Species delimitation in the bear scarabs: using GIS tools to clarify the *Paracotalpa ursina* (Coleoptera) species complex

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Abstract. Distributions and environmental conditions for the western North American *Paracotalpa ursina* (Scarabaeidae: Rutelinae: Areodina) species complex are assessed using niche modeling. This species complex occurs mainly in the California Floristic Province and includes as many as nine morphotypes. Its high phenotypic variation could be influenced by mechanisms associated with the complex topographies of the Californian landscape such as dispersal barriers and climate. Comparison of factors that influence the distribution of the highly variable *P. ursina* populations with less variable sister species populations may help to elucidate the mechanisms that lead to intraspecific variation.

1. Introduction

The *Paracotalpa ursina* species complex ("little bear beetle") is a morphologically hyper-variable beetle found in the California Floristic Province (CFP), an area of diversification in for many organisms [1]. Due to the high morphological variability of the group (Figure 1), hypotheses regarding its species diversity vary from as many as nine morphotypes [2] to as few as one morphotype [3]. Much of the variation in this species complex may be the result of topographic complexity [1]. Geographic Information System (GIS) tools will be used to analyze distributional data and examine potential barriers for gene flow that may have resulted in the high variation observed in this group of beetles.

Our research aims to determine the number of evolutionary lineages present in this species complex by combining GIS tools and evolutionary analyses. Besides clarifying biodiversity in this group, this work will add to our knowledge of important biogeographic barriers in the CFP. Most scarab classification relies exclusively on morphology, and our study would be a strong example of the utility of GIS and niche modeling in this group.

Figure 1. The nine morphotypes of the *Paracotalpa ursina* species complex.

2. Experiment and Significance

A distribution model for the morphotypes of *Paracotalpa ursina* will be built using specimen locality data, elevation, and climate data. Locality data from acquired museum specimens will be transformed into occurrence points in GIS. Shape images of hypothetical distributions for each *P. ursina* morphotype will be generated by performing a multivariate Boolean analysis using different layers for temperature, elevation, rainfall, and life zones. Climate data will be procured using WORLDCLIM (version 1.4, http://www.worldclim.org). WORLDCLIM provides 19 derived climate variables based on monthly precipitation and monthly mean precipitation, as well as minimum and maximum temperature at a 1 km resolution for each layer [4; 5]. The distributional models will be estimated using MAXENT (version 3.3.3k, http://www.cs.princeton.edu/~schapire/maxent) and its maximum entropy species distribution modeling approach [6]. Evaluations of the obtained values of the predictor variables will be analyzed by a jackknife test of importance (estimation of bias and standard error) [5]. Niche modeling can assist in identifying barriers to dispersal that may lead to isolation of populations and subsequent divergence (=evolutionary lineages) [7].

3. Conclusions

My research uses both geographic (geographic information systems) and phylogenetic (relationship hypotheses) components in order to understand the biogeographical dynamics that drive diversification in the CFP. Over time, the complex mountain systems of California may act to isolate populations, thereby creating unique genetic reservoirs. These distinct regions and their associated biota are important in conservation priorities. Understanding the *P. ursina* species complex using niche modeling, morphological, and molecular methods is one step toward developing conservation priorities in the CFP. In addition to disentangling the *P. ursina* species complex, this research allows us to understand the mechanisms that generate high intraspecific variation.

Although accurately assessing the earth's biodiversity is one of the fundamental tasks of biology, only about 1.9 million species are currently described despite 250 years of biodiversity science [8]. Invertebrates in particular are poorly known, creating a lack of basic knowledge and impeding conservation efforts [9]. The CFP is home to more than 30,000 species of insects, but as in most other biodiversity hotspots, detailed studies of insects are rare [10]. My research assists in filling this critical gap.

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