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DIEL VERTICAL MIGRATION OF ZOOPLANKTON IN RAYSTOWN LAKE'S JUNIATA BAY

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ABSTRACT

We investigated zooplankton population densities with respect to depth and light penetration over a twenty-four hour period in Juniata Bay of Raystown Lake (Pennsylvania). Rotifers, copepods, and cladocerans have been observed to migrate vertically. It was expected, based on appendage morphology, that copepods and cladocerans would show considerable vertical movement, whereas the rotifers would not. Unfortunately, because the lake was in turnover at the time of our study, we were unable to statistically demonstrate that diel migration was occurring in Juniata Bay. Since the lake was also experiencing a phytoplankton bloom, food abundance may have also influenced depth-specific zooplankton density. Further study is needed to determine which factors caused this lack of migration.

Keywords: Diel migration, Juniata Bay, limnology, Raystown Lake, zooplankton.

INTRODUCTION

The purpose of this study was to investigate the diel vertical migration of zooplankton in Juniata Bay of Raystown Lake, a large manmade lake in central Pennsylvania. Zooplankton may migrate vertically to and from the well-lit euphotic zone, because it is not only where their food source is most abundant, i.e., photosynthetic phytoplankton, but it is also where the risk of being eaten by visual predators is also the greatest (Horne, 1994; Hutchins, 2000).

Rotifers, copepods, and cladocerans are the chief kinds of zooplankton found in Juniata Bay (White, 1999). Copepods and cladocerans have swimming appendages facilitating quick, relatively long-distance movements, whereas the movements of rotifers are relatively limited, often involving circular trajectories (Zagorski, 1995). Therefore we hypothesized that copepods and cladocerans should show greater diel vertical migration than rotifers.

METHODS

Sampling was conducted over a 24-h period (March 31 to April 1, 2000) in Juniata Bay (Fig. 1) where depth is about 18-21 m with a relatively steep slope toward the central channel of Raystown Lake. Sampling was carried out from a pontoon houseboat, the Cormorant, which was secured between an anchor and a buoy.

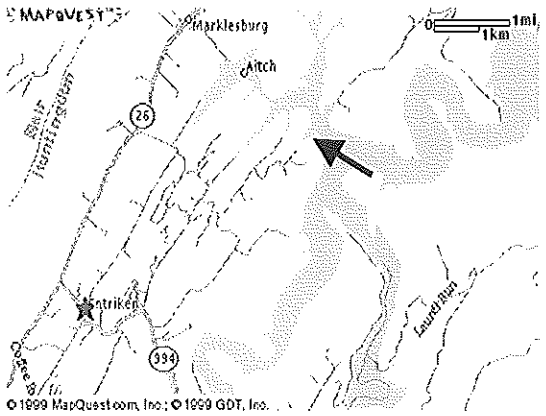

Figure 1. Location of Juniata Bay in Raystown Lake

A YSI dissolved oxygen meter was used to estimate dissolved oxygen and temperature at different water depths. Using a suspended oxygen probe, readings were taken at the water surface and then at 0.2-m increments for the first 2 m, and at 1-m increments until the bottom was reached. The meter was calibrated according to YSI instructions, but zeroing was not precise due to meter malfunctioning at low air temperature. The salinity dial was set to "fresh" because Raystown Lake is a freshwater lake. Oxygen, temperature and water clarity measurements were taken at approximately 7:30 PM, March 31 and 9:05 AM, April 1, 2000.

Light penetration was estimated using a secchi disk, lowered on the shady side of the boat (following White, 1999). The depth at which the disk could no longer be seen was recorded. Due to the variability of this observation, each member of our group followed this procedure and the readings were averaged to achieve a more accurate depth reading. This test was performed twice on April 1, 2000 at approximately 12:20 PM and 3:15 PM.

Zooplankton samples were collected using a Birge closing net with a #20 (80 μm) mesh size and 11.5-cm diameter opening. The net was dragged at four different depths (0-3, 4-7, 8-11, and 11-15 m) each six times, and then closed and brought to the surface. We collected samples every three hours during a 24-h period, equaling a total of eight samples per depth. For every meter that the net was dragged through the water column, 10.386 L of water was filtered. This equates to 186.964 L for the 3-meter drags and 249.285-L for the 4-meter drags. The first trial was performed at 6:40 PM, March 31, 2000, and the last was at 3:30 PM, April 1, 2000.

After each trial, the sample collector was removed from the Birge closing net and its contents emptied into a collection cup. All parts of the net and sample collector were rinsed in deionized water before more drags were made. The plankton samples were stored on ice for the duration of the sampling effort, and then refrigerated until density analyses were completed (within 3-7 d after collection). The sample cups were stored with their lids loosened to allow for air exchange so that the zooplankton would not suffocate. Refrigeration was used to lower plankton metabolic rates, thus decreasing mortality due to starvation, predation, and fouling of the water associated with decay of dead individuals. The work of White (1999) suggested that this delay in analysis after collection had minimal effects on the results.

The volume (ml) of each collection cup was estimated and used to calculate lake-plankton density. Plankton in micropipetted, ~1-ml premixed subsamples were counted in counting cells. Ten random counts were performed at 40x for each slide using Wild Lietz GMBH type # 020-502.101 compound, binocular light microscopes with known field of view diameters (estimated using a 2-mm stage micrometer with 0.01-mm subdivisions). After each count, the counting cell was rinsed with deionized water and dried, and the process was repeated until five to ten slides had been counted for each sample.

The densities of copepods, cladocerans and rotifers in the concentrated Birge closing net samples were converted to actual lake densities. Then these zooplankton densities were grouped by depth and plotted versus collection time. Kruskal-Wallis tests were performed to compare zooplankton densities among different depths over time.

RESULTS

Temporal trends in zooplankton density for each of four depth ranges are shown in Figs. 2-5. Although the zooplankton tended to decrease in abundance with depth (Fig. 6), this trend was not significant for any taxon examined (Kruskall-Wallis tests for rotifers: $P = 0.285$, $df = 3$, copepods: $P = 0.366$, $df = 3$, and cladocerans: $P = 0.989$, $df = 3$).

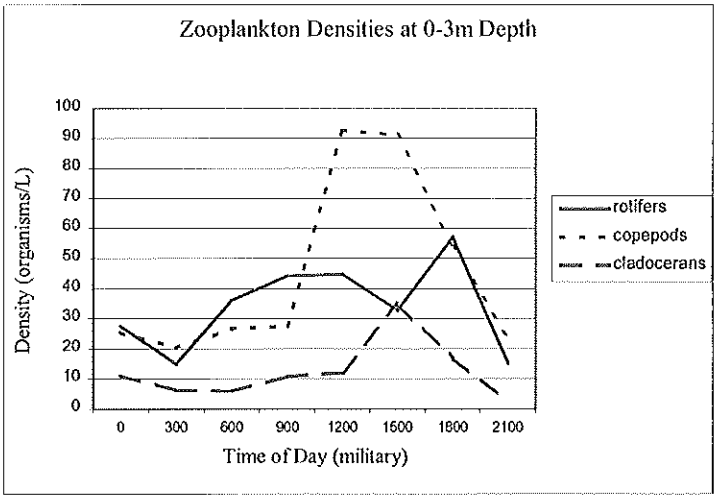

Figure 2. Graph of zooplankton densities over time at 0-3m lake depth. Note that sunset was at ~6:00 PM and sunrise at ~5:30 AM.

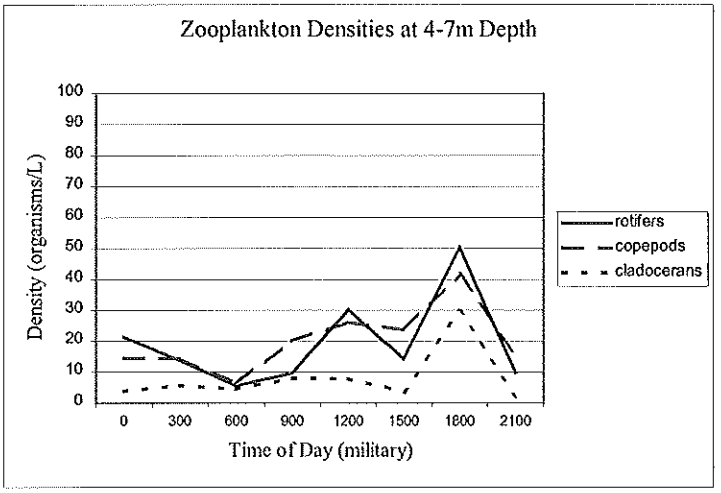

Figure 3. Graph of zooplankton densities vs. time at 4-7 mm lake depth.

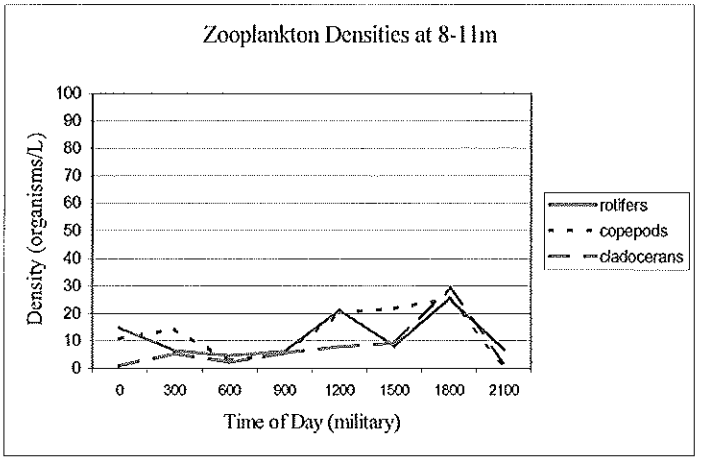

Figure 4. Graph of zooplankton densities vs. time at 8-11 mm lake depth.

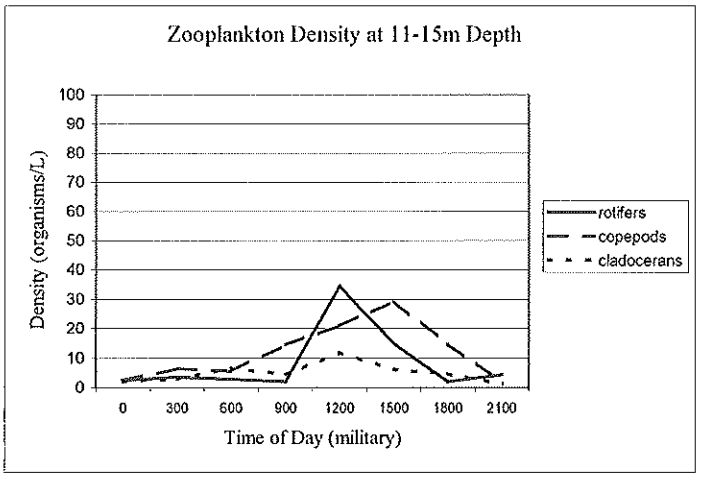

Figure 5. Graph of zooplankton densities vs. time at 11-15 mm lake depth.

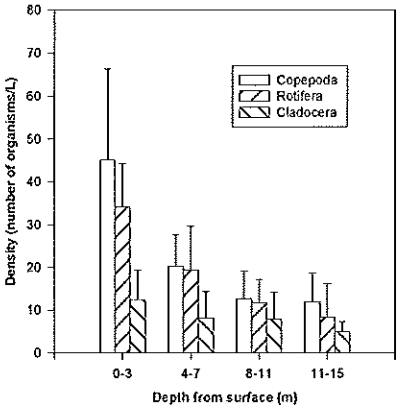

Figure 6. Zooplankton densities (24-h means ± 95% C.L.) at four different depths in Juniata Bay.

Figs. 7-10 compare the depth profiles for dissolved oxygen and temperature between the sampling period of this study (March 31 - April 1, 2000) and a similar study carried out in Juniata Bay in the fall of 1999 (White, 1999). The spring 2000 secchi disk readings averaged 1.56 m (euphotic zone depth = 4.67 m), whereas the fall 1999 readings averaged 3.73 m (euphotic zone depth = 11.19 m; after White, 1999).

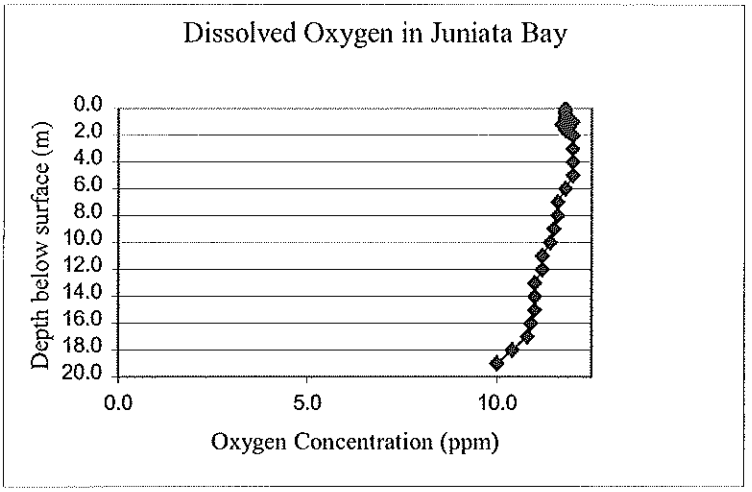

Figure 7. Dissolved oxygen depth profile for March 31 – April 1, 2000

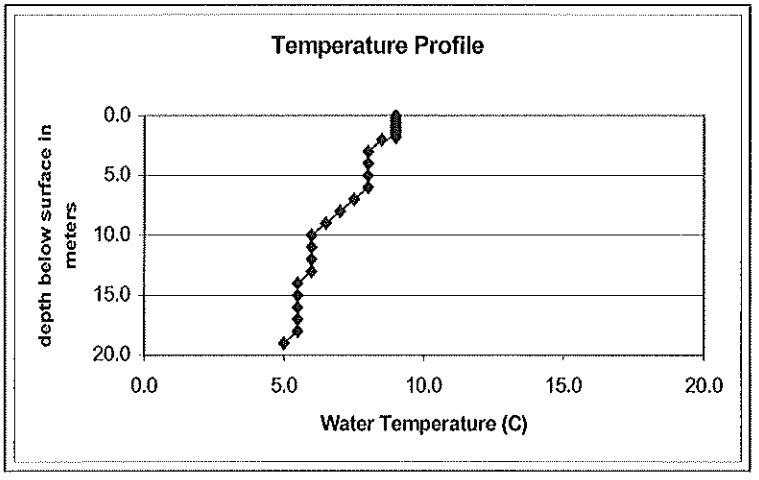

Figure 8. Dissolved oxygen depth profile for fall 1999.

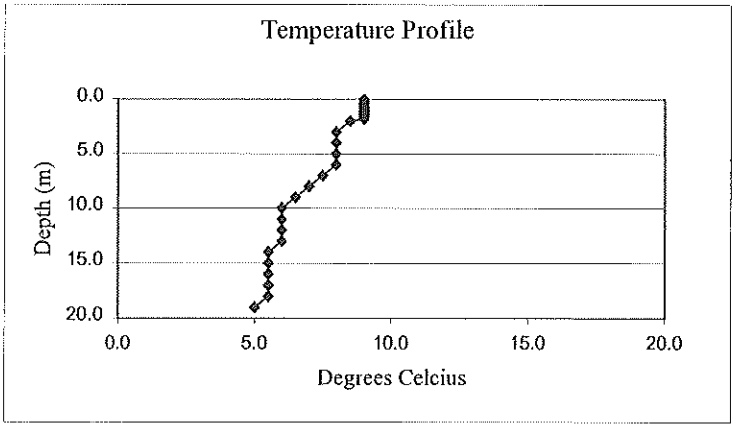

Figure 9. Temperature depth profile for March 31 – April 1, 2000.

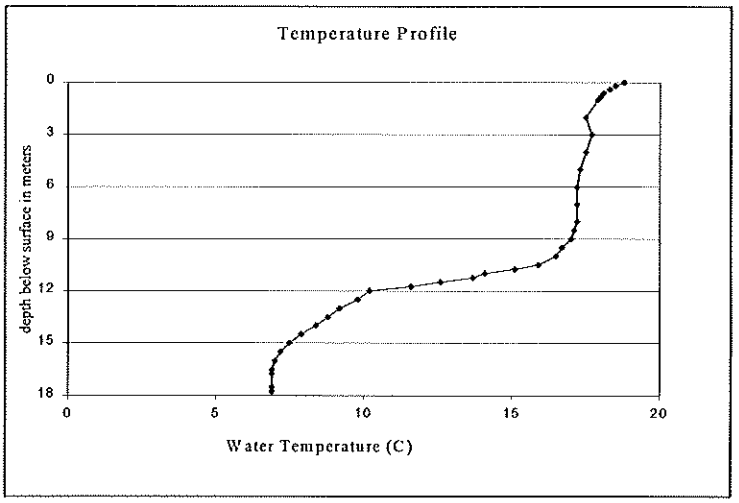

Figure 10. Temperature depth profile for fall 1999.

DISCUSSION

Our results showed no evidence of diel vertical migration by zooplankton in Juniata Bay. Furthermore, although there was a tendency for zooplankton densities to be greatest at the shallowest depths (Fig. 6), this trend was not significant.

Perhaps diel migration of zooplankton does not occur in manmade reservoirs, such as Raystown Lake. However, evidence for this migration has been provided by Noone et al. (1997). In addition, fish predators are plentiful in Raystown Lake, and thus one of the reputed causes for diel migration of zooplankton is present.

We offer two alternative hypotheses to explain the apparent lack of migration in our study. First, at the time of our study the lake was not yet stratified (Figs. 7, 9), and thus inter-depth mixing of the water column may have prevented the zooplankton from actively controlling their position with respect to depth. Second, at the time of our study the lake was experiencing a phytoplankton bloom, (as indicated by our estimates of low light penetration; see Results), and thus the zooplankton may have remained most

concentrated near the lake surface to maximize food intake and, in turn, offspring production, as would be expected of r-selected species.

To test these alternative hypotheses, additional sampling should be carried out during late spring or early summer when the lake was stratified, and then again in the fall when the lake is beginning to de-stratify. Lake turnover occurs during both early spring and late fall, but phytoplankton abundance is greater during early spring. Therefore, if the turnover hypothesis is correct, diel migration of zooplankton should be observed in the summer, but not in early spring or late fall. However, if the food-abundance hypothesis is valid, zooplankton migration should be less apparent during the early spring than late fall, despite the occurrence of turnover at both times.

In conclusion, further research is needed to identify the factors controlling the migration of zooplanktors within the water column of Juniata Bay (Raystown Lake). An ideal method for the determination of migration-limiting factors would be a year-long study, including a combined analysis of the physical, biological, and chemical characteristics of Juniata Bay.

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