TECHNICAL MONOGRAPH No. 4

Termite Pests Of Agriculture In The Indian Region And Their Control

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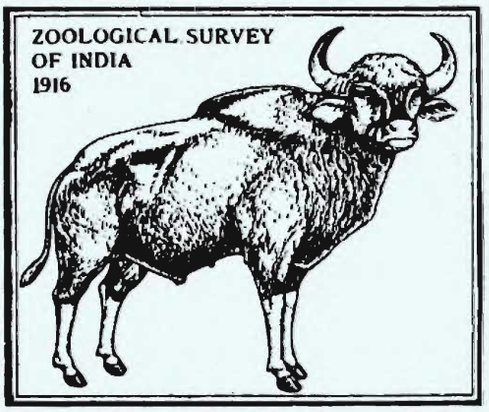
O. B. CHHOTANI



ZOOLOGICAL SURVEY OF INDIA

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TERMITE PESTS OF AGRICULTURE IN THE INDIAN REGION AND THEIR CONTROL

BY

O. B. CHHOTANI

Zoological Survey of India, Calcutta

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PREFACE

Termites are one of the foremost of social insects, showing an excellent example of disciplined living in a highly organised society. They have three major castes, each with duties assigned to them—the reproductive adults who are the founders of the colony to come, the sterile soldiers who defend the colony from marauders and the equally sterile workers who ungrudgingly work for the maintenance of the colony and its inmates. Their's is again a system par excellence of coordination in social behaviour and communication which are regulated by the pheromones.

These small insects play a very important role in the economy of a tropical country due to their habit of eating through and doing extensive damage to agricultural and plantation crops, forest nurseries, trees, buildings and the wood-works, furniture, books and other cellulose goods. Several hundred crores of rupees worth of agricultural products are lost every year due to these pests and there are reports of such severe infestation in the houses, so much so that the residents had to virtually abandon their houses or reconstruct them.

In this monograph, an attempt has been made to bring together the knowledge available on damage and control of termite pests of agriculture in India. Keeping in view the possible needs of agricultural entomologists, the identity, the distribution, the pest status and hosts, the ecology and biology of the various pest species and the control measures adopted with significant results have been dealt with, since a comprehensive work of this nature has been wanting. Keys based on soldier characters and field observations are provided for their easy identification in the field. Illustrations for the soldiers of all the species and the damage to different crops, trees and stored-articles are given. Lists of termite pests (general and crop-wise) are given. The present work will perhaps also be useful to the farmers in general and to tea, coconut and sugarcane planters since it gives information on the control of termite pests as far as possible.

O. B. CHHOTANI

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I. INTRODUCTION

From times immemorial, the destruction caused by the tiny insects, the termites, has been well known to men living in the tropics and to a lesser extent to those in the subtropical and subtemperate regions. Though small their destructive capacity is immense. These insects although generally called white-ants are not at all related to the true ants but need little or no introduction to the common man. Technically speaking, however, they are social, polymorphic insects living in large communes. They have-three major castes i. e., the reproductives (males and females), the sterile soldiers and the sterile workers. The reproductives are the future royal pair in a colony and their main functions are colony foundation and reproduction. The soldiers look after defence while the workers attend to various needs of the community, like providing food, the constructing and repairing the nest and looking after of the nurseries and the young-ones. Thus the division of labour is highly manifested in a termite community. The reproductives, in a colony, develop at a particular time when the ecological conditions are favourable for starting new colonies but the soldiers and workers are found all the year round. The workers being loyal to the community, in providing food, eat away man's resources of food, cloth and shelter. The activity of these insects is concealed and underground, so the damages done go unnoticed until the plants dry up and die, the building structures start crumbling down and the records, papers, books, clothes and wooden articles are shredded into debris.

The termites are serious pests of agriculture, horticulture, forestry and stored-products. They do extensive damage to our cereal, vegetable, oil (groundnut) and fibre (cotton, jute, sunnhemp) crops ; sugarcane, tea, coconut and rubber plantations ; fruit trees ; forests and timbers ; building structures and stored-products (paper, cloth, jute goods, wooden articles, ordinance stores, leather, etc.) in India. There is no exact estimate as to the losses and damages caused by these tiny insects. Fletcher (1912), however, estimated an annual loss of 280 million rupees worth of agricultural crops alone and Aggarwala (1955) estimated a loss of 2.5 per cent in sugarcane tonnage and 4.47 per cent in sugar output in Bihar (India). These insects also cause immense damage to tea and coconut plantations. Kapur (1958) reports that they are a serious menace to tea planters and Das (1962) estimated at least 15 per cent loss to the tea crop in certain districts of North-East India. Nirula et al. (1953) have reported a damage of 20 per cent of coconut seedlings on the western coast of India. The destructions caused to building structures, forest trees and timbers and stored-products are also colossal. The whole of the township of Sri Hargobindpur in Panjab (India) was reported to have been ruined (Roonwal,

1955) and large stocks of timber and stored products turned into debris. Thus the losses incurred due to these insects are of gigantic magnitude.

Roonwal and Chhotani (1961, 1967) have dealt with the Indian wood-destroying termites. More recently Sen-Sarma et al. (1975) have brought out a very useful monograph on the Indian wood-destroying termites. They have also discussed the natural resistance of timbers to termitè attack in respect of certain species and illustrated the damage caused to standing forest trees, timbers and building material. A number of authorities (Beeson, 1941 ; Harris, 1961, 1971 ; Hickin, 1971 ; etc.) have dealt extensively with the control of termites in buildings. Harris (1971), Sands (1973), Roonwal (1958, 1979), Kapur and Bose (1972) and some others have, to some length, dealt with the termites injurious to agriculture and their control, however, there is no available comprehensive work on the identity, distribution, pest status, biology and ecology and control of the Indian agriculture termites which bring down the production and yield of the much needed food grains and also destroy food and materials in storage. Much of the other information present in literature, is also scattered and not readily available. With these points in view an attempt has been made here to give diagnosis, illustrations, the identification keys of the more important termite pests and their pest status in the present monograph. The damages caused to various crops by different species and the control methods so far employed, with some significant results, are also enumerated. It is hoped that this contribution will serve as a useful guide to the entomologists engaged in the control of pests, to the farmers in general and to the tea, coconut and rubber planters.

II. IDENTITY, DISTRIBUTION AND PEST STATUS OF TERMITES OF AGRICULTURE

The living termites belong to the families Mastotermitidae, Kalotermitidae Hodotermitidae, Termopsidae, Rhinotermitidae, Stylotermitidae, Termitidae and Indotermitidae of the order Isoptera. All these families except the Mastotermitidae are known from the Indian subregion but the pests which are of agricultural significance belong to the families Kalotermitidae, Rhinotermitidae, Stylotermitidae and Termitidae.

Out of nearly two thousand species of termites reported from all over the world, a little over three hundred are known from the Indian region. Since these insects feed on cellulose most of them cause some kind of damage. In this chapter, only the more important species, which are responsible for reducing the production output of the most valued food grains, vegetables, fruits, sugar and for the destruction of stored materials are dealt with here. A key for the easy identification, based on the soldier caste and field observations

and the diagnostic characters, the hosts and pest status, the distribution and notes on the biology and ecology of the different species are given.

(A) FIELD KEY FOR THE IDENTIFICATION OF TERMITE PESTS OF AGRICULTURE

The worker caste in termites is responsible for all the damage and loss but it is very difficult to use any morphological characters of this caste in the identification of the different species. The imago and the soldier castes, however, provide some very useful characters for identification, but since the imagos are produced seasonally and the soldiers and workers are met with all through the year, a key based on soldier characters is of greater importance and the same is given here. Nesting behaviour and some field observations, etc. have also been included to aid in identification in the field as far as possible.

1. Fontanelle absent ; pronotum flat ; apical tibial spurs 3 : 3 : 3. Wood-dwelling termites ; nests having no connection with soil ... ... Kalotermitidae (2)

   Fontanelle present, pronotum flat or saddle-shaped ; apical tibial spurs 3 : 2 : 2. Either partly subterranean and partly wood-dwelling or solely subterranean termites ... ... Rhinotermitidae Stylotermitidae Termitidae (16)

2. Middle tibiae with an extra spine on outer margin ... ... *Postelectrotermes* (3)

   Middle tibiae without extra spine on outer margin 4

3. Larger species (head-length 2.88-3.31, head-width 1.98-2.34 mm) ; mandibles about half or a little more than half of head-length. A common tea termite in Sri Lanka ; attacks stem as well as roots ... ... *Postelectrotermes militaris* (Desneux)

   Smaller species (head-length 2.6, head-width 1.5 mm); mandibles much less than half of head-length. A rare species, recorded from only tea from Kerala (India) ... ... *Postelectrotermes bhimi* Roonwal & Maiti

4. Head generally long, not phragmotic 5

   Head short and phragmotic ... ... *Cryptotermes* (14)

5. Head with antero-lateral prominences ... ... *Glyptotermes* (12)

   Head without any antero-lateral prominences ... 6

6. Pronotum deeply concave or incissed at anterior margin. Nests in tree trunks and branches ; loose faecal pellets found in nest and also role down on ground at base ... ... *Bifiditermes beesoni* (Gardner)

   Pronotum not deeply concave or incissed at anterior margin. Nest galleries with masses of faecal matter ... ... *Neotermes*/*Kalotermes* (7)

7. Eyes absent ... *Kalotermes jepsoni* Kemner

Eyes present 8

8. Pronotum narrower than head. Confind to southern India ... *Neotermes fletcheri* Holmgren & Holmgren

Pronotum as wide as or wider than head 9

9. Anterior margin of pronotum distinctly notched at middle. A widely distributed species in Sri Lanka ; reported from tea and many other plants ... ... *Neotermes greeni* (Desneux)

Anterior margin of pronotum not distinctly notched at middle ... 10

10. Mandibles shorter in comparison to head-width ; index left mandible-length/head-width 0.61-0.71. Confined to eastern India ... ... *Neotermes mangiferae* Roonwal & Sen Sarma

Mandibles longer in comparison to head-width ; index left mandible-length/head-width 0.75-1.00 11

11. Anterior broader part of postmentum about half of its length. Restricted to southern India ... ... *Neotermes assmuthi* Holmgren

Anterior broader part of postmentum shorter than half of its length. Known from North-western and North-eastern India and Bhutan, common in Doon Valley ... ... *Neotermes bosci* Snyder

12. Larger species (head-length 2.0-3.0, width 1.27-1.67 mm) ... 13
Smaller species (head-length 1.43-1.73, width 1.07-1.13 mm). [Antero-lateral corners of head rounded ; Y-suture faint, lateral arms indistinct. Recorded only from Kumaon Hills, U. P.] ... *Glyptotermes almorensis* Gardner

13. Head longer and stouter (length 2.62-3.00, width 1.50-1.67 mm), with rounded antero-lateral corners ; mandibles short, thick and stout, left with 2 thick, marginal teeth. Restricted to Sri Lanka ... ... *Glyptotermes ceylonicus* Holmgren

Head smaller and narrower (length 2.0-2.23, width 1.27-1.35 mm), with pointed antero-lateral corners ; mandibles long and thin, left with 4 prominent marginal teeth. A common and serious pest species of tea, coffee, etc. in Sri Lanka ... *Glyptotermes dilatatus* (Bugnion & Popoff)

14. Frontal ridge of head strongly projecting in front medially ; head with ventral tubercle prominent and the dorsal one weakly developed. A pest of wooden-structures in buildings ; widely distributed in Oriental, Papuan and Neotropical regions ... *Cryptotermes domesticus* (Haviland)

Frontal ridge of head not projecting in front medially ; head with both dorsal and ventral tubercles prominent 15

15. Larger species (head-length 1.6-1.8 mm) ; mandibles longish and with prominent dentition ; frontal ridge strongly pushed back medially. An important pest of wooden structures in buildings ; widely distributed in Oriental, Papuan, Ethiopian, Australian and Neotropical regions ... ... *Cryptotermes dudleyi* Banks

Smaller species (head-length 1.13 1.47 mm) ; mandibles short and weakly dentate ; frontal ridge not strongly pushed back. The only semi-wild *Cryptoterms* species in India and Sri Lanka ; widely distributed in Oriental, Ethiopian, Malagasy and Neotropical, regions ... ... *Cryptotermes havilandi* (Sjöstedt)

16. Pronotum flat ... ... Rhinotermitidae (18)

Stylotermitidae (17)

Pronotum saddle-shaped ... ... Termitidae (22)

17. Tarsi 3-jointed ... ... Stylotermitidae

[Head-length 2.6-2.7, head-width 1.75-1.80 mm. Nests in trees in southern India] ... ... *Stylotermes fletcheri* Holmgren & Holmgren

Tarsi 4-jointed 18

18. Head-capsule oval ; fontanelle large, circular and lying medially at anterior margin ... ... *Coptotermes* (19)

Head-capsule subrectangular ; fontanelle small minute, lying at middle of head-dorsum ... ... *Heterotermes* (21)

19. Larger species (head-length 1.2-1.45, head-width 1.0-1.35 mm) ; waist of postmentum lying in middle between level of maximum width and hind margin 20

Smaller species (head-length 1.13-1.25, head-width 0 95-1.08 mm) ; waist of postmentum lying below middle point between maximum width and hind margin. Restricted to eastern India, attacks trees and wooden-articles ... ... *Coptotermes kishori* Roonwal & Chhotani

20. Postmentum wider at waist (0.25-0.34 mm) and less so contracted (postmentum-contraction index i. e., min. width/ max. width 0.63-0.76). A very common species of the genus in India and Pakistan ; highly destructive to all sorts of crops, fruit trees and goods in storage ... ... *Coptotermes heimi* (Wasmann)

Postmentum narrower at waist (0.20-0.25 mm) and more so contracted (postmentum-contraction index 0.57-0.66). Common in Sri Lanka and southern India ; quite destructive in habit ... *Coptotermes ceylonicus* Holmgren

21. Posterior margin of pronotum distinctly notched in middle ; antennal segments always more than 14 ; larger species. A very destructive pest of storage-goods and house-hold structures. Common on Indian subcontinent ... ... *Heterotermes indicola* (Wasmann)

	Posterior margin of pronotum nearly straight and without any notch in the middle ; antennal segments generally less than 14 ; smaller species. Confind to southern India ; a very destructive termite	*Heterotermes malabaricus* Snyder	
22.	Head not produced into a nasute ; mandibles well developed		23
	Head produced into a nasute ; mandibles degenerate		44
23.	Mandibles serrated on inner margin ...	*Microcerotermes*	(24)
	Mandibles not serrated on inner margin, a tooth or a few crenulations near base may be present		30
24.	Mandibles finely serrated		25
	Mandibles coarsely serrated		27
25.	Head sides slightly convex, head wider (0.96-0.99 mm) ; mandibles with a prominent denticle at basal third. Known only from Pakistan from dead portions of trees and roots and Jodhpur (India)	*Microcerotermes baluchistanicus* Ahmad	
	Head sides subparallel, head narrower (0.85-0.87 mm) ; mandibles without any prominent denticle at basal third		26
26.	Smaller species (head-length to base of mandibles 1.17-1.27 mm) ; mandibles long (0.87-0.95 mm) and slender, mandible-head length index 0.71-0.79. Known from North-western India ; reported damaging books	*Microcerotermes tenuignathus* Holmgren	
	Larger species (head-length 1.30-1.50 mm) ; mandibles short 0.80 mm) and thick, mandible-head length index 0.53-0.61. Restricted to Sri Lanka ; nests underground, globular, made up of carton material	*Microcerotermes bugnioni* Holmgren	
27.	Head widest at base of antennae, sides slightly coverging posteriorly. Recorded from fruit trees in southern India ...	*Microcerotermes fletcheri* Holmgren and Holmgren	
	Head almost uniformly wide throughout, sides subparallel		28
28.	Labrum tongue-shaped with broad distal tip		29
	Labrum pentagonal with pointed tip [head-length to base of mandibles 1.70-1.76, head-width 0.98-1.08 mm. Recorded from Nicobar Island from bark of coconut tree]	*Microcerotermes nicobarensis* Roonwal & Bose	
29.	Mandibles shorter and thicker (length 0.83-0.97 mm). Recorded from logs and damages fruit trees ; nests globular or oval, made up of carton material ; known from Northern, Eastern and Central India, Bangla Desh and Pakistan ...	*Microcerotermes beesoni* Snyder	
	Mandibles larger and thinner (length 0.95-1.03 mm). Reported from Nicobar Island from bark of coconut tree ...	*Microcerotermes danieli* Roonwal & Bose	

30. Head with a protuberance
[Mandibles thin, long, slender, weakly incurved apically and each with a prominent tooth at middle. Nests in soil ; feeds on roots of grasses and other plants] ... ... *Eremotermes paradoxalis* Holmgren

Head without any frontal protuberance 31

31. Clypeus bilobed
[Head-length to base of mandibles 1.07-1.44, head-width 0.85-1.15 mm. Reported from dry, barren areas of India and Pakistan ... ... *Amitermes belli* (Desneux)

Clypeus not bilobed 32

32. Mandibles asymmetrical, left mandible strongly twisted. Restricted to Sri Lanka, recorded from tea ... ... *Dicuspiditermes hutsoni* Kemner

Mandibles symmetrical, narrowed and slightly incurved anteriorly 33

33. Soldier dimorphic. Labrum with a hyaline tip ; fontanelle distinct, situated on mid-dorsum of head
[Soldier major : head-length to base of mandibles 4.3-6.6, head-width 3.9-4.15 mm. A large foraging termite, nesting in soil and collecting small heaps of earth on ground-surface] ... *Macrotermes estherae* (Desneux)

Soldier monomorphic. Labrum without a hyaline tip ; fontanelle not distinct 34

34. Left mandible with a prominent tooth 38

'Left mandible without any tooth 35

35. Larger species. Mandibles thick, left mandible with a few crenulations in basal half
[head-length to base of mandibles 1.18-1.39, head-width 1.02-1.05 mm. Reported from Sri Lanka and southern and eastern India *Hypotermes obscuriceps* (Wasmann)

Small, delicate species. Mandibles delicate, left mandible without any crenulations ... ... *Microtermes* (36)

36. Labrum tongue-shaped ; head larger (head-length to base of mandibles 0.85-1.03, head-width 0.78-0.95 mm) ; antennae with 15 segments. Occurs in wild and semi-wild parts of north-western India and Pakistan ; a pest of crops and fruit trees ... *Microtermes mycophagus* (Desneux)

Labrum lancet-shaped, with a triangular tip ; head smaller (head-length 0.80-1.0, head-width 0.75-0.86 mm) ; antennae 14-segmented 37

37. Head densely hairy ; 2nd joint of antenna shorter than 3rd and 4th combined. A pest of sugarcane and chillies in Pakistan ; fairly common in sub-continent ... ... *Microtermes unicolor* Snyder

Head moderately hairy ; 2nd joint of antenna as long as 3rd and 4th combined. A serious pest of wheat, sugarcane and many other crops ; a very common species of the subcontinent ... *Microtermes obesi* Holmgren

38. Tooth of left mandible situated above middle-point ; smaller species 40

Tooth of left mandible situated near middle or below middle-point ; larger species 39

39. Tooth of left mandible prominent and situated faintly below middle-point ; head sides subparallel. A subterranean termite pest of tea in Sri Lanka, and mango trees in India ... ... *Odontotermes horni* (Wasmann)

Tooth of left mandible weak and situated at proximal third ; head sides converging in front. A subterranean termite pest of tea in eastern India and a serious pest of red gram ... ... *Odontotermes parvidens* Holmgren & Holmgren

40. Head-capsule subrectangular ; antennae uniformly yellow ; mandibles short and stout
[Head-length 1.55-1.66, head-width1.09-1.24 mm. Generally a subterranean termite, sometimes builds mounds ; a serious pest of sugarcane in India] ... ... *Odontotermes assmuthi* Holmgren

Head-capsule oval or subrectangularly oval ; antennae darker anteriorly ; mandibles comparatively thin and long 41

41. Postmentum very wide and arched, slightly longer than wide [head-length 1.25-1.40, head-width 1.15-1.30. Known only from Andaman Islands] ... ... *Odontotermes latigula* Snyder

Postmentum not very wide and arched, much longer than wide ... 42

42. Mandibles strongly incurved in distal half ; tooth of left mandible situated a little above middle
[head-length 1.53-1.74, head-width 1.20-1.45 mm. Common mound-building termite of southern and central India ; a pest ofsugarcane and many other crops] ... ... *Odontotermes wallonensis* (Wasmann)

Mandibles not much incurved ; tooth of left mandible situated near distal third 43

43. Head-capsule subrectangularly oval ; larger species (head-length 1.50-1.61, width 1.25-1.32 mm). A pest of wheat and maize, occuring in north-western India and Pakistan ... ... *Odontotermes gurdaspurensis* Holmgren & Holmgren

Head-capsule oval ; smaller species (head-length 1.15-1.48, head-width 0.98-1.18). A very common mound-building termite of Indian subcontinent ; a serious pest of many crops ... ... *Odontotermes obesus* (Rambur)

A common mound building termite of Sri Lanka and southern and eastern India ; a serious pest of many crops ... ... *Odontotermes redemanni* (Wasmann)

44. Soldier monomorphic : Head not broadly rounded behind (head-length with nasute 1.35-1.50, without nasute 0.80, head-width

0.75-0.92 ; mandibles with spine-like process. A common nasute termite of Sri Lanka ; recorded attacking coconut and tea plants ... ... *Nasutitermes ceylonicus* (Holmgren)

Soldier dimorphic : Head very broadly rounded behind (Soldier major : Head-length with nasute 2.40-2.50, without nasute 1.40-1.50, head-width 1.38-1.42 mm ; mandibles without spine-like process. A widely distributed termite in India ; a serious pest of wheat, vegetable crops and fruit trees ... ... *Trinervitermes biformis* (Wasmann)

(B) DIAGNOSIS, DISTRIBUTION and PEST STATUS of MORE IMPORTANT TERMITE PESTS

Family KALOTERMITIDAE

Species of the family Kalotermitidae are strictly wood termites. They nest in dead portions of living trees, wooden structures in buildings, furniture, etc. As such they are a cause of damage to tea and rubber plantations, fruit and forest trees, wooden structures in houses and wooden articles. Fortythree species belonging to nine genera viz., *Postelectrotermes*, *Neotermes*, *Kalotermes*, *Glyptotermes*, *Incisitermes*, *Epicalotermes*, *Bifiditermes*, *Procryptotermes* and *Cryptotermes* are known from the Indian region. The species of the genera *Postelectrotermes*, *Neotermes* and *Glyptotermes* are pests of tea, coconut and rubber plantations, fruit trees and forest trees and those of the genus *Cryptotermes* are well known destructors of wood-works in houses and buildings in the coastal regions.

The following are some of the common pests which pertain to the subject matter of this publication :—

Genus **Postelectrotermes** Krishna

The species of the genus *Postelectrotermes* can be easily distinguished from others of the family for having an extra spine above the dorsal spur of the middle tibia in all its castes. Five species of the genus are reported from the Indian subregion, they are *pasniensis* Akhtar and *pishinensis* Ahmed from Pakistan ; *bhimi* Roonwal & Maiti and *nayari* Roonwal & Verma from southern India ; and *militaris* (Desneux) from Sri Lanka. *P pasnienesis* is recorded from *Ficus*, *Acacia* and *Zizyphus* spp. ; *pishinensis* from a willow tree and *nayari* from an unknown wood and as such they are pests of no economic significance. The other two species i.e., *bhimi* and *militaris* are reported from tea from Southern India and Sri Lanka, respectively. The latter species is recorded from several other trees and plants also and does consider-

able damage to tea plantations in Sri Lanka. The former species can be a potential pest of significance, as such these two species are being taken into account here.

1. **Postelectrotermes bhimi** Roonwal & Maiti

(Fig. 1 A)

1965. *Postelectrotermes bhimi* Roonwal and Maiti, *Indian J. Ent.*, **27** (3) : 255-261.

Diagnosis : IMAGO.—Not known.

SOLDIER (Fig. 1A).—Head brownish, pronotum paler than head and abdomen yellowish. Head-capsule subrectangular, parallel sided (length 2.69, width 1.50 mm), epicranial suture distinct ; eye-spots elongate, oval ; fontanelle and ocelli absent ; antennae 13+ segmented, segment 4 shortest ; labrum short, dome-shaped ; mandibles thick and long, left with 5 and right with 2 marginal teeth ; postmentum club-shaped, antenior broader part bilobed ; pronotum flat, with incurved and medially notched anterior margin. Length c 8.0 mm.

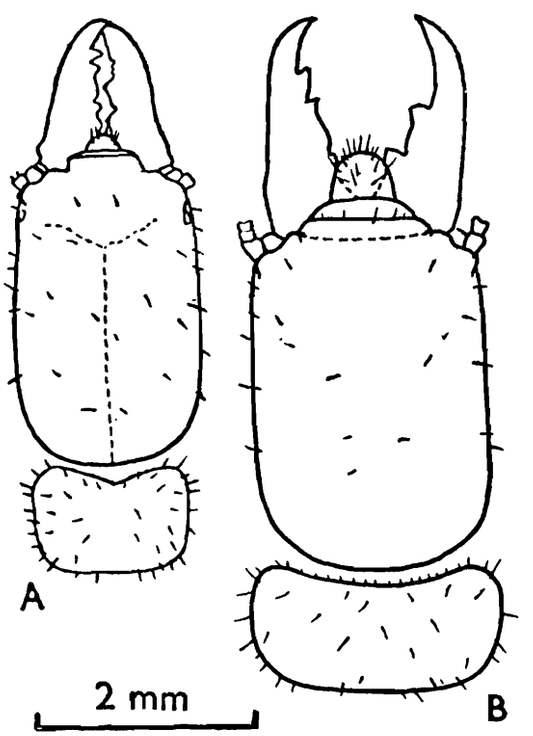

Fig. 1. Head and pronotum of soldier of *Postelectrotermes* : A, *bhimi* Roonwal & Maiti ; B, *militaris* (Desneux)

Distribution : India : Kerala : Vendiperiyar.

Hosts and pest status : This termite is recorded from a tea plant from Vendiperiyar, Kottayam District, Kerala. It is not a serious pest and has been recorded only once, but can be a potential pest of importance since its ally in Sri Lanka is reported as a serious pest of tea and other plants.

Biology and ecology : Nothing known.

2. **Postelectrotermes militaris** (Desneux)

(Fig. 1 B)

1904. *Calotermes militaris* Desneux, *Annls. Soc. ent. Belg.*, **48** (3) : 146.

Diagnosis : IMAGO.—Reddish brown, wings yellowish. Head-capsule subcircular (length to base of mandibles 1.4-1.7, width with eyes 1.90-1.95 mm), epicranial suture either absent or indistinct ; eyes circular, 0.45-0.50 mm in diameter ; ocelli oval, slightly separted from eyes ; antennae 19 to 20-segmented, segment 4 shortest ; pronotum subrectangularly flat, with broadly incurved anterior margin and faintly incurved posterior margin. Length with wings c 19-20.5 mm, without wings c 10.5-11.5 mm.

SOLDIER (Fig. 1B).—Head brown to castaneous brown, body yellowish white. Head-capsule subrectangular, parallel sided (length 2.88-3.15, width 2.04-2.40 mm), epicranial suture indistinct ; eye-spots suboval, small ; fontanelle and ocelli absent ; antennae 16 to 18-segmented, segment 4 shortest ; mandibles thick and stout, left with 4 and right with 2 marginal teeth ; postmentum club-shaped, bilobed at the anterior wider portion ; pronotum flat, subrectangular, as wide as head and with broadly and shallowly incurved anterior margin. Length c 10-11 mm.

Distribution : This species is widely distributed in Sri Lanka in the tea growing districts at altitudes of 1,065-1,300 m.

Hosts and pest status : This termite is very destructive to tea plants and has also been recorded from a large number of other plants and trees, such as *Acacia decurrens*, *Acacia* sp., *Aleurites* spp., *Albizzia moluccana*, *Albizzia* sp., *Cedrela toona*, *Crotolaria anagyroides*, *Calophylum tomentosum*, *Casuarina equisetifolia*, *Cinnamomum camphora* (camphor), *Cryptomeria japonica*, *Erythrina lithosperma*, *Doona zeylanica*, *Eucalyptus* spp., *Eugenia gardneri*, *Grevillea robusta* (silky oak), *Linociera purpurea*, *Litsea zelanica*, *Semecarpus coriacea*, *Symplocos spicata* and *Wendlandia notoniana*.

Since this termite does a considerable damage to tea plantations and is reported as a pest of several plants, it is of great economic importance.

Biology and ecology : *Postelectrotermes militaris* is found to occur at elevations of about 1,000 to 1,300 m (3,500-4,500 ft) in Sri Lanka. It is a great enemy of tea bushes and not only hollows out the stem and branches but infests the roots and rootlets. The infestation spreads either through the roots of healthy plants coming in contact with the infested-ones or through some weak spots above ground.

The nest of the species is generally in the heartwood and is made up of irregular cavities and tunnels which are filled partly with faecal matter. The colonies are generally small, but sometimes a tea bush may have 3,000-4,000 individuals (Pinto, 1941).

The winged adults, in the completely excavated tea bushes, have often been noted. Several (as many as 100) neotenics may also be produced due to the isolation of groups of pseudoworkers while spreading to the nearby plants through the roots.

In the laboratory colonies, the winged forms were obtained in one case after seven-and-a-half and in another after eight-and-a half, years. The brachypterous and apterous neotenics were raised in the laboratory by isolating last stage nymphs having wing pads and about nine months old larvae, respectively. The neotenics were also kept alive for as long as one year and eight months without the pseudoworkers, showing thereby that they could feed themselves but they did not lay fertile eggs (Pinto, 1941).

Genus **Neotermes** Holmgren

Sixteen species of the genus *Neoterms* are known from the Indian subregion. Of these, eleven are from India, two each from Bangla Desh and Sri Lanka and one from Burma. The species of this genus are pests of living trees and dead woods and are reported from a large number of plant species. The species *assmuthi* Holmgren, *bosei* Snyder, *fletcheri* Holmgren & Holmgren and *mangiferae* Roonwal & Sen-Sarma are pests of mango trees in India and *greeni* (Desneux) is a pest of tea and several other plants in Sri Lanka.

3. **Neotermes assmuthi** Holmgren

(Fig. 2A)

1913. *Calotermes (Neotermes) assmuthi* Holmgren, *J. Bombay nat. Hist. Soc.*, **22** (1) : 102-103.

Diagnosis : IMAGO.—Head-capsule brownish, body paler than head, wings transparent. Head-capsule subcircular, width (1.50 mm) subequal to length to base of mandibles (1.30 mm), epicranial suture not visible ; eyes large, subcircular, 0.50 mm in diameter ; ocelli oval, large, touching the eyes ; antennae with 18-19 segments, segment 3 chitinised and larger than 2 ; pronotum subrectangular with weakly incurved anterior and posterior margins ; wings not tuberculate. Length without wings c 7.5-8.0 mm.

SOLDIER (Fig. 2 A).—Head-capsule straw coloured to yellowish brown, body yellowish. Head-capsule subrectangular (length 2.7-3.1, width 2.0-2.1 mm), a little less than one-and-a-half times as long as wide, Y-suture present ; eye-spots oval ; ocelli and fontanelle absent ; antennae with 14-16 segments, segment 3 strongly chitinised and longer than 2 ; mandibles stout, as long as 2/3 rds of head without mandibles, left with 5 and right with 2 marginal teeth ; postmentum club-shaped, bilobed at club ; pronotum subrectangular, as wide as or wider than head, weakly incurved at anterior margin and shallowly incurved medially at posterior margin. Length c 9.5-11.0 mm.

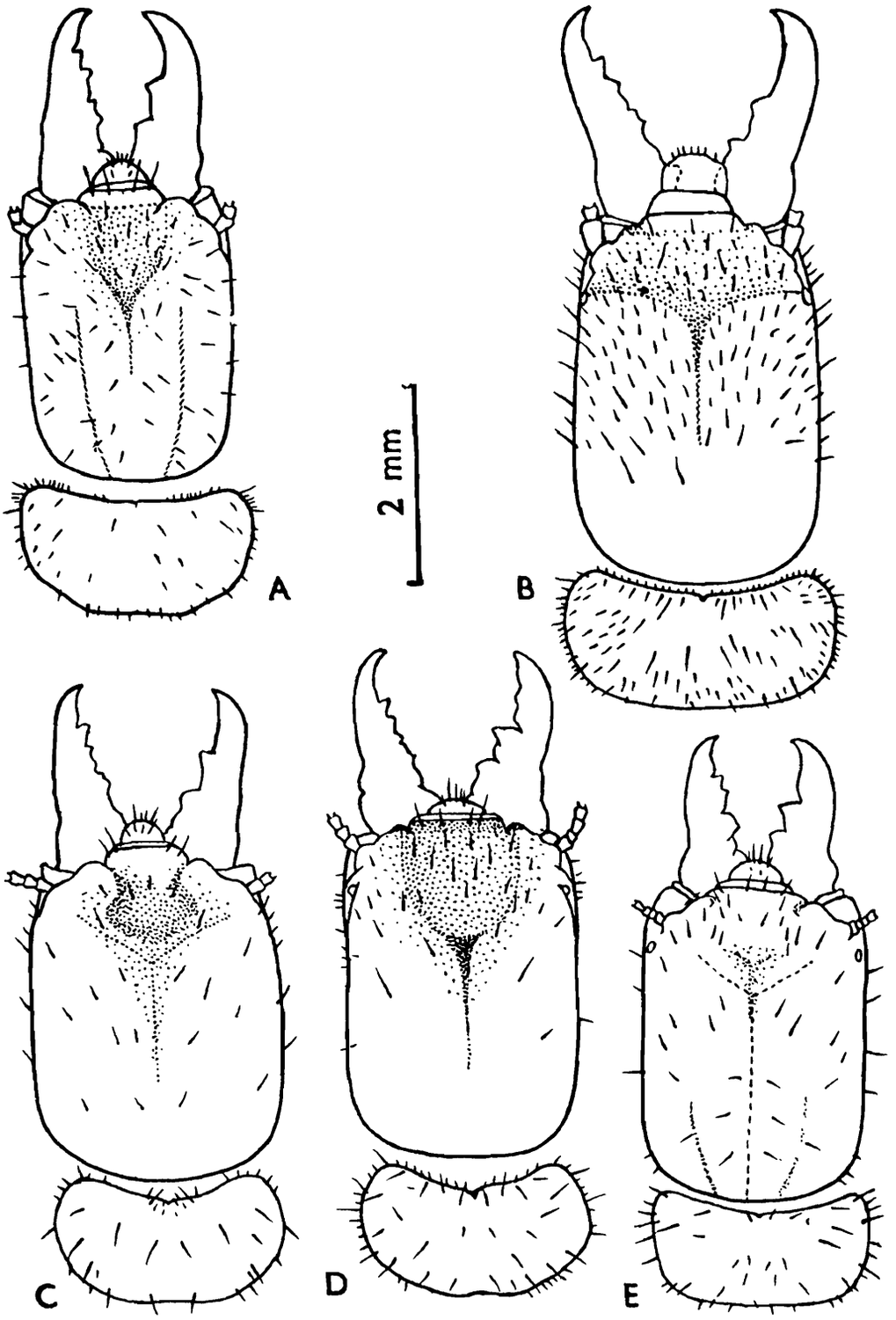

Fig. 2. Head and pronotum of soldier of *Neotermes* : A, *assmuthi* Holmgren ; B, *bosei* Snyder ; C, *fletcheri* Holmgren & Holmgren ; D, *greeni* (Desneux) ; E, *mangiferae* Roonwal & Sen-Sarma (After Roonwal & Sen-Sarma, 1960, drawings brought to same scale for comparison.)

Distribution : This species is confined to southern India and is known from Karnataka state and Goa (Western Coast).

Hosts and pest status : It is recorded from *Mangifera indica* (mango), *Artocarpus heterophyllus*, "Basri" and "Banyan" trees. It is not a serious pest of mango, however.

Biology and ecology : *N. assmuthi* attacks the branches and trunk and its damage is in the form of long, narrow galleries and cavities of irregular nature. The galleries are filled with masses of faecal matter, sometimes blocking the galleries. Swarming in small numbers has been recorded in the laboratory during May to October (Sen-Sarma et at., 1975).

4. **Neotermes bosei** Snyder

(Fig. 2B)

1933. *Kalotermes (Neotermes) bosei* Snyder, *Proc. U. S. natn. Mus.*, **82** (16) : 2-3.

Diagnosis : IMAGO.—Head castaneus brown, body brownish. Head-capsule subcircular, with eyes broader than length to base of mandibles (length 1.5-1.6, width 1.7-2.0 mm), epicranial suture distinct ; eyes large, subcircular, 0.65-0.67 mm in diameter ; ocelli oval, large, touching the eyes ; antennae 17-18 segmented, segment 3 shorter than or sometimes as long as 2 ; pronotum as wide as head, with anterior margin appreciably incurved and posterior margin nearly straight ; wings transparent, not tuberculate. Length with wings c 17-18, without wings c 8.5-10.5 mm.

SOLDIER (Fig. 2 B).—Head pale reddish brown, body straw coloured. Head-capsule subrectangular, length 1½ times that of width (length 2.9-4.0, width 2.2-2.5 mm), epicranial suture indistinct ; eye-spots small, oval ; antennae 14-16 segmented, segment 3 strongly chitinised, either subequal to or longer than 2 ; mandibles stout and strong, length 1/2 to 2/3 of head-length without mandibles, left with 5 and right with 2 marginal teeth ; postmentum long, club-shaped, club either indistinctly or not bilobed ; pronotum flat, subrectangular, anteriorly broadly incurving and posteriorly substraight. Length 9.5-12.00 mm.

Distribution : North and North-eastern India (Dehra Dun and vicinity ; Samsingh, West Bengal) and Bhutan (Phuntsholing, Samchi).

Hosts and pest status : It is a common species in Doon Valley and has been recorded from *Mangifera indica, Acer oblongum, Artocarpus hetrophyllus, A. lakoocha, Cedrela toona, Ficus* spp. and *Pterospermum acerifolium* trees (Sen-Sarma et al., 1975). The damage to standing trees is in the form of longitudinal galleries which penetrate deep into the heartwood but the species is not a pest of much importance.

Biology and ecology : It is a semi-wild species and its nest, like that of other *Neotermes* species, is made up of longitudinal galleries which run along the fibre of the wood and are filled with brownish masses of faecal pellets. The pellets are hygroscopic and probably help in maintaining humidity in the nest. The swarming has been recorded from February to July (Roonwal & Sen-Sarma, 1955 ; Mathur and Sen-Sarma, 1959).

5. **Neotermes fletcheri** Holmgren & Holmgren

(Fig. 2C)

1917. *Calotermes* (*Neotermes*) *fletcheri* Holmgren and Holmgren, *Mem. Dept. Agric. India (Ent.)*, **5** (3) : 139.

Diagnosis : IMAGO.—Head-capsule and body brownish, underside of obdomen yellowish. Head-capsule subcircular, width with eyes (1.55-1.70 mm) subequal to length (1.30-1.40 mm) to base of mandibles ; Y-suture faint or absent ; eyes moderately large, subcircular, 0.45-0.55 mm in diameter ; ocelli suboval, touching the eyes ; antennae with 18 segments, segments 3 and 4 subequal, shortest ; pronotum subrectangular, as wide as head with eyes, anterior margin appreciably incurved, posterior margin substraight and faintly incurving medially ; wings transparent, weakly tuberculate. Length with wings c 14-15, without wings 7.7-9.7 mm.

SOLDIER (Fig. 2 C).—Head-capsule castaneous brown, pronotum deep straw coloured, abdomen paler. Head-capsule subrectangular, length (2.90-3.75 mm) a little more than width (2.30-2.45 mm), epicranial suture faint ; eye-spots suboval, small ; antennae 13 to 15-segmented, segment 3 a little shorter to a little longer than 2, 4 shortest ; mandibles a little shorter to a little longer than half of head-length, left with 5 and right with 2 marginal teeth ; postmentum club-shaped, anterior lobe (club) bilobed ; pronotum narrower than head-capsule, anteriorly strongly incurved and posteriorly with a weak median incurving. Length c 10-11 mm.

Distribution : It is restricted to southern India and is reported from Coimbatore (Tamil Nadu) and Nilambur (Kerala).

Hosts and pest status : This termite attacks dead and dried parts of living trees of *Mangifera indica*, *Moringa oleifera*, *Artocarpus heterophyllus*, *Delonix regia* and logs of wood. Although reported from mango trees it is not a serious pest.

Biology and ecology : The nest of this termite is made up of narrow, longitudinal galleries which are partially filled with wood dust and faecal matter. Nothing is known about the swarming behaviour, the imagos, however, have been collected from the nests in the months of November and December.

6. **Neotermes greeni** (Desneux)

(Fig. 2D)

1908. *Calotermes greeni* Desneux, *Annls. Soc. ent. Belg.*, **51** : 388-389.

Diagnosis : IMAGO.—Head-capsule and body brown above ; sternites straw-coloured. Head-capsule subcircular, width (1.55-1.7 mm) subequal to length (1.3-1.4 mm) to base of mandibles ; eyes sub-circular, moderately large,

0.45-0.55 mm in diameter ; ocelli oval, faintly separated from eyes ; antennae with 16-19 segments, segment 3 either shorter than (19-segmented antenna) or as long as 2 (17-segmented-one), 4 as long as or shorter than 3 ; pronotum subrectangular, nearly as wide as head with eyes, anterior margin deeply incurved, posterior margin substraight with a faint incurving ; wings transparent, not tuberculate. Length with wings c 14, without wings c 7.5 mm.

SOLDIER (Fig. 2 D).—Head-capsule pale brown to dark brown ; body yellowish to pale brown. Head-capsule subsquarish to subrectangular, width (2.07-2.4 mm) nearly 2/3 to 3/4 of length (2.80-3.5 mm) to base of mandibles, Y-suture distinct ; eye-spots oval, vertically elongate ; antennae with 14-16 segments, segment 3 a little longer than 2 ; mandibles thick and stout, about 1/2 to 2/3 of head-length without mandibles, left with 5 and right with 2 marginal teeth ; postmentum club-shaped and elongate, club bilobed ; pronotum subrectangular and as wide as head, anterior margin broadly and deeply and posterior margin shallowly incurved. Length c 9-11 mm.

Distribution : It is quite widely distributed in Sri Lanka and is recorded from sea-level to nearly 1,500 m elevation.

Hosts and pest status : It is reported as a pest of some importance of tea plantations in Sri Lanka and has also been recorded from a large number of species of trees such as *Aleurites* spp., *Anacardium occidentale* (cashew nut), *Artocarpus integra*, *Araucaria cooki*, *Casia multijuga*, *Casuarina equisetifolia*, *Cedrela toona*, *Crotolaria anagyroides*, *Croton aromaticus* (croton oil plant), *Cupressus knightiana*, *Derris* spp., *Erythrina lithosperma*, *Elaeocarpus serratus*, *Ficus elastica*, *Grevillea robusta* (silky oak), *Hevea brasiliensis* (rubber), *Ligustrum walkeri*, *Litsea glutinosa*, *Macaranga roxburghii*, *Michelia champaca*, *Nephelium lappaceum*, *Ormosia dasycarpa*, *Samanea saman* (rain-tree), *Samanea* spp., *Pittosporum viridiflorum*, *Spondias lutea*, *Shorea robusta* (sal), *Solanum macranthum* and *Stercula* spp.

Biology and ecology : In Sri Lanka this species occurs from sea level to about 1,500 m (5,000 ft) altitude. Its nest is in the form of moderately large, longitudinal galleries. The attack is generally above ground and is not as destructive to tea plantations as that by *Postelectrotermes militaris*, even though this species is quite widely distributed in Sri Lanka and reported to infest a number of plants. Nothing is known about the swarming behaviour.

7. **Neotermes mangiferae** Roonwal & Sen-Sarma

(Fig. 2 E)

1960. *Neotermes mangiferae* Roonwal and Sen-Sarma, *Contrib. Syst. Orient. Termites* (ICRA Ent. Mongr. 10 28) : 139, 143, 208-211.

Diagnosis : IMAGO.—Not known.

SOLDIER (Fig. 2E).—Head-capsule brown, body yellowish. Head-capsule subrectangular, width (2.3-2.52 mm) nearly 3/4 of length (2.9-3.33 mm) without

mandibles, Y-suture prominent ; eye-spots broadly oval ; antennae with 13-16 segments, segment 3 subequal to 2, 4 shortest ; mandibles short and stout, shorter to a little longer than half of head without mandibles ; postmentum long, club-shaped, club bilobed ; pronotum subrectangular, as wide as head ; anterior margin broadly incurved, posterior margin substraight. Length c 10-10.5 mm.

Distribution : Eastern India (Tripura).

Hosts and pest status : While describing the species Roonwal and Sen-Sarma (1960) recorded it from a log of *Mangifera indica* in a timber depot in Calcutta. Evidently it attacks living mango trees and more recently it has been reported attacking dead branches and living portions of *Morus alba* in Tripura (Sen-Sarma et al., 1975).

Biology and ecology : Nothing is known about the biology and ecology of this species.

Genus **Kalotermes** Hagen

Of the two species of *Kalotermes* known from the Oriental region, only one viz., *K. jepsoni* Kemner is known from Sri Lanka, in the Indian subregion.

8. **Kalotermes jepsoni** Kemner

(Fig. 3)

1932. *Kalotermes jepsoni* Kemner, *Ent. Tidskr.*, **53** (2-3) : 146-149.

Diagnosis : IMAGO.—Head-capsule and body above dark brown ; sternites yellowish brown. Head-capsule subcircular (length 1.20, width 1.30 mm), sides subparallel, Y-suture not visible ; eyes small, subcircular (0.35 mm in diameter) ; ocelli oval, either touching eyes or slightly separated ; antennae with 15-16 segments, segment 3 shorter than or subequal to 2, 4 shortest ; pronotum subrectangular, slightly broader than head, anterior margin weakly incurved, posterior margin with faint, median incurving ; wings brown, tuberculate and with weak media. Length without wings c 6.5 mm.

SOLDIER (Fig.3).—Head-capsule brown, pronotum and legs yellowish, body whitish. Head-capsule subrectangular, about one-and-a-half times as long as wide (length 2.10-2.40, width 1.34-1.50 mm) ; eyes absent ; antennae 14-segmented, segment 3 longer than 2 and strongly chitinised, 4 shortest ; labrum large, tongue-shaped ; mandibles long, slender and almost straight, left mandible with 5 and right with 2 marginal teeth ; postmentum long, club-shaped, club strongly bilobed, waist long and in width almost 1/3 of maximum width at club ; pronotum trapezoidal, anterior margin deeply incurved and either slightly or not notched, posterior margin substraight or somewhat outcurved, Length c 8.4-8.8 mm.

Distribution : This is the only species of the genus *Kalotermes* known from the Indian region and is restricted to Sri Lanka from where it is reported from elevations of 1,000-1,200 m (3-4,000 ft) from Maskeliya and Pundaluoya.

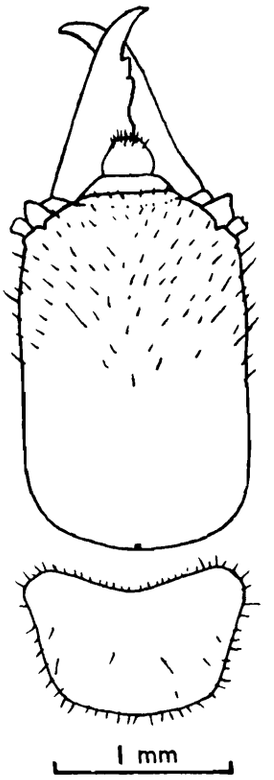

Fig. 3. Head and pronotum of soldier of *Kalotermes jepsoni* Kemner (After Roonwal & Sen-Sarma, 1960 ; drawings of head and pronotum brought to same scale).

Hosts and pest status : This species is reported from tree stumps of *Doona zeylanica* and dead and live woods of *Albizzia* sp., *Cederela toona* and *Eugenia gardneri*. Pinto (1941) states that it has not been found attacking cultivated crops, but according to Harris (1971) it is occassionally found on tea in Sri Lanka. It is not a serious pest of tea anyhow.

Biology and ecology : *Kalotermes jepsoni* prefers dead and decaying wood, but the live tissue is not ignored. The infestation is in the form of longitudinal galleries and the attack is generally confined to stem above ground. Nothing is known about the life-history and behaviour of this species. The winged adults have, however, been collected in the field in the month of September from a jungle stump.

Genus **Glyptotermes** Froggatt

Seventy-seven species of the genus *Glyptotermes* are known from all over the world, from the tropics. Out of these, 27 occur in the Indo-malayan region and 11 in the Indian subregion. Three species *viz.*, *almorensis* Gardner, *ceylonicus* Holmgren and *dilatatus* (Bugnion & Popoff) are of agricultural

importance. The former species is recorded from northern India and latter two from Sri Lanka. The other eight species are reported from India and Bangla Desh.

9. **Glyptotermes almorensis** Gardner

(Fig. 4 A)

1944. *Kalotermes (Glyptotermes) almorensis* Gardner, *Indian J. Ent.*, **6** : 104-105.

Diagnosis : IMAGO.—Head-capsule and body castaneous brown above, sternites paler. Head-capsule subcircular, width (0.90-0.97 mm) subequal to length to base of mandibles (0.90-0.97 mm), epicranial suture distinct ; eyes small, subcircular, 0.23-0.25 mm in diameter ; ocelli oval, generally touching the eyes but sometimes faintly separated ; antennae with 12 segments, segment 3 shorter than 2 ; pronotum subrectangular, narrower than head with eyes, anterior margin weakly incurved, posterior margin substraight ; wings dark brown, tuberculate. Length with wings c 7-8, without wings c 4.4-5.4 mm.

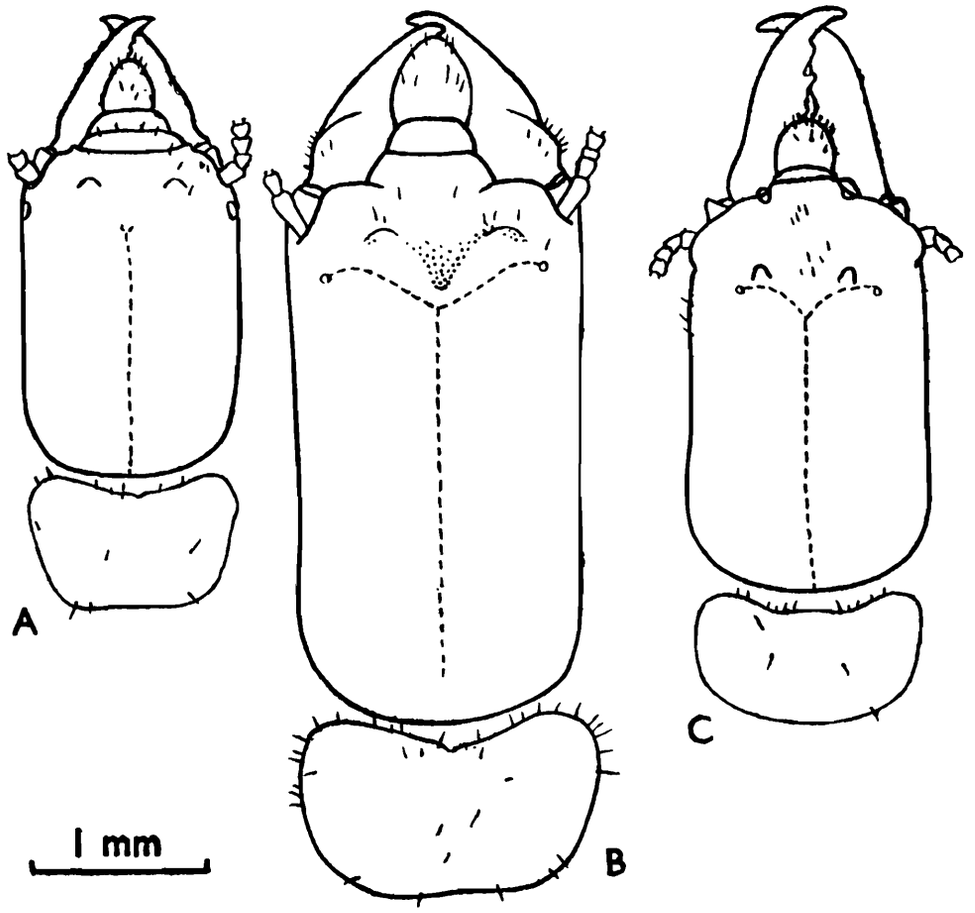

Fig. 4. Head and pronotum of soldier of *Glyptotermes* : A. *almorensis* Gardner ; B, *ceylonicus* Holmgren ; C, *dilatatus* (Bugnion & Popoff).

SOLDIER (Fig. 4 A).—Head-capsule reddish brown ; body pale yellowish brown, last tergite darker. Head-capsule subrectangular, length (1.43-1.73 mm) about one-and-a-half times that of width (1.07-1.13 mm), epicranial suture

faint, lateral protuberances of frons weak ; eye-spots oval, small, flush with head surface ; labrum broadly tongue-shaped ; mandibles short and stout, shorter than half of head-length without mandibles, left mandible with three and right with two marginal teeth ; postmentum long, club-shaped, a little shorter than half of head-length without mandibles ; pronotum subrectangular, slightly narrower to as wide as head, anterior margin incurved and weakly notched medially, posterior margin substraight. Length c 4.8-5.7 mm.

Distribution : India : Uttar Pradesh : Kumaon Hills.

Hosts and pest status : It is reported from dead branches and dead portions of the stem of *Mangifera indica*, *Celtis australis*, *Rhododendron arboreum* and *Shorea robusta*. It is not a serious pest of mango.

Biology and ecology : Nothing is known about the biology and ecology of this termite. It is, however, restricted to higher altitudes in northern India and the imagos have been collected from the nest in the month of June.

10. **Glyptotermes ceylonicus** Holmgren

(Fig. 4 B)

1911. *Calotermes (Glyptotermes) ceylonicus* Holmgren, in : Escherich's *Termitenleben auf Ceylon* : 187-189.

Diagnosis : IMAGO.—Head and body pale brown above, paler below. Head-capsule quadrately oval (length 1.33-1.52, width 1.15-1.30 mm) ; eyes small ; ocelli medium-sized, touching the eyes ; antennae 13-segmented, segment 3 as long as 2 ; pronotum as wide as or slightly narrower than head, posterior margin hardly sinuate ; wings hyaline, transparent, punctate, weakly iridescent. Length with wings c 8.5-11.0, without wings c 4.7-6.0 mm.

SOLDIER (Fig. 4 B).—Head-capsule pale brownish yellow ; body straw yellow. Head-capsule thick, large, subrectangular (length 2.67-3.0, width 1.50-1.67 mm) ; protuberances on frons prominent ; suture distinct ; eye-spots suboval, translucent ; ocelli dot-like, translucent, situated at each end of lateral arms of epicranial suture ; antennae with 12 segments, 3rd segment shortest ; mandibles thick, stout, short, about 1/3 of head without mandibles, both with 2 marginal teeth each ; labrum broadly tongue-shaped ; postmentum long, club-shaped, with fairly long and strongly incurved waist ; pronotum flat, subrectangular, as wide as or a little narrower than head, anterior margin fairly incurved and medially notched and posterior margin either notched or weakly incurved medially. Length c 6.5-10.4 mm.

Distribution : It is restricted to Sri Lanka and is recorded from a number of localities (for details Chhotani, 1975).

Hosts and pest status : This termite is not a serious pest and has been recorded only from wood of *Hevea* (rubber), *Artocarpus integra* and *Acacia sp.* and decaying logs of rubber trees.

Biology and ecology : Nothing is known about the biology and ecology of this species, It's damage, however, is in the from of longitudinal galleries excavated in the wood.

11. **Glyptotermes dilatatus** (Bugnion & Popoff)

(Fig. 4 C)

1910. *Calotermes dilatatus* Bugnion and Popoff, *Mem. Soc. zool. Fr.*, **23** : 137-143.

Diagnosis : IMAGO.—Head-capsule brownish yellow, body paler. Head-capsule subcircular (width with eyes 1.03-1.20) ; eyes medium sized, subcircular, 0.30-0.40 mm in diameter ; ocelli oval, either faintly separated or touching the eyes ; antennae with 13-15 segments, 3rd segment shorter to longer than either 2 or 4 ; pronotum either narrower than or as wide as head with eyes, anterior margin incurved, posterior margin weakly convex. Length without wings c 4.3-4.7 mm.

SOLDIER (Fig. 4 C).—Head-capsule yellowish brown to brownish red, body yellow to yellowish brown. Head capsule cylindrical, subrectangular (length 2.03-2.33, width 1.30-1.37 mm), frons sharply sloping in front, bilobed and with two prominent protuberances at base, epicranial suture prominent ; eye-spots small, oval, unpigmented ; ocelli minute, point-like, situated at end of lateral sutures ; antennae with 11-14 segments, segment 3 either shorter or longer than 2 ; mandibles long and stout, left with 4 and right with 2 marginal teeth ; postmentum long, club-shaped with weakly bilobed club and long and narrow waist ; pronotum narrower to wider than head-capsule, anterior margin incurved, posterior margin convex. Length c 7 mm.

Distribution : It is quite a common species in Sri Lanka and is recorded from several localities (for details vide Chhotani, 1975).

Hosts and pest status : *Glyptotermes dilatatus* is a pest of tea, coffee and rubber plantations and is also recorded from several other plants such as *Aleurites* spp., *Artocarpus integra*, *Casuarina equisetifolia*, *Cedrela toona*, *Clerodendrum nutans*, *Crotalaria anagyroides*, *Delonix regia*, *Eriobotrya japonica* (lokat), *Erythrina lithosperma*, *Ficus tsiela*, *Grevillea* spp., *Ligustrum walkeri*, *Magnolia grandiflora*, *Moringa oleifera*, *Musa sapientum* (plantain), *Psidium guyava* (guava), *Theobroma cacao* (cocoa) and *Wormia triquetra*.

The infestation of tea by this species has been reported up to 80 per cent of bushes in the infested areas but according to Fernando (1962) no specific analyses appear to have been made to confirm this and that the most recent observations indicate that there seems to be a definite preference for derelict and moribund bushes which anyhow need replacement.

Biology and ecology : This species occurs below 610 m of altitude in Sri Lanka and makes its nest in the heartwood of living trees. The nests are

ramification of longitudinal, interconnecting galleries and tunnels which run into the live tissue as well and give the wood a honey-comb appearance. The infested trees show very little evidence of attack externally. Laboratory experiments show that it takes about four-and-a-half years to obtain winged adults in the laboratory colony raised from a neotenic pair. As in *Postelectrotermes militaris*, the neotenics could be raised in the laboratory. All the castes including macropterous adults were also obtained from the eggs laid by the brachypterous or the apterus neotenics. The neotenics similarly were kept alive for as long as one year and eight months without the pseudoworkers, showing thereby that they could feed themselves but were not able to lay fertile eggs (Pinto, 1941).

Genus **Bifiditermes** Krishna

Of the three species of this genus known from the oriental region, two occur in the Indian subregion, one of which viz., *B. beesoni* (Gardner) can possibly become a pest of some importance since it is reported in semi-wild state near human habitations in India (Sen-Sarma et al., 1975). In Pakistan, it has been found infesting apple and 'ber' (*Zizyphus jujuba*) trees.

12. **Bifiditermes beesoni** (Gardner)

(Fig. 5)

1941. *Kalotermes beesoni* Gardner, *Indian J. Ent.*, **6** : 103.

Diagnosis : IMAGO.—Head-capsule brownish with reddish tinge ; body paler than head ; wings transparent. Head-capsule subcircular (length 1.18-1.56, width 1.36-1.51 mm), epicranial suture prominent ; eyes subcircular (0.48-0.59 mm in diameter), moderately large ; ocelli oval, touching eyes ; antennae with 16-18 segments, 3rd segment larger than 2, 4th shortest ; pronotum subtrapezoidal, broader than head with eyes and with incurved anterior and substraight posterior margins ; wings transparent, weakly tuberculate, media weak. Length with wings c 12.0-13.5, without wings 7.0-8.5 mm.

SOLDIER (Fig. 5).—Head-capsule reddish brown, thorax and legs brownish, abdomen straw-coloured. Head-capsule subrectangular, about one-and-a-quarter times as long as wide (length 2.02-2.47, width 1.57-1.95 mm), epicranial suture faintly visible ; eye-spots small, oval, black, facetted ; antennae 11 to 14-segmented, segment 3 longer than 2, 4th shortest ; mandibles large, robust, about 2/3rds of head without mandibles, swollen at base, left mandible with 4-5 and right with 2 marginal teeth ; postmentum long (sometimes short), club-shaped, width at waist about half of maximum width ; pronotum subrectangular, weakly wider than head and with deeply incurved anterior and straight or weakly outcurved posterior margins. Length 8.0-9.5 mm.

Distribution : This species is recorded from northern and north-western India (Uttar Pradesh, Haryana) and Pakistan (Lahore, Mianwali, Bhakkar).

Hosts and pest status : It is reported from *Acacia arabica*, *Dalbergia sissoo*, *Ficus bengalensis*, *Zizyphus jujuba* and apple trees, but is not a serious pest. Sen-Sarma et al. (1975), however, mention that since this termite is reported from near human habitations in the semi-wild state, there is a possibility of its becoming a serious pest at a later date.

Biology and ecology : The infestation of this termite in the trees is above ground. Although the beginning is made in the dead and damaged portions of the trees, attack extends to the live tissue as well. The damage is in the form of small, narrow, longitudinal galleries. These galleries are partly filled with dry, compressed, loose faecal pellets which are similar to those of *Cryptotermes* species.

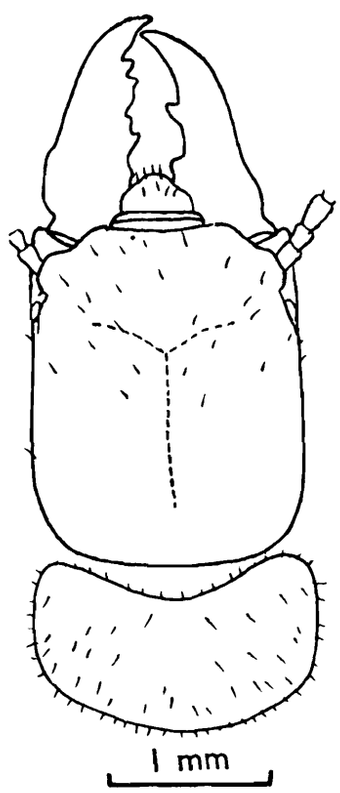

Fig. 5. Head and pronotum of soldier of *Bifiditermes beesoni* (Gardner).

The alates, soldiers and pseudoworkers are in the ratio of 1 : 5 : 94. All the alates collected in the field and those (nearly 90) emerged from a thriving laboratory colony with all the major castes and the youngs and eggs, were found to be females showing thereby reproduction by constant parthenogensis. The emergence of alates, in the laboratory colony, was during the months of June to August but emergence can not be ruled out during later months because some fully grown alates were noted in the laboratory colony when cut open in the month of September (Chhotani, 1959, 1962 *a*, *b*).

Genus **Cryptotermes** Banks

Six species *(domesticus, dudleyi, havilandi, karachiensis, perforans* and *roonwali)* of the genus *Cryptotermes* are known from the Indian subregion, of which *C. havilandi* only has been recorded from wild and semi-wild habitats in the coastal as well as interior parts of India, attacking mango trees and is consequently of some agricultural importance. The species *havilandi, dudleyi* and *domesticus* also damage wooden structures in buildings. The former is reported to do extensive damage to buildings in Tripura (India). The latter two are serious pests in buildings and houses in many parts of the world and cause damage to wooden articles, they are, however, not dealt with here individually since they are not of much significance as far as agriculture and stored-products are concerned.

13. **Cryptotermes havilandi** (Sjöstedt)

(Fig. 6 C)

1900. *Calotermes Havilandi* Sjöstedt, *K. Sv. Vet. Akad. Handl.*, **34** (4) : 37, 43-45, 218-220.

Diagnosis : IMAGO.—Head-capsule pale castaneous brown, body a little paler than head. Head-capsule subcircular, sides somewhat straight (length 0.90-1.03,width 0.93-1.07 mm), epicranial suture distinct ; eyes broadly oval (0.30-0.34 mm in diameter) ; ocelli oval, 0.09-0.13 mm long and touching the eyes ; antennae with 14-15 segments, 3rd and 4th segments subequal and shortest ; pronotum subrecrtangular, slightly narrower to a little wider than head with eyes and with anterior margin fairly and posterior-one shallowly, incurved ; wings hyaline with a brownish tinge, weakly punctate, media weak. Length with wings c 8-9, without wings c 4.7-6.5 mm.

SOLDIER (Fig. 6 C).—Head-capsule blackish anteriorly and reddish brown posteriorly ; body pale yellow to pale yellowish brown. Head-capsule thick, short, subsquarish (length 1.18-1.37, width 1.13-1.33 mm), sharply truncate and hollow in front and shallowly depressed at vertex, with a prominent frontal ridge overhanging the inclined frons and two knob-like tubercles of which dorsal being larger than the ventral-one, epicranial suture present ; eye-spots small, oval ; mandibles short, thick, stout and basally humped, each with 2 small, weak, marginal teeth, 2nd marginal of left mandible sometimes absent ; postmentum short, broader posteriorly and narrowing in front ; pronotum weakly narrower to as wide as head, anterior margin deeply and broadly incurved, posterior margin substraight. Length c 4.0-6.5 mm.

Distribution : Eastern, central and southern India ; Bangla Desh ; Africa ; Central and South America (for details vide Chhotani, 1970).

Hosts and pest status : This termite is recorded from *Mangifera indica, Heritiera minor, Erythrina indica,* a number of *Ficus* spp., some trees of un-

known species and dead stumps. The infestation sometimes extends to the live tissue as well although generally this species is reported from dead portions of trees. It is not a pest of much consequence at present.

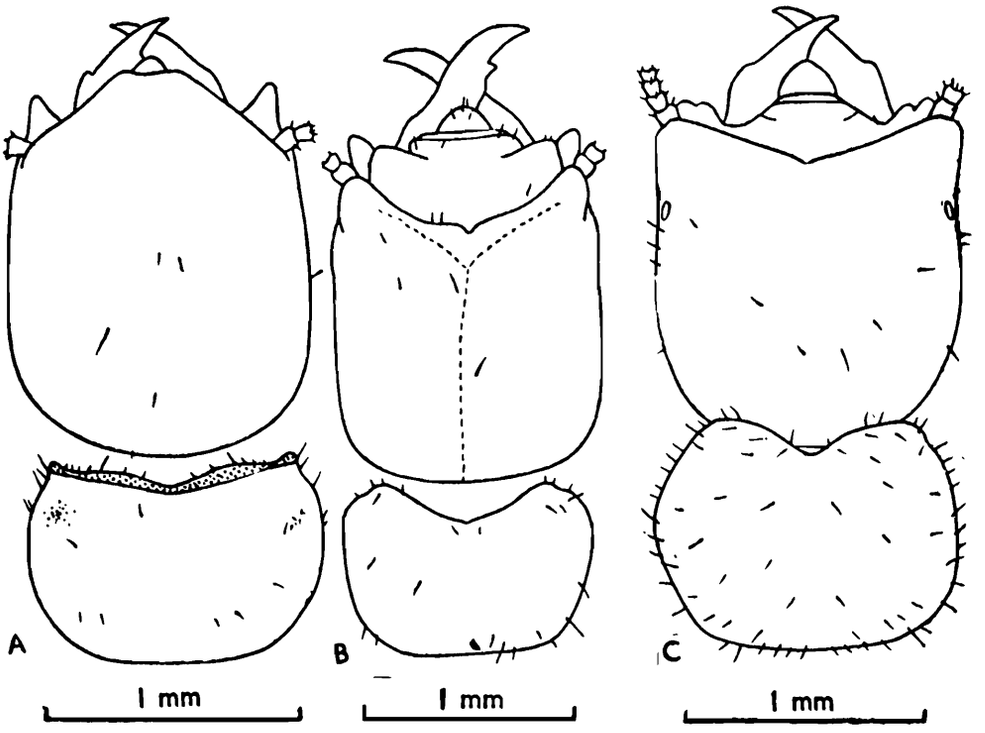

Fig. 6. Head and pronotum of soldier of *Cryptotermes* : A, *domesticus* (Haviland), B, *dudleyi* Banks, C, *havilandi* (Sjöstedt)

Biology and ecology : The nest of this species is made up of narrow, longitudinal galleries and flat chambers which are in the direction of the grain of the wood. Some parts of the chambers are filled with faecal pellets which are small and hexagonal in shape. The swarming has been observed in the months of May to June in a laboratory colony at Dehra Dun (Sen-Sarma et al., 1975) and during May to July at Calcutta (Chhotani, unpublished data). In the field, the imagos have, however, been collected during the months of February in Southern India and January and February in eastern India. Nothing is known about the life history of this termite.

As far as its ecological habits, it is recorded from wild and semi-wild habitats. Sen-Sarma and Thakur (1974) have reported it from the woodworks of buildings in Assam and Tripura, causing extensive damage to forest rest houses and buildings.

Family RHINOTERMITIDAE

The Rhinotermitidae includes termites having their main nests in soil under the ground-surface ; the nests extend to the trees and wooden structures in houses also. They are serious pests of fruit trees, forest trees and timber in timber yards, stored-products and structural timbers in houses and buildings.

The species which are pests of significance belong to the genera *Heterotermes* and *Coptotermes*. The common and widely distributed species viz., *Heterotermes indicola* in India and Pakistan and *Coptotermes heimi* in India, Pakistan and Bangla Desh, are two of the most notorious termites known from the subcontinent.

Subfamily HETEROTERMITINAE

Genus **Heterotermes** Froggatt

The genus *Heterotermes* is known by five species from the Indian subregion, out of which four species occur on the Indian mainland and one in Sri Lanka. *H. indicola* is the most common species and is highly injurious to stored-products, paper, cloth, jute goods and structural woods.

14. **Heterotermes indicola** (Wasmann)

(Fig. 7B)

1901. *Leucotermes indicola* Wasmann, *Zool. Jb.*, **17** : 118.

Diagnosis : IMAGO.—Head-capsule yellowish ; rest of body paler ; head and body fairly densely hairy. Head capsule subrectangular, parallel sided ; eyes oval, situated at about their long diameter from lateral margin of head ; ocelli indistinct or dot-like ; fontanelle minute, situated in middle of head ; antennae with 16-19 segments, segment 3 shortest ; labrum dome-shaped ; postclypeus faintly raised, short ; mandibles typically *Heterotermes*-type ; pronotum flat, narrower than head, anteriorly faintly incurved, posteriorly indistinctly emarginate ; wings whitish, densely punctate and sparsely hairy. Length with wings c 9.0-9.5, without wings c 4.5 mm.

SOLDIER (Fig. 7 B).—Head-capsule yellowish ; body paler than head. Head-capsule subrectangular, parallel sided (length 1.33-1.77, width 0.83-1.03 mm) ; fontanelle minute, circular, lying medially at about distal one-third of head-capsule and with a small fontanelle tube ; antennae with 14-15 segments ; labrum triangular with a long, thin, needle-like tip, a pair of long hairs at the base of tip and a few short-ones on body present ; mandibles long, thin, sabre-shaped, left with 3-4 crenulations in basal half ; postmentum long, club-shaped, with a long waist ; pronotum flat, weakly emarginate both anteriorly and posteriorly. Length c 3.5-5.0 mm.

Distribution : Widely distributed in India above 20° N latitude up to 2,500 m altitude in the Himalayan region (Roonwal, 1970) and extends to Pakistan and Afghanistan. It has recently been recorded from Bangla Desh.

Hosts and pest status : It is a highly injurious species as far as the stored-products and building structures are concerned and is a well known destroyer of paper, cotton textiles, leather and jute goods, timber in timber yards, wooden

articles and wooden structures in houses and buildings. Roonwal (1955) has recorded the complete ruining of Sri Hargobindpur township in Panjab. In Calcutta (West Bengal) a large number of old houses and in Karnal (Haryana) many of the houses in the Model Town area were found to be infested by this termite (author's observations). Chaudhury et al. (1972) record it as "one of the most notorious subterranean, wood destroying termite in West Pakistan." They have recorded it up to an altitude of 7,000 ft above sea level, damaging timber in buildings, forest plants, mulberry trees (seriously attacked on road-side, in Baluchistan and North-West Frontier province), library books, leather shoes, etc.

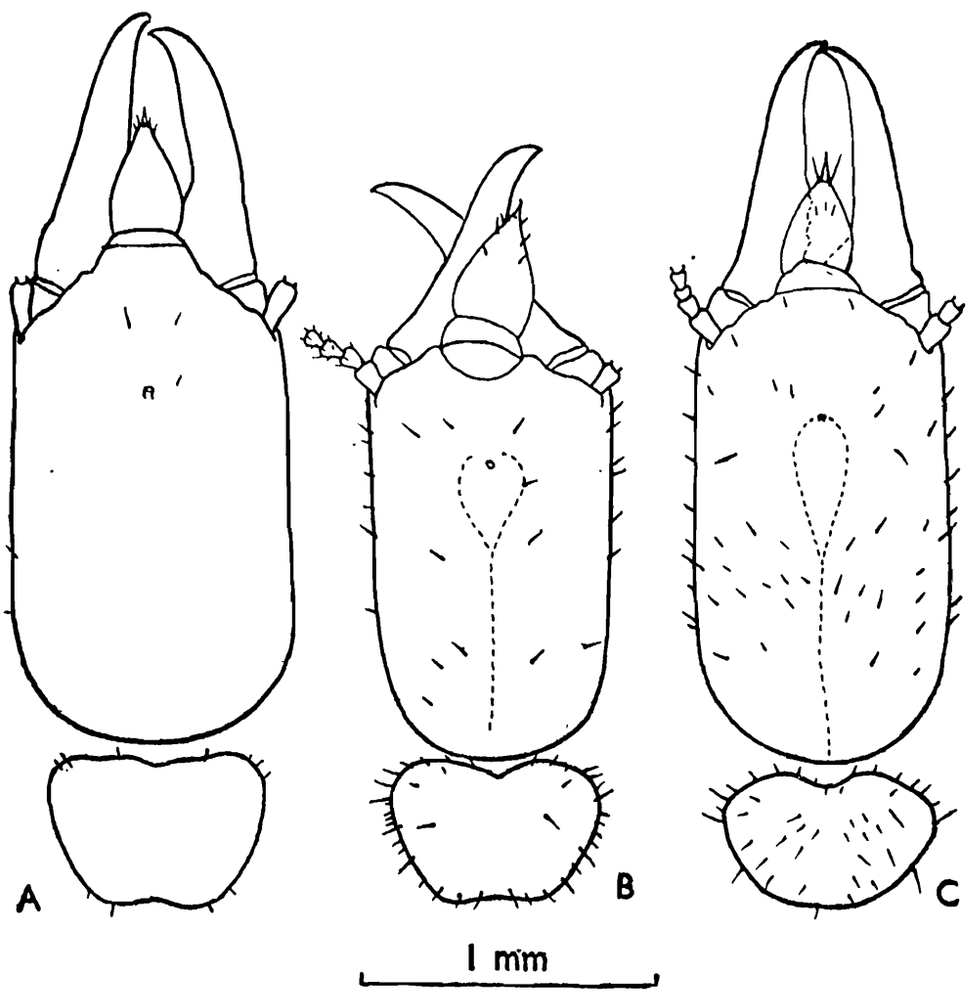

Fig. 7. Head and pronotum of soldier of *Heterotermes* : A, *ceylonicus* (Holmgren) ; B, *indicola* (Wasmann) ; C, *malabaricus* Synder.

It is also reported from woods of the following plant species :—*Abies pindrow, Acacia* sp., *Albizzia procera, Alnus nitida, Arotocarpus lakoocha, Bombax ceiba, Calotropis procera, Carapa* sp., *Cedrela toona, Dalbergia sissoo* (shisham), *Eriobotrya japonica* (lokat), *Eucalyptus* spp., *Flacourtia ramontchi, Melia azedarach, Morus alba, M. indica* (mulberry), *Pinus roxburghii* (chir pine), *Pinus wallichiana, Populus* sp., *Quercus leucotrichophora, Shorea robusta* (sal), *Tectona grandis* (teak), *Tamarix* sp., *Terminalia alata* and *Zizyphus* sp.

Biology and ecology : The nests of this termite are subterranean, but it constructs earthen galleries and tunnels to reach the source of food which is generally above the ground. The swarming of alates generally takes place after dusk during the rainy season from April to August. It has also been observed in the morning hours (Assmuth, 1913). In Calcutta, swarming has been observed from April to June. The colony founding is through swarming of reproductives but can be through substitute reproductives under laboratory conditions (Becker, 1962 ; Sen-Sarma & Chatterjee, 1965).

15. **Heterotermes malabaricus** Snyder

(Fig. 7C)

1933. *Heterotermes malabaricus* Snyder, *Proc. U.S. natn. Mus.*, 82 (Art. 16) : 4-6.

Diagnosis : IMAGO.—Head yellowish brown, body paler ; head and body fairly densely hairy. Head-capsule subrectangular (length to base of mandibles 0.83-0.85, width with eyes 0.85) ; eyes oval (long diameter 0.20-0.25 mm), separated from lateral margin of head by less than long diameter ; ocelli indistinct ; antennae 13 to 16 (usually 14)-segmented, segment 4 shortest ; postclypeus faintly swollen, more than 3 times as wide as long ; pronotum flat, narrower than head with eyes, anteriorly indented medially, posteriorly straight ; wings smoky, membrane punctate ; abdomen oblong. Length with wings c 9.5-9.75, without wings c 5.0 mm.

SOLDIER (Fig. 7 C).—Head-capsule yellowish to pale yellowish brown ; head sparsely and body fairly hairy. Head-capsule subrectangular (length to mandible-base 1.27-1.77, width 0.83-0.93 mm) ; fontanelle minute, circular, with a short tube, situated at distal third of head dorsum ; antennae with 12-15 segments, 3rd segment either shorter or subequal to 2 or 4 ; labrum triangular, with long, needle-like, apical tip ; mandibles long, sabre-shaped, left with 3-4 crenulations in basal half ; postmentum long, club-shaped, waist long and narrow ; pronotum flat, faintly emarginate anteriorly and straight posteriorly ; abdomen oblong. Length c 4.5-6.00 mm.

Distribution : Widely distributed in southern India, below 20°N latitude (Sen-Sarma et al., 1975).

Hosts and pest status : In southern India, this species has been recorded attacking stem and roots of *Eucalyptus* sp., *Ficus* sp., *Manihot glaziovil*, *Swietenia macrophyla*, *Shorea robusta* and damaging bamboo, record files, wood-racks, etc. (Sen-Sarma et al., 1975). The author has collected this termite damaging the heartwood of mango tree, from under bark of cashew trees and from dead stumps of *Casuarina* in Mangalore, southern India.

Roonwal (1970) reports that it causes considerable damage to construc-tional timber in houses and Sen-Sarma et al. (1975) mention that it has not so far been recorded as pest in buildings. Since this termite is fairly widely

distributed and common in southern India, its potentiality as a pest has probably not been properly investigated. Its close ally *H. indicola*, however, is quite a serious pest of building structures in northern India.

Biology and ecology : *Heterotermes malabaricus* has its nests under the surface of ground from where it visits the plants it attacks and the stumps and twigs lying on ground surface.

Nothing is known about the swarming behaviour of this termite except that the alates were collected at Mangalore in the month of May along with soldier and workers from which the species was described.

16. **Heterotermes** spp.

The other *Heterotermes* species from India are *balwanti* Mathur & Chhotani and *gertrudae* Roonwal, but they are not reported to be of any economic importance. *H. ceylonicus* Holmgren (Fig 7 A), from Sri Lanka, is also of not much importance, it is, however, not an uncommon species and is reported as a pest of building-timber and stored-materials.

Subfamily COPTOTERMITINAE

Genus **Coptotermes** Wasmann

The species of the genus *Coptotermes* are serious pests of living trees which they hollow out completely ; cereals and sugarcane crops ; stored-products such as paper, cotton cloth, wooden articles, leather, jute goods, etc ; and structural timbers in buildings. From the Indian region, the genus is known by nine species. The species, *C. ceylonicus* from Sri Lanka and southern India and *C. heimi* from India, Pakistan and Bangla Desh, are known for their notoriousness.

17. **Coptotermes ceylonicus** Holmgren

(Fig. 8 A)

1911. *Coptotermes ceylonicus* Holmgren, in : Escherich's *Termitenleben auf Ceylon* : 192-193, 206, 209.

Diagnosis : IMAGO.—Head-capsule dark brown, paler in fontanelle area ; wings transparent ; abdomen brown to dark brown above, paler below, head and body fairly pilose, wing-membrane thickly hairy with short hairs. Head-capsule subcircular, with eyes broader than length to base of mandibles (length 1.0-1.08, width 1.30-1.53 mm), dorsum depressed in region of fontanelle ; eyes medium sized, circular (0.38-0.43 mm in diameter) ; ocelli oval, translucent, either touching eyes or faintly separated ; fontanelle minute ; antennae 19 to 23-segmented, 3rd segment smallest ; mandibles typically *Coptotermes*-type ; pronotum subreniform, a little narrower than head with eyes, anteriorly weakly incurved and posteriorly with a median notch ; wings

thin, transparent, hairy ; abdomen elongate. Length with wings c 10.8-12.7, without wings 6.0-7.4 mm.

SOLDIER (Fig 8 A).—Head-capsule yellowish ; abdomen pale yellow ; head-capsule sparsely and body fairly pilose, hairs on abdominal terga arranged in a row at posterior margin. Head-capsule oval, longer than broad (length to mandible-base 1.14-1.50, width 1.00-1.20 mm) ; fontanelle large, circular, with a chitinoid rim and situated anteriorly just behind clypeus ; antennae with 13-15 segments, 3rd segment generally smaller to sometimes longer than 2 or 4 ; labrum triangular, with a short pointed hyaline tip and a pair of long bristles ; mandibles thin, sabre-shaped, left mandible with a basal projection and 4 crenulations ; postmentum long, club-shaped, with long and narrow waist ; pronotum flat, subreniform, anteriorly with an obtuse median notch and posteriorly either substraight or faintly incurved. Length c 4.0-5.8 mm.

Distribution : Sri Lanka (widely distributed below 1,200 m) and southern India.

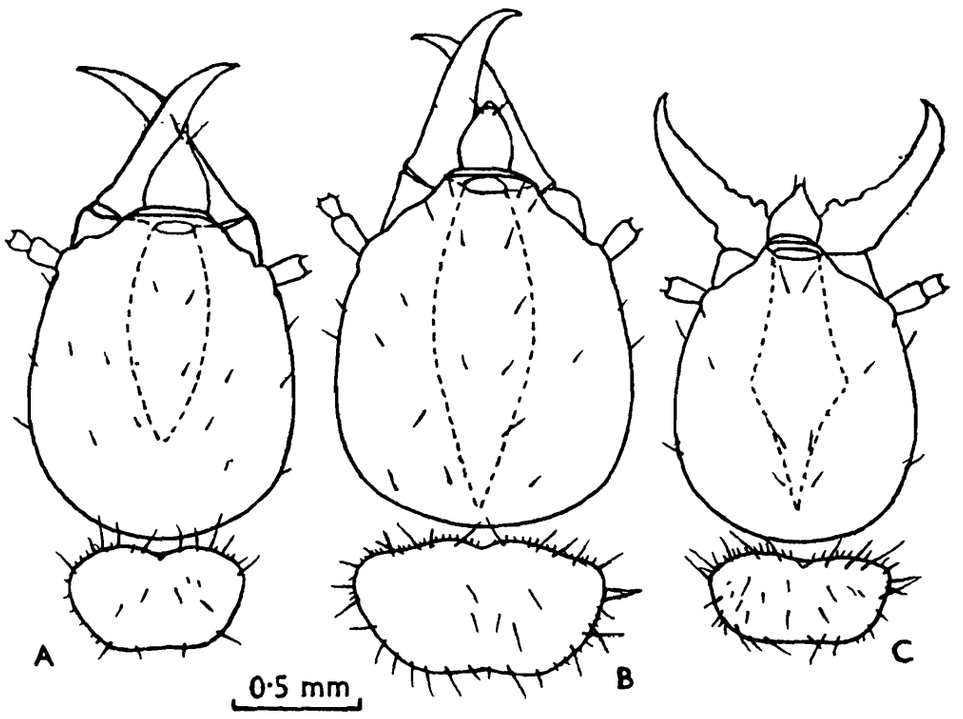

Fig. 8. Head and pronotum of soldier of *Coptotermes* : A, *ceylonicus* Holmgren ; B, *heimi* (Wasmann) ; C, *kishori* Roonwal & Chhotani

Hosts and pest status : It is a very common species of termites in Sri Lanka and has been recorded from a variety of trees such as *Albizzia stipulata*, *Aleurites* spp., *Camellia sinensis* (tea), *Citrus paradisi* (grape-fruit), *Cocos nucifera* (coconut), *Gliricidia sepium*, *Hevea brasiliensis* (rubber), *Ligustrum walkeri*, *Madhuca longifolia*, *Tamarindus indica* (imli) and *Theobroma cacao* (cocao). It is reported from living tea bushes in Sri Lanka but occurs comparatively rarely on tea and more so on rubber (Fernando, 1962). It is not a

serious pest, however, of rubber according to Harris, 1971. It is also reported to hollow out the coconut tree trunks (Jepson, 1931) and is a great destroyer of dead woods, packing cases, stored and structural timbers in timber depots and in buildings, etc., as such this species is of great economic importance.

Biology and ecology : *Coptotermes ceylonicus* is a subterannean species and attacks the diseased or dead portions of trees. The live tissue adjacent to the dead portions is also attacked, thus damaging the conducting tissue and cambium and resulting in hollowing out of the tree trunk and ultimately death of the tree. The nest in the tree trunk is in the form of spongy mass of wood carton. Nothing is known about the swarming behaviour of this termite but imagos have been collected during the months of February, March and July in southern India and in December in Sri Lanka.

18. **Coptotermes heimi** (Wasmann)

(Fig. 8B)

1902. *Arrhinotermes heimi* Wasmann, *Zool. Jb. (Syst.)*, **17** (1) 140, 160.

Diagnosis : IMAGO.—Head-capsule yellowish brown to dark brown, paler in region of fontanelle ; thorax and abdomen above somewhat paler than head ; wings transparent ; head and body fairly hairy, wings densely covered with short hairs. Head-capsule subcircular, shallowly depressed in region of fontanelle, with eyes wider than length to base of mandibles (length 1.04-1.16, width 1.30-1.40 mm) ; eyes subcircular, medium sized (0.37-0.40 mm in diameter) ; ocelli oval, translucent, either touching the eyes or slightly separated ; fontanelle minute ; antennae with 20-22 segments, 3rd segment smallest ; postclypeus flat ; mandibles typically *Coptotermes*-type ; pronotum flat, narrower than head with eyes, anteriorly weakly incurved and posteriorly prominently notched medially ; legs long and hairy ; wings thin, transparent and hairy ; abdomen elongate, hairy. Length with wings c 10.6-12.3, without wings 5.6-7.0 mm.

SOLDIER (Fig. 8B).—Head-capsule straw yellow to yellowish ; body yellowish white ; head sparsely and body fairly hairy, hairs on posterior margin of abdominal terga arranged in a row. Head-capsule variable in shape, oval to rounded but generally oval, longer than wide (rarely wider than long, length 1.20-1.48, width 1.05-1.35 mm) ; fontanelle large, circular, with a sclerotised border, situated at base of clypeus ; antennae with 14-16 segments, 3rd and 4th segments variable in size ; labrum subtriangular, with a hyaline tip and generally with a pair of long bristles apically ; mandibles sabre-shaped, long, left with a basal projection and 4 crenulations in basal half ; postmentum generally long and club-shaped, shape and size varying with the shape of head ;

pronotum flat, anteriorly with a prominent median notch, and posteriorly with a weak incurving ; abdomen oblong. Length c 4.2-6.0 mm.

Distribution : Widely distributed in India, Pakistan, Bangla Desh and Bhutan.

Hosts and pest status : This is one of most common species found in the subcontinent. It is well known for its notoriety in damaging and turning to debris paper, books, clothes, wooden articles, timber in timber yards, packing cases, wooden electric wire-casings, wood-work in railway coaches, railway sleepers, cotton and jute goods, structural timbers in houses and buildings and even insulated electric wirings. At Gurgaon (Haryana), it was noticed by the author to have eaten up almost all the wooden frames of doors, windows and ventilators in the P. W. D. Rest House, in the year 1959 and the authorities had plans to reconstruct the rest house. At Peshawar (Pakistan), it has been found infesting wooden bridge of *Cedrus deodara* (Chaudhury et al., 1972).

It is also a serious pest of sugarcane and fruit trees and is reported from rubber trees. The author has noticed trees of mango and mulberry completely eaten up by this termite in Haryana. Roonwal (1959) and Roonwal and Chhotani (1962) have reported this termite from the following plant species from India and Choudhury et al. (1972) from Pakistan and Bangla Desh. *Abies pindrow*, *Acacia arabica*, *Acacia* sp., *Albizzia* sp., *Avicennia* sp., *bamboo*, *Bauhinia vahlii*, *Boswellia serrata*, *Cactus* sp., *Carica papaya* (papita), *Casuarina equisetifolia*, *Cedrela toona*, *Dalbergia sissoo*, *Euphorbia nivulia*, *Excaecaria agallocha*, *Ficus bengalensis*, *Garuga pinnata*, *Heritiera minor*, *Jatropha curcas*, *Lagerstroemia parviflora*, *Lannea coromandelica*, *Mangifera indica* (mango), *Moringa pterygosperma*, *Morus alba* (mulberry), *Phoenix sylvestris* (khajur), *Pinus longifolia*, *Prunus persica* (peach), *Pterocymbium tinctorium*, *Rhizophora conjugata*, *Saccharum officinarum* (sugarcane), *Salmalia malabarica* (simal, silk-cotton tree), *Shorea robusta* (sal), *Swietenia floribunda*, *Tamarindus indica*, *Tamarix gallica*, *Tamarix* sp., *Tectona grandis* (teak) and *Xylocarpus gangeticus*.

Biology and ecology : The nests of *Coptotermes heimi* are in soil as well as in dead portions of trees, logs of wood and structural timbers. The nest in the trees, is dark greyish in colour and is in the form of porous structure composed of network of strands of hard wood-fibres left over from feeding and termite excrement. The soldier population in a colony is fairly high and when distrubed they come out in large numbers standing guard and waving their antennae. They also exude some sticky, milky-white fluid from the fontanelle in defence.

The swarming has been recorded generally at sunset during the months of January to August mainly from March to July.

19. **Coptotermes kishori** Roonwal & Chhotani

(Fig. 8 C)

1962. *Coptotermes kishori* Roonwal and Chhotani, *Indian Species of Coptotermes* (I.C.A.R. Ent. Monogr. 2) Delhi : 7, 9, 57-61, 77, 78, 108, 111.

Diagnosis : SOLDIER (Fig. 8 C).—Head-capsule yellow, body pale yellow ; head sparsely and body fairly, densely hairy. Head-capsule oval, longer than broad (length to mandible-base 1.13-1.25, width 0.95-1.08 mm) ; fontanelle large, prominent, circular, situated just behind clypeus ; antennae with 13-14 segments, 3rd segment variable, either shorter (14-segmented antennae) or slightly smaller to a little longer (13-segmented antennae) than 2nd or 4th ; labrum subtriangular, with hyaline tip having a pair of long bristles ; mandibles long, sabre-shaped, left with 4 crenulations and a basal projection in basal half ; postmentum short, club-shaped, moderately incurved at waist ; pronotum flat, anteriorly with prominent, obtuse, median incurving and posteriorly faintly incurved medially ; abdomen oblong. Length c 3.75-4.8 mm.

Distribution : India : West Bengal, Assam, Tripura.

Hosts and pest status : *C. kishori* has been recorded attacking trees, logs and dry stumps of *Mangifera indica* (mango), *Azadirachta indica* (neem), and *Bombax ceiba*. It is also reported from wooden articles (Sen-Sarma et al., 1975). It is not a widely distributed species and is not a serious pest.

Biology and ecology : Nothing is known about the biology and ecology of this species.

Family STYLOTERMITIDAE

To accomodate their new genus, Holmgren and Holmgren (1917) created the subfamily Stylotermitinae under the family Mesotermitidae which is a synonym of Rhinotermitidae. Chatterjee and Thakur (1964*a*) elevated the subfamily to the family level and ever since different authorities have treated it as a distinct family or subfamily of Rhinotermitidae. Only one genus i.e., *Stylotermes* is included and it is restricted to the oriental region.

Genus **Stylotermes** Holmgren & Holmgren

Of the 13 species known, eight occur in the Indian subregion (India, Bangla Desh). The species *S. fletcheri* Holmgren & Holmgren is of some economic importance.

20. **Stylotermes fletcheri** Holmgren & Holmgren

(Fig. 9)

1917. *Stylotermes fletcheri* Holmgren and Holmgren, *Mem. Dept. Agric. India (Ent.)*, **5** (3) : 142-144.

Diagnosis : IMAGO.—Head-capsule dark brown, body little paler ; fairly densely hairy. Head-capsule subcircular (width with eyes 1.50-1.55, length to base of mandibles 1.23-1.24 mm), Y-suture present ; fontanelle minute, situated medially on head dorsum ; eyes subcircular (0.40-0.42 mm in diameter) ; ocelli oval, situated at about half their long diameter from eyes ; antennae with 17-19 segments ; labrum broad, tongue-shaped ; mandibles typically *Stylotermes*-type ; pronotum flat, trapezoidal, anterior margin weakly incurved and faintly notched ; tarsi 3-segmented ; wings transparent, with a number of cross veins. Length with wings c 13.0-13.5, without wings c 7.5-7.6 mm.

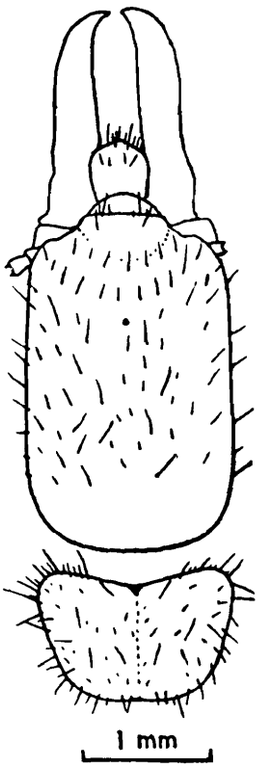

Fig. 9. Head and pronotum of soldier of *Stylotermes fletcheri* Holmgren & Holmgren.

SOLDIER (Fig. 9).—Head-capsule brownish yellow, pronotum paler and abdomen pale yellowish ; fairly hairy. Head-capsule subrectangular (length to mandible-base 2.35-2.43, width 1.65-1.73 mm) ; fontanelle minute, situated medially ; antennae with 14-15 segments, 3rd segment large, broad distally ; labrum tongue-shaped, broadly rounded anteriorly ; mandibles long, stout, weakly curved apically, left mandible with a weak crenulation below middle and a knob-like process basally, right with a weak crenulation and a large knob-like process on basal third ; pronotum flat, semilunar to trapezoidal, anteriorly fairly incurved ; femora swollen, tarsi 3-segmented. Length c 8.70-8.80 mm.

Distribution : It is known only from southern India.

Hosts and pest status : It is not a serious pest but has been reported to

attack dead and rotton parts of mango. The live tissue in the trees is also attacked.

Biology and ecology : The author has collected this species in southern India from a number of mango trees at Chickmagalur (Karnataka state). The nesting behaviour is more or less like that of a *Neotermes* species. The galleries are narrow, elongate and are partially filled with faecal matter. The imagos have been collected in the field during the months of October and November.

Family TERMITIDAE

This is the largest family of the order Isoptera and includes soil-dwelling termites showing a wide range of nesting behaviour and feeding habits. A few species of the subfamily Macrotermitinae are serious pests of standing crops, fruit trees and stored-products.

Subfamily TERMITINAE

Genus **Amitermes** Silvestri

Only three species of the genus *Amitermes* are known from the Indian

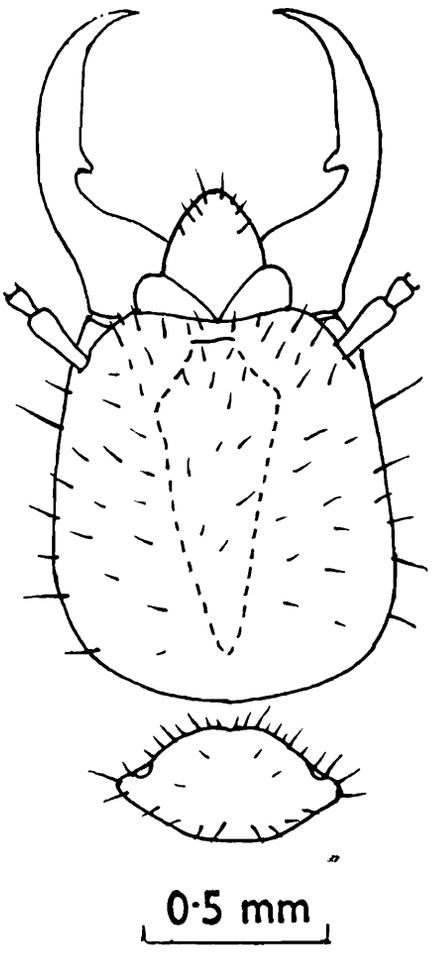

Fig. 10. Head and pronotum of soldier of *Amitermes belli* (Desneux).

subregion and are restricted to drier parts of India and Pakistan. *A. belli* (Desneux) according to Chaudhry et al. (1972) "appears to be of significant

economic importance" but it has not been reported to be directly involved in the damage of any serious nature to any crops or fruit trees. As such, it has not been dealt with in detail here, however, it is included in the key for identification and illustrated (Fig. 10).

Genus **Eremotermes** Silvestri

Of the five species of this genus known from the Indian subregion, the species *E. paradoxalis* only has been recorded attacking sugarcane and grasses in India.

21. **Eremotermes paradoxalis** Holmgren

(Fig. 11)

1913. *Eremotermes paradoxalis* Holmgren, *J. Bombay nat. Hist. Soc.*, 22 (1) : 115-116.

Diagnosis : IMAGO.—Head-capsule yellowish to chestnut brown and with numerous small, round, pale spots, pronotum slightly paler than head, abdomen pale brownish ; head and body densely hairy. Head-capsule small, roundish oval (length to mandible-base 0.65-0.75, width with eyes 0.70-0.80 mm) ; fontanelle-plate elongate, whitish ; antennae with 14-15 segments, 3rd segment shortest ; eyes round, small (0.20-0.23 mm in diameter) ; ocelli slightly separated from eyes ; postclypeus swollen, length about half of width, subtrapezoidal ; mandibles typically *Eremotermes*-type ; pronotum flat, subtrapezoid, strongly narrowed posteriorly, both anterior and posterior margins notched medially ; wing-membrane smoky and densely covered with micrasters. Length with wings c 8.0-9.8, without wings c 4.5-6.7 mm.

SOLDIER (Fig. 11).—Head-capsule pale yellowish, abdomen yellowish white ; fairly densely hairy. Head-capsule subrectangular, thick and with a prominent frontal protuberance (length to base of mandibles 0.80-0.95, width 0.68-0.75 mm) ; fontanelle prominent, lying below frontal protuberance, gland large ; antennae with 14 segments, 4th segment shortest ; labrum tongue-shaped, narrowed anteriorly ; mandibles thin, elongate, about 3/4ths to as long as head-capsule, sharply pointed and weakly incurved at tip, incurved medially at outer margin and with a sharply pointed tooth on inner margin at middle ; postmentum swollen, short, broadest a little in front of middle and narrowest near posterior end ; pronotum saddle-shaped, either faintly or not notched anteriorly, substraight at posterior margin ; abdomen elongate to subglobular. Length 3.50-4.20 mm.

Distribution : The species is quite common in India and Pakistan.

Hosts and pest status : *E. paradoxalis* is recorded attacking sugarcane and grasses in India. In Pakistan it is reported feeding on roots of grasses and other plants and roots of *Saccharum munja* in Sibi area (Chaudhry et al., 1972). It is not a serious pest of sugarcane anyway.

Biology and ecology : This termite makes its nests in soil under stones, etc. and generally feeds on roots of grasses and other plants. Nothing is known about the life-history of this species. The swarming of alates has

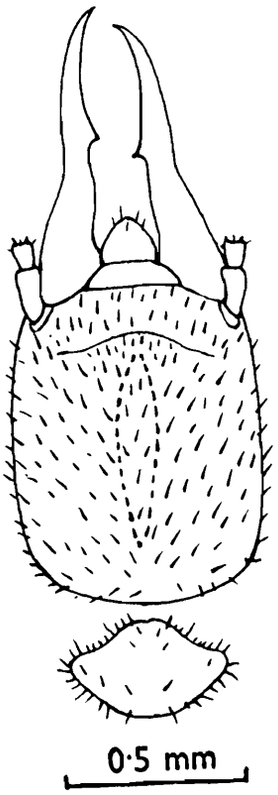

Fig. 11. Head and pronotum of soldier of *Eremotermes paradoxalis* Holmgren (After Roonwal & Sen-Sarma, 1960).

been reported from holes in the ground in the evening during the months of March to September, in India. Chaudhry et al. (1972), from Pakistan, have recorded swarming throughout summer from irrigated fields and heavy swarming on 22nd July after a heavy monsoon shower.

Genus **Microcerotermes** Silvestri

As many as 25 species of the genus *Microcerotermes* are known from the Indian subregion, of which the following species are pests of agricultural importance and are reported from sugarcane, tea, coconut and fruit trees.

22. **Microcerotermes baluchistanicus** Ahmad

(Fig. 12 A)

1955. *Microcerotermes baluchistanicus* Ahmad, *Biologia*, **1** : 243-245.

Diagnosis : IMAGO.—Head pale brown, postclypeus and body yellowish ; head sparsely and body moderately hairy. Head-capsule parallel sided, with eyes broader than length to base of mandibles (length 0.72-0.79, width 0.81-0.90 mm), Y-suture indistinct ; eyes oval, 0.20-0.24 mm long ; ocelli oval,

separated from eyes by their diameter ; antennae 13-segmeted ; postclypeus swollen, less than half as long as wide ; pronotum narrower than head, anteriorly indistinctly notched and posteriorly distinctly emarginate.

SOLDIER (Fig. 12 A).—Head brownish yellow, body yellowish ; head sparsely and body moderately densely hairly. Head-capsule oblong, thick, slightly narrowed in front and with weakly convex sides ; antennae with 13 segments ; labrum short, broadly rounded in front ; mandibles curved in distal half, indistinctly serrate ; postmentum short, club-shaped, widest in middle and narrowest basally ; pronotum saddle-shaped, indistinctly emarginate both at anterior and posterior margins. Total length c 4.00-6.00 mm.

Distribution : Common in sandy soil of Panjab and Baluchistan (Pakistan) and has recently been reported from Jodhpur, India (Verma and Thakur, 1977).

Hosts and pest status : It is reported from living apricot and mulberry trees in Pakistan but has not attained the status of a serious pest. It is also found attacking plants of the species *Acacia* sp., *Dalbergia sissoo*, *Populus* sp., *Prosopis glandulosa*, *Saccharum munja* (kana) and *Tamarix* sp. in Pakistan.

Biology and ecology : It is a soil inhabiting species but its nests were found in the dead portions of trees as well. In the dead portions of trees it makes longitudinal, narrow galleries filled with carton material. Neotenic queens are reported from an infested *Acacia* tree about 8 inches (20 cm) above ground-level (Chaudhry et al., 1972).

23. **Microcerotermes beesoni** Snyder

(Fig. 12 B)

1933. *Microcerotermes beesoni* Snyder, *Proc. U. S. natn. Mus.*, **82** (Art. 16) : 12-14.

Diagnosis : IMAGO.—Head-capsule brown to dark brown, body paler than head ; densely hairy. Head-capsule squarish, sides subparallel, Y-suture fairly prominent ; fontanelle-plate small, yellowish, situated medially ; eyes subcircular (0.20-0.22 mm in diameter) ; ocelli oval, situated as far as their long diameter from eyes ; antennae with 14 segments, 3rd segment shortest ; postclypeus swollen, as long as half of width ; labrum broad, tongue-shaped ; mandibles typically *Microcerotermes*-type ; pronotum trapezoidal, anterior margin nearly straight, posterior margin emarginate medially ; wings pale smoky brown, thickly covered with micrasters and sparsely hairy. Length with wings c 8.0-10.0, without wings c 5.0-6.0 mm.

SOLDIER (Fig. 12 B).—Head-capsule yellowish, body pale yellow ; head sparsely and body densely hairy. Head-capsule subrectangular, sides straight (length 1.28-1.55, width 0.77-0.91 mm) ; fontanelle minute, situated at anterior third of head ; antennae 13-segmented, 3rd segment shortest ; labrum with parallel sides, anteriorly sharply rounded ; mandibles a little more than half of

head-length, coarsely serrated ; postmentum club-shaped, widest at anterior third, waist lying below middle and slightly more than half as wide as maximum width ; pronotum saddle-shaped, anteriorly weakly notched, posteriorly slightly emarginate. Length c 4.00-5.50 mm.

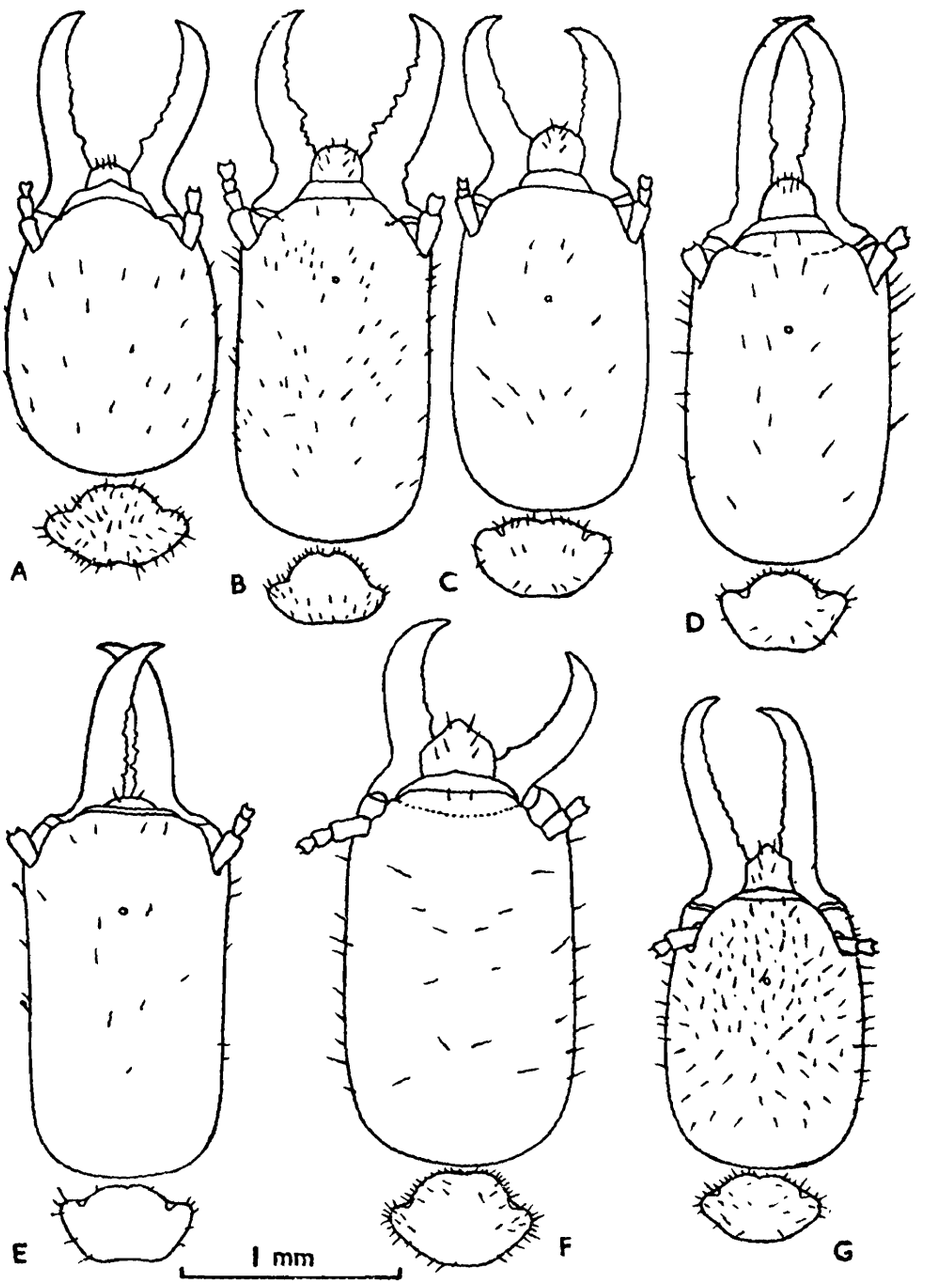

Fig. 12. Head and pronotum of soldier of *Microcerotermes* : A, *baluchistanicus* Ahmad ; B, *beesoni* Snyder ; C, *bugnioni* Holmgren ; D, *danieli* Roonwal & Bose ; E, *fletcheri* Holmgren & Holmgren ; F, *nicobarensis* Roonwal & Bose ; G, *tenuignathus* Holmgren. (A, after Ahmad, 1955, *Biologia*, 1 (2) : 244 ; C and E after Irashad, Thapa & Sen-Sarma, 1967, *Indian For. Bull.*, No. 246 and D and F, after Roonwal & Bose 1970, *Rec. zool. Surv. India.*, **62** (3 & 4) : 143, 152). All figures brought to same scale for comparison.

Distribution : This species is recorded from northern (Uttar Pradesh, Haryana, Punjab, Delhi), central (Madhya Pradesh) and eastern India, Bhutan, Pakistan and Bangla Desh.

Hosts and pest status : It is reported from sugarcane in Uttar Pradesh and from living trees, roots and dead stumps of a number of other plants, as follows : *Acacia catechu, Cassia fistula, Lyonia ovalifolia, Shorea robusta, Swietenia macrophyla* and *Lantana* sp.

Biology and ecology : *M. beesoni* lives in and under logs of wood, under the bark of trees and in soil. The nests which are made up of carton-type material are generally found partially burried in the soil and are either spherical or cone-like or subsquarish and flat. The internal structure of the nest is honey-combed and shows two zone, the outer-one with large, irregular, communicating passages and the inner-one with smaller chambers. This species is highly tolerant of the fluctuations of temperature and relative humidity and is an ideal species for tests in laboratory. The swarming of the species is reported during the months of May to July (Roonwal, 1970, Sen-Sarma et al., 1975).

In Kanha National Park (Madhya Pradesh), the author (1977) has recorded this species nesting in dead stumps, under stones, in mounds of *Odontotermes obesus* (Rambur) and in soil. In soil, it makes narrow galleries which are coated with greyish material. Alates ready for swarming were found in one of the nests in the month of June. In Calcutta, it has been found attacking a guava tree stem which was completely hollowed out (Pl. V, fig. 3).

24. **Microcerotermes bugnioni** Holmgren

(Fig. 12 C)

1911. *Microcerotermes Bugnioni* Holmgren, in : Escherich's *Termitenleben auf Ceylon* : 203-204.

Diagnosis : IMAGO.—Head-capsule brownish, body somewhat paler ; densely hairy. Head-capsule subsquarish (length 0.65-0.70, width with eyes 0.79-0.86 mm) ; Y-suture faint ; fontanelle plate suboval, faintly raised ; eyes subcircular (0.22 mm in diameter) ; ocelli oval, fairly large, from eyes situated at about 1/3rd of their long diameter ; antennae with 14 segments, 3rd segment smallest ; labrum broad, tongue-shaped ; mandibles typically *Microcerotermes*-type ; pronotum flat, trapezoidal, both anterior and posterior margins nearly straight ; wings smoky brown, pale, covered with micrasters and fairly hairy. Length with wings c 7.5, without wings c 4.0-5.6 mm.

SOLDIER (Fig. 12 C).—Head-capsule brownish, body pale yellow ; head sparsely and body fairly hairy. Head-capsule long, subrectangular (length 1.30 -1.50, width 0.85-0.87 mm), fontanelle minute, situated in front of middle of

head-dorsum ; antennae with 13 segments, segment 3 smallest ; labrum with parallel sides and narrowed anteriorly to a rounded margin ; mandibles a little longer than half of head-length without mandibles, finely serrated ; postmentum club-shaped, widest at anterior third, waist below middle and about 2/3rd of maximum width ; pronotum saddle-shaped, anteriorly faintly notched and posteriorly substraight. Total length c 5.0 mm.

Distribution : It is endemic to Sri Lanka and is recorded from Colombo, Ambalangoda (Seenigoda) and Maha Illupalama.

Hosts and pest status : This species has been found damaging the bark of coconut trees in Sri Lanka.

Biology and ecology : The nests of *M. bugnioni* are found underground. They are globular structures of 20-30 cm in diameter, having a large number of holes. More than one queen may be found in a nest ; four queens and a king are recorded from a nest in the mound of *Odontotermes redemanni* (Bugnion and Popoff, 1912 ; Bugnion, 1915 ; Roonwal, 1970).

25. **Microcerotermes** spp.

Microcerotermes spp. have been recorded as pests of tea in eastern India. The species *M. danieli* Roonwal and Bose (Fig. 12 D) and *M. nicobarensis* Roonwal and Bose (Fig. 12 F) are reported from the bark of coconut trees in Andaman and Nicobar islands, *M. longignathus* Ahmad from a living apricot tree in Pakistan and *M. tenuignathus* (Fig. 12 G) is reported damaging books in a library in Delhi, India, but they are not pests of any significance. As such these species are not dealt with individually here.

Subfamily MACROTERMITINAE

Genus **Macrotermes** Holmgren

Of the seven species and subspecies of the genus *Macrotermes* known from the Indian subregion, only one i.e., *M. estherae* (Desneux) is of some agricultural importance.

26. **Macrotermes estherae** (Desneux)

(Fig. 13)

1908. *Termes estherae* Desneux, *Annls. Soc. Ent. Belg.*, **51** : 390.

Diagnosis : IMAGO.—Head-capsule dark reddish brown, paler around fontanelle ; body somewhat paler than head ; head sparsely and body densely pilose. Head-capsule subcircular (length 2.10, width 2.93 mm) ; fontanelle-plate large, circular ; eyes large, circular, diameter 0.83 mm ; ocelli oval, large (length 0.35 mm), from eyes situated at about half of long diameter ; antennae 19-segmented, 3rd segment shortest ; postclypeus swollen, twice as wide as

long ; labrum broad, tongue-shaped ; mandibles *Macrotermes*-type ; pronotum a little narrower than head, anterior margin weakly notched and posterior-one straight. Length with wings c 32.0-33.0, without wings c 15.0-16.0 mm.

SOLDIER MAJOR (Fig. 13 A).—Head-capsule pale reddish brown, body pale brownish ; head sparsely hairy, abdomen bare or with a few short hairs. Head-capsule large, oval (length 4.30-6.60, width 3.90-4.10 mm) ; fontanelle

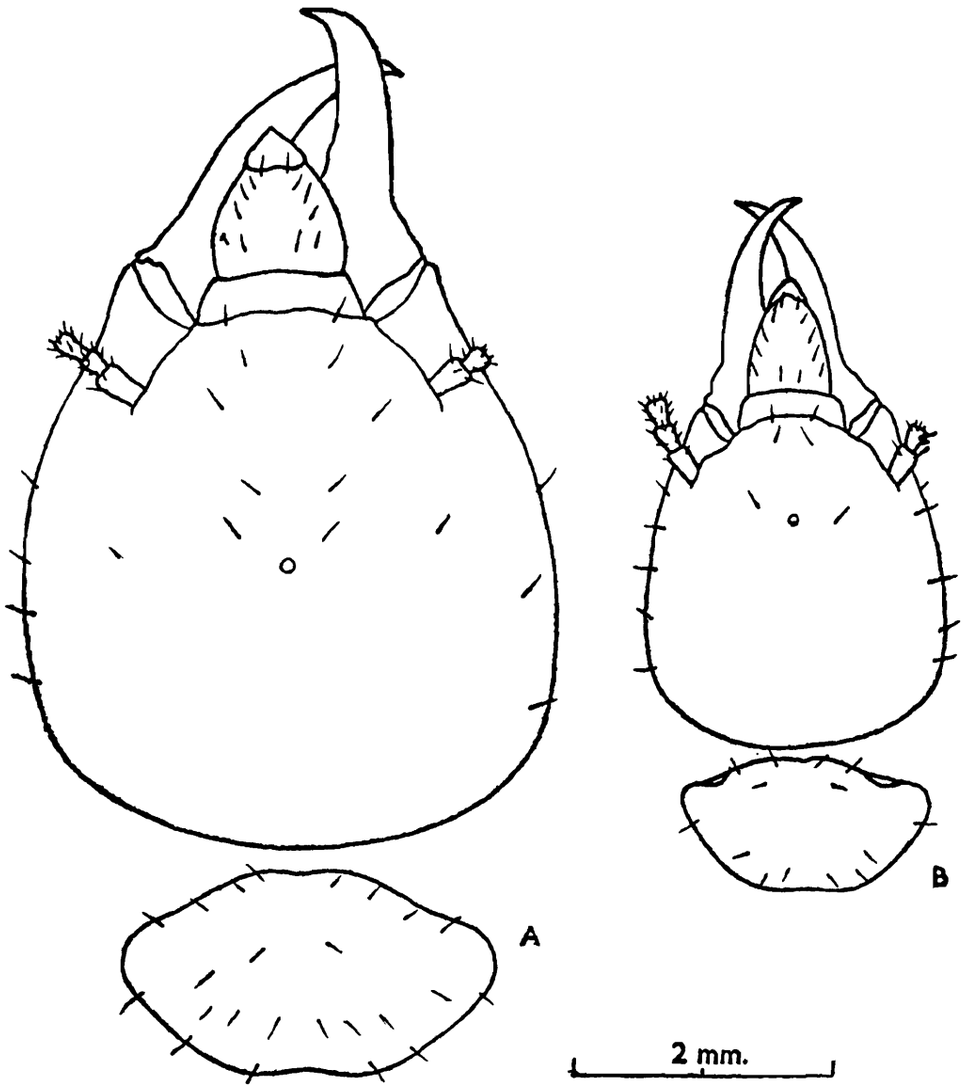

Fig. 13. Head and pronotum of soldier of *Macrotermes estherae* (Desneux) : A, soldier major ; B, soldier minor.

small, circular, situated on mid-dorsum ; antennae with 17 segments, 3rd segment longer than 2nd ; labrum triangular with a large, prominent, hyaline tip ; mandibles thick, short, stout, sabre-shaped, left mandible with 3 crenulations in basal half ; pronotum weakly saddle-shaped, anterior margin weakly and posterior-one distinctly notched medially. Length 11.00-14.00 mm.

SOLDIER MINOR (Fig. 13 B).—Resembles soldier major except for its generally smaller size, oval and comparatively longer than wide head (length 2.20-

2.70, width 1.88-2.35 mm), elongate labrum with narrower and hyaline apex and longer and slenderer mandibles. Length c 7-8 mm.

Distribution : It is quite a common species in southern India, and is reported from Sri Lanka also.

Hosts and pest status : This species is reported as a minor pest of sugarcane (Harris, 1971). It is also recorded from dead parts of plants in soil.

Biology and ecology : The nests of *Macrotermes estherae* are underground and extend in large areas. The termites collect small heaps of granular soil, about 2-8 cm high, over the ground surface at certain places in the vicinity of the nests. The nests are in the form of communicating galleries and chambers running horizontally for a distance of about 100 m or more. The fungus combs are small (about 5 cm in diameter) and have cavities likes the convolutions of a human ear. The soldiers and workers march in long processions over the leaves during foraging expeditions and when disturbed the soldiers raise their bodies and strike the dry leaves with their mandibles making peculiar rattling sound (König, 1779 vide Fletcher, 1921 ; Roonwal, 1970).

Swarming of alates has been recorded after rain in the evening in the month of July.

Genus **Odontotermes** Holmgren

It is the most common genus and as many as forty species are known from the Indian subregion. Some of the species are very widely distributed throughout the subcontinent and do extensive damage to a variety of crops, plantations, wooden structures, etc. They are mainly soil dwelling and fungus growers. Some species contruct mounds which may be as high as 3 m in height. The following species are recorded as pests :—

27. **Odontotermes assmuthi** Holmgren

(Fig. 14 A)

1913. *Odontotermes* (*Odontotermes*) *assmuthi* Holmgren, *J. Bombay nat. Hist. Soc.*, 22 (1) : 112-113.

Diagnosis : IMAGO.—Head and body blackish brown, postclypeus pale brownish, pronotum with T-shaped mark in middle ; head and body fairly densely pilose. Head-capsule subcircular (length 1.68-1.70, width with eyes 2.20-2.30 mm) ; fontanelle small, circular ; eyes moderately large, circular ; ocelli oval, from eyes situated at a distance of more than their long diameter ; antennae 19-segmented, segments 4 and 5 subequal and shortest ; postclypeus swollen, twice as wide as long ; pronotum subtrapezoidal, both anteriorly and posteriorly weakly notched medially ; wings dark brown, hairy near distal end. Length with wings c 24.00-26.50, without wings c 12.00-14.00 mm.

SOLDIER (Fig. 14 A).—Head-capsule golden yellow, body pale yellow; sparsely hairy. Head-capsule subrectangular, slightly converging anteriorly (length 1.44-1.70, width 1.09-1.25 mm); antennae 16-segmented, 4th segment shortest; labrum broadly tongue-shaped; mandibles short, stout, sabre-shaped, left mandible with a sharp, prominent tooth a little below distal third, postmentum subrectangular; pronotum saddle-shaped, deeply notched both at anterior and posterior margins. Length 4.30-5.00 mm.

Distribution : *O. assmuthi* has a wide distribution in India and is reported from almost all over the country except the far eastern states. From Pakistan, it is reported only from Hangu (Kohat Dist.) and from Bangla Desh from drier areas of Dinajpur and Rajshahi.

Hosts and pest status : It is quite a serious pest of sugarcane in India and has also been recorded attacking bark of mango, and logs of *Dalbergia sissoo*, *Ficus bengalensis* and *Vateria indica*. In Bangla Desh this species has been recorded attacking mango logs lying on road-side.

Biology and ecology : The species nests underground where it makes narrow galleries running for quite some distance and makes narrow covered runways for foraging. It was found making galleries and small chambers at the base of a mound of *Odontotermes obesus* in Kanna National Park. The swarming of alates has been observed from holes in the ground at about 4.45 P. M. in the afternoon at New Forest, Dehra Dun in the month of June (Chhotani, 1977).

Sen-Sarma (1962) has discussed the swarming in nature and colony foundation in laboratory. According to him the swarming is always preceded by heavy shower of rain and is generally on sunny afternoons. The eggs are laid 6-9 days of swarming when 100-300 eggs are laid in the first batch. Then there is a temporary cessation of egg laying till the third day of hatching of first batch, after which it is continued non-stop. Chaudhry et al. (1972) report that it is a common mound-building termite of Bangla Desh and Basalingappa (1968, '71, '74) has recorded mounds of this species in Karnataka state (India), which appear to be similar to the buttress-type mounds of *O. obesus* (Rambur).

28. **Odontotermes gurdaspurensis** Holmgren & Holmgren

(Fig. 14 B)

1917. *Odontotermes obesus* f. *gurdaspurensis* Holmgren and Holmgren, *Mem. Dept. Agric. India* (*Ent.*), **5** (3) : 149-150.

Diagnosis : IMAGO.—Head and body fuscous, densely hairy, pronotum with a T-shaped, paler mark. Head-capsule subcircular, broader than length to base of mandibles (length 1.90-2.10, width 2.47-2.70 mm); fontanelle minute, lying a little above middle of head-dorsum; eyes large, subcircular

(max. diameter 0.78-0.80 mm) ; ocelli large, oval (length 0.35-0.38, width 0.25 mm), from eyes situated at half their width ; antennae with 19 segments, 3rd segment short, subequal to 4th ; postclypeus swollen, almost half as long as wide ; pronotum trapezoidal, both anteriorly and posteriorly weakly notched ; wings long, pale brown and hairy near distal margin (forewing c 26-27, hindwing c 24-25 mm, long). Length with wings c 31-32, without wings c 15-16 mm.

SOLDIER (Fig. 14 B).—Head-capsule deep golden yellow to dark brown, body yellowish to pale brownish ; head sparsely and body moderately hairy. Head-capsule subrectangularly oval (length 1.40-1.60, width 1.13-1.40 mm) ; antennae 16 to 17-segmented ; labrum tongue-shaped ; mandibles long, slender, left mandible with a sharply pointed tooth near base of distal third and right with a minute tooth in middle third ; postmentum subrectangular ; pronotum saddle-shaped, anteriorly weakly to appreciably notched and posteriorly distinctly emarginate medially. Length c 5.0-6.50 mm.

Distribution : This species is widely distributed in northern and western India (J. & K., Panjab, Rajasthan) and Pakistan.

Hosts and pest status : *O. gurdaspurensis* has been reported damaging wheat and maize crops in Rajasthan (Kushwaha, 1960), it is, however, not a serious pest. It is also recorded from stumps, logs and twigs of *Cynodon dactylon*, *Acacia* spp., *Dalbergia sisoo* and *Zizyphus jujuba* (ber) in Pakistan and from bark and logs of *Acacia* spp., *Albizzia chinensis*, *Dalbergia sissoo*, *Cedrela toona*, *Pinus roxburghii*, *P. wallichiana* and *quercus incana*, in India.

Biology and ecology : Holmgren and Holmgren (1917) reported "Swarming from hole in ground after rain, at 9 A. M. No mound" and Chaudhry et al. (1972) also reported that this species makes underground, complex-type nest. Chatterjee and Thakur (1964*b*, 1967), however, have mentioned collections having been made from mounds but the mound has not been described. The swarming of alates is reported during July and August and the alates have been collected from a mound in the month of May.

29. **Odontotermes horni** (Wasmann)

(Fig. 14 C)

1902. *Termes horni* Wasmann, *Zool. Jb. (Syst.)*, **17** : 111-112.

Diagnosis : IMAGO.—Head-capsule dark brown, pronotum paler with a T-shaped, paler mark, abdomen brownish ; head and body densely hairy. Head-capsule subcircular broader than long (width with eyes 2.60-2.77 mm) ; fontanelle small, circular ; eyes of medium size, subcircular, 0.68-0.79 mm in diameter ; ocelli oval, from eyes situated only a little less than their length ; postclypeus paler, strongly swollen, about half as long as wide ; pronotum subsemicircular, a little narrower than head ; wings brownish, hairy in distal half. Length with wings c 26.5-30.0, without wings c 11.0-14.2 mm.

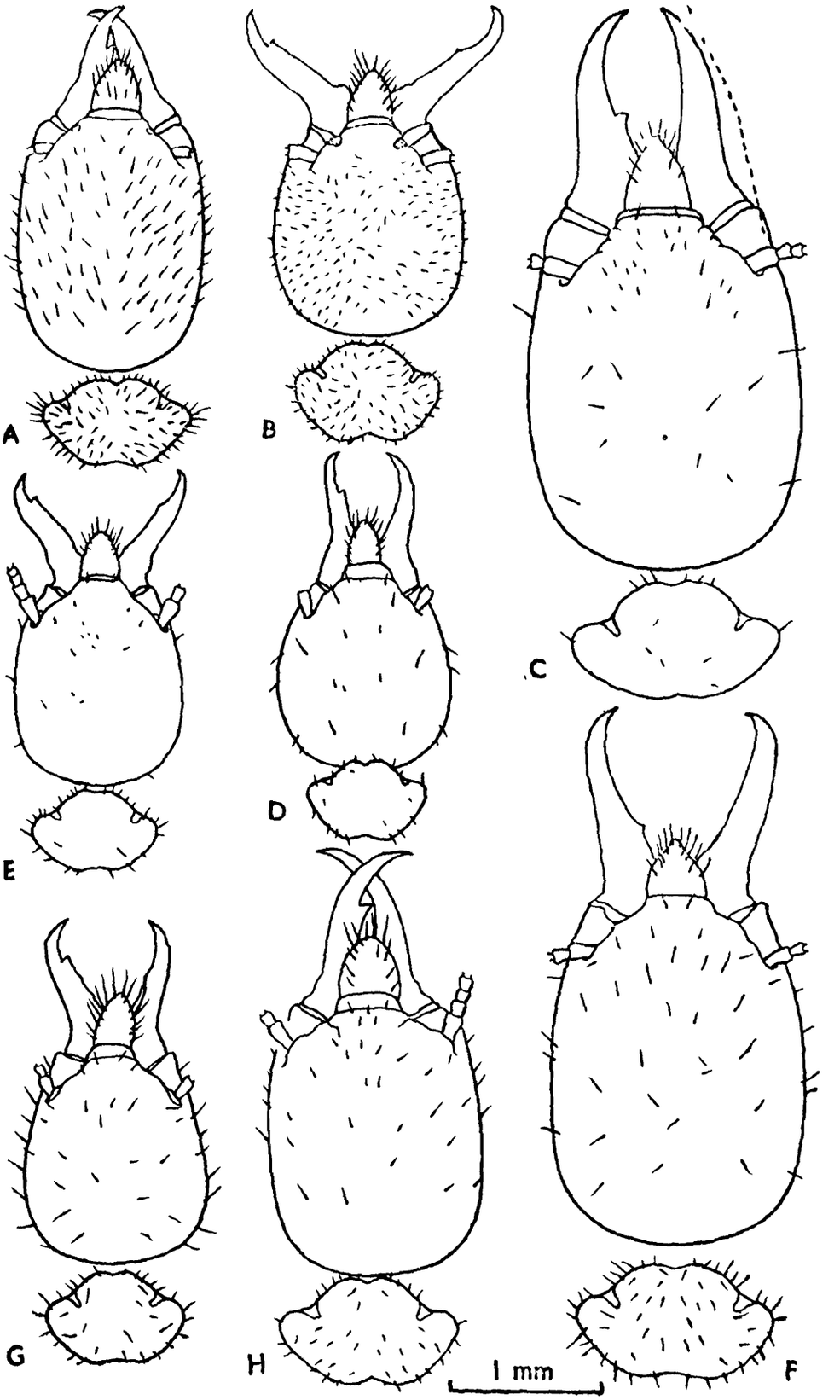

Fig. 14. Head and pronotum of soldier of *Odontotermes* : A, *assmuthi* Holmgren ; B, *gurdaspurensis* Holmgren & Holmgren ; C, *horni* (Wasmann) ; D, *latigula* Snyder ; E, *obesus* (Rambur) ; F, *parvidens* Holmgren & Holmgren ; G, *redemanni* (Wasmann) ; H, *wallonensis* (Wasmann).

SOLDIER (Fig. 14 C).—Head-capsule yellowish to yellowish brown, body paler. Head-capsule large, subrectangularly oval, converging in front (length 2.40-2.80, width 2.08-2.20 mm) ; antennae with 17 segments, 3rd segment shortest ; labrum short, tongue-shaped, pointed distally ; mandibles thick and stout, left with a prominent tooth a little below middle ; postmentum subrectangular, a little swollen medially ; pronotum saddle-shaped, anteriorly weakly and posteriorly deeply notched. Length c 7-7.50 mm.

Distribution : Widely distributed in India and Sri Lanka, also Combodia and Vietnam. According to Thakur (1976) it occurs in Sri Lanka and Peninsular India only.

Hosts and pest status : *O. horni* is reported as pest of tea and coconut in Sri Lanka and in India it is recorded from mango trees. It also attacks fallen logs of wood of *Hevea brasiliensis*, *Hopea odorata*, *Mangifera indica* and bark of living trees.

Biology and ecology : The nest of *O. horni* is subterranean and has a number of inter-communicating chambers in which the fungus combs are lodged. In Cambodia, this termite is reported to make dome-shaped mounds of the height of about 1 m and 1.20 m basal diameter (Bathelier, 1927).

The swarming of alates is reported in the months of October, December, and January from holes in the ground (Roonwal, 1970).

30. **Odontotermes obesus** (Rambur)

(Fig. 14 E)

1842. *Termes obesus* Rambur, *Histoire Naturelle des Insectes, Néèvroptires* : 304.

Diagnosis : IMAGO.—Head-capsule dark brown, postclypeus pale brown, pronotum and abdomen somewhat paler than head, the former with T-shaped, pale mark ; densely pilose. Head-capsule subcircular (width with eyes 2.43-2.80 mm) ; fontanelle minute ; eyes large, subcircular, projecting out, maximum diameter 0.73-0.90 mm ; ocelli large, oval, situated very close to eyes ; antennae with 19 segments ; postclypeus swollen, about half as long as wide ; pronotum subtrapezoidal somewhat emarginate both anteriorly and posteriorly ; wings brownish. Length with wings c 23-30, without wings c 10-14 mm.

SOLDIER (Fig. 14 E).—Head-capsule yellowish to dark reddish-brown, antennae paler basally and darker distally, body yellowish to yellowish brown ; head sparsely and body moderately pilose. Head-capsule oval, converging in front (length 1.20-1.67, width 1.07-1.37 mm) ; antennae with 16-17 segments, 3rd segment shortest ; labrum tongue-shaped ; mandibles thin, sabre-shaped, left mandible with a prominent tooth at base of distal third ; postmentum arched, convex laterally ; pronotum saddle-shaped, deeply notched both anteriorly and posteriorly. Length c 4-6 mm.

Distribution : *O. obesus* is the most common termite of the Indian subcontinent and is very widely distributed throughout except at higher altitudes.

Hosts and pest status : This species is a serious pest of all sorts of cereal and vegetable crops, sugar-cane (Pl. IV), cotton, tea and coconut plantations, fruit trees, fibre-crops, grasses (Pl. V, fig. 1) and even wooden structures in houses. Since this species is very common, the extent of damage is of enormous nature. It is also recorded from all types of woods in contact with soil, bark of living plants and trees, fuel wood, fallen logs and stumps, railway sleepers, etc. The following species of plants have also been reported to be attacked : *Abies pindrow*, *Acacia* spp., *Artocarpus integriceps*, *bamboo*, *Cassia fistula*, *Calophyllum* sp., *Cedrus deodara*, *Citrus* sp., *Cynodon dactylon*, *Dalbergia sissoo*, *Eucalyptus* spp., guava trees, *Mangifera indica*, *Morus* spp., *Pyrus sinensis*, *Shorea robusta*, *Tamarix* sp., *Triticum aestivum*, and *Zizyphus* spp.

Biology and ecology : *O. obesus* is the main mound-building termite of the Indian subcontinent. Different types of mounds are attributed to this species, they are either tall, unilocular-type with buttresses (Plate I, fig. 1) ; or dome shaped, multilocular-type with or without turrets ; or in the form of lumps of earth with the main nest underground. Roonwal (1962) studied the biology and ecology and the structure of the unilocular-type mound of this termite in some great detail. These mounds sometimes reach to a height of nearly 3 metres and are subcylindrical. Chhotani (1977) has described in brief the different types of mounds of this species found in the Kanha National Park. According to him the species specificity in respect of mound structure worths further investigations. Generally one queen and one king are found in the royal chamber, but more than one pair have also been reported. On the attacked wood or the trunks of trees, the workers make sheets of earth for cover.

Swarming starts with the beginning of monsoons and is generally at dusk time but may continue during the night. The ratio of soldiers, workers and nymphs in the mound is 7.7 : 49 : 43. 3 in the non-mound building months and 5.5 : 66. 5 : 28. in the mound-building months (Gupta, 1953).

31. **Odontotermes parvidens** Holmgren & Holmgren

(Fig. 14 F)

1917. *Odontotermes* (*Odontotermes*) *parvidens* Holmgren and Holmgren, *Mem. Dept. Agric. India* (*Ent.*), **5** : 159.

Diagnosis : IMAGO.—Head-capsule brown to castaneous brown, postclypeus light reddish brown, pronotum dark brown with a broad T-shaped, paler mark, abdomen dark brown ; moderately densely pilose. Head-capsule subcircular, 2.5-2.7 mm wide ; eyes subcircular, 0.60-0.65 mm in diameter ;

ocelli oval, small, length 0.20-0.27 mm, from eyes situated at a distance of their length or a little more ; antennae 19-segmented, segment 3 shorter than either 2 or 4, 5 shortest ; postclypeus swollen, about half as long as wide ; pronotum trapezoidal, anterior margin shallowly and posterior-one deeply invaginated medially ; wings large, yellowish brown. Length with wings c 28-30, without wings c 12-14 mm.

SOLDIER (Fig. 14 F).—Head-capsule yellowish brown, body creamy yellow ; head sparsely and body moderately pilose. Head-capsule large, subrectangularly oval (length 1.88-2.70, width 1.45-2.15 mm) ; antennae 17-segmented, 3rd segment shortest ; labrum triangular, apically pointed ; mandibles large and stout, left mandible with a small tooth at proximal third ; postmentum long, subrectangular ; pronotum saddle-shaped, distinctly notched both at anterior and posterior margins. Length c 5-8 mm.

Distribution : *O. parvidens* is quite well distributed in eastern and northern India, Bangla Desh and Pakistan. In Pakistan it is found inhabiting submountainous areas at an altitude of about 5,000 ft (Chaudhry et al., 1972). Southern Indian records of this species are doubtful.

Hosts and pest status : This species has been recorded as a pest of tea in Assam, India and as a serious pest of red gram (*Cajanus cajan*), eating away the roots. It is also reported feeding on bark of living trees and woods of the following plant species : *Duabanga sonneratioides*, *Mangifera indica*, *Melanorrhoea glabra*, *Pinus longifolia*, *Shorea robusta*, *Sterculia villosa* and *Tectona grandis*.

Biology and ecology : It is a large species and makes subterranean nests consisting of chambers having fungus combs. No mounds are reported to be constructed by this termite. It is a great destructor of woods lying on ground and covers them with soil. Roonwal (1954) has reported it damaging the bark and exposing the cambium to such an extent so as to cause death of the trees of teak plantations in Gorakhpur. The swarming of this species is reported to occur in the evenings in February to April from holes in the ground.

32. **Odontotermes redemanni** (Wasmann)

(Fig. 14 G)

1893. *Termes redemanni* Wasmann, *Wien Ent. Zeit.*, **12** : 239.

Diagnosis : IMAGO.—Head-capsule castaneous brown, body somewhat paler, pronotum brownish with a pale, T-shaped mark ; densely pilose. Head-capsule subcircular, width with eyes 2.67-2.87 mm ; fontanelle small, point-like ; eyes subcircular, large, diameter 0.80-0.88 mm ; ocelli large, oval, from eyes situated at about their short diameter ; antennae 19-segmented, segments 3 and 4 shortest, subequal ; postclypeus swollen, length about half

of width ; pronotum trapezoidal, anteriorly weakly notched, posteriorly substraight or faintly emarginate ; wings yellowish brown. Length with wings c 26-31, without wings c 11-14 mm.

SOLDIER (Fig. 14 G).—Head-capsule pale yellowish brown to dark brown, antennae paler basally and darker apically, body straw yellow to yellowish ; head sparsely and body moderately densely hairy. Head-capsule oval (length 1.15-1.33, width 0.98-1.05 mm), narrowing anteriorly ; antennae with 16-17 segments, segment 3 shortest or subequal to 4 ; labrum tongue-shaped ; mandibles sabre-shaped, curved at apices, left mandible with a sharp tooth near distal third, right with a small tooth a little below distal third ; pronotum saddle-shaped, deeply notched at middle both anteriorly and posteriorly ; abdomen oblong. Length c 4-6 mm.

Distribution : *Odontotermes redemanni* is common in Sri Lanka and is also quite widely distributed in southern and eastern India.

Hosts and pest status : Being a widely distributed and common species in Sri Lanka, it is a pest of importance. It attacks living plants of tea and rubber and also seedlings of coconut palms in Sri Lanka and living, standing trees of mango in India. It is reported from logs, stems and stumps of a number of plant species, such as *Acacia* sp., *Artocarpus hirsutus, Cassia siamea, Crotolaria brownei, Dalbergia latifolia, Ficus* sp., *Hopea odorata, Pterocarpus marsupium, Shorea robusta, Terminalia coriacea,* and *Xylia dolabriformis.* Wood and wooden structures in houses are also reported to be damaged by this termite.

Biology and ecology : It is a common mound-building termite in Sri Lanka and southern and eastern India. The mounds are large, dome-shaped to conical in shape and have large number of fungus chambers (multilocular-type). There is one central chamber also with a large fungus comb. The chambers inside are connected with each other by means of tunnels. The nest extends underground also to a depth of about 1.3 m. The royal chamber is generally situated eccentrically near the central chamber, rarely it is found above the ground-level. It is about 7-12 cm in diameter, and 2-2.5 cm in height and generally has a physogastric queen and a king, sometimes more than one queens are found (Escherich, 1911 ; Beeson, 1941 ; Roonwal 1970).

Nothing is known about the life-history of this termite. The swarming, however, is reported to occur in September in Eastern India and during November and December in Sri Lanka.

33. **Odontotermes wallonensis** (Wasmann)

(Fig. 14 H)

1902. *Termes obesus* sub sp. *wallonensis* Wasmann, *Zool. Jb.* (*Syst.*), **17** (1) : 106-109.

Diagnosis : IMAGO.—Head-capsule dark brown, paler around fontanelle, body slightly paler, pronotum with T-shaped, median, paler mark ; head and body densely hairy. Head-capsule subcircular, much broader than long (length 1.88-1.95, width with eyes 2.7-2.8 mm) ; fontanelle minute, circular ; eyes large, subcircular (0.80-0.85 mm in diameter) ; ocelli large, oval (length 0.37-0.45 mm), from eyes situated at a distance of less than half of length ; antennae 14 + segmented, segment 3 shortest ; postclypeus swollen, length half of width ; pronotum large, subtrapezoidal, both anterior and posterior margins notched medially. Length with wings c 30, without wings c 16 mm.

SOLDIER (Fig. 14 H).—Head-capsule yellowish to pale brownish yellow ; antennae paler basally, darker apically ; abdomen pale yellowish ; head sparsely and body fairly densely pilose. Head-capsule oval, converging in front (length 1.53-1.68, width 1.20-1.28 mm) ; antennae with 17 segments, 3rd segment shortest ; labrum tongue-shaped ; mandibles sabre-shaped, strongly curved at apices, left mandible with a prominent tooth a little above middle, right mandible with a minute tooth at middle ; pronotum saddle-shaped, deeply notched anteriorly, substraight at posterior margin ; abdomen elongately oval. Length c 5-7 mm.

Distribution : This species is quite common in Peninsular India and in Gujarat, Maharashtra, Madhya Pradesh, Orissa and Bihar States, in India.

Hosts and pest status : This termite is reported as a pest of sugarcane and is recorded from logs and woods of *Boswellia serrata, Pterocarpus marsupium, sterculia villosa, Tectona grandis* and plantations of *Casuarina equisetifolia* and *Dalbergia sisoo* (Sen-Sarma et al., 1975). It has also been found damaging maize, groundnut and soya bean crops (pl. II, fig. 1 ; pl. III) (information received through the courtesy of Shri D. Rajagopal, Bangalore).

Biology and ecology : *Odontotermes wallonensis* makes mounds which are made up of low, solid, irregularly-shaped structures of earth having a number of open chimneys leading deep into the mound (Plate I, fig. 2). Internally the mounds have chambers having fungus combs. The fungus combs are also arranged in tiers one over the other. The royal chamber lies much below the ground-level (Mathur and Chhotani, 1960) and may have more than one queens. The fungus combs are round or large, flaky, soft chunks. The termite also makes sheets of earth over the tree trunks as a cover, while feeding on the bark.

Genus **Hypotermes** Holmgren

Only four species of this genus are known and are restricted to the oriental region. The species *H. obscuriceps*, found in Sri Lanka and southern and eastern India is reported from tea in Sri Lanka. It is not of much signi-

ficance as such it is not dealt with in detail here. It is, however, illustrated and included in the keys for identification (Fig. 15).

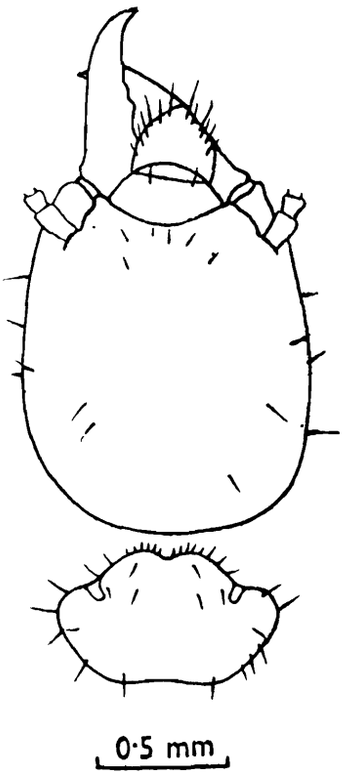

Fig. 15. Head and pronotum of soldier of *Hypotermes obscuriceps* (Wasmann).

Genus **Microtermes** Wasmann

Nine species of the genus *Microtermes* are known from the Indian sub-region, of which only three are pests of importance and are dealt with here.

34. **Microtermes mycophagus** (Desneux)

(Fig. 16 A)

1906. *Termes mycophagus* Desneux, *Annls. Soc. Ent. Belg.*, **49** : 348-352.

Diagnosis : IMAGO.—Head-capsule castaneous brown, abdomen paler than head ; head and body densely hairy. Head-capsule broad, circular (length 1.25-1.45, width 1.75-1.93 mm) ; fontanelle minute, circular , situated on mid-dorsum ; eyes large, round, 0.40-0.50 mm in diameter ; ocelli oval, 0.20-0.26 mm long, separated from eyes by less than half their long diameter ; antennae with 17-18 segments, segment 3 as long as 2, 4 shortest ; postclypeus swollen, length less than half of width ; pronotum subtrapezoidal, anterior margin substraight and with a faint, median notch, posterior margin round and distinctly notched medially. Length with wings c 20-24, without wings c 8-12 mm.

SOLDIER (Fig. 16 A).—Head-capsule yellowish brown, body much paler than head ; head and body fairly densely hairy. Head-capsule broadly oval,

converging anteriorly (length 0.85-1.03, width 0.78-0.95 mm) ; antennae with 15 segments, segments 3 and 5 subequal and shortest ; labrum tongue-shaped, extending up to distal third of mandibles ; mandibles weak and thin, weakly incurved at apices ; postmentum swollen, arched at sides, almost as long as wide ; pronotum strongly saddle-shaped ; anterior margin with a deep and posterior margin with a weak median notch. Total length c 3-5 mm.

Distribution : *M. mycophagus* is a common species of the genus and is found in drier parts of North-western India (Panjab, Delhi, Rajasthan) and Pakistan.

Hosts and pest status : It is recorded as a pest of "Bajra" (Pl. II, fig. 2) and fruit trees (Mango, mulberry, peach) in India and Pakistan and of cotton, vegetables, nurseries and sugarcane in Pakistan. It is also reported as a serious pest of forest nurseries in India (Sen-Sarma et al., 1975 ; Chaudhry et al., 1972).

M. mycophagus is also reported from dead stumps and logs of *Acacia* sp., *Dalbergia sissoo, Cedrus deodara, Ficus religiosa, Mangifera indica, Morus alba, Plantanus orientalis* and *Zizyphus* spp. It is a pest of significance.

Biology and ecology : This species is confined to arid and semi-arid parts of India and Pakistan. It is a subterranean species, living in small communities under stones, wooden logs, cowdung, etc. and makes small chambers for fungus combs. These chambers are connected with each other through communicating galleries. The swarming is reported to occur from July to August.

35. **Microtermes obesi** Holmgren

(Fig. 16 B)

1912. *Microtermes obesi* Holmgren, *J. Bombay nat. Hist. Soc.*, **21** (3) : 787-788.

Diagnosis : IMAGO.—Head-capsule yellowish brown to dark reddish brown, postclypeus yellowish brown, abdomen slightly paler than head ; head fairly and body densely hairy. Head-capsule subcircular (length 1.05-1.15, width with eyes 1.33-1.60 mm), epicranial suture weakly marked ; fontanelle small, circular, whitish spot ; eyes round (0.35-0.40 mm in diameter), buldging, separated from lower margin of head by about 1/4th of their diameter ; ocelli oval, medium sized (0.23-0.28 mm long), separated from eyes by about their short diameter ; antennae with 15-16 articles, segments 3 and 4 subequal and shortest ; postclypeus strongly swollen, length about half of width ; pronotum with indistinct median notch anteriorly and with a distinct notch at posterior margin. Length with wings c 13-15, without wings c 7-12 mm.

SOLDIER (Fig. 16 B).—Head yellowish, body whitish ; head and body

moderately hairy. Head-capsule broadly oval (length 0.80-1.00, width 0.76-0.88 mm) ; antennae 14-segmented, segment 4 shortest ; labrum lanceolate. reaching up to distal 1/4th of mandibles ; mandibles thin, weakly incurved distally ; postmentum arched, almost as wide as long ; pronotum strongly saddle-shaped, anteriorly deeply notched medially and posteriorly substraight. Length c 3.5-5.0 mm.

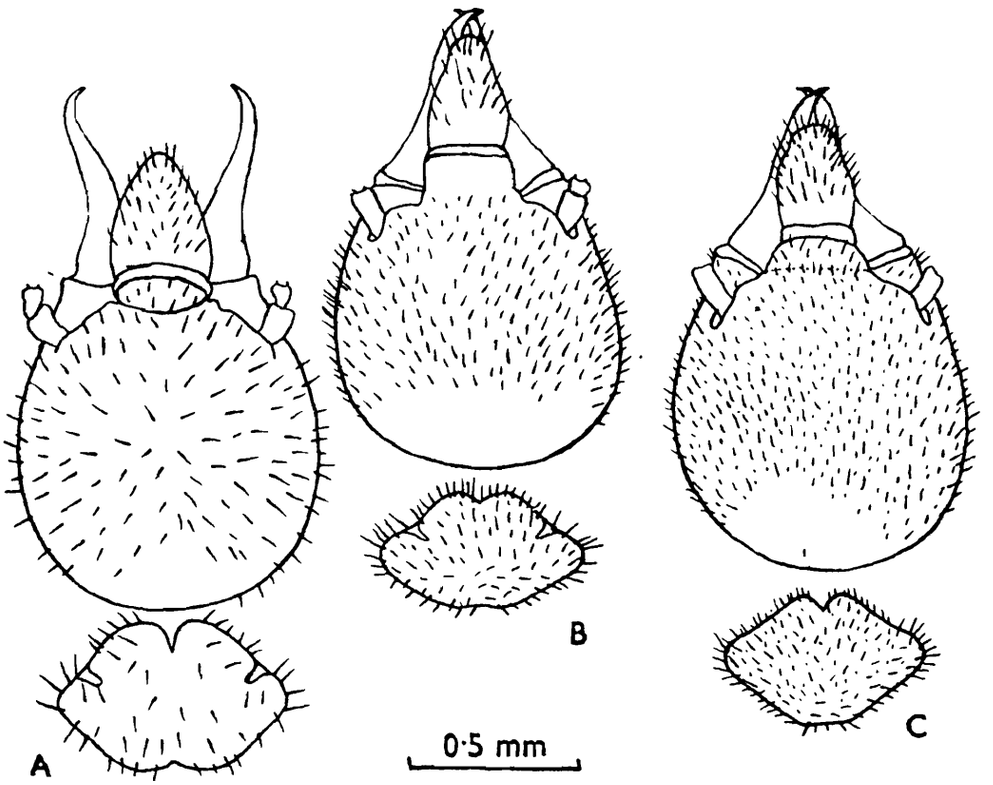

Fig. 16. Head and pronotum of soldier of *Microtermes* : A, *mycophagus* (Desneux) ; B, *obesi* Holmgren ; C, *unicolor* Snyder.

Distribution : Widely distributed throughout the Indian subcontinent and is also recorded from Bhutan, Burma and Thailand.

Hosts and pest status : *M. obesi* is one of the most highly injurious termite species of the subcontinent and is reported to do extensive damage to wheat, and other cereal crops, sugarcane, fruit trees, jute, cotton, vegetables, garden flower and ornamental plants, etc. Hussain (1935) mentions the loss to wheat crop to the extent of 6-25 per cent due to this termite alone. It eats away the roots of small plants causing yellowing of leaves and wilting. The damage to sugarcane in Bihar state of the Indian Union, mainly due to this termite, is colossal and is estimated to the tune of 2.5 per cent in tonnage of cane and 4.5 per cent in sugar output (Agarwala, 1955).

It is reported feeding on small branches, twigs and logs and woods of *Acacia* spp., *Anthocephalus chinensis*, *Artocarpus chaplasha*, *Bombax ceiba*, *Calotropis procera*, *Dalbergia sissoo*, *Dipterocarpus turbinatus*, *Ficus bengalensis*,

Gmelina arborea, *Morus alba*, *Mangifera indica*, *Pterocarpus marsupium*, *Shorea robusta*, *Tectona grandis*, and *Terminalia alata*.

In Pakistan it is reported to cause considerable damage to wood-works in buildings (Chaudhry et al., 1972).

Biology and ecology : It is a subterannean termite and makes its nest in soil or in mounds of other termites species such as *Odontotermes obesus*, *O. redemanni* and *O. microdentatus*. The nests have small, round chambers connected by means of thin, long galleries. The chambers contain fungus combs which are small, rounded structures made up of yellowish, granular pellets. They are extremely fragile and have weak ridges on the surface. The swarming is reported to occur during the months of April to August.

36. **Microtermes unicolor** Snyder

(Fig. 16 C)

1933. *Microtermes unicolor* Snyder, *Proc. biol. Soc. Washington.*, **46** : 92-93.

Diagnosis : IMAGO.—Head-capsule pale castaneous brown, body brownish ; head and body fairly densely hairy. Head-capsule subcircular (length 1.0-1.15, width with eyes 1.35-1.48 mm) ; fontanelle small, white, round spot ; eyes almost round, 0.33-0.40 mm in diameter ; ocelli oval, separated from eyes by less than half of width ; antennae 15-segmented, 3rd and 5th segments subequal and shortest ; postclypeus strongly swollen, length little more than half of width ; pronotum trapezoidal, indistinctly notched both at anterior and posterior margins. Length with wings c 12-14, without wings c 9-10 mm.

SOLDIER (Fig. 16 C).—Head-capsule pale yellowish, body whitish ; head and body densely hairy, more so than in *obesi*. Head-capsule oval, narrowed in front (length 0.82-0.96, width 0.75-0.86 mm) ; antennae with 14 segments, segments 3 and 4 subequal and shortest ; labrum lanceolate, tip comparatively broader than in *obesi*, reaching up to distal fourth of mandibles ; mandibles thin, feeble and weakly incurved apically, dentition not distinct ; postmentum strongly arched, slightly longer than wide ; pronotum saddle-shaped, deeply notched anteriorly and faintly so posteriorly. Length c 4-5 mm.

Distribution : *M. unicolor* is quite common in Northern India, Pakistan and Bangla Desh.

Hosts and pest status : This species is reported to damage roots and stumps of sugarcane and also attacks chillies in Pakistan (Chaudhry et al., 1972) but has not so far been reported from any agricultural crops in India. It is also found feeding on twigs, stumps and logs of wood of *Acacia* spp., *Dalbergia sissoo*, *Morus alba*, *Olea* sp., *Ricinus communis*, *Salix* sp., *Shorea robusta*, *Tamarix* sp., and *arial* roots of *Ficus bengalensis*,

Biology and ecology : The nests and nesting behaviour of this termite is similar to that of *M. obesi*. The swarming is, however, reported during April to August in the evenings after rains.

Genus **Nasutitermes** Dudley

Nearly 25 species of the genus *Nasutitermes* are known from the Indian subregion, of which only *N. ceylonicus* (Holmgren) is recorded as a pest of coconut trees in Sri Lanka.

37. **Nasutitermes ceylonicus** (Holmgren)

(Fig. 17 A)

1911. *Eutermes ceylonicus* Holmgren, In : Escherich's *Termitenleben auf Ceylon* : 197-198.

Diagnosis : IMAGO.—Head-capsule castaneous brown, thorax and abdominal tergites somewhat paler, sternites pale brown ; head and body with numerous short and a few, long hairs. Head-capsule subcircular (length 1.0, width 1.20 mm), slightly depressed medially, epicranial suture indistinct ; fontanelle-plate elongate, narrow, whitish ; eyes circular, 0.31-0.36 mm in

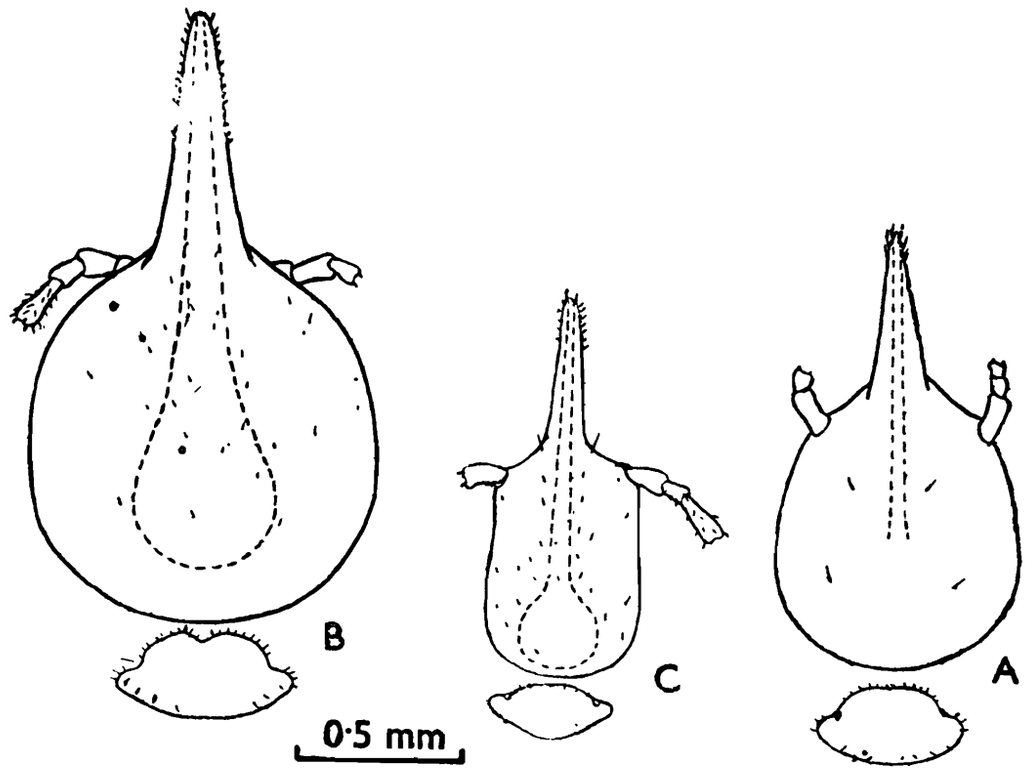

Fig. 17. Head and pronotum of soldier : A, *Nasutitermes ceylonicus* (Holmgren) ; B & C, *Trinervitermes biformis* (Wasmann), soldier major and soldier minor, respectively.

diameter ; ocelli oval, translucent, eye-ocellus distance a little less than their short diameter ; antennae with 14-15 segments, 4th segment shortest ; post-clypeus moderately swollen, length less than half of width ; labrum broadly

tongue-shaped ; pronotum subtrapezoidal, indistinctly emarginate anteriorly and deeply invaginated posteriorly ; wings pale brown, densely hairy and punctate. Total length with wings c 12-14, without wings c 7.4 mm.

SOLDIER (Fig. 17 A).—Head-capsule pale brown, abdomen straw coloured ; head scantily and abdomen with short and a few long hairs. Head-capsule pear-shaped, length to base of rostrum equal to width (length with rostrum 1.35-1.50, without rostrum 0.85-0.95, width 0.75-0.92 mm), straight in profile ; rostrum short, conical (length 0.50-0.55 mm) ; fontanelle gland and tube well marked ; antennae with 12-segments, 3rd segment longer than 2 ; mandibles vestigial, each with a spine-like process ; pronotum saddle-shaped, anteriorly weakly emerginate, posteriorly substraight. Length c 2.5-3.8 mm.

Distribution : It is quite a common species in Sri Lanka.

Hosts and pest status : *N. ceylonicus* has been found attacking the bark of coconut and tea plants in Sri Lanka, but is not a serious pest. It is also reported from wood-work of buildings (Lal and Menon, 1953).

Biology and ecology : The nests of this termite are made up of dark grey carton having large and small holes to give it a sponge-like appearance. These may be of two types, (i) a polydomous-type above the ground, and (ii) an undergroud-one with galleries and some chambers and having a few carton projections. In case of damage to galleries and nests the workers undertake the repair work immediately while the soldiers stand at guard and attack the predating ants by squirting out secretion from fontanelle gland. The imagos have been collected in the month of November (Escherich, 1911 ; Roonwal, 1970).

Genus **Trinervitermes** Holmgren

Five species of the genus *Trinervitermes* are known from the Indian subregion. The species *T biformis* (Wasmann), is very common and is widely distributed and recorded as a pest of cereals, vegetable crops, sugarcane, cotton and fruit trees.

38. **Trinervitermes biformis** (Wasmann)

(Fig. 17 B, C)

1902. *Eutermes biformis* Wasmann, *Zool. Jb. (Syst.)*, **17** (1) : 133-135.

Diagnosis : IMAGO.—Head-capsule and abdomen above brown with reddish tinge, pronotum pale brown, sternites brownish, paler medially ; head and body densely hairy. Head-capsule subcircular broader than length to base of mandibles (length 1.2-1.4, width 1.52-1.82 mm) medially depressed a little, epicranial suture either present or absent ; fontanelle plate Y-shaped or triangular ; eyes suboval, moderately large, 0.5-0.55 mm in diameter ; ocelli oval, translucent, length 0.18-0.25 mm, from eyes situated at distance

of 1/5 to 1/3 of length ; antennae with 15-16-segments, segment 3 longer than 2 ; postclypeus swollen, length little less than half its width ; labrum dome-shaped ; pronotum trapezoidal, anterior margin straight not incissed, posterior margin either straight or weakly convex and with a weak to strong, medial emargination ; wings hairy and punctate. Total length with wings c 18-19, without wings c 9-12 mm.

SOLDIER MAJOR (Fig. 17 B).—Head-capsule brown, rostrum reddish to dark brown and paler apically, abdomen pale brown to dark smoky brown dorsally. Head-capsule without rostrum almost round or pear-shaped, not constricted behind antennae (head length with rostrum 2.2-2.5, without rostrum 1.35-1.60, width 1.25-1.50 mm), in profile with a weak concavity at base of rostrum, occiput greatly arched in profile ; rostrum conical, uplifted apically, tip with a few, short hairs ; antennae 12 to 14-segmented, segment 3 variable depending on number of segments, slightly longer to nearly 2.5 times that of 2 ; mandibles vestigial, without spines ; pronotum saddle-shaped, anterior lobe greatly upturned and broadly invaginated at anterior margin, posterior margin weakly convex ; abdomen elongate, tergites without any long hairs, sternites with long and short hairs. Total length c 4.5-5.0 mm.

SOLDIER MINOR (Fig. 17 C).—Head-capsule yellowish to dark brown, rostrum darker, abdominal tergites fuscous. Head-capsule subrectangularly oval, length about one-and-a-half times that of width (length with rostrum 1.4-1.7, without rostrum 0.85-1.10, width 0.55-0.77 mm), in profile concave ; rostrum long, cylindrical, awl-shaped ; antennae long, 12 to 14-segmented, segment 3 about twice as long as 2 or a little longer ; mandibles vestigial, without any spines : pronotum small, saddle-shaped, not notched anteriorly and convex posteriorly ; abdomen as in soldier major. Total length c 3-4 mm.

Distribution : It is quite a widely distributed species in India and is known from Maharashtra, Madhya Pradeh, Rajasthan, West Bengal, Tamil Nadu, Andhra Pradesh and Kerala states. It is also known from Sri Lanka and Pakistan.

Hosts and pest status : *Trinervitermes biformis* is quite a serious pest of wheat, vegetable crops, sugarcane, groundnut, cotton and fruit trees. It is also the commonest foraging termite and a pest in grasslands and is reported attacking dry roots of *Euphorbia* sp. in Rajasthan and stumps of *Acacia* sp. in Pakistan.

Biology and ecology : It is a common foraging termite in India, the workers go out on foraging expeditions in thousands, a little before sunset, in regular columns with the soldiers taking up positions to guard from the attacks of ants and other predators. The nests of this species are geneally subter-

ranean and consist of ramification of galleries, tunnels and small chambers which are coated with black excretary matter. The chambers are used as nurseries and for storage of food such as pieces of grasses. Sen-Sarma and Mathur (1961) and Roonwal (1977, 1978), have recorded it making small, dome-shaped mounds, 8-30 cm high in southern India in the areas densely covered with grass.

The imagos have been collected in the field during June and July in India and during November in Sri Lanka.

III. TERMITE DAMAGE TO AGRICULTURE AND THEIR CONTROL

(A) General

The damage to crops due to a pest depends mainly on the population density of a particular pest. As rightly pointed out by Pradhan (1964), an insect becomes a serious pest once its population reaches a critical level. The locusts and grass-hoppers become serious pests in the gregarious-phase when their populations increase tremendously and assume epidemic proportions. Termites, being social insects, live in colonies. Although each colony is regarded as single unit but the number of individuals in a colony is so great that it may be said that the population of termites is generally at a critical level. A plant attacked by termites may have several hundred to several lacs of the tiny workers, feeding on its cellulosic matter. As such the rate of damage by termites is much faster and greater than caused by any other insect pest and is of continuous nature throughout the year. The damage caused by these insects is generally concealed since they do not attack the leaves, pods and fruits and goes unnoticed. They attack the roots of germinating wheat, roots and stem of sugarcane, maize jowar and bajra ; roots of vegetable plants ; roots, stem and branches of fruit trees and so on. Due to their infestation the yield is greatly reduced but the producer remains unaware of the reason since the damage is under cover.

The loss due to the infestation of these insects run into crores of rupees. There is no recent statistics available on the loss caused by these insects but keeping in view Fletcher's (1912) estimated loss to grain crops alone to the tune of Rs 280 million annually, Agarwala's (1955) estimation of loss caused to sugarcane, Das's (1962) to tea crop in certain districts of North-East India and the polyphagus habit of termites, it may be presumed that these tiny insects cause extensive damage to our agricultural crops and other plantations. Some major crops damaged by termites in India and the control measures recommended are dealt with here.

(B) Damage to Agricultural Crops

1. *Wheat*

Wheat is the major cereal crop in northern India and Pakistan. The termites of the species *Odontotermes obesus* (Rambur), *Microtermes obesi* Holmgren, *Nasutitermes* sp. and *Trinervitermes biformis* (Wasmann) are the major pests. The damage to the plants is done generally at the germinating or during earhead stages. The species *Microtermes obesi* feeds on the roots of seedlings and causes yellowing and wilting of leaves and is reported to cause loss up to 25 per cent, the average being about 6 per cent (Hussain, 1935). Generally 'Barani' wheat is damaged the most. Peswani and Katiyar (1972) report termite activity in only 5 per cent of the area in a field of 0.8 hectare at Delhi under 'Barani' conditions. Vyas (unpublished) observed 0.33-5.90 per cent of damage to wheat in the year 1976, 6.84-17.83 per cent in 1976-77 and 0.79-23.81 per cent in 1978, in the unirrigated crops in Rajasthan Canal Command Area and no damage in the irrigated crops. The damage caused by termites in certain localities, however, is much greater, which is evident from the much higher yields reported from treated fields. Patel (1962) has reported an increase of 55.9 per cent of the yield from fields in Gujarat where seed treatment with insectcides was given, before sowing and Bindra (1961) reported a yield of 1475 kg of wheat per hectare from treated fields as against 625 kg per hectare in the untreated ones.

Damage to wheat in India has been reported by *Microtermes obesi* from Panjab, Rajasthan, Delhi, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh and Bihar, states ; by *Odontotermes obesus* from Panjab, Delhi, Rajasthan, Uttar Pradesh, Madhya Pradesh and Gujarat ; by *Odontotermes gurdaspurensis* from Rajasthan ; by *Nasutitermes* sp. from Madhya Pradesh ; and by *Trinervitermes biformis* from Gujarat and Maharashtra, states. In Pakistan, the species *Odontotermes obesus* and *Microtermes obesi* are reported as pests of wheat (Janjua & Khan, 1955).

Outside India, damage to roots of young wheat plants is reported from Tanzania by *Microtermes vadschaggae*, by harvester termites in South Africa and by *Procorintermes triacifer* in Brazil (Harris, 1971)

Control.—Before the advent of chlorinated hydrocarbons, the soil treatment of wheat fields by "dharek" (*Melia*) or "akk" (*Calotropis*) leaves or by arsenic or Paris Green or crude oil in irrigation water was recommended to check the ravages of termites. The seed treatment with mercuric chloride or copper sulphate was also found quite effective. In the recent years, the chlorinated hydrocarbons have replaced all earlier treatments due to their lasting effect and for being economical.

In the experiments conducted in Maharashtra, Patel (1955) reported that

the stand of the crop in the untreated seeds was the best when organo-mercurial one per cent, mercury fungicide or 10 per cent DDT and BHC dusts or Mercurial plus 10 per cent DDT and BHC dusts or 2 per cent BHC and 2 per cent DDT pastes were used. According to Chatterjee, Sarup and Chopra (1960), the plots treated with Dieldrin (10-15 lbs per acre) showed less damage to wheat by termites and higher yield. Bindra (1961) got very good results in Madhya pradesh by mixing 5 per cent Aldrin dust with seeds just before sowing at the rate of 20-40 lbs per hectare. The wheat yield was also increased appreciably and he obtained 1475 kg per hectare in the treated plots as against 625 kg in the control plots. According to him this gives complete protection against termites and that Aldrin and Dieldrin appear to stimulate growth and tillering, while BHC, Lindane and Chlorodane inhibit growth. Patel (1962) got 83.5 per cent check of termites by drilling 5 per cent BHC along with the seed and 43.4 per cent increase in yield and got 55.9 per cent increased yield by seed-dressing (2 lbs of 50 per cent BHC per 112 lbs of seed). The higher dosage of 4 lbs of 50 per cent BHC per 112 lbs in seed-dressing, according to him, is harmful in the germination of the crop.

Ghosh (1964) while experimenting in the control of *Microtermes* sp. in wheat and paddy fields found that Aldrin and BHC at 3.40 kg per hectare each and Chlorodane (2.27 kg per hectare) had no adverse effect on germination and growth of crop and instead phytostimulation due to Aldrin was noted. The damage to wheat plants, observed after a month of sowing, was on an average found to have been reduced to 0.27-0.38 per cent due to soil treatment with these insecticides as against 18.06 per cent in untreated plots.

As *Odontotermes obesus* is one of the major termite pest and a mound-builder, it is recommended that the termite mounds of the species, if any, in and around the agricultural fields be destroyed. The cheapest method for this is to pour water suspension of 0.005 per cent BHC (9,000 cc per 10 cu ft of mound-volume) as recommended by Roonwal and Chatterjee (1962). Before sowing, seed-dressing with 5 per cent Aldrin (20-40 lbs per hectare) which has been found to be very effective against the ravages of termites and at the same time helps to stimulate germination, is recommended. By employing these control measures the crop yield can be significantly appreciated.

2. *Rice*

The paddy crop in India, is generally not subjected to damage by termites. Ghosh (1964) has, however, reported *Microtermes* sp. on autumn paddy in Maldah District, West Bengal. According to him, the same dosages of insecticides as applied for pre-sowing soil treatment in case of wheat crop, showed like efficiency as against about 80 per cent damage in the untreated fields, in spite of rains.

According to Harris (1971), paddy is subjected to losses by *Coptotermes formosanus* and to a lesser extent by *Pericapritermes nitobei* in Japan ; by *Odontotermes formosanus*, *Pericapritermes nitobei* and *Procapritermes mushae* in Formosa and by *Procornitermes araujoi*, feeding on roots and ripening stem in Brazil. In Nigeria, according to him, *Macrotermes bellicosus* attacks roots of seedlings, *M. subhyalinus* cuts the ripening stem and feeds on fallen heads, causing 15-20 per cent loss of the crop and that *Trinervitermes ebenerianus* may completely defoliate certain areas.

In India, none of the *Coptotermes* and *Odontotermes* species, which are otherwise very common, are reported as pests of paddy.

3. *Maize, Millets, Pulses, etc.* (Pl. II)

Other than wheat, maize and millets form the staple food in India and the pulses are a cheap source of protein in the daily diet of the common man. Very little information is available on the termite damage to these crops. Sarwar (1940) reported damage to maize by *Odontotermes* species in areas which now form Pakistan. Agarwala and Sharma (1954) reported that maize is often seriously damaged in the infested areas in Bihar, Bindra (1961) has reported damage to maize, jowar and red gram (arhar) in Madhya Pradesh and Kushwaha (1960) and Sharma (1964) have reported termite damage to maize and jowar respectively in Rajasthan. Vyas (unpublished) reports damage to gram crop in Rajasthan to the extent of 12.74-19.22 per cent under unirrigated conditions in December 1976 and to the extent of 0.43-19.88 per cent in the year 1977-78.

There is no over all assessment of the loss caused by termites to these crops in India but keeping in view the areas where there crops are grown the termite damage is presumed to be fairly high.

The termite species involved in damaging these crops are *Odontotermes obesus* and *O. gurdaspurensis* in Rajasthan. A considerable damage is reported to be caused by *O. obesus* to jowar seedlings of 2-3 leaf stages and that the destruction is maximum in plants of less than 15 cm height (Sharma, 1964). The maize is attacked both underground and at the ground-level (Kushwaha, 1960). The stem is also attacked and filled up with earth thus blocking the source of food and the plant dies. In Bihar, *Microtermes obesi* is reported as a serious pest of maize.

Chhabra (unpublished) in a paper presented at the second All India Symposium on Soil Biology and Ecology, held in April, 1979, at the University of Agriculture Sciences, Bangalore (India), reported the incidence of termite attack to pulses e.g., black gram, green gram, chick pea and lentil, in the pulse growing tracts of Punjab state. The damage was reported to be higher in the sandy soils and rainfed areas than in the heavy soil and was around 10 per cent in the districts of Ludhiana, Faridkot, Ferozpur, Bhatinda and Sangrur. He recommends 10 per cent BHC (25 kg per hectare).

Species of the genera *Macrotermes*, *Odontotermes*, *Allodontotermes*, *Microtermes* and *Ancistrotermes* are reported as pests of maize in Tanzania, Rhodesia and Congo in Africa. An average loss of 27 per cent over a period of five years is reported in Tanzania (Harris, 1971).

Control : Not much attention has been paid to the control of termites infesting these crops, the probable reasons being that they are cheaper crops and hence not much importance is given.

Agarwala and Sharma (1954), however, got best germination and least mortality of plants due to termite injury, and an appreciation of 173.5 lbs and 98.2 lbs in the yield of maize in the experimental plots treated with as little dosage as 0.2 lbs Aldrin and 0.25 lbs Dieldrin per acre. It is, therefore, recommended that Aldrin may be used in the form of dust, mixing it with the top six inches of soil as suggested by these workers in the areas of termite infestations.

4. *Vegetable, Flowering, Ornamental and Medicinal Plants*

A number of vegetable crops such as cabbage, cauliflower, pea, potato, brinjal, soya bean, chilli, etc. have been reported to be subjected to termite attack. Chilli crops in Pakistan and Gujarat (India) are damaged by *Odontotermes obesus* and *Trinervitermes biformis*, respectively. The termites are reported to feed on the roots thus cutting off the nutrition to the plant. The potato crop in Mysore is reportedly damaged by termites which eat away the potato pieces and cut away the germination (Rao, 1958). In Bihar, the attack by the species *Odontotermes obesus* and *Eremotermess* sp. has been observed in the tuber stage, thus reducing the production by 4.7 to 6.5 per cent (Kumar, 1965). Soya bean plants (Pl. III, fig. 2) are damaged by *Odontotermes wallonensis* in Karnataka (Rajagopal, unpublished).

Flowering plants such as rose and sunflower and ornamental plants e.g., *Amaranthus giganticus*, *Chrysanthemum* sp. and some cactus are reported to be attacked by the termite *Microtermes obesi* in Rajasthan and Panjab (Kushwaha, 1960 ; Arora, 1962). The species *Odontotermes obesus* has been found to infest 50-60 per cent of the plants of *Mentha arvensis haplocalyx* Briquet var. *piperascens* Holmes, the common japanese mint, which is cultivated for mint oil and menthol, in Jammu. The termites feed on the roots and the stem (Gupta and Agarwal, 1963).

Control : In case of chilli (*Capsicum*) crop, Chopra (1928) recommended soil treatment with 6.5 ozs arsenic and 8 ozs Paris Green mixed with ash per 100 sq ft. For the control of termites in case of Japanese mint, Gupta and Agarwal (1963) could check the infestation by water flooding the fields and application of 3 per cent heptachlor at the rate of 40-50 lb per acre. Since the species involved in case of these crops are subteranean in habit, soil treatment

with insecticides is the only method to save the crops from termite damage. An even dispersion of the insecticide would give a good protective barrier.

5. *Groundnut* (Pl. III, fig. 1)

The groundnut crop in India and Pakistan is attacked by the termites *Odontotermes obesus*, *O. wallonensis*, *Trinervitermes biformis* and *Microtermes obesi*. The termites penetrate the stem near the ground-level and hollow it out causing the plant to wilt. The seed pods are also eaten and thus are liable to infection by fungi (Harris, 1971). Rawat et al. (1970), in Madhya Pradesh, reported 35 per cent loss in cotrol plots as against 6-26 per cent loss in the plots treated with 6 per cent heptachlor (25 kg per hectare) applied to planting furrows and an increase in yield. Sands (1960) as quoted by Harris (1971), has reported loss up to 10 per cent in northern Nigeria.

Outside India, termites of the genera *Eremotermes*, *Amitermes*, *Microcerotermes*, *Macrotermes*, *Odontotermes*, *Ancistrotermes*, *Microtermes* and *Trinervitermes* are reported damaging groundnut crops and ripe pods in various parts of Africa. The species *Coptotermes formosanus* is reported to feed on ripe pods in South China (Harris, 1971).

Control : Shell Petroleum Company in an advertisement in Review Applied Entomology claimed to have achieved ten times more yield in irrigated and six times in unirrigated areas through treatment of soil with Aldrin (one lb/acre) for the control of *Odontotermes obesus* in Pakistan. Rawat et al. (1970) obtained more than double the yield by the application of 6 per cent heptachlor in furrows (25 kg per hectare) and according to Harris (1971), soil treatment with Gamma BHC (1 to 2 kg per hectare) or Aldrin dust (0.5 kg a. i. per hectare) or seed treatment with Aldrin (28.5 gms a. i. per kg of seed) or BHC application in drill give satisfactory protection.

(C) Damage to Plantation Crops

The main plantation crops in India are sugarcane, tea, rubber and coconut. Termites are reported to do extensive harm to sugarcane, tea and coconut. The rubber plantation in India is not that seriously damaged. In South-East Asia, however, the species *Coptotermes curvignathus* is reported as a serious pest of rubber trees.

1. *Sugarcane* (Pl. IV)

India is the largest sugarcane growing country of the world and has the maximum area under cultivation for this crop. Sugar is one of the major items of export and a big foreign exchange earner for the country. The sugarcane is a favourite crop for large number of insect pests and termites are well known major destructors and destroyers of this important crop. A number

of species are reported as pests from several parts of the country, the major pests, however, are *Coptotermes heimi*, *Odontotermes assmuthi*, *O. obesus*, *O. wallonensis*, *Microtermes obesi* and *Trinervitermes biformis*.

The loss to sugarcane due to termite attack is reported to be very heavy. Pruthi and Narayanan (1939) mentioned 30.45 ± 12.59 per cent of loss due to termites to the variety CO 299 in the year 1936 and that these insects caused significant loss to some other varieties in combination with root borers. Singh and Kishan (1946) have reported destruction of 40-60 per cent eye buds. Agarwala (1955) estimated a loss of 2.5 per cent in tonnage of sugarcane and 4.5 per cent in sugar output in the state of Bihar alone, mainly due to the termite *Microtermes obesi*. Narayanan and Lal (1952) reported loss up to 3.75 (average 1.666) per cent of setts in the year 1946 and up to 1.54 (average 1.078) per cent in 1947, due mainly to the termite *Odontotermes obesus* and also to some extent to *Eremotermes paradoxalis* and *Microtermes obesi*, at Delhi. So severe a damage to sugarcane crop has been reported in certain plots at Bhupalsagar in Chittor District, Rajasthan (Kushwaha, 1961) that the entire crop had to be destroyed to check further infestation. Teotia et al. (1963) have reported 30-60 per cent eye buds being destroyed by termites in Uttar Pradesh, the state which accounts for nearly 50 per cent of the country's sugarcane crop and according to Avasthy (1967) nearly 40 per cent of buds are destroyed, resulting in yield reduction of about 33 per cent. Agarwal (1972) has reviewed the loss to sugarcane caused by termites and increase in yield due to treatments as reported by different workers. From the above estimates it is evident that these insects are very serious pests of sugarcane and that the country may be losing several hundred crore of rupees worth of this useful crop year after year in the absence of proper control measures.

The damage to sugarcane is at two stages, firstly at the sowing time during the pre-monsoon period when the termites infest the eye buds and ends of the setts, causing in the failure of germination and secondly during post-monsoon period when the germinated stalks are attacked and destroyed leaving behind only the soil-filled shoots.

Control : To check the damage to sugarcane by termites there are two ways by which some satisfactory control can be obtained, (i) by treating the setts with poisons before sowing and (ii) by soil treatment. Fletcher (1917) found the treatment of setts with lead arsenate solution (1 lb in 2 gallons) and application of potassium sulphocarbonate in irrigated water to be quite effective but recommended use of crude oil emulsion in irrigated water since it gave good protection to growing crops (Fletcher, 1917, 1922) ; this method was recommended by different workers for other crops as well. Treatment of setts with 5 per sent solution of copper sulphate, 2.5 per cent crude oil emulsion, 2.5 per cent mercury chloride, 1.0 per cent arsenic and 1.0 per cent Paris

Green also, according to Department of Agriculture, Punjab, gave satisfactory protection to the crops. Soil treatment with neem cake, irrigation of fields with crude oil emulsion, painting of sugarcane setts with coal tar and treatment of setts with *Acorus calamus* and copper sulphate solution or lead arsenate and lime solution were also recommended (Gupta, 1937).

More recently the use of chlorinated hydrocarbons has been found to be much more satisfactory in combating the ravages by termites. Gupta (1950) has mentioned that dipping of setts in 2.5 per cent DDT emulsion or suspension and application of BHC (5 per cent) dust in furrows (20 kg per hectare) before planting are very effective against termites and according to Rao (1951), the treatment of setts with 5 per cent solution of BHC (Gammaxene) is superior to other treatments and also from the point of view of germination. In fact, all the insecticidal treatments have good effect on the control of termites and the yield of crop but BHC has been reported to have some toxic effect which inhibits the germination when applied in higher dosages. Agarwala et al. (1954) and Khanna et al. (1956) found that Dieldrin gave very good results in germination and in increasing the yield in Bihar state. Chlorodane (5 per cent dust @ 20 kg per hectare) was also found very effective and it produced stimulating effect on growth and gave higher yield (Siddiqi and Agarwal, 1954, 1956 ; Agarwal, 1957). Teotia et al. (1963) found that Heptachlor (3 kg per hectare) controlled termites as well as shoot borers. Since Dieldrin and Chlorodane have been found to check effectively the termite attack and stimulate germination, they are safe to be used to boost the yield. In a report in a newspaper it is mentioned that in the experiments conducted with Chlorodane at Sugarcane Research Station, Shahjahanpur, the germination was enhanced from 23 to 52 per cent, the early tillering from 20,000 to 60,000 per acre and the yield per acre from 900 to 1200 maunds. Treatment of cane-setts with these insecticides before sowing and application of insecticides in furrows are, therefore, recommended.

Macrotermes gilvus in Java, *Heterotermes philippinensis*, *Coptotermes vastator*, *Microcerotermes losbanosensis* and *Macrotermes gilvus* in the Phillippines and *Coptotermes formosanus* and *Odontotermes formosanus* in Formosa and South China are some of the important termite pests of sugarcane in the near East. *Coptotermes formosanus* has been introduced into Sri Lanka but has not been reported as a pest of any significance whereas in Hawaii it is introduced and reported feeding on sugarcane. *Odontotermes formosanus* though reported from N. E. India is not so far recorded as a pest of agriculture.

2. *Tea*

In the Indian subcontinent, tea is mainly grown in North-East India (Assam and West Bengal), southern India (Nilgiri Hills), Bangla Desh and Sri

Lanka. It is one of the most important plantation crops for India and Sri Lanka since tea exports fetch huge amount of foreign exchange which is essential for the developing countries. A few of the termite species are serious pests of tea plantations for they cause direct damage to living bushes and ultimately result in their death. Kapur (1958) mentions them to be a serious menace for tea cultivators. Das (1962) estimated that approximately 15 per cent of the crop is lost annually due to some *Microcerotermes* spp. in certain districts of North-eastern India. He also reported 50-100 per cent damage to tea bushes in Darrang and Cachar, but according to Hainsworth (1952) the termites do very little damage in North-East India and can be over looked and that they assist in clearing out process. In Sri Lanka, the damage, according to Pinto (1941) and Fernando (1962) is quite appreciable while Ranaweera (1962) states that it has been over-estimated.

The termites species, from the tea plantations, reported from eastern India are *Microcerotermes* spp., *Odontotermes obesus (=O. assmensis), O. parvidens* and *Microtermes obesi*. From southern India, *Postelectrotermes bhimi* and *Coptotermes ceylonicus* are reported from tea bushes, but the damage is not significant. In Bangla Desh *Odontotermes* sp. is reported but the damage is negligible. In Sri Lanka, a number of termites have been reported damaging tea, the more important species being *Postelectrotermes militaris, Glyptotermes dilatatus, Coptotermes ceylonicus, Odontotermes horni* and *O. redemanni*. According to Pinto (1941), *Postelectrotermes militaris (=Neotermes militaris)* occurs at altitudes from about 1,050-1,400 m (3,500-4,500 ft) and is the most destructive termite of living tea trees. It hollows out the stem and branches and infests the roots and rootlets as well and that *Glyptotermes dilatatus* is an important pest of tea at mid-elevations.

Outside the Indian region, the termites *Microtermes pallidus, Odontotermes javanicus* and *O. longignathus* are reported from tea in Malaysia, *Microtermes jacobsoni* in Java (Indonesia) and *Odontotermes formosanus* in southern China and Formosa. Some species of the genus *Odontotermes* are also responsible for damage to tea plantations in the African states of Rhodesia, Uganda, Tanzania and Malawi (Harris, 1971). Of the wood termites, eleven genera of Kalotermitidae are recorded from tea and other tree growing plantations in the world (Sands, 1973).

Control : The earlier control measures employed, to check and destroy the termite activity in tea plants in Sri Lanka, were of cleaning and painting of cavities with creosote and filling the same with cement (Hutson, 1923 and Andrews, 1924). Jepson (1928) recommended fumigation with carbon bisulfide or paradichlorobenzene and later (1929) used paris green to kill the colonies of wood termites. In India, mostly the *Odontotermes* species are the culprit. Harrison (1946) recommended treatment of tea bushes with 2 1/2 oz of

1.5 per cent gammaxene for three successive days and Hainsworth (1952) suggested treatment of soil around each bush with BHC at the beginning or end of rains and introduction of BHC or DDT into the termite mounds. Das (1957, 1962) also treated mounds by introducing DDT, BHC, Aldrin and Dieldrin and then pouring down water. He also suggested elimination of dead and diseased woods and painting the exposed wood by a protective paint.

For control of wood termites (Kalotermitidae) introduction of insecticides under pressure at the rate of one or two pints of 0.1 per cent Dieldrin or 0.25 per cent Chlorodane emulsion through the holes leading to nest galleries just after the prunning of tea bushes, as recommended by Tea Research Institute of Sri Lanka, and fumigation with aluminium phosphide in pellet form (Danthanarayana and Fernando, 1970) have been found quite effective. In case of subterranean termites, clearing up of the tea estates of dead branches, leaves, debris etc., treatment of soil with Aldrin or Dieldrin at 2.24 kg per hectare as suggested by Das (1962) and treatment of termite mounds in the tea growing estates, as recommended by Roonwal & Chatterjee (1962) should prove to be useful in combating the damage.

3. *Coconut* (Pl. V, fig. 2)

Coconut is cultivated all along the coastal regions of India, in Sri Lanka and in other islands and coastal areas in the tropics. In Kerala state, on the western coast of India, there are regular plantations and it is a priced cultivation. The termites attack the nursery seedlings and the young and mature trees. In the laterite soil, on the western coast, up to 20 percent of the seedlings are reported to be destroyed by the termite *Odontotermes obesus* (Nirula, Antony and Menon, 1953). The stem near the surface of ground is also damaged by this termite. In Sri Lanka, *Coptotermes ceylonicus* is reported to hollow-out the stem and *Odontotermes redemanni* destroys the seedlings. Other than these, the species *Microcerotermes danieli* and *M. nicobarensis* are reported from coconut palms in Andaman and Nicobar islands and *M. bugnioni* and *Nasutitermes ceylonicus* from Sri Lanka.

In Malaysia and Java, the species *Coptotermes curvignathus*, *C. sinabangensis*, *Globitermes sulphurus* and *Macrotermes carbonarius* are reported damaging young and old plants. *Microcerotermes losbanosensis* and *Nasutitermes luzonicus* are reported from the Philippines and large number of species are recorded from Pacific islands, East African coast and Central and South America. Harris (1971) gives a good account of damage done by termites in these parts of the world.

Control : Soil poisoning with 10 per cent BHC dust at 100 lbs per acre, according to Nirula and Menon quoted by Sankaran (1962), gives good

protection to coconut seedlings against *Odontotermes obesus* but 2 per cent Dieldrin (100 kg per hectare) has been found (Child, 1964) to be more effective. For older plants application of insecticide on the tree trunks may prove useful as in case of fruit trees.

4. *Rubber*

Rubber is another important plantation crop in Kerala (India) and Sri Lanka. *Coptotermes ceylonicus* and a *Glyptotermes* sp. are reported from rubber in southern India and *Coptotermes ceylonicus* and *Glyptotermes ceylonicus* from Sri Lanka but are not regarded as pests of much importance. Species of *Odontotermes* and *Microtermes* also feed on dead tree portions. In South-East Asia, *Coptotermes curvignathus*, however, is a serious pest of rubber trees. It attacks even the healthy young trees and if left undisturbed can inflict fatal injury within three or four weeks (Harris, 1971).

Control : There is no work available on the control of termites in rubber plantations in India since these insects are not a problem for rubber planters. Newsam and Rao (1958) found that treatment of soil around the tree trunks against *Coptotermes curvignathus* in Malaysia, with emulsions of Chlorodane (0.0375%), Aldrin (0.025%) and Dieldrin (0.015%) at the rate of half to one litre, depending on the girth of the tree, were quite effective when poured in the shallow channels dug around the trees. The residual effect lasts for at least three years and that Dieldrin was found to be most effective, according to them. This method of treating soil around trees should keep away the subterranean termites.

(D) DAMAGE TO FIBRE CROPS

Cotton and jute are the main fibre crops of India. Both these crops are commercially important and jute exports earn a good proportion of foreign exchange.

1. *Cotton*

Bhatnagar (1962) reported that the cotton growers suffered considerable losses due to termite attack on germinating cotton under unirrigated condition in Rajasthan but he did not mention the termite species involved. According to Vyas (unpublished) *Odontotermes obesus*, *Microtermes* sp. and *Eremotermes* sp. cause damage to different varieties of cotton under water-stressed condition in the Rajasthan Canal Command Area. The damage in the year 1976 ranged from 1.1 to 8 per cent in case of Bikaneri Narma variety at 18 locations and in the years 1977 and 1978, the damage to Bikaneri Narma, J-34, 320 F, Deshi and Ganganagar Agetti varieties ranged from 4.1-15.7 per cent. In Gujarat, while working on control of termites on wheat and cotton, Patel (1962) recorded two species viz., *Odontotermes obesus* and *Trinervitermes biformis* (his

rubidus). The other species reported from cotton are *Microtermes obesi* from India and *Microtermes mycophagus* from Pakistan. The germinating cotton, roots of seedings and roots and stem of mature plants and seeds are liable to attack.

Outside the Indian region some species of *Coptotermes*, *Hodotermes*, *Amitermes*, *Microcerotermes*, *Microtermes* and *Ancistrotermes* are reported from different parts of Africa and *Microcerotermes diversus* from Arabia. Harris (1971) gives somewhat detailed information about the attack and damage by these termites. A total of seventeen species are recorded as pests of cotton throughout the world except in United States (Hickin, 1971).

Control : Bhatnagar (1962) treated the soil of the fields with Technical Sevin and Technical Heptachlor at (10 and 15 lbs per acre) and got a yield of 1777 lbs seed cotton and 565 lbs lint from the "barani" fields treated with 15 lbs Sevin as against 387 and 198 lbs, respectively from the untreated fields, showing thereby an appreciable increase. In drilling experiments, 5 per cent BHC at the rate of 56 lbs per acre gave check of 81.4 per cent over the control and an increase of 33.3 per cent of seed cotton, whereas the seed-dressing was not found to be effective in the experiments conducted by Patel (1962) in Gujarat state, due to too small rate of application of BHC.

Both randomised and drilling application of insecticides in the fields before sowing are useful in the control of termite depredation. Dieldrin 2.5 per cent or 10 per cent Chlorodane (30 kg per hectare) as recommended by Buyckx for cotton in Congo (Harris, 1971) may also prove to be useful in India.

2. *Jute and Sunn-hemp*

Jute is a crop of wet areas and so far no termite was reported from jute plants until Dutt (1962) recorded damage to roots and stem by *Microtermes obesi*. The excavated portions are filled up with earth and since stem is the source of fibre, damage to this part of the plant is of significance. It appears, however, that the damage is not extensive.

Control : Dutt (1962) made some control trials in a field which was badly affected by termites, by treating the soil superficially and also 15 cm (6 in) below soil surface with Aldrin wettable powder (35 gallons) per acre of 0.2 and 0.4 per cent concentrations and found that 0.4 per cent formulation applied 15 cm below ground surface was more effective and useful in reducing termite incidence. The treatment was replicated six times.

Sunn-hemp has been found to be damaged by *Odontotermes obesus* at Sunn-hemp Research Station, Partapgarh (Uttar Pradesh) in sandy loam soil.

Generally older plants are damaged and the infestation is more in drier months after November. The nature of damage is similar to that in jute (Tripathi, 1972).

(E) DAMAGE TO FRUIT TREES

(Pl. V, fig. 3)

Fruit trees, such as mango, *Citrus* spp., guava, pomegrenate, mulberry, *Zizyphus* spp., apple, chiku, apricot, lokat, papaya, etc. are liable to termite damage by both wood and subterranean species.

Mango (*Mangifera indica*) is the main fruit tree all over India, Pakistan and Bangla Desh. The species *Neotermes assmuthi*, *N. bosei*, *N. flelcheri*, *N. mangiferae*, *Glyptotermes almorensis*, *Cryptotermes havilandi*, *Stylotermes fletcheri*, *Coptotermes heimi*, *C. kishori*, *Heterotermes indicola*, *Microcerotermes fletcheri*, *Odontotermes assmuthi*, *O. horni*, *O. latigula*, *O. guptai*, *O. parvidens*, *O. obesus*, *O. redemanni*, *Microtermes obesi* and *Trinervitermes biformis* are reported to attack mango trees in India and Bangla Desh. The mulberry trees (*Morus* spp.) are attacked by *Coptotermes heimi*, *Heterotermes indicola* and *Microtermes obesi*, the former species hollowing out the stem and causing death of the trees ; the guava (*Psidium guyava*) and citrus (orange) trees by *Glyptotermes dilatatus* in Sri Lanka and by *Microcerotermes* sp., *Odontotermes obesus* and *Trinervitermes biformis* in India ; pomegrenate (*Punica granatum*) by *Trinervitermes biformis* (India) ; *apricot* (*Prunus armeniaca*) by *Microcerotermes baluchistanicus* and *M. longignathus* in Pakistan ; peach by *Microtermes mycophagus* in North-West India ; apple (*Pyrus malus*) by *Bifiditermes beesoni* (in Lahore, Pakistan) ; lokat (*Eriobotrya japonica*) by *Glyptotermes dilatatus* in Sri Lanka ; and ber (*Zizyphus* spp.) by *Bifiditermes beesoni* and *Heterotermes indicola* (Pakistan). According to Sankaran (1962), the species *Odontotermes obesus* and some other *Odontotermes* species are responsible for damage to fruit trees all over India. Many more species are possibly involved in the depredations of these and other fruit trees.

The species *Coptotermes curvignathus* has been reported attacking citrus in Malaysia and Mango in Indonesia. The citrus is also damaged by *Mastotermes darwiniensis* in Northern Australia, by *Macrotermes bellicossus* and *M. subhyalinus* in Nigeria, by *Odontotermes latericius* in Mozambique and by *Microcerotermes diversus* in Arabia. The termite *Kalotermes flavicollis* has been reported to attack a wide variety of fruit trees such as fig, olive, pear and vines in southern Europe and Mediterranean islands (Harris, 1971).

Control : Copper sulphite, Paris green, lead arsenate with lime and sodium arsenate, etc. were earlier used for protection of fruit trees from the ravages of termites. But more recently soil treatment with insecticides around the fruit trees and spraying of insecticide emulsions and suspensions on the

tree trunks have been found to be very useful. Patel and Patel (1952) have recommended application of 5 per cent DDT solution in oil for older trees and Sankaran (1962) has suggested removal and destruction of dead wood, branches, refuse vegetation, etc. from the neighbourhood and application of 5 or 10 per cent BHC dust in soil around the bases of trees and 2 per cent aqueous suspension of DDT for younger plants, on the tree trunks. Soil treatment with insecticides around the trees for subterranean termites and fumigation of nests of wood termites would be useful to check termite damage.

(F) Damage to Stored-Products

(Pls. VI & VII)

Other than the extensive losses caused to agriculture, forestry and buildings, the termites can be responsible to inflict very heavy damage to stored-products of cellulosic nature such as paper, jute goods, textiles, cotton, tents, wooden articles, leather and rubber goods, food grains kept in storage, books in libraries, ordinance stores including ammunition boxes in Ordinance Depots and other house-hold goods, if proper precautions are not taken to prevent the entry of these insects into buildings, store-houses and godowns. There are newspaper reports of damage to ballot papers in the ballot boxes, records, books, etc. in India and severe destruction of priceless documents, valuable records, antique furniture, etc. in libraries and old palaces in Italy. To a long list of articles of cellulosic nature, may also be added some non-cellulosic materials, such as plastics, polythene sheets, polyurethane foam, ebonite, glass and even steel, which have been reported to be damaged by termites. The plastics and polythene sheets are cut through to reach the food. While glass gets eroded and steel corroded by the action of wet faecal pellets and saliva mixed earth sticking on the surface of these articles. The species of *Coptotermes* and *Heterotermes* have even been recorded to work through cement and mortar to reach the source of food.

The *Cryptotermes* species have been reported damaging frame of an oil painting and mango-wood model of a boat. The *Coptotermes* and *Heterotermes* species, particularly *C. heimi* and *H. indicola* in India, Pakistan and Bangla Desh and *C. ceylonicus* in Sri Lanka, do extensive damage to house-hold goods and stored-products, books in libraries and records. The species *Odontotermes obesus* attacks moist wood and books and textiles and *Microcerotermes tenuignathus* has been reported to damage books in a library in Delhi.

Control : The best way to check damage to the stored-products is to see that the termites do not gain entry into store-houses. Anti-termite measures such as soil treatment to eradicate termite colonies and use of mechanical barriers should be incorporated in designing the new structure to be built and the wood resistant to termite attack be only used. For larger

buildings, it is advisible to construct buildings on pillars of solid masonary. After the construction of the building, periodic inspection should be an essential feature so that adequate steps can be taken in time to check the infestation.

In old buildings and godowns, treatment of joints and cracks in the floors with insecticides or creosote or filling the same with coal tar or pitch are recommended to stop the entry of termites. Since some of the species can eat their way through mortar and cement and have been noticed boring through the walls, the stored materials should be kept a little away from the walls and preferably on dunnage so that inspection is possible. A periodic chemical treatment of the soil around the building is also recommended in case of soil termites of the genera *Coptotermes* and *Heterotermes* to check subsequent foundation and development of termite colonies.

The infested books and records in the libraries should be properly fumigated and replaced in thoroughly disinfected book-cases. Basu (1942) recommended fumigation of books with 40 per cent formaldehyde and placement of equal parts of orris root, cloves, black pepper and cinnamom in the book-cases, but benzene fumigation together with disinfection of book-cases with insecticides is more reliable. Since the paper and books are liable to get damaged if the insecticides are sprayed on the books, it is advisible to see that the termites do not gain access to the book-cases, as such insecticides be periodically sprayed around the almirahs and book-cases. Paradichlorobenzene which acts as a replenent should be kept in the book-cases.

IV. SUMMARY AND CONCLUSIONS

Termites do extensive damage to agricultural and plantation crops, fruit trees, forest nurseries, wood-work in buildings, books in libraries and other cellulose goods in storage. Loss to agricultural crops in India alone runs into hundreds of crores of rupees.

As many as 47 species of these insects are reported to cause damage of some type or other to agriculture in the Indian region. Key for identification, based on soldier caste, has been provided for these pests and diagnostic characters, distribution and pest status of each of the species are given. Illustrations useful in identification are provided.

Damage to various crops, and stored-products by the different species has been dealt with and illustrated. Control measures of significance are enumerated. A list of the pest species (general and crop-wise) has also been given.

Termites usually work in concealment and are noticed only after irrepar-

able damage has been done by them. Because of this quite often no control measures are taken up in time. Some anti-termite measures can be incorporated in buildings, godowns and silos when construction is started and prophylactic measures adopted later to keep them in check but in fruit gardens, farms, timber depots and the like control measures must be kept up year after year to prevent damage.

From the aforesaid account it is seen that insecticidal treatment is the most recommended for termite control for it is not possible to adopt biological control methods through parasites or predators due to the underground activities of these insects and also because the nests are so constructed as not to permit intruders.

Potentialities of various chlorinated hydrocarbon insecticides are now well known even to the ordinary farmer but indiscriminate spraying on plants or mixing in soil at various stages of growth of plants or using them for seed-treatment before sowing heedlessly will sooner or later lead to disastrous results. Residues of insecticides persist in soil, on fruits and food grains and are also washed into the river systems contaminating them as well as the whole fish and other life in the water enviroment. Ultimately this may, if not taken care in time, poison man himself. But till the time some other methods of control are found and implemented, control by chemicals has to be resorted to. Care, however, must be taken in their use in right dose so that residue may not exceed the tolerance limit.

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VI. APPENDIX—I

Termite Pests of Agriculture, Plantation Crops, Fruit Trees, Stored-products, etc.

(A) *General list*

Family KALOTERMITIDAE

Postelectrotermes bhimi Roonwal and Maiti
P. militaris (Desneux)
Neotermes assmuthi Holmgren
N. bosei Snyder
N. fletcheri Holmgren and Holmgren
N. greeni (Desneux)
N. mangiferae Roonwal & Sen-Sarma
Kalotermes jepsoni Kemner
Glyptotermes almorensis Gardner
G. ceylonicus Holmgren
G. dilatatus (Bugnion and Popoff)
Bifiditermes beesoni (Gardner)
Cryptotermes domesticus (Haviland)
C. dudleyi Banks
C. havilandi (Sjöstedt)

Family RHINOTERMITIDAE

Heterotermes ceylonicus (Holmgren)
H. indicola (Wasmann)
H. malabaricus Snyder
Coptotermes ceylonicus Holmgren
C. heimi (Wasmann)
C. kishori Roonwal & Chhotani

Family STYLOTERMITIDAE

Stylotermes fletcheri Holmgren and Holmgren

Family TERMITIDAE

Amitermes baluchistanicus Akhtar
Eremotermes paradoxalis Holmgren
Microcerotermes baluchistanicus Ahmed
M. beesoni Snyder
M. bugnioni Holmgren

M. danieli Roonwal & Bose
M. fletcheri Holmgren & Holmgren
M. nicobarensis Roonwal & Bose
M. tenuignathus Holmgren
Eurytermes ceylonicus Holmgren
Dicuspiditermes hutsoni (Kemner)
Macrotermes estherae (Desneux)
Odontotermes assmuthi Holmgren
O. gurdaspurensis Holmgren & Holmgren
O. horni (Wasmann)
O. latigula Snyder
O. obesus (Rambur)
O. parvidens Holmgren and Holmgren
O. redemanni (Wasmann)
O. wallonensis (Wasmann)
Hypotermes obscuriceps (Wasmann)
Microtermes mycophagus (Desneux)
M. obesi Holmgren
M. unicolor Snyder
Nasutitermes ceylonicus (Holmgren)
Trinervitermes biformis (Wasmann)

(B) *Crop-wise list*

(a) CEREALS

Coptotermes heimi (Wasmann)
Odontotermes gurdaspurensis Holmgren & Holmgren
Odontotermes obesus (Rambur)
Microtermes obesi Holmgren
Trinervitermes biformis (Wasmann)
Odontotermes, *Microtermes* and *Nasutitermes* spp.

(b) VEGETABLES, PULSES, GROUNDNUT, etc.

Odontotermes obesus (Rambur)
O. parvidens Holmgren and Holmgren
Microtermes obesi Holmgren
M. unicolor Snyder
Trinervitermes biformis (Wasmann)

(c) SUGARCANE

Coptotermes heimi (Wasmann)

Eremotermes paradoxalis Holmgren
Microcerotermes beesoni Snyder
Macrotermes estherae (Desneux)
Odontotermes assmuthi Holmgren
O. obesus (Rambur)
O. redemamni (Wasmann)
O. wallonensis (Wasmann)
Microtermes mycophagus (Desneux)
M. obesi Holmgren
M. unicolor Snyder
Trinervitermes biformis (Wasmann)

(d) COCONUT

Coptotermes ceylonicus Holmgren
Microcerotermes bugnioni Holmgren
M. danieli Roonwal and Bose
M. nicobarensis Roonwal and Bose
Odontotermes horni (Wasmann)
O. obesus (Rambur)
O. redemanni (Wasmann)
Nasutitermes ceylonicus (Holmgren)

(e) TEA

Postelectrotermes bhimi Roonwal and Maiti
P militaris (Desneux)
Neotermes greeni (Desneux)
Kalotermes jepsoni Kemner
Glyptotermes ceylonicus Holmgren
G. dilatatus (Bugnion and Popoff)
Cryptotermes havilandi (Sjöstedt)
Coptotermes ceylonicus Holmgren
Microcerotermes spp.
Eurytermes ceylonicus Holmgren
Dicuspiditermes hutsoni Kemner
Odontotermes horni (Wasmann)
O. obesus (Rambur)
O. parvidens Holmgren and Holmgren
O. redemanni (Wasmann)
Hypotermes obscuriceps (Wasmann)
Microtermes obesi Holmgren

(f) RUBBER

Glyptotermes ceylonicus Holmgren

G. dilatatus (Bugnion & Popoff)
Coptotermes ceylonicus Holmgren
C. heimi (Wasmann)
Odontotermes and *Microtermes* spp.

(g) FIBRE CROPS

Odontotermes obesus (Rambur)
Microtermes mycophagus (Desneux)
M. obesi Holmgren
Trinervitermes biformis (Wasmann)

(h) FRUIT TREES

Neotermes assmuthi Holmgren
N. bosei Snyder
N. fletcheri Holmgren & Holmgren
N. mangiferae Roonwal and Sen-Sarma
Glyptotermes almorensis Gardner
G. dilatatus (Bugnion and Popoff)
Bifiditermes beesoni (Gardner)
Cryptotermes havilandi (Sjöstedt)
Coptotermes heimi (Wasmann)
C. kishori Roonwal and Chhotani
Heterotermes indicola (Wasmann)
Prorhinotermes flavus (Bugnion and Popoff)
Stylotermes fletcheri Holmgren and Holmgren
Amitermes baluchistanicus Akhtar
Microcerotermes baluchistanicus Ahmad
M. fletcheri Holmgren and Holmgren
Odontotermes assmuthi Holmgren
O. horni (Wasmann)
O. latigula Snyder
O. obesus (Rambur)
O. parvidens Holmgren and Holmgren
O. redemanni (Wasmann)
Microtermes obesi Holmgren

(i) STORED-PRODUCTS, WOODEN-ARTICLES, PAPER, CLOTH, etc.

Cryptotermes domesticus (Haviland)
C. dudleyi Banks
C. havilandi (Sjöstedt)
Coptotermes ceylonicus Holmgren

C. heimi (Wasmann)
Heterotermes ceylonicus (Holmgren)
H. indicola (Wasmann)
Microcerotermes tenuignathus Holmgren
Odontotermes obesus (Rambur)

INDEX OF TERMITES (*) AND HOST PLANTS

1

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Plate I

1. A mound of the most common species, *Odontotermes obesus* (Rambur).
2. A mound of *Odontotermes wallonensis* (Wasmann).

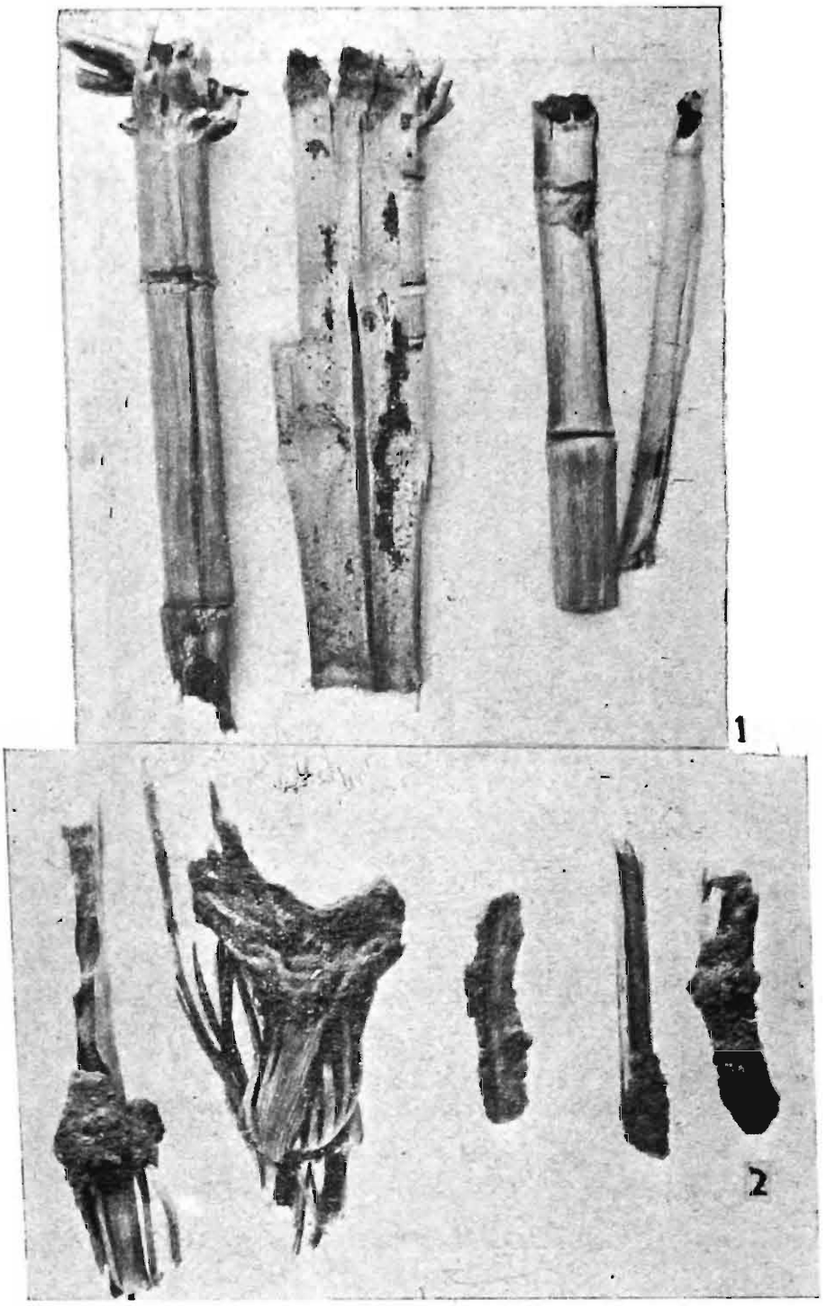

Plate II

1. Photograph showing damage to maize by *Odontotermes wallonensis* (Wasmann). Photograph received from Dr. D. Rajagopal, Bangalore.
2. Photograph showing damage to bajra by *Microtermes mycophagus* (Desneux). Photograph received from Dr. M. L. Roonwal, Jodhpur.

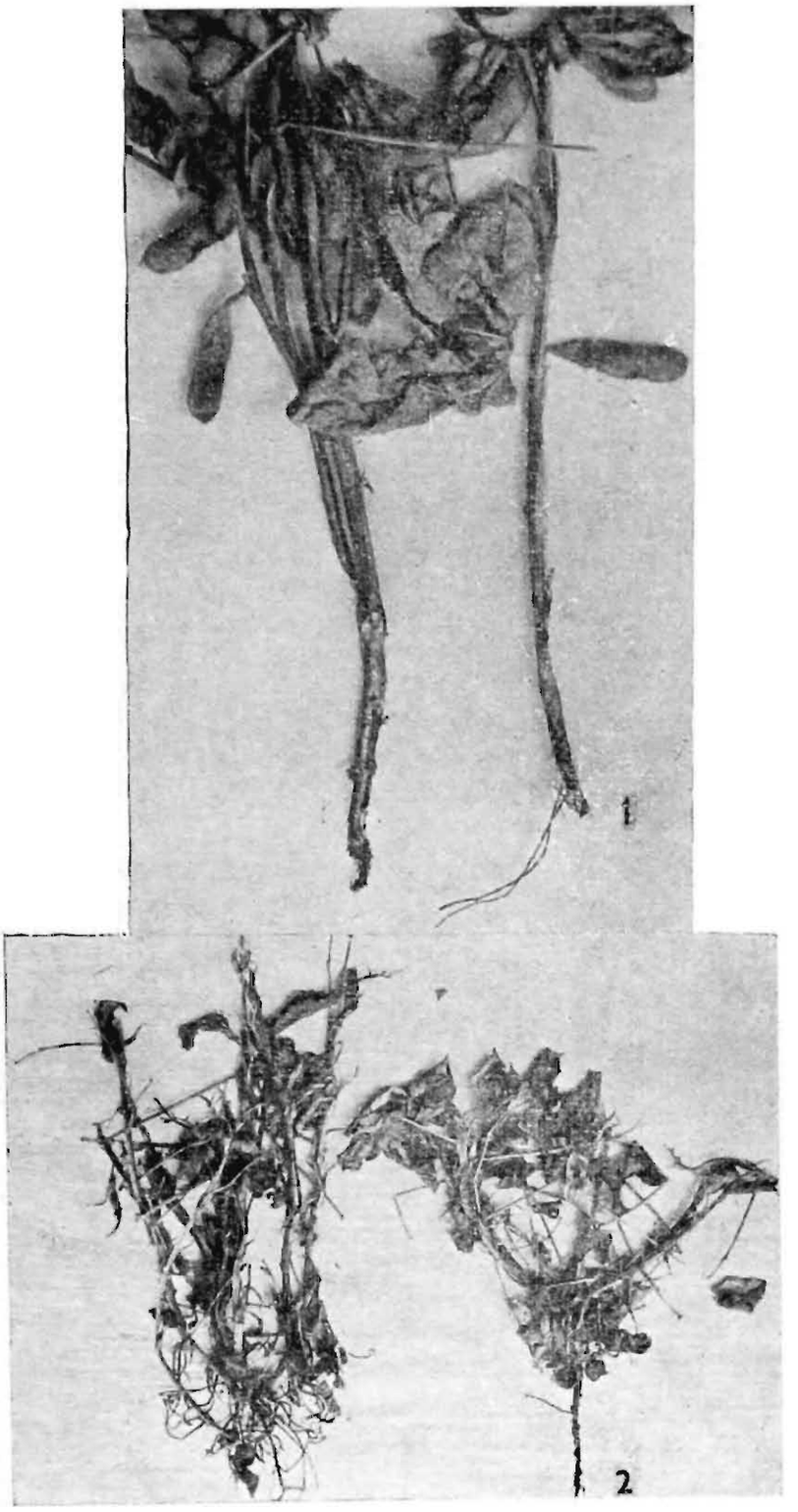

Plate III

1. Photograph showing damage to roots and pods of groundnut by *Odontotermes wallonensis* (Wasmann).
2. Photograph showing damage to roots of soya beans by *Odontotermes wallonensis* (Wasmann).

Photographs received from Dr. D. Rajagopal, Bangalore.

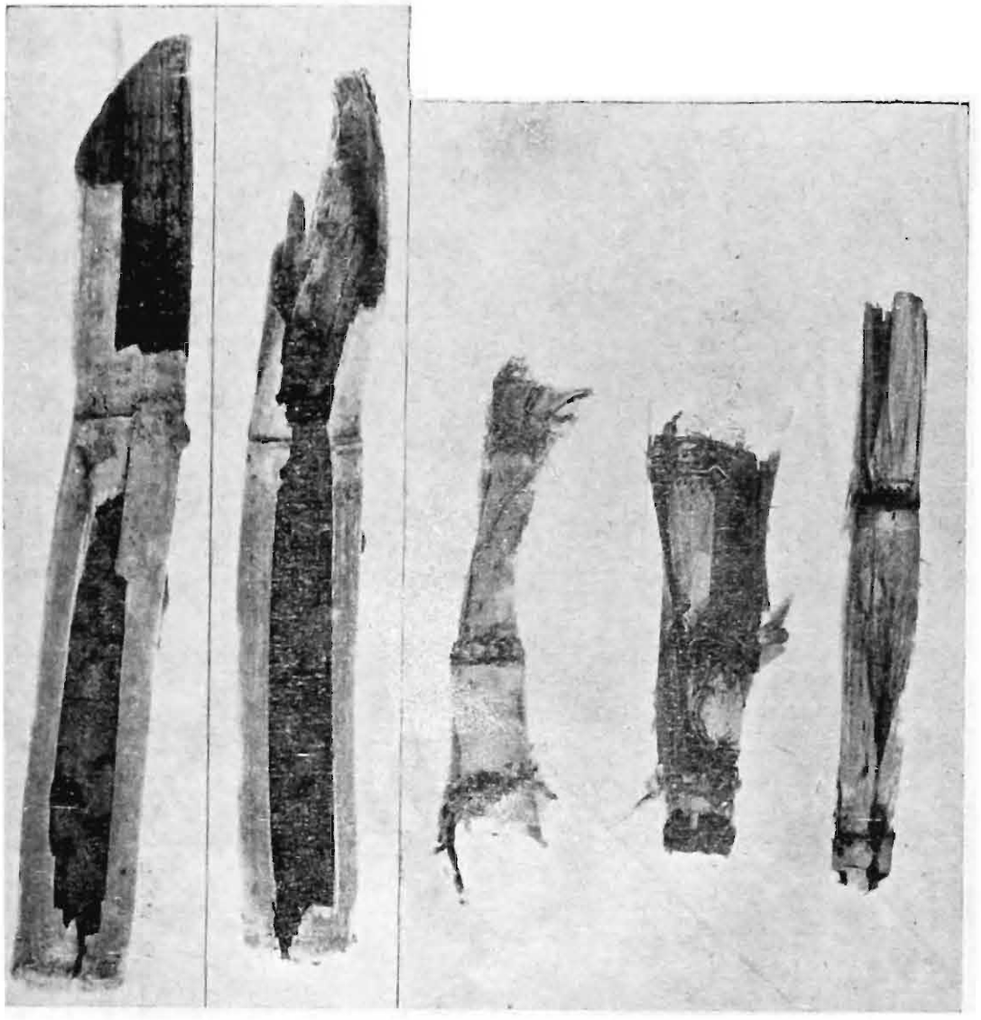

Plate 1V

Photographs showing mature sugarcane attacked and damaged by *Odontotermes obesus* (Rambur).

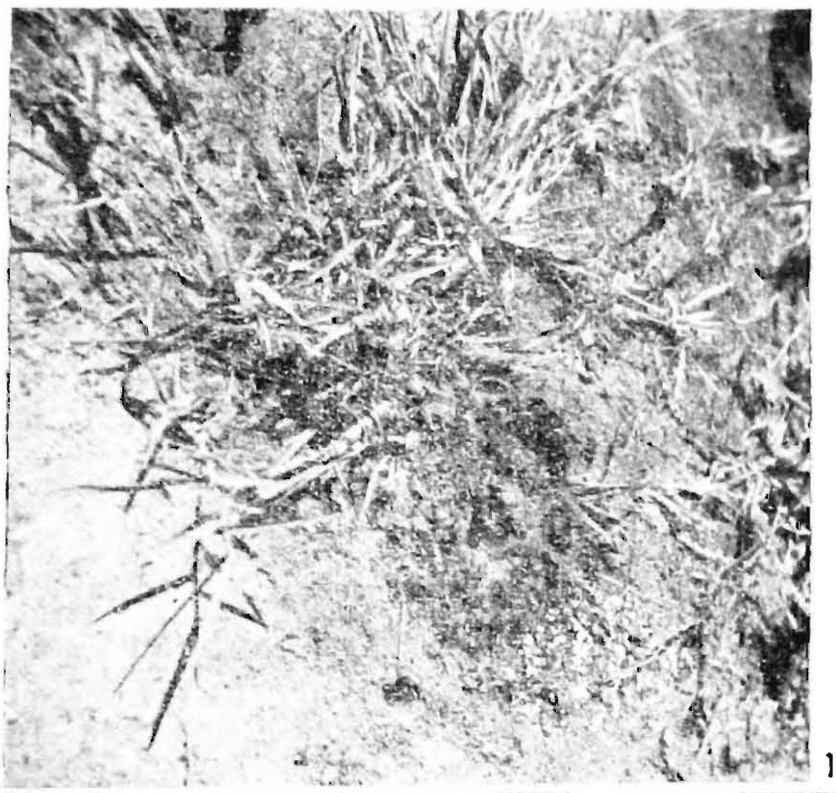

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Plate V

1. Photograph showing damage to grasses by *Odontotermes obesus* (Rambur).
2. Stem of coconut tree attacked and damaged by *Odontotermes obesus* (Rambur).
3. Stem of guava tree hollowed out by *Microcerotermes beesoni* Snyder.

Plate VI

1. Paper damaged in storage by *Heterotermes indicola* (Wasmann).
2. Paper rolls of metrological graphs damaged in storage by *Heterotermes indicola* (Wasmann).

1

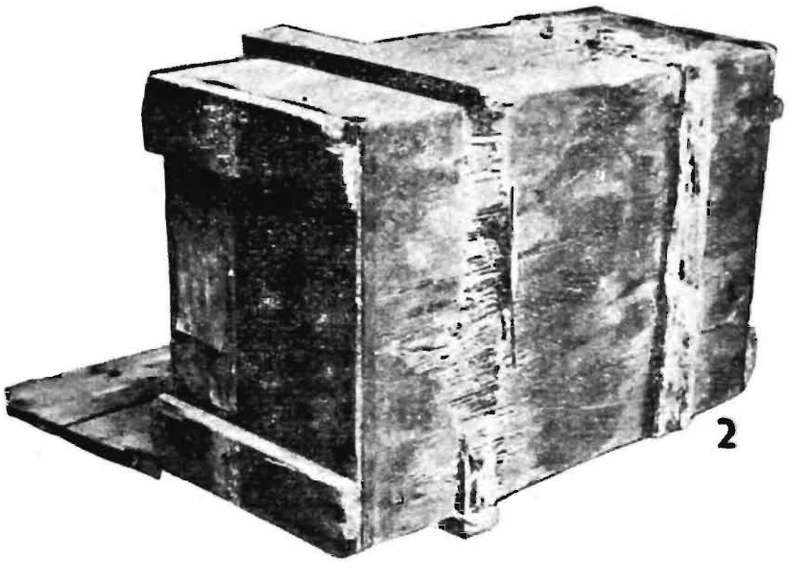

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Plate VII

1. A cricket ball damaged by termites. Photograph received from Dr. D. Rajagopal, Bangalore.
2. A wooden box damaged by *Heterotermes indicola* in a store-house.