Dissochaetus range is determined by precipitation, temperature, and elevation

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Introduction

The Coleoptera order is the most abundant order of insects with ranges that span the entire globe. Within Coleoptera, the family Leiodidae contains the genus Dissochaetus, a small beetle found in North and South America commonly called round fungus beetle (Evans 2014). Dissochaetus are scavenging beetles, feeding mostly on dung and carrion (Peck 2016). This genus is morphologically typical of Leiodidae, with an antennal club and an eighth antennomere reduced in size (Asenjo, Seago, and Chaboo 2016). While Dissochaetus is the subject of this report, little literature exists that specifically discusses this genus. Therefore, I will look to the family, Leiodidae for range and habitat information. Leiodidae is found over most of the earth, including across the Americas, indicating that it exists in the Nearctic and Neotropical realms. Overall there is a higher level of diversity within Leiodidae in the Neotropics, with more genera and species found than in the Nearctic. Leiodidae is thought to have dispersed from North America to South America during the ice ages of the Pleistocene in search of warmer climates (Peck 1972). However, Leiodidae diversified before the Pleistocene during the Tertiary epoch (Topp 2003). Since their dispersal south, some Leiodidae have specialized according to their microhabitats, especially those who arrived on islands in the Caribbean due to jump dispersal and are now species endemic to these islands (Peck and Cook 2014). These beetles overwinter but depending on their location show seasonality in breeding ensuring that larvae mature in the warmer months (Kocarek 2002). The current distribution of Leiodidae is controlled by soil moisture content and temperature (Topp 2003). Across the planet, Leiodidae is found primarily in forest habitats, in semi-arid to wet areas that vary in elevation from sea level to the montane tree line (Peck and Cook 2016). However, most collected samples of Leiodidae and Dissochaetus have been found at relatively higher elevations, which could be indicative of their range or simply because generally in their known distributions protected areas tend to occur at higher elevations making sampling at higher elevation more common (Peck 2010).

The questions discussed in this report ask about the differences in potential range between the Dissochaeuts samples collected in the Nearctic and Neotropics, the differences between all Neotropic samples and those collected in Argentina, and the effect of elevation on the potential range of Dissochaetus. I hypothesize that precipitation and temperature will be the two most important variables determining the possible range of Dissochaetus from both the Nearctic and Neotropics. However, the samples collected in the Nearctic will have a broader potential range due to the variable climate in the Nearctic. Additionally, when compared to the entire Nearctic realm, samples of Dissochaetus collected in Argentina will be limited by specific habitat type, or land cover, more than precipitation or temperature due to specialization to Argentinas specific habitats. Finally, I predict that elevation will not be a possible vicariant event for Dissochaetus and examining the genus when separated by elevation will not cause differences in their potential ranges.

Methods

A catalog of Dissochaetus samples was created using the Chicago Field Museum's collection of Dissochaetus specimens. Information was taken from the associated tags and compiled into Microsoft Excel. The latitude and longitude for each sample site was determined using Google Earth and the specific location information given about the collection. These data were entered into ArcGis, and a map was created that showed the location for each collection and the country that they were collected from in order to verify the coordinates found (fig. 1). The data was separated into Nearctic, Neotropics, Argentinian samples, low elevation, and high elevation. These separated sheets were converted to .CSV files with only coordinate and genus information. These data sheets were used to run Maxent models according to the instructions written by Phillips and Menke. As well as the five above listed separations, 21 variables were considered when building the potential ranges, including elevation, land cover, and precipitation and temperature data (see tables 1-6). The Nearctic realm was considered as all samples collected in the United States and Mexico while the Neotropical realm was all samples collected south of Mexico. Samples collected in Argentina according to the information found on their tags were included in the Argentinian category. Elevation information was recorded for 82 samples. These samples were split into a low elevation and high elevation group at 680 meters, with 680 m included in high elevation. 680 meters was chosen because it was the median elevation of the samples and I could find no literature that supported a different elevation at which to separate these samples. Samples that included elevation in feet were converted to meters and samples with no elevation data were excluded from this analysis.

Results

Hypothesis 1

It was predicted that while the Nearctic samples would have a larger potential range overall, the potential ranges of both Neotropical and Nearctic samples would be determined by temperature and precipitation. The data and models supported this hypothesis. When comparing the Nearctic to the Neotropics, the annual diurnal temperature is the most important factor in determining the range of Nearctic samples while the precipitation in the warmest time of the year was the most influential variable in the model for Neotropical samples. Seasonality is the second most influential variable when looking at the Neotropics while seasonal precipitation is important to the Nearctic realm (tables 2 and 3). Looking at the maps, it becomes clear that while there is a lot of overlap in the potential ranges, especially in Western Africa and Polynesia, the Nearctic samples give way to a larger overall potential range that spans more biomes and climates. (figures 2 and 3)

Hypothesis 2

The second hypothesis compared the samples collected in Argentina to the samples collected everywhere in the Neotropics. Looking at samples of Dissochaetus from Argentina, instead of temperature or precipitation being the most important factors in determining the potential range, land cover was the most important variable as opposed to precipitation. However, the samples collected in Argentina were from a much smaller geographic range, and this may have contributed to this. However, after landcover, seasonal precipitation is the second most influential variable determining the potential range of the Argentinian samples (table 3).

Examining the maps of potential ranges, the majority of area suitable for Argentinian samples (figure 4). Additionally, the potential range for the Argentinian samples was smaller overall than the Neotropical samples' potential range. This overlap may also be due to the fact that the Argentinian samples were included in the model using the Neotropical samples.

Hypothesis 3

The third hypothesis compared the potential ranges of samples collected at high and low elevations, to see if elevation could be a potential vicariant event that may lead to speciation. In the high elevation samples, isothermality, or the constancy of temperature was the most critical variable, while for the low elevation samples annual precipitation had the most effect on the potential range. Interestingly, isothermality was also important to the low elevation samples and precipitation in the warmest month had a large effect on the potential range of high elevation samples (tables 4 and 5).

When comparing the potential range maps (figures 5 and 6) between high and low elevation samples, samples collected at high elevations had a much larger potential range that included the majority of low elevation potential range.

Discussion

Hypothesis 1

These results support the first hypothesis, that precipitation and temperature will be the two most important variables determining the potential range of Dissochaetus from both the Nearctic and Neotropics. The second part of the hypothesis that the samples collected in the Nearctic will have a broader potential range due to the variable climate in the Nearctic was also supported, again potentially due to the increased temperature ranges in the Nearctic and the dependence of Dissochaetus and the Leiodidae family on temperature and moisture.

These results could indicate that in the Nearctic, temperature is more important in determining the distribution of Dissochaetus while in the Neotropics precipitation matters more. This result is due to the fact that temperatures are more variable in the Nearctic, which is more seasonal; therefore, temperature would bound the possible range for species and samples from the Nearctic while the Neotropical region is generally more isothermic and ranges may be determined by precipitation. The results are in line with the concept that the Leiodidae family distribution is dependent on soil moisture and temperature (Topp 2003). These ideas are held up by the map of potential ranges for Dissochaetus, where the Nearctic samples have a much larger potential range, especially in the Northern Hemisphere that includes a variety of biomes. This makes sense as Dissochaetus is thought to have moved south searching for warmer climates during the Pleistocene, any species that stayed north, or relatively more north would retain adaptations to variable and colder temperatures (Peck and Cook 2016).

Hypothesis 2

These results do support the second hypothesis that Dissochaetus collected in Argentina will be limited by specific habitat type more than precipitation or temperature due to specialization to Argentina specific habitats. This is seen both in the most influential variables for determining Argentina's potential range and in the map of Argentina's potential range when compared to the range for all Neotropical samples. It is important to note that all samples collected in Argentina were from Northern Argentina, which has a much milder climate than southern Argentina and thus should not be used to extrapolate information about the entire country.

As seen in the results, the most critical variable for determining the potential range for Dissochaetus samples collected in Argentina was land cover. This might indicate that within an area with common temperature and precipitation (such as the small area of northern Argentina the samples were collected in (figure 1)), Dissochaetus has begun to specialize to specific habitats. Dissochaetus is known to specialize to its location as on many islands in the Caribbean and in caves (Peck and Cook 2014; Peck and Cook 2011). While Leiodidae is commonly found in forest habitats, the type of forest, tree cover, forest floor make up and understory may all have different composition based on location (Tizado 2000). This is supported by the figure because while there is some overlap between the Argentinean samples and the Neotropical samples, there are places where the Argentinean potential habitat extends that the Neotropic potential range doesn't. This may correspond to the specific forest type or land cover seen in Argentina and other more specific places around the globe. It is worth noting that the difference in variables determining the potential range maps indicates that within a smaller area (i.e., Argentina) less variation in climate may make variation in habitat more important.

Hypothesis 3

The results comparing samples from elevations over 680 meters and below 680 meters do not support the hypothesis that there will be no difference in the potential ranges of these groups. The variables that most influence the predicted range and the maps of the potential ranges show that there is a difference between these two groups.

In the results that indicate the differences between high and low elevation, constant temperature was the most important variable for high elevation samples. Looking at the maps, one can see that overall these samples have a larger potential range, indicating that these samples may have a higher tolerance to many abiotic factors, especially since precipitation was the most important variable to low elevation samples and therefore they have a much smaller range. The literature suggests that the highest abundance of Leiodidae is found at higher elevations, which could be a remaining adaptation for these specific samples when they moved south during the Pleistocene (Peck 2010). Additionally, higher elevations are colder in general which would also support this. Additionally, Dissochaetus may have begun to specialize to the higher elevations and elevation may even be a vicariant event for this genus causing speciation in the future, or having already caused speciation.

Conclusion

Most research needs to be done specifically on Dissochaetus in order to confirm these results. The conclusions found are that Dissochaetus in the Nearctic have a wider potential range than those found in the Neotropics, indicating that Nearctic species are more adapted to wider climates. Additionally, these results may show that on a smaller spatial scale, habitat may be more important than climate to Dissochaetus, indicating the specialization of these beetles to microhabitats. Finally, elevation may prove to be a potential vicariant event for Dissochaetus. However, only phylogenetic studies and more research with a broader range of sampling data can confirm or deny these findings.

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