AQUATIC INSECTS OF SELECTED FISHPONDS AT MINOR CLARK FISH HATCHERY, ROWAN COUNTY, KENTUCKY

A Thesis

Presented to

the Faculty of the School of Sciences and Mathematics

Morehead State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

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3 May 1982

Accepted by the faculty of the School of Sciences and Mathematics, Morehead State University, in partial fulfillment of the requirements for the Master of Science degree.

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3 May 1982
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ABSTRACT OF THESIS

AQUATIC INSECTS OF SELECTED FISHPONDS AT MINOR CLARK FISH HATCHERY, ROWAN COUNTY, KENTUCKY

Aquatic insects are the dominant forms of animal life in aquatic ecosystems, but their life histories and trophic relationships are poorly understood or are unknown. Lentic habitats, such as the fishponds at Minor Clark Fish Hatchery, have not been studied as thoroughly as lotic habitats, primarily due to current water quality research trends.

Fish culturists are beginning to realize the economic value of lentic habitats in terms of food production. This increased interest in standing water systems requires in-depth understanding of lentic biotic habitats, particularly aquatic insect niches.

During the summer and fall of 1981, aquatic insect collections were made in 17 one-acre fishponds at the Minor Clark Fish Hatchery, Rowan County, Kentucky. Representatives of five aquatic orders were found and collections included 65 species of nymphs, larvae, pupae and adults. Species collected did not include some primary aquatic predators commonly found in fishponds, but various odonates, belostomatids and gyrinids collected are suspected piscivores. Data collected suggest that hatchery management practices are helping control the diversity and density of most aquatic insect communities and populations.

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ACKNOWLEDGEMENTS

I wish to express special appreciation to Dr. Gerald L. DeMoss for his guidance, encouragement and assistance in writing the manuscript and for the time spent in being the chairman of my graduate committee. I also wish to thank Dr. Jerry F. Howell, Jr. and Dr. Madison E. Pryor for their helpful suggestions and for serving on my graduate committee. I am also grateful to Morehead State University for providing the assistantship and facilities which made my studies and this research possible.

Special thanks goes to Dan Brewer and Mike Hearn for providing me with information and management data regarding the Minor Clark Fish Hatchery. Appreciation also to David Bruce Conn for his assistance in identifying some of the aquatic macroinvertebrates.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

Aquatic insects are the dominant macroinvertebrate forms in aquatic ecosystems. These fauna are characteristically considered vital intermediate stages in the flow of energy between the autotrophic elements and the higher heterotrophic forms in aquatic ecosystems, but their life histories are poorly understood and available distributional and ecological data are sketchy and incomplete. Aquatic biota identification is a necessary and logical first step leading to a basic understanding of aquatic ecosystems and the procedures allowing for the development of proper management strategies for these systems. Data generated through this research will provide initial background information on the aquatic insects of fish culture ponds at the Minor Clark Fish Hatchery and will serve as baseline data for future studies of these unique ecosystems.

Aquatic insect collections from selected fishponds were conducted from late June to early November, 1981. A total of 17 one-acre fishponds were sampled during pond drawdown stages at the time of fish harvest. Sampling was limited to the time of fish harvest to assist in concentrating the insects for collection, which permitted a more accurate overview of existing populations and increased the chances of collecting those forms having minimal population densities. This procedure also minimized any interference with fish management practices at the hatchery.

LITERATURE REVIEW

Authorization for Cave Run Lake was approved under the Federal Flood Control Act of June 1936, with project design and construction supervised by the Louisville District, U. S. Army Corps of Engineers. Control tower and conduit construction began in June, 1965 and the project became operational in February, 1974 (United States Department of Army 1981). Cave Run Lake serves as a multi-purpose flood control and recreational facility, in the comprehensive plan for the Ohio River Basin, designed to assist in flood water manipulation in the lower Licking River Basin. Contrastingly, the lake also serves as a water source insuring natural low flow conditions on the lower Licking River in the interest of water quality control.

An additional function for the impounded waters of Cave Run Lake was conceived by the Kentucky Department of Fish and Wildlife as a water source for a state funded fish hatchery. Minor Clark Fish Hatchery was concurrently constructed with Cave Run Dam, at a cost of two million dollars; funds derived through the sale of hunting and fishing licenses (Kentucky Department Fish and Wildlife 1976). The hatchery was built in the tail-water area of the lake and was completed in the summer of 1973. Some fish production began in 1973, but full production and operation did not begin until 1974 (Brewer 1982).

Minor Clark Fish Hatchery is the largest state operated hatchery in Kentucky and is one of the largest state owned warmwater hatcheries in the United States. The hatchery covers 300 acres of the Licking River alluvial flood plain and has 111 rearing and brood ponds (Kentucky Department Fish and Wildlife 1976). There are approximately 122.5 acres of water at the hatchery: 82 one-acre ponds, 25 tenth-acre ponds and four large brood ponds, one a natural oxbow lake.

Water supply for the hatchery is obtained from Cave Run Lake by gravity flow through an 18-inch watermain. Approximately 8,000 gallons of water per minute can be taken from the lake and water can be drawn from three separate levels at the dam's control tower. Inflow regulation allows partial temperature and dissolved oxygen control in water delivered to the hatchery.

Minor Clark Fish Hatchery produces several game fishes and two forage fish species. Major game fish produced at the hatchery are *Micropterus salmoides* (Lacepede) [Largemouth Bass], *Stizostedion vitreum* (Mitchill) [Walleye], *Esox masquinongy* (Mitchill) [Muskellunge] and *Morone saxatilis* (Walbaum)

[Striped Bass or Rockfish]. Other game fish species are reared experimentally. Game fishes produced are carnivorous, thus requiring the production of *Pimephales promelas* (Rafinesque) [Fathead Minnow] and *Carassius auratus* (Linnaeus) [Goldfish] as forage (Kentucky Department Fish and Wildlife 1976). All hatchery-reared game fishes are restricted to Kentucky waters for their release.

Fishponds at Minor Clark Fish Hatchery are artificial habitats, with a sloped bottom and a maximum depth of five feet and a minimum depth of two feet. The sloping bottom allows for uniform drawdown at the time of fish harvest, thus concentrating fish at one end of the pond to increase harvest efficiency. Fishpond banks are rip-rapped to reduce erosion, eliminate overhanging vegetation and provide spawning sites for forage fishes.

Management practices for the fishponds vary from year to year, due to the experimental methods employed by fish culturists. Fishponds are characteristically drained and overwintered empty to attempt control of aquatic floral and faunal pests (Brewer 1982). Other techniques used to prevent pest establishment include the use of herbicides, particularly algicides, and the application of diesel fuel. Fertilizers are added experimentally to induce plankton production as a food source for fish fry (Hearn 1982). Dissolved oxygen readings are regularly taken and ponds found to have oxygen deficiencies are backfilled with lake water. Wilson (1923b) notes that management practices for artificial ponds greatly restrict habitat availability and subsequently restrict community diversity.

Freshwater habitats are divided into two basic categories according to their physical environmental features. Those habitats characterized as standing water habitats are "lentic", while running water habitats are "lotic" (Cummins 1978). Environmental factors influencing the biota of these habitats are extremely variable (Usinger 1956). The physical and biological characteristics of lentic and lotic habitats must be studied individually if we are to understand their ecology.

Environmental conditions of lentic habitats that influence species diversity vary markedly from those of lotic habitats (Cummins 1978). These limiting factors are so stringent that each of these aquatic ecosystems supports distinctive biota (Usinger 1956). Factors influencing the lentic habitat biota of the Minor Clark Fish Hatchery ponds are more restrictive than those of natural lentic habitats because of applied fish management practices. An understanding of the general elements promoting insect occurrence and abundance in standing water habitats is prerequisite to the study of the unique fishpond ecosystem.

In recent years lotic habitat species studies have been given a great deal of attention as a result of increased concerns and awareness of stream and river water quality (Mason 1973). Such interest has also generated considerable data for large bodies of standing water (Usinger 1956). As a result, life cycles and trophic relationships of these biota are better understood than are those of small lentic habitats, such as ponds, marshes and ditches. These small lentic habitats characteristically support the most diverse aquatic insect fauna (Usinger 1956; Pennak 1978; Cummins 1978) due to adequate oxygen supply throughout the habitat, food availability and cover. Organisms living in standing water habitats are faced with a variety of limiting factors that may fluctuate daily, or even hourly, and their survival depends upon their ability to adapt to these fluctuations, or to escape from them. Insects are well suited to pond life uncertainties due to their short life histories and their ready means of dispersal (Usinger 1956). Coker (1954) considered lotic environments as "open systems", since they have a continuous external water and nutrients supply passing from one potential home of organisms to another. But he considered lentic environments as "closed or self-contained systems", because most materials essential to the support of life forms remain within the habitat and must be recycled. Nutrient circulation within the system is necessary to prevent permanent loss to an evergrowing bottom deposit, even though some nutrients are added and deleted through inflow and outflow.

Maintaining adequate dissolved oxygen concentrations is a major problem in lentic habitats (Usinger 1956). Aquatic insect movements and distribution are often governed primarily by the distribution of dissolved oxygen in the water. Hynes (1970) described the mechanism for oxygen distribution in lentic habitats as either resulting from vertical convection currents or from the wind driven circulation of the water. Usinger (1956) and Pennak (1978) suggest that adaptation to the problem of variations in oxygen concentration within aquatic habitats has greatly influenced aquatic insect evolution. The difficulty of adapting to oxygen fluctuations may help explain why the majority of aquatic insects remain air breathers. Sources of free oxygen in ponds include the atmosphere at the surface, vascular hydrophytes, filamentous algae, and microscopic phytoplankton.

Temperature variations in lentic habitats are more profound than are those in lotic habitats (Usinger 1956). These variations are proportional to the volume and depth of the habitat; the smaller the lentic habitat the greater the temperature variations. Usinger (1956) described temperature fluctuations as being more important to aquatic insect distribution than dissolved oxygen, but recognized that the dissolved oxygen concentration is directly related to water temperature.

Lentic habitats are divided into two broad categories: vegetated and nonvegetated. Merritt, Cummins and Resh (1978) distinguished these two habitats on the basis of rooted plants: those having rooted plants were "vegetated" and those without rooted plants were "nonvegetated". Neither category excludes the presence of algae. Pond insects are dependent upon phytoplankton and rooted vegetation (Usinger 1956). Wilson (1923b) has shown that a vegetated lentic habitat supports greater densities of aquatic insects. He concluded that the occurrence of more cover (habitat) and increased food availability were the primary reasons. Bobb (1974) suggested that the presence of submergent and emergent vegetation was critical to hemipteran diversity. He found that both productivity and diversity were greatest in vegetated habitats.

Cummins (1978) described aquatic insect feeding levels as herbivorous, detritivorous, and carnivorous. Aquatic biologists base their concept of the trophic relationships among aquatic insects upon the feeding mechanism, because a particular feeding mode reflects the type of food consumed. Six types of feeding mechanisms are recognized to help in the understanding of aquatic insect trophic relationships. Table 1 summarizes these categories, but it must be noted that these categories represent broad generalizations that show exceptions. Difficulties occur when using rigid classifications for feeding mechanisms because established categories are based on relatively small numbers of investigated species (Cummins 1978).

There are approximately 10,000 species of aquatic insects in North America (Merritt and Cummins 1978). Aquatic insect ecology and taxonomy are poorly understood and our knowledge is greatly lacking in terms of life cycles and feeding behavior, particularly for immature forms (Wilson 1923b; Usinger 1956; Cummins 1978; Pennak 1978). European aquatic biologists have a much better understanding of palaeartic aquatic insects; they are twenty years ahead of the North American aquatic

Table 1. Trophic Relationships Among Aquatic Insects Based on Feeding Mechanisms (after Cummins 1978).

Mechanisms	Relationships	Food Consumed
Shredders	Herbivores	Living Vascular hydrophytes
	Detritivores	Decomposing plant tissue
Collectors	Detritivores	Filter decomposing fine particulate matter
	Detritivores	Gatherers or deposit feeders on decomposing fine particulate matter
Scrapers	Herbivores	Graze on attached algae and vascular hydrophytes
Piercers	Herbivores	Pierce vascular hydrophytes and filamentous algae
	Carnivores	Pierce living animal tissue
Engulfers	Carnivores	Living animals (prey)
Parasites	Carnivores	Living animal tissue (host)

biologists in understanding life cycles and trophic relationships (Pennak 1978).

In order to understand life cycle complexities and trophic relationships, species identification for North American aquatic insects must first be determined. This task is complicated due to the lack of association between most immature forms and imago stages for individual species (Merritt and Cummins 1978; Pennak 1978). The problem has existed for some time because of the low priority given aquatic macroinvertebrates, probably resulting from their limited economic importance and lack of research interests among aquatic biologists (Wilson 1923b; Merritt and Cummins 1978). There are exceptions within certain aquatic groups, based on the sizes of the species complexes, their economic importance and/or their medical importance, e.g. Megalopterans, Culicids and Bivalves (Pennak 1978).

Aquatic biologists recognize twelve insect orders as having aquatic life cycle stages (Daly 1978). The number of aquatic taxa do vary, with some authorities acknowledging the presence of fewer orders (Usinger 1956; Pennak 1978). Of the twelve aquatic orders identified by Daly (1978), nine commonly occur in lentic habitats. Table 2 lists these orders and identifies their life zones and habits within standing water environments.

Representatives of the order Ephemeroptera have immature aquatic stages, but mayfly subimago and imago stages are terrestrial. Mayflies are highly preferred "fish food" and are found in most freshwater habitats having an abundance of oxygen (Pennak 1978). Mayfly nymphs found in lentic habitats are characteristically herbivorous and are considered beneficial to fish culture. Pennak (1978) suggests that mayfly incidence may be reduced in temporary ponds, such as fishponds, due to the short life of the adult mayfly. Lentic mayflies are most commonly associated with permanent bodies of water.

Dragonflies and damselflies have aquatic nymphs and terrestrial adults. These nymphs are best adapted to living conditions in slow-moving streams and standing waters. These odonates are among the most common residents of lentic habitats, particularly small ponds. Odonate nymphs are carnivorous and feed readily on appropriately-sized prey. Benke (1976 and 1978) and Pennak (1978) listed a wide variety of known prey for these nymphs and suggest that cannibalism is common. Large nymphs have been shown to feed on small fish in laboratory studies and may be considered pests by fish

Table 2. Orders of Aquatic Insects Found in Lentic Habitats.

Order	Aquatic Stage of Life Cycle	Life Zone	Habit
Ephemeroptera	N	Littoral	Swimmers Clingers Sprawlers Burrowers
Odonata	N	Littoral Vascular hydrophytes	Climbers Burrowers Sprawlers Clingers
Hemiptera	N,I	Limnetic Littoral Vascular hydrophytes Surface	Skaters Swimmers Climbers Sprawlers Clingers
Megaloptera	L	Littoral	Clingers Climbers Burrowers
Trichoptera	L	Littoral	Clingers Climbers Burrowers Sprawlers
Lepidoptera	L	Vascular hydrophytes	Climbers Swimmers Burrowers
Coleoptera	L,I	Vascular hydrophytes Littoral	Sprawlers Clingers Climbers Burrowers Swimmers Divers
Hymenoptera	L	---	Parasite
Diptera	L	Littoral Limnetic	Burrowers Clingers Sprawlers Planktonic Swimmers

culturists (Coker 1954). Wilson (1920) reported that odonate nymphs are effective predators on other piscivorous insects and that their presence may be beneficial to fish culturists. Several factors influence odonate occurrence and diversity in fishponds. Needham and Westfall (1955) noted that some large dragonfly nymphs require two years to complete their development and such forms are atypical residents of temporary ponds. Benke (1978) emphasized that early emergent odonates prey heavily upon smaller and late emergent odonate nymphs, thus restricting their ability to establish stable populations.

Hemiptera is one of two aquatic orders of insects in which the adult forms, as well as the nymphs, are aquatic. Aquatic hemipterans are most frequently associated with lentic habitats, but are not restricted to them (Pennak 1978). The majority of aquatic and semiaquatic hemipterans are classified as carnivores, but some groups are dominated by herbivores. Permanent ponds vegetated with submergent and emergent vascular hydrophytes support the most diverse hemipteran populations (Bobb 1974). Competition between hemipterans and fishes is both direct and indirect. Carnivorous hemipterans and young fish contend for the same food supply. Aquatic hemipterans serve as fish food, but their predaceous habits also allow them to effectively feed on fish fry (Bobb 1974) and, therefore, the majority of aquatic hemipteran species are considered detrimental to fish culture. Hoffman (1924) cited laboratory studies with the belostomatid *Lethocerus americanus*, in which individual giant water bugs consumed two 3.5 inch trout fingerlings per feeding. Pennak (1978) reported that these insects effectively feed on tadpoles and small frogs, as well as small fish.

Larvae of the order Megaloptera, commonly called hellgrammites, are carnivorous, holometabolous aquatics regarded as highly preferred "fish food" (Chandler 1956). Adult megalopterans are terrestrial and females oviposit on overhanging vegetation (Pennak 1978). Larval megalopterans are found in a variety of freshwater habitats, but are most generally associated with debris covered bottoms in lotic habitats. Megalopterans found in lentic habitats occur along vegetated shores and would not typically be found in temporary ponds because their larvae are long lived, generally two to three years (Pennak 1978). Hellgrammites are fierce predators that feed on a wide variety of animals, including small fish, but Megalopterans have not been shown to be fishpond culture pests.

Representatives of Trichoptera, the caddisflies, have aquatic larval and pupal stages and terrestrial adults. Caddisfly larvae typically construct portable retreats into which they withdraw for protection. The majority of trichopterans occupy lotic habitats, but a few families have representatives restricted to lentic habitats (Wiggins 1978), provided there is an abundant oxygen supply (Pennak 1978). Trichopterans are considered important "fish food" throughout their life cycles and are beneficial in fishpond culture. Larvae are usually herbivores or detritivores, but some larvae are carnivorous (Coker 1954; Pennak 1978). Carnivorous larvae are not reported to feed on fish.

Aquatic larvae of the order Lepidoptera typically occur in lentic habitats choked with vascular hydrophytes (Coker 1954). These moth larvae are herbivores and are the overwintering stages for all aquatic lepidopterans (Pennak 1978). Female moths producing aquatic larvae, oviposit on emergent vascular hydrophytes, and fixed or floating cases are constructed from these plants by the larvae (Pennak 1978). Lepidopteran larvae have not been reported as inhabitants of artificial fishponds.

Representatives of the order Coleoptera are the dominant insect life forms in aquatic habitats, with approximately 5,000 aquatic species (Doyen and Ulrich

1978). Like the hemipterans, beetle immatures and adults show considerable variation in their trophic relationships. Larval stages are generally carnivorous, but herbivores and detritivores occur throughout this order. Adult beetles may be either herbivores or carnivores, but Matta (1974) suggests that some species are omnivorous when reared under artificial conditions. Beetles are abundant in both lentic and lotic habitats, but show the greatest diversity and population densities in small, vegetated lentic habitats (Wilson 1923a and b; Matta 1974; Pennak 1978). Aquatic coleopterans are the dominant organisms of the littoral fauna in small vegetated ponds. Aquatic beetles are found in every type of freshwater habitat and adults move freely from one body of water to another (Zimmerman 1960). Limiting factors, such as temperature and dissolved oxygen, do not restrict coleopteran incidence because adult beetles are atmospheric breathers and have a ready dispersal mechanism should they encounter environmental extremes (Wilson 1923b).

Most aquatic coleopterans prefer ponds in open fields rather than ponds in forest communities. This suggests that acid water found in ponds with a forested watershed may be a limiting factor (Leech and Chandler 1956), and ponds surrounded by trees could restrict flight activity. Muttkowski (1918) stated that aquatic beetles are virtually absent in large bodies of standing water, but are the dominant macroinvertebrate forms in fishponds. Wilson (1923b) described aquatic beetles as being the most permanent insect inhabitants of artificial fishponds, but indicated that our knowledge of fishpond taxa is inadequate to allow understanding their economic importance. Michael and Matta (1977) suggested that such a deficiency still exists.

There are 14 families of aquatic beetles, three of which are known piscivores: Gyrinidae, Hydrophilidae and Dytiscidae (Wilson 1923a and b; Coker 1954; Matta 1974; Michael and Matta 1977). Gyrinid larvae are carnivorous, and Wilson (1923b) observed the gyrinid larvae, Dineutes, feeding on the fry of Ictulurus punctatus Rafinesque during the drawdown stage at the time of fish harvest. Several larvae reportedly attacked the same fry.

Hydrophilid larvae are reported as fishpond culture pests by several researchers. Matta (1974) indicates that large hydrophilid larvae effectively feed on fish and small larvae serve as micropredators. Wilson (1923a), during studies with Hydrous larvae, found that 20 percent of the examined larvae had fed on fish, and that 75 percent of those had fed exclusively on fish. He observed Hydrous larvae feeding on Ictiobus cyprinellus Valenciennes fry and indicated that Hydrophilus larvae have similar capabilities (Wilson 1923b).

Dytiscid larvae and adults are reported as voracious carnivores, feeding on most aquatic fauna, including odonates, fish and tadpoles (Doyen and Ulrich 1978; Pennak 1978). Wilson (1923b) reported the feeding of Dytiscus and Cybister larvae on 2.0 - 2.5 inch Micropterus dolomieui Lacepede fry during the drawdown stage at the time of fish harvest. He later observed these larvae feeding on fish, even when other food was readily available. This observation suggests selectivity.

Several representatives of the order Hymenoptera are associated with aquatic forms, but these wasps are all parasitoids on other aquatic insects and their life histories are poorly understood (Hagen 1978). Aquatic hymenopterans parasitize the eggs, larvae or pupae of host species, and always destroy them. Pennak (1978) did not recognize the group as being truly aquatic due to their specialized lifestyle. Host species include representatives of most other aquatic orders; lentic insects are more readily parasitized than are lotic forms (Hagen 1978). Aquatic hymenopterans are not reported from fishponds, but are undoubtedly present.

Aquatic dipterans include some of the most beneficial insects to fish culturists. There are approximately 2,000 species of aquatic dipterans, and both larval and pupal stages are aquatic (Pennak 1978). Adult dipterans are all terrestrial. Aquatic dipteran larvae inhabit a wide variety of freshwater habitats and show considerable tolerance for temperature fluctuations and changes in dissolved oxygen levels. Many dipteran larvae and pupae are atmospheric breathers (Pennak 1978).

Trophic relationships among larval dipterans are equally diverse (Teskey 1978). Larvae may be predaceous, phytophagous or detritus feeding; predaceous forms are characteristically micropredators. Dipteran larvae are important in aquatic communities as forage for larger predators, including fish. Most larvae are benthic forms that live within the littoral life zone (Matheny and Heinrichs 1970); one exception is the zooplankton-feeding phantom midge larvae, <u>Chaoborus</u> (Johannsen 1934; Pennak 1978). These larvae are the only insect larvae to inhabit the limnetic life zone. <u>Chaoborus</u> larvae can tolerate significant oxygen level changes and can survive below the photic zone (Wirth and Stone 1956). Phantom midge larvae compete with small fish fry for zooplankton and may be a problem for fish culturist.

MATERIALS AND METHODS

The 17 one-acre fishponds sampled during this study were overwintered empty. Management practices for these fishponds vary according to the types of game or forage fishes reared in them. Many of the fish culture techniques employed at the Minor Clark Fish Hatchery are experimental, particularly those methods employed for pest control. Fishponds sampled were stocked with two species of game fishes, the muskellunge and striped bass, and two species of forage fishes, goldfish and fathead minnows. Management data for ponds stocked with these fishes are included in Tables 3-5.

Table 3 includes management data for the six fishponds stocked with Esox masquinongy, the muskellunge. These data reflect experimental liming of the pond bottom to reduce bottom acidity, herbicide use to control vascular hydrophytes and filamentous algae, and the use of diesel fuel to assist in controlling air breathing insects. Data for fish releases, forage added to ponds, and harvest are included. The musky harvest for 1981 was poor in terms of numbers, but fish harvested were of "good" size.

Management data for the six fishponds stocked with Morone saxatilis [the striped bass] are presented in

Table 3. Management Data For Fishponds Stocked With *Esox masquinongy*.

Management Techniques.	Pond Numbers					
	24	32	43	44	61	63
Date Limed 1000 lbs/acre	-	3-11	-	-	3-11	3-11
Date Flooded	4-3	4-3	4-3	4-3	4-3	4-3
Date Diesel Fuel Added 5 gals/pond	4-22	4-22	4-22	4-22	4-22	4-22
Algicides						
Aquazine	5 lbs.	5 lbs.	7.5 lbs.	7.5 lbs.	5 lbs.	5 lbs.
Cutrine	2 gal.	1 gal.	1 gal.	1 gal.	4 gal.	-
$CuSO_4$	6 lbs.	6 lbs.	14 lbs.	13 lbs.	10 lbs.	10 lbs.
Fertilizers						
Soybean Meal	100 lbs.	100 lbs.	100 lbs.	100 lbs.	100 lbs.	100 lbs.
Hay	10 bales	10 bales	10 bales	10 bales	10 bales	10 bales
Alfalfa Meal	200 lbs.	200 lbs.	200 lbs.	200 lbs.	200 lbs.	200 lbs.
$KMnO_4$	26 lbs.	30 lbs.	26 lbs.	26 lbs.	26 lbs.	31 lbs.
Forage Added	1074 lbs.	1104 lbs.	1324 lbs.	1334 lbs.	1379 lbs.	1354 lbs.
Fry Stocked ½"	7000	4500	7000	7000	4500	7500
Date of Harvest	8-7	8-7	8-27	8-27	8-25	8-25
Mixed Forage Harvested	256 lbs.	455 lbs.	153 lbs.	152 lbs.	380 lbs.	380 lbs.
Number of Musky Harvested	332	124	373	493	151	139
Mean Size of Fry Upon Harvest	9.3"	9.8"	10.6"	11.1"	10.4"	10.8"

Table 4. Experimental practices involving the use of lime and diesel fuel were the same as for fishponds stocked with muskies. Herbicides used differed because copper sulfate, $CuSO_4$, has been shown to be detrimental to striped bass culture. Hatchery harvest data showed that 1981 was an excellent year for striped bass production.

Fishponds stocked with forage fish were subjected to management practices similar to those used for game fish. Management data for the three ponds stocked with _Carassius auratus_ [goldfish] and the two ponds stocked with _Pimephales promelas_ [the fathead minnow] are presented in Table 5. The numbers of forage fish harvested from these fishponds were as expected for the time of harvest.

Aquatic insects were collected during pond drawdown stages at the time of fish harvest. Various sampling techniques were employed to obtain maximum diversity of aquatic insects. Hand and dip nets were used to collect swimming, floating, skating, and sprawling forms. Rip-rap were moved and aquatic forms found clinging beneath rocks were collected with nets and by hand picking. Bottom samples were taken to a depth of two inches and were placed in a 30-mesh sample to separate sediments from benthic larvae. Aquatic insects

507385

Table 4. Management Data For Fishponds Stocked With *Morone saxatilis*.

Management Techniques	Pond Numbers					
	20	50	59	78	80	81
Date Limed 1000 lbs/acre	-	3-11	3-11	-	3-11	3-11
Date Flooded	5-4	4-23	4-26	5-5	4-20	4-21
Date Diesel Fuel Added 5 gals/pond	5-5	4-27	4-30	5-5	4-27	4-27
Algicide Karmex	0.9 lb.	0.8 lb.	0.8 lb.	0.7 lb.	0.9 lb.	.75 lb.
Fertilizers						
Soybean Meal	150 lbs.	150 lbs.	150 lbs.	150 lbs.	150 lbs.	150 lbs.
Alfalfa Meal	600 lbs.	650 lbs.	550 lbs.	550 lbs.	750 lbs.	750 lbs.
0-46-0	72 lbs.	72 lbs.	72 lbs.	72 lbs.	72 lbs.	72 lbs.
$KMnO_4$	13 lbs.	9 lbs.	-	17 lbs.	17 lbs.	17 lbs.
Purina Trout Chow	200 lbs.	200 lbs.	200 lbs.	200 lbs.	200 lbs.	200 lbs.
Fry Stocked	150,000	100,000	100,000	150,000	100,000	100,000
Date of Harvest	7-8	6-30	6-30	7-8	6-23	6-23
Number of Striped Bass Harvested	60,270	45,413	83,840	66,375	13,090	24,130
Mean Size of Fry Upon Harvest	1.75"	1.75"	1.5"-1.75"	1.5"	1.75"-2.0"	1.5"-1.75"

Table 5. Management Data For Fishponds Stocked With *Carassius auratus* and *Pimephales promelas*.

Management Techniques	Pond Numbers				
	10	49	76	30	79
Date Limed 1000 lb/acre	-	-	3-11	3-11	-
Date Flooded	6-30	7-14	7-31	7-14	7-14
Date Diesel Fuel Added 5 gals/pond	-	-	-	7-16	7-16
Algicides					
Karmex	0.5 lbs.	2.0 lbs.	5.0 lbs.	3.0 lbs.	4.0 lbs.
$CuSO_4$	-	-	-	20 lbs.	15 lbs.
Cutrine	-	-	-	1.0 gal.	1.0 gal.
Fertilizer					
Soybean Meal	650 lbs.	450 lbs.	300 lbs.	450 lbs.	450 lbs.
0-46-0	72 lbs.	54 lbs.	-	54 lbs.	54 lbs.
$KMnO_4$	-	-	-	-	-
Feed Used					
Soybean Meal	150 lbs.	375 lbs.	350 lbs.	-	-
Minnow Meal	-	-	-	350 lbs.	350 lbs.
Brood Stocked	70 adults	70 adults	70 Adults 160# 2" fry	15 lb. brood	15 lb. brood
Date of Harvest	9-23	10-19	11-3	11-2	11-3
Forage Harvested	349 lbs.	485 lbs.	320 lbs.	200 lbs.	175 lbs.
Mean Size of Fry Upon Harvest	1"-3"	1"-3"	1"-3"	1"	1"

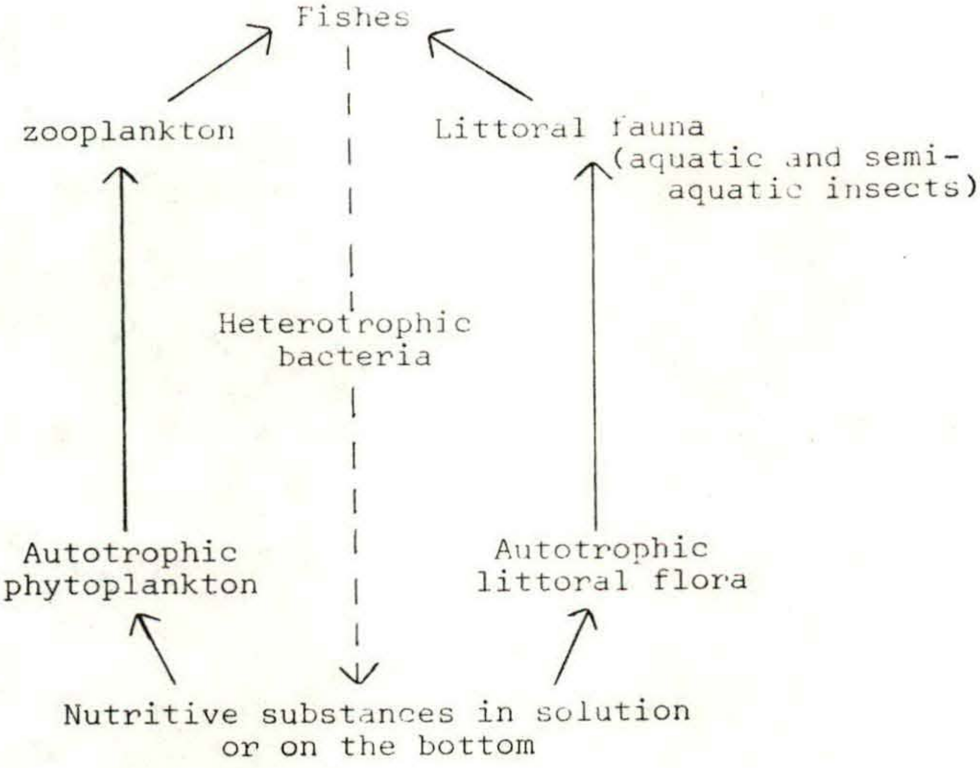
were temporarily placed in 10 percent formalin, taken to the laboratory, sorted and placed in 70 percent ethanol. Other fishpond macroinvertebrates were collected and preserved.

Identification of insects collected were made in the laboratory with dissecting and compound microscopes. Family and subfamily determinations were made with generalized keys, such as those in Merritt and Cummins (1978), Pennak (1978), and Usinger (1956). Generic and specific designations were made when specialized keys for individual taxa were available. Benthic larvae were cleared in 10 percent KOH and mounted on microscope slides to allow for accurate determinations. Early instar nymphs and most larvae could not be identified beyond the generic level because adequate species keys are not yet available. Classified specimens were placed in the Entomological Collection at Morehead State University.

RESULTS AND DISCUSSION

Management practices for fish culture ponds at Minor Clark Fish Hatchery may influence the aquatic faunal diversity in these artificial habitats. The use of herbicides, to control vascular hydrophytes and filamentous algae, limits food availability for herbivores and detritivores and minimizes microhabitats by eliminating cover. Autotrophic littoral floral reduction restricts the establishment of a diverse littoral fauna, particularly aquatic insects diversity. Figure 1 illustrates the dynamics of a typical aquatic community. In the fishpond ecosystem, fish culturist procedures disrupt this natural energy flow by restricting the biota of the littoral zone. Aquatic insect diversity is generally greatest in the littoral zone. Data presented for the 17 one-acre fishponds at Minor Clark Fish Hatchery only mimics the diverse insect fauna of natural lentic habitats.

Other benthic macroinvertebrates provide additional fish forage and compete with aquatic insects for food and cover. Gastropods were very common in ponds sampled during the summer months, but populations were noticeably reduced in fall collections. Two genera of gastropods, Helisoma and Physa, were taken from those



Simplified diagram of the dynamics of an aquatic community. Solid arrows represent constructive steps; dotted lines, reductive steps.

Figure 1. Role of Insects in Aquatic Communities.

fishponds studied. Crustaceans were found in association with the rip-rapped banks of the fishponds and decapods (crayfish) were the most common. Two species of crayfish collected could be identified, *Procambarus acutus* and *Cambarus diogenes*. Juvenile crayfish, especially the females, could not be classified. Conchostracan crustaceans (clam shrimp), Hydracarina (water mites), and the freshwater leech *Helobdella fusca* were found among samples taken from studied fishponds.

Taxonomic data generated from the study of the 17 one-acre fishponds includes five orders of aquatic insects representing 20 families and 65 species. Most of the taxa collected are characteristically found throughout most of eastern North America in lentic habitats. Taxa collected can be found in either erosional or depositional situations in lotic environments.

Four orders of aquatic insects characteristically found in lentic habitats were not collected in sampled fishponds. Megalopterans were probably eliminated by the practice of overwintering the fishponds empty, because their characteristic two-year life cycle would be disrupted by this practice. Another factor that may greatly limit the occurrence of megalopterans in fishponds is the lack of available oviposition sites.

Female megalopterans oviposit on overhanging vegetation. Trichopterans were not taken from those ponds studied; their absence may be attributed to the lack of construction materials for larval cases and/or their low tolerance for dissolved oxygen fluctuations. Lepidopterans were not collected from ponds studied. Aquatic Lepidopterans characteristically occur in ponds choked with vascular hydrophytes, and the use of herbicides in fishponds would suppress the establishment of lepidopteran populations. Lepidopterans overwinter as larvae; therefore their absence in fishponds may also be explained by the practice of overwintering the ponds empty. Aquatic hymenopterans may, or may not, occur in the Minor Clark Fish Hatchery fishponds. Sampling techniques employed did not accurately test for their presence or absence.

The aquatic insect taxa found in the sampled fishponds are represented in Table 6. These data are presented according to their occurrence in fishponds stocked with muskellunge, striped bass and forage fishes. Data for the individual ponds stocked with each type of fish are presented in the appendices. Differences in taxa between those ponds stocked with each type of fish are not considered significant.

Data show aquatic insect diversity to be greatest in the six ponds stocked with striped bass.

Table 6. Comparison of the Aquatic Insects Collected From Selected Fishponds.

Taxa	Musky	Striped Bass	Fathead Minnows	Goldfish
Odonata				
Corduliidae				
Tetragoneuria cynosura	X		X	
Epicordulia princeps	X	X	X	X
Epicordulia sp.		X		
Libellulidae				
Ladona deplanata	X			
Tramea carolina			X	
Pantala hymenea	X			
Plathemis lydia			X	
Pachydiplax longipennis	X			
Perithemis domitin				X
Aeshnidae				
Anax junius	X	X	X	
Coenagrionidae				
Enallagma geminatum		X		
Enallagma doubledayi				X
Enallagma civile		X		X
Enallagma sp.		X		X
Argia translata		X		
Ischnura posita		X	X	
Ischnura ventricalis		X		X
Ischnura sp. 1			X	X
Ischnura sp. 2		X	X	

Table 6. Continued.

Taxa	Musky	Striped Bass	Fathead Minnows	Goldfish
Ephemeroptera				
Baetidae				
Callibaetis sp.		X		
Caenidae				
Caenis sp.		X		X
Heptageniidae				
Stenonema tripunctatum		X	X	X
Hemiptera				
Notonectidae				
Notonecta undulata		X		
Notonecta raleighi			X	
Notonecta sp.		X		
Buenoa confusa			X	
Buenoa sp.		X		
Corixidae				
Trichocorixa calva		X		
Hespercorixa vulgaris		X		
Hespercorixa sp.		X		
Sigara alternata		X		
Sigara sp.		X		
Hydrometridae				
Hydrometra australis		X		
Hydrometra martini		X		

Table 6. Continued.

Taxa	Musky	Striped Bass	Fathead Minnows	Goldfish
Belostomatidae				
Belostoma lutarium		X	X	X
Belostoma sp.	X	X		
Gerridae				
Trepobates inermis				X
Gerris argenticollis		X		
Limnogonus hesione		X		
Coleoptera				
Haliplidae				
Haliplus triopsis	X		X	
Peltodytes sexmaculatus	X			
Hydrophilidae				
Berosus striatus		X		
Berosus sp.	X	X		
Tropisternus lateralis		X		
Tropisternus mixtus		X		
Tropisternus sp.		X		
Gyrinidae				
Dineutus assimilis	X	X	X	X
Dineutus discolor	X			
Dineutus sp.	X	X		X

Table 6. Continued.

Taxa	Musky	Striped Bass	Fathead Minnows	Goldfish
Dytiscidae				
Ilybius biguttulus		X		
Ilybius sp.		X		
Agabetes sp.		X		
Laccophilus maculosus	X	X	X	X
Noteridae				
Suphisellus bicolor		X		
Suphis infatus	X	X		
Diptera				
Chironomidae				
Procladius sp.	X	X		
Ablabesmyia sp.	X	X		
Clinotanypus sp.		X		
Dicrotendipes sp.		X		
Cryptochironomus sp.	X	X	X	X
Chironomus sp.	X	X		X
Polypedilum sp.	X			
Glyptotendipes sp.				X
Chaoboridae				
Chaoborus sp.	X	X	X	X
Culicidae				
Anopheles sp.		X		X

Representatives of five orders were taken from these ponds; a total of 50 species representing 18 families were collected. Ponds stocked with forage fish produced 28 species representing 5 orders and 15 families. Musky stocked ponds were the least productive. Only 19 species of insects, represented by 4 orders and 10 families, were taken from these ponds.

Differences for fishponds reported in Table 6 suggest that aquatic insect diversity for managed fishponds is dependent upon fish management practices. Striped bass fry (1.5-2.0 inches) had not attained a size sufficient at harvest to effectively prey on aquatic insects. Muskies average about 10 inches at harvest and their carnivorous habits may account for the reduction of aquatic insects. Forage minnows are detritus feeders and their feeding habits might account for the reduction in benthic larvae, particularly the chironomids. Forage fishponds were sampled during the fall and reduced diversity may reflect normal seasonal changes in fishpond biota.

Aquatic insects inhabiting the sampled fishponds represent various life cycle stages. Aquatic hemimetabolous orders, including Odonata. Hemiptera and Ephemeroptera, are aquatics as nymphs. Aquatic holometabolous orders, Coleoptera and Diptera, are aquatics as larvae. Various dipteran pupae are aquatic, as are adults of both Hemiptera and Coleoptera. Data presented in Table 7 show the life cycle stages (N=nymph; L=larvae; I=imago or adult) collected from the fishponds.

Sampling techniques employed for this study provided qualitative data for aquatic insects. Incidence is reported according to the relative abundance of species as reflected by the number of specimens collected (Table 7). Species collected 1-3 times are considered rare (R), those collected 4-6 times are considered occasional (O), and those collected 7 or more times are considered common (C). Quantitative sampling techniques were not employed.

Trophic relationships for taxa collected show that carnivores dominate the fishpond ecosystem. Fifty species reported in Table 7 are known carnivores and this imbalance in feeding types would not be expected in most ecosystems. Benke (1976) reported that predator dominated ecosystems exist in small lentic habitats and that imbalance is maintained through interspecific and intraspecific competition. Data obtained in a one year study are insufficient to make such determinations for artificial habitats.

Mayflies, order Ephemeroptera, were represented in the fishpond fauna by three species of detritus feeding

Table 7. The Relative Abundance, Stage of Life Cycle and Trophic Relationships of Aquatic Insects Collected from Selected Fishponds at Minor Clark Fish Hatchery.

Taxa	Stage of Life Cycle	Abundance	Trophic Relationships
Odonata			
Corduliidae			
Tetragoneuria cynosura	N	O	Carnivore
Epicordulia princeps	N	C	Carnivore
Epicordulia sp.	N	R	Carnivore
Libellulidae			
Ladona deplanata	N	R	Carnivore
Tramea carolina	N	R	Carnivore
Pantala hymenea	N	O	Carnivore
Plathemis lydia	N	R	Carnivore
Pachydiplax longipennis	N	O	Carnivore
Perithemis domitin	N	R	Carnivore
Aeshnidae			
Anax junius	N	C	Carnivore
Coenagrionidae			
Enallagma geminatum	N	R	Carnivore
Enallagma doubledayi	N	O	Carnivore
Enallagma civile	N	O	Carnivore
Enallagma sp.	N	O	Carnivore
Argia translata	N	R	Carnivore
Ischnura posita	N	O	Carnivore
Ischnura ventricalis	N	C	Carnivore
Ischnura sp. 1	N	O	Carnivore
Ischnura sp. 2	N	R	Carnivore

Table 7. Continued.

Taxa	Stage of Life Cycle	Abundance	Trophic Relationships
Ephemeroptera			
Baetidae			
Callibaetis sp.	N	O	Detritivore
Caenidae			
Caenis sp.	N	O	Detritivore
Heptageniidae			
Stenonema tripunctatum	N	C	Detritivore
Hemiptera			
Notonectidae			
Notonecta undulata	I	R	Carnivore
Notonecta raleighi	I	R	Carnivore
Notonecta sp.	N,I	R	Carnivore
Buenoa confusa	I	R	Carnivore
Buenoa sp.	N	R	Carnivore
Corixidae			
Trichocorixa calva	I	R	Carnivore
Hespercorixa vulgaris	I	R	Carnivore
Hespercorixa sp.	N	R	Carnivore
Sigara alternata	I	R	Herbivore
Sigara sp.	I	R	Herbivore
Hydrometridae			
Hydrometra australis	I	R	Carnivore
Hydrometra martini	I	R	Carnivore

Table 7. Continued.

Taxa	Stage of Life Cycle	Abundance	Trophic Relationships
Belostomatidae			
Belostoma lutarium	I	C	Carnivore
Belostoma sp.	N	C	Carnivore
Gerridae			
Trepobates inermis	N	C	Carnivore
Gerris argenticollis	I	R	Carnivore
Limnogonus hesione	N	R	Carnivore
Coleoptera			
Haliplidae			
Haliplus triopsis	I	R	Herbivore
Peltodytes sexmaculatus	I	R	Herbivore
Hydrophilidae			
Berosus striatus	I	R	Herbivore
Berosus sp.	L	C	Carnivore
Tropisternus lateralis	I	O	Herbivore
Tropisternus mixtus	I	R	Herbivore
Tropisternus sp.	L	R	Carnivore
Gyrinidae			
Dineutus assimilis	I	C	Carnivore
Dineutus discolor	I	R	Carnivore
Dineutus sp.	L	C	Carnivore

Table 7. Continued.

Taxa	Stage of Life Cycle	Abundance	Trophic Relationships
Dytiscidae			
Ilybius biguttulus	I	R	Carnivore
Ilybius sp.	L	C	Carnivore
Agabetes sp.	L	C	Carnivore
Laccophilus maculosus	I	C	Carnivore
Noteridae			
Suphisellus bicolor	I	R	Carnivore
Suphis infatus	I	C	Carnivore
Diptera			
Chironomidae			
Tanypodinae			
Procladius sp.	L	C	Carnivore
Ablabesmyia sp.	L	R	Carnivore
Clinotanypus sp.	L	R	Carnivore
Chironominae			
Dicrotendipes sp.	L	R	Herbivore
Cryptochironomus sp.	L	C	Carnivore
Chironomus sp.	L	C	Herbivore
Polypedilum sp.	L	C	Herbivore
Glyptotendipes sp.	L	R	Herbivore
Chaoboridae			
Chaoborus sp.	L	O	Carnivore
Culicidae			
Anopheles sp.	L	R	Detritivore

nymphs. Mayfly nymphs would be beneficial to fishpond culture, but fishpond construction does not provide sufficient habitat to allow for the establishment of diverse mayfly populations.

Aquatic dipterans were represented in the fishpond fauna by three families which were collected as larvae. Diversity was not as great as expected, except for the family Chironomidae. Chironomid larvae serve as a valuable food source for micropredators and are beneficial to fishpond ecosystems. The reason for the absence of some dipteran families, Tipulidae and Tabanidae, is not clear, but it is probable that fish management practices are at least partially responsible for the absence. The dipteran larvae Chaoborus, a zooplankton feeder, was taken from several ponds (Appendices) and these larvae are not normally considered beneficial fishpond fauna. Chaoborids compete with small fish fry for available zooplankton and may become pests in ponds that support high population densities.

Odonates were the most diverse group of aquatic insects collected in the fishponds; nineteen species of dragonflies and damselflies were collected. Damselflies were most common in striped bass ponds where their natural food, zooplankton, should have been abundant as a result of fish management practices. Dragonfly nymphs were taken from all sampled ponds, but showed their greatest diversity in those ponds stocked with muskies. Dragonfly nymphs are opportunistic, sprawling macropredators that have the ability to successfully feed on small fish. The importance of fish to the odonate diet is unknown and Wilson (1920) stated that odonate nymphs are not important pests, but are beneficial to fish management practices by eliminating other competitive invertebrates. Species collected have not been determined to be piscivores, but large nymphs such as _Anax junius_ and _Epicordulia princeps_ are large enough to be piscivorous. Nymphs of both species were common in fishponds at Minor Clark Fish Hatchery.

Hemipteran diversity was second to that of the Odonates. Aquatic hemipterans were collected as adults and/or nymphs, with 5 families and 17 species represented in the fishpond fauna. Hemipterans readily invade temporary ponds since the adult forms are aquatic, but establishment and diversity for most species is dependent upon the presence of vegetated habitats. Non-vegetated habitats, such as fishponds, do not provide sufficient cover to support stable populations of hemipterans. Data from Table 6 show that 14 species of hemipterans were taken from striped bass ponds while only 1 species was found in musky stocked ponds.

Species from striped bass ponds included both swimmers and skaters; the single species collected in the musky pond was a swimming form. These data show the importance of vegetation as cover for aquatic hemipterans and clearly reflect the problems encountered in nonvegetated, predator dominated communities. None of the hemipterans collected at Minor Clark Fish Hatchery have been determined to be piscivores, but some belostomatids have been shown to feed effectively on fish; therefore, *Belostoma lutarium* may be a fish-eating hemipteran. Nymphs and adults of *Belostoma lutarium* were among the most common insects in those fishponds sampled.

It was expected that representatives of Coleoptera would be the most common and diverse aquatic insects in the fishpond ecosystem at Minor Clark Fish Hatchery. Only 16 species of beetles, representing 5 families were found in the managed fishponds (Table 6). These data show that aquatic beetles were most successful in striped bass ponds and that musky ponds had significantly reduced beetle populations. Adult beetles are known to be among the first invaders of newly formed bodies of water, but establishment of stable populations may be influenced by several factors such as available food and cover. The lack of cover in fishponds clearly influenced coleopteran diversity, but not as drastically as it influenced hemipteran presence (Table 6). Beetle species collected were mainly micropredators that were fed upon by macropredators, and reduced cover may have limited food abundance by restricting prey populations. Aquatic beetles would also fall prey more readily to predaceous fish in habitats without cover. These data, for Coleoptera and Hemiptera, show that fish management strategies at Minor Clark Fish Hatchery influence species diversity for aquatic insects.

Two species of beetles, a gyrinid and a dytiscid, were among the most numerous aquatic insects in sampled fishponds. The gyrinid Dineutus assimilis, a gregarious skater-swimmer, was taken from 15 fishponds. Dineutus larvae have been observed feeding on fish fry in stressed environments, but these forms are not generally viewed as pests by fish culturists. Detailed studies of gyrinid life cycles and trophic relationships must be made if we are to understand their importance to fishpond culture. Some larval dytiscids and hydrophilids have been shown to be piscivores and their presence in fishponds is considered detrimental by fish culturists. Although both families were well represented in hatchery ponds, species known to be pests were not taken. Laccophilus maculosus, a common dytiscid, was taken from 15 of the sampled fishponds, but these micropredators do not attain a size sufficient to feed on fish fry.

CONCLUSION

Aquatic insect diversity in sampled fishponds at Minor Clark Fish Hatchery was not as great as expected for small lentic habitats. These artificial habitats provide stressed environments for aquatic macroinvertebrates as a result of methods employed in fishpond culture. Fluctuating levels of dissolved oxygen and temperature variations are not the primary limiting factors for fishpond insects, because both elements are partially controlled through fish culture practices. The stressed environments restrict establishment of diverse faunal communities through the reduction of suitable habitat and by limiting food availability. Predation pressure exerted on insect fauna by large numbers of carnivorous fish further restricts aquatic insect diversity. Ponds support a greater diversity of aquatic insects when fish fry have not attained a size sufficient for feeding on macroinvertebrates. Habitats densely populated with fish capable of exploiting insects as food support marginal communities. These communities are replenished and maintained through the immigration of adult insects from adjacent ecosystems which provide a source of newly hatched immatures. The short life cycles of most aquatic insects facilitate such maintenance.

The 65 species of insects inhabiting the 17 one-acre fishponds include common and widely distributed representatives of the macroinvertebrate biota of eastern North America. Odonates, aquatic hemipterans, and aquatic coleopterans were the dominant faunae in sampled ponds; aquatic dipterans and ephemeropterans were present, but few species were collected. Odonate incidence is considered as being natural for small lentic habitats since fish management practices do not directly restrict the occurrence of benthos. Sprawling odonate nymphs may, however, be more readily preyed upon by fishes due to the lack of cover and high predator density in some fishponds. Diversity of aquatic bugs and beetles was not as great as expected for small lentic habitats. Predation pressures from fishes and other macroinvertebrates are increased through the practices of fish culturists. The littoral zone of small ecosystems, characteristically dominated by aquatic coleopterans and hemipterans, is virtually eliminated through the use of herbicides in fishponds. Fishpond habitats could be considered as being limnetic because of the absence of littoral flora. Limnetic life zones do not support diverse communities of aquatic insects.

Management practices at Minor Clark Fish Hatchery that promote fish culture, restrict aquatic insect diversity in these artificial ecosystems. Aquatic insects known to be pests to fish culture were not present in collected data, suggesting that management practices employed to control destructive biota was successful. Potential pests were present, but their determination as probable piscivores has not been made.

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APPENDICES

Appendix A
Aquatic Insects Collected From Selected Fishponds Stocked With *Esox masquinongy* Fry.

Taxa	Pond 32	Pond 24	Pond 63	Pond 61	Pond 43	Pond 44
Odonata						
Corduliidae						
Tetragoneuria cynosura			X	X		X
Epicordulia princeps			X	X		X
Libellulidae						
Ladona deplanata			X			
Pachydiplax longipennis				X		
Plathemis hymenea						X
Hemiptera						
Belostomatidae						
Belostoma sp.		X				
Coleoptera						
Noteridae						
Suphis infatus				X		
Haliplidae						
Haliplus triopsis						X
Peltodytes sexmaculatus						X
Hydrophilidae						
Berosus sp.					X	
Gyrinidae						
Dineutus assimilus	X	X	X	X	X	X
Dineutus sp.	X	X	X	X	X	X

Appendix A. Continued.

Taxa	Pond 32	Pond 24	Pond 63	Pond 61	Pond 43	Pond 44
Dytiscidae						
Laccophilus maculosus		X	X	X	X	X
Diptera						
Chironomidae						
Procladius sp.	X					X
Ablabesmyia sp.					X	
Cryptochironomus sp.					X	X
Chironomus sp.			X			X
Polypedilum sp.		X			X	X
Chaoboridae						
Chaoborus sp.						X

Appendix B
Aquatic Insects Collected From Selected Fishponds Stocked With *Morone saxatilis* Fry.

Taxa	Pond 80	Pond 81	Pond 50	Pond 59	Pond 78	Pond 20
Odonata						
Corduliidae						
Epicordulia princeps					X	
Epicordulia sp.				X		
Libellulidae						
Pantala hymenea			X			
Aeshnidae						
Anax junius	X				X	
Coenagrionidae						
Enallagma geminatum		X				
Enallagma civile						X
Ischnura posita	X	X				
Ischnura ventricalis	X		X	X		
Enallagma sp.		X				
Ischnura sp. 2					X	
Argia translata	X					
Ephemeroptera						
Baetidae						
Callibaetis sp.	X	X		X	X	
Caenidae						
Caenis sp.					X	

Appendix B. Continued.

Taxa	Pond 80	Pond 81	Pond 50	Pond 59	Pond 78	Pond 20
Heptageniidae						
Stenonema tripunctatum					X	
Hemiptera						
Notonectidae						
Notonecta sp.	X	X				
Buenoa sp.	X					
Notonecta undulata	X					
Corixidae						
Trichocorixa calva	X		X			
Hespercorixa vulgaris				X		
Hespercorixa sp.	X					
Sigara alternata	X			X		
Sigara sp.						X
Hydrometridae						
Hydrometra australis					X	X
Hydrometra martini	X					
Gerridae						
Gerris argenticollis	X				X	
Limnogonus hesione		X				
Belostomatidae						
Belostoma lutarium		X	X			X
Belostoma sp.	X		X	X		X

Appendix B. Continued.

Taxa	Pond 80	Pond 81	Pond 50	Pond 59	Pond 78	Pond 20
Hydrophilidae						
Berosus striatus				X		
Coleoptera						
Noteridae						
Suphisellus bicolor	X					
Suphis infatus					X	
Hydrophilidae						
Berosus striatus			X			
Berosus sp.		X	X	X		
Tropisternus mixtus						X
Tropisternus lateralis	X	X	X			
Tropisternus sp.				X		
Gyrinidae						
Dineutus assimilus	X	X	X	X	X	X
Dineutus sp.	X		X	X	X	X
Dytiscidae						
Ilybius biguttulus					X	
Ilybius sp.	X	X		X		X
Agabetes sp.	X	X	X			
Laccophilus maculosus	X	X	X	X	X	X

Appendix B. Continued.

Taxa	Pond 80	Pond 81	Pond 50	Pond 59	Pond 78	Pond 20
Diptera						
Chironomidae						
Procladius sp.	X		X			X
Ablabesmyia sp.			X			
Clinotanypus sp.				X		
Dicrotendipes sp.						X
Cryptochironomus sp.	X					X
Chironomus sp.				X		X
Chaoboridae						
Chaoborus sp.						X
Culicidae						
Anopheles sp.	X					

Appendix C
Aquatic Insects Collected From Selected Fishponds Stocked With Broodfish of *Carassius auratus* and *Pimephales Promelas*.

Taxa	Pond 10	Pond 76	Pond 49	Pond 30	Pond 79
Odonata					
Corduliidae					
Tetragoneuria cynosura					X
Epicordulia princeps		X			X
Libellulidae					
Tramea carolina					X
Plathemis lydia					X
Perithemis domitin	X				
Aeshnidae					
Anax junius					X
Coenagrionidae					
Enallagma doubledayi			X		
Enallagma civile					X
Ischnura posita				X	
Ischnura ventricalis			X		
Ischnura sp. 1	X			X	
Ischnura sp. 2					X
Enallagma sp.	X				
Ephemeroptera					
Caenidae					
Caenis sp.			X		

Appendix C. Continued.

Taxa	Pond 10	Pond 76	Pond 49	Pond 30	Pond 79
Heptageniidae					
Stenonema tripunctatum		X			X
Hemiptera					
Notonectidae					
Notonecta raleighi				X	
Buenoa confusa					X
Gerridae					
Trepobates inermis	X				
Belostomatidae					
Belostoma lutarium	X		X	X	X
Coleoptera					
Haliplidae					
Haliplus triopsis				X	
Gyrinidae					
Dineutus assimilus	X		X		X
Dineutus sp.			X		
Dytiscidae					
Laccophilus maculosus	X	X	X	X	

Appendix C. Continued.

Taxa	Pond 10	Pond 76	Pond 49	Pond 30	Pond 79
Diptera					
Chironomidae					
Cryptochironomus sp.	X			X	
Chironomus sp.	X				
Glyptotendipes sp.			X		
Chaoboridae					
Chaoborus sp.	X			X	
Culicidae					
Anapheles sp.	X				