids were the most abundant nekton. The abundance of each community was highest during the summer and lowest in the spring. Overwintering populations were adversely affected by reduced water levels. Maintaining higher water levels until the ponds freeze would increase winter survival and result in larger macroinvertebrate populations available for consumption by waterfowl during the spring.

INTRODUCTION

In recent years the loss of aquatic and wetland habitat has become a paramount concern in wildlife management. The construction of ponds has been important in mitigating the impacts of agricultural and domestic encroachment on aquatic habitats. This is particularly true in arid regions, where the creation of lakes and ponds may greatly increase the carrying capacity of land managed for wildlife enhancement. Waterfowl obviously benefit, and the management of many newly constructed ponds is directed toward increasing duck and goose production.

The use of recently created ponds as breeding sites by waterfowl, however, has not always been successful (Street 1977). Aquatic invertebrates are an important and perhaps essential protein source for nesting waterfowl and non-fledged ducklings (Swanson and Serie 1979). Eriksson (1978) and Street (1978) found correlations between aquatic macroinvertebrate abundance and lake selection by breeding ducks along with the survival of ducklings. Numerous researchers have reported that chironomids are a preferred food item of ducks, and Danell and Sjoberg (1977) attributed the success of dabbling ducks on new impoundments in Sweden to high densities of Chironomidae. Knowledge of macroinvertebrate production levels in ponds is, therefore, of considerable value in waterfowl management.

Although the development of macroinvertebrate communities in newly formed water bodies has received attention due to the rapid proliferation of man-made impoundments, few published studies pertaining to small impoundments are available from the United States. A notable exception is an analysis by Burris (1952) of the bottom fauna in a 0.4 hectare (ha) pond in Oklahoma during the first year of inundation. Most investigations have focused on river reservoirs; either large tropical impoundments (Petr 1971; MacLachlan 1970) or mountain reservoirs (Nursall 1952; Patterson and Fernando 1969a; Aggus 1971). The most thorough studies of small lowland impoundments have been in Europe (Grimas 1961; Armitage 1977). Much of the information provided by these studies appears applicable to water bodies less than 300 ha in area.

Numerous factors regulate the development of macroinvertebrate faunas in new impoundments; however, substrate instability and fluctuating water levels are frequently considered the most important environmental variables (Paterson and Fernando 1969b; Benson and Hudson

1975; McAfee 1980). Chironomids are inevitably among the first and most abundant macroinvertebrates to colonize new water bodies. The predominance of Chironomidae in man-made impoundments has been attributed to their ability to exploit the unstable environments typical of these water bodies (Paterson and Fernando 1969b). Although chironomids are more resilient to water level fluctuations than most other varieties of macroinvertebrates, their abundance is greatly effected by the duration and timing of drawdowns (Kaster and Jacobi 1978).

The Canyon Ferry Wildlife Management Area ponds provided a unique opportunity to study developing macroinvertebrate communities and the factors regulating their composition and abundance. The four ponds, which are managed primarily as nesting and rearing areas for Canada geese (Branta canadensis), have numerous physical and chemical similarities. Thus, many of the interacting environmental factors affecting macroinvertebrate populations are consistent between the ponds. The parameters which do vary significantly between ponds, extent of water level fluctuation, amount of aquatic vegetation and water clarity, can therefore be more easily evaluated.

DESCRIPTION OF STUDY AREA

The Canyon Ferry Wildlife Management Area is located at the upper end of Canyon Ferry Reservoir near Townsend in southwestern Montana. As part of the Canyon Ferry Conservation and Wildlife Enhancement Project, the Bureau of Reclamation constructed a series of dikes on the seasonally exposed mud flats where the Missouri River enters the reservoir. The dikes enclosed approximately 800 ha of the exposed area and created four ponds ranging from 150 to 250 ha in size. Ponds 1, 2 and 3 are located on the eastern shore of the reservoir while Pond 4 is on the western side (Figure 1). Construction of the dikes and supply canals began in 1972. The westside dike (Pond 4) was completed in 1973 while the dikes forming Ponds 1, 2 and 3 were finished in 1977, 1976 and 1974, respectively. Construction of 350 dredge islands within the ponds continued until 1978.

Owing to their proximity, similar dimensions and common water source, the ponds exhibited a number of physical and chemical similarities. The maximum depth in each pond was slightly more than three meters (m); however, only 30 to 40% of the area within each pond exceeded 1 m in depth. When the ponds were full, mean depths were

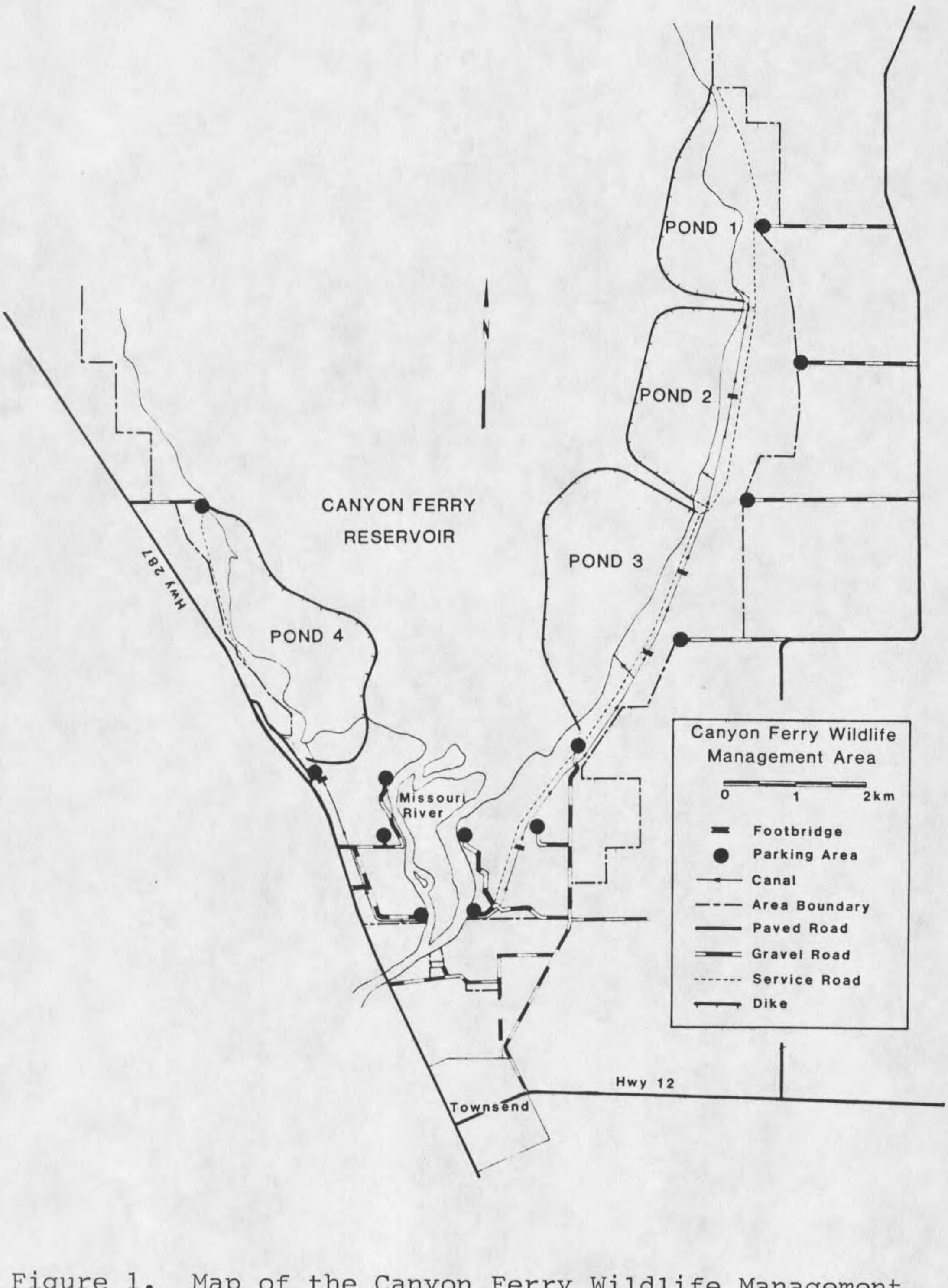

Figure 1. Map of the Canyon Ferry Wildlife Management Area showing the locations of the study ponds.

approximately 1 m. Extensive water level fluctuations (Table 1) alternately inundated and exposed large portions of the ponds.

Table 1. Water depth (meters) at the deepest station in each of the Canyon Ferry ponds from March 1979 to August 1980.

DATE	POND 1	POND 2	POND 3	POND 4
3/29/79	0.0	0.0	0.4	0.7
4/28/79	0.0	0.2	1.8	2.4
5/21/79	0.1	1.0	2.8	2.2
6/26/79	2.4	2.2	3.2	2.6
7/26/79	3.1	2.8	3.0	2.5
8/22/79	2.0	2.5	2.7	1.7
9/23/79	1.8	1.9	2.5	1.4
10/26/79	0.8	1.2	2.0	1.3
11/12/79	0.2	0.6	1.8	1.1
3/11/80	0.0	0.0	1.7	1.1
4/18/80	0.0	0.4	2.6	2.4
5/15/80	2.4	0.8	2.6	2.8
6/16/80	2.8	3.2	3.1	3.0
7/13/80	2.0	2.6	2.7	2.2
8/27/80	2.2	2.4	2.6	2.0

In 1979, Ponds 3 and 4 began filling in April, Pond 2 in May and Pond 1 in June. Maximum water levels occurred during July in response to high water levels in Canyon Ferry Reservoir. Beginning in August and continuing until ice formation in November, water levels declined sharply. During the winter Ponds 1 and 2 were dry while small portions of Ponds 3 and 4 remained inundated. During

1980, the ponds filled in the same order but at earlier dates and water level fluctuations during the summer were less erratic then in 1979.

Water was supplied to the ponds via the canal system from the Missouri River. Consequently, the chemical composition of water entering the ponds was similar. Only minor chemical changes occurred within the ponds and no significant differences were detected in the parameters measured (Table 2). Similarly, water temperature and dissolved oxygen concentration was consistent between ponds. Maximum daily water temperature exceeded 20 degrees Centigrade (C) from mid June to early September with the maximum recorded temperature of 29 C occuring on August 21st, 1979. Water temperature fluctuated 5 to 9 C on a diel basis. Dissolved oxygen concentration was uniformly high during the period of open water and ranged from 80 to 100% of saturation. After four months of ice cover, the dissolved oxygen level had fallen to 35% of saturation (4 ppm) in Pond 3 and 40% of saturation (5ppm) in Pond 4.

The ponds were originally conceived as a means of reducing the amount of blowing dust during periods of reservoir drawdown. To this end, silt excavated from an

Table 2. Mean values and ranges (in parentheses) of selected chemical parameters in the Canyon Ferry ponds from June to November, 1979.

PARAMETER	POND 1	POND 2	POND 3	POND 4
pH	8.6 (8.0-8.9)	8.7 (8.1-9.0)	8.5 (7.7-8.9)	8.6 (7.6-9.0)
Conductivity (umhos/cm @ 25 C)	505 (454-551)	491 (395-585)	463 (333-541)	431 (360-512)
Total alkalinity (mg/l $CaCo_3$)	137 (120-150)	133 (120-160)	134 (120-165)	130 (110-150)
Total hardness (mg/l $CaCo_3$)	157 (130-190)	154 (120-190)	152 (120-180)	148 (120-170)
Calcium hardness (mg/l $CaCo_3$)	130 (110-170)	128 (110-170)	130 (110-180)	120 (100-140)
Sulfates (mg/l)	25 (25)	30 (25-35)	25 (25)	28 (25-30)
Chlorides (mg/l)	27 (25-30)	27 (25-30)	23 (20-25)	25 (25)
Nitrogen (mg/l NO_2 + NO_3)	0.07 (0.05-0.08)	0.08 (0.05-0.11)	0.07 (0.05-0.08)	0.08 (0.05-0.10)
Total phosphorus (mg/l)	0.07 (0.06-0.07)	0.06 (0.05-0.07)	0.05 (0.04-0.05)	0.06 (0.05-0.07)

additional 1,100 ha of reservoir bottom was deposited in Ponds 2, 3 and 4. The resultant water clarity was poor. The turbidity level was highest in Pond 4, intermediate in Ponds 2 and 3 and lowest in Pond 1 (Table 3). Water clarity remained fairly constant within each pond throughout the period of open water (Table 4). During 1979, Secchi disk transparency averaged 0.4, 0.4 and 0.2 m in Ponds 2, 3 and 4, respectively. The mean Secchi disk transparency in Pond 1, which did not receive sediment additions, was 1.3 m.

Table 3. Mean turbidity (Jackson Turbidity Units) at the outflows of the Canyon Ferry ponds during August of 1979 and 1980.

	POND			
DATE	1	2	3	4
8/24/79	11	26	28	63
8/29/80	13	28	24	61

Table 4. Mean Secchi disk transparency (meters) in the Canyon Ferry ponds during 1979 and 1980.

	POND			
DATE	1	2	3	4
5/21/79	-	0.4	0.6	0.2
6/26/79	2.0	0.5	0.4	0.2
7/26/79	1.2	0.5	0.3	0.1
8/22/79	1.3	0.4	0.4	0.3
9/23/79	1.2	0.5	0.3	0.2
10/26/79	0.8*	0.4	0.4	0.2
11/10/79	0.2*	0.3	0.4	0.2
4/18/80	-	0.1	0.4	0.2
8/28/80	1.0	0.3	0.5	0.3

* Secchi disk visable to the bottom throughout the pond.

In addition to causing turbidity, the abundant silt and clay reduced the heterogeneity of substrates within the ponds. Before the ponds were filled in the spring, hard packed silt and clay were identified as the predominant substrate with sand and gravel comprising an appreciable portion of the bottom near the ditch inlets. The substrate in the deepest portions of the ponds contained a considerable amount of organic material, primarily decaying Potamogeton spp. Detritus was most prevalent in Pond 3 and was essentially absent in Ponds 1 and 2. Upon filling, wind induced wave action redistributed the fine materials resulting in a ubiquitous layer of clay and silt.

The dominant form of vegetation in the ponds was Potamogeton pectinatus. Potamogeton filliformis, Polygonum sp. and Alisma sp. also occurred in limited quantities. Small patches of P. pectinatus were initially noticed in Pond 3 during June, 1979. By August, P. pectinatus had spread to most areas of Pond 3 where the water depth was less than 0.3 m, and sparse patches were present in the other ponds. The declining water level curtailed plant growth for the remainder of the year; however, senescent patches of Potamogeton were numerous until November. The extent of vegetation increased dramatically in 1980. Sparse growths of P. pectinatus covered more than half the total areas of Ponds 1, 2 and 3 and dense patches were numerous, especially in Pond 3. Submerged vegetation was confined to a small area of Pond 4 during both years. Emergent vegetation consisted of small patches of bulrush (Scirpus sp.) and cattail (Typha sp.) in Ponds 3 and 4.

METHODS

Samples were obtained on nine occasions in 1979 and on three occasions in 1980. A preliminary examination of the ponds was conducted during April and May of 1979 and a monthly sampling program was established for the remainder of the open water period. Monthly sampling was discontinued when the ponds froze in December. Ponds 3 and 4 were sampled through the ice in March of 1980 and all four ponds were sampled one week after ice out, in April. An additional set of samples was obtained in August, 1980.

Physical and Chemical Analysis

The water temperature, dissolved oxygen concentration and Secchi disk transparency were recorded concurrently with each biological sample while conductivity, pH, total alkalinity, total hardness and calcium hardness were determined at the inlet and outlet of each pond during each sampling stanza. Water temperature and dissolved oxygen were measured with a Yellow Springs Instuments Model 54 meter which was calibrated daily with the average of two Winkler dissolved oxygen determinations (APHA 1971). Conductivity was assessed using a Hach Model 2510 conductivity meter and pH was measured with a LaMotte

Model HA meter. Total alkalinity, total hardness, calcium hardness, sulfates and chlorides were determined colorimetrically with a Delta Model 50 portable water chemistry kit. During August of both years, water samples from the pond inlets and outlets were transferred to the laboratory in one liter polyethelylene bottles for turbidity and inorganic nutrient analyses. Combined nitrate and nitrite nitrogen and total phosphorus were determined using Hach Chemical Company reagents. Turbidity was measured using a Hach Model 2100 tubidometer.

Biological Analysis

Two methods were used to sample macroinvertebrates. Benthic samples were obtained with an Ekman grab sampler enclosing an area of 232 centimeters (cm). To insure penetration of the sampler to a uniform depth into the substrate, a wooden handle was attached to the sampler for collecting in shallow water. While sampling in water deeper than 2 m, a rope and triggering messenger were used. Littoral habitats were sampled with a circular dipnet which had a diameter of 80 cm and netting mesh of 0.6 millimeters (mm). Each sample consisted of sweeping the net through the water column over approximately 36 square meters. Sampling was limited to two minutes of actual collecting at each location. All samples were concentrated in a U.S. Number 30 mesh seive bucket and preserved in 5% formalin.

The preliminary surveys in April and May, 1979 were used to determine the depth profile and substrate types within each pond. Biological sampling at this time consisted of randomly collecting 45 Ekman grab samples and 20 sweepnet samples. Sampling effort was concentrated in Pond 4 which was the only pond containing an appreciable amount of water. When sampling was initiated on April 16th, less than 50% of Pond 3, less than 20% of Pond 2 and 0% of Pond 1 were inundated.

Beginning in June, permanent sampling locations were selected in each pond based on depth, presence or absence of vegetation and distance from the ditch inlets. During each sampling stanza, 21 Ekman samples and 14 sweepnet samples were collected. Benthic samples were differentiated using water depth, with 1.5 m delineating shallow and deep water habitats. Single deep water stations were designated in Ponds 1 and 2 while two deep water stations were sampled in each of Ponds 3 and 4. Three or four shallow water locations were established in each pond including one station in each pond in the depositional zone near the inlet. Single sampling stations at transitional depths (approximately 1.5 m) were also located in Ponds 3 and 4. Single sweepnet samples were taken along shorelines with and without submerged vegetation and along rocky sections of the dikes in each pond. Additional sweepnet samples were collected in stands of bulrush in Ponds 3 and 4.

In the laboratory, samples were rinsed in a U.S. No. 35 seive (0.50 mm appartures). Macroinvertebrates were then separated from the sample and stored in 70% ethanol. Macroinvertebrates were identified to the lowest practical taxon, usually genus, using keys by Brinkhurst and Jamieson (1971), Brown (1972), Hilsenhoff (1975), Hiltunen and Klemm (1980), Mason (1973) Oliver, et al. (1978), Penak (1978) and Roemhild (1975 and 1976). Microscope slides of Oligochaeta and Chironomidae, prepared with Hydramount mounting media, were examined using a compound microscope. Oligochaetes were cleared in Amman's lacto-phenol prior to examination. Naididae and sexually mature Tubificidae were identified to species while immature tubificids were distinguished as those with or without capilliform chaetae.

Benthic macroinvertebrate community distribution and variability were quantified using similarity indices and ordination techniques. The chironomid and oligochaete assemblages at each station were compared using the Czeckanowski index of similarity (S), as described by Clifford and Stephenson (1975):

$$S = (2C)/(A + B)$$

where A = the number of taxa occurring at station A,

B = the number of taxa occurring at station B, and

C = the number of taxa common to both stations.

This index is a presence/absence comparison of the community similarity between any two stations. Since the Czeckanowski index gives equal weight to all taxa regardless of their abundance, the coefficient of percentage similarity (Whittaker 1975) was also determined. This index is calculated as:

$$PS = 100 - 0.5 \sum (a - b) = \sum \text{minimum } (a,b)$$

where a = the percentage of a taxon at station A, and

b = the percentage of the same taxon at station B.

The values of both indices range from 0 to 1 with high values indicating similar species composition between stations. The coefficient of percentage similarity was further employed in computing a two axis ordination of community similarity between stations. The locations of stations within the ordination were calculated as described by Beals (1960). A matrix of the coefficient of percentage similarities was constructed for all stations. The station with the lowest average coefficient (most different from all other stations) was selected as one end of the X axis. The other end point on the X axis was the station exhibiting the greatest dissimilarity (1 - PS) to the first reference station. The length of the X axis was equivalent to the dissimilarity value between the stations selected as end points. The location of the remaining stations along the X axis were determined using the formula:

$$x = (L^2 + A^2 - B^2)/2L$$

where L = the dissimilarity value between reference stations,

A = the dissimilarity value of a given station and the first reference station, and

B = the dissimilarity value of a given station and the second reference station.

The first end point on the Y axis was selected on the basis of the highest value of e among stations along the X axis. The value of e was calculated as:

$$e^2 = A^2 - x^2.$$

The other end point of the Y axis was the station most dissimilar to the first. The positions of the remaining stations along the Y axis were determined as they were for the X axis. The stations were then plotted on a two-dimensional graph.

RESULTS

Preliminary Survey

The two month preliminary investigation of macroinvertebrate populations was initiated in April of 1979 as the ponds began filling. Sampling was concentrated in Ponds 4 and 3 which were the first ponds to receive water in the spring. Sampling in Pond 2 was limited to eight Ekman and three sweep samples due to the low water level and Pond 1, which remained dry until June, was not sampled.

When first sampled, the macroinvertebrate fauna of the ponds consisted of a few species present in low numbers (Tables 5 and 6). Organisms were concentrated in the deep areas of the ponds and near the inlets while recently inundated areas were barren. Macroinvertebrates were most numerous in Pond 4 which had contained the most water during the previous winter. Macroinvertebrate populations increased rapidly as the ponds received water; however, their distribution remained patchy. By the end of May, the diversity and average density of benthic organisms were similar in all three ponds (Table 5). The average number of organisms per sweep sample increased from 3.2 in April to 13.0 in May (Table 6). Littoral organisms remained concentrated near the inlets while the highest densities of benthic organisms were still found in the deepest regions of Ponds 3 and 4.

Table 5. The number of samples (n), total number of taxa and mean density per square meter of organisms collected in benthic samples from Ponds 2, 3 and 4 during April and May, 1979.

	POND					
	2		3		4	
	April	May	April	May	April	May
n	4	4	9	8	11	9
Taxa	7	17	14	20	19	19
Density	452	1012	388	1744	904	971

Table 6. The number of samples (n), total number of taxa and mean number of organisms collected per two minute sweepnet sample from Ponds 2, 3 and 4 during April and May, 1979.

	POND					
	2		3		4	
	April	May	April	May	April	May
n	0	3	4	4	5	4
Taxa	–	4	4	10	9	15
Organisms	–	6.7	2.8	9.5	5.6	14.8

A total of 39 taxa were collected by both sampling methods during April and May (Table 7). Twenty-nine taxa were identified in benthic samples, including 21 dipterans, seven oligochaetes and one beetle. Of the 20 taxa captured in sweep samples, seven were dipterans and two were oligocheates. Ten species were collected only in sweep samples, including three species each of Corixidae and Ephemeroptera and two species of Gastropoda. Single specimens of the crustaceans, Hyallela azteca and Orconectes sp. were collected in sweepnet samples from Pond 4.

Table 7. The frequency of occurrence (Freq.), total number and relative abundance (RA) of macroinvertebrates in 45 Ekman and 20 sweepnet samples from Canyon Ferry Ponds 2, 3 and 4 during April and May, 1979.

	EKMAN SAMPLES			SWEEPNET SAMPLES		
TAXON	Freq. (%)	Total number	RA (%)	Freq. (%)	Total number	RA (%)
Limnodrilus spp.	64	311	30	5	7	5
Procladius spp.	38	203	20	25	14	9
Tanytarsus spp.	31	124	12	25	7	5
Tubifex sp.	33	106	10	25	22	14
Paracladius sp.	36	77	7	55	27	17
Cryptotendipes sp.	24	28	3	0	0	0
Cricotopus spp.	22	23	2	40	23	15
Chironomus sp.	16	20	2	5	1	1
Harnishia sp.	16	17	2	0	0	0
Paracladopelma sp.	18	15	2	0	0	0
Lumbricidae	7	13	1	0	0	0
Dero digitata	9	10	1	0	0	0
Orthocladius spp.	11	9	-	0	0	0

Table 7. (continued)

TAXON	EKMAN SAMPLES Freq. (%)	Total number	RA (%)	SWEEPNET SAMPLES Freq. (%)	Total number	RA (%)
Odontomesa sp.	11	9	-	0	0	0
Cladotanytarsus sp.	11	9	-	0	0	0
Uncinais uncinata	7	8	-	0	0	0
Nais variabilis	4	8	-	0	0	0
Ophiodonais serpintina	7	6	-	0	0	0
Parakiefferiella sp.	4	5	-	0	0	0
Phaenopsectra sp.	7	5	-	0	0	0
Polypedilum sp.	7	3	-	0	0	0
Diamesa sp.	4	3	-	0	0	0
Dubiraphia sp.	4	3	-	10	7	4
Bezzia sp.	4	2	-	25	6	4
Paratanytarsus sp.	4	2	-	0	0	0
Dicrotendipes sp.	4	2	-	0	0	0
Tanypus sp.	2	1	-	0	0	0
Cryptochironomus sp.	2	1	-	0	0	0
Pagastia sp.	2	1	-	0	0	0
Ephemerella sp.	0	0	0	15	11	7
Corixidae nymphs	0	0	0	15	9	6
Baetis sp.	0	0	0	15	6	4
Corisella decolor	0	0	0	5	4	3
Physa sp.	0	0	0	10	4	3
Callibaetis sp.	0	0	0	10	3	2
Gyraulus sp.	0	0	0	10	2	1
Sigara alternata	0	0	0	5	2	1
Sigara grossolineata	0	0	0	5	1	-
Hyallela azteca	0	0	0	5	1	-
Orconectes sp.	0	0	0	5	1	-

Principal Investigation

Water column samples

Sweepnet samples from June to November 1979 showed striking differences in diversity between ponds. The mean number of taxa retained per two minute sample ranged from 4.8 in Pond 4 to 9.0 in Pond 1. A total of 46, 41, 56 and 36 taxa were collected in Ponds 1 through 4, respectively. For all ponds combined, a total of 78 taxa were identified in sweepnet samples, although most were rarely collected (Appendix Table 21). The relative densities in each pond exhibited a similar pattern, ranging from a low of 17.2 in Pond 4 to a high of 99.8 in Pond 3. The mean densities in Ponds 1 and 2 were 77.5 and 36.3, respectively. Despite the substantial difference in relative densities, the percentage composition of major taxonomic groups was similar between ponds (Table 8). Chironomids, corixids and oligochaetes dominated in each pond; however, there were notable differences in the abundance of individual taxa among ponds (Table 9).

The relative densities and diversities of organisms frequenting the water column were substantially higher during the summer (Tables 10 and 11) than during the preliminary survey conducted in April and May (Table 6).

The highest values occurred in July, corresponding with maximum water temperature and macrophyte development. The variety of organisms obtained in sweepnet samples remained relatively stable from June to September; however, the mean density steadily declined following the July maximum.

Table 8. The mean density per two minute sweepnet sample and percentage composition (in parentheses) of macroinvertebrate orders collected in the Canyon Ferry ponds from June to November, 1979 (n is the number of samples per pond).

	POND			
	1	2	3	4
ORDER n	15	18	24	24
Diptera	36.1 (47%)	17.8 (49%)	50.0 (50%)	7.8 (45%)
Hemiptera	13.1 (17%)	7.6 (21%)	21.3 (21%)	2.1 (12%)
Oligochaeta	18.8 (24%)	2.7 (7%)	19.2 (19%)	2.4 (14%)
Gastropoda	4.5 (6%)	3.2 (9%)	3.5 (4%)	1.1 (6%)
Others	5.0 (6%)	5.0 (14%)	5.8 (6%)	3.8 (23%)

Table 9. The mean density per two minute sweepnet sample and percentage numerical composition (in parentheses) of taxa comprising at least 5% of the fauna in one or more of the Canyon Ferry ponds from June to November 1979.

	POND			
TAXON	1	2	3	4
Diptera				
Cricotopus sylvestris	20.9 (27%)	10.0 (28%)	16.2 (16%)	1.1 (7%)
Paratanytarsus sp.	2.5 (3%)	0.1 (1%)	18.1 (18%)	0.0
Tanytarsus spp.	2.4 (3%)	1.1 (3%)	4.3 (4%)	2.2 (13%)
Cladotanytarsus sp.	1.4 (2%)	1.2 (3%)	2.6 (3%)	1.2 (7%)
Dicrotendipes sp.	1.8 (2%)	0.6 (2%)	2.0 (2%)	1.3 (8%)
Bezzia spp.	5.7 (7%)	3.6 (10%)	3.6 (4%)	1.0 (6%)
Hemiptera				
Sigara grossolineata	3.6 (5%)	2.2 (6%)	21.3 (21%)	1.5 (9%)
Sigara alternata	0.9 (1%)	1.9 (5%)	6.8 (7%)	0.1 (1%)
Cenocorixa wileyeae	2.7 (3%)	2.1 (6%)	2.3 (2%)	0.1 (1%)
Oligochaeta				
Nais variabilis	15.7 (20%)	0.7 (2%)	2.3 (2%)	0.6 (4%)
Uncinais uncinata	1.4 (2%)	0.2 (1%)	5.0 (5%)	0.0
Ophiodonais serpintina	1.9 (2%)	1.8 (5%)	3.3 (3%)	1.8 (10%)
Gastropoda				
Physa sp.	1.7 (2%)	1.2 (3%)	1.1 (1%)	0.9 (5%)
Gyraulus sp.	2.7 (4%)	2.1 (6%)	2.3 (2%)	0.1 (1%)
Amphipoda				
Hyallela azteca	0.3 (1%)	2.1 (6%)	0.7 (1%)	0.9 (5%)

Table 10. The total number of taxa collected and the mean number of taxa per two minute sweepnet sample in each of the Canyon Ferry ponds from June to November 1979 and during April and August 1980. Three samples per month in Ponds 1 and 2; four samples per month in Ponds 3 and 4.

	POND									
	1		2		3		4		Combined	
DATE	total	mean	total	mean	total	mean	total	mean	total	mean
6/26/79	15	7.3	15	6.3	21	8.8	17	6.5	41	7.3
7/26/79	31	15.0	13	7.7	21	8.3	21	8.0	46	9.5
8/23/79	17	7.7	24	11.0	25	12.0	12	3.0	43	8.3
9/23/79	16	9.0	22	9.3	28	10.8	11	3.0	36	7.9
10/26/79	14	6.0	16	8.3	21	7.8	13	4.3	32	6.5
11/12/79	-	-	9	3.3	14	5.0	10	3.8	22	4.1
4/18/80	-	-	5	2.7	7	2.8	13	4.0	16	3.2
8/26/80	41	22.0	31	19.3	43	22.5	20	8.3	64	17.6

Table 11. The mean macroinvertebrate density per two minute sweepnet sample in each of the Canyon Ferry ponds from June to November 1979 and during April and August 1980. Three samples per month in Ponds 1 and 2; four samples per month in Ponds 3 and 4.

	POND				
DATE	1	2	3	4	Combined
6/26/79	80.7	28.3	57.5	17.0	44.7
7/26/79	196.7	33.3	205.5	28.0	116.0
8/23/79	45.7	90.0	184.3	23.5	88.4
9/23/79	49.3	35.3	106.3	7.0	50.5
10/26/79	15.0	24.7	36.0	17.8	23.9
11/12/79	-	6.0	9.3	10.0	8.6
4/18/80	-	6.7	4.8	9.5	7.0
8/26/80	225.3	131.3	240.8	57.5	163.4

Macroinvertebrates rapidly colonized the habitat provided by aquatic vegetation. All major groups of invertebrates were more abundant in vegetated areas than in areas of the ponds lacking aquatic vegetation. Several genera of chironomids and naidids were particularly numerous on Potamogeton (Table 12). Due to their greater abundance, variations in the number of dipterans and oligochaetes tended to obscure trends in the abundance of other organisms. Figures 2 and 3 depict the development of invertebrate populations excluding Diptera and Oligochaeta in vegetated and nonvegetated areas.

Table 12. The mean density of selected Chironomidae and Oligochaeta per two minute sweepnet sample in vegetated and nonvegetated areas of the Canyon Ferry ponds during July, August and September 1979 and August 1980. Twenty-seven and 29 samples from nonvegetated and vegetated areas, respectively.

Taxon	Vegetated	Nonvegetated	Ratio
Chironomidae			
Cladotanytarsus sp.	6.9	2.0	3.5
Cricotopus spp.	21.5	9.3	2.3
Glyptotendipes sp.	1.1	0.2	5.2
Paratanytarsus sp.	19.4	1.6	12.2
Tanytarsus spp.	5.4	1.4	3.7
Oligochaeta			
Nais variabilis	18.9	0.7	25.5
Uncinais uncinata	7.1	0.6	12.8

The influence of aquatic vegetation on macroinvertebrate populations was readily detectable by comparing data from August of 1979 and 1980. Stands of *Potamogeton* were more extensive in Ponds 1, 2 and 3 during 1980 than in the preceeding year and a dramatic increase in the abundance and variety of phytophylic organisms was evident. During August of 1979, the mean number of organisms collected per two minute sweep sample was 88 compared with 163 organisms per sample in August of 1980. All major taxonomic groups, with the exception of dipterans, increased in abundance during 1980 compared to 1979 (Table 13). Higher densities of Hemiptera, principally *Sigara grossolineata*, *Cenocorixa wileyeae* and

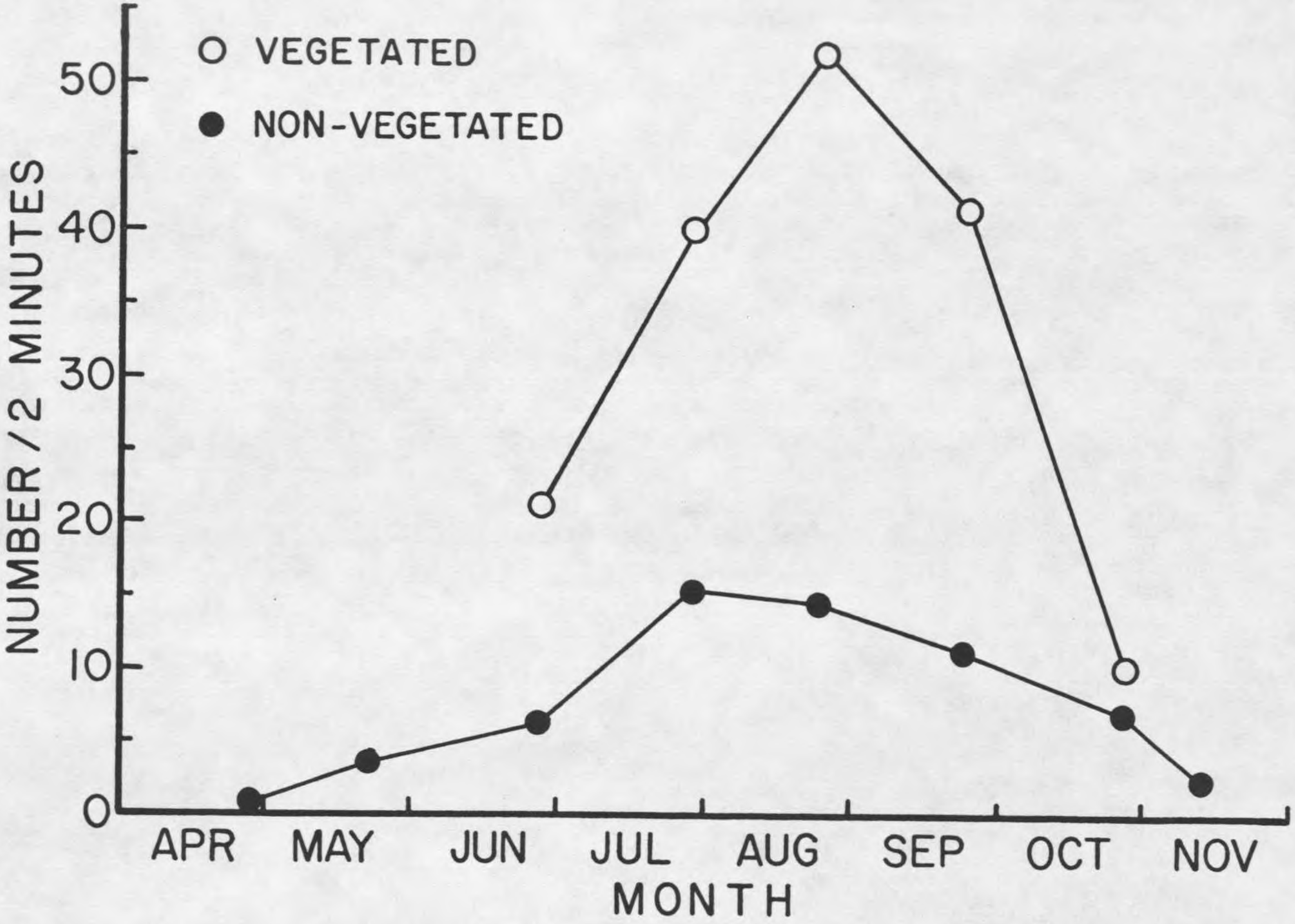

Figure 2. The mean density of macroinvertebrates (excluding Diptera and Oligochaeta) per two minute sweepnet sample in vegetated and nonvegetated areas of the Canyon Ferry ponds during 1979.