

Diel Vertical Migration in Demersal Zooplankton

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ABSTRACT

This study focused on diel vertical migration of demersal zooplankton in Crampton Lake located in the University of Notre Dame Environmental Research Center (UNDERC). Demersal zooplankton are those that reside in or near the substratum for a portion of their life cycle. Diel vertical migration is performed by some demersal zooplankton species. Diel vertical migration occurs when demersal zooplankton residing near the substratum enter the water column and migrate to shallower depths. The most common species of demersal zooplankton found in Crampton Lake were *Bosmina* spp., *Keratella cochlearis*, *Polyarthra vulgaris*, and *Trichochera* spp.. The environmental factor determining vertical migration could not be satisfactorily determined due to variation in total zooplankton population within each core. Vertical migration was found to occur in the previously listed species found in Crampton Lake. Demersal zooplankton population was found to decrease up to a depth of three millimeters into the sediments. Variations in demersal zooplankton populations were attributed to different sampling sites, weather changes, and the sub sampling method used.

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INTRODUCTION

Diel vertical migration is the process in which zooplankton who are residing near the substratum enter the water column and migrate to shallower depths. In lakes, this process occurs at night. The most widely accepted explanations for this phenomenon are the avoidance of predation and the struggle to obtain a higher food quality (Stich & Lampert 1981). Diel vertical migration has been observed and studied in several species of demersal zooplankton in varying habitats. Demersal zooplankton are those species which reside in or near the substratum for some portion of their life cycle. Demersal zooplankton are found nearest the substratum during periods of intense light. Species of demersal zooplankton that are commonly found in Crampton Lake are *Bosmina* spp., *Keratella cochlearis*, *Polyarthra vulgaris*, and *Trichochera* spp.

It has been previously suggested that vertical migration offers a metabolic advantage due to a slowing down of the metabolic rate of the nondemersal zooplankton when it enters deeper waters after feeding in shallow zones. Also, it has been suggested that the substratum in the deeper parts of the lake provide resources which have a higher nutritional value. However, this is contradicted by a recent study which suggests that diel vertical migration does not offer a metabolic advantage over non migrating individuals (Guisande et al. 1991). The reduced availability of food in the substrate and the amount of energy required for vertical migration results in a reduced capacity for growth and reproduction. Despite the large amount of research on diel vertical migration in nondemersal zooplankton, studies of diel vertical migratory patterns by demersal zooplankton in freshwater lakes are rare.

Diel vertical migration in nondemersal zooplankton is associated with periods of failing light such as sun or moon set (Tranter et al. 1981). This phenomenon is supported by the high zooplankton catches that occur within one to two hours after sunset or right before dawn, which is a time of low planktivore activity due to visual difficulty for tropical fish (Munz & McFarland 1973). This period provides a refuge for invertebrates migrating to shallow depths. The zooplankton that migrate are the larger individuals (Guisande et al. 1991). From this, it has been inferred that visual predators have a strong influence on migratory behavior. Research has indicated that zooplankton larger than one millimeter are rarely present in the upper water column during the day (Ohlhorst 1982). Migration peaks have been found to be lowest on the full moon and highest on moonless nights.

A hypothesis which has not been fully studied is the idea that

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nondemersal zooplankton are negatively phototatic such that they move away from light in response to increasing light intensity. This would then explain their return to the substrate at sunrise (Tranter 1981). This hypothesis has been disputed in other studies which concluded that the elements of available data do not present a strong correlation between differing light intensities and migration patterns (Enright & Honneger 1977).

Information on diel vertical migration of demersal zooplankton in the freshwater environment is extremely limited. It appears that its main function is to aid the larger zooplankton in escaping predation. The larger demersal zooplankton avoid predation during daylight hours by burrowing into the sediments. These demersal zooplankton escape predation at night by moving into the water column during periods of poor visibility. The environmental stimulus that initiates the migrating behavior in zooplankton remains to be determined. This study was initiated to determine the effect of oxygen concentration and light intensity on vertical migration of demersal zooplankton. Other contributing factors studied were the identification of emergent species and the depth that demersal zooplankton were located in the substratum.

Materials and Methods

The samples for this experiment were obtained in Crampton Lake located in the University of Notre Dame Environmental Research Center (UNDERC) near Land O'Lakes, Wisconsin.

The first step in this study was to determine whether oxygen concentration and light intensity had an effect on the vertical migration of demersal zooplankton. To determine the effects, core samples were subjected to four different treatments in which light intensity and sediment oxygenation were varied. Core samples were taken in the early afternoon so that the zooplankton would have returned to the sediments and would not yet have begun migration. These samples were obtained with Plexiglas cores. They were taken at a depth of approximately ten feet. The cores were 12 centimeters in diameter with a height of 15 centimeters. The sediment level did not exceed fifty percent of the core's total volume. The ends of the core were then capped with rubber stoppers before they were removed from the lake bottom. They were transported vertically to the surface. This resulted in the least sediment disturbance possible.

These cores were brought to the laboratory and exposed to the four treatments within twelve hours. In the first set of treatments,

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oxygen concentration were varied, but light conditions remained constant. In the second set of treatments, the light conditions were varied, but the sediments maintained a constant high oxygen availability (Figure 1).

To vary the gas concentrations, the top stopper was removed and replaced with a penetrable seal that allowed simultaneous control of light intensities and sediment oxygenation. The gases were bubbled at a slow rate of speed to prevent sediment disturbance. These were allowed to run for one hour so that the water would become completely anoxic and the anoxic conditions would penetrate the sediments up to a depth of three millimeters. This depth was determined through the use of micro electrodes placed at varying depths in the mud. After an hour, a Winkler titration was performed to determine the oxygen concentration of the water. The zooplankton were then removed from the sediment through a siphon into a "dolphin bucket" used to siphon zooplankton catches. This sample was preserved in a ten percent formalin solution and analyzed in one mL increments. Ten milliliters of each sample were counted to determine the number of zooplankton present. From these data, the relative abundance was then determined.

The second part of this experiment involved the quantification of zooplankton emergence from the sediments. The emergence traps used in this study (Figure 2) were a modified version of the Hobson- Chess model (Hobson & Chess 1979). The traps were placed directly into the sediments in the early evening before dusk. They were retrieved at varying times the following morning. It was not possible to remove them at varying times throughout the night due to poor visibility. The samples were removed by reaching into the sediments which were of a jello-like consistency and placing a rubber stopper into the small mouth of the funnel. They were brought to the surface and the mason jar was removed from the top of the trap. These samples were preserved in ten percent formalin. The relative abundance was determined through sub sampling. Ten replications of one milliliter were randomly sampled from each 355 mL mason jar with the aid of a plastic pipet. The demersal zooplankton in each sample were counted with the aid of a Sedgewick Rafter and a microscope.

The third part of this experiment determined how far the demersal zooplankton burrowed into the sediments. Core samples were taken from depths of ten to fifteen feet in Crampton Lake. Samples were taken with the use of cut off 30 mL syringes. The syringes were placed at the mud's surface, making sure not to move the stopper (Figure 3a). The shell was then pressed into the substratum (Figure 3b). This is an important step to avoid the compression of the sediments which would occur if they were drawn in. The cutoff syringes were stoppered on the

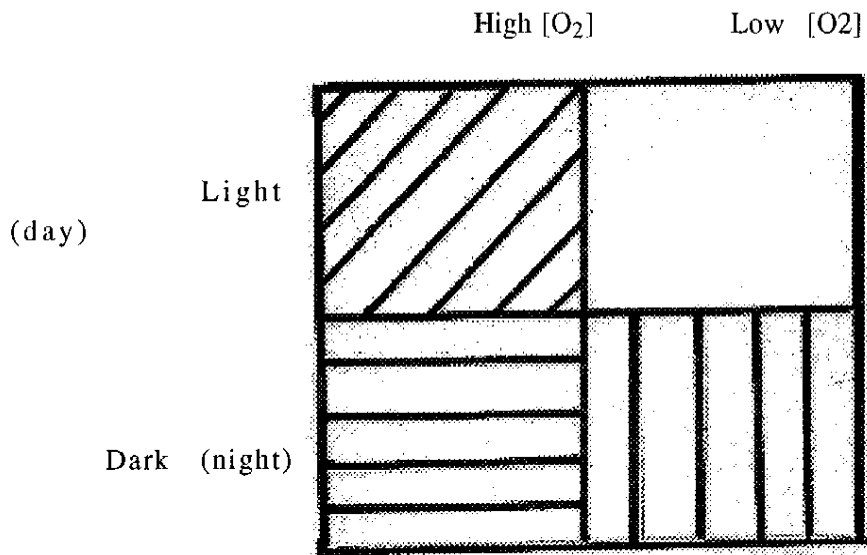


Figure 1: The four treatment combinations used to determine the environmental cue(s) that stimulate vertical migration of demersal zooplankton.

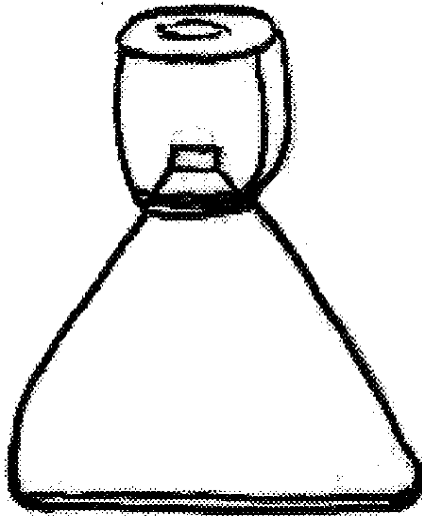


Figure 2: The emergence trap used in this experiment was two chambered. It is composed of a removable mason jar and a plastic funnel, 30 cm in diameter.

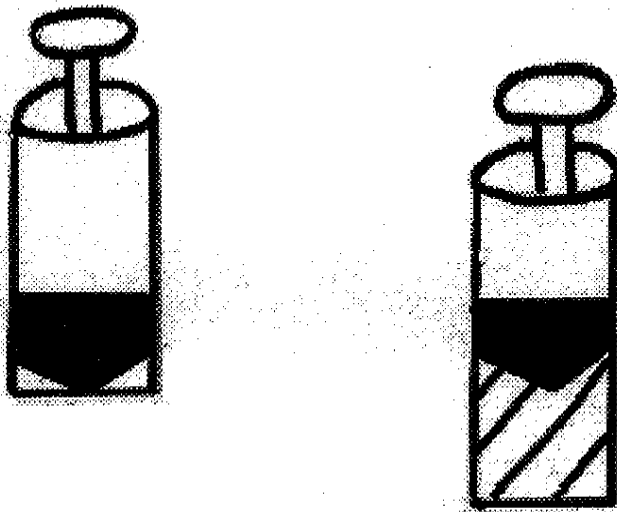


Figure 3: (a) The position of the syringe at the surface of the mud; (b) The position of the syringe shell and the stopper which did not move as it was pushed into the substratum.

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bottom to prevent sediment displacement. These samples were taken to the lab and sliced at one millimeter intervals yielding three samples from each cut off syringe. Samples were preserved in a ten percent formalin. Rose Bengal was used as a stain for easier identification of the zooplankton. Relative abundance of demersal zooplankton at the various depths was determined by analyzing the samples under a microscope.

Results

The cores numbered 9, 10, 11, 12, 13 , 14, and 15 were taken on June 30, 1992 at depths of approximately ten feet. The cores numbered 16, 17, 18, 19, 20, and 21 were taken from the substratum at a depth of approximately ten feet on July 8, 1992.

When the relative abundance of the demersal zooplankton present in the cores exposed to the oxygen and light treatments is considered, there is a large discrepancy in the average number of zooplankton present and in the amount of each species present (Figure 4). In comparison, the cores exposed to the nitrogen and light treatments have a relatively consistent average number of demersal zooplankton present (Figure 4). If the overall numbers of demersal zooplankton present are considered, there is a higher average number of demersal zooplankton present in the water column for the nitrogen and light treatment.

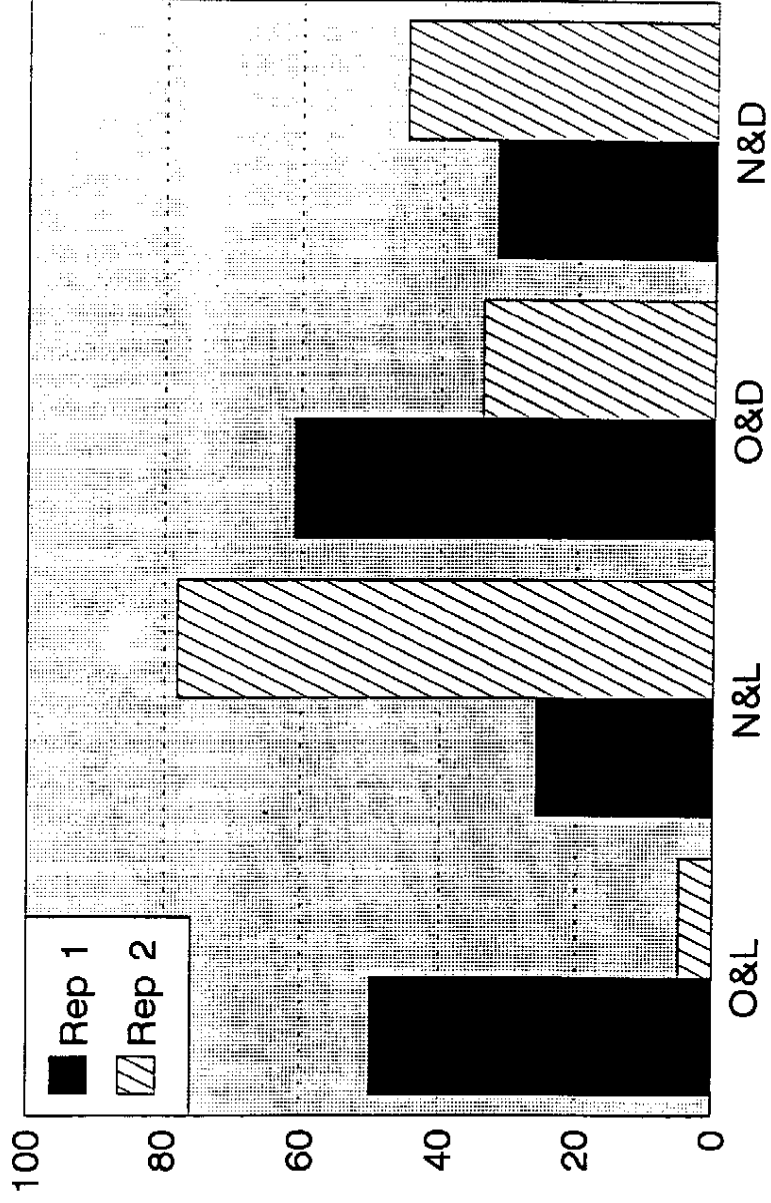
The cores 16 and 17 that were exposed to the oxygen/nitrogen and dark treatments show a consistent number of demersal zooplankton present. The overall abundance was also consistent. The cores 19 and 21 show a consistent number for the amount of demersal zooplankton present in each species. In the cores exposed to these treatments, the number of demersal zooplankton found in the water column does not vary significantly.

The second part of this experiment was to determine whether vertical migration of demersal zooplankton occurs in UNDERC lakes. Samples were taken on two separate occasions. The traps numbered one through six were put in at 6:00 pm and removed at 8:00 am. The data shows definite migration with an average number of demersal zooplankton per trap being 419 (Figure 5). The traps numbered seven through ten were put in at 12:30 pm and removed at 10:30 am. This data also shows definite vertical migration with an average number of demersal zooplankton per trap being 842 (Figure 5). For a total number of demersal zooplankton per trap refer to Figure 5.

The third part of this experiment was to determine if and how deeply the demersal zooplankton burrowed into the sediments. Samples

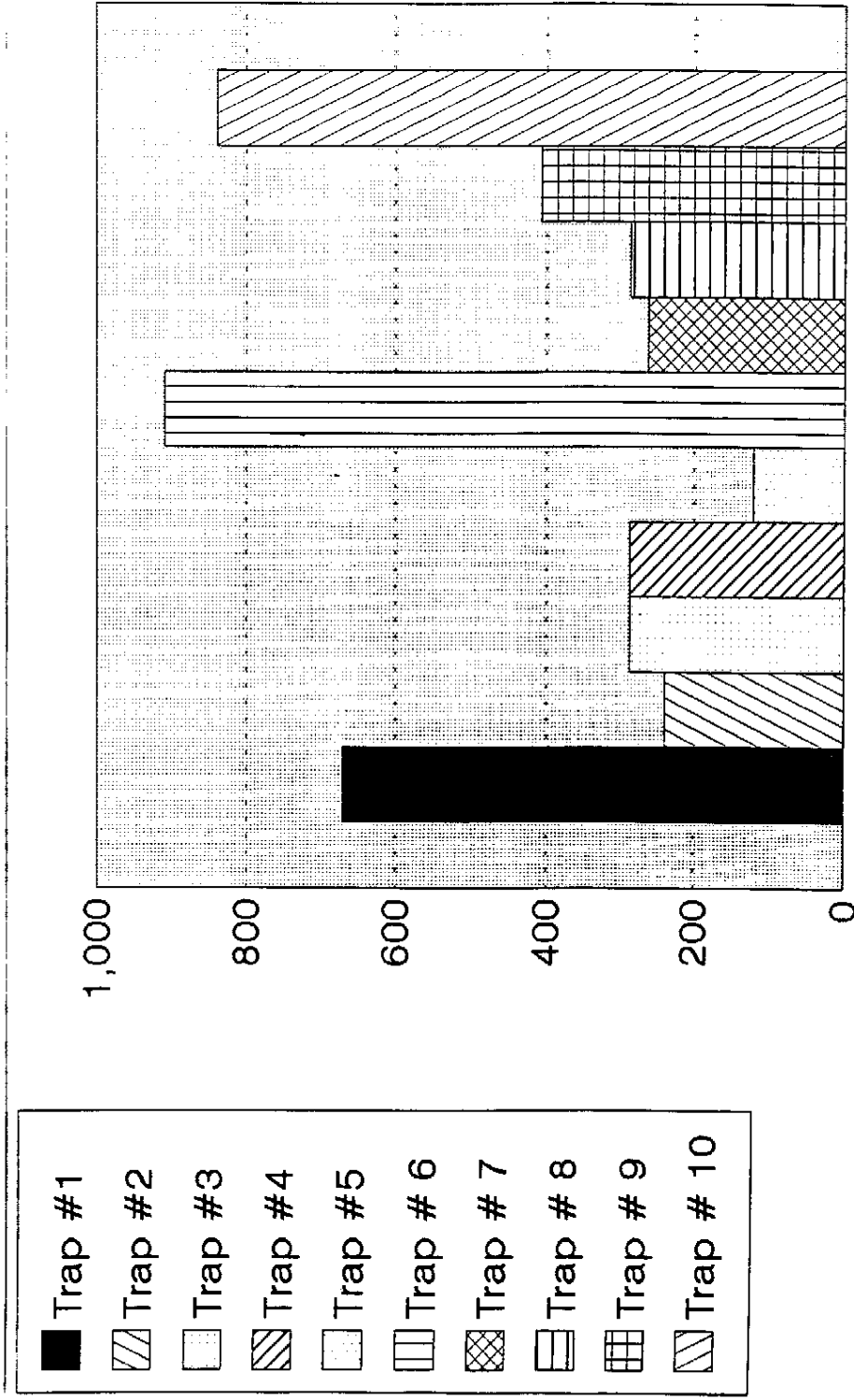
Zooplankton abundance in cores

Figure 4 ;



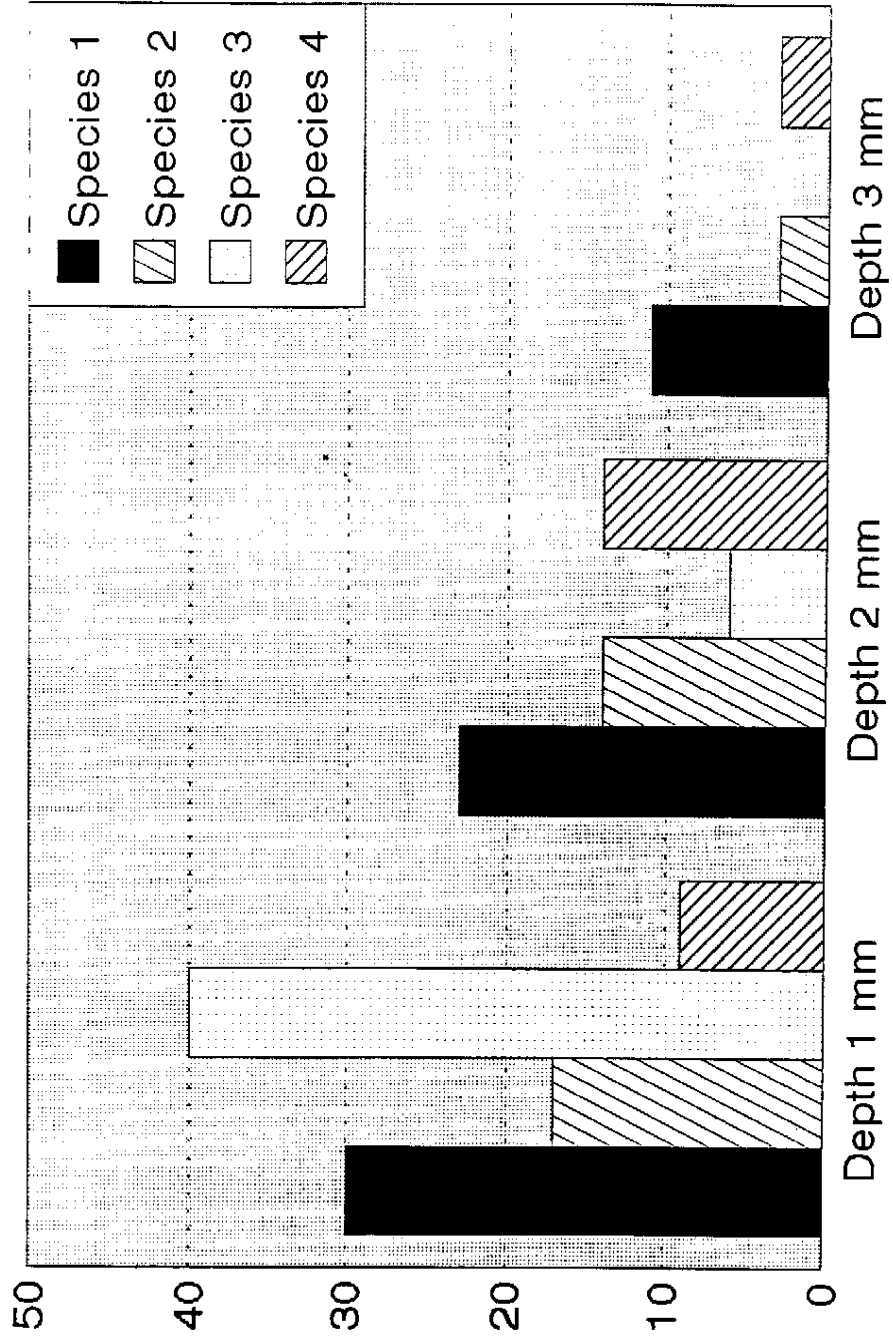
Emergence traps

Figure 5



Average number of zooplankton in substratum

Figure 6



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for this experiment were taken at a depth of ten feet. Although, the value of demersal zooplankton in each syringe varied, there was a significant decrease in the number of demersal zooplankton for each millimeter depth into the sediments (Figure 6).

Discussion

The difference in the values of demersal zooplankton present in the water column between repetitions varies significantly. The difference in these values was caused by several factors. The first factor was that the cores were taken from two different sites on different days, but at the same depth. The population of demersal zooplankton present in this area is not necessarily similar. A second factor that affected the total number of demersal zooplankton was the way in which the data was quantified. Ten milliliters of a thirty to fifty milliliter sample left a large chance for variance.

However, even if the data is analyzed within the repetitions, the results are contradictory. For repetition one, there is a larger number of demersal zooplankton present in the water column for the oxygen/light treatment than the nitrogen light treatment. Considering the original hypothesis that demersal zooplankton respond to a decrease in oxygen concentration in the water column, these would prove it incorrect. This data is contradicted by the second repetition of these conditions in which there was a larger number of demersal zooplankton present in the water column for the nitrogen and light treatment.

From the results for the second part of this experiment, it can be seen that vertical migration of demersal zooplankton does occur in UNDERC lakes. The variance in the number for each trap was attributed to the difference in site conditions, varying weather conditions when the traps were set, and the sub sampling method used to quantify the data.

From the results of the third part of this experiment, it can be seen that the demersal zooplankton population decreases up to a depth of three millimeters into the sediments. Whether demersal zooplankton survive deeper into the sediments was not determined. This would suggest that this is the area penetrated by oxygen as a result of periphyton photosynthesis.

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Conclusion

The environmental stimulus that causes diel vertical migration could not be determined. Further research must be done with special attention paid to consistent core samples with comparable populations of demersal zooplankton. Also, many more replicates must be done to determine the full effect of gas concentration on zooplankton. Despite the varying results from the first part of this experiment, evidence suggests that demersal zooplankton are affected by gas concentration. This would also suggest that periphyton photosynthesis plays an important role in determining when demersal zooplankton begin vertical migration. Vertical migration does occur in some species of demersal zooplankton present in Crampton Lake. Demersal zooplankton can be found up to depths of three millimeters into the substratum. Further studies should be done to determine the deepest point at which demersal zooplankton are located in the sediments.

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