The Effects of Light and Temperature on Grazing Patterns of Douglas Lake Snails

Mark Fate, Caitlin Fey, Krista Hoffman, Samhitha Sudheendra
EEB 381: General Ecology
Prof. Joel Heinen
University of Michigan Biological Station

Abstract

The purpose of this study was to determine if varying light or temperature conditions influence the grazing rates of *Elimia livescens.* We expected to see increased grazing rates with greater temperatures and with greater light exposure. *E. livescens* were collected from the littoral zone in South Fishtail Bay of Douglas Lake near Pellston, Michigan, and individually placed into pint sized jars with lake water and one algae-covered rock. We used environmental chambers to simulate six 24-hour light and temperature treatments. Statistical tests between the mean area grazed in light treatments, as well as temperature treatments, showed significant results. Additional tests also yielded significant results, showing that *E. livescens* were more likely to be found grazing at the end of the 24-hour period in longer light periodicities and higher temperatures. From these results, we were able to conclude that *E. livescens* grazed the most in settings with longer light exposure and higher temperatures. We were also able to determine that in darker and colder conditions *E. livescens* are less likely to graze.

Keywords: *Elimia livescens*, grazing, littoral zone, Douglas Lake

Introduction

Both biotic and abiotic factors may limit the realized niche of a species. Many species have developed adaptions to their surroundings and expanded their realized niches. Variations such as fluctuating metabolic rates based on abiotic conditions may be an adaptation that could increase fitness and survivability. Slow metabolic rates in low temperatures may help an organism survive harsh winters when food is scarce, and fast metabolic rates in high temperatures may increase the energy level in an organism. *Elimia livescens,* a species of freshwater snail, feed by slow grazing on benthic algae and can be commonly found throughout the year in shallow water, usually at a depth of 4 meters or less (Russell-Hunter, 1978). Huryn *et al.* (1995) found that freshwater snails tend to lose large amounts of biomass during the winter due to reduced metabolism, and to compensate they rapidly graze during the spring and summer. Sharland (1995), who studied Douglas Lake snails, showed that *E. livescens* prefer to graze on rocky substrates rather than sandy shoals, indicating that the substrate and location also affect snail-grazing patterns. Sharland also found that food availability affects the abundance and distribution of *E. livescens*. These studies show that snail metabolism and grazing patterns are influenced by abiotic as well as biotic conditions.

Because we wanted to quantify food consumed as a measure of metabolic rates, *Elimia livescens* were chosen as our study species because they leave behind easily identifiable grazing trails. Our focus was on the abiotic conditions of temperature and light, so we simulated conditions that may be found during the *E. livescens* grazing period in Douglas Lake. Because sunlight exposure and average temperature vary together from season to season, they could cause similar environmental reactions. The purpose of this study was to determine if various light and temperature conditions are able to influence the grazing patterns of *E. livescens*. We tested two hypotheses: 1) The grazing rates of *E. livescens* will increase with greater light exposure; 2) The grazing rates of *E. livescens* will increase with greater temperatures.

Methods

We collected snails and algae covered rocks from the littoral zone of South Fishtail Bay in Douglas Lake, near the boatwell of the University of Michigan Biological Station. To limit effects of confounding variables on area grazed by *E. livescens*, we collected snails of the same basic morphotype and size, and rocks between 30 and 100 mm in diameter with similar amounts of algal coverage. The snails were placed in a bucket of lake water for a 24 hour period of starvation to encourage grazing during the experiment. At the end of the 24-hour interval, we filled 24 pint-sized glass jars with lake water and one rock. One snail was assigned to each jar, and placed relatively close to the rock, so that they had approximately the same opportunity to graze on the rock. We repeated each treatment with the same protocol.

We used environmental chambers to simulate varying light and temperature conditions. We used a controlled lab experiment because our interest was in specific temperature and light conditions, which could not be controlled for in the natural habitat of *E. livescens*. By using this type of experiment, we avoided variables that could have affected snail-grazing rates other than temperature and light, i.e. predation and competition with other grazers.

There were six treatments lasting 24 hours each and consisting of one intermediate control treatment, two light treatments, and three temperature treatments. The intermediate treatment for both light and temperature was 14 hours of light and 10 hours of darkness at 65° F. These conditions were chosen to simulate an average day in late May to early June near Douglas

Lake. The light treatments were 24 hours of light and 24 hours of darkness (both at 65° F), and the temperature treatments were 80° F, 50° F, and 35° F (all using the light periodicity of 14 hours of light and 10 hours of darkness). The extreme light treatments were designed to generate the greatest differences in snail grazing rates for lighting conditions. The temperature treatments were chosen to stay within the habitable range and actual experience of *E. livescens,* and increments were standardized for accurate comparisons.

After each treatment, we recorded the length and width of the grazing trail found on rocks in order to determine the area grazed in millimeters^2 by each snail. If we found that a snail did not graze on the rock, i.e. the snail was found on the surface of the jar and there was no identifiable trail, the measurement was recorded as 0 mm^2. We then placed all used snails and rocks back into their respective locations within Douglas Lake.

We performed an ANOVA test between all light treatments and between all temperature treatments in order to find differences between mean areas grazed for each treatment. We also conducted Chi-Square tests to look for any correlation between the location of the snail at the end of the treatment (on the rock or on the jar) and the different light and temperature treatments. A p-value of less than .05 was chosen *a priori* for all statistical tests.

Results

The ANOVA test between the three light treatments (14 hours of light and 10 hours of darkness, 24 hours of light, and 24 hours of darkness) resulted in an F statistic of 22.468 and a p-value < .001 (Figure 1). Also, the ANOVA test between the four temperature treatments (65° F, 80° F, 50° F, and 35° F) resulted in an F statistic of 17.060 and a p-value < .001 (Figure 2). The mean areas grazed for the light treatments were 29.981 mm^2 for the intermediate treatment, 70.246 mm^2 for 24 hours light, 20.448 mm^2 for 24 hours darkness. The mean areas for the temperature treatments grazed were 65.250 mm^2 for 80° F, 14.441 mm^2 for 50° F, and 2.759 mm^2 for 35° F.

The temperature treatment and location of snail Chi-Square test resulted in a X^2 value of 20.848 and a p-value < .001 (Figure 3). This result indicates that under cooler conditions the snails are less likely to be located on the rock at the end of the treatment. The light treatment and location of snail Chi-Square test resulted in a X^2 value of 7.821 p-value of 0.020 (Figure 4), indicating that under dark conditions *E. livescens* are less likely to be located on the rock at the end of the treatment.

Discussion

We were able to reject the null hypotheses that light and temperature variations have no effect on grazing patterns of *E. livescens.* The highly significant p-values showed that snail grazing patterns vary with differences in both light periodicity and temperature. We specifically observed that when temperatures are held constant, *E. livescens* will graze more in 24 hours of light than in 14 hours of light, and more in 14 hours of light than in 24 hours of darkness, demonstrating that the amount of daylight received by the snail is a factor in grazing rates. We also found that *E. livescens* will graze more at a temperature of 80° F than at 65° F, more at 65° F than at 50° F, and the least under our coolest temperature treatment of 35° F. These results establish a trend in decreased metabolic needs as the ambient temperature continues to cool. The results of the Chi-Square tests suggest that snails under cooler temperature and shorter daylight conditions are less likely to graze, perhaps in favor of seeking out more favorable environmental conditions or as a prompt to begin hibernation behavior (Tuchman and Stevenson, 1991).

The snails are able to sense suitable food sources and other factors in their surroundings by using tactile tentacles and a chemoreceptory organ located in the mantle cavity (Morton, 1979). Detection of light periodicities is important because daylight hours vary seasonally along with temperature conditions, and our results suggest that temperature and light periodicity affect grazing rates of *E. livescens* independently. Slower grazing rates that coincide with decreasing temperature and light conditions may be an inclination by the snail to move toward a state of hibernation (Tuchman and Stevenson, 1991). Increased grazing rates under warmer temperatures and longer light periods also support the idea that *E. livescens* make up for biomass lost during hibernation (Huryn et al. 1995).

As global average temperatures continue to increase we may expect to see an increase in snail grazing on benthic algae in Douglas Lake. It has been demonstrated that the grazing habits of *E. livescens* impact the structure of benthic algal communities by creating opportunities for smaller, later blooming diatoms to colonize (Tuchman and Stevenson, 1991). If there were to be an increase in *E. livescens* grazing, we might expect to see more dramatic changes in the benthic algal communities within Douglas Lake. Foy *et al*. (1976) found that certain species of algae had faster growth rates than others under continuous light and high temperatures, showing that algal species composition could change due to increased temperatures. The complex system of the littoral zone of Douglas Lake may fluctuate due to the effects of climate change on both snail grazing patterns and algal growth rates. Further research is needed to determine if these snails are capable of inflicting a relevant amount of grazing on benthic algae, to determine how snail and algal populations will respond to warmer climatological conditions and how these changes will impact the other trophic levels in the Douglas Lake community.

In future studies like ours, we recommend that the algae and substrates be weighed before and after each treatment as another means of measuring the total amount of algae grazed. This could limit the amount of human error in finding and identifying snail trails. We also suggest cultivating algae in a laboratory setting on desirable substrates to eliminate the risk of encountering older snail trails which may be found on substrate collected from a natural environment. A greater variety of treatments (more varied air temperature ranges, light conditions, and water temperatures), and samples from other areas of Douglas Lake may also provide more specific data about the grazing behaviors of *E. livescens*.

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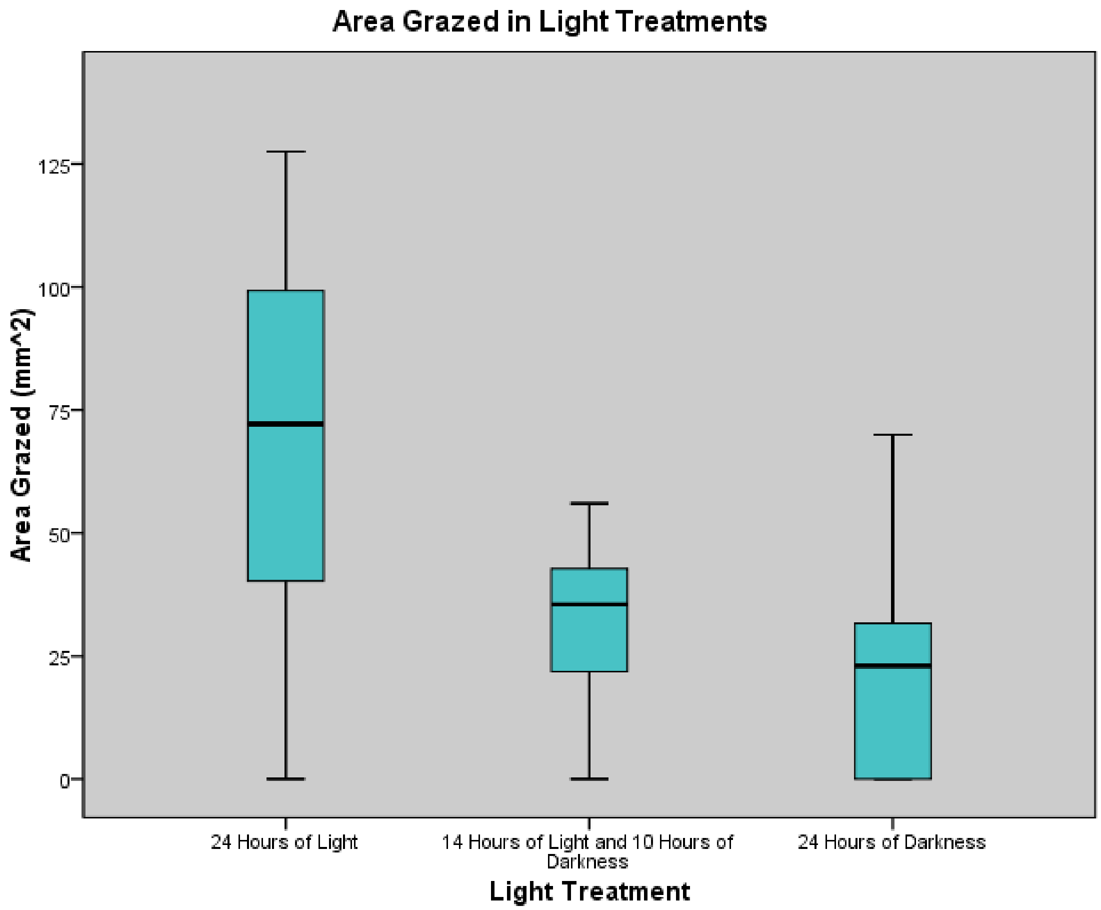

Figure 1: Boxplot of areas of algae grazed on a rocky substrate by *E. livescens* in mm^2 under three different light treatments. Mean area grazed decreases as light periodicity decreases. (ANOVA; p-value < .001)

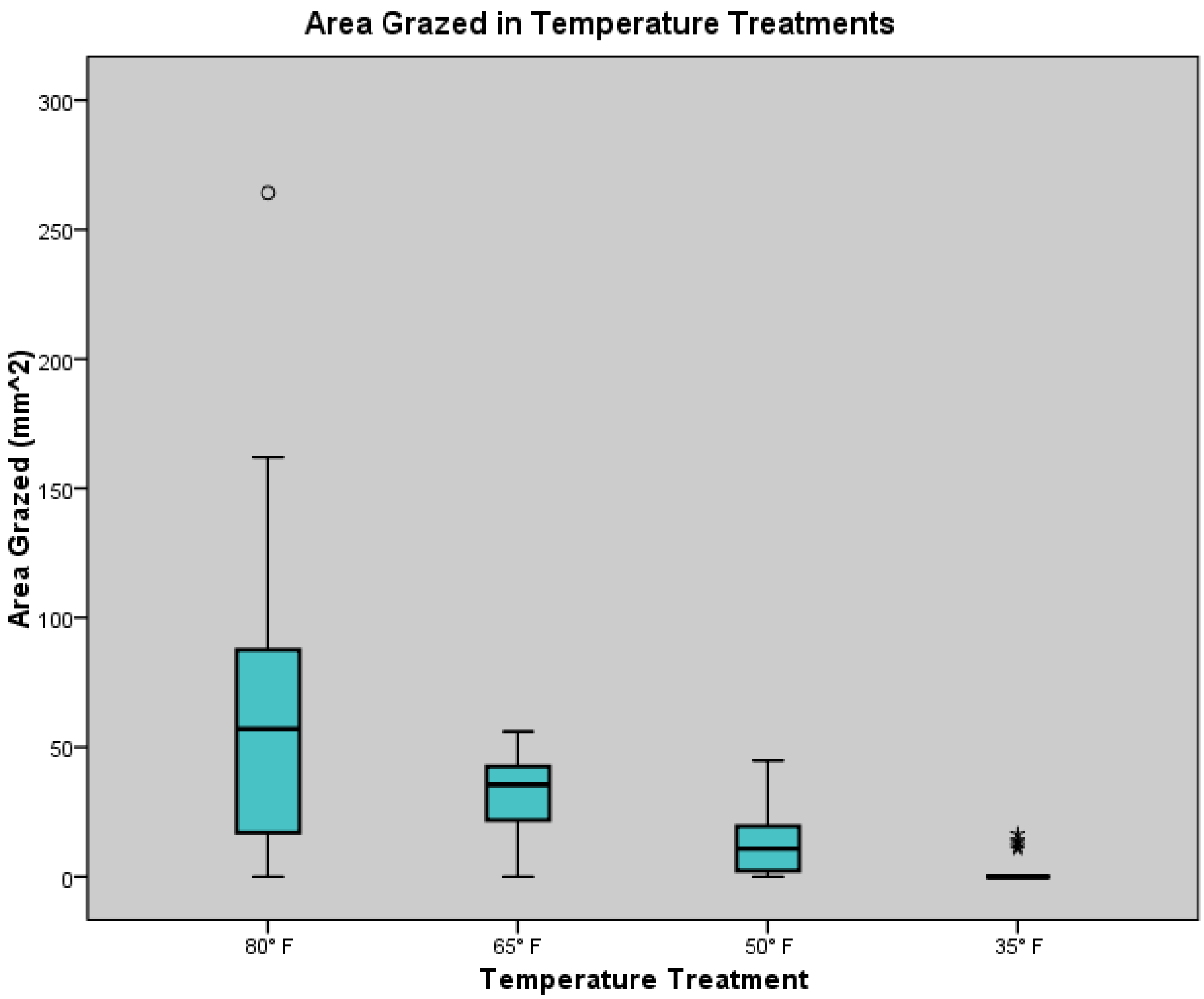

Figure 2: Boxplot of areas grazed by *E. livescens* on a rocky substrate in mm^2 under four different temperature treatments. Mean area grazed decreases as temperature decreases. (ANOVA; p-value < .001)

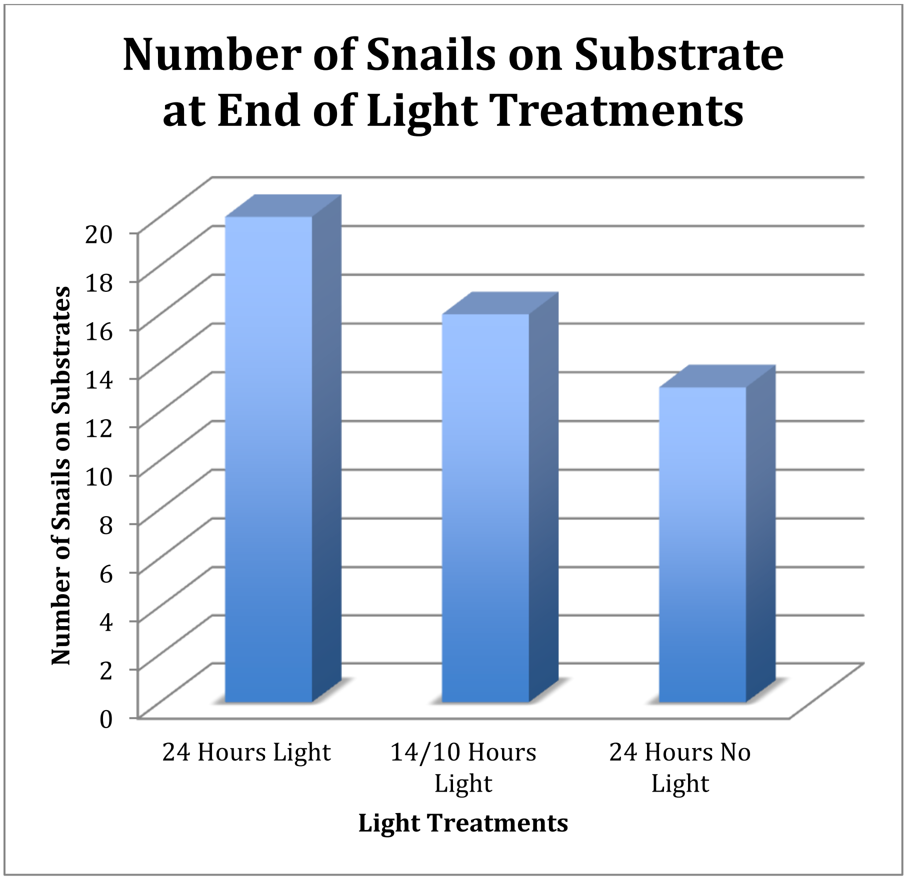

Figure 3: Bar chart of number of snails (of 24) found to be grazing on a rocky substrate after various 24 hour light treatments. As light periodicity decreases, number of snails on the rocky substrate at the end of the experiment decreases.

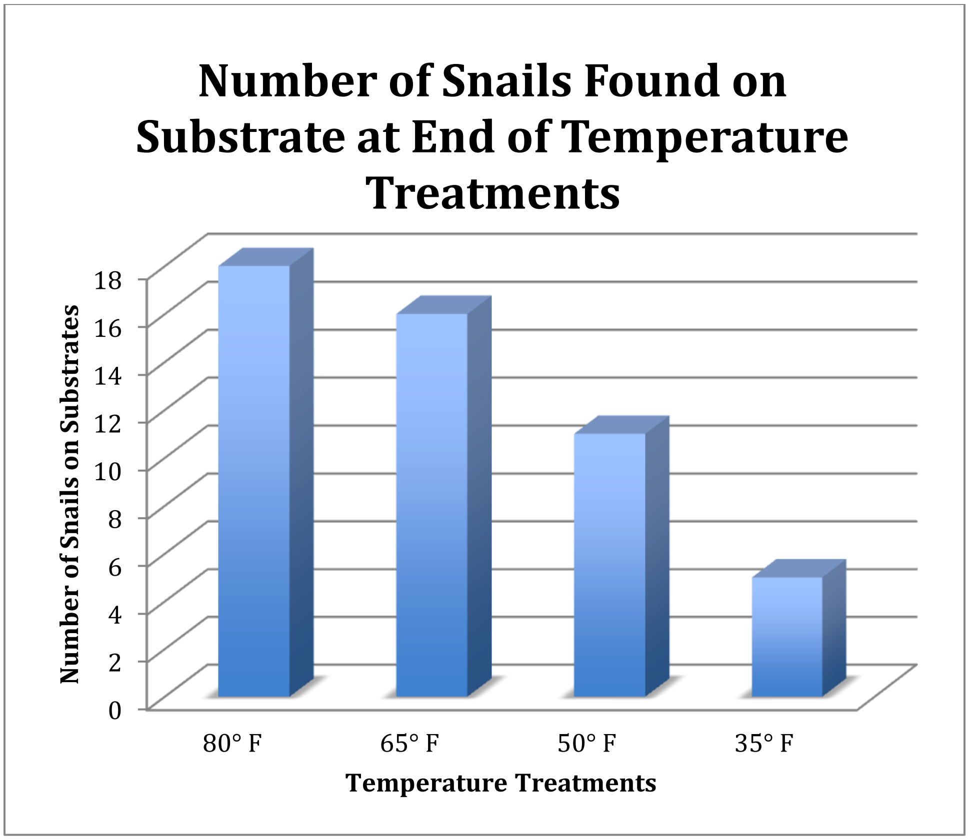

Figure 4: Bar chart of number of snails (of 24) found to be grazing on a rocky substrate after various 24 hour temperature treatments. As temperature decreases, number of snails on the rocky substrate at the end of the experiment decreases.