The difference in the population density of pill bugs in the Metro Vancouver area

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Abstract

The differences in the population density of pill bugs between two different locations in Metro Vancouver were studied to determine if there was a difference between the locations. The significance of studying pill bugs is due to the fact that they are quite essential to nutrient cycling since they help remove harmful metals from the soil. The population density was measured in November from the 9^{th} to 18^{th} and was calculated using Chapman's estimator, a capture-recapture method to obtain an unbiased estimated population size. The experiment assumed that the population was static without immigration or migration occurring. Pill bugs were marked two days before their recapture and the captured pill bugs were recorded along with the temperature. After two days, the sites were revisited to count the total number of marked and unmarked pill bugs. As for statistical analysis, the temperature was recorded but returned a value of r=0.022599 which supported that temperature does influence population density. As for the difference between the North Shore area and UBC area, with the r-value obtained above, it was concluded that there is no difference in population density between the two areas as the p-value obtained was p=0.966108. This did not provide sufficient evidence to reject the null hypothesis which led to the conclusion that the difference was due to chance.

Introduction

The common pill bug, *Armadillidium vulgare*, is an ectotherm, which means its body temperature is regulated by the surrounding environment. Pill bugs face many challenges on terrestrial land including desiccation, predation, nutrient acquisition, and temperature regulation. Studies indicate that pill bugs prefer a habitat with a moderate temperature between 24°C and 34°C and damp soil (Morgado et al., 2015). Despite this preference, pill bugs are known to have a tolerance of temperatures ranging from -2°C to 36°C. This insinuates that any temperature below -2°C and above 36°C is lethal for pill bugs (Morgado et al., 2015). Furthermore, pill bugs often reside under rotting wood characterized by high ambient moisture levels (Franklin et al. 2015). To test the effects of temperature and environment on the population density of pill bugs, a mark and recapture will be performed on 6 different populations of pill bugs, with the ultimate goal of determining the difference between the density of pill bugs that inhabit the North Shore as opposed to those that inhabit land on UBC.

This technique is ideal for this experiment as it is not practical to count all the individuals in the population. Essentially, the technique involves capturing a portion of a pill bug population at a certain location, marking them, and releasing them back into the population. Later, another portion is captured, while making a note of the number of marked individuals that remain in the captured population. The number of marked individuals in the second sample should be proportional to the number of marked individuals in the whole population. (Wildlife Preservation Canada, 2020). Subsequently, the Chapman estimator will be used to provide an unbiased estimate of the population size. The Chapman estimator is:

$$\hat{N}_C = \frac{(K+1)(n+1)}{k+1} - 1$$

Where N = Number of pill bugs in the population, n = Number of pill bugs marked on the first visit, K = Number of pill bugs captured on the second visit, and k = Number of recaptured pill bugs that were marked. This value is rounded down to the nearest whole unit.

Having already established that pill bugs prefer moderate temperatures, it is predicted that lower temperatures will cause higher mortality rates in pill bugs. As such, it is expected that the pill bugs recapture population density will be lower in areas where it is colder. Additionally, research also states that soil moisture cannot be too high. The moisture level of soils around 50% seems to be optimal so with the current season, like temperature, conditions may be suboptimal. Given that the North Shore is generally wetter and colder than UBC, expectations seem to favour a higher recapture population at UBC. On account of this, the difference between the 2 locations may strongly affect the population density of these insects through different abiotic means. The significance of studying the effect of temperature on the population density of pill bugs is heightened by the fact that they are essential to nutrient cycling as they can remove harmful metals from the soil. As their densities decrease, so would the amount of nitrogen being recycled back into the environment. Additionally, Pill bugs are important in mitigating the release of carbon from the soil. Studies have shown that pill bugs help in reducing the carbon that is released from the soil via fungus when temperatures go up (Crowther et al., 2015). With this being said, climate change poses a major threat to the survival of these essential decomposers and may cause their numbers to decline in the future due to global warming.

Method

This field experiment was carried out at three different locations in the North Shore and three other locations at UBC. Along the North Shore, the first sample was collected at Highland Boulevard in North Vancouver, the second sample was collected at William Griffin Park in North Vancouver and the third sample was collected at Ambleside Park in West Vancouver. Initially, a $5m^2$ transect area equivalent to the approximate area of a sizable log was set up at each location. The air temperature at each location was then recorded with a thermometer. The tree log found at each location was then lifted and a portion of the population, equal to 17 pill bugs, was captured from the exposed area under each log. Subsequently, their backs were marked with orange nail polish and the pill bugs were placed back into their original habitat under the log. The initial capture of all pill bug samples in the North Shore took place on Sunday, November 14. The samples were collected and marked at 1-hour intervals, with the first population collected and marked at 10: 00 AM and the last population collected at noon. Two days following the initial marking, the amount of the marked pill bugs as well as any unmarked pill bugs were recorded and the Chapman estimator was used to estimate the approximate population of the pill bugs at each of the three locations. The recapture took place on Tuesday, November 16.

A similar method was implemented when collecting samples from the Vancouver area, however, the samples were collected on different dates. Following the collection of all relevant data, an analysis of the data on temperature and population density of pill bugs was performed. The models used in this analysis included linear regression and Pearson's correlation coefficient for calculating the R-value. Subsequently, a t-test was performed to determine whether the temperature and population density of pill bugs can be linearly correlated in a significant way.

Figure 1. Approximate area from which pill bugs samples were collected (UBC).

Figure 2. Pill bugs were collected in a cup and marked before being placed into their original habitat.

Results

Table 1: Table of results for the 6 field samples. The values highlighted in yellow pertain to the North Shore and the values highlighted in orange were obtained from the Vancouver area (UBC campus).

Temperature	population density of pill bugs		
9.5	3.509		
8.2	3.585	coefficient (r)	0.022599
9.1	3.269	N:	6
7.9	2.157	T statistic :	0.045209
9.2	5.333	DF:	4
3.9	3.962	P value:	0.966108

Using the data collected at all locations, a Pearson coefficient (r-value) of 0.022599 was obtained. Furthermore, a p-value of 0.966108 was obtained. Finally, a t-statistic of 0.045209 was also calculated.

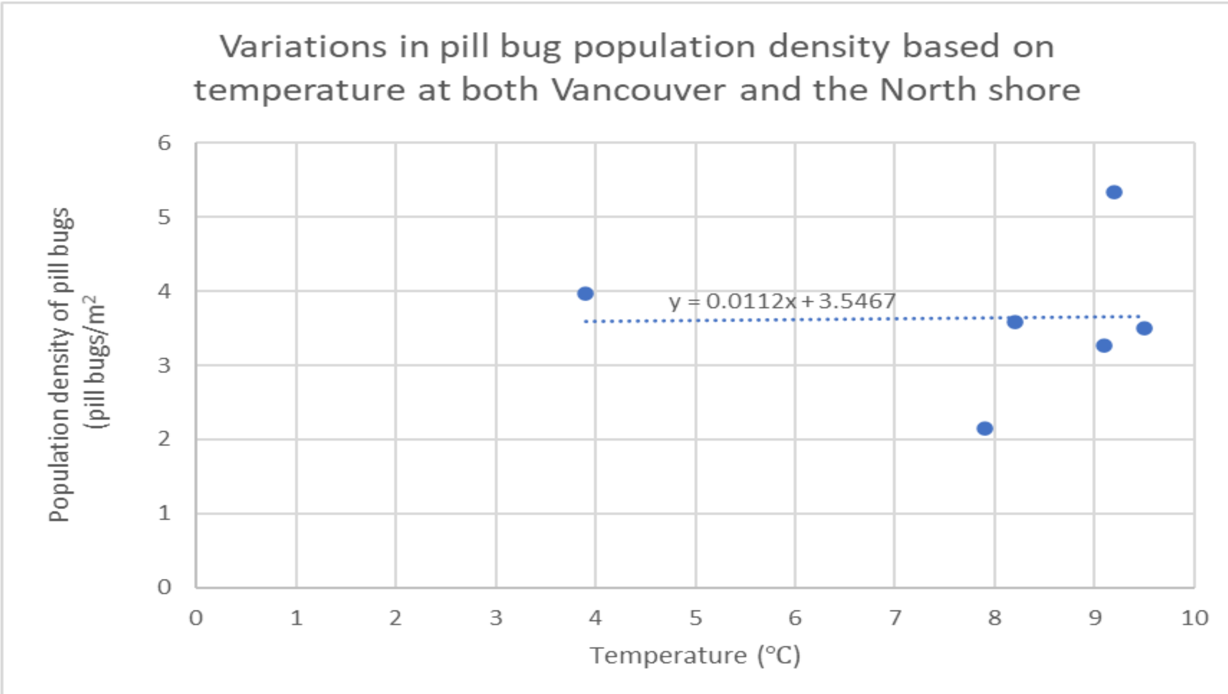

Figure 3: A scatter-plot displaying how pill bug population density differs based on variations in temperature during a 2-week period in November at 6 different locations. The graph aims to establish a correlation between temperature and pill bug population density using a simple linear regression line. Based on the results, there is no observable trend on the graph.

Each of the six data points in figure 3 corresponds to a location from which pill bug samples were collected. Each point represents the pill bug population density at a specific temperature.

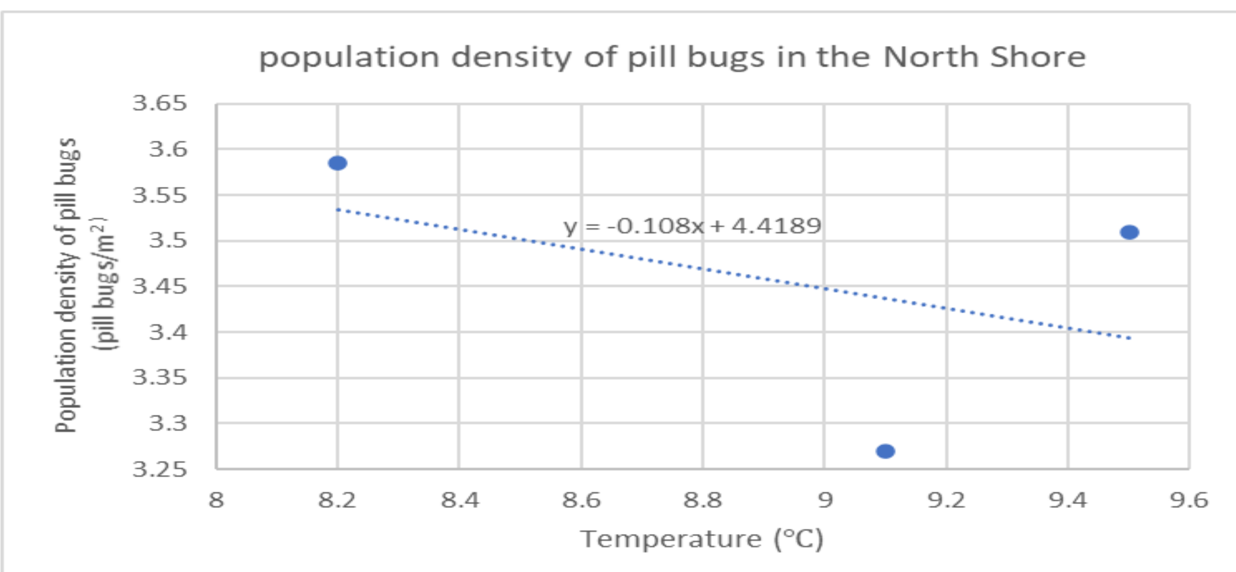

Figure 4a: A scatter-plot displaying the population density of pill bugs at three different locations in the North Shore. The regression line shows an overall negative trend with an increase in temperature associated with lower population density. However, there is no clear observable trend on the graph.

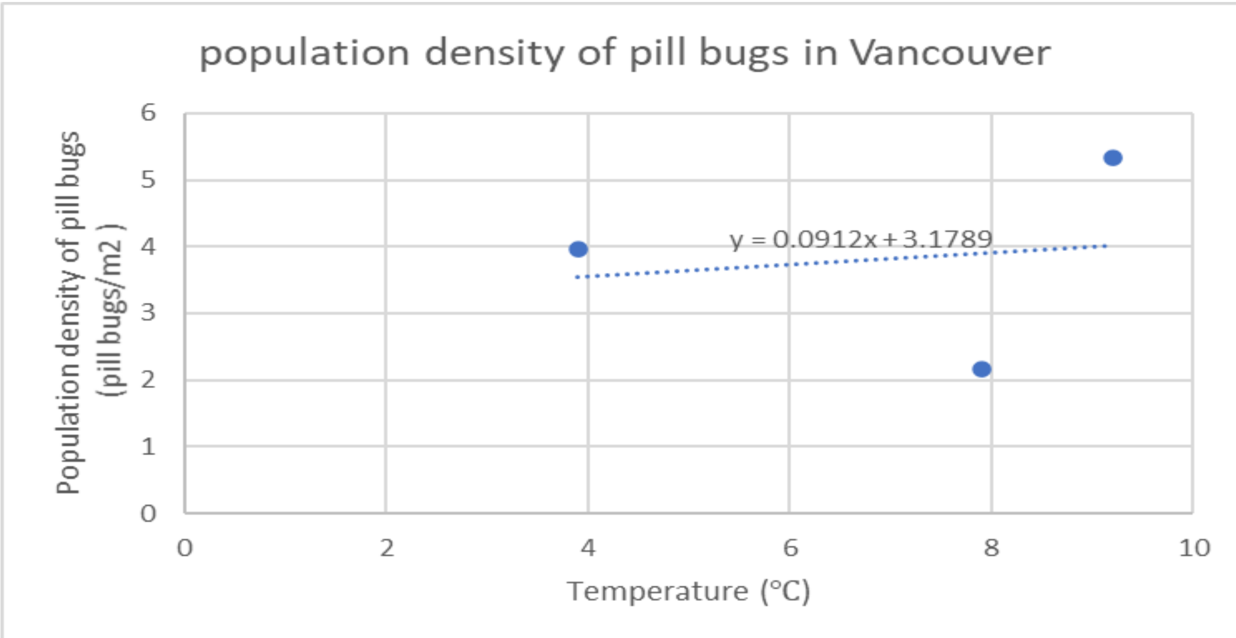

Figure 4b: A scatter-plot displaying the population density of pill bugs at three different locations in Vancouver (UBC campus). The regression line shows an overall positive trend indicating an increase in population density with an increase in temperature. However, there is no clear observable trend based on the data points.

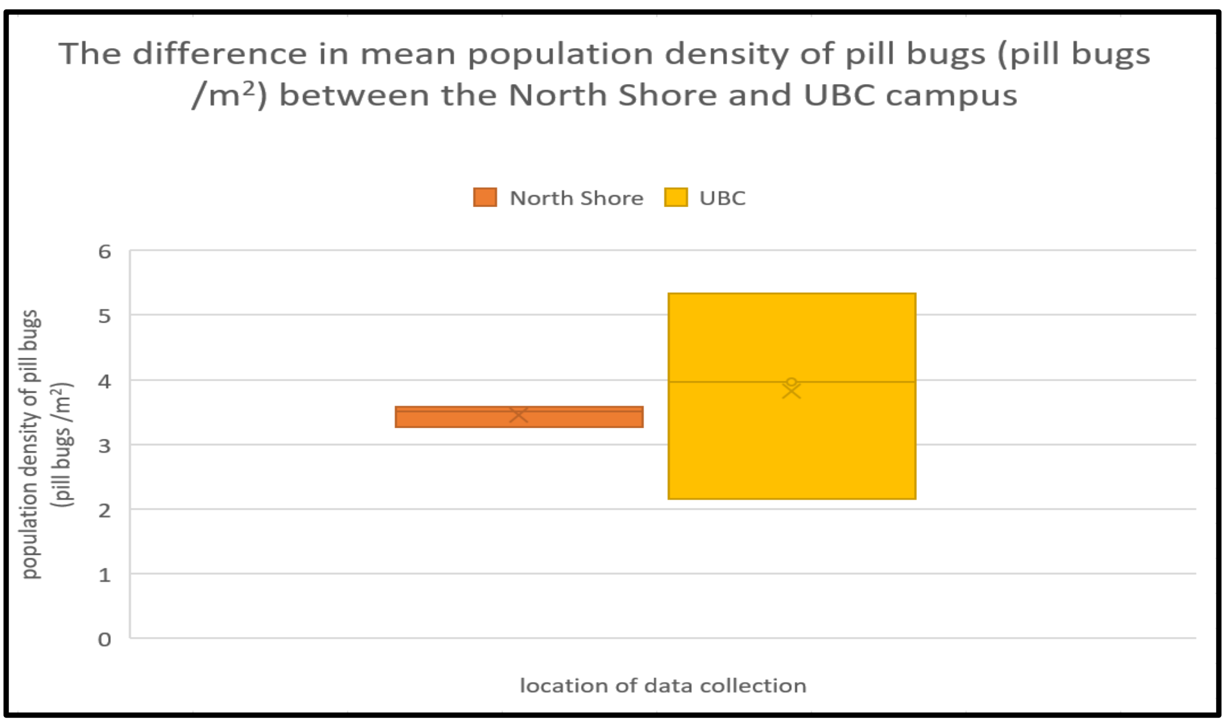

Figure 5: A box-plot representing the difference in mean pill bug population density (pill bugs /m^2) between the North Shore and the UBC campus. $N_{North\ shore}$ = 3, N_{UBC} = 3. N_{total} = 6, df =4, p-value= 0.966108.

The box plot in Figure 6 indicates a slightly higher population density of pill bugs at the UBC campus. To determine the significance of these findings, a one-tailed, two-sample t-test was performed. Hence the variance between the North shore and UBC was assumed to be equal. The t-statistic was calculated to be 0.045209. Both areas (North Shore and UBC) had an equal sample size of 3, giving a total sample size of 6. This would result in a degree of freedom of 4 and give a p-value that is more than 0.05. Hence, the findings of this experiment were deemed to be insignificant.

Discussion

After analyzing the data we fail to reject the null hypothesis which states that there is no significant difference in the population density of pill bugs in the North Shore area and Vancouver. Therefore, we reject our alternative hypothesis that there is a significant difference between the pill bug population density of the North Shore area and Vancouver. Due to insufficient data, as well as conflicting data, we cannot conclude that temperature plays a significant role in the population density of pill bugs. The r-value obtained from the experiment is 0.022599. Since the value is positive it indicates some sort of correlation between temperature and population density of pill bugs. However, the degree of correlation itself is very low which means that there is a very small correlation between the two continuous variables. In our calculations we also got a p-value of 0.966108, keeping in mind that $p > 0.05$. This means that the data we obtained was insignificant, in turn providing evidence for the null hypothesis that there is no significant difference between the population density of pill bugs in the North Shore and Vancouver. On top of this, obtaining a t-statistic of 0.045209 which in itself is a low number indicates further support to the rejection of the alternative hypothesis that there is a difference between the population density of pill bugs in the Metro Vancouver area.

Perhaps we could not find a strong correlation between the two variables we measured, temperature and pill bug population density, due to other factors influencing our results. Messina et al. (2016) explain how other factors can influence the distribution and density of isopods, factors such as vegetation, and the type of area such as coastal vs terrestrial. It is also proven that when competition for food is reduced, it leads to higher growth rates and increased population density (Hasall et al., 1997). Another obvious reason why our results could be inaccurate is that marking agents can generate lesser activity in pill bugs, which decreases their usefulness in mark-recapture experiments since this lesser activity can lead to biased results (Tuf et al., 2012).

Limitations that occurred during the experiment could have led to different results. In future trials, it is recommended to take the samples on the same date to try to keep the weather conditions in the two areas consistent. Transect areas across locations should remain relatively similar when collecting samples. Additionally, the sample size that was taken was relatively small to obtain statistically sound data. For future trials, up to 10 samples in the same location are recommended to decrease the possibility of obtaining results simply due to chance. As this topic is not researched in-depth, we hope that our study will provide adequate precursors for carrying out a more in-depth and detailed study in the future.

Moreover, the success of the mark-recapture procedure may have been influenced by several extraneous factors. Firstly, the marks placed on the backs of the pill bugs with nail polish may have inadvertently caused harm to the organisms or made them more susceptible to predation in the 2-day time gap between the collection of data. Secondly, even though the possibility of excess movement into or out of the population or deaths between the counts remains low, it cannot be entirely ruled out as a possible factor that may have impacted the results of the experiment, in turn leading to our rejection of the alternative hypothesis.

It is also important to note that research from multiple sources has constantly found that there is a negative relationship between precipitation and isopod activity, with higher levels of mortality attributed to large amounts of rainfall, as it creates difficult conditions for isopod survival (Messina et al., 2016). This is largely significant as the forecast was rainy on most of the days when our field trials were conducted, hence high amounts of precipitation may have affected the survival of the pill bugs by acting as a confounding variable. Furthermore, an interaction between temperature and rainfall accentuates the negative effects on excess moisture in the soil (Hassal et al., 1997).

On account of this information, it is likely that the time and season at which our data was collected (i.e. the cold autumn month of November) negatively impacted the results of the mark-and-recapture process. To reiterate, isopods such as pill bugs generally prefer humid weather conditions and thrive at moderate temperatures, with peak survival at temperatures between 10-25°C, which sees a 50% drop in both extreme ranges of 5°C and 35°C respectively. (Morgado et al., 2015). Therefore, the lack of a significant difference between the pill bug population density in the North Shore and Vancouver can be attributed to the cold period of the study in November, during which temperatures and rainfall were largely similar across both regions.

Conclusion

The population density of pill bugs in the two locations, North Shore and UBC were examined. The temperature was seen to have an impact on population density as the population showed a decline with decreasing temperatures. In terms of differences in location, the data was unable to show a difference between the two areas. These results suggest that biotic and abiotic factors are similar between the two locations. Although this study does not address the multiple factors that can affect population density, it provides evidence that temperature and potentially humidity can affect the pill bugs.

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