Journal of Entomology

ISSN 1812-5670

Academic Journals Inc.

www.academicjournals.com

Journal of Entomology 8 (3): 250-258, 2011
ISSN 1812-5670 / DOI: 10.3923/je.2011.250.258

Biodiversity of Termites in Agro-ecosystem and Relation between their Niche Breadth and Pest Status

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ABSTRACT

Termite sampling was carried out in four selected crops (i.e. sugarcane, wheat, cotton and castor) and unhealthy plants were sampled/checked to find out presence of termites. Furthermore, all possible habitats on hedges of agriculture field were also checked and termites were collected if present. Overall, 15 termite species were recorded from the study area, out of which only five species were found as a pest of selected crops. A species, *O. obesus* was dominant and recorded as a pest of all four crops. All pest species were common and dominant (highest percent presence) in the study area. Furthermore, all pest species had wider niche breadth as compare to other species. Relation between pest species and their niche breadth is discussed.

Key words: Termite, Niche breadth, pest, agro ecosystem

INTRODUCTION

Social insects are among the world's most successful species at invading of new habitats (Moller, 1996; Pardeshi and Prusty, 2010). Among these, Termites form a significant proportion of the soil macro fauna and highly successful group of insects coevolving for over 300 million years and constituting an integral component of the ecosystem (Dobzhansky, 1941; Emerson, 1943; French, 1988). They are the most important soil fauna in the semi-arid tropics (Lobry de Bruyns and Conacher, 1990). They are found in wide range of terrestrial environments and are distributed throughout the tropical, subtropical and temperate regions of the world (Smeathman, 1781; Freise, 1949; Krishna and Weesner, 1970; Pearce, 1997). Some termite species extend their range of occurrence to the relatively cool zones of temperate regions (Emerson, 1955; Araujo, 1970; Wood and Johnson, 1986; Eggleton, 1999).

Termites are useful recyclers of organic compounds (i.e., cellulose) because their bioturbating activities accelerate the soil rehabilitation process by (1) breaking up of surface crusts, (2) reducing soil compaction, (3) increasing soil porosity, (4) improving water infiltration into the soil and (5) enhancing water holding capacity of the soil, thereby reducing surface runoff (Pardeshi and Prusty, 2010). However in their natural habitat, in many settings, they have severely disrupted the ecological system and/or caused significant economic damage (Williams, 1994). They are highly destructive pests that feed on wooden components of buildings in urban areas. Further termites are mostly associated with negative values as cause damage to living trees, many crop plants, power poles, railway sleepers, timber-in-service, both inside and outside of the buildings. Even materials

that do not contain cellulose are also sometimes destroyed for reasons not yet fully understood (Thakur, 2000). Despite the absence of literature on the economic damage they inflict on crops which is considered moderate compared to other pests (Iroko, 1996), they are, however, often regarded as pest because they attack roots and above ground plants and stored food supplies (Iroko, 1996; Wood, 1996).

The feeding habits of termites are very complex. They live in communities and the workers forage for food for which they travel long distances. Termites make use of available food material in the soil (Agarwal, 1972). Since, the principal food of most of the termites is cellulose, they can cause damage directly in many ways to the host. Termites feed on a wide variety of food items including fresh, dead or decaying woody materials as well as dung and soil rich in organic matter (Waller and La Fage, 1987). Termites are lucky that they have an abundant supply of food in the form of cellulose and very few competitors to compete with.

Diet plays a major role in the ecological niche of these insects. Therefore, understanding ecological characters associated pests is crucial not only for pest control but also for prediction of insects that have potential to become pests (Tuda *et al.,* 2005). Basic knowledge of pest biology and ecology is a prerequisite for adequate pest management. Furthermore, such information is crucial for designing successful control measures of the pest. Understanding about their niche breadth is an important step towards developing control measures against these destructive insects.

Studies from Gujarat: The first published record of termites from Gujarat State was back in the year 1913 when Holmgren studied Assmuth's collection and recorded five species. After that in the same year, Assmuth (1913) reported four new species from Gujarat. Chatterjee and Thakur (1968) and Roonwal (1973) dealt with taxonomy and biology of many termite species from Gujarat. Chatterjee and Thakur (1968) recorded three species i.e., *Neotermes fletcheri, Heterotermes malabaricus* and *Microcerotermes cameroni* from Valsad. Roonwal (1973) described the mound structure, fungus comb and primary reproductives of *Odontotermes brenneus* from Rajkot. Thakur (1976, 1981), recorded the occurrence of *Odontotermes assmuthi, Odontotermes distans, Odontotermes indicus, Odontotermes obesus* and *Odontotermes wallonensis* from various other areas of Gujarat. Thakur (1989) (sandal research centre, Bangalore) did most extensive work in Gujarat on termite fauna and recorded 46 species, 14 genera and 4 families with discussion on sound taxonomic base, field ecology and distribution in Gujarat and other states. Further more, in addition to the already known taxa of three families, six genera and thirteen species; Thakur added one more family, eight genera and thirty-three species, which included six species new to science. Thakur (1991) published a series on the field ecology, eco-biogeography and economic importance of termites. During this survey he recorded occurrence, abundance, distribution and economic significance of termites of Gujarat. Recently, Rathore and Bhattacharya (2004) added to the taxonomic strength of termite fauna of Gujarat (one more genus and fourteen species). Presently, 60 species of 16 genera, four families and eight sub-families are reported from Gujarat. Out of which, 18 species, belonging to 7 genera and 2 families were from Vadodara district (study area). Pardeshi *et al.* (2010) reported five species of termites infesting various crops, i.e., sugarcane, wheat, castor and cotton. Though the termite taxa is well identified, no detail studies exists particularly on niche breadth of termites in agro ecosystem. It is anticipated that this piece of research will partially fill that void. The aim of this study is to investigate the relation between termite pests and their niche breadth in agro ecosystem.

MATERIALS AND METHODS

Location, climate and soils: Gujarat state lies at the western most end of India, the West coast. The State spreads over 1, 95, 984 km^2 area and is situated on the west coast of India between 20° 1' N to 24° 7' N latitude and 68° 4' E and 74° 4' E longitude. It is bounded by the Arabian Sea on the West, the state of Maharashtra on the South, Madhya Pradesh on the East, Rajasthan on the North and Pakistan on the North West. Administratively, Gujarat state has been delineated into a total of 25 districts. Indian Meteorological Department conveniently divided the year into four principal seasons i.e.,

- Cold weather or winter season : Mid-December-February
- Hot weather or summer season : March-May
- South-West monsoon season : June-September and
- Retreating South-West monsoon : October-Mid December

Gujarat is endowed with a wide range of soil type. The soils of Gujarat can be broadly classified into nine groups namely, black soils, mixed red and black soils, residual sandy soils, alluvial soils, saline/alkali soils, lateritic soils, hilly soils, desert soils and forest soils. In the study area (Vadodara district) there are mainly two types of soils, sandy loam soil (locally called as Goradu) and deep black soil.

Crop selection: Sugarcane, wheat, cotton and castor are the main cash crops grown in these areas. These crops were selected for study because of the following reasons:

- Economic importance to the farmers and
- Farmers rated crops of Sugarcane, Wheat, Cotton and Castor are more susceptible to termite attack

Field survey method and damage assessment: Four selected crops were surveyed at seedling stage and the stage just before maturing. Plants near the ripening stage are more vulnerable to termite attack (Pearce, 1997). From the general survey it was clear that the general activity of termites was more during mornings and late evenings. Hence, the studies were mainly carried out during that time. Crop susceptibility to termite damage was checked. Samples of unhealthy looking plants from the crop field were located and sampled. Termites were collected from different parts of the unhealthy plants. Furthermore, efforts were also made to sample all possible habitats (i.e., mounds, dead tree stumps, under dung pads, heap of crop and weed residue, under leaf litter, under opaque bark of tree, logs, under big boulders etc.) on hedges of agricultural field for termites. Vials of collected termites were labeled. All possible observations on their habitats were noted.

Collection, preservation and identification: Soldiers play an important part in the termite classification and identification of species. More efforts were made to collect soldier caste. All individuals of worker caste were also collected by keeping infested object on big white hard paper sheet. Termites were collected with the help of brush and preserved in 70% alcohol. For Identification of termites the scheme of Roonwal and Chhotani (1989) and Chhotani (1997) was used, which is more acceptable and seems to be more practical and satisfactory in Indian context (Rathore and Bhattacharya, 2004).

Statistical analysis: Percent presence of each species was calculated by using the formula (Southwood and Henderson, 2000),

$$d_i = (n_i \times 100)/N$$

where, d_i is Percent presence, n_i is No. of individuals of taxa, N is total no of individuals of taxa. Niche breadth was estimated by measuring the standardized Levin's index (*B*) and Levin's standardized niche breadth (B_A) (Krebs, 1989).

$$B = 1/\Sigma (P_j^2)$$

where, P_j is the proportion of records in each food category j.

$$B_A = B - 1/n - 1$$

where, n is the number of possible food categories.

RESULTS

Pest status: Overall 15 termite species belonging to 7 genera and 2 families were recorded from different habitats of the study area (Table 1). Out of 15 species, five species belonging to 3 genera 2 sub families and 2 families were identified as pests of the selected crops viz., Sugarcane, cotton, wheat and castor. All these five species were recorded from hedges of every crop fields. Furthermore, all pest species occurred in more number of habitats as compare to other species (non pest). Among all species, *O. obesus* occurred in maximum number of habitats and found infesting all four crops. Percent presence calculation also showed the dominancy of the pest species over non pest species in the study area (Fig. 1). Among pest species, *O. obesus* ranks top and had percent presence of 28.16 followed by *M. obesi* (25.26), *M. mycophagus* (16.69), *O. redemanni* (9.03) while *C. heimi* had least percent presence of 5.38.

Table 1: Termite species recorded from the study area (pest and non pest species)

No.	Family	No.	Subfamily	No.	Genus	No.	Species
1	Rhinotermitidae	1	Coptotermitinae	1	Coptotermes	1	**Coptotermes heimi*
		2	Heterotermitinae	2	Heterotermes	2	*Heterotermes indicola*
2	Termitidae						
		3	Amitermitinae	3	Amitermes	3	*Amitermes belli*
				4	Microcerotermes	4	*Microcerotermes beesoni*
						5	*Microcerotermes tenuignathus*
		4	Macrotermitinae	5	Odontotermes	6	*Odontotermes assmuthi*
						7	*Odontotermes bhagwathi*
						8	*Odontotermes feae*
						9	*Odontotermes guptai*
						10	**Odontotermes obesus*
						11	**Odontotermes redemanni*
				6	Microtermes	12	**Microtermes mycophagus*
						13	**Microtermes obesi*
						14	*Microtermes unicolor*
		5	Nasutitermitinae	7	Trinervitermes	15	*Trinervitermes biformis*

*Termite species recorded as a pest of selected crops

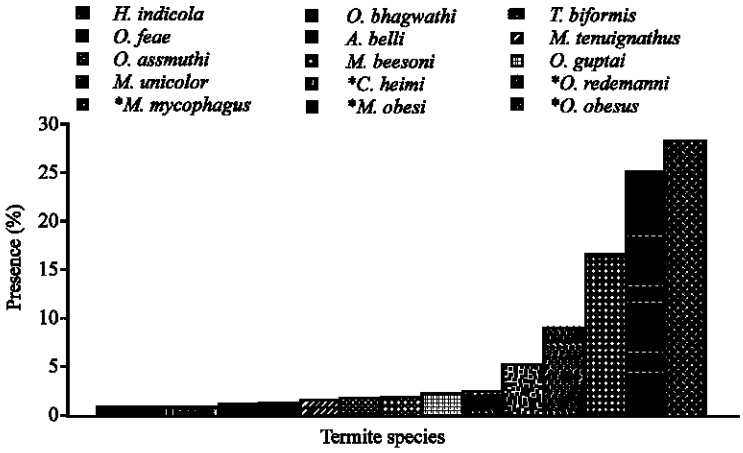

Fig. 1: Percent presence of all termite species recorded from study area. (*Termite species recorded as a pest of selected crops)

Table 2: Occurrence of termite species in various habitats in the study area

No.	Termite species	*B*	B_A	No. of habitats occupied
1	**C. heimi*	3.80	0.31	4
2	*H. indicola*	1.00	0.00	1
3	*A. belli*	1.00	0.00	1
4	*M. beesoni*	2.50	0.17	3
5	*M. tenuignathus*	1.97	0.11	2
6	*O. assmuthi*	1.00	0.00	1
7	*O. bhagwathi*	2.85	0.21	3
8	*O. feae*	1.91	0.10	2
9	*O. guptai*	2.85	0.21	3
10	**O. obesus*	8.42	0.80	10
11	**O. redemanni*	3.90	0.32	5
12	**M. mycophagus*	6.13	0.57	7
13	**M. obesi*	7.92	0.77	9
14	*M. unicolor*	1.94	0.10	2
15	*T. biformis*	1.99	0.11	2

B: Levin's index, B_A: Levin's standardized niche breadth, *Termite species recorded as a pest of selected crops

Niche breadth: Based on habitat occupancy, niche breadth of each species was analyzed. Analysis illustrated that the all pest species had wider niche breadth (generalists) compare to other termite species while three species were found highly specialist (Table 2). Among all species, *O. obesus* had widest niche breadth (0.80) followed by *M. obesi* (0.77), *M. mycophagus* (0.57), *O. redemanni* (0.32) and *C. heimi* (0.31). The niche breadth of non pest species was relatively low; it reached at maximum value of 0.21 and for pest species, maximum value of 0.80.

DISCUSSION

Termite fauna of the world is estimated to be around 2,761 species, distributed over 11 families and 283 genera (Miles, 1998). Indian termite fauna shares a very small portion of the global fauna, i.e., 240 species/9% species, 37 genera/13% of generic strength and 07 families/64% of the total families out of which 60 species from 04 families were recorded from Gujarat (Rathore and

Bhattacharya, 2004). During present study, 15 species of 07 genera and 02 families were recorded of which only five species were found as pests of selected crops.

In India, loss to agricultural crops due to termites ruins hundreds of crores of rupees (Chhotani, 1980). The most economically important termite subfamily that attacks crops in India is Macrotermitinae (Pearce, 1997) from which four species were recorded from study area during present study. Remaining one species i.e., *C. heimi* from subfamily Coptotermitinae has been reported from study area which is widely distributed and occurs throughout India and Pakistan (Thakur, 1991).

All these five species have been recorded as a pest by many researchers. In India and Pakistan, *O. obesus* and *M. obesi* species are recorded as the principal pest of Sugarcane (Thakur, 1996). Agarwala (1955) estimated a loss of 2.5 percent in sugarcane tonnage and 4.47 per cent in sugar output in Bihar (India). Narayanan and Rattanlal (1952) reported loss up to 3.75 (average 1.66) per cent of setts in the year 1946 and up to 1.54 (average 1.078) per cent in 1947, due to *O. obesus* and also to some extent due to *Eremotermes paradoxalis* and *M. obesi*.

According to Roonwal (1981) the most important species attacking wheat and cotton were *M. obesi* and *O. obesus,* further in Gujarat *T. biformes* has also been recorded to attack Wheat. *O. obesus and M. obesi* are known to infest Chilli in arid areas of Rajasthan and *O. obesus and T. biformes* (Nasutitermitinae) in Gujarat (Thakur, 1996). Damage to Wheat by *M. obesi* has been reported from Punjab, Rajasthan, U.P, Madhya Pradesh and Gujarat state (Chotani, 1980). Till now in Gujarat, while working on control of termites on wheat and cotton, Patel (1962) recorded two species viz., *O. obesus* and *T. biformis*. *M. mycophagus* damages the castor crop at seedling and maturing stages (Parihar 1978). *C. heimi* was reported by Thakur (2000) as the most common wood destroying termite in India. According to Chhotani (1980), this is the common species found in the subcontinent. In Gujarat it is recorded from I and III ecological zones (Thakur, 1991). *C. heimi* is one of the wood destroying subterranean termite species and feed the inner portion of the attacked material leaving the outer sheath intact (Sen-Sarma, 1989).

Results of the present study clearly indicate that, the species possess wider niche breadth (generalist) having more chances to become a pest when encounter to the crop during foraging activity. The species which were recorded as pests were recorded from agriculture hedges of all agriculture fields (means very common in the study area) and also from maximum habitat types compare to other species (means wide niche breadth) (Table 2). Being a common and having a wide niche breadth they (pest species) can be referred as generalists. Based on the ecological specialization hypothesis, species with the widest niche breadth should be more widespread and locally abundant than specialized species (Gaston and Lawton, 1990; Pomeroy and Ssekabiira, 1990). A subterranean termite species, *O. obesus* is distributed throughout India (Sen-Sarma, 1989) furthermore this species has been recorded from many localities in all three ecological zones of Gujarat sate (Thakur, 1991). During present study *O. obesus* species had widest niche breadth among all species. Probably this reason increases the possibility of access or attack to the crops at the time of foraging. However, Termites remain active throughout the year (Imms, 1919) and cause extensive damage to agricultural crops at any time in suitable environmental conditions.

It was observed that the food availability promotes the activity of termites since wooden structures, tree bark, leaf litter, crop residue and weed heaps are good food and habitat for termites. It was also noted that, big objects lying on hedges of the agriculture field i.e., big boulders, manure heaps, huge wooden logs, opaque tree bark and tree stumps provide habitat for termites. Where

they construct galleries and number of tubes in ground which sometimes extend towards the agriculture fields to accessing the food sources where they encounter with roots of crops, which they start infesting. More plant cover of the crop increases the ground shade and reduces the water evaporation rate thus increasing the humidity and moisture of the soil which is the main factor that provide the appropriate habitat to promote termite activity (Pearce, 1997). The major and common problem in India was due to many species of termites being subterranean necessitating ground connection for moisture requirement (Thakur, 2000).

It is expected that, out come of the present study regarding niche breadth of termite pest species will be useful to entomologists carrying research work on further ecological aspects and also in control and management practices in various agro ecosystems.

ACKNOWLEDGMENTS

Authors are thankful to the Head of Zoology Department of M. S. University of Baroda and Director of Gujarat Institute of Desert Ecology (GUIDE), Bhuj for providing facilities for this research work.

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