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DISTINCTIVENESS OF TERMITE ASSEMBLAGES IN TWO FRAGMENTED FOREST TYPES IN HANTANE HILLS IN THE KANDY DISTRICT OF SRI LANKA

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ABSTRACT

This study compares the termite assemblages in a natural and a secondary forest located at two different elevations in the Hantane hills, a tropical evergreen forest in mid country Sri Lanka, with a view to identify their distinctiveness. To sample the termites in the two forest types the belt transect method was used supplemented by random collections. A total of 11 species of termites in four genera belonging to three subfamilies and one family, Termitidae were recorded; nine species from the secondary forest and two species from the natural forest. The two species, *Ceylonitermellus hantanae* and *Dicuspiditermes incola* showed a distinct distribution in being confined only to the natural forest at high elevation. Termites recorded were put into feeding groups based on their taxonomic identity. Termites of the natural forest were found to be exclusively true soil feeders. Those of the secondary forest were wood feeders; either fungus growing (8 spp.) or non-fungus growing wood feeders (1 sp.). The high abundance and low diversity of the natural forest termite species in comparison to secondary forest species also make them distinct. Elevation, climate, vegetation, ground cover and the degree of human interference appear to contribute to the distinctiveness of termite assemblages in the two forests types reported here.

Key words: natural forest, secondary forest, species diversity, functional groups, elevation

INTRODUCTION

The Asian tropical forests are known for their rich fauna, particularly the termites due to the role they play in the recovery of forest ecosystems (Davies *et al.*, 1999). Termites, as dominant arthropod detritivores, are important in decomposition processes. The termite assemblages in forests are very sensitive to habitat disturbances like fire, forest clearance (Davies, 1997; Davies *et al*., 2003; Eggleton *et al*., 1995, 1996), canopy loss (Gathrone-Hardy *et al*., 2001) and forest fragmentation (Davies *et al.*, 2003).

Studies conducted in Southeast Asia have reported the richness of termite species in dry deciduous dipterocarp forests of Thailand (Davies, 1997), where 16 species of soil, wood and fungus feeding termites have been documented. Eggleton *et al*. (1997) reported 92 species of termites from the Danum valley in Malaysia, and 29 species have been reported from the Pasoh forest in Malaysia (Morimoto, 1976; Abe, 1978; Abe and Matsumoto, 1979; Tho, 1982; Jones and Brandel, 1998). The largest assemblage of termites from tropical Asia, numbering 102 species, is reported from the Leuser Ecosystem in Indonesia (Gathone-Hardy *et al*., 2001).

For the Indian sub region as a whole, comprising India, Pakistan, Nepal, Bhutan, Bangladesh, Burma and Sri Lanka, 337 species of termites in 59 genera have been listed and comprehensively described by Roonwal and Chhotani (1989) and Chhotani (1997). Bose (1984) reported 95 species of termites in five families and their distribution in Southern India. A study conducted in Western Ghats in Southern India on the termite community and the impact of anthropogenic disturbances recorded 12 species of termites representing nine genera in three subfamilies in the family Termitidae. Our recently prepared checklist of termites from Sri Lanka, based on published literature on termites, reports 64 species in 27 genera and awaits publication. Early records on termites from Sri Lanka reported 57 species (Snyder, 1949) and 58 species (Sands, 1975). With respect to forest termites of Sri Lanka, the only available literature is a study by Green

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(2005) on termites in Himbiliyake forest reserve near Wasgamuwa, (Pollanaruwa District in the North Central Province) from where nine species of termites in the two families Termitidae and Rhinotermitidae have been recorded. The area of natural forests in Sri Lanka is rapidly decreasing and a majority of the remaining forests are fragmented and degraded due to both legal and illegal wood extraction (Gunatilleke and Gunatilleke, 1990). Here, we report the diversity and species composition of termites in two fragmented tropical evergreen forests in the Hantane hills of Kandy (Central Province). The two fragmented forests comprise a natural forest and a secondary forest about 3 km apart, from where termites were examined by random collections and the belt transect sampling method.

MATERIALS AND METHODS

Forest sites

The Hantane forest range is situated in the wet zone of Sri Lanka at approximately 7˚ 17' N and 80˚ 36' E. It extends over an area of 432 ha. The forest consists of a series of hills separated by valleys at elevations ranging from 518 – 1110 m. The area is characterized by hot, humid and sub-temperate climate (Greller *et al*., 1980). The mean annual temperature is 24.1^0 C and the mean annual precipitation is 2,121 mm. The average annual precipitation for the period of 1999 to 2009 was 1924.2 mm (data from Natural Resource Management Centre, Peradeniya). Rain is received from both the Southwest and Northeast monsoons and is evenly distributed throughout the year. During the British Colonial Period, lower and upper lands of Hantane forest were opened up first for coffee and later for tea and rubber plantations. When the major part of the land was acquired by the University of Peradeniya in 1946, most parts of the land were devoid of natural vegetation. A few *Pinus* plantations were established in 1980. Restoration of plant diversity in *Pinus* plantations in Lower Hantane was initiated in 2002 (Ambagahaduwa, 2008). At present, six vegetation types can be identified in Hantane hills. They are: *Albizia* woodland (12.5%, introduced as a shade tree for tea), *Alstonia* woodland (5%), mixed species woodland (18%), *Pinus* woodland (23%), Patana grasslands (39.5%) and patches of undisturbed natural forest (2%) (Ratnayake, 2001). This study examines the termite assemblages in patches of undisturbed natural forest (Fig.1) at an elevation of > 900 m and a disturbed secondary forest in the mixed species woodland (Fig. 2) at elevations between 700-900 m.

Figure 1. Section of the natural forest in Hantane hills, Kandy.

Figure 2. Section of the mixed species woodland representing the secondary forest in Hantane hills, Kandy.

Sampling of termites

Standardized transect method of Jones and Eggleton (2000) was used for sampling termites. A belt transect (2 x 100 m) was laid in each forest. Each transect was divided into 20 (2 x 5 m) sections and in each section one man-hour was spent searching for termites. Within each section the following microhabitats were searched; surface soil (12 samples, each about

12 x 12 cm, to 10 cm depth), leaf litter and humus on the forest floor (at the base of trees, between buttress roots etc.), inside dead logs, tree stumps, branches, twigs, subterranean nests, mounds, carton sheetings and runways on trees up to a height of 2 m above ground and arboreal nests up to 2 m height. Mainly soldier and worker castes were collected from the different microhabitats, while alates were collected only from nests. The number of encounters with termites (hits) of a given species within a transect was taken as the relative abundance of that species within that transect. An encounter is the presence of a species in one transect section (5 x 2 m). Termite diversity was compared using Shannon Diversity Index. In addition to sampling, random collections of termites were carried out in several areas within the two forest types for species determination. Termite specimens collected for identification were stored in 80% isopropyl alcohol.

Termite nests encountered were examined and recorded both during sampling and random collections. Nest type of termites whose nests were not encountered during the study was determined on the basis of species identity, using information given in Bose (1984) and Roonwal (1970).

Recorded termites were placed in to feeding groups based on their identity, using the classification of Donovan *et al.* (2001).

RESULTS

Species composition and distribution in the two forest types

Termites collected from the two forests types belonged to a single family, Termitidae, and were represented by three subfamilies and four genera (Table 1). A total of 11 morphospecies were identified; six to species level and five to generic level (Genus *Odontotermes*). The identified six species are *Nasutitermes fletcheri* (Holmgren & Holmgren), *Ceylonitermellus hantanae* (Holmgren) (Fig. 3), *Dicuspiditermes incola* (Wasmann), *Odontotermes horni* (Wasmann), *O. globicola* (Wasmann), and *O. ceylonicus* (Wasmann) (Table 1). The identities of these six species were confirmed using keys, descriptions and measurements given in Roonwal and Chhotani (1989) and Chhotani (1997).

A distinct difference in the species composition of termites in the two forest types was seen. In the natural forest only two species, *C. hantanae* and *D. incola*, were present. Both species were recorded from transect as well as from random collections. These two species were not found in the secondary forest, from where a total of 9 species, 8 species of *Odontotermes* and *Nasutitermes fletcheri*, were recorded. Of the nine termite species found in the secondary forest, four species were collected from transect, three from random collections and two (*Odontotermes horni* and *Odontotermes* sp. 2) from both transect and random collections (Table 1).

Termite species diversity

Transect sampling involving 20 sections per transect where 20 man hours were spent in each transect, enabled the comparison of termite diversity in the two forest types. Species diversity index calculated using Shannon Diversity Index gave a value of H'=1.630 for the secondary forest, which was much higher compared to the natural forest (H'= 0.683)

Figure 3. The endemic termite *Ceylonitermells hantanae* (a) soldier caste (b) winged reproductive (alate).

Termite feeding groups

The termite species identified from the study sites belonged to two distinct feeding groups (Table 1) according to the classification of Donovan *et al.* (2001), based on mandible features. The feeding group I that includes lower termites was not represented in either of the two forest types in the Hantane hills. Similarly, termites of the feeding group III, represented by organic rich soil feeders, were absent from both types of forests in the Hantane hills. According to the feeding group classification, termites of the feeding group II which are wood feeders represented by fungus growing and non-fungus growing wood feeders were present only in the secondary forest. Feeding group IV termites that are true-soil feeders were confined to the primary forest. The feature of the right mandible molar plate of *C. hantanae*, where there were no ridges, was used to place this endemic species in the feeding group IV of Donovan *et al.* (2001). Thus, the majority of the secondary forest termite species, according to the feeding group classification are fungus growing wood feeding species, while the two natural forest species are 'True soil feeders' (Fig. 4).

Species accumulation curve

From the data gathered on termites in the 20 sections of transect in each forest type, a species accumulation curve was plotted (Fig. 5). The curve reached a plateau at the 5th transect section in the natural forest (Fig. 5) suggesting that no further increase in species would be encountered with an increase in the area sampled. In contrast, the rising species accumulation curve for the secondary forest suggests that yet more species await collection and identification, with further sampling effort.

Termite abundance

The relative abundance levels based on number of hits per transect indicated that the endemic species *C. hantanae* and the native *D. incola* inhabiting the natural forest have high abundance levels versus the several *Odontotermes* species in the secondary forest (Fig. 6).

Table 1. Details of termite taxa recorded from the two forest types in Hantane.

Termite Taxa	Forest Type	Method of Collection	Feeding group	Nesting group
Family TERMITIDAE				
Subfamily Nasutitermitinae				
Nasutitermes fletcheri	Secondary	R	II(NF)	2
Ceylonitermellus hantanae	Natural	T, R	IV	1
Subfamily Termitinae				
Dicuspiditermes incola	Natural	T, R	IV	1
Subfamily Macrotermitinae				
Odontotermes horni	Secondary	T, R	II(F)	1
O. globicola	Secondary	T	II(F)	1
O. ceylonicus	Secondary	R	II(F)	1
Odontotermes sp.1	Secondary	T	II(F)	1
Odontotermes sp.2	Secondary	T, R	II(F)	1
Odontotermes sp.3	Secondary	T	II(F)	1
Odontotermes sp.4	Secondary	T	II(F)	1
*Odontotermes sp.*10	Secondary	R	II(F)	1

(Method of collection: R= random collection, T= transect sampling)
(Feeding groups: II = wood feeders, IV= true soil feeders, NF= non-fungus growing, F= fungus growing)
(Nesting groups: 1= subterranean, 2= arboreal)

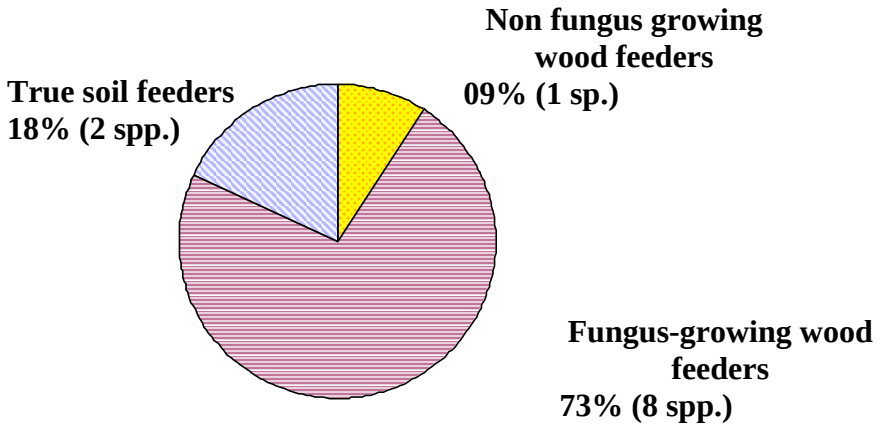

Figure 4. Proportion of termite species per feeding group in the two forest types in Hantane hills. (Data from transect sampling and random collections).

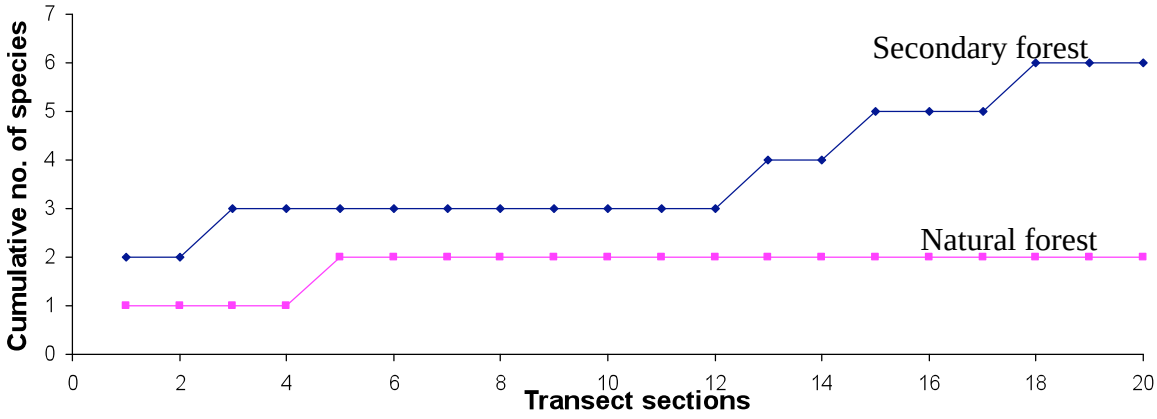

Figure 5. Termite species accumulation curves in the transects sampled in two different forest types in the Hantane hills.

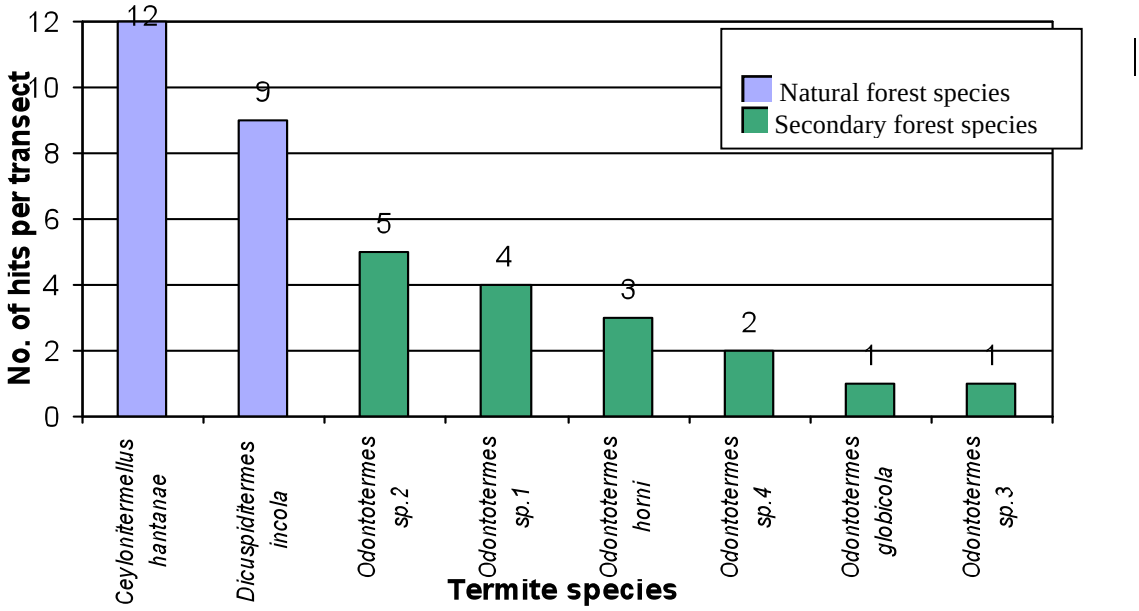

Figure 6. Abundance of termite species in the two forest types sampled in Hantane hills.

Nesting groups of termites

Nests of termite species inhabiting the natural forest were observed during both transect sampling and random collections. Subterranean nests of *C. hantanae* and *D. incola* were encountered in subsurface soil at about 10 cm depth, and all the developing stages together with the different castes were present in these nests. Nests of the remaining termite species inhabiting the secondary forest were not encountered. However, the nest type of these four identified termite species was inferred on the basis of information given in Bose (1984) and Roonwal (1970). Accordingly, all of the identified termite species (6 spp.) except one are subterranean nesters. *Nasutitermes fletcheri* is the only arboreal nester (Table 1)

DISCUSSION

The distinct species composition of termites with only two species inhabiting the fragmented natural forest is an interesting finding. Of the two species, *C. hantanae* is endemic to Sri Lanka and was first recorded in 1911 from Hantane, which is also its type-locality (Chhotani, 1997). This species has not been recorded since from the island until the present study. Even in this study it was recorded only from the natural forest located at high elevation that is subjected to frequent fires that spread from the adjacent grassland. Invasion by the exotic plant *Clusia rosea* is also a recent threat to this natural forest.

Of the nine species recorded from the secondary forest, only *N. fletcheri* is a new record for Sri Lanka. It has been previously recorded only from India (Chhotani, 1997). Its identity was confirmed on the basis of features given in Chhotani (1997).

The differences in species composition and distribution of termites observed between the two forest types can be attributed to several factors among which habitat disturbance in the secondary forest is a key factor. The fragmented secondary forest is separated from patches of the natural forest by grasslands and *Pinus* plantations. These grasslands and the *Pinus* litter are fire prone as there is a tendency by local inhabitants to frequently set fire to the grasslands to facilitate new growth for cattle grazing. This practice is important in maintaining regeneration in the grassland community.

The distinctiveness of the termite assemblages in the natural forest can be attributed to the lower montane conditions relating to altitude, climate and vegetation. Several studies have shown that termite species diversity and richness decrease with increase in altitude (Gathorne-Hardy *et al*., 2001; Jones, 2000; Collins, 1980; Donovan *et al*., 2002; Inoue *et al*., 2006). Furthermore, environmental temperature decreases with altitude. Maintenance of a fairly constant environmental temperature is important for the survival of termite colonies (Korb and Linsenmair, 1998). These factors act differentially on different termite clades (Donovan *et al.*, 2002). Therefore, only certain species are able to survive at the lower temperatures that prevail at higher altitudes. Low temperature negatively affects the active foraging habit, particularly of the wood feeding termite subfamily Macrotermitinae (Donovan *et al.*, 2002) and the growth of their fungus cultivations (Inoue *et al*., 2006). This explains the absence of *Odontotermes* species in the natural forest situated at a higher elevation. On the other hand, at lower altitudes the majority of the secondary forest termites comprised *Odontotermes* species.

The high abundance of the two termite species (based on the number of hits per species in a transect) in the natural forest compared to those in the secondary forest may be attributed to several factors. The most significant feature among them is that the two abundant natural forest species come under the feeding group IV that includes true soil feeders. The absence of termites of the feeding group II, which are wood feeders, from the natural forest located at high altitude (900 m or above) is noteworthy. With respect to the distribution of termite feeding groups at different altitudes, Gathorne–Hardy *et al*, (2001) have demonstrated that group II termites (wood feeders) decreases significantly with increasing altitude. In our study too, group II feeders were confined to the lower altitude secondary forest and were absent from the natural forest. Termites of the feeding group II are known to be active foragers moving from their subterranean or arboreal nests to high energy wood resources.

A distinct difference in the foraging habits of the subterranean termite species in the natural and secondary forest is evident. The natural forest termite species not only nests in soil but also feeds on soil. On the contrary, the secondary forest subterranean species that nest in soil forage above ground in dead wood (fallen branches and trunks of trees) making runways from their nesting site to the foraging site. The arboreal nesting species in the

secondary forest similarly make runways in search of dead wood on ground to forage.

The vegetation in natural forest is dominated by species such as endemic *Strobilanthus* sp., *Toddalia asiatica, Neolitsea cassia, Melicope lunu-ankenda* and *Symplocos cochinchinensis.* The secondary forest is dominated by large woody shade trees of the former tea plantations such as *Alstonia macrophylla* and *Albizia falcataria* and economically important species such as *Semecarpus obscura, Michelia champaca, Nothopegia beddomi, Artocarpus heterophyllus* and *Artocarpus nobilis.* Invasive *Clusia rosea* is becoming a threat to both forests as it is expanding its range to the exclusion of other species.

Accompanying the variation in the plant species composition is the differences in leaf litter distribution in the two forest types. The ground litter layer in the natural forest was relatively sparse but with higher moisture content. In contrast, the secondary forest ground cover was more complex, was much more heterogeneous and comparatively dry with obvious signs of termite activity, which was lacking in the ground cover of the natural forest. In the secondary forest the woody litter comprised mainly larger diameter branches, while that in the natural forest is of pencil size woody twigs and smaller branches.

The species accumulation curve provides a means of assessing sampling efforts with species turn over. In describing the sampling protocol by Jones and Eggleton (2000) a section of a transect was considered as a unit sampling effort. The same criterion has been used in interpreting the findings of this study.

In drawing conclusions from this preliminary study two problems were encountered. One of them stems from limited sampling carried out during this preliminary investigation, which would be extended to a couple of more transects as the study progresses. However, a previous study conducted by Jones and Eggleton (2000) to test the belt transect protocol has concluded that each transect captures approximately 31-36% of the known local termite fauna in a given site. A study on termite fauna in a 50 hectare plot of Pasoh forest, Malaysia, used only three transects (Jones and Brendel, 1998), while a study in Indonesia in the Sungai Tabalong Kiwa area used only one transect for each of the four sites (Jones and Prasetyo, 2002).

The other problem encountered in the study is the confounding factor due to a particular elevation and forest type not occurring together. Due to the manner in which the two forest types occur, where the natural forest is limited to high elevations and the secondary forest to lower elevations, it is not possible to dissociate forest type from elevation. Unless sampling is carried out along an elevation gradient in the Hantane hills, spanning across both forest types, the confounding factor cannot be addressed. A similar confounding factor was encountered in the study by Gathorne–Hardy *et al,* (2001) where nine different study sites representing five different forest types were located at 12 different altitudes

This preliminary study highlights the distinctiveness of the natural forest termite assemblage in the Hantane hills where altitude, vegetation, ground cover, lower montane climatic conditions and the relatively low human interference have helped to preserve its uniqueness. Sampling in progress at this site would further confirm the distinctiveness of the species encountered. Furthermore, work in different natural forests, at different elevation and climatic conditions are advocated to test the uniqueness of natural forest termites reported here.

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