Effects of Forest Disturbance on Ant Diversity in Singapore

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ABSTRACT

Urbanisation in Singapore has led to a major landscape change and currently, only patches of forested areas are left. Ants, being an important ecological insect group, are diverse and abundant, play important functional roles at all trophic levels, and are highly sensitive and respond quickly to environmental changes. In this study, the effect of forest disturbance (disturbed vs. undisturbed) on ant diversity was investigated in Bukit Timah Nature Reserve, Central Catchment Nature Reserve and Kent Ridge Park. Pitfall trapping from ten study sites recorded 64 ant species representing 27 genera from 1108 individuals. This study found that there was no statistical significant difference in mean ant species richness and abundance between disturbed and undisturbed forests even though the undisturbed forests had higher species richness but lower abundance than the disturbed forests. Ant diversity in Singapore is little known and this study had shown that there is a rich diversity of ants present.

INTRODUCTION

Deforestation in tropical Southeast Asia is rapid and in Singapore, urbanisation has led to a major landscape change and today, only patches of forested areas totalling 20 km\textsuperscript{2} or 3\% of Singapore’s total land area were left (Lum, 1999). Among the forest patches, only about 192 ha of primary forest survive (Corlett, 1997). This has had a great impact on the species diversity in Singapore, and a few studies have shed light on the negative impact of deforestation and forest disturbance on tree species richness (Turner \textit{et al.}, 1997) and bee diversity (Liow \textit{et al.}, 2001).

Ants are an important ecological insect group (Hymenoptera: Formicidae) in tropical forests and they play an important role in the structure and functioning of many ecosystems. Hence, many studies have been conducted to establish the use of ants as bioindicator for conservation monitoring (Brown, 1997), disturbance and habitat monitoring (Burbidge \textit{et al.}, 1992; New, 2000), land management (Andersen \textit{et al.}, 2002), and soil monitoring (Lobry de Bruyn, 1999). As such, it would be useful to establish the effect of forest disturbance on ant diversity in Singapore. A survey was conducted to compare the species richness and abundance of ants between undisturbed (primary) and disturbed (secondary) forests. I predicted that undisturbed forests would have a higher diversity than disturbed forests in terms of ant species richness and abundance. Furthermore, as there is currently no inventory on ant species in Singapore, I would attempt to partly fill it.

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METHODS

This study was conducted from January 2003 to March 2003 at ten sites from three forest fragments in Singapore, namely Bukit Timah Nature Reserve (BTNR), Central Catchment Nature Reserve (CCNR) and Kent Ridge Park (KR). BTNR and CCNR are made up of a mixture of primary and secondary forests, while KR is composed solely of secondary forests. Three sites were set up in 112 ha of primary patches, while the rest of the sites were set up in 471 ha of secondary forests. The total sampling area was 3240 m².

A total of 160 pitfall traps were set up at the study sites where traps at each site were arranged in a 4 x 4 grid with 6 m spacing (i.e. a total of 16 traps in an area of 324 m²). Each trap consisted of a plastic cup (diameter 8.8 cm; depth 12.5 cm) and a plastic board (13.0 x 13.0 cm) was placed slightly above each cup to prevent rainwater from flooding the trap. Traps were partly filled with ethanol-glycerol mixture and buried with their rims flushed with the soil surface. Ethanol in traps was not known to attract or repel ants (Greenslade and Greenslade, 1971). The traps were set up between 0800 to 1200 and 1300 to 1700 and left for one week prior sampling to reduce “digging-in” effects (Greenslade, 1973). Traps were then emptied after 48 hours. Ant samples collected were brought back and sorted to species, identified and enumerated.

Data was checked for normal distribution using Kolmogorov-Smirnov test and nested ANOVAs were performed to determine the effects of forest disturbance on species richness and abundance per trap. The study sites were nested within type of forest to avoid pseudoreplication.

RESULTS

A total of 64 ant species (from 1108 individuals), representing four subfamilies and 27 genera, were recorded. The distribution of species in the different subfamilies showed a dominance of Myrmicinae (43.8 %), followed by Ponerinae (31.2 %), Formicinae (18.8 %), and lastly Dolichoderinae (6.2 %). The three most common species – Pheidologeton sp. 2 (31.3 %), Aphaenogaster sp. 1 (12.1 %) and Pheidole sp. 3 (10.9 %) – made up 54.3 % of the total number of individuals sampled. For 28 species, only one individual per species was recorded. These species were considered to be rare and they represented 43.8 % of the total ant species sampled.

A total of 32 species was recorded from the undisturbed forest sites while 42 species were recorded from the disturbed forest. 18 species (28.1 %) were common to both forest types, while another 14 species (21.9 %) and 32 species (50 %) were exclusive to the undisturbed and disturbed forest types respectively. In general, the mean species richness (± SE) per trap of undisturbed forests (2.5 ± 0.2) was slightly higher than that of disturbed forests (2.1 ± 0.1). Nevertheless, no significant difference in the number of species was found between the disturbed and undisturbed forests (Nested ANOVA: F₁,150 = 2.11, p = 0.149). There was also little difference in the mean number (± SE) of individual ants found per trap between disturbed and undisturbed forests (Nested ANOVA: F₁,150 = 0.94, p = 0.334). The mean abundance per trap of disturbed forests (7.5 ± 1.1) was only slightly more than that of undisturbed forests (5.6 ± 1.6).
DISCUSSION

Rare species made up almost half of the species recorded. These rare species might be from a nearby source population or could have resulted from temporal changes in populations, representing either the remnant of a declining population or the first examples of an increasing population (Longino and Colwell, 1997). It could also be a result of methodological edge effects in which the species were abundant at the study site but were undersampled due to the inadequacy of the sampling method (Longino et al., 2002). Pitfall trapping is commonly used in the sampling of ants and many other ground arthropods, but there is a certain extent of biases depending on the species distribution, foraging behaviour and locomotor behaviour (Andersen, 1991). However, for this study, the use of pitfall traps was effective for sampling ant communities and sufficient to provide an unbiased comparison of ant diversity between disturbed and undisturbed forest.

Many studies have shown that habitat degradation, disturbance and fragmentation have a negative effect on ant diversity and abundance where undisturbed forests have higher species richness than those in disturbed habitats (Greenslade and Greenslade, 1977; Olson, 1991; Suarez et al., 1998; Vasconcelos, 1999; Watt et al., 2002). However, in this study, no significant difference in the ant species richness and abundance between the disturbed and undisturbed forests sampled was found even though undisturbed forests generally had higher species richness but lower abundance than disturbed forests.

The undisturbed forests were located on relatively higher grounds and sleeper slopes as compared to disturbed forests. Given the high rainfall throughout the year, it is probable that undisturbed forests might not be less favourable sites for nest establishment as compared to disturbed forests. Moreover, it was possible that there might be a certain extent of disturbance in the undisturbed forest since the reserves (BTNR and CCNR) received a substantial number of visitors during the weekends. Furthermore, it is possible that moderate habitat disturbance could enhance species richness by creating mosaics of disturbed and undisturbed microsites suitable for a greater variety of species (Samson et al., 1997). There has been evidence that intermediate forest disturbance in the form of plantation establishment after partial forest clearance has resulted in an increase in species richness in comparison to uncleared forests (Watt et al., 2002). In addition, most of the disturbed forests are located in close proximity with undisturbed forests. This would suggest that dispersal and establishment of ant colonies from undisturbed patches to the surrounding disturbed forests was favourable since these forests could act as source populations for recolonisation and/ or maintenance of these species (Vasconcelos, 1999). Moreover, it has been shown that the recovery of ground-foraging ant fauna after land abandonment has been found to be relatively rapid – usually less than 25 years (Vasconcelos). This might imply that the ant fauna in local disturbed forests had almost achieved a relatively high recovery in terms of diversity.

Ant diversity in Singapore is little known and this survey had shown that there is a rich diversity of ants present despite the limitation of pitfall sampling. Forest disturbance, deforestation, fragmentation and habitat destruction has led to the loss of many local flora and fauna. Thus, more ecological studies should be conducted to determine the various effects and impacts of such disturbance in different taxon groups especially arthropods, which are still understudied locally.
REFERENCES


