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SURVEY AND IDENTIFICATION OF TERMITE IN SOME SELECTED PARTS OF INDIA

Talat Parween, Pinki Bhandari*, S K Raza

Department of Bioscience, Institute of Pesticide Formulation Technology,

Sector-20 Udyog Vihar, NH-8**,** Gurgaon -122016

ABSTRACT

A systematic survey of termite species has been carried out in some selected parts of India. Three states with two districts each has been taking into consideration. In order to make the survey as representative as possible, quadrat based methods were employed. Eight species belonging to five genera and two families viz., Termitidae and Rhinotermitidae were identified. They are *Microtermes mycophagus* (Desneux), *Microtermes obesi* (Holm.), *Odontotermes feae* (Wasmann), *Odontotermes obesus* (Ramb), *Odontotermes redemanni*, *Trinervitermes biformis*, *Corpotermes hemi* (Wasmann) and *Heterotermes indicola* (Wasmann).

KEYWORDS: Identification, Survey, Termitidae, Rhinotermitidae

***Corresponding Author: Dr. Pinki Bhandari** Ph.D

Department of Biosciences,

Institute of Pesticide Formulation Technology,

Sector-20 Udyog Vihar, NH-8**,** Gurgaon -122016

*Corresponding Author Email Address: drpbhandari.ipft@gmail.com

1.INTRODUCTION

Termites are the most important and most efficient lignocellulose (e.g., dead wood) decomposers (Sugimoto et al. 2000). 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

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composition of soils, their hydrology, drainage and infiltration rates. 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 Tracy and Gromadzki (2003). The termites process a variety of plant organic matter at all stages of decomposition, ranging from leaf litter to rotten wood to soil humus. 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 (Davies et al. 2012). 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 (Ackerman et al. 2009). 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 (Hemachandra et al. 2010). On the other hand, however, because of their large colony size, nesting behavior, and feeding preferences, termites can cause considerable damage to artificial structures and commodities. Su (2002) estimated that the overall damage and cost to control termites exceeds $20 billion annually worldwide. The overall termite infestation at different stages of various crops has been shown in Table 1.

Table 1: Overall termite infestation (%) at different stages of some selected crops

Family	Genus	Species	Crop stages				
				Sugarcane	Wheat	Castor	Cotton
Termitidae	Microtermes	*M. mycophagus* (Desneux)	Seedling	100.00	0.00	80.2	61.8
			maturity	0.00	0.00	19.8	38.2
		M. obesi (Holm.)	Seedling	75.5	26.2	0.00	0.00
			maturity	24.5	74.8	0.00	100.00
	Odontotermes	*O. feae* (Wasmann)	Seedling	50.2	45.6	0.00	0.00
			maturity	49.8	55.4	0.00	0.00
		O.obesus (Ramb)	Seedling	81.5	35.5	55.2	40.0
			maturity	18.5	65.5	45.8	60.0
		O. redemanni	Seedling	0.00	35.5	0.00	0.00
			maturity	100.0	65.5	0.00	0.00
	Trinervitermes	*T.biformis*	Seedling	0.00	87.00	0.00	27.00
			maturity	0.00	13.00	0.00	73.00
Rhinotermitidae	Corpotermes	*C. hemi* (Wasmann)	Seedling	100.00	0.00	28.00	0.00
			maturity	0.00	100.00	72.00	0.00
	Heterotermes	*H. indicola* (Wasmann)	Seedling	0.00	0.00	0.00	0.00
			maturity	0.00	0.00	0.00	0.00.

Termite species vary in their basic biology and ecology, including colony size, nesting and feeding, swarming and reproductive behavior. Proper identification of termite species and knowledge of their distribution are the first steps in developing environmentally compatible/sustainable integrated pest management (IPM) strategies. Table 2 depicts the occurrence of termite spp. in different microhabitats. Identification of termite species is a challenging task due to the ambiguity in their morphological characters, the difficulty of collecting morphologically distinct castes (e.g., soldiers and alates), geographical variations, and the overall lack of termite systematic studies. There is no termite survey data available in some districts of India. To fill this gap we have surveyed and identified the diversity, distribution, and abundance of the termite

species in two districts of three states of India viz. Uttar Pradesh, Haryana and Rajasthan.

Table 2: Occurrence of termite species in different microhabitats.

Genus	Species	Microhabitats
Microtermes	*M.mycophagus* (Desneux)	Stone, heaps of dung, weed and crop residue, tree log, tree stump, leaf litter.
	M. obesi (Holm.)	Ground nest, dead tree stump, tree log, bamboo fencing, tree bark, leaf litter, dung, heaps of weed and crop residue
Odontotermes	*O. feae* (Wasmann)	Tree log, boulder
	O.obesus (Ramb)	Mound, bamboo fencing, stone, leaf litter, tree bark, tree log and stump, fallen tree twigs, heaps of dung, crop residue and fuel wood
	O. redemanni	Mound, tree log, tree stump, tree bark, stone
Trinervitermes	*T.biformis*	Rock crevices, boulder
Corpotermes	*C. hemi* (Wasmann)	Soil, bark, tree log, wooden house
Heterotermes	*H. indicola* (Wasmann)	Dead tree stump

2.MATERIALS AND METHODS

The survey was conducted in various farmer's field in all the locations. Major crops include sugarcane, wheat, castor and cotton were selected for study because of their importance to the farmers as well as their susceptibility to termite attack. Surveys were carried out to assess the damage at all stages, especially during seedling and maturing stages. Collections during morning and late evening were preferred as termites were found to be mostly active during that time. The survey of termites in the area was carried out using quadrat methods as elaborated by Jones et al (2005). 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. 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 were separated and preserved in 80% ethanol in 20 ml glass bottles. The preserved sample was labeled carefully with all required information. Identification of termite is mainly based on soldier caste and efforts were made for collection of the same along with other castes.

Identification of termites was done following the schemes proposed by Roonwal and Chhotani (1989) and Chhotani (1997).Percent presence was calculated using the formula (Southwood and Henderson, 2000), di = (ni X 100) lN, where, di = Percent presence, ni = No. of individuals of taxa, and, N = Total individuals.

3.RESULTS AND DISCUSSION

Eight species belonging to five genera and two families viz., Termitidae and Rhinotermitidae (Table 3) were identified. They are *Microtermes mycophagus* (Desneux), *Microtermes obesi* (Holm.), *Odontotermes feae* (Wasmann), *Odontotermes obesus* (Ramb), *Odontotermes redemanni*, *Trinervitermes biformis, Corpotermes hemi* (Wasmann) and *Heterotermes indicola* (Wasmann).

TERMITE SPECIES RECORDED

Family I: TERMITIDAE WESTWOOD, 1934

Genus 1. *Microtermes* Wasmann, 1902

1. Microtermes mycophagus Desneux, 1905

Distribution: Uttar Pradesh: Bijnor

Rajasthan: Dausa

Haryana: Palwal, Gurgaon

Economic importance: During present study the species was found to cause damage in cotton, sugarcane and castor.

Nature of damage: In case of sugarcane, the species tunneled through the eye bud and cut ends of sowed *'setts'* due to which the *'setts'* failed to propagate. *M. mycophagus* also damaged the root system of the newly emerged shoots. Cottons are damaged by this species both at seedling and fully grown stage. This species was found to be one of the important pests of castor. It attacked the root region, nibbled the tap root in the grown up plants. Although the species preferred to feed on roots but in certain cases it was seen to devour the stem at a height of two feet above the ground level. It also survived on the fallen castor fruits.

Remarks: M. mycophagus, a subterranean species inhabited logs, cow dung, heaps of weed and crop residues, dead tree stumps, leaf litter, etc., and makes small interconnected chambers lined with fungus combs.

2. Microtermes obesi Holmgren, 1913

Distribution: Uttar Pradesh: Gonda

Rajasthan: Sawai Madhopur

Haryana: Palwal, Gurgaon

Economic importance: Recorded as pest of cotton, sugarcane and wheat.

TABLE 3. TERMITE SPECIES AND SPATIAL DISTRIBUTION IN THE STUDY AREA

Genus	**Species**	**Species distribution in the community**					
		Uttar Pradesh		**Rajasthan**		**Haryana**	
		Bijnor	**Gonda**	**Dausa**	**Sawai Madhopur**	**Palwal**	**Gurgaon**
Family-Termitidae							
Microtermes	*M. mycophagus* (Desneux)	+	-	+	-	+	+
	M. obesi (Holm.)	-	+	-	+	+	+
Odontotermes	*O. feae* (Wasmann)	+	+	-	+	-	+
	O.obesus (Ramb)	+	+	+	+	+	+
	O. redemanni	-	+	-	+	-	+
Trinervitermes	*T.biformis*	+	+	+	-	+	+
Family-Rhinotermitidae							
Corpotermes	*C. hemi* (Wasmann)	+	+	+	+	+	-
Heterotermes	*H. indicola* (Wasmann)	+	+	-	+	+	-
Total	**8**	**6**	**7**	**4**	**6**	**6**	**5**

Nature of damage: Severity of damage due to *M. obesi* in sugarcane was much more as compared to that of wheat and cotton. *Microtermes obesi* tunneled through internodes of sugarcane stems at maturing stage but caused damage to the roots at seedling stage. It damaged the root system of wheat at seedling and maturing stages. Occasionally during maturity the species cut the stems of wheat plant near the ground level. As a result the ear head became dry and failed to produce any grain. It damaged the roots of germinating plants, the plants withered away and ultimately the plants die. This species also tunneled through cotton stem near soil surface. Sometimes *M. obesi* destroyed the entire crops at maturing stage by making tunnel through their roots.

Remarks: M. obesi, a subterranean species, was one of the most common and widely distributed species in the study area. This species can tolerate wide range of ecological fluctuations. Nests of this species had small, round chambers, connected by means of thin, long capillaries. *M. obesi* was also collected from tree stumps, logs, bamboo fencings, barks, leaf litter, cow dung, heaps of weed and crop residues, etc.

Genus 2. *Odontotermes* Holmgren, 1912

3. Odontotermes feae (Wasmann, 1896)

Distribution : Uttar Pradesh: Bijnor, Gonda

Rajasthan: Sawai Madhopur

Haryana: Gurgaon

Economic importance: Recorded as pest in sugarcane and wheat.

Nature of damage: The damage caused by *Odontotermes feae* in wheat was much more as compared to that of sugarcane. It damaged the root system of wheat at seedling and maturing stages. Occasionally during maturity the species cut the stems of wheat plant near the ground level. As a result the ear head became dry and failed to produce any grain. It damaged the roots of germinating plants, the plants withered away and ultimately the plants die. *Odontotermes feae* damage to the roots at seedling stage and tunneled through internodes of sugarcane stems at maturing stage.

Remarks : *M. obesi*, a subterranean species, was one of the most common and widely distributed species in the study area. This species can tolerate wide range of ecological fluctuations. Nests of this species had small, round chambers, connected by means of thin, long capillaries. *M. obesi* was also collected from tree stumps, logs, bamboo fencings, barks, leaf litter, cow dung, heaps of weed and crop residues, etc.

4. Odontotermes obesus (Rambur, 1842)

Distribution: Uttar Pradesh: Bijnor, Gonda

Rajasthan: Dausa, Sawai Madhopur

Haryana: Palwal, Gurgaon

Economic importance: The species attacked the tender and matured cotton, wheat, sugarcane and castor plants.

Nature of damage: The species entered into the sugarcane *'setts'* through the cut ends and also by making tunnels through the root at seedling stage. It damaged the roots of the maturing sugarcane plants and made soil sheet on outer side of the shoot. The species damaged the tender roots of young wheat plant which resulted in dislodgement of the plant. A full-grown plant also gets infested through stem and the infestation spread up to the apical portion of the plant. Roots of cotton plants are damaged by this species at seedling stage but it destroyed the stems at matured stage and made tunnels through it near the ground level. Castor stems (up to a height of one foot above the ground level) were found to be most vulnerable to the attack by this species. O. *obesus* made a covering of soil around the fallen castor fruits of the damaged plants and started devouring it.

Remarks: O. *obesus* was the main mound-building termite species in the studied area. This species was commonly found in almost all microhabitats and caused wide range of damages. Besides its occurrence in crop field the species was also collected from a variety of habitats like wooden structures, tree bark, stones and logs, leaf litter, heaps of fuel wood and crop residues, dead tree stumps, etc. It constructed soil sheeting on fallen tree branches and twigs.

5. *Odontotermes redemanni* Wasmann,

1893 *Distribution:* Uttar Pradesh: Gonda

Rajasthan: Sawai Madhopur

Haryana: Gurgaon

Economic importance : This species was found to be a pest of sugarcane and wheat.

Nature of damage : This termite species built tunnels in sugarcane which resulted into death of the plant. Plant became weak due to poor conduction of nutrients. Sometimes the species entered into the stem through the holes made by sugarcane stem borer. In wheat, this species was found to damage the root system at both the seedling and maturing stage. However, it causes damage to the stem at mature stage only.

Remarks: Besides agricultural crops, this widely distributed species made mounds, the chambers of which are inter-connected by tunnels. The outer wall of the mound was thick and solid. O. *redemanni* was also collected from tree logs, dead tree stumps, etc. Genus 3. *Trinervitermes* Holmgren, 1912

6. Trinervitermes biformis Wasmann, 1902

Distribution : Uttar Pradesh: Bijnor, Gonda

Rajasthan: Dausa

Haryana: Palwal, Gurgaon

Economic importance: It was found to infest cotton and wheat

Remarks: It damaged the root system of wheat at seedling and maturing stages. Occasionally during maturity the species cut the stems of wheat plant near the ground level. As a result the earhead became dry and failed to produce any grain. Roots of cotton plants are damaged by this species at seedling stage but it destroyed the stems at matured stage and made tunnels through it near the ground level. The species live in the subterranean nest, rock crevices etc.

Family I: RHINOTERMITIDAE

Genus 4. *Coptotermes* Wasmann, 1896

7. Coptotermes heimi Wasmann, 1902

Distribution: Uttar Pradesh: Bijnor, Gonda

Rajasthan: Sawai Madhopur

Haryana: Palwal

Economic importance: It was a serious pest of sugarcane and wheat.

Nature of damage: C. *heimi* damaged sugarcane at *'seed cane'* stage but wheat was infested from early to full-grown stage. Workers entered through the cut ends and eye buds of the *'setts'* (planting stalk) by tunneling, thus inhibiting the plant growth. Seedlings of wheat were attacked by this species. C. *heimi* destroyed the roots of wheat plants and ultimately the injured plant became weak and withered away. Strong wind or other disturbances at this stage bend the spikelet to such an extent that the ear head fell on the ground, resulting into death even before it reaches the harvesting stage. The affected plants can be easily uprooted with a little pressure. Pest continued its infestation and started consuming the fallen ear head.

Remarks : *Coptotermes heimi* was a subterranean species and found abundantly in the adjoining areas. The workers tunneled through wood and devoured the inner wood completely, leaving the outer portion intact. The nests of C. *heimi* were found under barks, logs and wooden structures, etc.

Genus 5. *Heterotermes* Froggatt, 1896

8. Heterotermes indicola Wasmann, 1902

Distribution : Uttar Pradesh: Bijnor, Gonda

Rajasthan: Sawai Madhopur

Haryana: Palwal

Economic importance: It was not found to be a pest of any crop.

Remarks : This subterranean species inhabited the diffused nests built below soil surface. *H. indicola* was collected from tree stumps of *Acacia* sp. and *Calotropis procera* situated in the adjoining areas of crop field.

KEY TO TERMITE TAXA
(BASED ON SOLDIER CASTE)

[I] **TERMITIDAE** - Pronotum saddle-shaped

A. **Microtermes**: Mandibles fine, without any crenulations; left mandible without any tooth ***Microtermes mycophagus*:** Antennae with fifteen segments.

***Microtermes obesi*:** Head-capsule moderately hairy; second segment of antennae equal to the combined length of third and fourth segments.

B. **Odontotermes:** Left mandible with prominent tooth.

***Odontotermes feae*:** Tooth on left mandible placed near the middle; mandible tooth-index 0.50-0.54; head-capsule widest near posterior third.

***Odontotermes obesus*:** Mandible short, slender with weakly curved outer margin; mandible index length/head length 0.59- 0.68 mm; labrum short, broadly rounded interiorly.

Odontotermes redemanni: Mandible longer, outer margin shortly bent near the basal third; mandible index length/ head length 0.69-0.79 mm.

C. **Trinervitermes**: Head formed into nasute; mandibles degenerated.

***Trinervitermes biformis*:** Antennae 12-14 segmented; in fourteen segmented condition, third segment is a little longer than the second one; pronotum weakly invaginated anteriorly.

[II] **RHINOTERMITIDAE** - Pronotum flat

A. **Corpotermes:** Head-capsule oval-shaped; fontanelle large, circular and lying medially at the interior margin.

***Coptotermes heimi* :** Larger species; waist of postmentum lying in the middle of the line connecting the level of maximum width and hind margin; postmentum with a minimum width of 0.25-0.34 mm; head: length 1.2-1.4, width 1.0-1.35 mm; soldier population maximum in a colony.

B. **Heterotermes:** Head capsule sub-rectangular; fontanelle small and lying at the middle of the dorsum of head.

***Heterotermes indicola*:** Smaller species; pronotum distinctly notched at both anterior and posterior direction, antennal segments generally more than 14; head: length 1.33-1.77 mm, width 0.83-1.00 mm.

DISCUSSION

Reliable information on economic losses may not be available in India but the threats imposed by termites on the production of food and industrial crops are quite evident. In India, termites are responsible for the loss of 15–25% of maize yield and about 1478 million Rupees (Joshi et al., 2005). As many as 13 species of termite are reported to cause damage to sugarcane in India. Termite infestation caused 30-60% destruction of buds (Roonwal, 1981). Avasty (1967) reported it as 40%, which results 33% loss in yield. Subterranean termites are the major problem attacking sugarcane crop from its germination through shoot emergence and finally it affects the quality of canes. At germination stage, the losses up to 90- 100% have been recorded (Salihah *et al*., 1988). Koto *et al.* (2000) reported that termites live in the soil and damage sugarcane by excavating through the cane setts, leading to the death of buds and young shoots. Termite may attack any part of sett, but in the hard rinded varieties, they prefer to attack the ends, eye buds and root bands (Mill, 1992)

There are other studies on termite survey in which sampling was done randomly or by following other methods. Anantharaju et al. (2014) spotted ten species of termites belonging to eight genera and three families in Northeastern Puducherry. Ali et al (2013) have identified six termite species in the Islamia University of Bahawalpur, Pakistan by sampling termites. Primanda et al (2003) 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 (Prasad and Intodia, 2013). 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 (Roonwal and Bose, 1978). Twelve termite species were identified in the Western Ghats, South India to understand impact of human disturbance on pristine ecosystem (Basu et al. 1996). Kumar and Pardeshi (2011) recorded fifteen termite species in Vadodra district of Gujarat. Kumar and Thakur (2010) 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. A survey by Rao et al. (2012) to investigate diversity of termites and their damage to living trees of forest region of Bhadrachlam forest (1, 44,603 ha) in Andhra Pradesh and

they found thirteen species of termite. Six termite species was identified from different localities in Bahawalnagar, Pakistan by collecting termites from 250 soil cores (Akhtar and Rashid, 2001).

4.CONCLUSION

An effort was made to study the termite fauna of wheat, cotton, castor and sugarcane in and around the crop fields of some selected parts of India. Of the eight species belonging to two families and five genera, all were found to cause damage to agriculturally important crops. *Odontotermes obesus, Microtermes obesi* and *Corpotermes hemi* occur in maximum number. *Odontotermes obesus* was the most destructive species and destroyed seedling and maturing stages of all crops.

CONFLICT OF INTEREST

The authors declare that no competing financial interests exist.

REFERENCES

1. Ackerman IL, Constantino R, Gauch HG, Lehmann J, Riha SJ, Erick CMF (2009) Termite (Insecta: Isoptera) Species Composition in a Primary Rain Forest and Agroforests in Central Amazonia. The Association for Tropical Biology and Conservation Biotropica 41(2):226–233
2. Akhtar MS, Rashid MI (2001) Studies on Population Density and Diversity of Termites of District Bahawalnagar. Journal of Research (Science) Bahauddin Zakariya University Multan Pakistan 12(2).
3. Ali M, Sial N, Ashraf S, Hasanat A (2013) A survey of subterranean Termite (isoptera) Fauna and its population diversity in district Bahawalpur. Standard Scientific Research and Essays. 1(11):289-293
4. Anantharaju T, Gurjeet K, Gajalakshmi S, Abbasi SA (2014). Sampling and identification of termites in Northeastern Puducherry. Journal of Entomology and Zoology Studies 2014; 2 (3): 225-230
5. Avasthy PN (1967). Sugarcane pests in India. *PANS (A),* 13: 111-117
6. Basu P, Blanchart E, Lepage M (1996). Termite (Isoptera) community in the Western Ghats, South India: influence of anthropogenic disturbance of natural vegetation. Institute Francais de Pondicherry. European Journal of Soil Biology. 32(3):113-121
7. Chhotani OB (1997). Fauna of India-Isoptera (Termites). Vol. II. Zoological Survey of India Publication, Calcutta, 800 pp.
8. Davies AB, Berndt JV, Rensburg, Eggleton P, Parr CL (2012). Assessing the efficiency of termite sampling methods in southern African savannas. Journal of insect conservation University of Van Pretoria 76-77

9. Hemachandra J, Edirisinghe P, Karunaratne WAIP, Gunatilleke CVS (2010). Distinctiveness of termite assemblages in two Fragmented Forest types in Hantane hills in the Kandy district of Sri Lanka. Ceylon Journal of Science (Biological Sciences); 39(1):11-19

10. Joshi PK, Singh NP, Singh NN, Gerpacio RV, Pingali PL (2005). Maize in India: Production Systems, Constraints, and Research Priorities. D.F. CIMMYT, Mexico, p. 22
11. Jones DT, Verkerk, RHJ, Eggleton P (2005). Methods in Ecology. Insect Sampling in Forest Ecosystems (Edited by Leather SR). pp. 221–253, Blackwell Publishing, Oxford, U.K
12. Kumar D, Pardeshi M (2011). Biodiversity of termites in agro ecosystem and relation between their niche breadth and pest status Gujarat Institute of Desert Ecology Bhuj Gujarat India. Journal of Entomology; 8(3):250-258
13. Kumar S, Thakur RK (2010). A check list of Termites (Insecta: Isoptera) from Haryana Agricultural University campus, Hisar, Haryana. Journal of Experimental Zoology India; 13(2)523-526
14. Prasad A, Intodia A (2013). Biodiversity of Termites (Insecta: Isoptera) in South Rajasthan (Zone IV-A) Agroclimatic region with special emphasis on their mound dimensions and structure. Electronic Journal of Environmental Sciences; 6:5-12.
15. Primanda A, Ischak TM, Basukriadi A (2003). Termite Species Richness on the Campus of Universities Indonesia, Depok. Department of Biology, Faculty of Mathematics and Natural Sciences, University of Indonesia, Depok 16424, Indonesia. MAKARA SAINS; 7:9-14
16. Rao N, Sravanthy AC, Chinta S (2012). Ecology and Diversity of Subterranean Termites in Bhadrachalam Forest Region, Andhra Pradesh, India. AGRES–An International e-Journal; 1(3):244-250
17. Roonwal ML (1981). Termites of agricultural importance in India and their control. In "Progress in soil biology and Ecology in India".(Vereesh, G.K.ed.). Tech. Ser. 37. Univ. Agric, Sci., Bangalore. P 253-256
18. Roonwal ML, Chhotani OB (1989). Fauna of India-Isoptera (Termites). Vol. I. Zoological Survey of India Publication, Calcutta, 672 pp
19. Roonwal ML, Bose G (1978). Vegetational distribution of termites of Rajasthan (India) and their importance. Practical Indian Natural Science; 44(5):320-329
20. Salihah Z, M Shah, Sattar A (1988). Survey of sugarcane termites of Nowshehra and Charsadda Tehsils. *In: Proceedings of 8th Pakistan Congr. Zool.*, 8: 289-97

21. Sugimoto A, Bignell DE, Macdonald JA (2000). Global impact of termites on the carbon cycle and atmospheric trace gasses, pp. 409Ð435. *In* T. Abe, D. E. Bignell, and M. Higashi [eds.], Termites: evolution, sociality, symbioses, ecology, Kluwer Academic Publishers, Dordrecht, Boston, London

22. Su NY (2002). Novel technologies for subterranean termite control. Sociobiology 40: 95-101.

23. Tracy Z, Gromadzki D (2003). Sampling subterranean termite species diversity and activity in tropical savannas: an assessment of different bait choices. CSIRO Sustainable Ecosystems, Tropical Ecosystems, Research Centre, Winnellie, Australia. Ecological Entomology; 28:397–404