Islands in the sky: epiphytic bird's nest ferns (*Asplenium nidus* complex) as microcosms for the study of ant community ecology

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Abstract

Here we present the bird's nest fern as a microcosm for the study of ant community ecology. The distribution of the ferns within an area of primary rain forest is documented and the factors affecting this distribution explained. Methods used for the collection of arthropod specimens from the ferns are also described. We found that the ferns occur at high densities and can be easily sampled for arthropods. One species, *A. nidus*, is present at all heights in the canopy, while a second, *A. phyllitidis* is present only in the lower canopy. *A. nidus* is found at higher densities in areas with more emergent trees and lower understory vegetation density. *A. phyllitidis* is found at higher densities in areas with greater lower canopy height. In addition the ferns are amenable to experimental manipulation, making both species ideal microcosms for the study of ant ecology.

Introduction

Understanding community ecology at large scales can be a challenging task. In order to shed light on the processes at work in an ecosystem a smaller system, or microcosm, can be studied (Srivastava *et al*., 2004). The conclusions drawn regarding the microcosm are then applied at larger scales. Islands have long been regarded as systems of particular interest to ecologists (e.g. MacArthur & Wilson, 1968) as they represent discrete habitat patches, the inhabitants of which can be monitored with relative ease. The bird's nest fern can be thought of as an island microcosm. It is a common rain forest epiphyte, which derives its nutrients from intercepted leaf litter. This leaf litter decomposes in the fern's root mass, providing a habitat for large numbers of arthropods (Ellwood & Foster, 2004).

Of these arthropods the most abundant and ecologically important are the ants. Unlike other arthropods it is easy to determine whether or not ants are resident in a fern by assessing presence of brood and reproductive individuals. The ferns provide a number of habitats for ants (Figure 1), and many different species may live in a fern at any one time (Ellwood *et al*., 2002). In order to understand the ecology of the fern inhabitants it is important to understand the factors affecting the distribution of the ferns themselves. We investigate a number of questions pertaining to the fern's suitability as a microcosm.

Questions

- What are the factors affecting the distribution of the ferns?
- Can sufficient numbers of ferns be collected and processed in order to use them as microcosms?
- How easy are the ferns to manipulate?

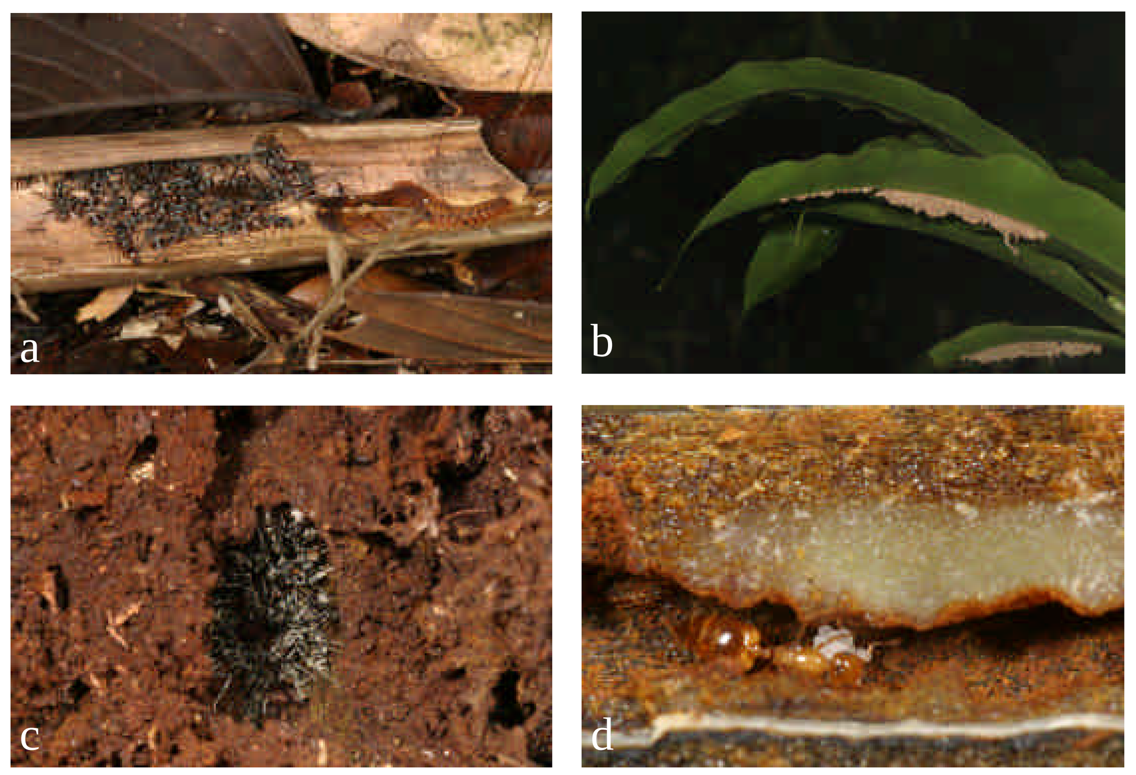

Figure 1

The ferns provide a variety of micro-habitats for ants. a) *Polyrhachis* colony in the leaf litter of a fern. b) *Polyrhachis* carton nests on underside of a frond mid-rib. c) *Diacamma* colony in a hollowed out chamber in the root mass of a fern (the majority of colonies found in the ferns are in this microhabitat). d) *Crematogaster* queen inside frond mid-rib (only larger ferns of the species *A. nidus* support colonies such as this).

Figure 2

a) *Asplenium* ferns in primary rain forest are found at heights of up to 60m. b) Single rope technique was used to collect 28 of the ferns. Ferns were placed in plastic bags immediately after removal. The loose leaf litter within the nest of fronds of each fern was collected separately from the rest of the plant. c) A further 28 ferns were collected using an aluminum ladder.

Methods

Primary lowland rain forest in Danum Valley Conservation Area, Sabah, Malaysia was chosen as a study site.

Ferns were surveyed from the ground along 20 randomly selected 0.2ha transects (100m by 20m). For each fern height above ground and location within transect were measured using a laser rangefinder. Root mass size was also estimated. A number of environmental variables were recorded on each transect.

A subset of the ferns surveyed was then chosen to be collected using a stratified random sampling design to give a wide range of fern heights and sizes. Of the 86 ferns collected 30 were accessed using ground-based methods (0-2.5m), 28 using an 8m ladder (2.5-8m), and 28 using single rope technique (8-35m) (Figure 2). The leaf litter and fern root masses were collected separately and placed in plastic bags.

Animals were extracted using Winkler apparatus, with the fern root masses being dissected prior to this to assist drying. Signs of the presence of ant colonies were noted during dissection. Samples were left in the Winkler apparatus for three days and then remaining arthropods were sorted by hand. Material was taken from a frond of each fern after dissection for genetic analysis. A single frond from each fern was also pressed and dried.

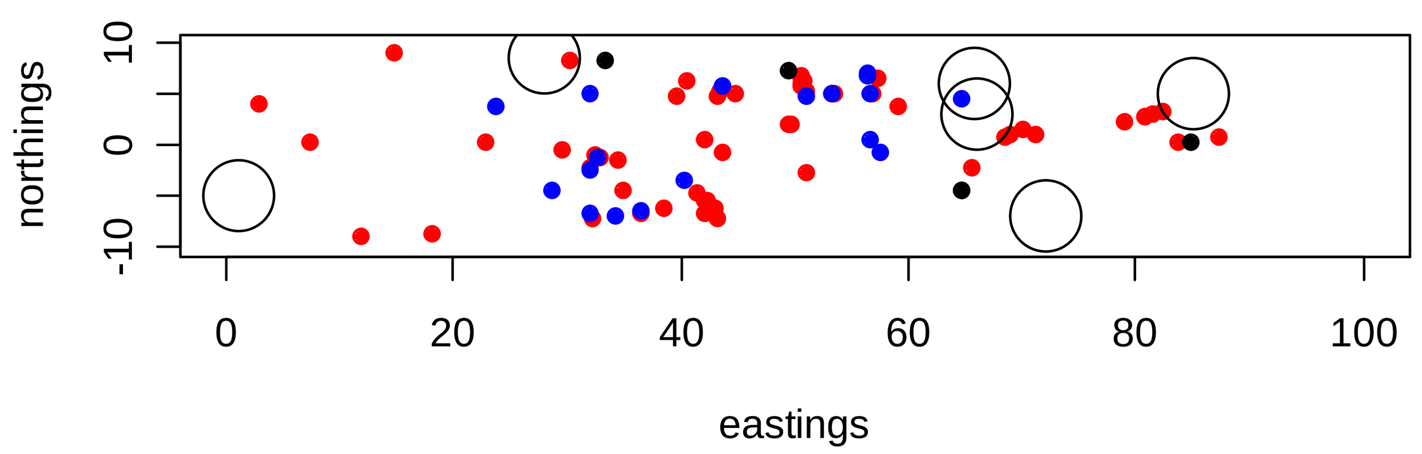

Figure 3 A map of a typical transect. Red points: *A. phyllitidis*, Black points: *A nidus*, Blue points: Unidentified ferns, Open circles: Emergent trees. Eastings and northings are in metres. The total area of the transect is 0.2ha.

Results

In total 718 ferns were recorded at a density of 180 ferns per hectare (Figure 3). The two species recorded were stratified with respect to height; *A. phyllitidis* was found exclusively in the lower canopy, whereas *A. nidus* was found at all heights ($?^2=119$, p<0.001, Figure 4a). A number of smaller unidentified ferns were distributed in a similar manner to *A. phyllitidis*. Higher densities of *A. phyllitidis* were found in transects where lower canopy height was greater ($F_{1,18}=16.9$, p<0.001, Figure 4b). The density of unidentified ferns varied in the same manner. Higher densities of *A. nidus* were found in transects with more emergent trees and lower understory density ($F_{2,17}=22.1$ emergents: p<0.001, understory density: p=0.03, Figure 4c). The majority of the ferns contained ant colonies with only the smallest being unoccupied.

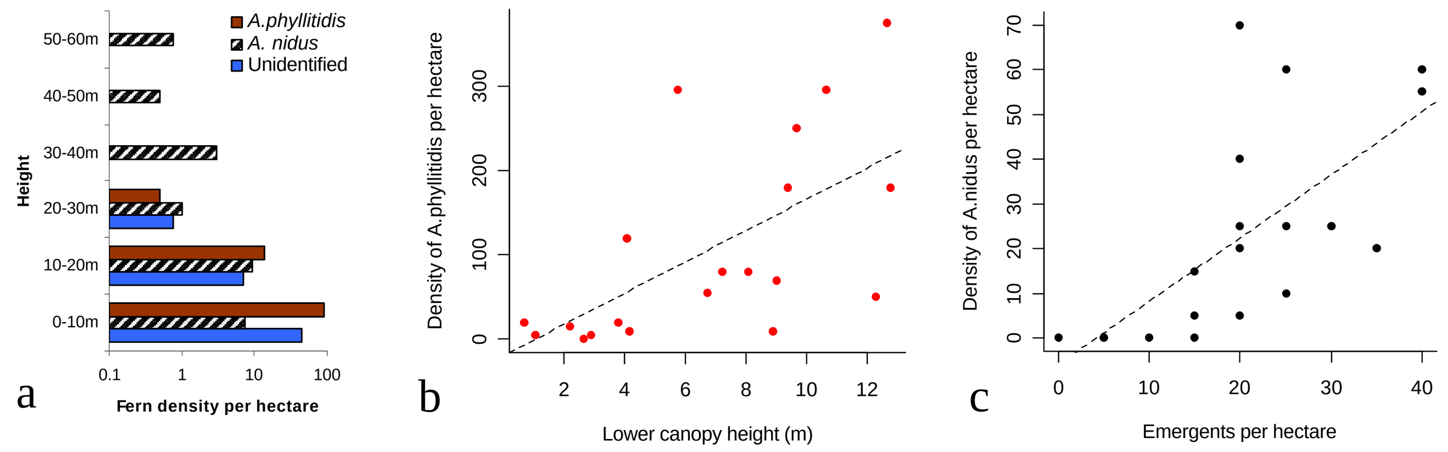

Figure 4 a) There was vertical stratification of the two fern species with canopy height. b) Higher densities of *A. phyllitidis* were found where lower canopy height was greater. c) Higher densities of *A. nidus* were found in transects with larger numbers of emergent trees

Discussion

The ferns occur at high densities making them an ideal sampling unit to investigate ant community ecology. *A. nidus* could be used to investigate the effects of height in the canopy on ant community dynamics as it is abundant at all heights. *A. phyllitidis*, on the other hand, seems more suited for investigations where obtaining large numbers of similar ferns is necessary, due to its high densities at more easily accessible heights. It could be used in translocation experiments, or studies of ant community assembly rules. The smaller unidentified ferns seem to follow broadly the same distribution as *A. phyllitidis*, although positive identification of these will require molecular work.

Future work

The arthropods from the ferns will be sorted to order, with the ants being identified to morphospecies within genera. This will allow patterns in community structure with respect to height and fern size to be understood. Hypotheses regarding the factors driving these patterns can then be made and will be experimentally tested in future field seasons. The ferns themselves can be cleaned of their faunas and replaced in the forest, where they then have a high rate of survival. In addition we have already succeeded in experimentally manipulating the ant fauna of a fern (Figure 5). If this proves to be possible on a larger scale then it will open up many exciting avenues of research.

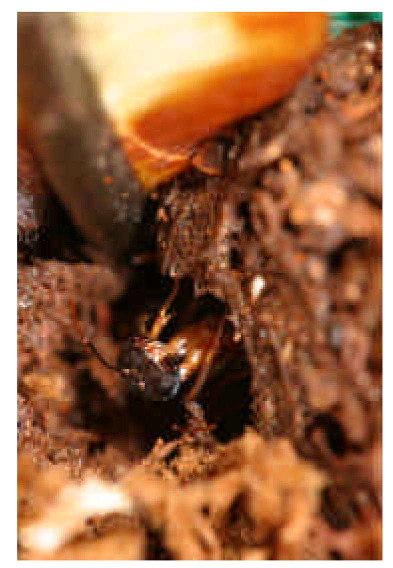

Figure 5 A *Camponotus* major peers out from a nest entrance in a fern root mass. A queen and c. 20 workers were introduced into a clean fern after extraction from a different fern.

Acknowledgements

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