DIVERSITY OF SCARAB BEETLES ACROSS AN ELEVATIONAL GRADIENT IN A TROPICAL MONTANE CLOUD FOREST

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INTRODUCTION

Tropical montane cloud forests (TMCF) are high elevation tropical rainforests characterised by high precipitation, low temperatures, and permanent/seasonal cloud cover[1]. TMCF make up 14% of all tropical forests worldwide and contain exceptionally high levels of endemism and diversity[2,3].

Mountain ecosystems show high levels of species diversity at intermediate elevations[4]. This produces a 'hump' shaped curve in diversity (Fig. 1)[4]. This 'hump' is common in mountain taxa around the globe. These patterns are studied across large scale elevation gradients. However, with large intervals between sample sites (e.g. 250–400 m[5-7]) many narrow range species are missed from sampling, resulting in underestimation of diversity.

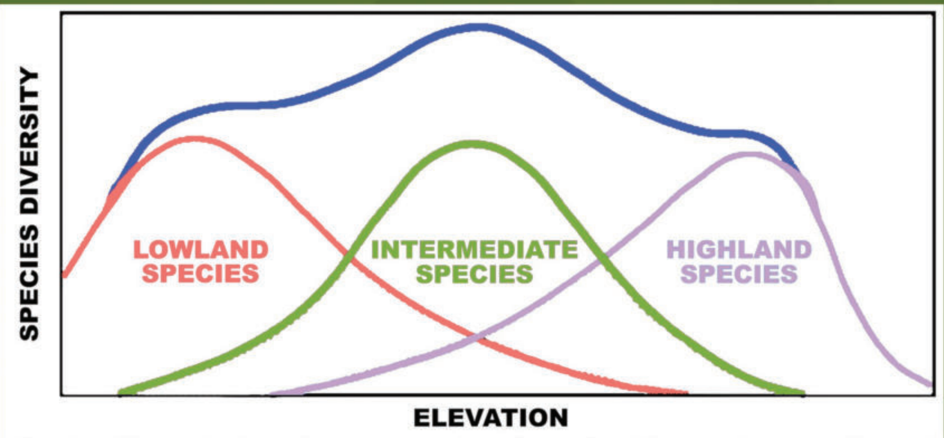

Fig. 1. Effect of elevation on species diversity. Figure shows a 'hump' shaped curve in diversity. Figure modified from Becker et al. (2007)

Beetles are often used as bioindicators for monitoring climate change[6] and studying patterns of diversity as they are highly speciose, sensitive to climate, and participate in most ecosystem functions[8]. However, their use as bioindicators requires good baseline species data, which is often lacking in the tropics. The phytophagous scarab beetles (Cetoniinae, Dynastinae, Melolonthinae and Rutelinae) in this study are a highly diverse group with many endemics, and play an important role in forest nutrient cycling.

TMCF are particularly vulnerable to climate change as increasing temperatures, in combination with lowland land-use change, causes upslope shifts in permanent cloud cover, the habitat's critical feature[9,10]. This study provides a species inventory and specimen data analyses for the phytophagous scarabs found in a TMCF in Chiriquí, Panama to better understand the mechanisms behind local diversity.

MATERIALS AND METHODS

The elevational gradient transect was located near Boquete in the Province of Chiriquí, western Panama, on the edge of the La Amistad International Park. Four elevation zones were set up at 1400 m, 1530 m, 1660 m and 1800 m. Each elevation zone was sampled at three sites at elevations ± 29 m of the zone elevation to accommodate for habitat variation (Fig. 2). Phytophagous scarabs were hand collected at a 400W metal halide mercury vapour bulb and a 15W ultraviolet light trap, running between 19:00–00:00 each night (Fig. 3)[11].

Fig. 2. Map of specimen collecting sites. Red, 1400 m; green, 1530 m; blue, 1660 m; and purple, 1880 m.

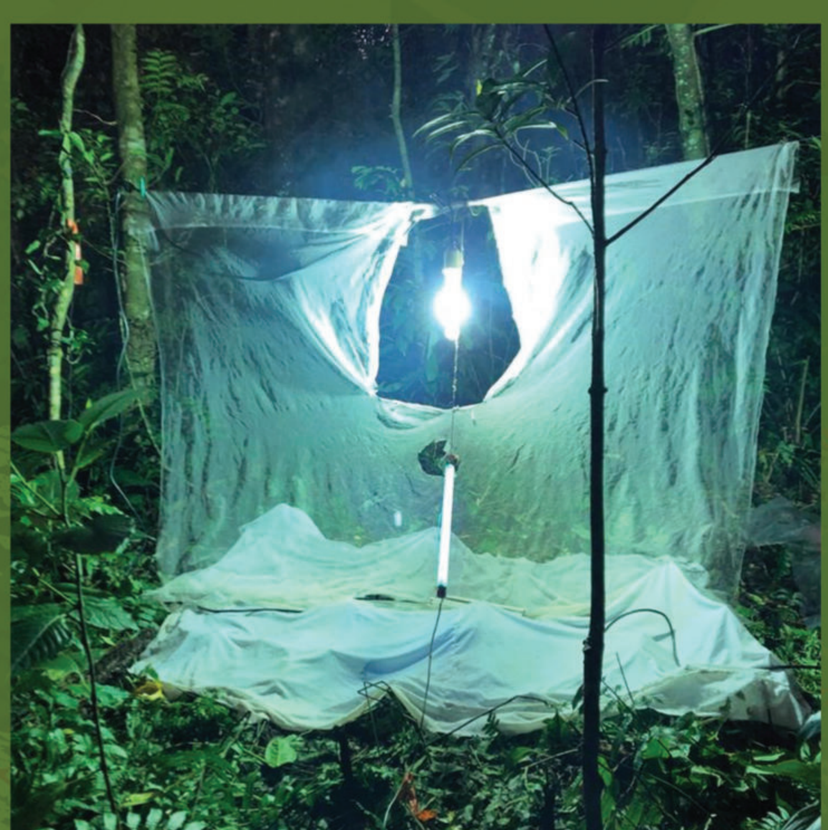

Fig. 3. Light trap set up used to collect scarab specimens. Photography by William P.

Specimens were sent to the UK, and identified by dissection of the male genitalia and referring to taxonomic keys. Specimen diversity (α-diversity, Shannon's index; β-diversity, Jaccard's index) and dissimilarity data (NMDS, Bray-Curtis similarity) was analysed using Rstudio. Figures produced using Google Maps and Rstudio.

RESULTS

DIVERSITY

A total of 1574 scarab beetles were collected, representing 4 subfamilies, 20 genera, and 73 species (Table 1). Overall species diversity varied significantly across all four elevations ($F_{3,8} = 6.912$, $p < 0.05$), with the highest diversity at the intermediate elevation of 1530 m and a decline either side of this peak in diversity (Fig. 4).

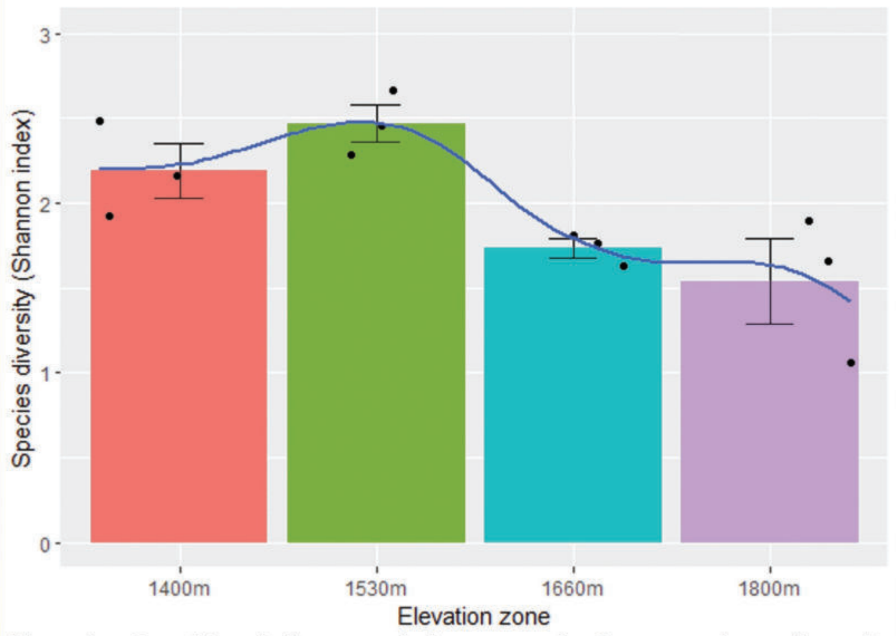

Fig. 4. Combined line and bar graph for species diversity (Shannon index) at each elevation zone. Each point represents a sample site.

Subfamily	Genera	Species	Specimen count
Cetoniinae	1	1	1
Dynastinae	8	16	249
Melolonthinae	4	20	412
Rutelinae	7	36	912

Table 1. Count of taxonomic groups from each scarab subfamily.

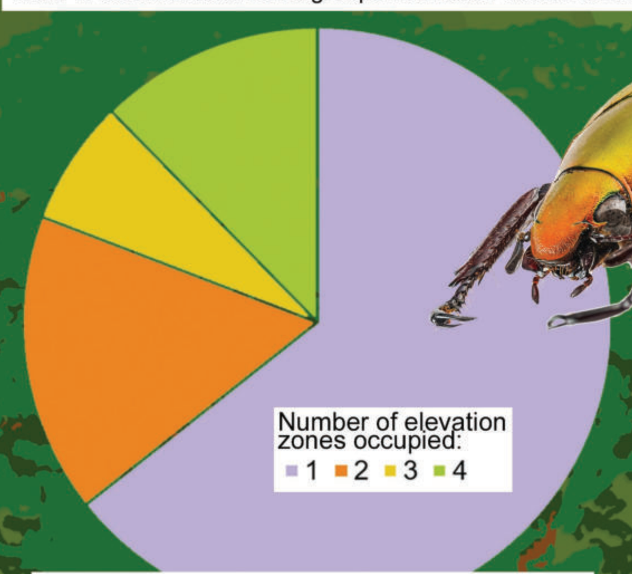

Fig. 5. Site specificity of scarab species.

SPECIES SPECIFICITY

A high level of specificity in elevation was found for species across the transect with 64% of species being found at only one elevation zone (Fig. 5).

COMMUNITY COMPOSITION

Beta-diversity analysis found a high total dissimilarity between scarab communities at different elevations showing community composition varied by up to 81% across all sample sites. Further analysis revealed species turnover was responsible for 73% of this dissimilarity, and the remaining 8% was due to community nestedness (the community being a subset of population). Dissimilarity between sites increased with difference in elevation. Communities at elevation zones closer in elevation were more similar in species composition than communities that with a greater difference in elevation between them (Fig. 6).

Ordination analysis showed data points at similar elevations clustered together, suggesting community composition becomes less similar with changes in elevation (Fig. 7). Elevation was responsible for the majority of group dissimilarity (R^2 = 0.62).

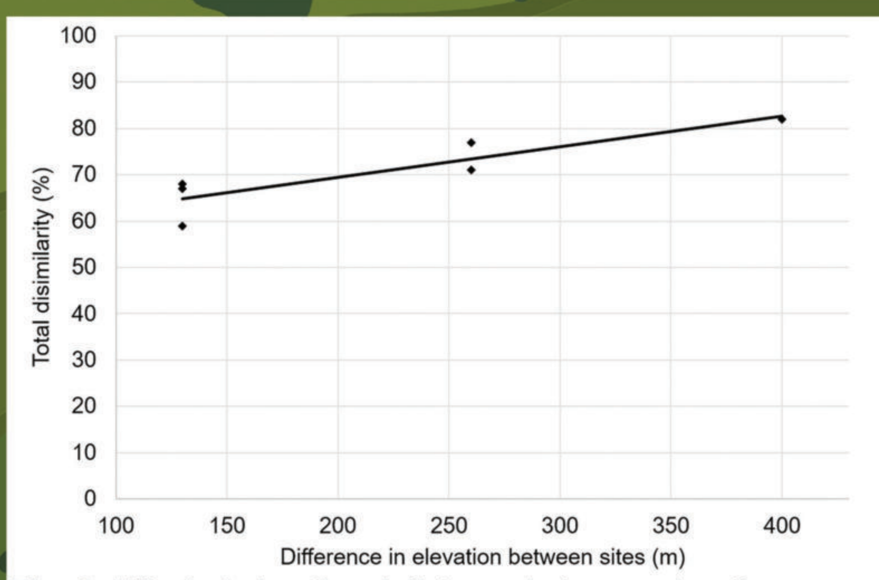

Fig. 6. Effect of elevational distance between elevation zones on the total dissimilarity between scarab community composition. Data from β-diversity analysis.

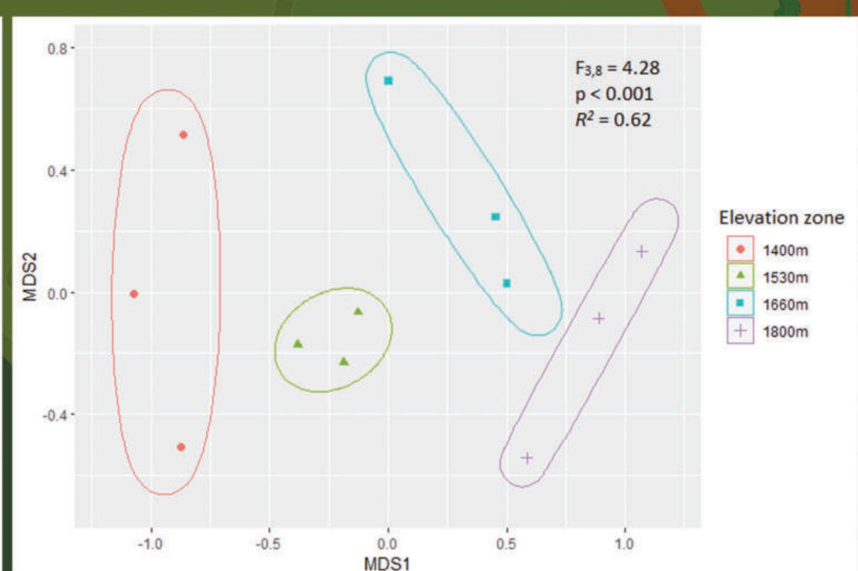

Fig. 7. NMDS of scarab communities as each elevation zone. (Stress = 0.06). Points represent sample sites, and ellipses highlight elevation zones.

CONCLUSIONS

Phytophagous scarab diversity is concordant with the pattern of highest diversity at intermediate elevations, showing a 'hump' shaped curve in diversity (see Figs. 1,4)[4]. This is likely driven by the high rate of elevation specific species, and range overlaps at mid-elevations[12].

Community differences were mostly driven by elevation as communities at closer proximities were shown to be more similar. The high specificity of most species likely drives the high rate of species turnover, as rapid changes in climate (and habitat) with elevation provides a diverse gradient of climate envelopes/niches for many species to fill without range overlap.

Rapid community change occurred over a relatively short elevation range of 400 m, at 130 m intervals. Few studies have previously reported community changes over such a small range and this study highlights the level of biodiversity missed by large scale studies with large site intervals of >250 m[5-7].

The majority of scarabs are highly specialised to elevation and climate, and predicted climate change will likely have a major impact on species distributions. Results from this study show protecting small areas of TMCF may conserve disproportionately high levels of biodiversity, relative to other ecosystems[3], and provide refuge for species predicted to experience upslope range shifts[13].

REFERENCES

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