The effect of light intensity on terrestrial snail population density

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Abstract

Terrestrial snails are commonly known to reside in many habitats on land including gardens, forests, and meadows with varying light intensities. Although previous research has suggested terrestrial snails prefer greater light intensity regions in a controlled lab setting, there is little research surrounding the influence of light intensity on snail abundance in their natural habitats (Perea et al., 2007). This project aimed to understand how light intensity may influence snail abundance in natural garden settings. We utilized the mark and recapture method in five 225 ft^2 garden plots to estimate the population density of snails and performed a simple linear regression analysis to determine whether there was any relationship with the average light intensity in the gardens. No significant correlation was found between light intensity and terrestrial snail population density ($R = 0.1371$, $p = 0.8259$). It was concluded as a preliminary result that light intensity does not correlate with terrestrial snail population density, but more research is needed to confirm this outcome. The results of this study may have implications in furthering the understanding of environmental factors associated with the fundamental niche and spatial distributions of terrestrial snails, including light intensity.

Introduction

Terrestrial snails comprise of several species from the phylum Gastropoda and are found in land areas with cool, humid climates as well as hot, dry ones (Schweizer et al., 2019). Within these areas, snails have been shown to select their living spaces carefully depending on the variability in environmental conditions (Perea et al., 2007). Further, different habitat conditions are also thought to impact the reproductive success, growth, and survival of snails (Perea et al., 2007). For these reasons, variables such as light intensity are important aspects when considering snail distributions.

A previous study has suggested that areas with ambient light and greater light intensity are preferred for a snail species commonly known as the garden snail (*Helix aspersa)* instead of dim, low-intensity regions (Perea et al., 2007). In natural settings, the results of another study indicated that terrestrial snails (*Theba pisana)* avoided regions directly exposed to sunlight (Cowie, 2009). These sunlit regions were associated with higher temperatures, desiccation, and physiological stress in the snails (Cowie, 2009). Members of an aquatic snail species (*Radix swinhoei*) were also observed to increase in growth with increased levels of light intensity (Li et al., 2005).

Despite these prior studies, there is overall limited research available on the impact of light intensity on terrestrial snails, particularly in their natural habitats (Perea et al., 2007). Consequently, this subject remains an area needing further research. Our study was motivated by the opportunity to address this knowledge gap and further understand how light intensity and terrestrial snail abundance may be correlated in natural settings. Further, our study aimed to understand the impact of light intensity on the population density of terrestrial snails specifically within a garden habitat. It was hypothesized that if light intensity is higher, then terrestrial snail abundance will increase in a garden habitat. This hypothesis is consistent with the results of existing literature (Perea et al., 2007).

With this research project, the abundance in nature of terrestrial snails can be better understood with respect to light intensity levels and how this may tie in with other environmental variables. The results of our research may have implications in understanding current and projected terrestrial snail distributional patterns, planning strategies for future habitat conservation initiatives, and furthering knowledge on the importance of terrestrial snails in their ecosystems. This study may also serve as a foundational piece of literature for light intensity studies and inspire future research studies to expand upon the topic.

Methods

Our study was carried out in three gardens in Surrey, BC, one garden in Vancouver, BC, and one garden in Delta, BC for a total of five gardens. The level of shade in the gardens varied with weather. A 225 ft^2 plot (15 x 15ft) was measured using measuring tape and closed off in each garden with masking tape. Light intensity was measured in each garden simultaneously using a lux meter once a day at noon for 17 consecutive days from March 7 – March 23. The lux meter was provided through an app called "Lux" available for mobile phones. Therefore, this measurement was made with mobile devices rather than traditional lux meter devices. The devices were calibrated before use by placing them in front of a 10,000 lux light box to reduce error in measurements. One researcher was designated to collect light intensity measurements at each garden site at noon throughout the data collection period of the study.

In this 225 ft^2 plot, we derived population size estimates of the terrestrial snails at each garden site by implementing the mark and recapture method, which is considered a useful population estimating tool (Carvalho et al., 2013). Terrestrial snail species were accounted for irrespective of a particular species type. On March 7 at noon, we collected 7 snails by hand from each garden using a container and marked their shells with nail polish. These snails were then released, and subsequent capturing took place every 4 days following the initial marking on March 7. There were 4 field trials in total.

Figure 1: Capaea nemoralis is a common terrestrial snail species found in gardens in B.C. From "Tumblr", 2021. https://www.tumblr.com/tagged/Grove-Snail?sort=top.

The mean light intensity at each garden site was calculated by taking the sum of the light intensity measurements over the 17 days and dividing this sum by 17. The population size was also estimated by taking the sum of snails captured/recaptured during the trials and inserting these values into the Lincoln-Peterson formula:

$$N = \frac{Kn}{k} \tag{1}$$

In this equation, *N* is the population size estimate given as number of snails, *K* is number of snails initially captured and marked (which was 7 in our study), *n* is the total number of snails collected during trials (captured and recaptured) after initial capturing, and *k* is the total number of snails that were recaptured during the trials. Following this, the population size was divided by the 225 square feet area to calculate population density at each garden site. The data collected from each garden site as well as a sample calculation to derive population density can be found in the supporting information section of this paper.

Following this, we performed a simple linear regression analysis by incorporating our calculations of mean light intensity and population density at each garden site as X, Y values respectively in the data analysis software GraphPad Prism 9.0.2(161) to determine whether a significant correlation existed between light intensity and population density.

Results

Using the daily light intensity measurements at each of the 5 garden sites, we found that the mean light intensity ranged from 5131 lux at the site receiving the lowest light intensity (Garden 1) to 6764 lux at the site receiving the greatest light intensity (Garden 2).

Table 1: Mean light intensity at each garden site.

	Garden 1	**Garden 2**	**Garden 3**	**Garden 4**	**Garden 5**
Mean Light Intensity	5131 lux	6764 lux	6390 lux	6251 lux	6487 lux

The estimated population density was found to range from 0.116 snails/ft^2 (Garden 1) to 0.173 snails/ft^2 (Garden 4). As a sample result, we estimated the population size (*N)* of Garden 1 to be 26 snails using the Lincoln-Peterson formula given that the total snails captured and recaptured were 22 (*n*) and 6 (*k*) respectively. This population size was divided by 225ft^2 to find the population density value of 0.116 snails/ft^2.

	Garden 1	**Garden 2**	**Garden 3**	**Garden 4**	**Garden 5**
Population density	0.116 snails/ft^2	0.124 snails/ft^2	0.097 snails/ft^2	0.173 snails/ft^2	0.138 snails/ft^2

Table 2: Population density at each garden site

Simple linear regression analysis provided a goodness of fit (R^2) measure of 0.018. We took the square root of this value to find that the correlation measure (R) is 0.137. The p-value obtained was 0.83, with the α significance threshold set at 0.05. This analysis is visualized in Figure 2:

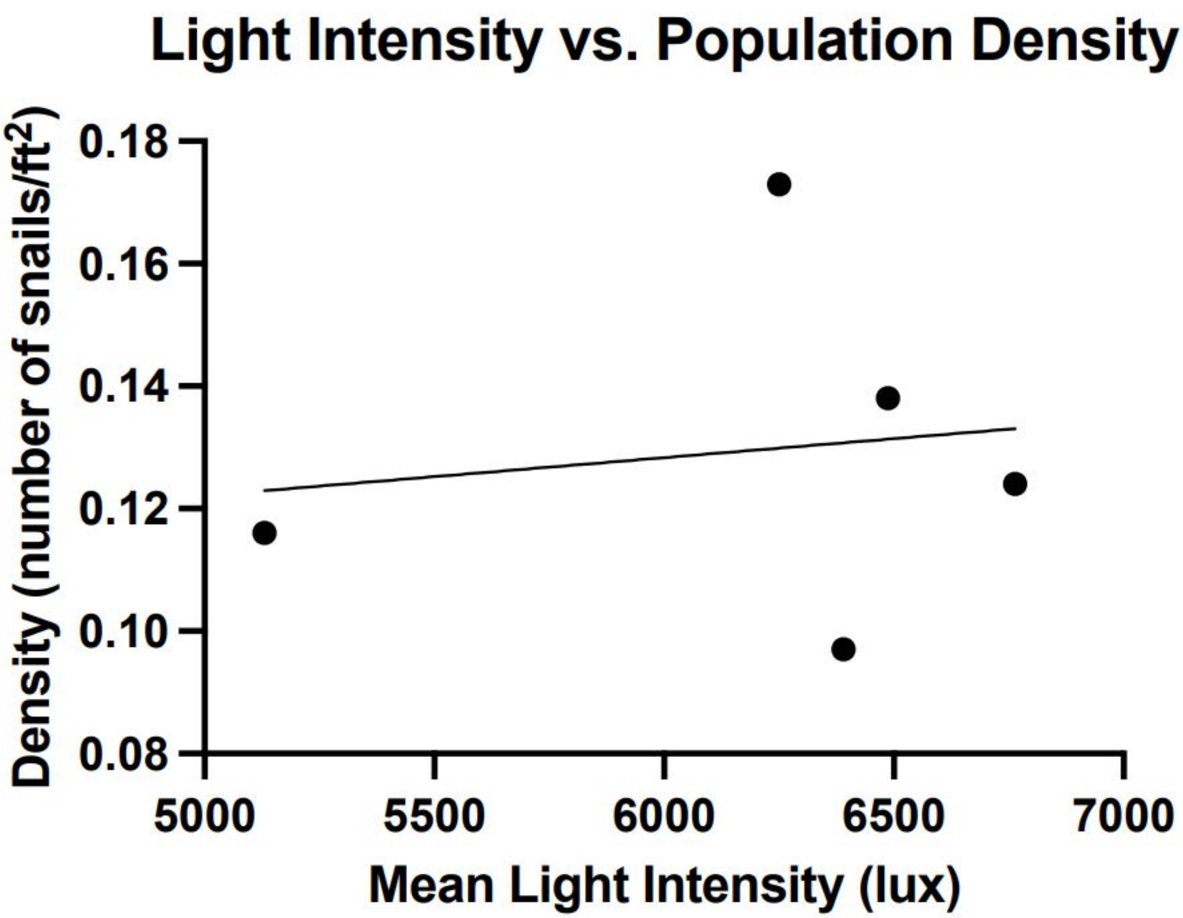

Figure 2: Simple linear regression analysis of mean light intensity (x axis) and population density (y axis). Each data point represents the calculated mean light intensity and population density values at each of the garden sites for a total of 5 points. $R^2 = 0.0188$, $R = 0.1371$, p-value = 0.8259.

Each data point in the graph was representative of the mean light intensity and population density at each of the five garden sites.

Discussion

Given the p-value of 0.83 for the linear regression analysis, our findings suggest that there is no significant correlation between light intensity and population density. Therefore, we fail to reject the null hypothesis that there is no correlation between light intensity and population density. The R^2 value of 0.018 indicates that 1.8% of the variation observed in population density is explained by light intensity. Further, the R value of 0.137 indicates a potential positive but weak correlation between light intensity and population density, meaning that population density would be expected to increase with increasing light intensity. However, given the non-statistically significant nature of this analysis, a correlation cannot be assumed to exist as there is no evidence to support this. Consequently, we fail to support the alternate hypothesis that snail abundance will be greater in regions with higher light intensity.

The results of our research do not draw parallels with the findings of Perea et al. which suggested that the terrestrial snail *H. aspersa* prefer regions of higher light intensity within their habitats than dim regions (Perea et al., 2007). However, this study was conducted in a laboratory setting controlling for environmental variables such as temperature and relative humidity (Perea et al., 2007). Further, the snails were raised on an experimental farm and were of the same age when tested (Perea et al., 2007).

There was also no evidence that the snails avoided highly sunlit regions as suggested by Cowie (Cowie, 2009). However, light intensity measurements were not recorded as the study focused on temperature tolerance (Cowie, 2009).

Despite these results, our study is not without limitations which contribute uncertainty to our findings. For one, it is important to realize that the population size values were estimated from field samples, which are not entirely representative of the true population size. Therefore, the population density values used in our analysis can only be estimates as well. Secondly, the confounding variables in our field study were not controlled for. This leaves room for variability in weather patterns including temperature, wind speed, and precipitation to potentially influence these outcomes. These variables may tie in with the results of previous research, which has indicated that the activity of terrestrial snails can vary due to temperature differences (Cameron, 2009). Furthermore, our data collection period was restricted to only 17 days in the month of March, with light intensity measurements taken at only one time of day (noon). Thus, uncertainty remains as to how the abundance of snails may have changed during different times of the day as well as year. Additionally, terrestrial snail species were recorded irrespective of species type. It is possible that distinct species vary in their fundamental niche and ability to tolerate abiotic factors such as light intensity as well as biotic factors within their environment which could have impacted our observations. Finally, we relied on 5 different mobile devices to take light intensity measurements. This introduced uncertainty in the reliability of the instruments we used as they may vary in their precision and accuracy in detecting and measuring light intensity despite our efforts to calibrate them prior to taking measurements.

Due to the small-scale nature of our sampling, this study should be viewed as a preliminary framework for further research to expand upon. We believe that future studies would benefit from collecting data from more locations, multiple times daily, for a longer period of months throughout the year. Furthermore, it would also be worthwhile to take measurements of additional environmental variables such as weather and soil quality to capture potential significant effects of confounding variables on abundance observations. Increased specificity of terrestrial snail species may also allow for future studies to increase the clarity of their results. Finally, the use of a consistent kind of calibrated lux meter device across study sites with proven precision and accuracy can be helpful in reducing the variability associated with measuring instruments.

Conclusion

In conclusion, we did not find a statistically significant correlation between light intensity and terrestrial snails in their natural habitats. The results of this study can have implications in obtaining a preliminary understanding of the impacts of environmental variables such as light intensity on terrestrial snail distributions and also serve as a foundation for future studies to build upon with more detailed, comprehensive methodologies.

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Appendix A

Supplemental Table 1: Light intensity measurements at each garden site daily at noon through the 17-day collection period.

	Garden 1	**Garden 2**	**Garden 3**	**Garden 4**	**Garden 5**
March 7	4836 lux	5742 lux	5369 lux	4971 lux	5127 lux
March 8	5312 lux	8484 lux	7384 lux	6744 lux	8391 lux
March 9	5017 lux	6129 lux	5973 lux	5538 lux	5751 lux
March 10	4643 lux	5680 lux	5465 lux	5792 lux	5684 lux
March 11	5692 lux	8698 lux	6981 lux	7041 lux	7530 lux
March 12	5179 lux	7038 lux	6703 lux	6685 lux	7139 lux
March 13	5534 lux	7864 lux	6420 lux	6489 lux	5931 lux
March 14	4697 lux	5133 lux	5054 lux	5208 lux	5094 lux
March 15	5642 lux	8374 lux	7488 lux	7093 lux	7928 lux
March 16	5290 lux	7612 lux	7021 lux	6777 lux	6946 lux
March 17	5009 lux	6035 lux	6823 lux	6574 lux	6389 lux
March 18	5126 lux	5743 lux	6703 lux	6094 lux	6232 lux
March 19	5148 lux	6192 lux	5871 lux	5930 lux	6334 lux
March 20	4725 lux	5891 lux	5355 lux	5462 lux	5701 lux
March 21	4834 lux	5787 lux	6562 lux	6376 lux	6032 lux
March 22	5197 lux	6914 lux	6238 lux	6582 lux	6885 lux
March 23	5341 lux	7671 lux	7217 lux	6903 lux	7189 lux

Supplemental Table 2: Mark and recapture schedule of snails with 4 field trials taking place in 4-day intervals.

Trial #	**Initial Markiing Date**	**Capture/Recapture Date**
---	March 7	--
1	--	March 11
2	--	March 15
3	--	March 19
4	--	March 23

Supplemental Table 3: Number of snails captured and recaptured (Captured/recaptured)

	Trial 1	Trial 2	Trial 3	Trial 4
Garden 1	5/1	3/0	8/3	6/2
Garden 2	9/3	4/1	5/1	10/2
Garden 3	6/3	7/1	8/3	7/2
Garden 4	5/1	6/0	8/2	9/2
Garden 5	9/2	9/3	7/2	6/0

Appendix B

Calculations: Population density at each garden site

Garden 1: $N=Kn/k$ $K = 7$, $n = 22$, $k = 6$, $N = 26$ = population size Population density = 26 snails/225ft^2 = 0.116 snails/ft^2
Garden 2: $N=Kn/k$ $K = 7$, $n = 28$, $k = 7$ $N = 28$ = population size Population density = 28 snails/225ft^2 = 0.124 snails/ft^2
Garden 3: $N=Kn/k$ $K = 7$, $n = 28$, $k = 9$ $N = 22$ = population size Population density = 22 snails/225ft^2 = 0.097 snails/ft^2
Garden 4: $N=Kn/k$ $K = 7$, $n = 28$, $k = 5$ $N = 39$ = population size Population density = 39 snails/225ft^2 = 0.173 snails/ft^2
Garden 5: $N=Kn/k$ $K = 7$, $n = 31$, $k = 7$ $N = 31$ = population size Population density = 31 snails/225ft^2 = 0.138 snails/ft^2