Research Article

Diversified Feeding in Termites (Isoptera: Insecta) in Southern Haryana

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ABSTRACT

Termites are the significant decomposers in an ecosystem that helps to recycle nutrients and other raw materials. Termites are also known as pests of crops and timber plants. Hence, this study is carried out to document different feeding types of termites concerning various feeding diets. A total of 233 colonies were collected from the different localities of Southern Haryana by conducting a random sampling process in two years of study from 2020-2021. Samples were identified into 26 termite species under 3 families, 4 subfamilies and 8 genera by utilizing phenotypic features of the soldier and worker castes. These species were further characterized according to feeding groups. In the present study, 5 feeding groups were reported. Out of 26 species, 11 species were recorded as wood feeders whereas, in soil feeder, soil-wood intermediate feeder, litter feeder and grass feeder 6, 9, 5 and 4 species were noted. The most dominant was the wood feeder, followed by the soil-wood intermediate feeder, soil feeder, litter feeder, and finally grass feeder. Among wood feeders *Microtermes mycophagus* and soil-wood intermediate feeder *Amitermes belli* were dominant. The feeding groups diverged significantly among the surroundings, based on habitat disturbances.

Keywords: Feeding group, Termites, Termitidae, Wood feeder.

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INTRODUCTION

Alongside earthworms and ants, termites are also called eco-systematically vital insects due to the role of decomposers and notorious pests of crops and timbers.[1,2] Termites consume cellulose-rich woody items that are further changed into biofuel.[3,4,5] It's the most diverse insect that constructs a colony found at every locality of the earth except Antarctica,[6,7] due to cold weather that opposed its survivability.[8,9] Colony size can vary with the number of individuals.[10] Termite mounds erection capability supports soil processing activities like soil turnover and soil rejuvenation.[11,12] The termites that cause damage generally include subterranean, damp wood and dry wood termites.

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Termites mainly feed on a variety of organic materials and these materials are digested with the help of gut microflora.[5] Termites' diets consist of plant stuff including living plants as well as decaying parts of all stages.[13,14] The feeding of plant materials mainly includes dead branches, a decomposed layer of detritus with minerals-rich soil, living roots and shoots, and litters of woody twigs, leaves, and branches.[15,16] Hence, on the basis of feeding diets, termites were generally classified into five major overlapping feeding groups.[17] They are litter-foragers, soil-feeders, wood-feeders, grass-feeders, and soil-wood intermediate feeders.[18,19] However, on the basis of termite's worker gut morphology, termites can also be classified into 4 feeding groups; (a) Type I, (b) Type II, (c) Type III, and (d) Type IV were recorded.[20]

Hence, it becomes interesting to know the diversified feeding in termites in relation to their vast variety of feeding diets and strategies. This present study was designed to analyze and identify the different feeding groups of termites as no previous study was done on the

ecological behaviour of the termite fauna of Southern Haryana.

MATERIALS AND METHODS

Study Sites

All termites' samples were collected from six districts of Southern Haryana (Nuh, Mahendragarh, Rewari, Palwal, Gurugram and Faridabad) which are positioned between 28.25° N 76.29° E. A total of 233, colonies of termites' were collected from various feeding habitats for a period of two years (2020-2021) including dry woody items, the soil within and beneath very rotten logs, soil mounds, dry grasses, cattle dung cakes, *Acacia*, bushes, Sisam and Neem tree. At the time of collection, the locality of collected samples was noted using a GPS recorder which detailed the day, date, time, altitude, latitude and longitude.

Termite survey

Termites were randomly collected from the study areas.[4,21,22] Some special skill were used while searching the termites such as termite invasion signs have been noticed i.e., woody logs notably invaded by termites when it produces noise at the time of exploiting with the screwdriver, damaged woods, finding of imago's wings, termite excreta which are grey-brown in an appearance on woody planes, soil mounds with mud tunnels, soft wood that is simply searched by knife or screwdriver and devoting the main probing to the wood basements and under porches.

Termite identification

30-50 specimens were randomly collected from each colony and preserved in 70% ethanol with 2 drops of glycerol till examination. The preserved sample was labelled carefully with all required information (date, time, source and location). Every caste of termite species was selected if found, but the priority was given to soldier and worker castes as these are easy to identify. Identification was done by morphometric analysis of soldier and worker caste features act as valuable keys for the documentation of termite samples.[23,24] However, the feeding diversity of termites was notified by recording the feeding preferences of termites (Table 1).[18]

Table 1: Different types of feeding groups of termites.

Sr. No.	Feeding groups	Description
1	Wood feeders	This group feeds on woody items and dead twigs that still connected to trees and creates galleries for their colony.[17,18] Most of the "lower" termites are known as wood feeders whereas, in "higher" termites, all subfamilies of the family Termitidae, except the Apicotermitinae feed on woods.[17,25,26]
2	The soil feeders	They feed on the topmost layer of mineral-rich soil as well as surface litter (twigs and leaves) (Apicotermitinae, Termitinae, and Nasutitermitinae).[17]
3	Litter feeders	They forage on softened parts of woody items and leaf litter (Macrotermitinae, Apicotermitinae, Termitinae and Nasutitermitinae).[17,18]
4	Soil-wood intermediate	This forager feeds on extremely decayed wood that turn into soil-like and friable (Termitinae, Apicotermitinae and Nasutitermitinae).[17]
5	Grass feeder	In addition, according to,[27] termites also include another feeding group, the Lastely grass feeder consumes grass and dung (Hodotermitidae).[27]

RESULTS

A total of 233 termite colonies were collected from the different localities with different feeding sites. Based on the phenotypic study, samples were identified into 26 species belonging to 3 families (Termitidae, Rhinotermitidae and Kalotermitidae). Then, on the feeding preferences, 26 species are classified into 5 major feeding groups (soil-feeding, soil-wood intermediates feeder, litter feeding, grass feeder and wood-feeders). Wood feeders comprised the highest 31% diversity followed by soil-wood intermediate feeder (26%), soil feeders (17%), litter feeders (14%) and grass feeders (12%) (Figure 1).

Wood-feeding termites have comprised 11 species i.e., *Coptotermes emersoni, C. gestroi, C. heimi, C. kishori, Eremotermes paradoxalis, O. anamallensis, O. feae, Microtermes mycophagus, Microcerotermes raja, Neotermes sp.*1., and *Neotermes sp.*2, while 6 species i.e., *O. assmuthi, O. giriensis, O. guptai, O. gurdaspurensis, O. obesus* and *M. obesi* were classified as soil feeders. Nine species of termites named *Amitermes belli, O. feae*, *M. baluchistanicus*, *M. beesoni, M. cameroni, M. newmani, M. mycophagus*, *O. redemanni* and *O. parvidens*, were fallen into the soil-wood intermediate feeder, 5 were litter feeder named *Angulitermes akhorisainensis*, *Eremotermes neoparadoxalis*, *O. assmuthi*, *O. guptai* and *M. obesi*. However, grass feeders comprised 4 species (*Eremotermes neoparadoxalis, M. mycophagus, O. obesus* and *A. belli*) (Figures 1-6).

Out of all studied species, *A. belli*, *E. neoparadoxalis*, *O. assmuthi*, *O. guptai*, *O. feae*, *O. obesus*, *M. obesi* and *M. mycophagus* showed the highest diversity and distribution with a variety of feeding preference

(Figure 1). *A. belli* and *O. feae* mostly preferred soil/wood intermediate diets. *O. assmuthi*, *O. guptai*, *O. obesus* and *M. obesi* were mostly nourished on soil and diversity of *M. mycophagus* species was highly recorded on woody things.

Figure 1 indicated the percentage of termite species with different feeder groups. *Microtermes mycophagus* species was the most abundant wood feeders (WF) with 31%, followed by *C. heimi* (25%), *C. kishori* (11%), *O. anamallensis* (8%), *E. paradoxalis, M. raja* and *C. gestroi* with 5% where rest with 1-4% respectively (Figure 2). For soil feeders (SF) *M. obesi* was the most encountered species with 30%, followed by *O. obesus* (25%), *O. guptai* (16%), *O. gurdaspurensis* (13%), *O. assmuthi* (10%) and *O. giriensis* (6%) (Figure 3). *Amitermes belli* dominated 21% of the total soil-wood intermediate feeders (S/WF) followed by *M. beesoni* (19%), *M. Cameroni* (16%), *M. newmani* (14%) and the rest were (*O. feae*, *O. parvidens*, *O. redemanni* and *M. baluchistanicus*) denoted by 19% (Figure 4). In litter feeder (LF), *O. guptai* represented the highest diversity (37%) followed by *M. obesi* (26%), *O. assmuthi* (21%), *E. neoparadoxalis* (11%) and *Angulitermes akhorisainensis* with 5% (Figure 5). However, in grass feeders (GF), 4 species (*M. mycophagus, A. belli*, *O. obesus* and *E. neoparadoxalis*) were represented by 32%, 32%, 26% and 10% (Figure 6).

DISCUSSION

Termites' diversity was calculated according to their feeding habit and habitat preference.[19,28-30] Termites were classified into 4 (Group I, Group II, Group III and Group IV).[31] All four feeding groups were recorded as Type I (lower termites- mainly wood and grass feeders), Type II (higher termites-fungus growing wood feeders/

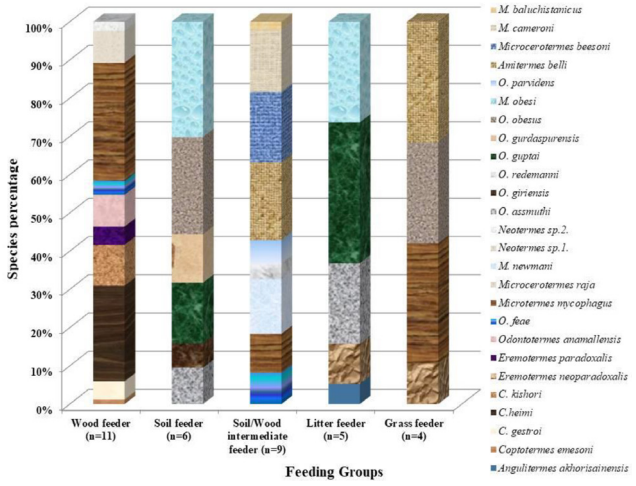

Figure 1: Relation between termite species (%) and its feeding groups.

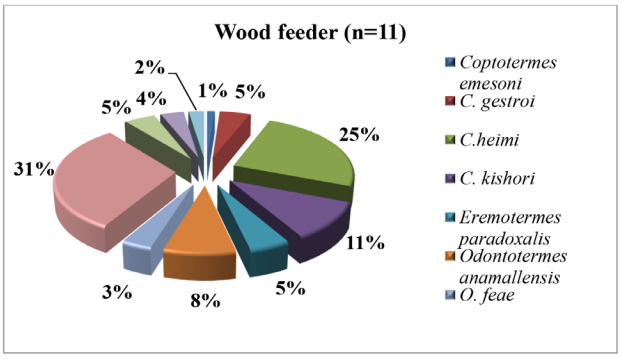

Figure 2: Percentage feeding of wood feeder termite species.

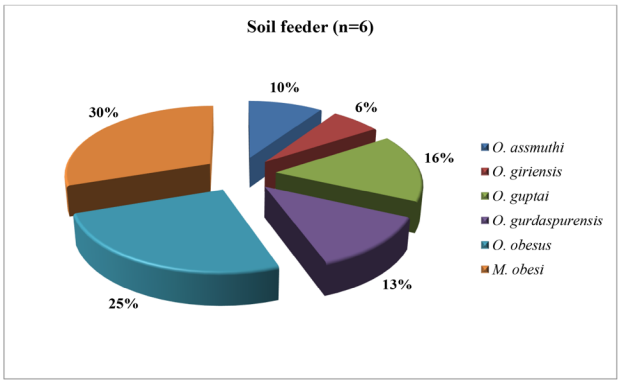

Figure 3: Percentage feeding of soil feeder termite species.

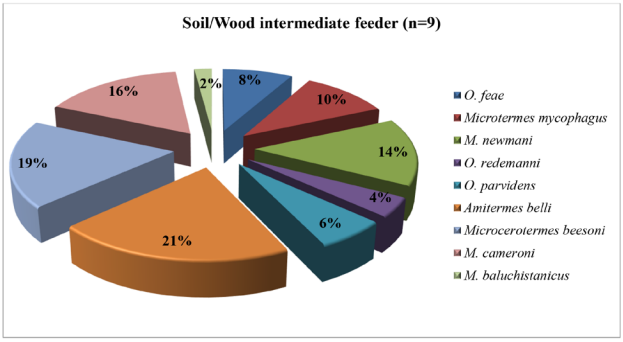

Figure 4: Percentage feeding of soil-wood intermediate feeder termite species.

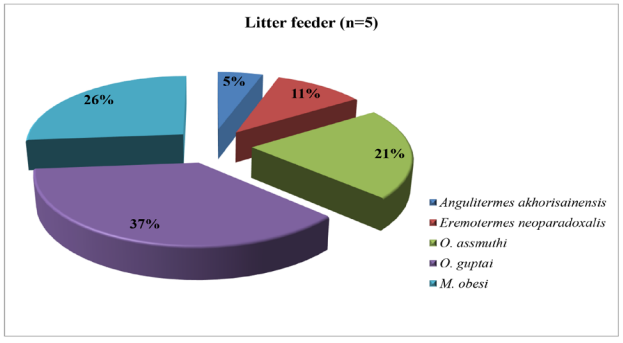

Figure 5: Percentage feeding of litter feeder termite species.

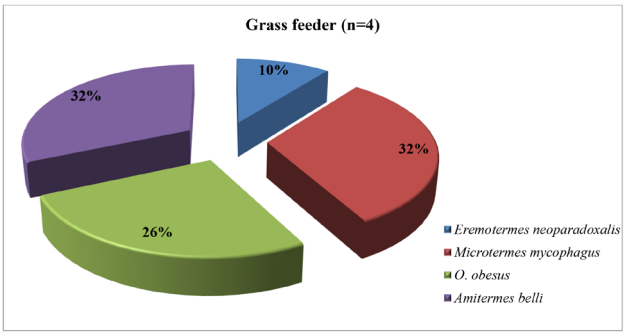

Figure 6: Percentage feeding of grass feeder termite species.

litter feeders, micro epiphytes), Type III (organic-rich soil feeders/ humus feeders) and Type IV (true soil feeders).[32] Type II feeding group was the most dominant group, followed by Type III, Type I and finally Type IV.[20,22] However,[17,18] reported 5 feeding groups (litter-foragers, soil-feeders, wood-feeders, grass-feeders and soil-wood intermediate feeders).

During the present study, 5 types of feeding groups of termites were recorded from Southern Haryana (wood feeder, soil feeder, soil-wood intermediate feeder, litter feeder and grass feeder). The highest species diversity came under wood feeders as they can feed on a variety of woody items however few were having specific feeding preferences.

Out of 26 identified species, 11 are dominated as wood feeders, 6 as soil feeders, 9 are soil-wood intermediate feeders, 5 as litter feeders and 4 as grass feeders.[22] *Amitermes, Coptotermes, Microtermes, Odototermes*, have been encountered at a wider level in the environment among all species. The overall termite richness and their feeding diversity did not provide significant differences among various habitat types (Figure 1).

In this study, grass feeders showed the lowest diversity in comparison to other feeders probably due to human activities. Similarly, the variety of food quality from various trees was also related to different feeding habits.[33] Kalotermitidae and Rhinotermitidae termites were fed on dry wood but Kalotermitidae termites do not form foraging pathways where termites of Rhinotermitidae formed.[34] In our findings, the genus *Coptotermes*, *Odontotermes Microcerotermes*, *Microtermes* and *Amitermes* fall under the wood feeder, soil and soil-wood intermediate feeding groups similar to findings of Donovan SE *et al* and Amina P,[20,22] except the genus *Coptotermes* that fell under Group I (wood and grass feeders).

Our findings broadly validate the results of,[13,35,36] who reported family Termitidae and subfamilies Macrotermitinae, and Termitinae comprised both leaf litter and wood-feeding termites. According to Donovan SE *et al* and Amina P,[20,22] *Angulitermes* fall under soil feeders, whereas in the present study *Angulitermes* were identified as litter feeders. Same with *Microcerotermes sp.* that was found to feed on mangoes, dead coconuts leaves, citrus, and cashews dead parts.[36] But in this study, *Microcerotermes* species were mostly found to be nourished on roots of common rush (*Juncus effusus*).

CONCLUSION

Our studies specify that termites are a highly diversified group of insects that can be further classified into 5 feeding groups (wood feeder, soil feeder, soil-wood intermediate feeder, litter feeder and grass feeder). In the present study also, 5 types of feeders have been reported from Southern Haryana, India. Out of 5 feeding groups, the highest diversity of termites belongs to the wood feeder. Termite's feeding diversity noticeably changed along with the habitat preferences *Angulitermes* can forage on the soil as well as litter. Similarly, with *E. neoparadoxalis*, *A. belli*, *M. obesi*, *M. mycophagus, O. feae*, *O. assmuthi*, *O. guptai* and *O. obesus* displayed the maximum diversity and distribution with feeding preference.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

WF: Wood Feeders; **SF:** Soil Feeders; **S/WF:** Soil-Wood intermediate Feeders; **LF:** Litter Feeder; **GF:** Grass Feeder.

SUMMARY

Termites are vital insects from an ecological point of view, as they help in nutrient fluxes in the ecosystem and can also improve soil quality. Being pests, their central role is to decompose necessary and unnecessary items.[1,2] They are also known as voracious feeders of woody things, timber plants, crops, and electrical things. It's being the most diverse insect found in every locality of the earth except Antarctica.[6,7]

Termites have a different diet to forage mainly woody twigs, leaves and dead branches, minerals-rich soil, living roots and shoots.[15,16] Hence, with a variety of food, termites were commonly categorized into five feeding groups: soil-feeders, litter-foragers, wood-feeders, soil-wood intermediate feeders and grass-feeders.[18,19] However,[20] classified termites into 4 feeding groups (Type I, Type II, Type III and Type IV) based on worker caste gut morphology. The wood feeder is also classified into damp wood, sub-terranean and dry wood termites that cause damage to woody logs.

During the present study, a total of 233 samples of termite were collected from the various feeding sites of Southern Haryana, India. Collections were made possible by using the random sampling method.[4,21,22] Termite samples were identified into 26 species belonging to 3 families (Termitidae, Rhinotermitidae and Kalotermitidae) and further classified into five feeding groups (SF, WF, S/WF, LF and GF). Wood feeder covered the maximum 31% diversity, followed by soil-wood intermediate feeder (26%), soil feeder (17%), litter feeder (14%) and grass feeder (12%).

Out of 26 species, 8 species (*E. neoparadoxalis*, *A. belli*, *M. mycophagus*, *M. obesi*, *O. assmuthi*, *O. guptai*, *O. feae* and *O. obesus*) can feed a variety of things. Hence, based on their feeding preference, they show the highest diversity and fall under more than 2 feeding groups (Figure 1). For example, *Angulitermes* can forage on the soil as well as litter.[20,22]

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