Comparison of Terrestrial Arthropod Composition between Sand and Clay Soil Types in a Bornean Mixed Dipterocarp Rainforest

Noor M.R. Beckwith[1], **Deodhar Shreekant J.**[2], and **Karl Kmiecik**[3]

[1] Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, USA

[2] Center for Ecological Sciences, Indian Institute of Science, Bangalore, 560 012, INDIA

[3] Department of History and Science, Harvard University, Cambridge, MA, USA

ABSTRACT

To determine the effect of soil type on terrestrial arthropod species composition, three pitfall trap arrays were placed randomly within one hectare plots on each of the two dominant soil types (sand and clay), located at the Arnold Arboretum-Center for Tropical Forest Science plot at Lambir, Sarawak, Malaysia. A total of 1048 specimens, comprising 15 orders and 143 morphotypes were collected . Analysis of the composition revealed no difference in level of diversity between clay and sand soil locations. While the sand soil samples formed a distinct cluster of similarity, variation within the clay samples was too large to provide a significant contrast across soil types. Correcting for distance revealed that the experiment lacked the resolution required to separate the effects of purely spacial separation from soil type and other factors in determining species composition. While our results were inconclusive the study does not rule out the possibility of elucidating distinct patterns across soil types. We suggest that our results be used as a pilot for future larger scale research.

Key words: Borneo, species composition, pitfall traps, soil type, arthropods.

INTRODUCTION

The Bornean rainforest, as a locus of incredible biological diversity, has long been an object of scientific curiosity and investigation (Wallace 1869). Since the pioneering work of the 19th century, many studies have explored the patterns and processes influencing the composition and diversity of tropical flora and fauna (e.g. Connell 1978, Novotny 2006, Beck and Vun Khen 2007). The Arnold Arboretum-Center for Tropical Forest Science (AA-CTFS) field site at Lambir, Sarawak, Malaysia is a plot of mixed Dipterocarp forest with well documented ecological and geological conditions that provides an excellent tool for research (Baillie et al. 2006). The two dominant soil types at the Lambir AA-CTFS site, sand and clay, are known to have different nutrient profiles (Davies, personal communication). Recent work has not only supported that soil type, leaf litter characteristics, and substrate nutrient content are variable (Baillie et al. 2006), but also that they may be important drivers in determining floral composition (Yamada et al. 2000).

Since these factors are major components of the micro-habitat of many terrestrial arthropods, it is reasonable to hypothesize that the species compositions of arthropods may vary with them. It has been suggested that between sandy and clay soils, differing communities of insect herbivores may in fact drive floral composition (Fine et al. 2004). However, detailed comparison of terrestrial arthropod communities between sandy and clay soil types is virtually absent from the literature. Therefore, the principal objective of this study is to explore whether the composition of terrestrial arthropod communities differs significantly between the clay and sandy soil regions at the AA-CTFS Lambir site.

METHODS

One hectare plots were selected within the sand and clay substrate regions of the AA-CTFS Lambir site. Each plot was divided into 25 subplots, 20 x 20 m each. Random subplots were selected to provide three sample locations on each soil type. Locations were screened to exclude canopy gaps and steep slopes.

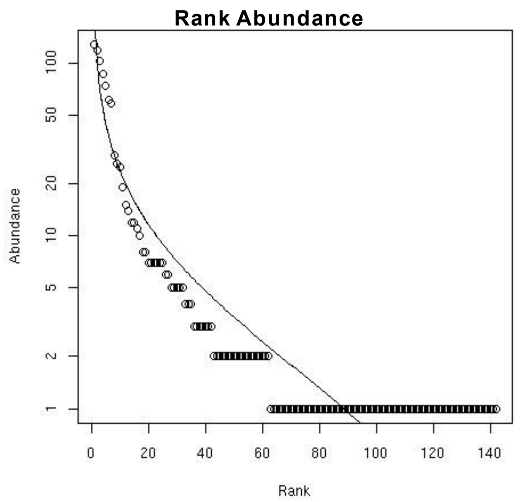
Pitfall trap arrays were placed on each sample location. Each array consisted of five embedded cups (diameter = 9 cm, depth = 12 cm) arranged in a 1 x 1 m cross. The arrays were also covered with a tarp to prevent flooding in the case of rain. Each cup was half-filled with soapy water and left for approximately 24 hours before collection. While sampling was staggered over two days, all arrays were run pairwise between soil types to allow direct comparison between sandy region and clay region samples. The study was conducted on July 6-8, 2008 with little to no rain during the observation period.

All cups from each array were pooled to treat each location as one data point. These pooled samples were sorted and identified to the taxonomic order and morphotype levels. The statistical programming platform R was used for data-analysis.

Shannon indices of species diversity were computed for each sample and compared across soil type with a Wilcoxon test. The Bray-Curtis method was used to compute the compositional disparity between sample sites and also across soil types. Mantel tests were also used to determine the significance of correlation between sample disparity versus soil type and physical distance.

RESULTS

A total of 1048 specimens were collected by the six pitfall arrays and classified into 15 orders and 143 morphotypes (Figure 1). Shannon indices, ranging from 2.068 to 3.152, revealed similar levels of diversity at all sample sites with a Wilcoxon test showing no significant difference between the sandy and clay soil locations (p-value = 1). The Bray-Curtis method yields the dendrogram (Figure 2) and the similarity boxplot of morphotype composition (Figure 3) shown below. Mantel correlation tests for species composition versus soil type, geographic distance, soil type given geographic distance, and geographic distance given soil type yield p-values of 0.207, 0.235, 0.679, and 0.809 respectively. The above tests were re-run isolating the most abundant orders and species; however, this did not yield any lower p-values or more distinct groupings of the samples.



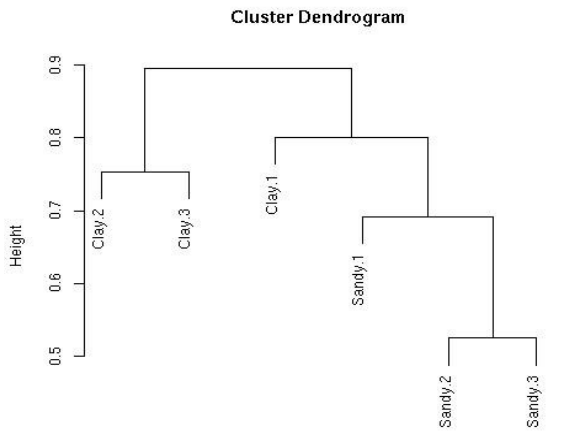


FIGURE 1: Rank abundance curve of our specimens plotted with a log normal curve.	FIGURE 2: Cluster diagram formed utilizing the Bray-Curtis method showing the relationship between samples.

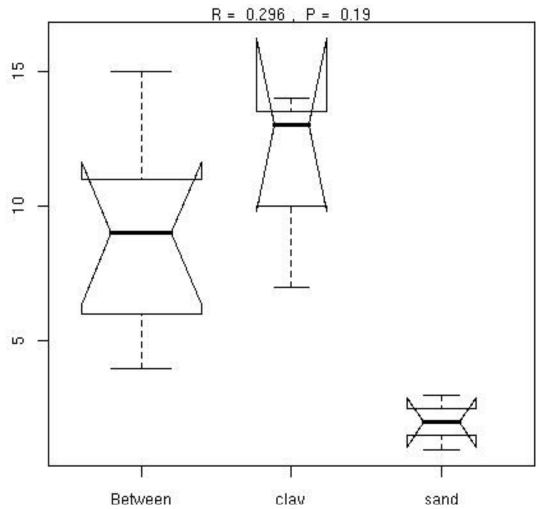


FIGURE 3: Similarity box plot derived from Bray-Curtis method.

DISCUSSION

Many communities in the biological world exhibit a log normal rank abundance curve. The specimens collected fit this curve well, suggesting that the relative abundance of species matches a priori composition expectations (Figure 1).

The Shannon indices and Wilcoxon test across soil types reveals a low probability for a significant difference in level of diversity between the clay and sandy soils. Figure 2 reveals that the composition of all three sandy soil samples are more similar to each other than any of the clay samples, however the first clay sample is more closely related the sandy soil samples than the other clay samples. This disparity is explained by the similarity boxplot (Figure 3). Large variation between the clay soil samples – mainly from Clay 1 species composition differing from Clay 2 and 3 – yields the less significant result. The Mantel tests reveal that after correcting for the possibility of geographic distance being the driving cause for the patterns shown, our data does not have enough power to make any conclusions whether or nor soil type is a causal factor in driving arthropod community composition.

Overall, the study did not reveal any conclusive evidence that the terrestrial arthropod communities differ between the clay and sandy soils of the AA-CTFS plot at Lambir. However, the relationships illustrated by the dendrogram and similarity boxplot suggest that a larger scale study may provide the statistical power and scope to uncover underlying differences across the soil types. Should significant differences be found, an interesting extension of the research would be to determine whether insect herbivory, as suggested by Fine et al., is in fact a driver of the differing floral communities that exist between the soil types.

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APPENDIX

Table 1: Summary of data.

	Clay 1	Clay 2	Clay 3	Sandy 1	Sandy 2	Sandy 3
# of Orders	8	10	13	10	10	10
# of Indiv	160	43	87	223	252	283

Table 2: Data sorted by order.

Order	Clay 1	Clay 2	Clay 3	Sandy 1	Sandy 2	Sandy 3	Total
Acari	0	1	1	0	1	4	7
Amblipygida	0	0	0	1	0	0	1
Aranae	1	3	1	4	2	3	14
Blattodea	1	4	0	1	10	0	16
Chilopoda	0	0	1	0	0	1	2
Coleoptera	37	4	7	96	53	31	228
Collembola	2	7	22	19	32	9	91
Diptera	102	8	12	31	79	128	360
Embioptera	0	0	1	0	0	0	1
Heteroptera	5	3	11	32	23	35	109
Hymenoptera	7	6	21	36	49	63	182
Isopoda	0	3	1	2	1	6	13
Opiliones	2	1	0	0	0	0	3
Orthoptera	3	3	7	1	2	3	19
Unknown A	0	0	1	0	0	0	1
Unknown B	0	0	1	0	0	0	1
						Total	1048