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The Effects of Pool Size on the Microinvertebrate Populations of Chaney Lake, an Ephemeral Wetland located in Bowling Green, Kentucky

Shannon Gaines
Western Kentucky University

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Shannon Gaines
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Abstract

Studies concerning the microinvertebrate communities of differing pool sizes were conducted at Chaney Lake, an ephemeral, karst wetland located in Bowling Green, Kentucky. As the lake begins to dry in the early summer, smaller, isolated ponds begin to form. Several ponds of various sizes were marked for analysis. Microinvertebrate samples and physiochemical readings were taken at each of the sites and were counted in the lab. T-tests were performed on the samples to determine if the microinvertebrate densities differed between ponds that dried later in the season as opposed to those that dried earlier. Ostracoda densities of the late dry ponds were significantly higher than the densities for the early dry ponds for the second sampling date, suggesting that ponds that hold water longer may have higher densities of microinvertebrates. *Bosmina* and *Diaphanasoma* densities tended to show the same trends, but large standard errors caused these differences to be deemed insignificant. Food and space availability would likely become limiting sooner in the early dry ponds, a situation which could explain the larger increase in numbers of Ostracods for the late dry ponds.

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Introduction

A swamp, as defined by Penfound (1952), is a woody community occurring in an area where the soil is usually saturated with water or covered with surface water for one or more months of the growing season. According to Ziser (1978), swamplands are usually found in low-lying areas, and their water levels tend to fluctuate drastically over a season. These water level fluctuations often subject swamplands to large variations in their water chemistry and pH. Swamplands are also characterized by standing water which either reduces or completely eliminates the hydrologic exchange of nutrients and minerals between the swampland and other areas such as lakes and other open regions of water (Wenner and Beatty, 1988). Swamplands are extremely abundant and are found throughout the continental United States; however, in recent years, many swampland habitats have been drained for agricultural purposes, municipal expansion, and industrial development. Less than 46% of the original wetlands at the time of European settlement remain in the conterminous United States (Broschart and Linder, 1986). Other threats to swamplands include pollution because of waste runoff from farms and chemical runoff from roadways. This is a major dilemma because wetland habitats are critical to many wildlife species, particularly migratory

waterfowl. These areas are essential to adult and juvenile waterfowl during egg-laying and brood-rearing (Bataille and Baldassarre, 1993).

Although swamplands are common and widespread, they have been little studied. Recent advances in aquatic invertebrate ecology have emphasized the processes underlying community structure and organization. However, scientific understanding of the mechanisms controlling the dynamics of wetland invertebrate communities has lagged behind that of other systems (Neckles et al., 1990).

Chaney Lake is a Kentucky State Nature Preserve that is located on 31W in Bowling Green, Kentucky. Chaney Lake is a unique ecosystem that sits atop the Lost River Cave system. This cave system is composed of a karst, or limestone, substrate, and the limestone is so porous that multiple connections have been forged between the cave system and the lake. This type of geology is not very common among swamp-like habitats because limestone normally does not hold water very well. However, in Chaney Lake, the limestone substrate is covered with a chert layer. Chert, a type of silica containing microcrystalline quartz, is impermeable to water, and it helps hold water in the Chaney Lake basin. Chaney Lake is an ephemeral lake, meaning that it is only temporary in nature because it fills with water during the winter and then dries over the summer. The lake fills with water because of surface water runoff and because of water bubbling from estavelles, which are openings into the water-filled cave system located below the lake.

Chaney Lake can be divided into five main habitats. These include the Central Marsh, the Sweet Gum Area, the West Basin, the East Basin, and the Open Field. The

Central Marsh is an area that is inundated with water for the majority of the year. Thus, not many woody plants grow in this area, and only plants that are well adapted to aquatic habitats are found here. The Sweet Gum Area is a very woody area that was previously cleared to be used as farmland but is now slowly reverting back to forest. The East Basin and the West Basin are separated from each other by the Sweet Gum Area, but these two areas are similar in regard to their physical habitats. Both basins host basically the same types of plant life including several species of oak trees. The Open Field contains plants such as cockleburs. The Open Field also contains a large ditch, an attempt to direct water off the land during flooded periods. This attempt failed, but the ditch still remains.

Because Chaney Lake is an ephemeral pond, it continually fills with water and then dries. After the lake initially fills with water, it is one large lake or system, and as the lake begins to dry, it forms many smaller, ephemeral ponds in lower-lying areas. These ponds are isolated habitats which are surrounded by an inhospitable, dry terrain (Jeffries, 1994). Thus, they impose rigorous conditions upon the organisms which live in them (Hartland-Rowe, 1966). For a pond to form, a combination of factors must be present. For example, a depression in the terrain with neither a permanent inlet or outlet must exist. A source of water is also essential, and finally, the ground must have poor drainage and a relatively impermeable substrate to hold the water until it evaporates (DesMeules and Nothnagle, 1997).

The purpose of this study is to observe how the habitats and communities of the ponds that dry ealier in the season differ from the ponds that dried later in the season.

The drying season lasts from early summer until the entire habitat is dry. These observations will then be used to test the null hypothesis, H_o, which states that no variations will be noted between the physiochemical readings or the densities of the microinvertebrate populations for the differing ponds over the drying season.

Previous research on the subject of ephemeral ponds suggests that seasonal ponds in every region of the country tend to function in similar ways. The particular species that inhabit these ponds may vary from site to site, but certain organisms are common to all of these habitats (DesMeules and Nothnagle, 1997). Some examples of microinvertebrates normally found in ephemeral ponds include such organisms as various types of Cladocera, Copepoda, Ostracoda, and Colicidae (Bataille and Baldassarre, 1993). Research also suggests that invertebrates that are found in these types of habitats must possess various adaptive mechanisms in at least one stage of their life cycle in order to survive the dry conditions that are present throughout parts of the year (Hartland-Rowe, 1966).

The motive for performing this experiment is to help the Kentucky State Nature Preserves Commission characterize the habitats of Chaney Lake. This habitat characterization will then be used to help the Kentucky State Nature Preserves Commission develop a management plan to be implemented at Chaney Lake.

Materials and Methods

FIELD SAMPLING

All sampling took place in the area surrounding the Central Marsh. This area had previously been divided into several smaller transects that measured approximately thirty to forty meters in length. When the isolated ponds began to form, several of these transects around the Central Marsh were randomly generated. If an isolated pond was located in the vicinity of the transect, it was marked for further analysis. However, if no isolated pond was found, an alternate transect was randomly generated. The ponds were marked with PVC piping, which was hammered into the ground and then marked with orange flagging and numbered.

Sampling at these ponds occurred on three dates, June 12th, June 23rd, and July 7th, until the ponds dried. Three of the marked ponds were of a smaller size. These ponds dried before the July 7th sampling date and were grouped as early dry ponds. Obviously, these three ponds were not sampled on July 7th because no water was left from which to obtain samples. The other three ponds that were sampled were larger in size and dried after the July 7th sampling date, and they were, therefore, grouped as late dry ponds.

At each site, physiochemical parameters and invertebrate populations were assessed. The water parameter readings, including temperature, pH, turbidity, dissolved oxygen (DO), percent dissolved oxygen (DO%), and specific conductivity, were measured with a 6250 YSI Multi-Probe. The water level at each site was measured, and if the water level was under fifty centimeters deep, the readings with the YSI were taken at approximately mid-depth. However, if the water level was over fifty centimeters deep, one reading was taken near the surface and another was taken near the bottom. The invertebrate populations were measured by taking samples at each site using a seven-centimeter diameter Spencer Corer which had a volume of ten liters. These specimens were preserved in 90% ethanol. Since Chaney Lake is a nature preserve, only a limited number of invertebrate specimens could be taken back to the lab for further analysis.

LABORATORY ANALYSIS

At the lab, the samples were sorted into their taxonomic groups using an invertebrate key (Pennak, 1989). One-half of each sample was counted as a subsample. Each organism was identified to the family level with the aid of a microscope. Organisms were stored again in 90% ethanol for future identification to the species level.

DATA ANALYSIS

The means and the standard errors of each taxonomic group and of the water parameters for the early and late dry ponds were determined using SYSTAT. The two-tailed t-test was employed to determine whether any significant differences existed

between taxon abundance for the early versus the late dry ponds. T-scores were judged to be significant at the $p \leq 0.05$ level. These tests were only performed on those taxon which were present at all of the pond sites. Graphs were then derived for each of these taxon by plotting the data for the early dry ponds versus the data for the late dry ponds. The number of individuals per ten liters were plotted for both the June 12th and the July 23rd sampling dates, and a straight line was then drawn between these two points to see any trends that might exist. The July 7th sampling date was not included on the graph because the early dry ponds were already dry by this date. Two-tailed t-tests were also run on the water parameters to see if these differed significantly between the early and the late dry ponds.

Results

TAXONOMIC COMPOSITION

Table 1: Mean values and standard errors of major taxa collected on June 12th, June 23rd, and July 7th.

Taxa (Family)	Date	Pond Type	Mean Value (#/10L)	Std Error
Rotifera	June 12th	Early Dry	93.3	61.5
		Late Dry	175.7	106.0
	June 23rd	Early Dry	42.7	10.4
		Late Dry	106.7	55.1
	July 7th	Early Dry	------	------
		Late Dry	2565.3	1164.5
Bosmina	June 12th	Early Dry	14.7	3.5
		Late Dry	26.0	11.0
	June 23rd	Early Dry	9.3	4.4
		Late Dry	183.3	108.9
	July 7th	Early Dry	------	------
		Late Dry	120.7	112.8
Ostracoda	June 12th	Early Dry	49.3	18.5
		Late Dry	166.7	67.6
	June 23rd	Early Dry	166.7	60.9
		Late Dry	440.0	70.2
	July 7th	Early Dry	------	------
		Late Dry	89.3	58.1

Table 1: cont.

Taxa (Family)	Date	Pond Type	Mean Value (#/10L)	Std Error
Diaphanasoma	June 12th	Early Dry	13.3	5.3
		Late Dry	9.3	4.8
	June 23rd	Early Dry	22.7	5.7
		Late Dry	58.7	21.8
	July 7th	Early Dry	-----	-----
		Late Dry	1650.7	1336.2
Cyclopoida	June 12th	Early Dry	15.3	5.2
		Late Dry	27.3	19.3
	June 23rd	Early Dry	77.3	28.8
		Late Dry	68.0	18.3
	July 7th	Early Dry	-----	-----
		Late Dry	693.3	369.7

Table 2: Frequency of occurrence and density of aquatic microinvertebrates (presented as percent of total) collected from early and late dry ponds at Chaney Lake for the sampling dates June 12th and June 23rd.

	Early Dry	Early Dry	Late Dry	Late Dry
Taxa	Av. Frequency %	Av. Density %(#/L)	Av. Frequency %	Av. Density % (#/L)
Rotifera	11.1	11.2	9.8	9.8
Bosmina	2.0	2.0	7.3	7.3
Ostracoda	53.2	53.3	63.3	63.3
Diaphanasoma	8.9	8.9	7.1	7.1
Cyclopoida	22.8	22.9	9.9	9.9
Diptera	0.77	0.77	0.39	0.40
Gastropoda	0.05	0.05	0.09	0.09
Nauplii	0.60	0.61	2.0	2.0
Juv. Arthropoda	0.21	0.21	0.00	0.00
Isopoda	0.05	0.05	0.05	0.05
Corixidae	0.00	0.00	0.02	0.02
Ephemeroptera	0.05	0.05	0.02	0.02

Twelve taxa of microinvertebrates were collected; however, five taxonomic groups accounted for 98.3% and 97.4% of the density for the early dry ponds and late dry ponds, respectively. Therefore, these were the only groups used in calculations. The taxonomic composition did not differ greatly between the early and late dry ponds -- with two notable exceptions being the ostracods and the cyclopoids. The ostracods tended to be more common in the late dry ponds, while the cyclopoids were more frequent in the early dry ponds. The t-tests that were run to find significant differences between the two pond types showed no significant differences for the June 12th sampling date for any of the groups studied. However, the t-tests for the June 23rd sampling date did show a significant difference in the ostracod densities with higher numbers of ostracods in the late dry ponds as compared to the early dry ponds. The t-score was significant (p=0.042), but the t-tests for the other taxonomic groups did not show a significant difference for this sampling date. No t-tests were performed on the July 7th sampling date data because the early dry ponds were already dry by this time.

The following graphs depict both the population trends for the early and the late dry ponds that each major taxon demonstrated from the June 12th to the June 23rd sampling dates. The July 7th sampling date is not included on the graph because the taxon densities measured on this date for the late dry ponds were so much larger than those measured on the two earlier sampling dates. Thus, the large density for this sampling date would make it very difficult to see any trends between the two earlier sampling dates.

Figure 1: Trends seen for Rotifera at the early dry ponds plotted against those seen for the late dry ponds for the June 12th and June 23rd sampling dates.

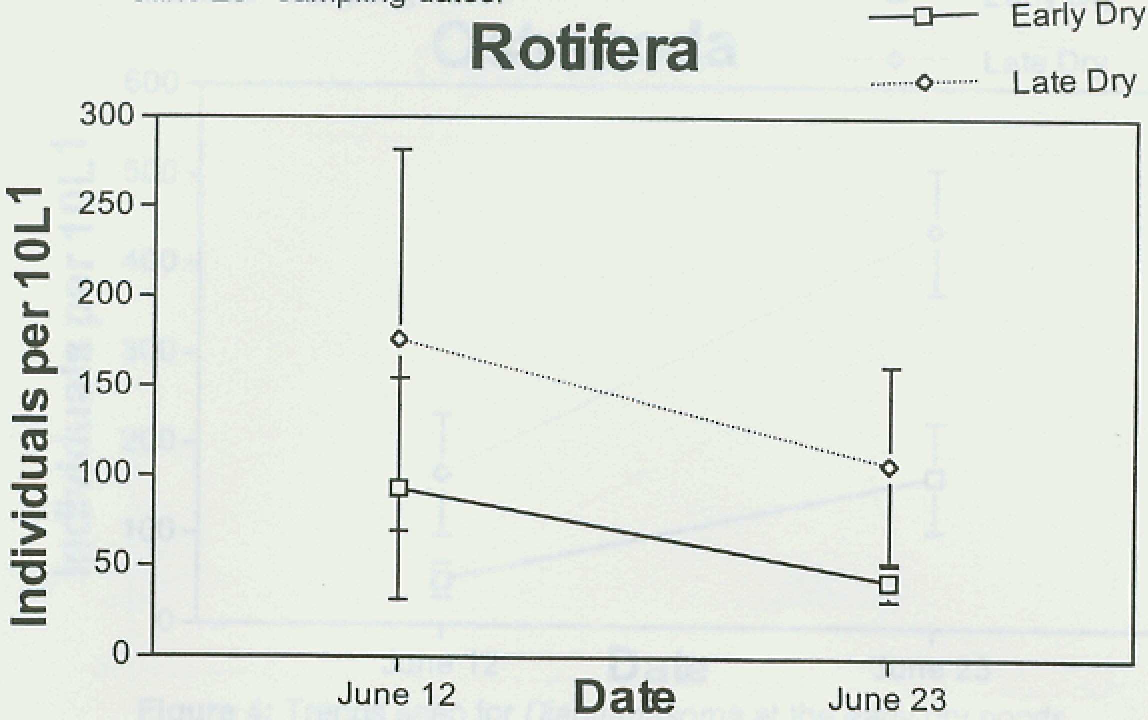


Figure 2: Trends seen for *Bosmina* at the early dry ponds plotted against those seen at the late dry ponds for the June 12th and June 23rd sampling dates.

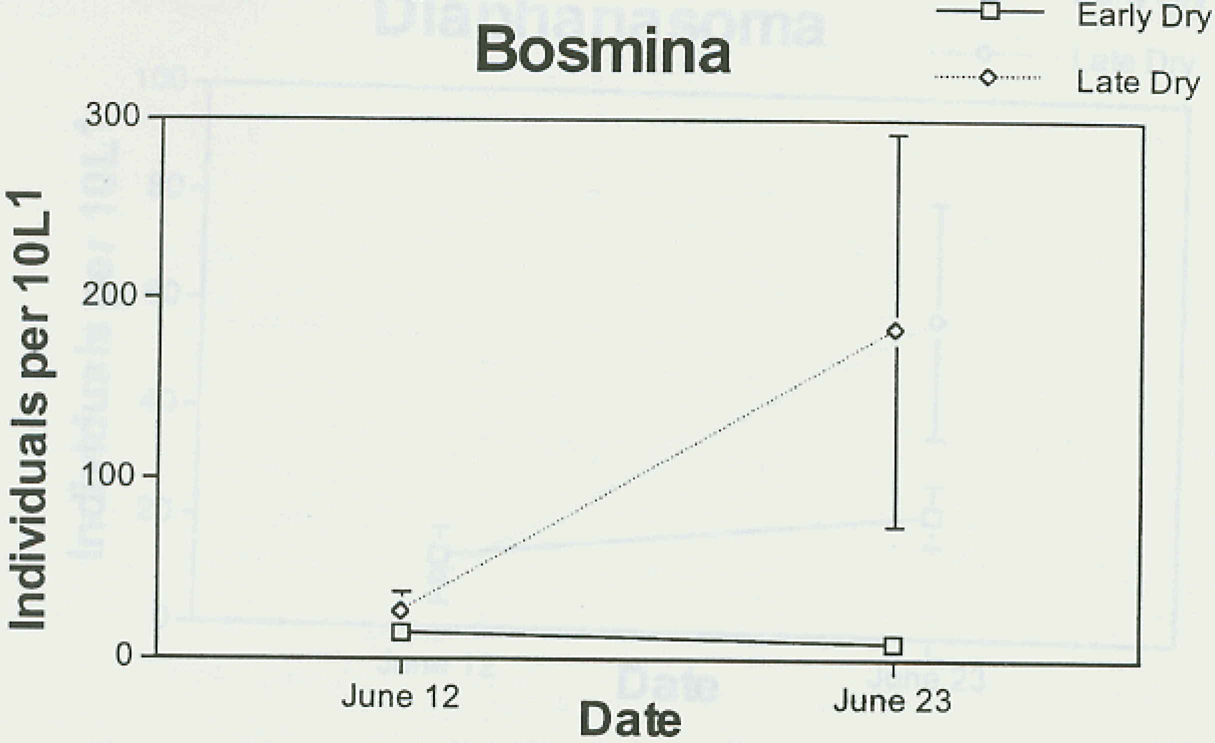


Figure 3: Trends seen for Ostracoda at the early dry ponds plotted against those seen at the late dry ponds for the June 12th and the June 23rd sampling dates.

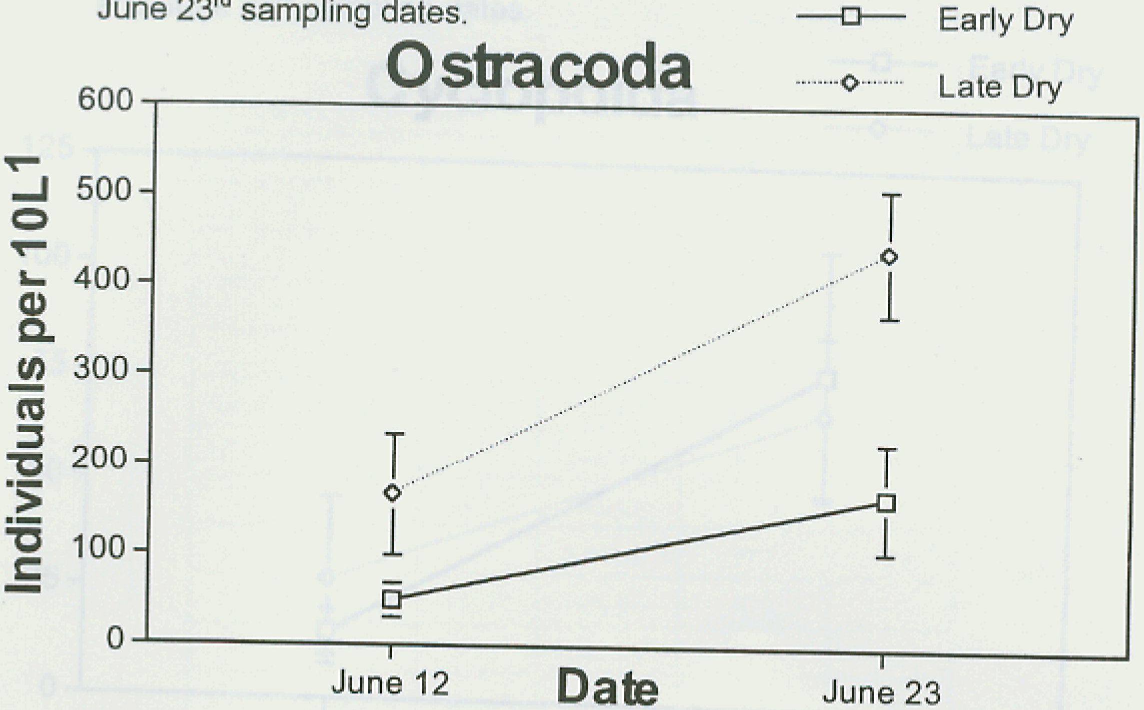


Figure 4: Trends seen for *Diaphanasoma* at the early dry ponds plotted against those seen at the late dry ponds for the June 12th and June 23rd sampling dates.

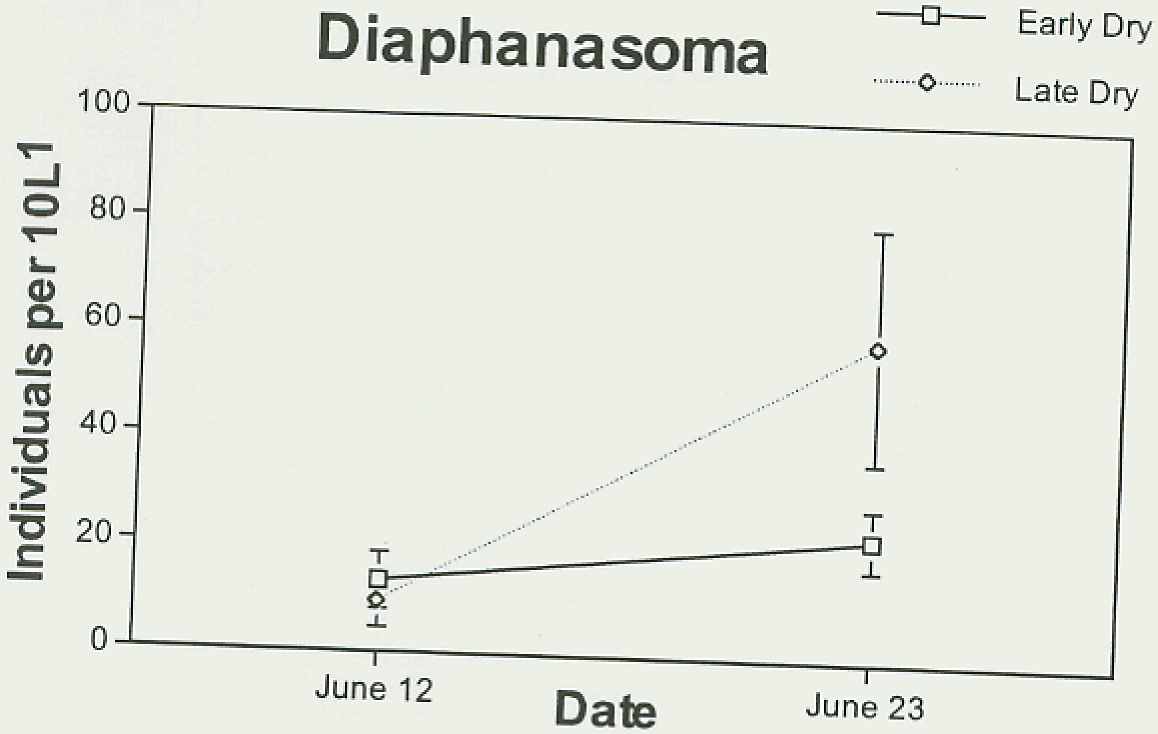
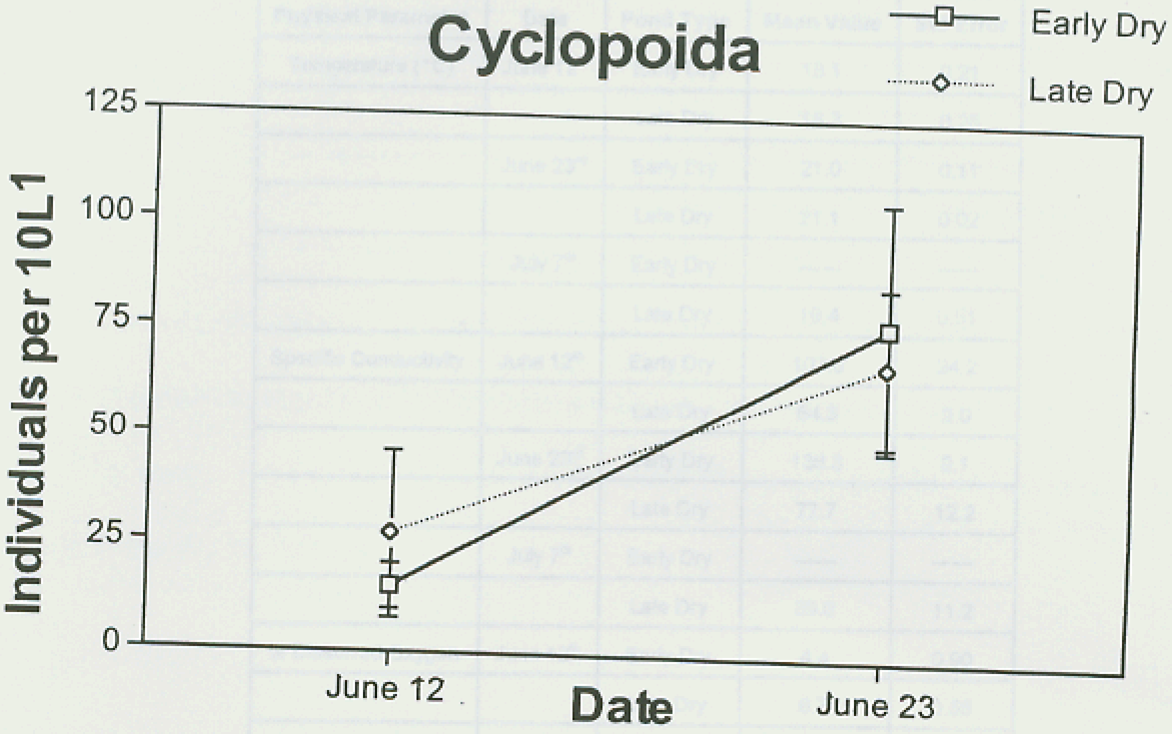


Figure 5: Trends seen for Cyclopoida at the early dry ponds plotted against those seen at the late dry ponds for the June 12th and June 23rd sampling dates.



PHYSICAL PARAMETERS

Table 3: Mean values and standard errors of physical parameters tested on three sampling dates.

Physical Parameter	Date	Pond Type	Mean Value	Std Error
Temperature (°C)	June 12th	Early Dry	18.1	0.21
		Late Dry	18.3	0.28
	June 23rd	Early Dry	21.0	0.11
		Late Dry	21.1	0.02
	July 7th	Early Dry	------	------
		Late Dry	19.4	0.51
Specific Conductivity	June 12th	Early Dry	103.0	24.2
		Late Dry	64.3	9.0
	June 23rd	Early Dry	136.3	9.1
		Late Dry	77.7	12.2
	July 7th	Early Dry	------	------
		Late Dry	39.0	11.2
% Dissolved Oxygen	June 12th	Early Dry	4.4	0.90
		Late Dry	6.7	0.58
	June 23rd	Early Dry	9.5	3.2
		Late Dry	12.6	3.6
	July 7th	Early Dry	------	------
		Late Dry	11.1	1.7
Dissolved Oxygen	June 12th	Early Dry	0.42	0.09
		Late Dry	0.61	0.06
	June 23rd	Early Dry	0.71	0.17
		Late Dry	1.1	0.28
	July 7th	Early Dry	------	------
		Late Dry	1.0	0.14
pH	June 12th	Early Dry	5.7	0.09
		Late Dry	5.7	0.08
	June 23rd	Early Dry	5.8	0.21
		Late Dry	5.9	0.32
	July 7th	Early Dry	------	------
		Late Dry	6.0	0.10

Table 3: cont.

Physical Parameter	Date	Pond Type	Mean Value	Std Error
Turbidity	June 12th	Early Dry	28.0	11.7
		Late Dry	34.3	1.3
	June 23rd	Early Dry	48.5	23.0
		Late Dry	56.8	21.9
	July 7th	Early Dry	------	------
		Late Dry	48.8	26.4

The t-tests comparing the physical parameter data for the early and late dry ponds showed no significant differences between the water parameters for any sampling date. No t-tests were run on the July 7th sampling date because the early dry ponds were dry by this date.

Discussion

The null hypothesis, H_o, was partially supported because no significant differences were noted between the early and late dry ponds in regard to their physical habitats. According to previous research, the absence of significant environmental differences between study sites, in this case the early and late dry ponds, suggests that habitat features may have had less influence on population densities between the two sites than did the life-history traits intrinsic to the resident organisms (Neckles et al., 1990). The life histories of the organisms captured in the two pond types may be a key in understanding why a significant difference was observed between the ostracod densities in the two pond types.

Ostracods are generalists, that is, they are suited to live in many different types of aquatic environments. However, because they are generalists, they are not adapted to any one specific type of environment such as ephemeral habitats. Thus, it is logical to assume that the ostracods are not specifically adapted to Chaney Lake because it is an ephemeral system. Ostracods may be more affected by the changing environmental conditions of the drying ponds than an organism specifically adapted to ephemeral habitats. This effect from changing environmental conditions can be seen in Figure 3,

which shows that the ostracod densities in the late dry ponds increased more than those for the early dry ponds. Differences in the water parameters were not responsible for this observation because the results showed that the water parameters did not differ significantly between the two pond types. This smaller increase in density for the early dry ponds was probably because certain environmental factors such as food and space availability presumably became limiting sooner in the early dry ponds. As the water in the ponds began to evaporate, the organisms in the ponds were crowded into smaller spaces. These crowded conditions probably led to shortages in the food supply. Initially, predators would be more likely to find prey because of the crowded condition, but as the numbers of prey diminished, some predators would plausibly die of starvation. When the factors started to become limiting, the ostracods would probably have ceased to lay eggs which would hatch during the current season and would have presumably begun to lay diapausing eggs, eggs which would have been in a resting stage and very resistant to environmental conditions such as drying. The eggs would likely hatch the next season, when the lake began to fill with water. This part of their life history, therefore, may account for the smaller increase in ostracods for the early dry ponds. The ostracods in the late dry ponds would also eventually begin to lay diapausing eggs, but they would lay these eggs later than the ostracods in the early dry ponds because the factors would become limiting later than they would for the early dry ponds. This helps to account for the larger increase in ostracod density for the late dry ponds.

The *Bosmina* and the *Diaphanasoma* also show the same trends in their graphs,

Figures 2 and 4, respectively, that the ostracods showed in their graph. They probably show this same trend because, like the ostracods, they are both generalists. The densities in the late dry ponds increase more than those for the early dry ponds. The *Bosmina* density for the early dry ponds actually decreased slightly. The reasons for this larger increase in the densities for the late ponds as compared to the early dry ponds are probably the same as those for the ostracods. Because the environmental factors would likely become limiting sooner in the early dry ponds, the organisms would probably lay their diapausing eggs earlier. These two groups showed the same trend as the ostracods, but the density difference between the early and the late dry ponds was not deemed significant, possibly because of large standard errors.

The rotifers, Figure 1, showed the same basic trend for both the early and the late dry ponds. The densities for both pond types decreased at basically the same rate. This parallel decrease is most likely due to the high reproductive rate and short generation time of the rotifers. Since they lay eggs much more frequently than most other microinvertebrates, they may begin to lay their diapausing eggs sooner than other microinvertebrates. The rotifer's short generation time may also cause them to lay their diapausing eggs at about the same time in both the early and late dry ponds. These suggestions possibly account for the decrease in the rotifer density for both pond types. Also, rotifers are usually preyed on by other microinvertebrates because of their smaller size, and as the amount of water in the ponds begins to decrease, all of the organisms living in the ponds will be crowded together in a smaller space. Therefore, it will become more likely for the rotifers to encounter their predators. This fact could

also play a major role in the decrease in rotifer densities for both pond types.

The density for Cyclopoida increased for both pond types (Figure 5). This observation was surprising because this taxonomic group tends to be generalist as well. Thus, a trend such as seen with ostracods would be expected. However, the particular species of cyclopoids which were captured are specifically adapted to the environmental conditions found in ephemeral habitats, and are, therefore, termed ephemeral specialists. These groups of cyclopoids are found only in ephemeral environments and have evolved structural, behavioral, and physiological adaptations to intermittent and uncertain drought and reflooding (Neckles, Murkin, and Cooper, 1990). Because this group is specifically adapted to ephemeral conditions, it should increase in number because the factors will not be limiting, and only when the pond is just about completely dry will this taxa lay diapausing eggs. Taking these facts into consideration, one may conclude that the densities should increase for both pond types.

Certain taxonomic groups were present only in low numbers in the ponds, and some groups were altogether absent from all of the ponds. Corixidae, Caenidae, and Diptera are three groups of insects found in aquatic habitats. These three groups comprised less than 1.00% of the organisms collected. A possible explanation for their low numbers is that when the ponds started to dry, they emigrated or relocated to another part of Chaney Lake where more water was available, such as the Central Marsh. This ability to emigrate to a more suitable habitat is an advantage that several species of insects have over other microinvertebrates (DesMeules and Nothnagle,

1997). The nauplii and juvenile arthropods were also present in very small numbers. This could be because they are both juvenile stages of microinvertebrates, and as previously mentioned, most organisms were probably beginning to lay diapausing eggs rather than eggs to hatch this season. Therefore, the numbers of juvenile organisms would be low. The number of gastropods captured was also small, which may due to the fact that they are benthic organisms and are not very common in the water column, which is where the samples were taken. An example of a taxonomic group that was completely absent from all of the ponds was Amphipoda. This group is normally present in large numbers in most aquatic habitats and is usually abundant in Chaney Lake. However, this group is drought sensitive and not common in most semipermanent wetlands (Bataille and Baldassarre, 1993). They require water throughout the year, a situation which usually restricts them to more permanent wetland habitats (Hartland-Rowe, 1966). The amphipods probably inhabit Chaney Lake via the estavelles, and because they do not survive well under ephemeral conditions, they were probably one of the first groups to succumb to the drying of the wetland. They require water throughout the year, a situation which restricts them to more permanent wetland habitats (Hartland-Rowe, 1966).

From previously conducted research, Baskin (1994) suggested that pool size may have a large effect in determining which pools are most similar in terms of taxa composition. She concluded that larger pools will probably have larger numbers of organisms because there are more habitats that they can subdivide and because larger pools tend to hold water longer. This is supported by the data collected from all the

ponds that were sampled in this study. The ponds that dried earlier were smaller than the ponds that dried at a later date. Also, all of the large or late dry ponds had overall higher densities of organisms than did the early dry ponds. Thus, from this study, as well as previous research done on ephemeral wetlands, it becomes evident that ponds that dry later should have larger densities of organisms when compared to ponds that dry earlier. A variety of factors, such as those mentioned when explaining the graphs, interact to control the abundance of microinvertebrates in temporary waters (Neckles et al., 1990). However, the precise factors that provide the stimulus for microinvertebrates of temporary wetlands to lay diapausing eggs or enter some type of dormant stage in order for that group of organisms to survive the dry conditions is still poorly understood and needs to be investigated.