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# Sampling and identification of termites in Northeastern Puducherry

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**ABSTRACT**
In the course of efforts to harness the lignin-degrading ability of termites in processing those portions of solid waste which resist composting/vermicomposting, a systematic survey of termite species present in a 210 acre region near the Puducherry coast has been carried out. In order to make the survey as representative as possible, transect as well as quadrat based methods were employed. It led to the spotting of ten species of termites belonging to eight genera and three families. The findings have been used to determine the species richness and abundance.

**Keywords:** Termites, sampling, transect, quadrat, termigradation, termireactors.

## 1. Introduction
Termites play strong roles as mediators of ecological processes in the soil. They, especially their subterranean species, exert a powerful influence on soil functioning through the regulation of soil organic matter, enhancement of the bioavailability of nutrients contained in the debris they consume, and impacts on soil porosity, aeration, water infiltration and storage. These impacts transmit across trophic levels to influence very diverse forms of plant and animal communities [1]. The termites process a variety of plant organic matter at all stages of decomposition, ranging from leaf litter to rotten wood to soil humus. They play a vital role in recycling wood and plant materials, modifying soil condition, improving soil composition and fertility, and providing food for other animals. They are responsible for the redistribution of soil particles and altering of the mineral and organic composition of soils, their hydrology, drainage and infiltration rates. Termites are also considered to be the dominant arthropod decomposers in tropical systems and hence influence nutrient cycling and distribution. Their vast biomass gives them a dominant presence in the tropical and sub-tropical ecosystem [2]. Tropical rain forests are often associated with low-fertility soils, and termites' cycling of organic matter contributes to the efficient return of nutrients to the vegetation in such forests [3]. Termites are the most populous and most efficient among insects capable of decomposing lignocellulose. In addition termites harbor nitrogen fixing bacteria and their foraging enhances the nitrogen content of the soil [4].

## 2. Material and methods
The survey was conducted in the verdant campus of Pondicherry Engineering College (PEC) situated in northeastern Puducherry (12.0133°N, 79.8538°E). The campus is spread across 210 acres with thick vegetation interspersed with buildings. The map of the area was obtained from the Horticulture Department of the institution. It was scaled down to 1:3000 (Figure 1a).

### 2.1 Termite survey
The survey of termites in the area was carried out using transect and quadrat methods as elaborated by Jones *et al* [5].

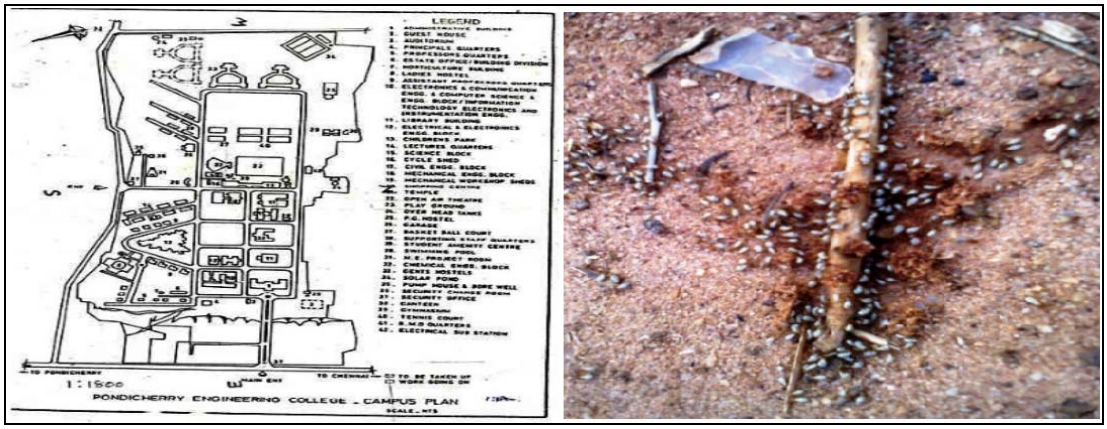
#### 2.1.1 Transect method
Each transect was 100 m long and 2 m wide, divided into 20 contiguous sections (each 5 m X 2 m) and numbered sequentially. Samples were collected in each section for 30 minutes by two persons.

In each section the following microhabitats were searched for termites: 12 samples of surface soil (each 12 cm X 12 cm, to 10 cm depth); accumulations of litter and humus at the base of trees and between buttress roots; the inside of dead tree stumps, logs, branches, and twigs (Figure 1b); the soil within and beneath rotten logs; all mounds and subterranean nests encountered; arboreal nests, carton runways, and sheeting on vegetation up to a height of 2 m above ground level.

### 2.1.2 Quadrat method

A 100 m x 100 m plot was randomly selected and marked. In it five sub-sections of 2 m x2 m were marked randomly and the termites were sampled as done in the transect based method.

The termites were collected using a brush dipped in ethanol and preserved in 80% ethanol. The animals were separated from the debris with the help of the brush by placing them in a petri dish. Then the workers and soldiers (major and minor) were separated and preserved in 80% ethanol in 20 ml glass bottles (Figure 2a). The preserved sample was labeled carefully with all required information.




**(a)** **(b)**

**Fig 1:** (a) Map of Pondicherry Engineering College campus (b) termites around a twig on the surface of soil

### 2.2 Identification

The termites were identified using a key compiled by us from various Zoological Survey of India (ZSI) sourcebooks [6-8] and other compendia [9]. They were identified upto genus level by the morphological characters of body parts such as head, eyes, antennae, pronotum, mesonotum, metanotum, legs, rostrum (in nasute), cerci, etc. (Figure 2b). Postmentum, labrum and mandible were mounted. Species were identified by taking measurements of different parts and matching them to the compiled keys.

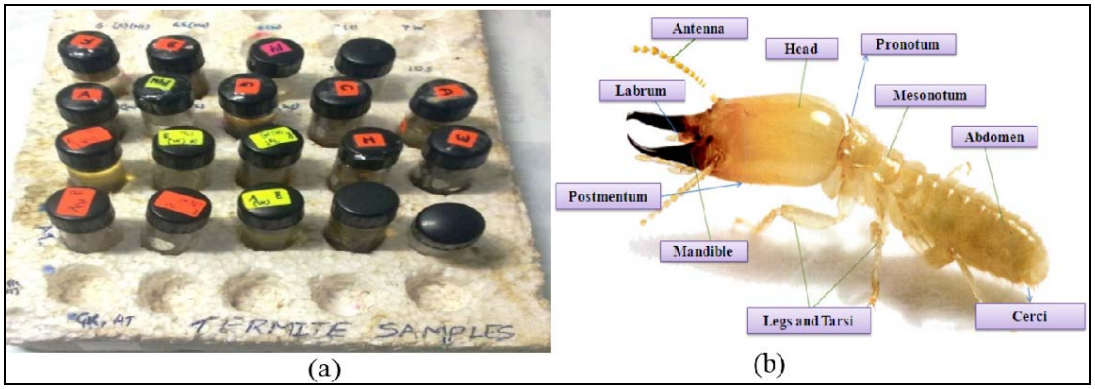



**Fig 2:** (a) Termite samples preserved in 80% ethyl alcohol, (b) the termite body parts on which the identification was based.

### 3. Results and discussion

Ten species belonging to seven genera and three families viz., Termitidae, Rhinotermitidae and Kalotermitidae (Table 2) were identified. They are *Hypotermes obscuriceps, Macrotermes convulsionarius, Odontotermes anamallensis, O.brunneus, O.globicola, Microcerotermes fletcheri, Microtermes obesi, Trinervitermes biformis*, *Coptotermes heimi,* and *Neotermes assmuthi.* The termites were classified based on their feeding preference described by various authors.

Abe[10] has identified six nesting trends based on different nest systems and the feeding habits of the termites: a) drywood termites, which nest in and consume only the dry, hard wood in which they live (mainly the Kalotermitidae); b) dampwood termites, which feed exclusively on the wet, decaying wood in which they live (Archotermopsidae, and some Rhinotermitidae); c) intermediate termites, which nest in wood and construct galleries in the soil or on the ground, and consume other wood sources in addition to the nest itself (Mastotermitidae, some Kalotermitidae, most Rhinotermitidae, and some Termitidae); d) arboreal termites, which nest on living tree trunks and construct covered galleries leading to food sources completely separate from the nest (many Termitidae); e) subterranean termites, which make epigeous and /or

subterranean nests, also constructing galleries to food sources separate from the nest (Hodotermitidae, some Rhinotermitidae, Serritermitidae, and many Termitidae); and f) humus feeding termites, which make epigeous or subterranean nests and construct galleries to access humus food sources (many Termitidae). These trends were dubbed life types, and can be further grouped into three main categories of nests: one-piece, intermediate, and separate types of nests**.**

**Table 1:** Eight lifeways of termites proposed by Eggleton and Tayasu [11].

| Life type (Abe,1987) ↑ | | Non-Termitidae | | Termitidae | | |
|---|---|---|---|---|---|---|
| | | I | | II | III | IV |
| | Single | Sing(I) ww | Sing(I) dw | Int(I) | | |
| | Intermediate | Int (I) | | Sep(II) | | |
| | Separate | Sep(I) | | | | |
| | Soil feeding | | | | (III) | (III) |

→ (Feeding group Donovan *et al.* [12])

**Group I** [wood (wet and dry), grass, detritus]; **Group II** (wood, fungus, grass, detritus, litter, microepiphytes).; **Group III** (soil–wood interface, soil); **Group IV** (soil)

Another classification of termites based on feeding groups correlating substrate consumed with the morphology and anatomy of worker termites was proposed by Donovan [12]. Group I includes wet and dry wood, grass, and detritus feeders with one-piece or intermediate nest types. Group II includes wood, fungus, grass, detritus, litter, and microepiphyte feeders with intermediate or separate type nesting. Groups III and IV include soil-wood interface and soil feeders, respectively. These last two groups essentially have separate type nests, but occasionally feed on them, thereby confounding the original definition of a separate type nest [12]. Eggleton and Tayasu [11] combined the life types from Abe [10] and feeding groups from Donovan [12] to synthesize a single classification scheme (dubbed 'lifeways') encompassing all these factors. In this new scheme, one-piece nesting in either wet or dry wood remains only in the most basal clades. Feeding groups II, III, and IV are only found in the Termitidae. The distinction between arboreal, epigeal, and subterranean separate type nests was not incorporated into the lifeways categorization. Although the lifeways are more complete classifications of the functional diversity of termites, Abe's [10] life types are still frequently used to differentiate termite nesting strategies [12].

Based on the feeding behavior of termites as described by Donovan [12]**,** we have grouped the termite species sampled from the study area (Table 2). Out of ten species identified, three species (*O. anamallensis*, *O. brunneus* and *O. globicola*) are dead wood and leaf litter feeders. *M. obesi* is wood and litter feeder. *N. assmuthi* and *C. heimi* are dead wood feeders. *T. biformis* is soil and grass feeder. *M. convulsionarius* is leaf litter and soil feeder. *H. obscuriceps* is leaf litter feeder whereas *M. fletcheri* is dead /live wood feeder.

Seven of the species – *O. anamallensis, O. brunneus, O. globicola, N. assmuthi, M. obesi, M. fletcheri* and *T. biformis* – belong to intermediate nesting type. Two species *M. convulsionarius* and *H.obscuriceps* belong to separate-piece nesters and *C. heimi* belong to single-piece nester (Table 2).

**Table 2:** Taxa and the feeding groups of the termites recorded from Pondicherry Engineering College campus

| Family | Sub family | Name of the species | Foraging/feeding substrate | Type of nesting |
|---|---|---|---|---|
| Termitidae | Macrotermitinae | *Hypotermes obscuriceps* | leaf litter | Sep |
| | | *Macrotermes convulsionarius* | Leaf litter/soil | Sep |
| | | *Odontotermes anamallensis* | Dead wood and leaf litter | Int |
| | | *O.brunneus* | Dead wood and leaf litter | Int |
| | | *O. globicola* | Dead wood and leaf litter | Int |
| | | *Microtermes obesi* | Wood and litter feeder | Int |
| | Amitermitinae | *Microcerotermes fletcheri* | Dead /live wood | Int |
| | Nasutitermitinae | *Trinervitermes biformis* | Soil and grass | Int |
| Rhinotermitidae | Coptotermitinae | *Coptotermes heimi* | Dead wood | Sing |
| Kalotermitidae | - | *Neotermes assmuthi* | Dead wood | Int |

**Sep**- Separate-piece nesters; **Int**- Intermediate nesters; **Sing**- Single-piece nesters

The termite survey was done to compare the species richness and diversity in the sampled area of the present study with that of others who have also followed the same sampling method. Termite belonging to 26 species was identified in the Terra Firme Forest, central Amazonia in approximately a million ha [13]. In a study conducted by Palin *et al* [14] in southeast Peru at five 1-ha forest sample plots, 59 termite species were identified**.** Twenty seven species of termite were sampled in the natural habitats of Guiembe village 30 km from Korhogo and reported the Shannon index (H') and Simpson index of diversity to be 2.88 and 0.94 respectively [15]. Fourteen termite species were sampled from two different land use systems in Western Ghats, India by Shanbang and Sundaraj [16]. They have reported Simpson's diversity index as 7.3 and 5.5 in forest areas and plantations/agroforest respectively and the Shannon Wiener's index (H') value as 2.2 and 1.56, respectively. The Pielou's evenness index for the two areas was 0.85 and 0.76. Dosso *et al* [17] sampled termites from four different habitats of Savannah (annually burned savannah, savanna woodland, forest

island and gallery forest) in Cote d'Ivoire, West Africa and recorded a total of thirty species. Simpson's index of diversity generally ranges between 0-1, where 0 represents infinite diversity and 1 represents no diversity. The Simpson index reported by Dosso *et al.,* (2012) [17] ranged between 0.80 to 0.90 which indicates less diversity compared to the present study index of 0.20 which represents relatively high diversity.

Termite assemblages were examined in patches of undisturbed natural forest and disturbed secondary forests comprising 432 ha by Hemachandra *et al* [4]. They recorded eleven species. The Shannon diversity index was higher in the case of disturbed secondary forest (H'1.630) compared to undisturbed natural forest (0.683). The Shannon index of the present study shows higher Shannon index (H'1.83) compared to the undisturbed natural forest reported by them. The Shannon value of 1.83 represents relatively diverse community as higher value of index indicate more diverse and equally distributed community.

A termite survey was conducted by Carrijo and Brandao [18] in two areas: pasture and natural vegetation of State Park, Goias, Brazil by using, modified protocol with some ideas of that used by Jones and Eggleton's (2000) [19]. They have reported twenty nine species of termites (seventeen in pasture and twenty one in natural vegetation). The Shannon index is 2.55 for pasture and 2.82 for natural vegetation. Pielou's eveness values are 0.94 in pasture and 0.93 in natural vegetation. The higher value of Pielou's eveness (0.93) indicates less variation in the species distribution in the natural vegetation compared to our study area (0.79). Zeidler *et al* [20] sampled termite in Southern Kuene region, Namibia and reported a total of ten species. The Shannon indices ranged from 0-1.46. Termite species assemblages differed between the various forms, as well as across the land-use intensity gradients.

The study of termite species richness and abundance was done using standardized transect by Eggleton *et al* (1996) [21] around an area of about 53,000 ha in Dar es Salaam, Rufiji river in South Africa in three different areas like cropland, forest and grassland. They calculated the Shannon Wiener's index in wet and dry season: in cropland: wet-2.0485 and dry-1.7432; forest: wet-2.2836; dry- 1.8724 and grassland: wet-1.4854; dry-1.2669. The Pielou's evenness index value in three different areas in wet and dry season: in cropland, wet- 0.73885; dry- 0.62872.forest: wet-0.82362; dry-0.67534.grassland: wet- 0.53573; dry- 0.0458[22]**.** Kaur *et al* [23] have identified thirteen species of termite in Pondicherry University campus in northeastern Puducherry and reported that the area exhibited moderate evenness in distribution with Pielou's eveness value 0.57. The Simpson's index of 0.34 indicate more number of rare species and Shannon diversity index of 1.45 indicate few abundant species as well. In another study by Kaur *et al* [23] in an area located closer to Pondicherry University, Auroville, a total of ten species belonging to two families were identified. The termite species exhibited less evenness in distribution. The Simpson's index of 0.17 to 0.21 indicates richly diverse area, whereas Shannon diversity index (1.74-1.82) indicates presence of few abundant species. A survey of termites in different land use regimes in Dindigul, Tamilnadu was conducted by Sathiyabama and Ravindran [24] and reported ten termite species. The diversity of termites in young eucalypt plantation in tropical forests in Kerala by transect sampling and additionally every month sampling of foraging termites for one year reported fourteen species (eleven by transect and three by monthly sampling) and among fourteen species surveyed, only four were found attacking eucalypt seedlings [25].

There are other studies on termite survey in which sampling was done randomly or by following other methods. Ali *et al* [26] have identified six termite species in the Islamia University of Bahawalpur, Pakistan by sampling termites where spotted. Primanda *et al* [27] identified six termite species in a University campus in Indonesia, in an area of 16.000 $m^2$ using 10m x 10m quadrats. In India, survey carried out in Udaipur district (Rajasthan) has recorded 12 termite species [28]. Twenty five species of termites around 22,400 $km^2$ in three states: Tamil Nadu 400 $km^2$, Karnataka 13,000 $km^2$ and Kerala 9,000 $km^2$ were sampled in a study conducted to assess the economic damage caused to forest trees and ecological habitat by termites [29]. Twelve termite species were identified in the Western Ghats, South India to understand impact of human disturbance on pristine ecosystem [30]. Kumar and Pardeshi, 2011 [31] recorded fifteen termite species in Vadodra district of Gujarat. Kumar and Thakur (2010) [32] sampled fifteen species of termites in Haryana Agricultural University Campus, Hisar, Haryana around 7,219 acres and also they have reported 27 termite species from different localities of Punjab in 2013 [32].

A survey was conducted to investigate diversity of termites and their damage to living trees of forest region of Bhadrachlam forest (1, 44,603 ha) in Andhra Pradesh. Thirteen species were recorded [33]. Six termite species was identified from different localities in Bahawalnagar, Pakistan by collecting termites from 250 soil cores [34].

Pielou's index (J) of evenness has been calculated for the sampled termite species in the present study. In general Pielou's index of evenness falls between 0-1. The Pileou's indices reported by Dosso *et al.,*(2012) [17] ranged between 0.27–0.46 representing uneven to relatively more even distribution of species in four different study sites. In the present study, the Pileou's index was 0.79 which shows that the termites are distributed quite evenly.

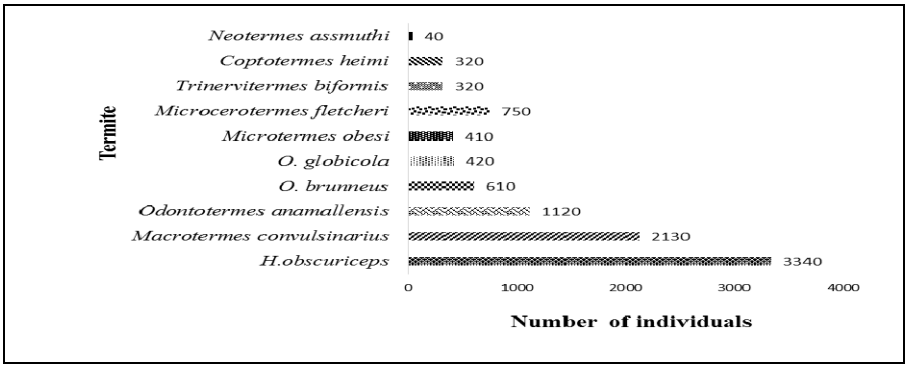



**Fig 3:** Relative abundance as expressed in number of individuals of different species sampled during survey of Pondicherry Engineering College campus

The proportion of the identified species based on the number of individuals sampled is shown in Figure 3. *H. obscuriceps* was the most abundant species (35%) in sampled area followed by *M. convulsionarius* (23%), *O. anamallensis, M. fletcheri, O. brunneus O. globicola, N. assmuthi, T. biformis* and *C. heimi. N. assmuthi* was sampled from only one location.

## 4. Conclusion

A repertoire of locally established termite species was developed using a systematic survey. A total of ten species belonging to three families: Termitidae, Kalotermitidae and Rhinotermitidae; and four subfamilies: Macrotermitinae, Amitermitinae, Nasutitermitinae and Coptotermitinae and eight different genera were identified. Out of the ten identified species eight belonged to higher termites and the rest to lower termite. *H. obscuriceps* was the most abundant and dominant species sampled from both mound and arboreal habitats.

## 5. Acknowledgement

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