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TERMITE (INSECTA : ISOPTERA) FAUNA OF SOME AGRICULTURAL CROPS OF VADODARA, GUJARAT (INDIA)

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INTRODUCTION

Termite or white ant, locally called 'Udai' or 'Deemak', is associated with human civilization from time immemorial. Termites are represented by three castes, viz., workers, soldiers and reproductives, and live in small to large colonies, sometimes a single colony containing a million or more individuals. In the ancient Sanskrit literature termites were known as 'Kashtaharika' or wood-feeders. Termites cause damage to both cellulose- and non-cellulose containing substances like living trees, crop plants, wooden electric poles, railway sleepers, telephone and electrical cables, etc. Termites inhabit the tropical, subtropical and temperate regions of the world (Smeathman, 1781; Freise, 1949; Krishna and Weesner 1970; Pearce, 1997).

Few works have been carried out on termites of agricultural importance. Hussain (1935) estimated 6-25% yield loss in wheat due to termite attack. Patel and Patel (1954) observed serious damages in cotton, wheat, groundnut, etc. caused by *Trinervitermes biformis*. Damages in wheat by *Microtermes obesi*, *Odontotermes obesus* and *O. gurdaspurensis* was earlier reported from Punjab, Rajasthan, Delhi, Uttar Pradesh, Andhra Pradesh, Bihar and Gujarat. Wheat-growers of Madhya Pradesh, Gujarat and Maharashtra also faced major loss in production due to the attack of *Trinervitermis biformis* and *Nasutitermes* sp. (Chhotani, 1980). Chhotani (1980) published a technical monograph on

termite pests and dealt with distribution, ecology, biology and control measure of some termite species. Sen-Sarma (2000) studied the ecological factors that influenced the distributional pattern of termites.

Rathore and Bhattacharyya (2004) carried out a taxonomic investigation on the termite fauna of Gujarat and reported four families which included sixteen genera and sixty species.

Key words : Termite, pest, sugarcane, wheat, cotton, castor, Vadodara, India.

MATERIAL AND METHODS

Four agricultural fields [Savli (North), Dabhoi (East), Padra (West) and Karjan (South)] around Vadodara were surveyed during 2002 to 2005. Study areas were chosen keeping in mind the variation in soil type. Major crops like sugarcane, wheat, cotton and castor 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 pre-maturing stages. Collections during morning and late evening were preferred as termites were found to be mostly active during that time.

Identification of termite is mainly based on soldier caste and efforts were made for collection of the same along with other castes. Termites were collected with the help of alcohol-moistened brush, preserved in 70%

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alcohol and properly labeled. Termites thus collected were photographed in laboratory by Sony Digital Camera (DSC H2, 12X optical zoom). 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), $d_i = (n_i \times 100)/N$, where, d_i = Percent presence, n_i = No. of individuals of taxa, and, N = Total individuals.

OBSERVATION AND RESULTS

Fifteen termite species belonging to two families and seven genera were recorded in the present study. Only five species belonging to three genera were identified as pests of the above crops. Pest species were recorded from all study areas.

Termite species recorded

Family I RHINOTERMITIDAE FROGGATT, 1896

Genus 1. *Coptotermes* Wasmann, 1896

1. *Coptotermes heimi* Wasmann, 1902

(Plate 1.1)

Distribution : *Vadodara*: Karjan, Padri, Dabhoi and Savli. *Elsewhere in Gujarat* : Banaskantha, Dangs, Mahesana.

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 earhead 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 earhead.

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. Aggressive soldiers, when disturbed, exude milky white fluid from fontanelle. *Coptotermes heimi* population had the maximum number of soldiers among all castes, sometimes outnumbering the soldiers of other species. After a heavy shower, the species usually built capillary nests under dead tree bark, capillary length sometimes exceeding six meters. Living *Acacia senegal* and *Prosopis juliflora* trees in the surrounding areas were also found to be susceptible to attack by this species.

Genus 2. *Heterotermes* Froggatt, 1896

2. *Heterotermes indicola* Wasmann, 1902

(Plate 1.2)

Distribution : *Vadodara*: Dabhoi. *Elsewhere in Gujarat*: Banaskantha, Gandhinagar, Kutch.

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

Remarks : Earlier the species was not recorded from Vadodara. 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.

Family II TERMITIDAE WESTWOOD, 1934

Genus 3. *Amitermes* Silvestri, 1901

3. *Amitermes belli* (Desneux, 1906)

(Plate 1.3)

Distribution : *Vadodara*: Savli and Karjan. *Elsewhere in Gujarat* : Ahmedabad, Banaskantha, Kutch, Mahesana, Sabarkantha, Surendranagar.

Economic importance : Pest status is not known.

Remarks : *A. belli* was collected from dead tree stumps in the surrounding areas. It built sponge-like nests inside the stumps of *Melia azadirachta* and *Eucalyptus* trees.

Genus 4. *Microcerotermes* Silvestri, 1901

4. *Microcerotermes beesoni* Snyder, 1933

(Plate 1.4)

Distribution : *Vadodara* : Savli and Karjan.

Economic importance : During present study the species was not found to damage any crop.

Remarks : *M. beasoni* made narrow galleries in soil under dry and moist logs.

5. *Microcerotermes tenuignathus* Holmgren, 1913
(Plate 2.5)

Distribution : Vadodara : Padra and Dabhoi. Elsewhere in Gujarat : Banaskantha, Junagadh, Kutch, Surendranagar.

Economic importance : The species was not found to cause any damage to any crops mentioned above.

Remarks : *M. tenuignathus* was a soil-dwelling species and inhabited the adjoining fields where it built subterranean nests under logs.

Genus 5. *Odontotermes* Holmgren, 1912

6. *Odontotermes assmuthi* Holmgren, 1913
(Plate 2.6)

Distribution : Vadodara : Padra and Karjan. Elsewhere in Gujarat : Dangs, Kutch.

Economic importance : The species did not enjoy the status of a pest.

Remarks : This is the first record of *O. assmuthi* from Vadodara. *O. assmuthi* was one of the subterranean species which built diffused nest made of narrow galleries. In addition to their abundance in soil the species was also found under logs.

7. *Odontotermes bhagwathi* Chatterjee & Thakur,
1967
(Plate 2.7)

Distribution : Vadodara : Karjan. Elsewhere in Gujarat : Sabarkantha, Surat.

Economic importance : This species was not found to damage any crop.

Remarks : This is the first record of the species from Vadodara. *O. bhagwathi* was collected from beneath the boulders and logs. It was found constructing underground galleries in moist places.

8. *Odontotermes feae* (Wasmann, 1896)
(Plate 2.8)

Distribution : Vadodara : Karjan. Elsewhere in Gujarat : Valsad.

Economic importance : During present study the species was not found infesting any crop.

Remarks : The species was recorded for the first time from Vadodara. *O. feae* was found living under logs and boulders in moist places, often in association with *O. bhagwathi*.

9. *Odontotermes guptai* Roonwal & Bose, 1961
(Plate 3.9)

Distribution : Vadodara : Dabhoi and Karjan.

Economic importance : This species was not found to be a pest of any crop during the present study.

Remarks : Prior to this study the species was not known from Gujarat.

Remarks : *O. guptai* is subterranean in habit and was collected from soil, logs and dung around the agricultural fields.

10. *Odontotermes obesus* (Rambur, 1842)
(Plate 3.10)

Distribution : Vadodara : Karjan, Padri, Dabhoi and Savli. Elsewhere in Gujarat : Ahmedabad, Banaskantha, Bharuch, Dangs, Jamnagar, Kutch, Kheda, Mahesana, Panchmahal, Sabarkantha, Surat, Valsad.

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 upto 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 (upto 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 and around Vadodara. The mounds were unilocular or multilocular (Plate 4.16). 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.

11. *Odontotermes redemanni* Wasmann, 1893
(Plate 3.11)

Distribution : Vadodara : Karjan, Padri, Dabhoi and Savli. *Elsewhere in Gujarat* : Banaskantha, Bharuch, Mahesana, Panchmahal.

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 : Prior to this study, the species was not known to be a pest of any agricultural crops in Gujarat. 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 6. *Microtermes* Wasmann, 1902

12. *Microtermes mycophagus* Desneux, 1905
(Plate 3.12)

Distribution : Vadodara : Karjan, Padri, Dabhoi and Savli. *Elsewhere in Gujarat* : Ahmedabad, Banaskantha, Dangs, Gandhinagar, Kutch, Mahesana, Sabarkantha, Surendranagar.

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. The species was also collected from living *Acacia tortolis*, *Calotropis procera*, *Zizyphus nummularia* and *Euphorbia caducifolia* trees.

13. *Microtermes obesi* Holmgren, 1913
(Plate 4.13)

Distribution : Vadodara : Karjan, Padri, Dabhoi and Savli. *Elsewhere in Gujarat* : Banaskantha, Sabarkantha.

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

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 earhead 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.

14. *Microtermes unicolor* Snyder, 1933
(Plate 4.14)

Distribution : Vadodara : Dabhoi and Karjan.
Elsewhere in Gujarat : Banaskantha, Dangs, Junagadh, Mahesana, Sabarkantha, Surendranagar.

Economic importance : It was not found to damage any crop.

Remarks : Being a subterranean species, *M. unicolor* built diffused nest in soil. This species was also found to be present under logs and inside the dead tree stumps.

Genus 7. *Trinervitermes* Holmgren, 1912

15. *Trinervitermes biformis* Wasmann, 1902
(Plate 4.15)

Distribution : Vadodara : Padra and Karjan.
Elsewhere in Gujarat : Banaskantha, Gandhinagar, Jamnagar, Junagadh, Kutch, Mahesana, Panchmahal, Rajkot, Sabarkantha, Surendranagar, Valsad.

Economic importance : It was not found to infest any crop.

Remarks : The species live in the subterranean nest, rock crevices, etc.

Key to termite taxa

(based on soldier caste)

1. Pronotum flat Rhinotermitidae (3)
2. Pronotum saddle-shaped Termitidae (6)
3. Head-capsule oval-shaped; fontanelle large, circular and lying medially at the interior margin
Coptotermes (4)
– Head capsule sub-rectangular; fontanelle small and lying at the middle of the dorsum of head ..
..... *Heterotermes* (5)
4. 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
..... *Coptotermes heimi*

5. 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
..... *Heterotermes indicola*
6. Nasute absent; mandibles well-developed (7)
– Head formed into nasute; mandibles degenerated
..... *Trinervitermes* (18)
7. Inner margin of mandible serrated
..... *Microcerotermes* (8)
– Inner margin of mandible smooth, a tooth or a few crenulations near base may be present; head without protuberance *Amitermes* (11)
– Mandibles fine, without any crenulations; left mandible without any tooth *Microtermes* (12)
– Left mandible with prominent tooth
..... *Odontotermes* (15)
8. Mandibles finely serrated (9)
– Mandibles coarsely serrated (10)
9. Smaller species, mandibles long (length 0.87-0.95 mm), slender *Microcerotermes tenuignathus*
10. Mandibles shorter (0.83-0.97 mm) and thicker; antero-median margin of pronotum weakly notched; postmentum relatively less narrowed at the posterior fourth *Microcerotermes beesoni*
11. Clypeus bilobed; head: length 1.07-1.44 mm, width 0.85-1.15 mm *Amitermes belli*
12. Labrum tongue-shaped (13)
– Labrum comparatively broad at tip (14)
13. Antennae with fifteen segments
..... *Microtermes mycophagus*
14. Head-capsule densely hairy; second segment of antennae shorter than combined length of third and fourth segments *Microtermes unicolor*
– Head-capsule moderately hairy; second segment of antennae equal to the combined length of third and fourth segments *Microtermes obesi*
15. Smaller species; tooth placed at mid-region of the left mandible, situated above middle point ... (16)
– Larger species; tooth of left mandible placed near or below middle point (17)

16. Postmentum not wide, sides sub-parallel to weakly arched; head and body more hairy; antennae with 15-16 segments; mandible shorter and stouter; labrum broadly rounded interiorly; postmentum convex laterally
 *Odontotermes guptai*
- Mandible longer, outer margin shortly bent near the basal third; mandible index length/ head length 0.69-0.79 mm
 *Odontotermes redemanni*
 - Mandible short, slender with weakly curved outer margin; mandible index length/head length 0.59-0.68 mm; labrum short, broadly rounded interiorly
Odontotermes obesus
 - Smaller species; mandible parrot's beak-like; inner margin anterior to tooth on left mandible wavy; mandible tooth index 0.33-0.37 mm
 *Odontotermes assmuthi*
17. Tooth on left mandible placed a little below the middle; mandible tooth index 0.51-0.55 mm
 *Odontotermes bhagwathi*
- Tooth on left mandible placed near the middle; mandible tooth-index 0.50-0.54; head-capsule widest near posterior third ... *Odontotermes feae*
18. Antennae 12-14 segmented; in fourteen-segmented condition, third segment is a little longer than the second one; pronotum weakly invaginated anteriorly
 *Trinervitermes biformis* (Soldier major)
- Anterior margin of pronotum without any emargination
 *Trinervitermes biformis* (Soldier minor)

Of the four study areas, maximum number (13) of species were known from Karjan, 9 from Dabhoi, 8 from Padra and 7 from Savli (Fig. 1). In terms of cropwise occurrence (Fig. 2), sugarcane was attacked by maximum (5) species, followed by wheat (5), cotton (3) and castor (2). The incidence and attack of *Coptotermes heimi* was maximum (76%) and minimum (24%) in sugarcane and wheat respectively (Fig. 3). This particular species was found attacking the planting stalks of sugarcane but in wheat crop damage was mainly noticed in maturing stage (Table 3). *Odontotermes obesus* acted as pest to all the four crops, irrespective of any stages. However, that attack was more prominent in sugarcane

(43%) than cotton (27%), wheat (19%) and castor (10%) (Fig. 3). This species caused more damage during seedling stage (82%) of sugarcane, as compared to maturing stage (18%). Such difference in occurrence between the seedling and maturing of any crop is only noticed in sugarcane (Table 3).

It was wheat which was mostly (73%) liked as food rather than sugarcane (27%) by *Odontotermes redemanni*. Seriousness of attack was more in maturing sugarcane (Table 3). However, another subterranean species, *Microtermes mycophagus* showed preference for castor (53%) rather than to cotton (29%) and sugarcane (18%) (Fig. 3). *M. mycophagus* species attacked the young plants of sugarcane, castor and cotton, matured crops was less vulnerable (Table 3). However, *M. mycophagus* was not recorded from wheat. *Microtermes obesi* was found to be a serious pest of sugarcane (58%), particularly at seedling stage, wheat (37%) and cotton (6%) was less preferred by *M. obesi*. However, matured wheat crops were more susceptible to the attacks of *M. obesi*. Cotton was damaged only at its maturing stage. In terms of occurrence, *O. obesus* occupies the highest position (28%), followed by *Microtermes obesi* (25%) and *M. mycophagus* (17%). *O. redemanni* and *C. heimi* were very rare and a very few specimens were collected (Table 2).

Termite damage in sugarcane occurred both at seedling ('setts') and maturing stage. In wheat, the infestation was much more in seedling stage than maturing stage. There were no marked difference in the intensity of damage to any stage in cotton and castor. Thakur (1996) recorded *Odontotermes obesus* and *Microtermes obesi* as a major pest of sugarcane in India and Pakistan.

Odontotermes obesus, *Microtermes obesi* and *M. mycophagus* were found to be the most versatile species in this study, and besides their occurrence in the crop field (Table 2), they also showed their marked presence in a number of other microhabitats (Table 4).

DISCUSSION

Agarwala (1955) estimated 2.5% loss in sugarcane tonnage and 4.47% in sugar production in Bihar. Roonwal (1981) noticed that the most important termite species attacking wheat and cotton were *Microtermes*

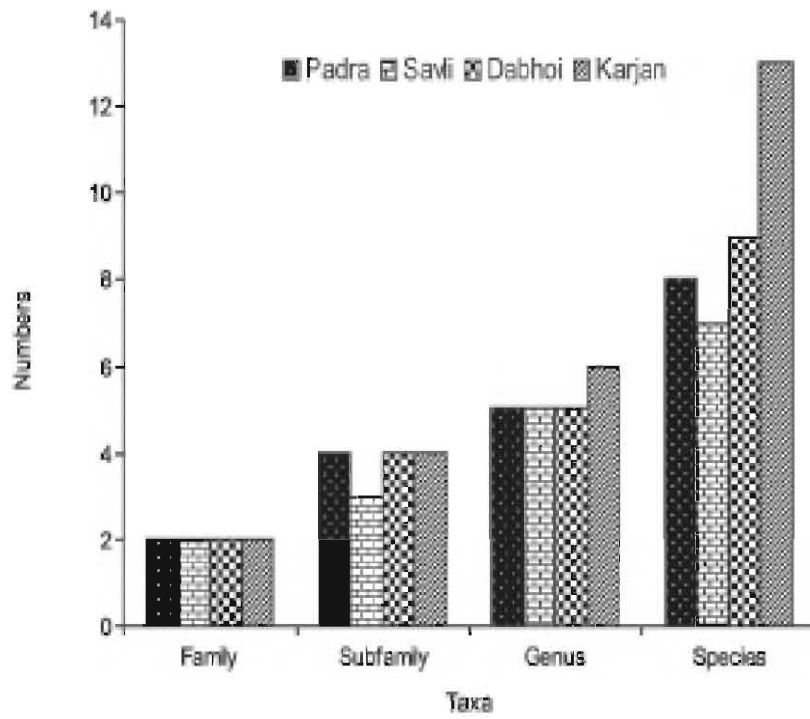


Fig. 1. Areawise occurrence of termite taxa

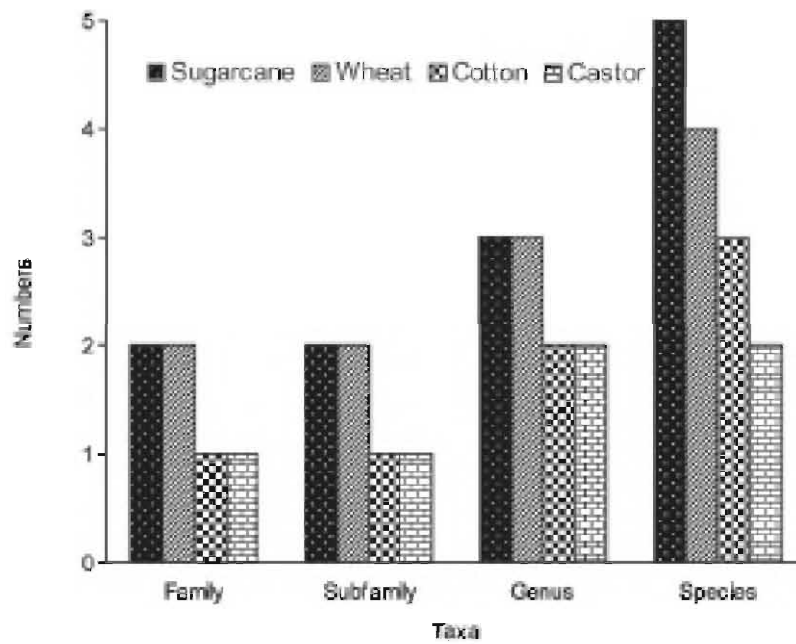


Fig. 2. Cropwise occurrence of termite taxa

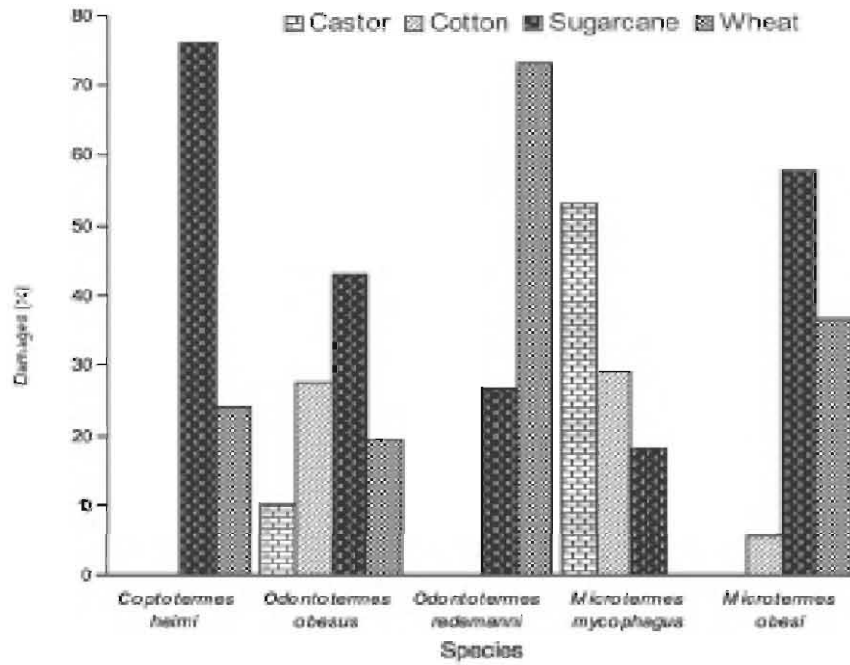


Fig. 3. Damage in different crops

Table 1 : Recorded termite taxa

Family	Subfamily	Genus	Species	
Rhinotermitidae Froggatt, 1896	Coptotermitinae Holmgren, 1911	<i>Coptotermes</i> Wasmann, 1896	<i>C. heimi</i> (Wasmann, 1902)	
	Heterotermitinae Froggatt, 1896	<i>Heterotermes</i> Froggatt, 1896	<i>H. indicola</i> (Wasmann, 1902)	
Termitidae Westwood, 1934	Amitermitinae Kamner, 1943	<i>Amitermes</i> Silvestri, 1901	<i>A. belli</i> (Desneux, 1906)	
		<i>Microcerotermes</i> Silvestri, 1901	<i>M. beelsoni</i> Snyder, 1933 <i>M. tenuignathus</i> Holmgren, 1913	
	Macrotermitinae Kemner, 1934	<i>Odontotermes</i> Holmgren, 1912	<i>O. assmuthi</i> Holmgren, 1913	<i>O. assmuthi</i> Holmgren, 1913
			<i>O. bhagwathi</i> Chatterjee & Thakur, 1967	<i>O. bhagwathi</i> Chatterjee & Thakur, 1967
			<i>O. feae</i> (Wasmann, 1896)	<i>O. feae</i> (Wasmann, 1896)
			<i>O. guptai</i> Roonwal & Bose, 1961	<i>O. guptai</i> Roonwal & Bose, 1961
			<i>O. obesus</i> (Rambur, 1842)	<i>O. obesus</i> (Rambur, 1842)
			<i>O. redemanni</i> (Wasmann, 1893)	<i>O. redemanni</i> (Wasmann, 1893)
	Nasutitermitinae Hare, 1937	<i>Microtermes</i> Wasmann, 1902	<i>M. mycophagus</i> (Desneux, 1905)	<i>M. mycophagus</i> (Desneux, 1905)
			<i>M. obesi</i> Holmgren, 1911	<i>M. obesi</i> Holmgren, 1911
<i>M. unicolor</i> Snyder, 1933			<i>M. unicolor</i> Snyder, 1933	
		<i>Trinervitermes</i> Holmgren, 1912	<i>T. biformis</i> (Wasmann, 1902)	

obesi and *Odontotermes obesus*. He observed that intensity of damage to wheat by *Microtermes obesi* was less when the crop received two or three as against nil or only one irrigation.

In the present study, only a single species, *O. redemanni* was recorded to damage the sugarcane at mature stage while *Microtermes obesi*, *O. obesus* were found to infest seedling and maturing stages. Sugarcane provides maximum shade and is more susceptible to termite attack. Shade provided by sugarcane plantation, high sugar content and faster growth rate are some of the major reasons for the preference of this crop by a wide variety of termites. *Microtermes obesi* damages both young and maturing (earhead stage) wheat plants. Three species, viz., *O. obesus*, *Microtermes mycophagus* and *M. obesi* damaged cotton crops.

Food and habitat greatly influenced the termite activity. Termite-infested organic manure when applied to field also increased the intensity of attack. Sandy loam soil was found at Padra, Savli and Dabhoi but crop fields of Karjan were formed of black soil. Incidence of termite attack was found less at Padra, Savli and Dabhoi than Karjan which is probably due to high evaporation rate and low water-holding capacity of sandy loam soil. High evaporation rate of sandy loam soil poses desiccation threat to the soft-bodied termites which probably restricts their distribution in those areas.

Shady area provided a good quantity of moisture to the termites which justified the intensity of attack in shady places than in open areas. In addition to shade and plant cover, objects like big boulders, manure heaps, wooden logs, tree stumps, etc. also provided shelter and moisture to the termites. Because of their affinity to shady and moist places, the termites made galleries in and around these objects. Thick vegetation provided the ground shade which in turn supplied more moisture and humidity to the soil, one of the major factors promoting termite activity. Owing to unique phyllotactic arrangement, castor leaves are mainly restricted to the apical region for which termites get very little shade around castor plants. Since the termites are soft-bodied animals and are very much prone to desiccation, for obvious reasons they either kept themselves away from these somewhat drier areas around castor plants or penetrate deep into the soil.

This is in accordance with our study as only two termite species were recorded from castor.

Primarily the termites attacked the young plants, immediately after planting or when they were very young, devoured the tap root and the injured plants become weak, leaves become yellowish. Young plant exhibited signs of drooping of tender leaves, followed by withering and death. Plants which were already weak due to drought, abnormally high and low moisture conditions, nutritional stress or pest attack, became easily vulnerable to termite attack. Occasionally, soft plant parts, exposed due to mechanical injuries (strong wind, cattle-grazing, several anthropogenic activities, etc.) become susceptible to termite attack (Anonymous, 1981; Wardle, 1987; Thakur, 1996). Occurrence of some species in a number of microhabitats confers them an added advantage to survive in dry, arid, harsh environments, an important factor for a species to be considered as a pest.

Most termite pest species are subterranean and management of these species primarily relies on soil treatment with termiticides at the site of attack. As a result of adverse effect of the organochlorines on the environment, research shifted towards third and fourth generation insecticides like carbamates, organophosphates and synthetic pyrethroids.

SUMMARY

An effort was made to study the termite fauna of wheat, cotton, castor and sugarcane in and around the crop fields of Vadodara. Of the fifteen species belonging to two families and seven genera, five were found to cause damage to crops. *Odontotermes obesus*, *Microtermes obesi* and *Microtermes mycophagus* occur in maximum number. *Odontotermes obesus* was the most destructive species and destroyed seedling and maturing stages of all crops.

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Table 2 : Presence of termite species

Species	Percentage	Species	Percentage
<i>Coptotermes heimi</i>	5.38	<i>Odontotermes guptai</i>	2.24
<i>Heterotermes indicola</i>	0.87	<i>Odontotermes obesus</i>	28.16
<i>Amitermes belli</i>	1.33	<i>Odontotermes redemanni</i>	9.03
<i>Microcerotermes beelsoni</i>	2.03	<i>Microtermes mycophagus</i>	16.69
<i>Microcerotermes tenuignathus</i>	1.61	<i>Microtermes obesi</i>	25.26
<i>Odontotermes assmuthi</i>	1.82	<i>Microtermes unicolor</i>	2.53
<i>Odontotermes bhagwathi</i>	0.91	<i>Trinervitermes biformis</i>	0.99
<i>Odontotermes feae</i>	1.16		

Table 3 : Termite infestation (%) at different crop stages

Species	Stages	Crops			
		Castor	Cotton	Sugarcane	Wheat
<i>Coptotermes heimi</i>	Seedling	0.0	0.0	100.0	0.0
	Maturing	0.0	0.0	0.0	100.0
<i>Odontotermes obesus</i>	Seedling	58.6	44.2	82.4	40.5
	Maturing	41.4	55.8	17.6	59.5
<i>Odontotermes redemanni</i>	Seedling	0.0	0.0	0.0	40.2
	Maturing	0.0	0.0	100.0	59.8
<i>Microtermes obesi</i>	Seedling	0.0	0.0	78.3	28.6
	Maturing	0.0	100.0	21.7	71.4
<i>Microtermes mycophagus</i>	Seedling	84.8	62.9	100.0	0.0
	Maturing	15.2	37.1	0.0	0.0

Table 4 : Occurrence of termite species in different microhabitats

Species	Microhabitats
<i>Coptotermes heimi</i>	Soil, bark, tree log, wooden house
<i>Heterotermes indicola</i>	Dead tree stump
<i>Amitermes belli</i>	Dead tree stump
<i>Microcerotermes beelsoni</i>	Ground nest, tree log
<i>M. tenuignathus</i>	Ground nest, tree log
<i>Odontotermes assmuthi</i>	Ground nest
<i>O. bhagwathi</i>	Ground nest, stone, tree log
<i>O. feae</i>	Tree log, boulder
<i>O. guptai</i>	Ground nest, tree log, dung
<i>O. obesus</i>	Mound, bamboo fencing, stone, leaf litter, tree bark, tree log and stump, fallen tree twigs, heaps of dung, crop residue and fuel wood
<i>O. redemanni</i>	Mound, tree log, tree stump, tree bark, stone
<i>Microtermes mycophagus</i>	Stone, heaps of dung, weed and crop residue, tree log, tree stump, leaf litter
<i>M. obesi</i>	Ground nest, dead tree stump, tree log, bamboo fencing, tree bark, leaf litter, dung, heaps of weed and crop residue
<i>M. unicolor</i>	Tree log, dead tree stump
<i>Trinervitermes biformis</i>	Rock crevices, boulder

REFERENCES

- Agarwala, S.B.D. 1955. Control of sugarcane termites (1946-1953). *J. Econ. Entomol.*, **48**(5) : 533-537.
- Anonymous, 1981. Termite control in Eucalyptus plantations. *KFRI Information Bull.*, No. 3 : 1-6.
- Chhotani, O.B. 1980. Termite pests of agriculture in Indian region and their control. Tech. Monog. No. 4, Zoological Survey of India Publication, Calcutta, 84 pp.
- Chhotani, O.B. 1997. Fauna of India–Isoptera (Termites). Vol. II. Zoological Survey of India Publication, Calcutta, 800 pp.
- Freise, F. 1949. The significance of ants and termites in tropical forests. *An. Brasil. Econ. Forestal.*, **2** : 145-154.
- Hussain, M.A. 1935. Pest of wheat crop in India. Proceedings of 2nd World Grain Exhibition and Conference, p. 562-564.
- Krishna, K. & Weesner, F.M. 1970. Biology of Termites. Vol. II. (Eds. K. Krishna & F. M. Weesner). Academic Press, New York, 643 pp.
- Patel, G.A. & H.K. Patel, 1954. Seasonal incidence of termite injury in the northern parts of the Bombay State. *Indian J. Entomol.*, **15**(4) : 376-378.
- Pearce, M.J. 1997. Termites Biology and Pest Management. CAB International, Cambridge University Press, Cambridge, U.K., 172 pp.
- Rathore N.S. & Bhattacharyya A.K. 2004. Termite (Insecta : Isoptera) Fauna of Gujarat and Rajasthan–Present state of knowledge. *Rec. zool. Surv, India.*, Occ. Paper. No. 223 : 1-77.
- Roonwal, M.L. 1981. Termites of agricultural importance in India and their importance. In : Progress in soil biology and ecology in India (Ed. G.K. Veeresh), UAS, Bangalore, Tech. Ser. No. **37** : 253-265.
- Roonwal, M.L. & Chhotani, O.B. 1989. Fauna of India–Isoptera (Termites). Vol. I. Zoological Survey of India Publication, Calcutta, 672 pp.
- Sen-Sarma P.K., 2000. Ecology and biogeography of the termites of India. In : Forest Entomology (Ed. M.L. Thakur). Sai Publication, Dehradun, 422 pp.
- Smeathman, H. 1781. Some account of termites which are found in Africa and other hot climates. *Phil. Trans.*, **71** : 139-192.
- Southwood, T.R.E. & Henderson, P.A. 2000. Ecological Methods. 3rd Rev. Ed., Blackwell Science Ltd., Oxford, 575 pp.
- Thakur R.K. 1996. Termite problems in arid zones and their management. *Indian Forester*. **122**(2) : 161-169.
- Wardle, D.A. 1987. Control of termites in nurseries and young plantations in Africa : Established practices and alternative courses of action. *Commonw. Forest Rev.*, **66**(1) : 77-89.

PLATE-I



1. *Coptotermes heimi*



2. *Heterotermes indicola*



3. *Amitermes bellii*



4. *Microcerotermes beesoni*



5. *Microcerotermes tenuignathus*



6. *Odontotermes assmuthi*



7. *Odontotermes bhagwathi*



8. *Odontotermes feae*

PLATE-II



9. *Odontotermes guptai*



10. *Odontotermes obesus*



11. *Odontotermes redemanni*



12. *Microtermes mycophagus*



13. *Microtermes obesi*



14. *Microtermes unicolor*



15. *Trinervitermes biformis*



16. Mound of *Odontotermes obesus* in castor field