Introduction

Biodiversity can be defined as the variability of living organisms from all sources and the ecological complexes they are a part of, such as diversity between species and ecosystems, and within species (Titley et al., 2017). Most diversity is discussed at the species level, as that is the complex that correlates best with species richness. Species richness on the other hand is the number of different species that are present in a specific area. Species richness is a good measure of species biodiversity because it provides researchers or scientists with a measure of how assorted a population is. Species richness across regions can only be changed and explained based on speciation, extinction, and dispersal (Pyron and Wiens, 2013). Once there is a general idea of how many different species there are present in the region of study, species’ abundance can be observed. Species’ abundance is a measure of how many individuals there are from one species relative to the entire population. These concepts can be used to understand complex habitats and provide reasons for varied biodiversity across numerous regions such as the tropics or temperate zones.

Tropical regions tend to be humid, wet, and consist of savannahs and rainforests (Romer, 2013). They tend be located at lower latitudes near the equator where there are large amounts of rainfall, high temperatures, an abundance of water, and products of biological decay (Romer, 2013). On the other hand, temperate regions are defined as having moderate annual temperatures and tend to have four distinct seasons throughout the year (Pratolongo et al., 2019). Tropical environments are said to be more stable and are associated with stable climatic factors, while temperate environments consist of a wider range of climates that can vary based on the time of the year and are found in more locations (Romer, 2013; Pratolongo et al., 2019). Due to the varying levels of stability that the two environments can provide, it creates questions as to which regions are prone to more speciation events and which regions can support a larger biodiversity.

Biodiversity varies from region to region and a major theme within is the debate of why species diversity is higher in tropical regions compared to temperate regions. There are over 100 tested hypotheses that take this question into account and try to explain this phenomenon (Wiens et al.,, 2006). A major idea that involves numerous hypotheses is that tropical re

1:20 dilution was shaken thoroughly and then 50 uL was pipetted out and onto the surface of a pre-labeled TSA plate. 5-7 sterile glass beads were added to the TSA plate and the plate was rotated to spread the suspension over the entire surface of the agar. The beads were then dumped out of the plate and into a waste jar. This procedure was repeated for each sample. All the tubes were saved and refrigerated in case of plate errors. Once all the plates were completed, parafilm was wrapped around the edges to seal each one and then they were inverted and placed in a 360C incubator, which occurred at 2:00pm. The plates were first checked after 48 hours and every subsequent 24 hours until enough bacteria grew for analysis. After 7 days in the incubator, enough bacteria grew, pictures were taken of each plate, and plates were placed in a refrigerator to prevent further bacteria growth and to have as a resource. Each plate was analyzed for bacterial growth and all the different bacterial species were differentiated by color, shape, and size, and then given a letter code for easy referral.

A two-sample paired t-test for means was performed for the mean bacterial species richness present in the concha and belly button. The Shannon-Wiener diversity index was calculated for each sample and then the mean index value was calculated for the concha and belly button. A two-sample paired t-test for means was performed for the mean Shannon-Wiener diversity index value for the concha and belly button.

Table 1: Table showing the 18 different bacterial species found in the concha of the ear and belly button of 20 sampled individuals. The species are identified by their color, shape, and size, and then the bacterial species are given a letter code for easy referral. The site in which the bacterial species was found is also recorded.

Results

18 different bacterial species were found between the belly button and the concha of the ear for 20 sampled individuals. We organized the bacterial species by color, shape, and size (Table 1). Of those 18 species, 6 were unique to just the belly button and 3 were unique to just the concha (Table 1). There was a lot of variability for the number of species found on each plate but the most species present on a single concha sample plate was 3, while for a single belly button sample plate it was 6 species. The average number of bacterial species present on the concha plates was 1.6 species while the average was 2.4 species for the belly button plates (Fig. 1). A paired two-sample t-test was performed for the average number of bacterial species present on concha versus belly button plates but it was not significant (t19 = -1.6895, p = 0.1075).

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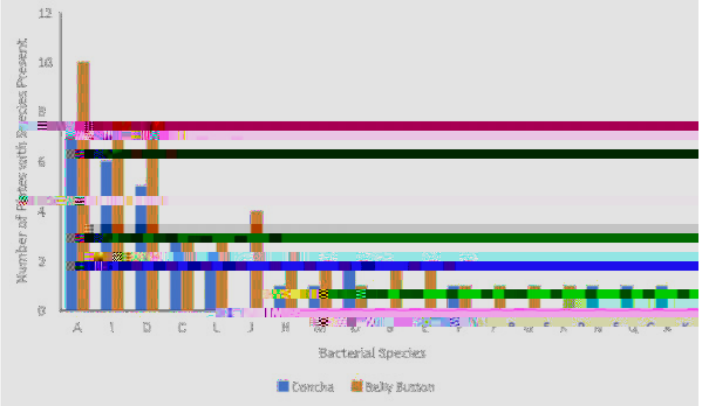

Figure 2: Bar graph showing the number of plates in which bacterial species were found in the concha of the ear and the belly button of 20 sampled individuals. The blue bars represent the concha while the orange bars represent the belly button.

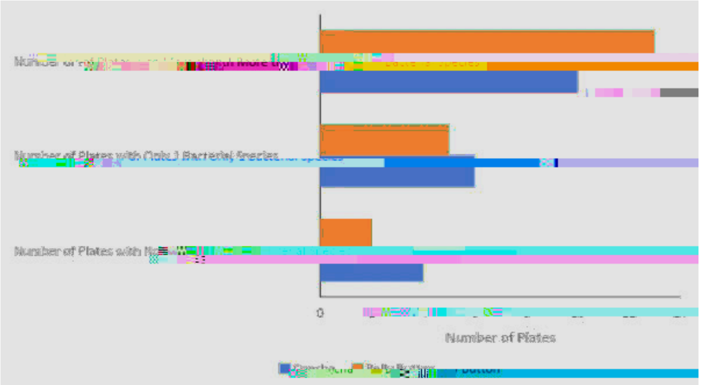

Figure 3: Bar graph comparing the number of belly button and concha plates of 20 individuals that had one or less bacterial species present and more than one bacterial species present. Blue bars represent the concha while orange bars represent the belly button.

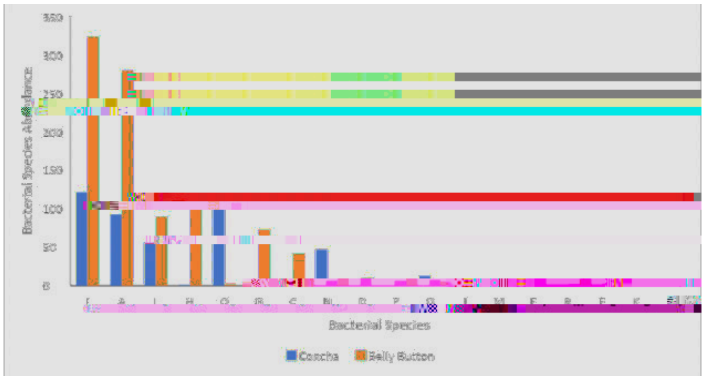

Figure 4: Bar graph showing the abundance of bacterial species found in the concha and belly button of 20 sampled individuals. Blue bars represent the concha while orange bars represent the belly button.

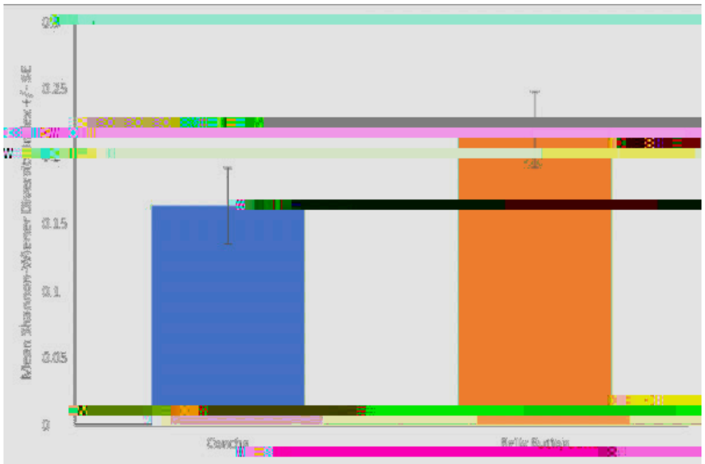

Figure 5: Bar graph displaying the average Shannon-Wiener diversity index value for the diversity of bacterial species present in 20 individuals’ concha and belly button. The blue bar represents the concha while the orange bar represents the belly button. Black lines represent standard error.

Discussion

Based on our results, belly buttons have more bacteria and more species compared to the concha of the ear. This is consistent with our hypothesis in which we predicted the belly button, analogous to a tropical region, would have a larger bacterial species biodiversity compared to the concha, analogous to a temperate region. Belly buttons not only had more species present, but they also had a larger abundance of species and a higher species diversity (Fig. 4 and 5). Much like a tropical region, the belly button can be seen at a lower latitude, as a “wet” environment, and has a more stable climate, so as a result, it had a higher bacterial species diversity compared to the concha. Much like a temperate region, the concha is at a higher latitude, is a “dry” environment, and has a changing climate as it is more exposed to external factors compared to the belly button, so as a result, it was found it had less bacteria present and at a lower diversity. There was more bacterial species found to be unique to the belly button, so that can show the bacteria could be adapted to the belly button environment, whereas almost all the species found in the concha were also found in the belly button, which can show concha bacteria are more willing to disperse outward. Although we found our data to show the belly button has more bacterial species and more diversity of the species, the t-tests performed for the average number of species per plate and the average Shannon-Wiener diversity index, were not significant. This does not invalidate our findings, it just shows that the concha also has a significant number of bacterial species and diversity of those species relative to the belly button, just at a lower level.

Previous studies have shown that tropical environments have more species diversity compared to temperate environments, so we can use former hypotheses and former findings to explain what we found. Species found in the topics have narrow thermal breadths, decreased dispersal and higher population structure, and higher diversity and speciation rates (Polato et al., 2018). This idea can help explain why the bacteria we found in the belly button tended to stay in the belly button and became more abundant. Another idea from this is that more species could have been found in the belly button because overtime speciation could have occurred which created different looking bacterial species. Also, if bacteria that originated in the belly button dispersed all the way to the concha, they could have not been able to survive the different environment, which can explain the number of species found in the belly button and not in the concha. Other hypotheses that explain that the tropics are more stable, and the species found in the tropics have a small niche range, have more biotic interactions, and more diversification events (Lawrence and Fraser, 2020), help support our findings as the belly button represents a tropical region. Another thing we found is that even though there were more bacterial species in the belly button, the abundance was not always large, so species populations were somewhat small in the belly button. This idea is supported by the genetic drift hypothesis in which tropical species tend to have small population sizes which leads to genetic drift which creates speciation and hence, more species (Lawrence and Fraser, 2020). On the other hand, in a previous study that focused on plant genetic variation between temperate and tropical regions, they found that there were different alleles that appeared in the different regions, but the overall genetic variability remained similar in both regions. The diversity of the species and the richness was not significantly different between the two regions (Lehner et al., 2017). This finding can support the fact that even though we found more species and more diversity in the belly button, it was not significantly different compared to the concha. Numerous previous research can support our findings based on the idea that the belly button is a tropical region while the concha is a temperate region.

Looking into the future, we can expand our field of study to other body parts to test and observe if different regions of the body yield more bacterial species. We can compare the habitat of the new sample site to the habitat of the belly button and concha and then make predictions. As we have found, regions that are “wet” tend to have more species, a more abundance of species, and a higher level of diversity compared to “dry” regions. We can use this knowledge to test other regions that could be “wet” or “dry” and observe if this idea remains true. An example of a different “wet” environment could be the armpit while a different “dry” environment could be the forearm. Another expansion of this study could be trying to find every region of the body that has a specific species of bacteria. This would be hard to achieve, but it would allow us to understand how bacteria moves around the outside of the human body. Bacteria of the o " ʋ ꝑ M