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DIVERSITY AND DISTRIBUTION PATTERN OF TERMITES IN RELATION WITH HUMAN INTERFERENCE: A STUDY AT JNANABHARATHI CAMPUS, BANGALORE, INDIA

M. K. PRANESH[1] AND B. P. HARINI*[2]
[1]Centre for Applied Genetics, Bangalore University, Bangalore - 560 056, Karnataka, INDIA
[2]Department of Zoology, Bangalore University, Bangalore - 560 056, Karnataka, INDIA
e-mail: dr.bpharini@gmail.com

ABSTRACT

The study gives an insight to termite distribution pattern and alsorelative species diversity that has affected due to human habitats in Jnanabharathi campus. Human religious rituals and other activities have affected directly or indirectly on the population density and distribution pattern of termites especially at open fields where human interference is more. Among the five different species collected from January to December three nesting sites of each species were considered for continuous assessment for a period of three years (2010 to 2012). *Odontotermis cylonicus* was observed only in open field (L1) area while its number was declined in the third year during the same season which might be due to human activities. Similarly *Trinervitermis biformis* also shows decline in their number in the year 2012. *O. horni* number remained constant in the three regions during all the three years of observation. *O. obesus* and *O. redemanni* species were affected by human activities and the number was dropped down during 2012. The other two regions forest edge (L2) and Inner forest (L3) which shows less human activity reveals no change in nesting sites. Of all the five species *O. horni* does not fluctuate in their nesting sites. Thereby human interference has not influenced their nesting habitats. The Simpson's 1-D value (0.7889) and Shannon-H index value (1.583) specifies very high biodiversity of termites.

KEY WORDS
Termite fauna
Biodiversity
Distribution pattern, population density, religious rituals, human interference.

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*Corresponding author

INTRODUCTION

The termites are well known eusocial group of insects classified under the taxonomic rank of order Isoptera. Termites are further classified into nine families of living forms; Termitidae being the largest family contains 14 subfamilies, 280 genera and over 2600 species (Krishna, 1970; Pearce and Waite, 1994; Kambhampati and Eggleton, 2000; Eggleton, 2001, Ohkumaet *al.,* 2004; Roonwal and Chhotani, 1989). Termites mostly feed on dead plant material for its cellulose content, generally in the form of wood, leaf litter on soil, animal dung.It is important to note that only about 10% of the estimated 4,000 species (among which only 2,600 are taxonomically known) are considered as pests. Termites excreta are placed in an orderly fashion and the fungi are grown on these excreta. The fungus thus eaten but the spores pass undamaged through the intestine of the termites to complete the cycle by germinating in the fresh fecal pellets (Aanen *et al.,* 2002 and Mueller *et al.,* 2002).

As eusocial insects, termites live in colonies which at maturity vary in number from hundreds to several million individuals. Typical colony contains nymphs (semi-mature young), workers, soldiers, winged alates (seen only during winter season) and reproductive individuals of both genders, sometimes containing few egg-laying queens. Termites are economically significant as pests that can cause serious structural damage to buildings, crops or plantation forests. Apart from being pests, termites are less known for their major contribution asdetritivores which are particularly in the subtropical and tropical regions. They recycle woods, other plant matters and also they are food for many insectivore animals. Thus they are of considerable ecological importance.

Landscape structural alterations affect the population dynamics and composition of the concerned species or communities (Vasconcelos 1999; Barros *et al.,* 2002; Mathieu *et al.,* 2005). Habitat loss is a known major threat to global biodiversity (Fahrig, 2002; Brooks *et al.,* 2002), leading to increased extinction rate of species in most ecosystems (Brooks *et al.,* 2002). This loss is generally intense in the tropics, where many tropical forests are replaced with agricultural and silvicultural systems (Tilman *et al.,* 2001). Habitat conversion obviously hampers natural communities, resulting in the promotion of species that are tolerant to altered environments like termites. Furthermore, it is responsible for the elimination of many unique species required for normal food chain processes (Boren *et al.,* 1999; Hansen and Rotella 2002). Biomass density species richness, clade complements and energy flow can be altered due to different biogeographical histories of the area (Eggleton *et al.,* 1999).

Generally by studying the distribution of any species we can address many questions related to management of biodiversity under future climate (Sinclair *et al.,* 2010). Since change in climate in present days create unprecedented challenges for biological conservation. Study of termite biodiversity and distribution pattern help us understand the reason for its prevalence and variation. Also this study helps us understand a probability of how human interference play crucial role in converting a nonepidemic termite into a pest.

Termites are the most dominant macroarthropod detritivores in the tropics.They are particularly diverse and abundant in these areas (Jones *et al.,* 2000; Eggleton *et al.,* 1999; Eggleton, 2000). They are major agents which aids in decomposition. They play an important part in nutrient cycles and carbon fluxes (Lawton *et al.,* 1996; Tayasu *et al.,* 1997). Their activities include soil feeding, subterranean tunneling and mound building as well as maintaining the very important macropore structures, redistributing organic matter, improve soil stability and quality, and improve water absorbing and storing capacity (Lawton *et al.*,1996; Jones *et al.,* 2003). Termites playing the critical role of decomposition in food web it regulates plant growth and the influence that termites have on ecosystem, also how they affect their assemblages (Lavelle *et al.,* 1997; Bignell and Eggleton, 2000). While a few studies have demonstrated that termites are sensitive to habitat disturbance (Bignell and Eggleton, 2000; Eggleton *et al.,* 2002), only a very limited number of such studies have compared the communities living in areas exposed to different levels of disturbance. Thus the present study has explored the diversity and distribution pattern of termites in relation with human interference at Jnanabharathi campus which is an unexplored location.

MATERIALS AND METHODS

Termites were collected at Jnanabharathi campus in the month of November, December and January 2010 at three different localities that is, in open field (human activity is more) termed Locality 1, forest edge (human activity scarce) termed Locality 2 and inner forest (absence of human activity) termed Locality 3 (Harini and Sujaymeendra, 2010). Further the samples were collected in the same season for two more years 2011 and 2012from the same localitiesto confirm their taxonomic position. The method used to collect the termites were hand pick using feather light forceps or vacuum pump aspirator (Pranesh and Harini, 2014). The collected termite samples were brought to the laboratory in 70% alcohol, categorized, counted and identified under Motic microscope attached with 3MP camera. The measurements were taken by calibrated Motic Images Plus 2.0v software. A total of 47 samples were collected from different localities of JB, the details of the collection are mentioned (Table 1). Based on the description given by Roonwal and Chhotani (1989) 5 species were identified (Fig.1) and certain types of nests were recorded (Fig. 2).

Simpson's diversity index and Shannon diversity indices are calculated using PAST software. The results are then tabulated (Table 2). Among these five species three nests from each species were marked and observed every year in the same period and the obtained data were tabulated (Table 3) and the data of nest damage intensity were tabulated in Table 4.

RESULTS AND DISCUSSION

Termite diversity

The termites have very high tolerance to any environment and its biodiversity is especially high in low land tropical forests (Eggleton, 2000). The study showed that the termite assemblage has been considerably shrunken in the rural area, which is obviously due to various human activities occurring in this habitat (Eggleton *et al.,* 2002). To fulfill various human needs of growing population, forest sites are frequently harvested due to which there is a reduction in physical complexity of these habitats, causing a decline in the variety and abundance of suitable nesting and feeding sites, as well as changes in microclimate. Microhabitats of termites such as rotting tree stumps, dead logs, humus soil, etc. will be often shrunken from intensively used area. Thus decreased biodiversity due to human activities is suspected to reduce succession of alates in establishing new colonies (Eggleton and Bignell, 1997, Jones *et al.,* 2003; Dosso *et al.,* 2010). This change in microhabitat also disrupts natural enemies of termite and may prone termites to become pests rather than just a part of the food chain. This is one of the main consequences of such type of destruction of micro and macrohabitats. It is certainly due to the settlement of many colonies despite agricultural intensification which leads to a trend that is less evident in forests (Jones *et al.*,2003).

Table 1: Distribution of different species of termites in different localities of Jnanabharathi

Different types and No. of species collected	No. nest samples collected	Number of individuals collected Workers	Soldiers	Total
1. *O. ceylonicus*(Wasmann)	4	1091	61	1152
2. *O. horni*(Wasmann)	13	921	645	1566
3. *O. obesus*(Rambur)	10	1462	672	2134
4. *O. redemanni*(Wasmann)	6	727	621	1348
5. *T. biformis*(Wasmann)	16	13	1233	1246

Table 2: Diversity indices

	B(Mean)	LowerLimit	UpperLimit
Taxa_S	5	5	5
Individuals	7446	7446	7446
Dominance_D	0.2111	0.2088	0.2134
Simpson_1-D	0.7889	0.7866	0.7912
Shannon_H	1.583	1.578	1.589

Such a pattern may be explained by the massive appearance of species that are peculiar to this heterogeneous savanna (Sands 1965; Dosso *et al.,* 2012).

Similar results were observed for the sampling period (November to January)in winter season. Termite diversity in the study region was generally high (Table 2) and probably typical for the study area. The value of Simpson index

Table 3: Observation of nests in three years

Location Different types of species and their number	Type of nest	Open field (Human activity is more)-L1 No. nest samples collected during November, December and January 2010	No. nest samples collected during November, December and January 2011	No. nest samples collected during November, December and January 2012	Forest edge (human activity scarce)-L2 No. nest samples collected during November, December and January 2010	No. nest samples collected during November, December and January 2011	No. nest samples collected during November, December and January 2012	Inner forest (human activity absent)-L3 No. nest samples collected during November, December and January 2010	No. nest samples collected during November, December and January 2011	No. nest samples collected during November, December and January 2012
1. *O. ceylonicus* (Wasmann)	Tree galleries and land soil	3	3	1	0	0	0	0	0	0
2. *O. horni*(Wasmann)	Tree galleries	3	3	3	3	3	3	3	3	3
3. *O. obesus*(Rambur)	Mount, tree galleries and land soil	3	3	2	3	3	3	3	3	3
4. *O. redemanni* (Wasmann)	Mount	3	3	2	2	2	2	1	1	1
5. *T. biformis*(Wasmann)	Land soil	3	3	1	3	3	2*	3	3	3

Note:- *A nest was missing and not damaged

(Dominance) ranges from 0.2088 to 0.2134 and its base line (B) or mean value is0.2111. Simpson index and Simpson 1-D values can be interchanged. The low value of D specifies high diversity and if the value is high then it specifies low diversity or single taxa domination. Since we have obtained very low D value we can clearly specify that the diversity is very high in the locality.The Shannon index (entropy) is the diversity index calculated based on the number of individuals as well as the number of taxa. The value obtained ranges from 1.578 to 1.589 and the B or mean value is 1.583. This high value also specifies communities with many taxa.As termite activity can be seasonal, this sampling in a single season may not represent the full diversity at the sites, but might allow for a comparative evaluation between the sites during this specific season (Chakraborty *et al.*, 2014; Singh and Roy, 2008).

The small sample numbers indicate few clear differences in diversity between the species. However, diversity was generally higher at the L-1 sites in the open areas compared to the L-3 sites at the inner forests. This might be because of thickness of the forest which made sampling difficult or termite population might be under the control of its ecosystem. This could be attributed to the fact that these sites are situated in an area with moderate rainfall, which is less arid. In such system, resource availability as well as microclimatic conditions might not restrict termite diversity even during summer. The high diversity in L1 region might be due to high resource availability provided by manmade structures and decreased predators.

Human interference on termite species richness

The field collection of Termites from the Jnanabharathi Campus for a period of 3 years has yielded a total of 7446individuals during year 2010 - 2012 (4214 workers and 3232 soldiers). The soldiers were grouped on the basis of morphological characters and analyzed taxonomically. The data (Table 1) from the present survey has revealed 5 different species of termites among which *O. horni* (Wasmann) and *T. biformis* (Wasmann) is more abundant among the collected five species.

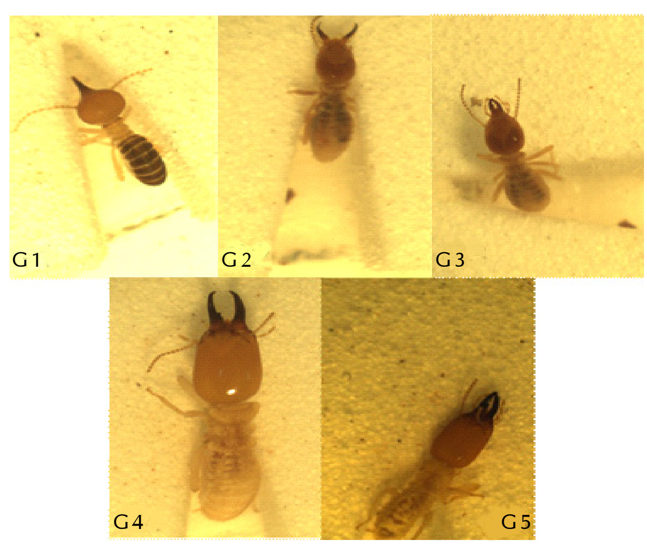

Figure 1: Five different types of species collected during the study G1- *T. biformis* (Wasmann); G2- *O. redemanni* (Wasmann); G3- *O. obesus* (Rambur); G4- *O. horni* (Wasmann) and G5- *O. ceylonicus* (Wasmann)

Table 4: Intensity of damage observed at the nesting sites in L1 region

Types of Species	Number of nests under reconstruction		Number of nests partially damaged	Number of nests fully damaged
	At the same site marked	Near the site marked		
1. *O. ceylonicus*(Wasmann)	0	0	0	2
2. *O. horni*(Wasmann)	2	0	0	0
3. *O. obesus*(Rambur)	0	0	0	1
4. *O. redemanni*(Wasmann)	0	0	0	1
5. *T. biformis*(Wasmann)	0	2	0	0

Figure 2: Different types of nests N1- *O. redemanni* (Wasmann) nest; N2- *O. redemanni* (Wasmann) N1 nest destroyed due to human interference; N3- *O. horni* (Wasmann) tree gallery; N4- *T. biformis* (Wasmann) ground nest and N5- *O. obesus*(Rambur) grass or leaf litter nest

In addition to this, *O. ceylonicus* (Wasmann) was not found to appear in the L-2 and L-3 regions, but it was recorded in L-1 region all the three years. Interestingly, very few numbers of soldiers belonging to species *O. ceylonicus* (Wasmann) was found in all the above assessed months in L-1 locality. Similarly very fewer number of workers belonging to species *T. biformis* (Wasmann) was found in all the above assessed localities which specifies that the soldiers protected their colony aggressively during sample collection.This data implies that *O. obesus* (Rambur), *T. biformis* (Wasmann) and *O. horni* (Wasmann) are more capable of adapting to the changing environment whereas *O. ceylonicus* (Wasmann) is more sensitive which might be due to human interference or its natural predators.

Table 3 data specifies the identified nests and effect of human interference on different species of termites at different localities of the JB Campus.In open field (L-1) six nests among fifteen are missing, this might be due to two commonly influencing factors like environment and human interference. Environmental factors like natural predators (ants and spiders), certain fungal parasites, colony destruction by larges predators like birds and reptiles may affect loss of whole colony or just few nesting sites or few alates. Human interference like pesticides, insecticides and even cultural rituals has also influenced in depletion of whole colony (Barros *et al.,* 2002 and Fahrig 2002).

At Forest edge (L-2) location only one nesting site belonging to *T. biformis* (Wasmann) was missing which might be due to less availability of plant litters on the ground. This might have altered regular nesting sites but not the whole colony since *T. biformis* (Wasmann) is an underground dweller, nocturnal detretivorus animal relaying on dead plant materials on the ground. This is the possible reason since the colony had started reconstruction at the other site near to the old marked site as mentioned in Table-4.

Among the samples collected in Forest interior (L-3)majority of the colonies and nests were intact. It clearly shows that the termite distributions are largely affected by the human habitat where disturbance gradient is frequent in L-1 and also at the edges of forest L-2. The number of termite species found was highly undisturbed or kept under control at L-3 locality of the present study by natural means.

Table-4 specifies the intensity of damaged nesting sites in L1 region. Two nests of *O. ceylonicus* (Wasmann) were completely damaged where nest debris was found with dried exoskeleton of the workers and soldiers. Similarly *O. horni* (Wasmann) shows damage in the existing tree gallery but they had also reconstructed their nest at the same place. The species *O. obesus*and *O. redemanni*(Wasmann) nests were completely destroyed due to human activities.

Thereby the present study provides information on the distribution and diversity of the termites in three environments (open field, forest edge and inner forest) along the winter season during three years 2010 to 2012. The study suggests that diversity and distribution of the termites which have been affected enormously where human habitat is frequently sensed. In addition to this environmental factors also have a direct or indirect effect on the population density of termites. Thus in the presence or absence of a species in an ecological niche, and its richness or abundance in that area is an indicator of both biological and ecological diversity of that ecosystem. This is not an exception for termites.In this study we can also interpret that due to human interference there is loss of biodiversity and also increases the abundance of termite diversity where there is high human activity. This might be due to availability of enough resources and decline of natural predators.

The available data also suggests that low vegetation in L1 locality is due to human interference and this has resulted in decreased natural control over termite infestation. This means that termites will infest manmade structures because of low availability of natural resources and fewer predators. Human interference is moderate in L-2. This depletes microhabitat and results in decreased termite biomass and richness. Human interference is very low in L-3 area due to which nature controls termite biomass and richness.

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