

RE-SURVEY OF THE TERMITE FAUNA OF RAJASTHAN, INDIA, AND ITS ZOOGEOGRAPHY

By

M. L. ROONWAL* AND S. C. VERMA†

Desert Regional Station,

Zoological Survey of India, Paota, Jodhpur

(With 4 Tables and 23 Text-figures)

INTRODUCTION

1. *General*

Rajasthan is the large westernmost State of India, covering 3,42,274 sq. km. (ca. 1.32,152 sq. miles). Two-thirds of it, lying W and NW of the diagonally running Aravalli Hills, is very arid and forms the bulk of the Great Indian Desert; the remaining one-third, lying S and SE of the Aravallis is relatively wet. It has 26 administrative districts (Text-fig. 1).

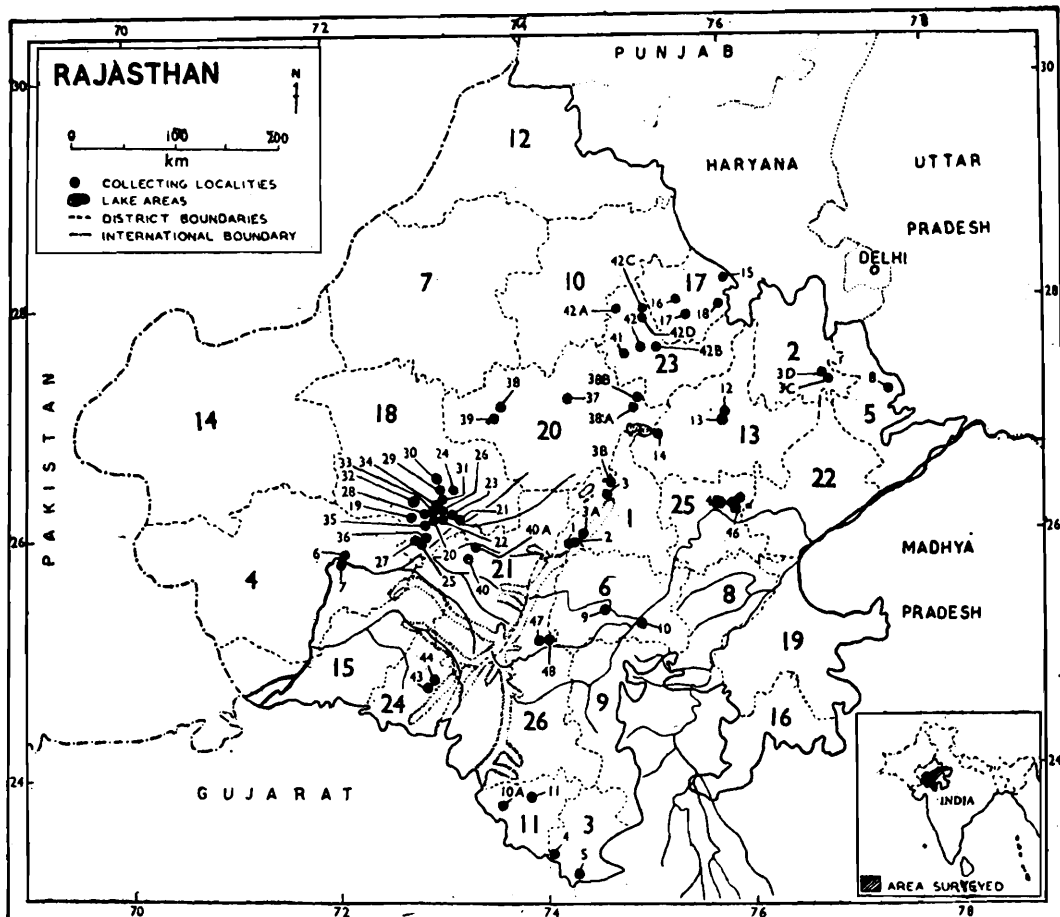
Until 1960, only 7 species of termites (Insecta : Isoptera) were known from Rajasthan. As a result of active exploration and study, Roonwal and Bose (1964) recorded 19 species and subspecies in their monograph. In the following 10 years (1964-73), we ourselves and parties from the Desert Regional Station, Zoological Survey of India have made intensive collections around Jodhpur and from several other districts of Rajasthan. As a result, one family (Kalotermitidae), one subfamily (Termitinae), 2 genera (*Incisitermes* and *Angulitermes*) and the following 14 species have been added to the Rajasthan fauna:—

1. *Incisitermes didwanaensis* Roonwal & Verma
2. *Microcerotermes palestinensis* Spaeth
3. *M. sakesarensis* Ahmad
4. *Angulitermes jodhpurensis* Roonwal & Verma
5. *Odontotermes brunneus* (Hagen)
6. *O. dehraduni* (Snyder)

* Honorary Correspondent, Zoological Survey of India.

† Junior Research Fellow (C.S.I.R.). (Now Assistant Zoologist, Zoological Survey of India, Dehra Dun).

7. *O. distans* Holmgren & Holmgren
8. *O. feae* (Wasmann)
9. *O. giriensis* Roonwal & Chhotani
10. *O. gurdaspurensis* Holmgren & Holmgren
11. *O. latiguloides* Roonwal & Verma
12. *O. parvidens* Holmgren & Holmgren
13. *O. wallonensis* (Wasmann)
14. *Microtermes unicolor* Snyder



Text-fig. 1. Map of Rajasthan, showing the collecting localities for termites. (Inset : India, showing the area surveyed.) Large numerals (1—26) : Administrative Districts : 1, Ajmer. 2, Alwar. 3, Banswara. 4, Barmer. 5, Bharatpur. 6, Bhilwara. 7, Bikaner. 8, Bundi. 9, Chittorgarh. 10, Churu. 11, Dungarpur. 12, Ganganagar. 13, Jaipur. 14, Jaisalmer. 15, Jalore. 16, Jhalawar. 17, Jhunjhunu. 18, Jodhpur. 19, Kota. 20, Nagaur. 21, Pali. 22, Sawai Madhopur. 23, Sikar. 24, Sirohi. 25, Tonk. 26, Udaipur. Small numerals (1—48, etc.) : Collecting localities as listed in Table 1.

One species, *Trinervitermes heimi* (Wasmann), has been sunk as a junior synonym of *T. biformis* (Wasmann), and the following subspecies raised to full species rank:—

Microcerotermes tenuignathus laxmi Roonwal & Bose, raised to *M. laxmi* Roonwal & Bose.

Microcerotermes championi raja Roonwal & Bose, raised to *M. raja* Roonwal & Bose.

Microcerotermes tenuignathus tenuignathus Holmgren, now regarded simply as *M. tenuignathus* Holmgren, without any subspecies.

Odontotermes bellahunisensis guptai Roonwal & Bose, raised to *O. guptai* Roonwal & Bose.

Odontotermes brunneus kushwahi Roonwal & Bose, raised to *O. kushwahi* Roonwal & Bose.

The termite fauna of Rajasthan now comprises of 32 species spread over 4 families and 14 genera, as follows:—

List of termites known from Rajasthan

Note : Species (or subspecies) from Rajasthan listed by Roonwal and Bose (1964) are marked with an asterisk (*); the rest are additional records.

Family I. KALOTERMITIDAE

1. *Incisitermes didwanaensis* Roonwal & Verma

Family II. HODOTERMITIDAE

2. *Anacanthotermes macrocephalus** (Desneux)

Family III. RHINOTERMITIDAE

Subfamily (i) PSAMMOTERMITINAE

3. *Psammotermes rajasthanicus** Roonwal & Bose

Subfamily (ii) HETEROTERMITINAE

4. *Heterotermes indicola** (Wasmann)

Subfamily (iii) COPTOTERMITINAE

5. *Coptotermes heimi** (Wasmann)

Family IV. TERMITIDAE

Subfamily (i) AMITERMITINAE

6. *Speculitermes cyclops cyclops** Wasmann
7. *Amitermes belli** (Desneux)
8. *Synhamitermes quadriceps** (Wasmann)
9. *Eremotermes neoparadoxalis** Ahmad
10. *E. paradoxalis** Holmgren
11. *Microcerotermes laxmi** Roonwal & Bose
[*M. tenuignathus laxmi* R. & B.]
12. *Microcerotermes palestinensis* Spaeth
13. *Microcerotermes raja** Roonwal & Bose
[*M. championi raja* R. & B.]

14. *Microcerotermes sakesarensis* Ahmad
15. *Microcerotermes tenuignathus** Holmgren
[*M. t. tenuignathus* Holmg.]

Subfamily (ii) TERMITINAE

16. *Angulitermes jodhpurensis* Roonwal & Verma

Subfamily (iii) MACROTERMITINAE

17. *Odontotermes brunneus* (Hagen)
18. *O. dehraduni* (Snyder)
19. *O. distans* Holmgren & Holmgren
20. *O. feae* (Wasmann)
21. *O. giriensis* Roonwal & Chhotani
22. *O. guptai* Roonwal & Bose
[*O. bellahunisensis guptai* R. & B.]
23. *O. gurdaspurensis* Holmgren & Holmgren
24. *O. kushwahi** Roonwal & Bose
[*O. brunneus kushwahi* R. & B.]
25. *O. latiguloides* Roonwal & Verma
26. *O. obesus** (Rambur)
27. *O. parvidens* Holmgren & Holmgren
28. *O. wallonensis* (Wasmann)
29. *Microtermes mycophagus** (Desneux)
30. *M. obesi** Holmgren
[Syn. *M. anandi* Holmgren]
31. *M. unicolor* Snyder

Subfamily (iv) NASUTITERMITINAE

32. *Trinervitermes biformis** (Wasmann)
[Syns. *T. heimi* (Wasmann) and *T. longinotus* (Snyder)]

In the present paper, we have dealt with 29 species which constitute either new records from Rajasthan or are extensions of range in this area. Measurements (taken as defined in Roonwal, 1970a) and illustrations are provided only in those species for which they were not given in the earlier monograph (Roonwal and Bose, 1964). For a general account of the biology of several of the species, *vide* Roonwal (1970b). For distributional purposes, the records of Ahmad (1955) and Chaudhri and Ahmad (1972) for Pakistan and Bangla Desh were useful for comparison.

Ecological and zoogeographical importance of Rajasthan : A detailed faunistic study of so large an area as Rajasthan is in itself a desideratum. This need is further accentuated by the fact that the area is ecologically and zoogeographically of unusual interest. Ecologically, it is two-thirds arid and grades into semi-arid and wet areas, so that the ecological distri-

bution of the various species can be compared. Zoogeographically, the area forms a border zone between the western portion of the Palaearctic Region and the Oriental Region. For both these purposes, this taxonomic account, along with the earlier monograph of Roonwal and Bose (1964), provide the basic taxonomic framework. Zoogeography is discussed at the end.

2. Abbreviations used

Alt., Altitude, above mean sea-level.

Dist., District.

Ex., Exs., Out of; also example(s).

Im., Imago.

L., Length.

Pw., Pseudoworker.

S., Soldier.

Sev., Several.

Syn(s), Synonym(s).

Type-loc., Type-locality.

W., Width.

Wk., Worker.

COLLECTIONS AND THE COLLECTING LOCALITIES

(Table 1 and Text-fig. 1)

TABLE 1. Collecting Stations for termites included in the present paper (also *vide* Text-fig. 1 where the Stations are indicated by the Serial Nos. given in this Table).

Collecting Stations		Approximate latitude (N)	Approximate longitude (E)
1		2	3
1. Ajmer District (No. 1 in Fig. 1)			
1.	Beratia village, <i>ca.</i> 6 km. from Bar	25°50'	74°16'
2.	Forest plantation, near Beratia village, <i>ca.</i> 3 km. from Bar.	25°50'	74°15'
3.	Forest plantation, <i>ca.</i> 6 km. from Ajmer.	26°25'	74°35'
3A.	Sendra, <i>ca.</i> 13 km. E. of Bar on Ajmer road	25°50'	74°17'
3B.	Taragarh Fort, Ajmer	26°27'	74°42'
2. Alwar District (No. 2 in Fig. 1)			
3C.	Jugrabar village, <i>ca.</i> 22 km. from Alwar.	27°20'	76°50'
3D.	Sahejpur Roadside, <i>ca.</i> 18 km. from Alwar	27°25'	76°48'
3. Banswara District (No. 3 in Fig. 1)			
4.	Danpur village	23°50'	74°21'
5.	Hill near Kuthumbi	23°30'	74°35'
4. Barmer District (No. 4 in Fig. 1)			
6.	Balotra	25°50'	72°15'
7.	Mevanagar (Nakhora), <i>ca.</i> 6 km. SW of Balotra	25°45'	72°10'

Collecting Stations	Approximate latitude (N)	Approximate longitude (E)
1	2	3
5. Bharatpur District (No. 5 in Fig. 1)		
8. Noah village, <i>ca.</i> 7 km. E of Bharatpur	27°12'	77°35'
6. Bhilwara District (No. 6 in Fig. 1)		
9. Danta-ka-Khera	25°21'	74°32'
10. Mandalgarh	25°10'	75°05'
7. Dungarpur District (No. 11 in Fig. 1)		
10A. Nallah, <i>ca.</i> 12 km. W of Bichiwara	23°45'	73°26'
11. Sabella	23°50'	73°40'
8. Jaipur District (No. 13 in Fig. 1)		
12. Amber, <i>ca.</i> 10 km. N. of Jaipur	27°00'	75°50'
13. Jaipur	26°55'	75°52'
14. Sambhar Lake	26°54'	75°13'
9. Jhunjhunu District (No. 17 in Fig. 1)		
15. Jhojhu village, <i>ca.</i> 62 km. SE of	28°30'	76°05'
16. Jhunjhunu	28°05'	75°24'
17. Khokund village, <i>ca.</i> 25 km. NE of Raghunathgarh	27°45'	75°35'
18. Moi village, <i>ca.</i> 46 km. SE of Jhunjhunu.	28°30'	75°55';
10. Jodhpur District (No. 18 in Fig. 1)		
19. Agolai, <i>ca.</i> 45 km. W of Jodhpur	26°15'	72°35'
20. Arnaji, <i>ca.</i> 33 km. S of Jodhpur	26°18'	73°04'
21. Banar, <i>ca.</i> 15 km. NE of Jodhpur	26°15'	73°05'
22. Beriganga, <i>ca.</i> 20 km. N of Jodhpur	26°10'	73°04'
23. Bisalpur, <i>ca.</i> 30 km. W of Jodhpur	26°10'	73°15'
24. Borunda	26°25'	73°45'
25. Dipla village, <i>ca.</i> 58 km. W of Jodhpur	26°10'	72°35'
26. Jodhpur	26°18'	73°04'
27. Kalyanpur village, <i>ca.</i> 68 km. W of Jodhpur	26°00'	72°35'
28. Kaylana Lake <i>ca.</i> 10 km. W of Jodhpur	26°15'	72°55'
29. Khokaria village, <i>ca.</i> 11 km. N of Jodhpur	26°20'	73°05'
30. Mathania, <i>ca.</i> 30 km. NW of Jodhpur	26°32'	72°59'
31. Mandore, <i>ca.</i> 12 km. N of Jodhpur	26°20'	73°00'

Collecting Stations		Approximate latitude (N)	Approximate longitude (E)
1		2	3
32.	Megalasia village, <i>ca.</i> 10 km. W of Jodhpur	26°15'	72°50'
33.	Pratapsagar	26°20'	73°05'
34.	Rohila village, <i>ca.</i> 8 km. W of Jodhpur	26°18'	73°00'
35.	Salawas village, <i>ca.</i> 18 km. W of Jodhpur	26°05'	72°55'
36.	Satlana village, <i>ca.</i> 56 km. SW of Jodhpur	25°55'	72°55'
11. Nagaur District (No. 20 in Fig. 1)			
37.	Didwana	27°20'	74°30'
38.	Nagaur	27°11'	73°41'
38A.	Panchota village, <i>ca.</i> 12 km. from Maroth	27°03'	75°05'
38B.	Solayana village, <i>ca.</i> 4 km. S of Maroth	27°08'	75°10'
39.	Soyala village, <i>ca.</i> 20 km. SW of Nagaur	26°55'	73°20'
12. Pali District (No. 21 in Fig. 1)			
40.	Hemawas Dam, near Pali	25°40'	73°20'
40A.	Sardarsamand	25°54'	73°25'
13. Sikar District (No. 23 in Fig. 1)			
41.	Badalas village, <i>ca.</i> 20 km. SW of Sikar	27°25'	75°00'
42.	Harshnath, <i>ca.</i> 25 km. NW of Sikar	27°30'	75°18'
42A.	Lachmangarh, <i>ca.</i> 25 km. NW of Sikar	27°45'	75°00'
42B.	Palsana, <i>ca.</i> 20 km. SE of Sikar	27°25'	75°20'
42C.	Pipardi village, <i>ca.</i> 10 km. NE of Sikar	27°40'	75°20'
42D.	Purohiton-ka-Bas, <i>ca.</i> 5 km. NE of Sikar	27°38'	75°18'
14. Sirohi District (No. 24 in Fig. 1)			
43.	Mount Abu	24°25'	72°45'
44.	Oria village, near Mt. Abu	24°30'	72°45'
15. Tonk District (No. 25 in Fig. 1)			
45.	Banasthali, <i>ca.</i> 56 km. SE of Jaipur	26°27'	75°55'
46.	Newai village, <i>ca.</i> 60 km. SE of Jaipur	26°25'	75°55'
16. Udaipur District (No. 26 in Fig. 1)			
47.	Amet, <i>ca.</i> 50 km. NE of Udaipur	25°15'	73°55'
48.	Olna-khera, near Amet	25°10'	74°00'
TOTAL: 60 Stations			

Termites studied for the present account comprised about 187 vials collected mostly during the 10-year period (1964-73), and were obtained from 60 stations in 16 districts (Table 1 and Text-fig. 1) situated mostly in the central, eastern and southern Rajasthan, largely leaving out the western and north-western desert area except the eastern fringe (Jodhpur, etc.). Of these 16 districts, 9 were repeats from those mentioned in the earlier monograph (Roonwal and Bose, 1964) and 7 were districts not covered earlier. In this way, between the present and the earlier accounts, 24 out of the total of 26 districts of Rajasthan have been covered as follows, only two relatively small districts viz., Chittorgarh and Jhalawar, thus remaining unsurveyed:—

Districts of Rajasthan indicating where termite surveys have been carried out

Notes : * Districts covered in the earlier monograph (Roonwal and Bose, 1964).

+ Districts covered in the present account.

- | | |
|-----------------|---------------------|
| 1. Ajmer+ | 14. Jaisalmer* |
| 2. Alwar+ | 15. Jalore* |
| 3. Banswara+ | 16. Jhalawar |
| 4. Barmer** | 17. Jhunjhunu** |
| 5. Bharatpur+ | 18. Jodhpur** |
| 6. Bhilwara+ | 19. Kota* |
| 7. Bikaner* | 20. Nagaur** |
| 8. Bundi* | 21. Pali** |
| 9. Chittorgarh | 22. Sawai Madhopur* |
| 10. Churu* | 23. Sikar** |
| 11. Dungarpur+ | 24. Sirohi** |
| 12. Ganganagar* | 25. Tonk+ |
| 13. Jaipur** | 26. Udaipur** |

SYSTEMATIC ACCOUNT

Family 1. KALOTERMITIDAE

1. *Incisitermes didwanaensis* Roonwal & Verma 1973

(Text-fig. 2)

Roonwal & Verma, 1973, c. p. 390.

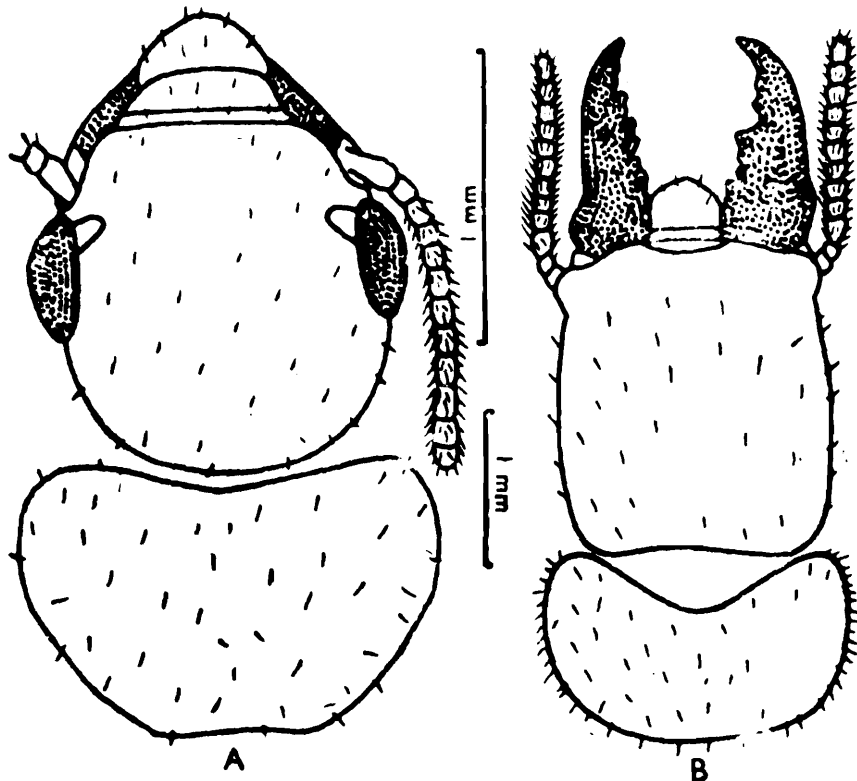
Castes known.— Im. (dealate ♀), S., Pw.

Material.—A dealate ♀ imago, and several soldiers and pseudoworkers;

Measurements.—For details, see Roonwal and Verma, 1973c.

Distribution.—Didwana (Nagaur Dist., Rajasthan).

Remarks.—The above (Roonwal and Verma, 1973c) is the third record of the genus from the orient and the first one from India. The other two oriental species are from the Philippines (*I. mcgregori* Light and *I. taylori* Light).



Text-fig. 2. *Incisitermes didwanaensis* Roonwal & Verma. Didwana (Nagaur Dist., Rajasthan). Head and pronotum, dorsal view. (A) Imago (dealate ♀). (B) Soldier.

Family II. HODOTERMITIDAE

2. *Anacanthotermes macrocephalus* (Desneux)

Hodotermes macrocephalus Desneux, 1906, p. 344.

Castes known.—Im., S., Wk.

Material.—35 vials, 1964-73, mostly S. and Wk., and a few Im., from Rajasthan thus : (i) Barmer Dist. : Balotra and Mevanagar (Nakhora). (ii) Jodhpur Dist. : Agolai, Arnaji, Beriganga, Bisalpur, Jodhpur, Kalyanpur, Kaylana, Mathania, Megalasia, Rohila, Salawas and Satlana.

Distribution.—From E. Afghanistan, via Pakistan (Baluchistan, Sind, Punjab) to western Rajasthan in India. The present records add a few more localities in western Rajasthan. The species does not seem to go much further east beyond Jodhpur.

Remarks.—Swarming in Jodhpur occurs in August. This is an arid zone species. For its distribution in Rajasthan in relation to vegetation and soil, vide Roonwal and Bose (1973). Sex ratios, body-weight in dealates and sexual dimorphism in external body-parts of imagoes have been discussed by Roonwal and Rathore (1972).

Family III. RHINOTERMITIDAE

Subfamily (i) HETEROTERMITINAE

3. *Heterotermes indicola* (Wasmann) 1902

(Text-fig. 3)

Leucotermes indicola Wasmann, 1902, *Zool. Jb. (Syst.)*, Jena, 17 (1), pp. 118-119, S., Wk.

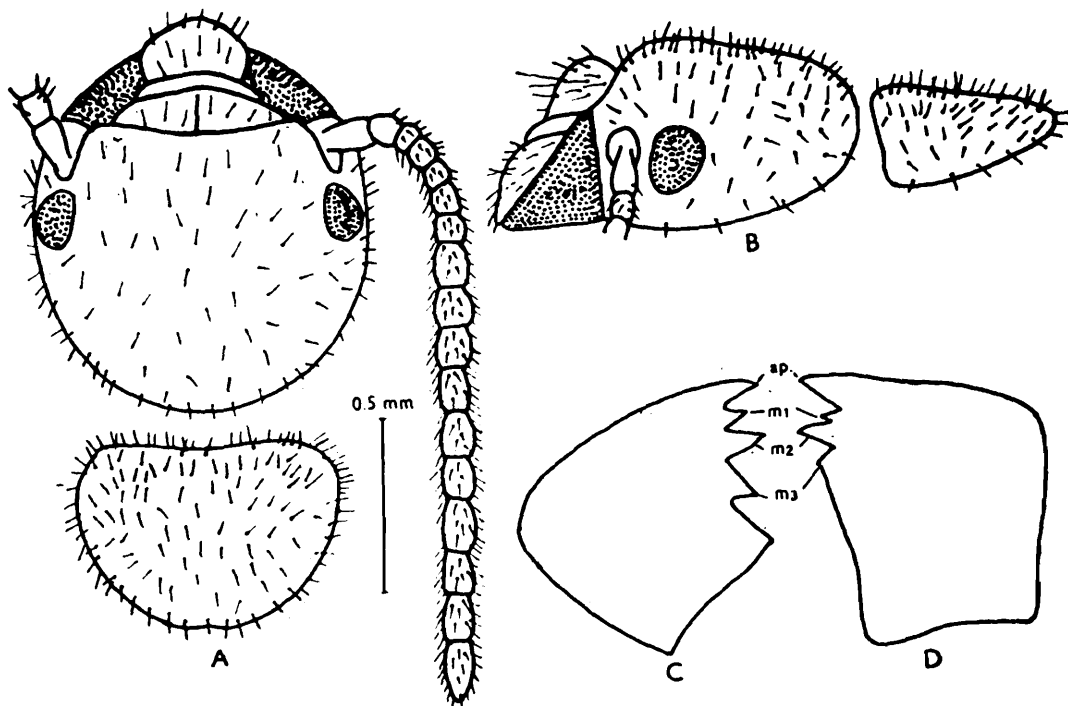
Castes known.—Im., S., Wk.

Material.—5 vials, 1972-73, Im., S., Wk., Jodhpur city; imagoes from swarms and soldiers and workers from wood-work in houses.

Measurements (mm.), etc.

Imago (1 ex., Jodhpur)

1. Total length with wings	10.0
2. Total length without wings	5.0
3. Head-length to tip of labrum	1.26
4. Head-length to mandible-base	0.84
5. Max. width of head, with eyes	0.89
6. Max. height of head	0.58
7. Labrum (Median L × W)	0.14 × 0.30
8. Eyes (L × W)	0.23 × 0.18
9. Min. eye-antennal distance	0.027
10. Pronotum (L × W)	0.37 × 0.68
11. No. of antennal segments	17



Text-fig. 3. *Heterotermes indicola* (Wasmann). Imago. Jodhpur (Rajasthan) : (A) Head and pronotum, dorsal view. (B) Ditto, side view. (C), (D) Left and right mandibles, respectively.

ap., apical teeth; *m1-m3*, marginal teeth 1-3 respectively.

For measurements of soldiers from Rajasthan, *vide* Roonwal and Bose (1964).

Distribution.—Widely distributed in Pakistan and North India south to about 20°N latitude.

Remarks.—The present is the first breeding record, as indicated by the presence of imagoes, from Rajasthan. Swarming occurs in Jodhpur in July and August in the early part of the night (8—8.30 P.M.). The species was found to seriously damage wood-work in houses in Jodhpur city.

Subfamily (ii) COPTOTERMITINAE

4. *Coptotermes heimi* (Wasmann)

(Text-fig. 4)

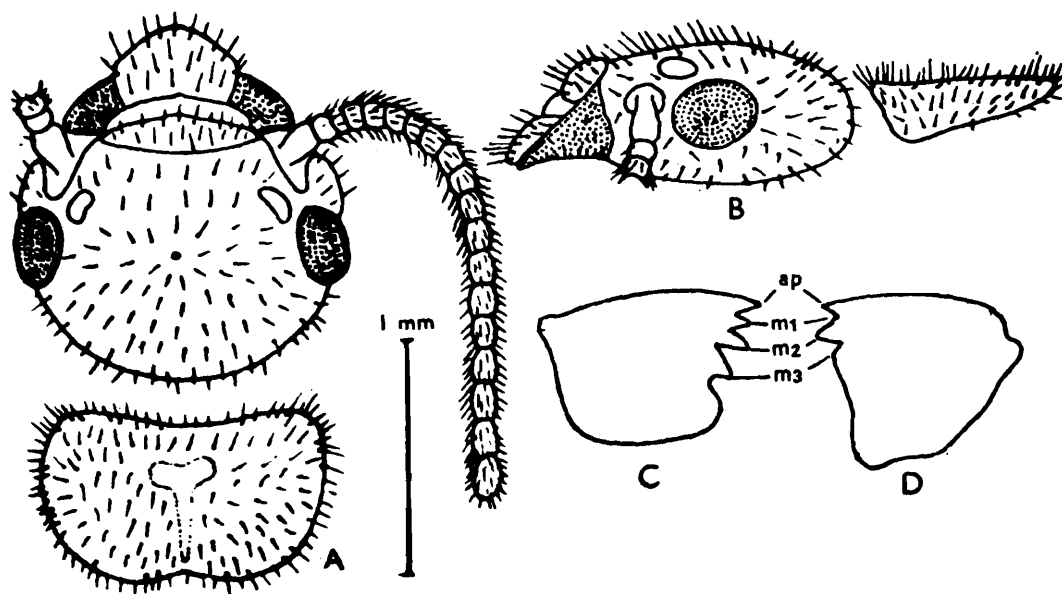
Arrhinotermes heimi Wasmann, 1902, *Zool. Jb. (Syst.)*, Jena, 17 (1), p. 104, Pl. 4, Im.

Coptotermes heimi (Wasm.), 1962*b*, Roonwal & Chhotani, p. 38.

Castes known.—Im., S., Wk.

Material.—5 vials, 1973, Im., S., Wk., from Rajasthan, thus: (i) Jodhpur Dist.: Jodhpur. (ii) Sikar Dist.: Pipardi village and Purohitonka-Bas.

For measurements of imagoes *see* Roonwal and Chhotani (1962 *b*) and for soldiers, Roonwal and Bose (1964).



Text-fig. 4. *Coptotermes heimi* (Wasmann). Imago (alate ♂). Jodhpur (Rajasthan). (A) Head and pronotum, dorsal view. (B) Ditto, side view. (C), (D), Left and right mandibles respectively.

ap., apical teeth; *m1—m3*, marginal teeth 1-3 respectively.

Distribution.—Widely distributed almost all over India and Pakistan. First recorded from Rajasthan by Roonwal and Bose (1964) from the districts of Jaisalmer, Jodhpur, Pali, Nagaur and Jaipur; the present records from the Sikar district are new.

Remarks.—Breeding, as indicated by the presence of imagoes, from Rajasthan is here recorded for the first time. Swarming in Jodhpur occurs from end-May to early August (31 May to 3 August) at night (ca. 8 to 9 P.M.).

Family IV. TERMITIDAE

Subfamily (i) AMITERMITINAE

5. *Speculitermes cyclops cyclops* Wasmann

(Text-fig. 5)

Speculitermes cyclops Wasmann, 1902, *Zool. Jb. (Syst.)*, Jena, 17 (1), pp. 160-162, Im., Wk.; Roonwal and Sen-Sarma, 1960, p. 16.

Castes known.—Im. (not Rajasthan); Wk.

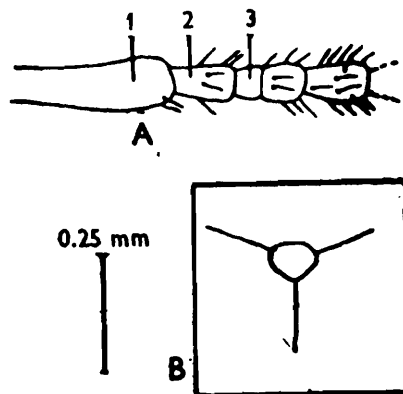
Material.—A vial, sev. Wk.; Nallah, ca. 10 km. E of Bichiwara (Dungarpur Dist.), P. D. Gupta & Party coll., 11. iii. 1972, ex under stone.

Measurements (mm.), etc.

Workers (1 ex., Dungarpur Dist.)

1. Total length	6.8
2. Head-length to mandible-base	1.16
3. Max. width of head	1.32
4. Mid-dorsal spot (L × W)	0.21 × 0.21
5. Pronotum (L × W)	0.47 × 0.79
6. No. of antennal segments	15

Distribution.—Found in the relatively moist areas of North India (eastern and southern Rajasthan, Uttar Pradesh, Madhya Pradesh) and Maharashtra; and Pakistan. Records from Burma are doubtful.



Text-fig. 5. *Speculitermes cyclops cyclops* (Wasmann). Worker. Bichiwara (Dungarpur Dist., Rajasthan). (A) Basal segments of a 15-segmented antenna, showing the subdivision of segment 3 (of a 14-segmented antenna) into two segments (3 and 4). (B) Mid-dorsal spot on head.

Remarks.—From Rajasthan it was hitherto known only from the Kota district; the present record from the Dungarpur district extends the range further south. In Rajasthan it occurs only in the wet zone (open or dense forests). The number of worker antennal segments, normally 14, is here often 15 (by the subdivision of segment 9). The soldier caste is mostly wanting in the genus (*vide* Roonwal and Chhotani, 1960).

6. *Amitermes belli* (Desneux) 1906

Termes belli Desneux, 1906, p. 352.

Castes known.—Im., S., Wk.

Material.—A vial, 6 S., sev. Wk., Jodhpur, N. S. Rathore coll., 8, iv. 1973, ex *neem* tree.

For measurements of imagoes and soldiers from Rajasthan, *vide* Roonwal and Bose (1964).

Distribution.—Pakistan (Baluchistan, N.W.F.P., Sind, Punjab) and western India (Rajasthan).

Remarks.—It is an arid to wet zone species; for its distribution in Rajasthan in relation to soil and vegetation, *vide* Roonwal and Bose (1973).

7. *Eremotermes neoparadoxalis* Ahmad 1955

Ahmad, 1955, p. 252.

Castes known.—S., Wk.

Material.—5 vials, 1964-72, S., Wk., Jodhpur Dist. (Agolai, Beriganga, Jodhpur and Satlana).

Distribution.—Pakistan (Sind, Baluchistan, N.W.F.P.) and western India (Rajasthan and Delhi). In Rajasthan known from the districts of Jodhpur (present record), Bikaner and Jaipur.

Remarks.—It is an arid zone species.

8. *Eremotermes paradoxalis* Holmgren 1913

(Text-fig. 6)

Eremotermes paradoxalis Holmgren, 1913, *J. Bomaay nat. Hist. Soc.*, Bombay, 22 (1), pp. 115-116. S., Wk.

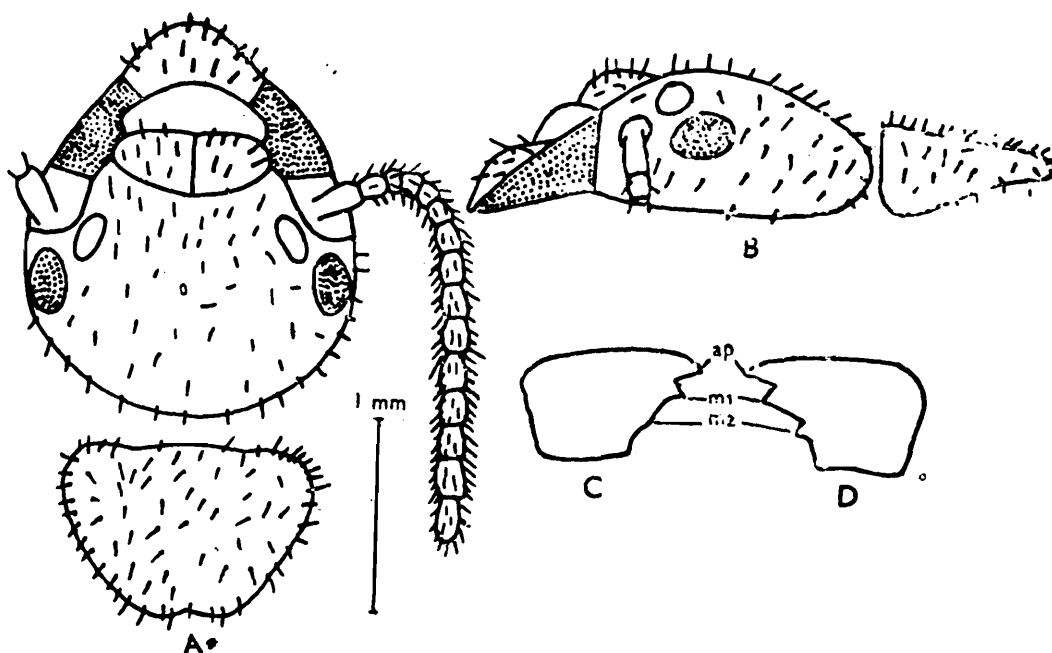
Castes known.—Im., S., Wk.

Material.—5 vials, 1969-73, Im., S., Wk., Jodhpur (Jodhpur Dist.).

Measurements (mm.) etc.

Imagoes (8 exs., Jodhpur)

1. Total length with wings	8.9—10.3
2. Total length without wings	5.1—5.7
3. Head-length to tip of labrum	1.00—1.05
4. Head length to mandible-base	0.52—0.74
5. Max. width of head with eyes	0.70—0.89
6. Max. height of head	0.40—0.53
7. Labrum (Median L × W)	0.08—0.16 × 0.27—0.37
8. Eyes (L × W)	0.18—0.22 × 0.15—0.19
9. Ocelli (L × W)	0.10—0.11 × 0.08—0.09
10. Min. eye-ocellus distance	0.027—0.036
11. Min. eye-antennal distance	0.027—0.045
12. Pronotum (L × W)	0.32—0.47 × 0.52—0.68
13. No. of antennal segments	15



Text-fig. 6. *Eremotermes paradoxalis* Holmgren. Imago. Jodhpur (Rajasthan) A) Head and pronotum, dorsal view. (B) Ditto, side view. (C), (D), Left and right mandibles respectively.

ap., apical teeth; m1—m2, marginal teeth 1 and 2 respectively.

For measurements of soldiers from Rajasthan, *vide* Roonwal and Bose (1964).

Distribution.—Widely distributed in India (Rajasthan, Punjab, Delhi, and Peninsular India down to Kerala); and Pakistan (Punjab, N.W.F.P.).

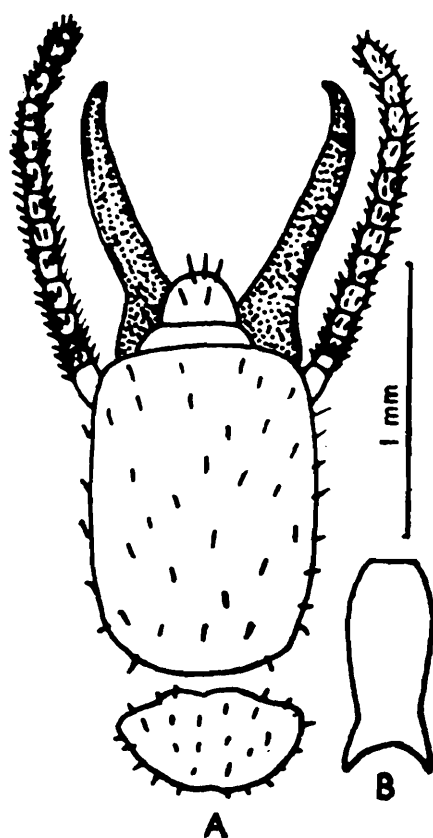
Remarks.—In Rajasthan it was hitherto known from the districts of Nagaur, Jaipur and Kota; the present is the first record from the Jodhpur district. The present is also the first record of breeding in Rajasthan. Swarming occurs at Jodhpur during June and August in the afternoons and evenings (*ca.* 4.45 to 7.30 P.M.). It is a semi-arid zone species.

9. *Microcerotermes palestinensis* Spaeth 1962

(Text-fig. 7)

(Nec Emerson of authors, *vide* discussion in Roonwal, 1974.)*Castes known*.—Im. (not Rajasthan), S., Wk.*Material*.—2 vials : (i) 3 S., sev. Wk., Mathania (Jodhpur Dist.), S. C. Verma & N. S. Rathore coll., 3 viii.1970, mixed with *Odontotermes obesus* (ex mound). (ii) 2 S., sev. Wk., Amet (Udaipur Dist.), S. C. Verma coll., 16.vii.1972, ex earthen runway on 'Khejri' (*Prosopis spicigera* Linn.).*Measurements* (mm.), etc.*Soldiers* (3 exs., Mathania and Amet, Rajasthan)

1. Total length with mandibles	5.0—5.3
2. Head-length with mandibles	2.21—2.26
3. Head-length to mandible-base	1.26
4. Max. width of head	0.95
5. Max. height of head	0.68—0.74
6. Length of mandibles (left; right)	1.0; 1.0
7. Postmentum (Median L × W)	0.58 × 0.32
8. Pronotum (L × W)	0.32—0.37 × 0.63—0.68
9. Mandible-Head Index (Left Mandible-length/Head-length to mandible-base)	0.79
10. No. of antennal segments	13

Distribution.—India (western and southern Rajasthan, e.g., Jodhpur and Udaipur Dists.), and West Asia (Israel).Text-fig. 7. *Microcerotermes palestinensis* Spaeth. Soldier. Amet (Udaipur Dist., Rajasthan). (A) Head and pronotum, dorsal view. (B) Postmentum, *in situ*.

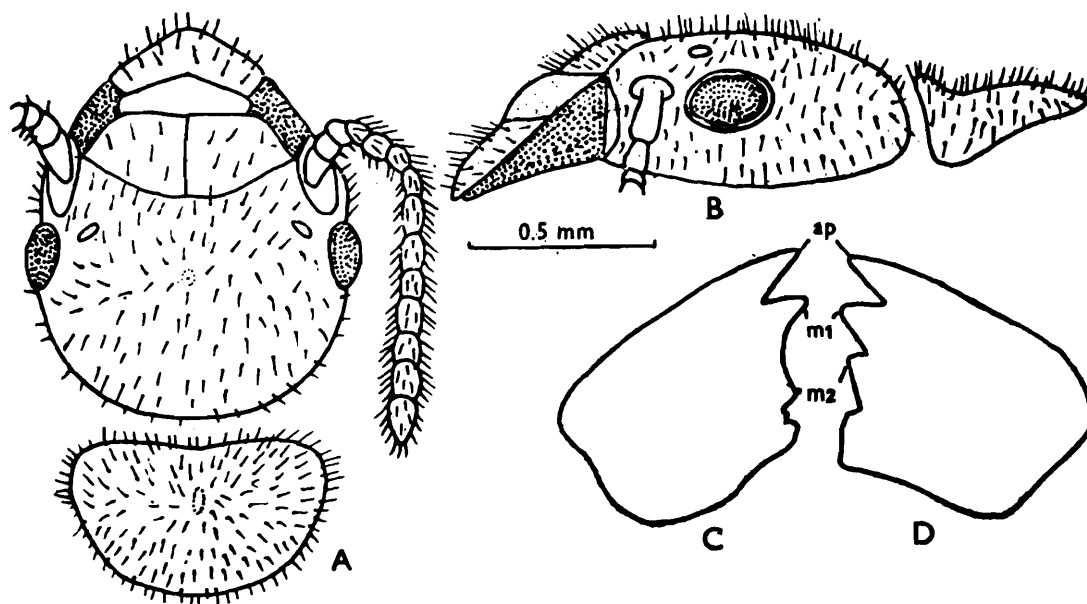
Remarks.—This is the first record from India. The species was originally described from Israel (an arid area) and this widely separated discontinuous distribution is of interest. In India it has been found both in the semi-arid areas as well as in relatively wet forested zones. The shape and distribution of micrasters on its wing-membranes have been described by Roonwal, Verma and Rathore (1974).

10. *Microcerotermes raja* Roonwal and Bose 1964

(Text-fig. 8)

Microcerotermes championi raja Roonwal & Bose, 1964, p. 26.

Castes known.—Im., S., Wk.



Text-fig. 8. *Microcerotermes raja* Roonwal & Bose (*M. championi raja* R. & B.). Imago. Jodhpur (Rajasthan). (A) Head and pronotum, dorsal view. (B) Ditto, side view. (C), (D), Left and right mandibles respectively.

ap., apical teeth; *m1-m2*, marginal teeth 1 and 2 respectively.

Material.—8 vials, Im, S., Wk., 1969-73, districts of Jodhpur (Jodhpur and vicinity) and Nagaur (Salayana village, ca. 4 km. S of Maroth).

Measurements (mm.), etc.

Imago (4 exs., Jodhpur)

1. Total length with wings	8.0—9.8 (48 exs.)
2. Total length without wings	3.2—6.2 (54 exs.)
3. Head-length to mandible-base	0.95—1.00
4. Max. head-width with eyes	0.72—1.42 (54 exs.)
5. Labrum (Median L × W)	0.11—0.15 × 0.39
6. Eyes (max. × min. diameter)	0.18 × 0.16
7. Ocellus (max. × min. diameter)	0.072 × 0.045
8. Min. eye-ocellus distance	0.07—0.08
9. Pronotum (L × W)	0.47 × 0.74—0.79
10. No. of antennal segments	14

Distribution.—Rajasthan : Jodhpur and Nagaur Dists., as above.

Remarks.—It is a semi-arid zone species. The imago has been described by Roonwal, Verma and Rathore (1973) who have also made observations on gallery-system, swarming, etc. Swarming at Jodhpur occurs in the day (about 11 A.M. — 3 P.M.) during the monsoon for a period of about six weeks (end-June to second week of August). The shape and distribution of micrasters on wing-membrane have been described by Roonwal, Verma and Rathore (1974), and sex ratios and sexual dimorphism in external body-parts discussed by Roonwal and Verma (1973). Roonwal and Rathore (*in press, c*) have discussed its swarming and egg-laying.

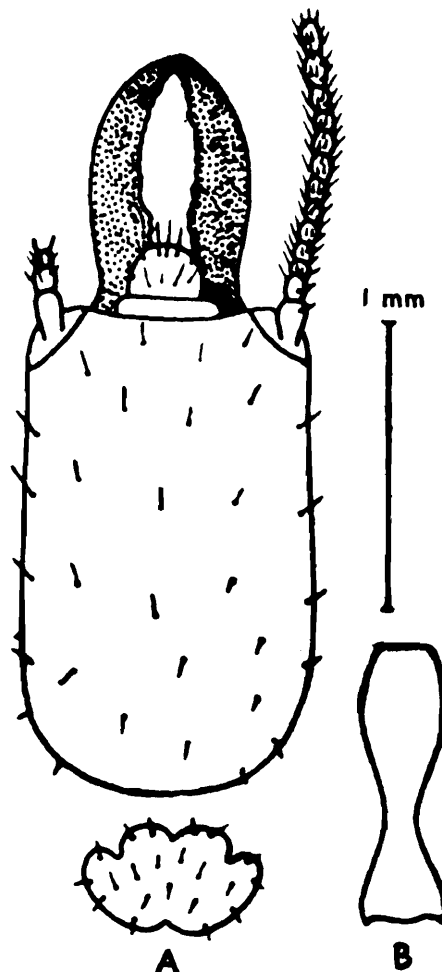
11. *Microcerotermes sakesarensis* Ahmad 1955

(Text-fig. 9)

Ahmad, 1955, p. 247.

Castes known.—S., Wk.

Material.—A vial, sev. S., Wk., Sambhar Lake (Jaipur Dist.), S. C. Verma coll., 6.ii.1972, ex wood.



Text-fig. 9. *Microcerotermes sakesarensis* Ahmad. Soldier. Sambhar Lake (Jaipur Dist., Rajasthan). (A) Head and pronotum, dorsal view. (B) Postmentum, *in situ*.

*Measurements (mm.), etc.**Soldiers* (2 exs., Sambhar Lake)

1. Total length with mandibles	5.3
2. Head-length with mandibles	2.47—2.58
3. Head-length to mandible-base	1.63—1.74
4. Max. width of head	0.95
5. Length of mandibles (left; right)	0.89; 0.89
6. Pronotum (L × W)	0.37 × 0.63
7. No. of antennal segments	13

Distribution.—India (Sambhar Lake, Jaipur Dist., Rajasthan); and Pakistan (Punjab, N.W.F.P.).

Remarks.—This is the first record from India. It is evidently an arid zone species.

12. *Microcerotermes tenuignathus* Holmgren

Microcerotermes tenuignathus Holmgren, 1913, *J. Bombay nat. Hist. Soc.*, Bombay, 22 (1), pp. 116-117. S., Wk. (major and minor).

Microcerotermes t. tenuignathus Roonwal & Bose, 1964, p. 28.

Castes known.—S., Wk.

Material.—2 vials : (i) 2 S., sev. Wk., Agolai (Jodhpur Dist.), P. D. Gupta coll., 17.vii.1965, ex under stone. (ii) 2 S., sev. Wk., Jodhpur, S. C. Verma coll., 22.vii.1970, ex wood.

Distribution.—Western India (Gujarat and Rajasthan); and Pakistan (Baluchistan, N.W.F.P., Punjab, Sind). In Rajasthan it is known from the districts of Barmer, Jaisalmer, Jodhpur, Jaipur and Kota. The present is the first record from Jodhpur proper.

Subfamily (ii) TERMITINAE

13. *Angulitermes jodhpurensis* Roonwal & Verma (in press)

(Text-fig. 10)

Roonwal & Verma, *in press*. Im., S., Wk.

Castes known.—Im., S., Wk.

Material.—2 vials, 1972-73, Im., S., Wk., Jodhpur.

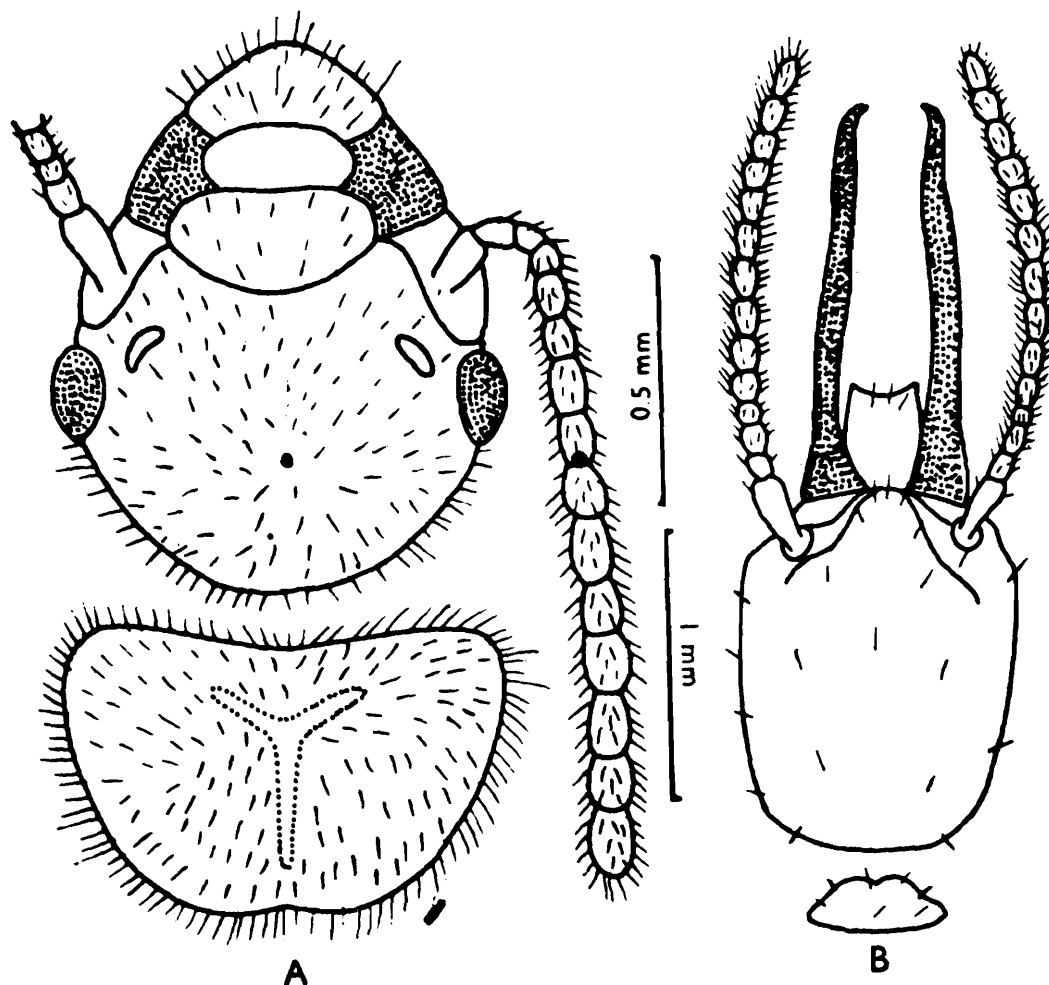
*Measurements (mm.), etc.**Imagoes* (5 exs., Jodhpur)

1. Total length with wings	10.0—11.0
2. Total length without wings	6.0—7.0
3. Head-length with mandibles	1.00—1.11
4. Head-length to mandible-base	0.68—0.84
5. Max. width of head with eyes	0.95—1.00
6. Max. height of head	0.53
7. Labrum (Median L × W)	0.09 × 0.36
8. Eyes (max. × min. diameter)	0.23—0.25 × 0.20—0.22
9. Pronotum (L × W)	0.47—0.53 × 0.89—0.95
10. No. of antennal segments	15

Soldiers (5 exs., Jodhpur)

1. Total length with mandibles	3.7—4.7
2. Head-length with mandibles	2.42—2.74
3. Head-length to mandible-base	1.11—1.32
4. Head-length with frontal projection	1.32
5. Max. width of head	0.95—1.00
6. Max. height of head	0.58
7. Max. length of mandibles (left; right)	1.32—1.42; 1.32—1.42
8. Labrum (Median L × W)	.25 × 0.210
9. Postmentum (Median L × W)	0.32—0.27
10. Pronotum (L × W)	0.21 × 0.58—0.63
11. No. of antennal segments	14

Distribution.—India : Jodhpur (Rajasthan).



Text-fig. 10. *Angulitermes jodhpurensis* Roonwal & Verma. Head and pronotum, dorsal view. Jodhur (Rajasthan). (A) Imago (♀). (B) Soldier.

Remarks.—Swarming occurs in August in the afternoon (for fuller details of breeding, *vide* Roonwal and Verma, 1974). The shape and distribution of micrasters on wing-membranes have been described by Roonwal, Verma and Rathore (1974). The shape and the width/

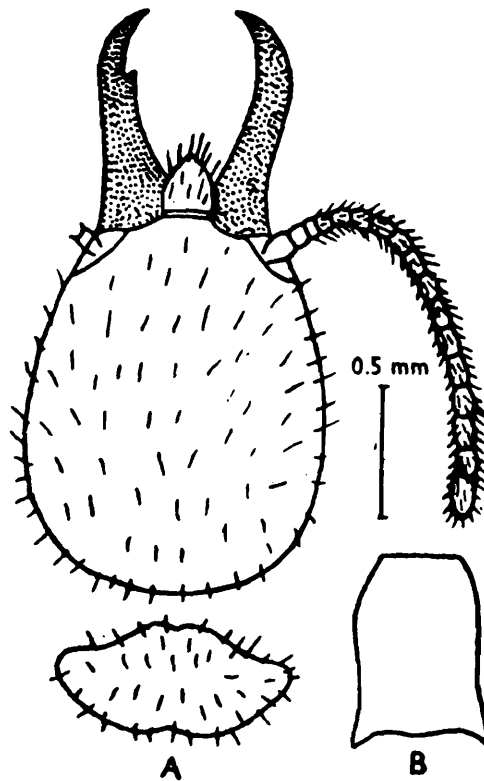
length ratio of eggs have been discussed by Roonwal (1973b). Egg-laying, hatching, etc. have been described by Roonwal and Rathore (in press, c).

Subfamily (iii) MACROTERTITINAE

14. *Odontotermes brunneus* (Hagen)

(Text-fig. 11)

Termes brunneus Hagen, 1858, *Linn. Entom.*, Berlin, 12, p. 133 Im., S.



Text-fig. 11. *Odontotermes brunneus* (Hagen). Soldier. Banasthali (Tonk Dist., Rajasthan). (A) Head and pronotum, dorsal view. (B) Postmentum, *in situ*.

Castes known.—Im. (not Rajasthan), S., Wk.

Material.—A vial, 2 S., sev. Wk., Banasthali (Tonk Dist.), Y. P. Sinha coll., 7.x.1973, ex. log of wood.

Measurements (mm.), etc.

Soldier (1 ex., Banasthali, Tonk Dist.)

1. Total length with mandibles	5.0
2. Head-length with mandibles	2.31
3. Head-length to mandible-base	1.32
4. Max. width of head	1.21
5. Length of mandibles (left; right)	1.0; 1.0
6. Distance of tooth from apex in left mandible	0.32
7. Left Mandibular Index (Tooth distance/Mandible-length)	0.32
8. Pronotum (L × W)	0.47 × 1.05
9. No. of antennal segments	16

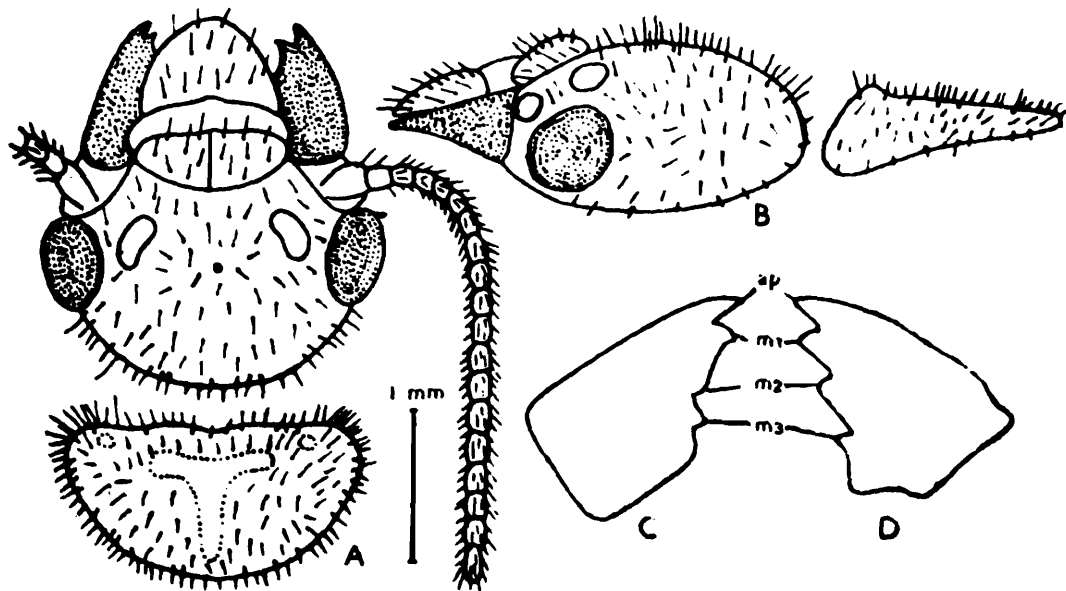
Distribution.—Widely distributed in India. (Sri Lanka records given by some authors are doubtful.) This is the first record from Rajasthan.

Remarks.—The structure of its dome-shaped earthen mounds has been described by Roonwal (1973a) from Gujarat.

15. *Odontotermes dehraduni* (Snyder) 1934

(Text-fig. 12)

Termes (Termes) dehraduni Snyder, 1934, *Proc. U. S. natnl. Mus.*, Washington, 82 (16), pp. 6—7. Im.



Text-fig. 12. *Odontotermes dehraduni* (Snyder). Imago. Jodhpur (Rajasthan). (A) Head and pronotum, dorsal view. (B) Ditto, side view. (C), (D), Left and right mandibles, respectively.

ap., apical teeth; m1—m3, marginal teeth 1-3 respectively.

Castes known.—Im. only.

Material.—A vial, sev. Im., Jodhpur, P. D. Gupta coll., 5.vii.1965, ex light-trap.

Measurements (mm.), etc.

Imago (2 exs., Jodhpur)

1. Total length with wings	27.5—27.9
2. Total length without wings	13.4
3. Head-length to tip of labrum	2.79—2.89
4. Head-length to mandible-base	1.84
5. Max. width of head with eyes	2.58—2.63
6. Labrum (Median L × W)	0.58 × 0.79
7. Eyes (L × W)	0.74 × 0.63
8. Ocelli (L × W)	0.32 × 0.42
9. Min. eye-ocellus distance	0.11
10. Pronotum (L × W)	1.05—1.16 × 2.05—2.21
11. No. of antennal segments	19

Distribution.—North India (Dehra Dun, Uttar Pradesh; Delhi; and Jodhpur, Rajasthan); and Pakistan (Jhelum Dist.; Lahore and Rawalpindi).

Remarks.—This is the first record from Rajasthan. Only imagoes (at swarms) have so far been obtained. Swarming occurs at Jodhpur in early July at night; at other places, from end-June to early September. In Delhi, Vishnoi (1957*b*) reported sporadic swarming in small numbers in early monsoon (end-June and July) at night.

16. *Odontotermes distans* Holmgren & Holmgren 1917

(Text-fig. 13)

Odontotermes distans Holmgren & Holmgren, 1917, *Mem. Dept. Agric. India (Ent.)*, Calcutta, 5 (3), p. 153. Im.

Castes known.—Im. (Rajasthan); S., Wk. elsewhere.

Material.—A vial, sev. Im., Khokaria village, ca. 11 km. N of Jodhpur (Jodhpur Dist.), R. C. Sharma & Party coll., 16.viii.1972, ex ground.

Measurements (mm.), etc.

Imagoes (2 exs., Jodhpur)

1. Total length with wings	27.0—28.0
2. Total length without wings	14.0—15.0
3. Head-length to tip of labrum	3.26—3.31
4. Head-length to mandible-base	1.74—1.84
5. Max. width of head with eyes	2.63—2.74
6. Labrum (Median L × W)	0.58—0.68 × 1.0
7. Eyes (L × W)	0.63 × 0.53—0.58
8. Ocelli (L × W)	0.26 × 0.16
9. Min. eye-ocellus distance	0.26
10. Pronotum (L × W)	1.16 — 1.32 × 2.47—2.53
11. No. of antennal segments	19

Distribution.—Widely distributed in India (Uttar Pradesh, especially the northern hilly areas; Rajasthan; West Bengal; Assam; Tamil Nadu); going up to ca. 2100 metres.

Remarks.—This is the first record from Rajasthan. Swarming occurred on 16 July, in the evening (6.30 P. M.).

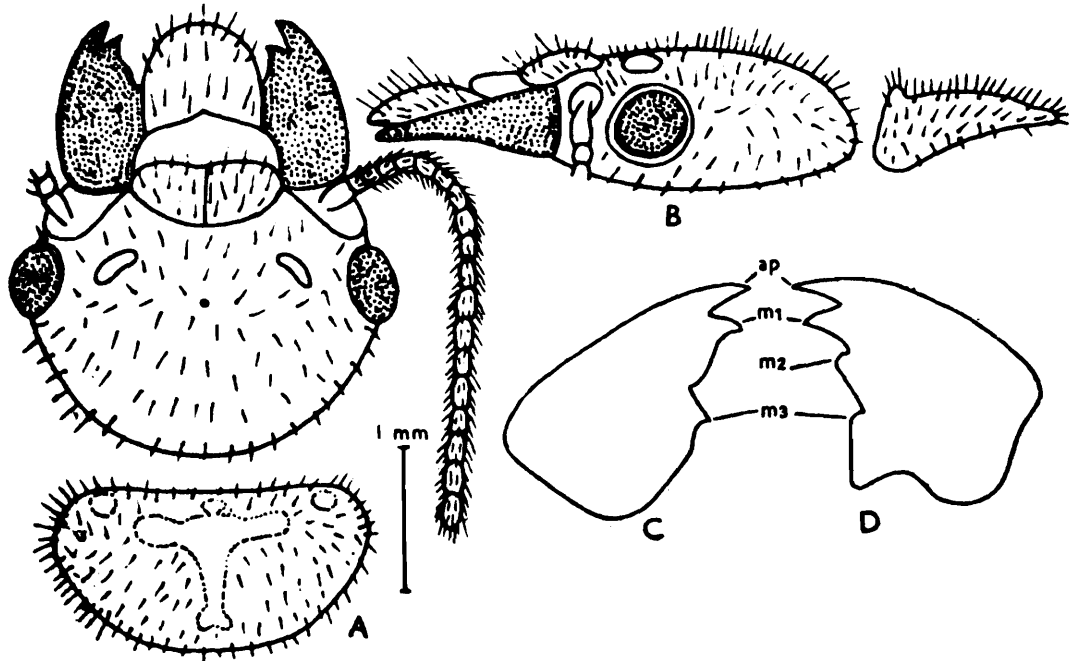
17. *Odontotermes feae* (Wasmann)

(Text-fig. 14)

Termes feae Wasmann, 1896, *Ann. Mus. Stor. nat. Genova*, Genoa, (2) 16, pp. 625-626. S., Wk.

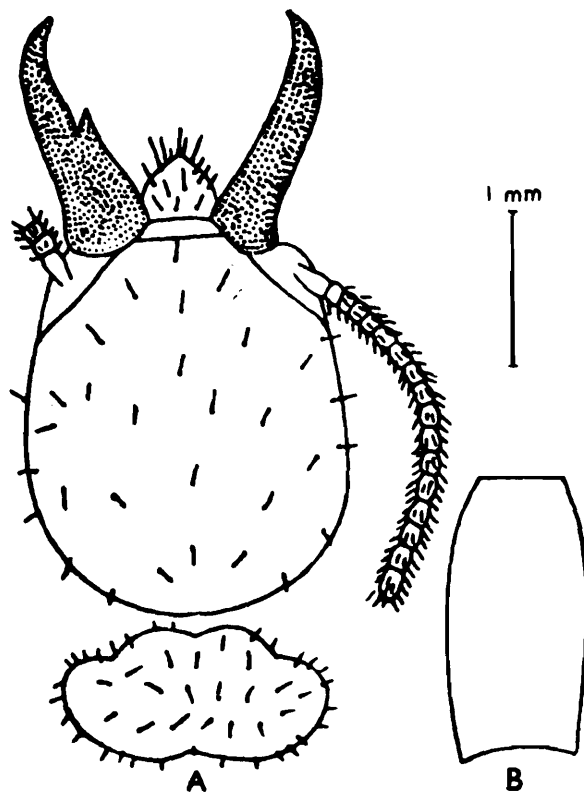
Castes known.—Im. (not Rajasthan), S., Wk.

Material.—2 vials, 1972, S., Wk., Mt. Abu and Oria village (near Mt. Abu), Sirohi Dist.



Text-fig. 13. *Odontotermes distans* Holmgren & Holmgren. Imago (alate ♂). Khokharia village (Jodhpur Dist., Rajasthan). (A) Head and pronotum, dorsal view (B) Ditto, side view. (C), (D) Left and right mandibles, respectively.

ap., apical teeth; *m1—m3*, marginal teeth 1-3 respectively.



Text-fig. 14. *Odontotermes feae* (Wasmann). Soldier. Oria village near Mt. Abu (Sirohi Dist., Rajasthan). (A) Head and pronotum, dorsal view. (B) Postmentum, *in situ*.

*Measurements (mm.) etc.**Soldiers (3 exs., Mt. Abu)*

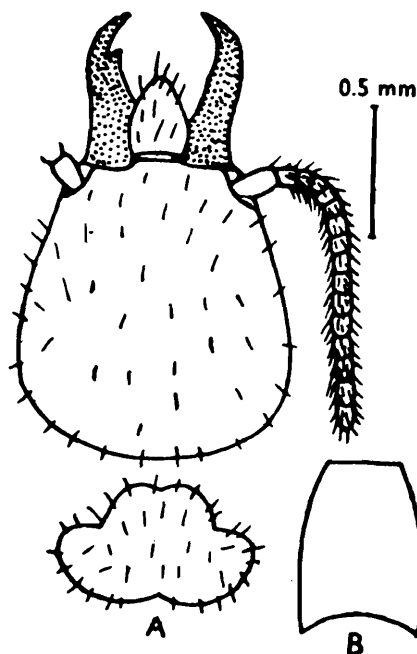
1. Total length with mandibles	7.6—9.6
2. Head-length with mandibles	4.16—4.21
3. Head-length to mandible-base	2.58—2.63
4. Max. width of head	2.21—2.26
5. Labrum (Median L × W)	0.37 × 0.53
6. Length of mandibles (left; right)	1.53; 1.53
7. Distance of tooth from apex, in left mandible	0.74—0.79
8. Postmentum (Median L × W)	1.74 × 0.84
9. Pronotum (L × W)	0.89—0.94 × 1.63—1.68
10. No. of antennal segments	17

Distribution.—Widespread in India, Sri Lanka and farther east (Bangla Desh, Burma, Thailand).

Remarks.—This is the first record from Rajasthan.

18. *Odontotermes giriensis* Roonwal & Chhotani 1962

(Text-fig. 15)

Roonwal & Chhotani, 1962 *a*, p. 341.*Castes known.*—S., Wk.

Text-fig. 15. *Odontotermes giriensis* Roonwal & Chhotani. Soldier. Didwana (Nagaur Dist., Rajasthan). (A) Head and pronotum, in dorsal view. (B) Postmentum, *in situ*.

Material.—(i) A vial, a few S., Wk., Didwana (Nagaur Dist.), S. C. Verma coll., 3.viii. 1972, ex soil. (ii) A vial, a few S., Wk., Palsana (Sikar Dist.), I. Prakash coll., 29.xii.1973.

*Measurements (mm.), etc.***Soldiers (2 exs., Didwana, Nagaur Dist.)**

1. Total length with mandibles	4.2—4.5
2. Head-length with mandibles	1.89—1.95
3. Head-length to mandible-base	1.16—1.21
4. Max. width of head	1.11
5. Max. height of head	0.63—0.68
6. Labrum (Median L × W)	0.26 × 0.21—0.26
7. Length of mandibles (left; right)	0.74; 0.74
8. Postmentum (Median L × W)	0.79 × 0.53
9. Pronotum (L × W)	0.53 × 0.84
10. No. of antennal segments	15

Distribution.—Eastern India: Meghalaya and Arunachal Pradesh [N.E.F.A.] and Western India (Rajasthan : Nagaur and Sikar Dists.); and Bangla Desh.

Remarks.—This is the first record from Rajasthan. The widely discontinuous distribution (the eastern area in the wet forest zone and the western in the semi-dry zone) is of interest. Examples from the two areas are exactly alike and cannot be separated.

19. *Odontotermes guptai* Roonwal & Bose 1962

Odontotermes bellahunisensis guptai Roonwal & Bose, 1962a, p. 588.

Castes known.—S., Wk.

Material.—A vial, 4 S., sev. Wk., Berata village ca. 5 km. from Bar (Ajmer Dist.), R. C. Sharma coll., 10.viii.1973, ex under stone.

Distribution.—Western India (widely distributed in Rajasthan in both dry and wet districts, viz., Sikar, Jhunjhunu, Bikaner, Nagaur, Ajmer and Udaipur); and Pakistan.

Remarks.—This is the first record from the Ajmer district.

20. *Odontotermes guardaspurensis* Holmgren & Holmgren 1917

(Text-fig. 16)

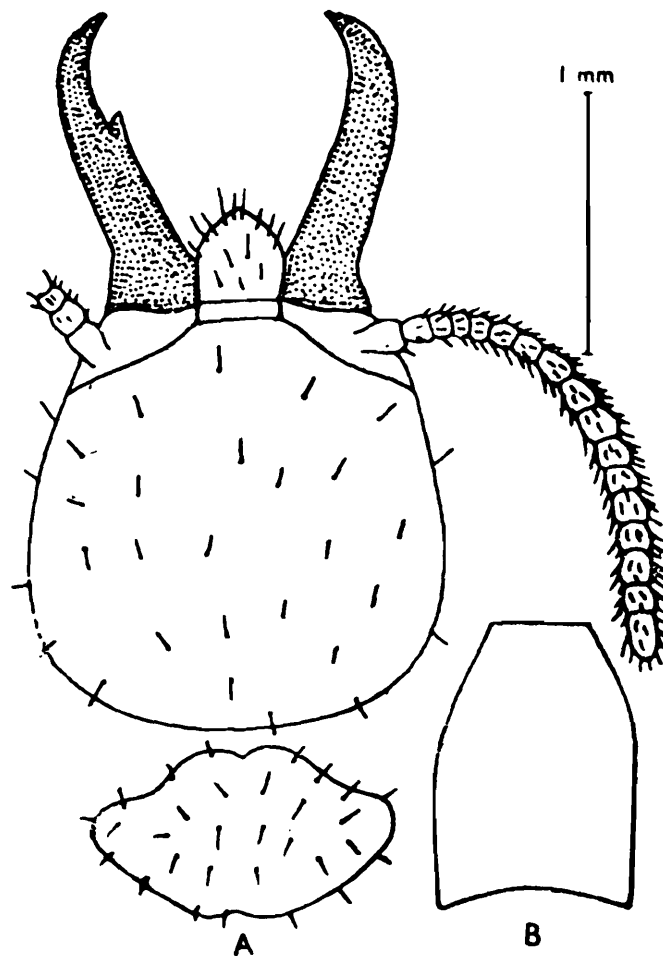
Odontotermes (Cyclotermes) obesus guardaspurensis Holmgren & Holmgren, 1917, *Mem. Dept. Agric. India (Ent.)*, Calcutta, 5 (3), pp. 149-150. Im., S., Wk.

Odontotermes gurdaspurensis Chatterjee and Thakur, 1967, *Indian Fo r. Rec. (Ent.)* Delhi, 11 (1), pp. 36-38.

Castes known.—Im. (not Rajasthan), S., Wk.

Material.—9 vials, S., Wk., 1972-73, from Rajasthan, thus : Jodhpur, Nagaur, Ajmer, Bharatpur and Banswara Districts.

Z. S...29



Text-fig. 16. *Odontotermes gurdaspurensis* Holmgren Holmgren. & Soldier. Danpur village (Banswara Dist., Rajasthan). (A) Head and pronotum, dorsal view. (B) Postmentum, *in situ*.

Measurements (mm.), etc.

Soldiers (3 exs., Banswara Dist.)

1. Total length with mandibles	5.8—7.1
2. Head-length with mandibles	2.47—2.79
3. Head-length to mandibles-base	1.42—1.58
4. Max. width of head	1.26—1.53
5. Max. height of head	0.74—0.79
6. Length of mandibles (left; right)	1.11—1.21 × 1.11—1.21
7. Distance of tooth from apex, in left mandible	0.37—0.42
8. Labrum (Median L × W)	0.32—0.42 × 0.32—0.42
9. Postmentum (Median L × W)	0.79—0.95 × 0.53—0.58
10. Pronotum (L × W)	0.53—0.79 × 1.05—1.16
11. No of antenal segments	17

Distribution.—Widely distributed in western and northern India (Punjab, Haryana, Rajasthan, and Muzaffarabad Dist., Kashmir); and Pakistan (Punjab, N.W.F.P., Baluchistan).

Remarks.—This is the first record from Rajasthan where it occurs in the wet to semi-arid zones, west up to Jodhpur District and south up to Banswara District, but seems to be absent from the very arid western districts. In the wet area (Banswara District) it was taken from a mound.

21. *Odontotermes kushwahi* Roonwal & Bose 1964

Odontotermes brunneus kushwahi Roonwal and Bose, 1964, p. 33.

Castes known.—S., Wk.

Material.—A vial, sev. S., Wk., Amet (Udaipur Dist.), S. C. Verma coll., 16.viii.1972, ex soil.

Distribution.—Western India (Rajasthan : Udaipur Dist.; and Gujarat : Kaira Dist.); and South India (Tamil Nadu : Salem Dist.).

Remarks.—The present lot is also from the Udaipur District where the type came from. Its discontinuous distribution is noteworthy.

22. *Odontotermes latiguloides* Roonwal & Verma

(Text-fig. 17)

Odontotermes latiguloides Roonwal & Verma, 1973b, p. 83.

Castes known.—S., Wk.

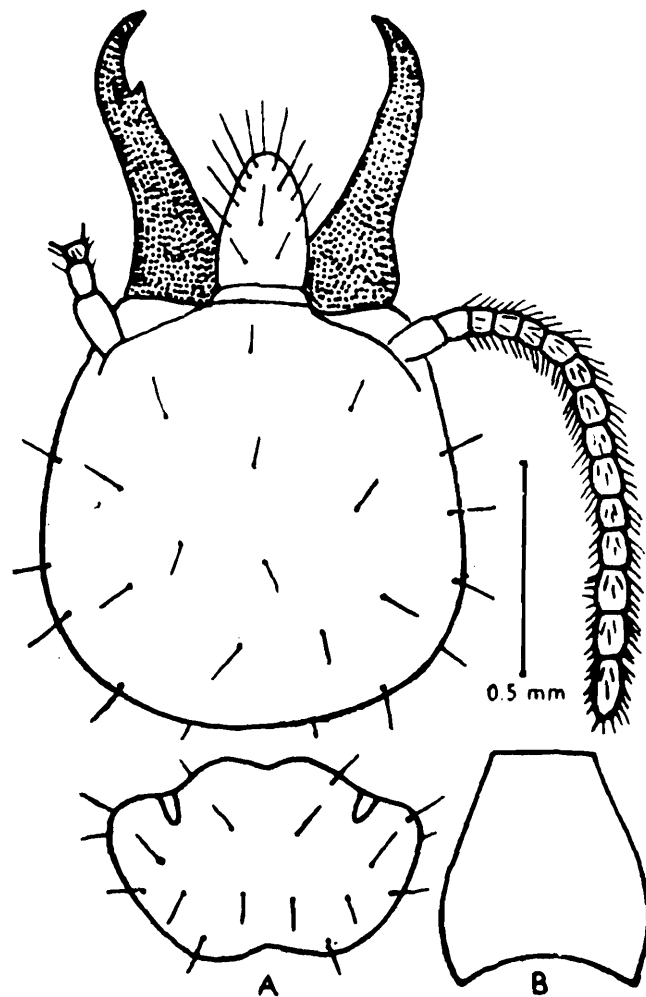
Material.—12 vials, 1964-73, S., Wk., from 8 wet and semi-arid districts of Rajasthan (except the western arid zone), as follows : Jhunjhunu, Sikar, Jaipur, Jodhpur, Bhilwara, Sirohi, Banswara and Dungarpur.

Measurements (mm.), etc.

Soldiers (14 exs., Rajasthan)

1. Total length with mandibles	3.8—5.1
2. Head-length with mandibles	1.79—2.16
3. Head-length to mandible-base	1.00—1.26
4. Max. width of head	1.00—1.21
5. Max. height of head	0.53—0.74
6. Max. length of mandibles	0.79—0.89
7. Distance of tooth from apex, in left mandible	0.26—0.34
8. Labrum (Median L × W)	0.26—0.37 × 0.26—0.32
9. Postmentum (Median L × W)	0.53 × 0.47
10. Postmentum Index (W/Median L)	0.92
11. Pronotum (L × W)	0.47—0.58 × 0.79—0.95
12. No. of antennal segments	17

Distribution.—Widespread in Rajasthan; recorded from 8 districts as given above; up to ca. 1200 m. altitude (Mt. Abu). Apparently confined to moist forests or gardens and areas where the vegetation is rich due to large quantities of subsoil water (e.g., Borunda). Absent in the very arid western areas of Rajasthan.



Text-fig. 17. *Odontotermes latiguloides* Roonwal & Verma. Soldier. Mandalgarh, Bhilwara Dist., Rajasthan). (A) Head and pronotum, dorsal view. (B) Postmentum, *in situ*.

23. *Odontotermes obesus* (Rambur)

Termes obesus Rambur, 1842, *Hist. natur. Insecta Néuroptères*, Paris, p. 304. Im.

Castes known.—Im., S., Wk.

Material.—26 vials, 1971-73, Im. (5 vials), and mostly S. and Wk. from the following districts of Rajasthan : Ajmer, Bhilwara, Jaipur, Jhunjhunu, Jodhpur, Nagaur, Pali, Sikar and Udaipur.

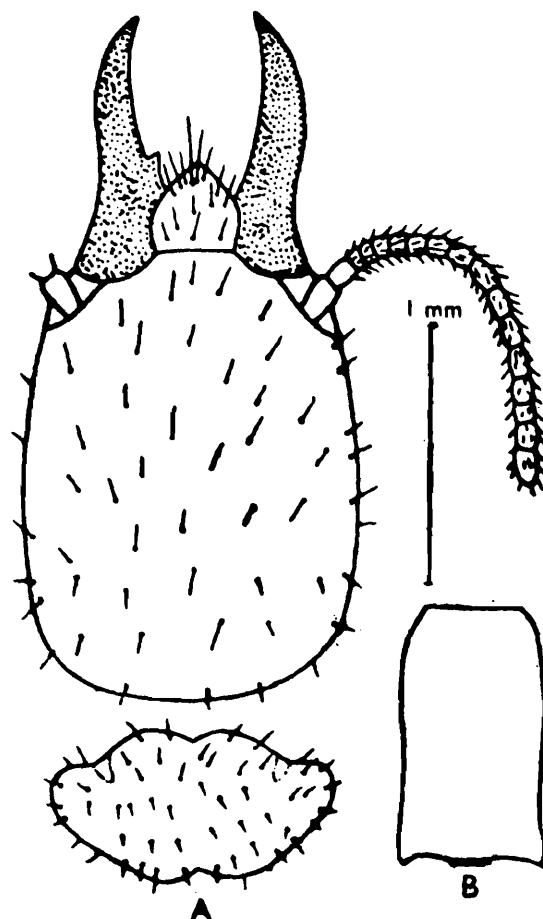
Distribution.—Common all over India, Pakistan and Bangla Desh. Occurs all over Rajasthan in both wet and dry areas.

Remarks.—The present record is new for the Rajasthan districts, of Bhilwara and Jhunjhunu. Very common and highly variable as regards size of soldiers and workers. Imagoes were obtained at Jodhpur from swarms on 16 August (light swarm) and 18 August (very heavy swarm) in the early part of the night (*ca.* 8-9 P.M.).

24. *Odontotermes parvidens* Holmgren & Holmgren 1917

(Text-fig. 18)

Odontotermes (Odontotermes) parvidens Holmgren & Holmgren, 1917, *Mem. Dept. Agric. India (Ent.)*, Calcutta, 5(3), p. 154.



Text-fig. 18. *Odontotermes parvidens* Holmgren & Holmgren. Soldier. Khokund village (ca. 25 km. NE of Raghunathgarh, Jhunjhunu Dist., Rajasthan). (A) Head and pronotum, dorsal view. (B) Postmentum, *in situ*.

Castes known.—S. only from Rajasthan; S., Im., Wk. from other parts of India.

Material.—A vial, 2 S., Khokund village, ca. 25 km. NE from Raghunathgarh (Jhunjhunu Dist.), Y P. Sinha & Party coll., 27.ix.1973, ex cowdung. (Mixed with *O. obesus*.)

Measurements (mm.), etc.

Soldiers (2 exs., Jhunjhunu Dist.)

1. Total length with mandibles	6.1
2. Head-length with mandibles	2.89—2.95
3. Head-length to mandible-base	1.84—1.89
4. Max. width of head	1.47
5. Max. length of mandibles (left; right)	1.05; 1.05
6. Distance of tooth from apex, in left-mandible	0.63
7. Left Mandibular Index (Tooth distance/Mandible-length)	0.60
8. Postmentum (Median L × W)	1.16 × 0.58
9. Pronotum (L × W)	0.63—0.68 × 1.05
10. No. of antennal segments	16—17

Distribution.—Widely distributed in Pakistan (up to ca. 1525 m. alt., N.W.F.P.), India, Bangla Desh and Burma.

Remarks.—This is the first record from Rajasthan.

25. *Odontotermes wallonensis* (Wasmann) 1902

(Text-figs. 19 and 20)

Termes obesus sub sp. *wallonensis* Wasmann, 1902, *Zool. Jb. (Syst.)*, Jena, 17 (1), p. 106. Im., S.

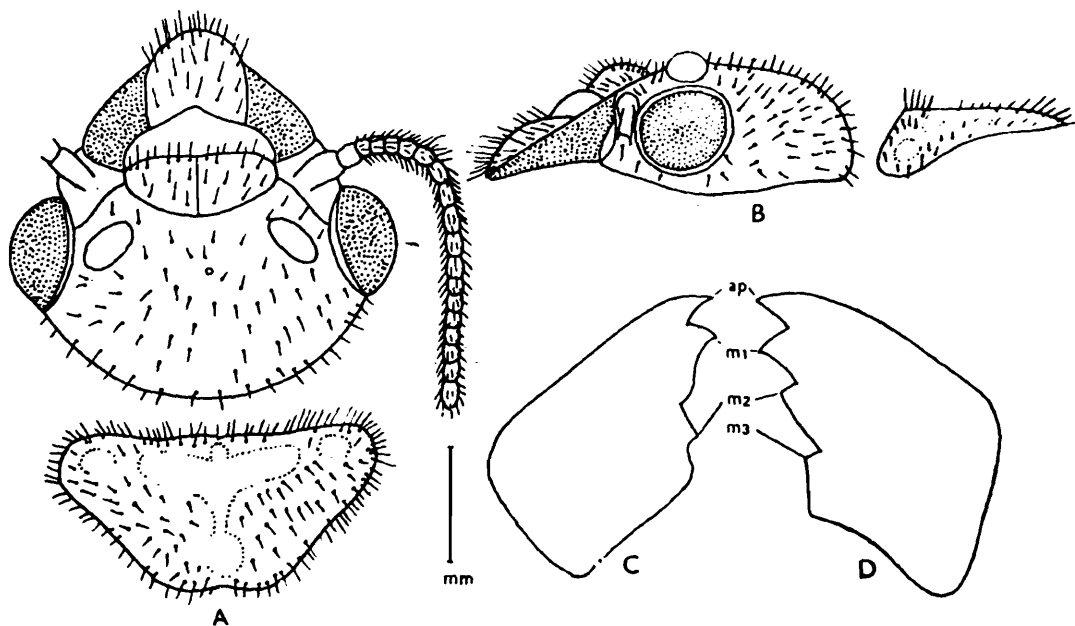
Castes known.—Im., S., Wk.

Material.—2 vials, Bar (Ajmer Dist.), one with sev. Im., 9.viii.1973, at light; the other with sev. S., ex under stone.

Measurements (mm.), etc.

Imago (1 ex., Bar, Ajmer Dist.)

1. Total length with wings	30.0
2. Total length without wings	15.0
3. Head-length to tip of labrum	3.26
4. Head-length to mandible-base	2.0
5. Max. width of head with eyes	3.10
6. Max. height of head	1.32
7. Labrum (Median L × W)	0.68 × 1.0
8. Eyes (L × W)	0.95 × 0.79
9. Ocelli (L × W)	0.42 × 0.32
10. Min. eye-ocellus distance	0.11
11. Pronotum (L × W)	1.42 × 2.79
12. No. of antennal segments	19



Text-fig. 19. *Odontotermes wallonensis* (Wasmann). Imago ♂. Forest plantation, ca. 3 km. E of Bar village (Ajmer Dist., Rajasthan). (A) Head and pronotum, dorsal view. (B) Ditto, side view. (C), (D) Left and right mandibles respectively.

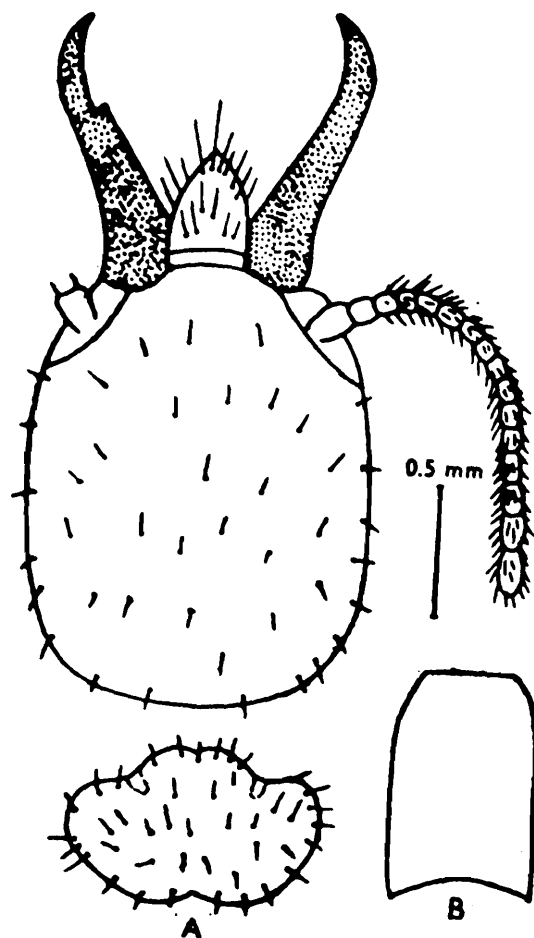
ap apical tooth; *m1-m3*, marginal teeth 1-3 respectively.

Soldier (1 ex. Bar, Ajmer Dist.)

1. Total length with mandibles	5.3
2. Head-length with mandibles	2.84
3. Head-length to mandible-base	1.68
4. Max. width of head	1.42
5. Labrum (Median L × W)	0.42 × 0.37
6. Length of mandibles (left; right)	1.16; 1.16
7. Distance of tooth from apex, in left mandible	0.47
8. Postmentum (Median L × W)	0.89 × 0.58
9. Pronotum (L × W)	0.63 × 1.05
10. No. of antennal segments	16

Distribution.—Widespread in India from central Rajasthan (Bar, Ajmer Dist.), Gujarat and Delhi in the west to Orissa in the east; and the whole of Peninsular India.

Remarks.—This is the first record from Rajasthan. Swarming was noted at Bar (Ajmer Dist.) on 9 August.



Text-fig. 20. *Odontotermes wallonensis* (Wasmann). Soldier. Forest plantation, ca. 3 km. E of Bar village (Ajmer Dist., Rajasthan). (A) Head and pronotum, dorsal view. (B) Postmentum, *in situ*.

26.- *Microtermes mycophagus* (Desneux) 1906

Termes mycophagus Desneux, 1906, p. 348.

Castes known.—Im., S., Wk.

Material.—27 vials, 1972-73, Im., S., Wk., from following districts in Rajasthan : Jaipur (Sambhar Lake), Nagaur (Didwana); and Jodhpur (mostly imagoes from swarms) and Sikar (Palsana).

Distribution.—India (western and northern Rajasthan, east to Sikar and Alwar Dists.; and Delhi); and Pakistan (Sind, Punjab, N.W.F.P., Baluchistan).

Remarks.—Common in arid and semi-arid areas. Swarming occurred at Jodhpur from 26 June to 22 August at night (8 to 9 P.M.). It is an arid zone species (for its distribution in Rajasthan in relation to soil and vegetation, *vide* Roonwal and Bose, 1973).

27. *Microtermes obesi* Holmgren 1913

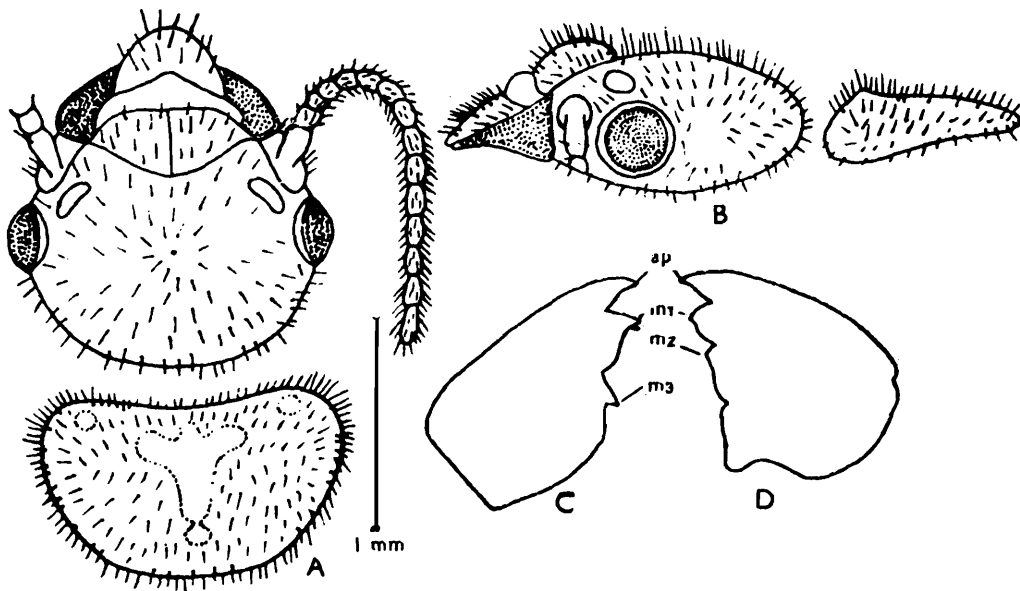
(Text-fig. 21)

(Synonym : *M. anandi* Holmgren)

Microtermes obesi Holmgren, 1913, *K. Svensk. Vetensk. Akad. Handl.*, Stockholm, 50 (2), p. 150. Im.

Microtermes anandi Holmg., Roonwal & Bose, 1964, p. 39.

Castes known.—Im., S., Wk.



Text-fig. 21. *Microtermes obesi* Holmgren (synonym *M. anandi* (Holmgren)). Imago, Jodhpur. (Rajasthan). (A) Head and pronotum, dorsal view. (B) Ditto, side view. (C), (D) Left and right mandibles, respectively.

ap., apical teeth; *m1-m3*, marginal teeth 1-3 respectively.

Material.—12 vials, 1965-72, Im., S., Wk., from the following districts in Rajasthan : Jodhpur, Nagaur, Jaipur and Udaipur.

*Measurements (mm.), etc.**Imagoes (4 exs., Jodhpur)*

1. Total length with wings	14.1—14.8
2. Total length without wings	9.4—10.2
3. Head-length to mandible-base	1.53—1.83
4. Max. width of head with eyes	1.58—1.79
5. Labrum (Median L × W)	0.26—0.39 × 0.68
6. Eyes (max. × min. diameter)	0.38—0.39 × 0.31—0.33
7. Min. eye-ocellus distance	0.05
8. Pronotum (L × W)	0.95—1.05 × 1.37—1.58
9. No. of antennal segments	15

For measurements of soldiers, *vide* Roonwal and Bose (1964).

Distribution.—Widespread in India (including Rajasthan), Pakistan and Bangla Desh; also reported from Sri Lanka.

Remarks.—The present records from the Rajasthan districts of Nagaur and Udaipur are new. The species seems to occur in both dry and wet areas. Swarming occurred at Jodhpur from 14 June to 17 August during the day (about 11 A.M. to 1.30 P.M.). For further details of swarming, post-swarming behaviour, egg-laying and hatching, *vide* Roonwal and Rathore (in press, *b*).

28. *Microtermes unicolor* Snyder

(Text-fig. 22)

Microtermes unicolor Snyder, 1933, *Proc. biol. Soc. Wash.*, Washington, 46, pp. 92-93. Im.

Microtermes pubescens Snyder, 1933, *Proc. U. S. natnl. Mus.*, Washington, 82 (Art. 16), p. 9. S.

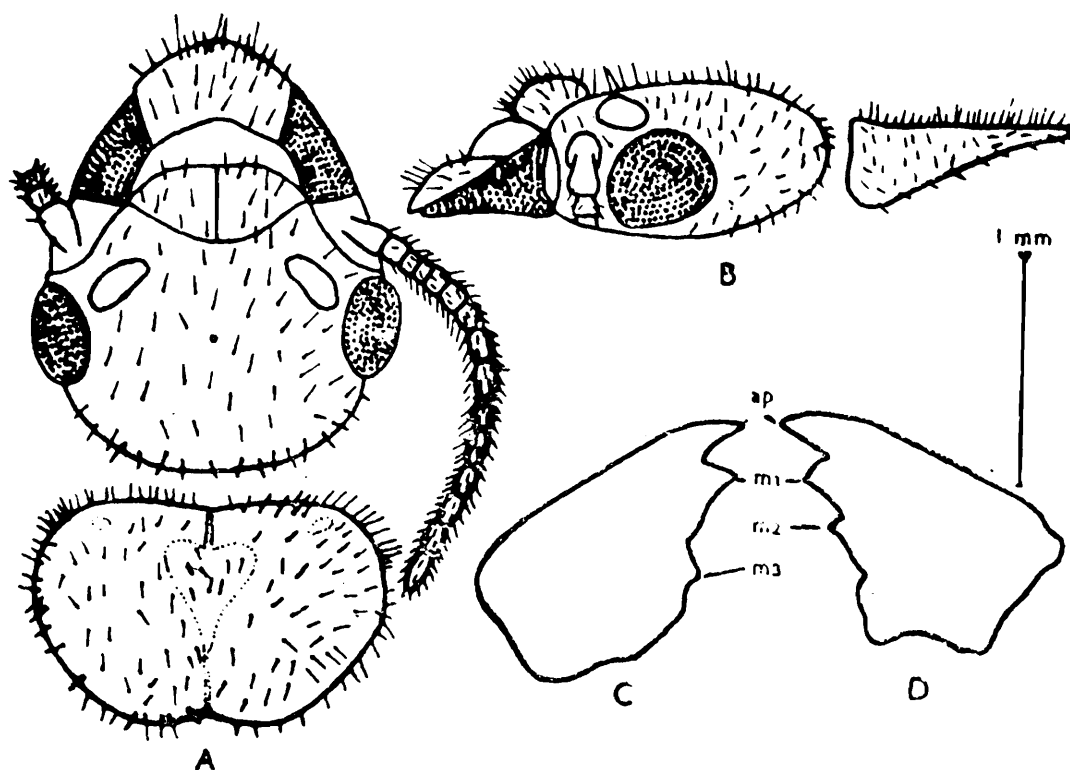
Castes known.—Im. (Rajasthan), S. and Wk. (Uttar Pradesh).

Material.—3 vials, Im., 1965-72, Jodhpur Dist. (Mandore, Banar, Jodhpur).

*Measurements (mm.), etc.**Imagoes (5 exs., Jodhpur Dist.)*

1. Total length with wings	17.3—18.7
2. Total length without wings	9.4—10.8
3. Head-length to tip of labrum	1.63—1.84
4. Head-length of mandible-base	1.05—1.16
5. Max. width of head with eyes	1.58—1.68
6. Max. height of head	0.58—0.68
7. Labrum (Median L × W)	0.26 × 0.42—0.53
8. Eyes (L × W)	0.41—0.47 × 0.36—0.42
9. Lateral ocelli (L × W)	0.18—0.23 × 0.14—0.18
10. Min. eye-antennae distance	0.045—0.063
11. Pronotum (L × W)	0.84—0.95 × 1.42—1.53
12. No. of antennal segments	15

Distribution.—Pakistan (Punjab, N.W.F.P., Sind), western and north-western India, e.g., Rajasthan (Jodhpur Dist.) and Uttar Pradesh (Dehra Dun); and Bangla Desh.



Text-fig. 22. *Microtermes unicolor* Snyder. Imago. Jodhpur (Rajasthan). (A) Head and pronotum, dorsal view. (B) Ditto, side view. (C), (D) Left and right mandibles respectively.

ap., apical teeth; *m1-m3*, marginal teeth 1-3 respectively.

Remarks.—This is the first record from Rajasthan. Swarming occurred at Jodhpur and vicinity during 5 July to 20 August at night (about 8.45 P.M.). (Also *vide* Roonwal and Rathore, *in press, b*, for further observations on swarming.)

Subfamily (iv) NASUTITERMITINAE

29. *Trinervitermes biformis* (Wasmann)

[Synonyms : *T heimi* (Wasmann) and *T longinotus* (Synder)]

1902. *Eutermes biformis* Wasmann, *Zool. Jb. (Syst.)*, Jena, 17 (1), p. 133. Im., S., Wk.

Castes known.—Im., S. (dimorphic), Wk.

Material.—7 vials, 1964-73, S., Wk., from the following districts of Rajasthan : Ajmer, Bhilwara, Jodhpur, Pali and Udaipur.

Distribution.—Widely distributed in western and southern India (Rajasthan, Madhya Pradesh, Maharashtra, Karnatak and Tamil Nadu); and Sri Lanka; also Pakistan (Punjab).

Remarks.—Roonwal and Bose (1964) had first recorded it from Rajasthan (districts of Jaipur, Kota, Nagaur and Udaipur); the present are new records from the districts of Ajmer, Bhilwara, Jodhpur and Pali, thus considerably extending its range, especially to the western, semi-arid areas of Jodhpur and Nagaur.

ZOOGEOGRAPHY AND ECOLOGY

1. *General*

Rajasthan, the westernmost State of India, lies close to, almost adjoining, the traditional eastern border of the Western Palaearctic Zone whose eastern limit is the River Indus, so that it is not surprising that the area is, like Pakistan east of the Indus, in some respects transitional and not sharply defined. This is specially so for the Vertebrates (*vide infra*, Discussion), but is less marked for other groups of animals. In the Isoptera, for example, only a small part shows Palaearctic facies, the bulk being Oriental but of Ethiopian origin).

Sclater's (1855) zoogeographical divisions based on birds, amplified further on the basis of other major groups of animals, are accepted today virtually without substantial change (*vide* Beaufort, 1951, for the world; and Roonwal and Ali, 1965, for the Indian fauna). These regions, which have also been widely adopted by termitologists for faunistic and zoogeographical purposes (Snyder, 1949; Emerson, 1955), are as follows: Nearctic, Neotropical, Palaearctic, Ethiopian, Malagasy, Oriental (Indo-Malayan of some authors), Australian and Papuan.

2. *Generic and Specific Analyses*

(Table 2)

For the zoogeographical status of the genera, the earlier analysis of Emerson (1955) and the general evolutionary trends of the order Isoptera as summarised by Weidner (1966, 1970) have been of considerable help.

For generic endemism, Emerson's (1955) definition is : "*Endemic genera* are those genera found only in a single major zoogeographical region." For the present purpose "endemism" has been evaluated only in terms of Rajasthan which is a vast enough extent of landmass (3,42,274 sq. km.) to justify a more restricted approach. In this limited sense, no genus is endemic in Rajasthan, but a few species are.

Family KALOTERMITIDAE

1. Genus *Incisitermes* Krishna

This is a widespread genus with some 25 species occurring in the Papuan region (Fiji, Hawaii, etc.), Asia (the Philippines, India), North

TABLE 2.—Zoogeographical distribution of the termite species of Rajasthan (Western India).

Abbreviations: + Present;— absent; Eth., Ethiopian; Nt., Neotropical; Or., Oriental; Pal., Palaearctic.

Species	INDIA					Pakistan	Rest of Oriental Region	Afghanistan	Rest of West Asia (upto Mediterranean)	Else-where	Zoogeographical status	Endemism	Origins
	Rajasthan only	Rest of India	North India down to lat. 20°N	Peninsular India below lat. 20°N									
FAMILY I. KALOTERMITIDAE													
1. <i>Incisitermes didwanaensis</i> Roonwal & Verma	+	—	—	—	—	—	—	—	—	—	Or.	+	?
FAMILY II. HODOTERMITIDAE													
2. <i>Anacanthotermes macrocephalus</i> (Desneux)	+	—	—	—	+	—	+	—	—	—	Pal.	—	Pal.
Family III. RHINOTERMITIDAE													
Subfamily (i)													
PSAMMOTERMITINAE													
3. <i>Psammotermes rajasthanicus</i> (Roonwal and Bose)	+	—	—	—	+	—	—	—	—	—	Or.	—	Eth.
Subfamily (ii)													
HETEROTERMITINAE													
4. <i>Heterotermes indicola</i> (Wasmann)	—	+	+	—	+	+	+	—	—	—	Or.	—	?
Subfamily (iii)													
COPTOTERMITINAE													
5. <i>Coptotermes heimi</i> (Wasmann)	—	+	+	+	+	+	—	—	—	—	Or.	—	Or.
Family IV. TERMITIDAE													
Subfamily (i)													
AMITERMITINAE													

Table 2 — Cond.

6. <i>Speculitermes cyclops</i> Wasmann	—	+	+	+	+	—	—	—	—	Or.	—	Nt. (distantly)
7. <i>Amitermes belli</i> (Desneux)	+	—	—	—	+	—	—	—	—	Or.	—	?
8. <i>Synhamitermes quadriceps</i> (Wasmann)	—	+	+	+	—	+	—	—	—	Or.	—	Or.
						(Bangla Desh)						
9. <i>Eremoterme neoparadoxalis</i>	—	+	+	—	+	—	—	—	—	Or.	—	Or.
10. <i>Eremoterme paradoxalis</i> Holmgren	—	+	+	+	+	+	—	—	—	Or.	—	Or.
11. <i>Microceroterme laxmi</i> Roonwal & Bose	+	—	—	—	—	—	—	—	—	Or.	+	Eth.
12. <i>Microceroterme palestinensis</i> Spaeth	+	—	—	—	—	—	—	+	—	Or.	—	Eth.
								Israel				
13. <i>Microceroterme raja</i> Roonwal & Eose	+	—	—	—	—	—	—	—	—	Or.	+	Eth.
14. <i>Microceroterme sakesarensis</i> Ahmad	+	—	—	—	+	—	—	—	—	Or.	—	Eth.
15. <i>Microceroterme tenuignathus</i> Holmgren	—	+	+	—	+	—	—	—	—	Or.	—	Eth.
												(Rajasthan, Gujarat)
Subfamily (ii) TERMITINAE												
16. <i>Anguliterme jodhpurensis</i> Roonwal & Verma	+	—	—	—	—	—	—	—	—	Or.	+	Or.
Subfamily (iii) MACROTERMITINAE												
17. <i>Odontoterme brunneus</i> (Hagen)	—	+	+	+	—	+	—	—	—	Or.	—	Eth.
						(Sri Lanka)						
18. <i>O. dehraduni</i> (Snyder)	—	+	+	—	+	—	—	—	—	Or.	—	Eth.
19. <i>Odontoterme distans</i> Holmgren & Holmgren	—	+	+	+	—	—	—	—	—	Or.	—	Eth.

Table 2 — Cond.

20. <i>Odontotermes feae</i> (Wasmann)	—	+	+	+	—	+	—	—	—	Or.	—	Eth.
21. <i>Odontotermes giriensis</i> Roonwal & Chhotani	—	+	+	—	—	+	—	—	—	Or.	—	Eth.
						(Bangla Desh)						
22. <i>Odontotermes guptai</i> Roonwal & Bose	+	—	—	—	—	—	—	—	—	Or.	+	Eth.
23. <i>Odontotermes gurdaspurensis</i> (Holmgren & Holmgren)	—	+	+	—	+	—	—	—	—	Or.	—	Eth.
24. <i>Odontotermes kushwahi</i> Roonwal & Bose	—	+	+	+	—	—	—	—	—	Or.	—	Eth.
25. <i>Odontotermes latiguloides</i> Roonwal & Verma	+	—	—	—	—	—	—	—	—	Or.	+	Eth.
26. <i>Odontotermes obesus</i> (Rambur)	—	+	+	+	+	+	—	—	—	Or.	—	Eth.
27. <i>Odontotermes parvidens</i> Holmgren & Holmgren	—	+	+	+	+	+	—	—	—	Or.	—	Eth.
						(Bangla Desh)						
28. <i>Odontotermes wallonensis</i> (Wasmann)	—	+	+	+	—	—	—	—	—	Or.	—	Eth.
29. <i>Microtermes mycophagus</i> (Desneux)	—	+	+	—	+	—	—	—	—	Or.	—	Eth.
30. <i>Microtermes unicolor</i> Snyder	—	+	+	—	+	+	—	—	—	Or.	—	Eth.
						(Bangla Desh)						
31. <i>Microtermes obesi</i> Holmgren	—	+	+	+	+	+	—	—	—	Or.	—	Eth.
						(Bangla Desh, Sri Lanka)						
Subfamily (iv) NASUTITERMITINAE												
32. <i>Trinervitermes biformis</i> (Wasmann)	—	+	+	+	+	+	—	—	—	Or.	—	Eth.
[syn. <i>T. heimi</i> (Wasmann)]						(Sri Lanka)						

America, Mexico, Central and South America and the West Indies. Three species are found in the Oriental region, viz., two in the Philippines (*mcgregori* Light and *taylori* Light) and one in Rajasthan, India (*didwanaensis* Roonwal & Verma). The origin of the genus is difficult to establish. Almost half the number of known species are from the Neotropical region (southern U.S.A., Mexico, Central America and the West Indies), and it is probable that the genus originated there (*vide* also Krishna, 1961, p. 387). Thence it may have spread to Oceania (the Papuan region) and the Orient in the early Mesozoic age before the continents drifted apart in the sense of Wegener (1922), but the route is by no means clear. If the eastward migrations occurred through North Africa, the genus is to-day absent, there, possibly by extinction. *I. didwanaensis* might represent a remnant on the route farther east, leading to the Philippines and the islands of the Papuan region. If this line of argument is correct, *I. didwanaensis*, while being restricted to Rajasthan and thus endemic and Oriental, must be regarded against the background of the probable distant Neotropical origin of the genus.

Family HODOTERMITIDAE

2. Genus *Anacanthotermes* Jacobson

This is a small subtropical genus of large harvester or grass-cutting desert termites, with some 10 species which occur from West and Central Asia to Western India (Rajasthan east up to Jodhpur), with one species, *A. viarum* (König), going down to the drier regions of South India.

According to Emerson (1955, p. 482), the genus probably arose "in the Southern Palaeartic steppes and deserts and dispersed eastwards to tropical Indomalaya." This event must have occurred early enough (Miocene or Pliocene) to allow time for the genus to reach South India and evolve a second species.

The sole Rajasthan species, *A. macrocephalus* (Desneux), occurs from Eastern Afghanistan *via* Pakistan (Baluchistan, Sind, Punjab) to Western India (western Rajasthan : Districts of Bikaner, Barmer and Jodhpur, its easternmost limit being Jodhpur and vicinity, i.e., up to the eastern edge of the Indian Desert). Like most other members of the genus, *A. macrocephalus* should be regarded as a Palaeartic species derived from its other Palaeartic fellow species, though Harris (1970) excludes it from his Palaeartic list.

Ecologically, *A. macrocephalus*, though an arid zone species (*cf.* *Psammotermes*, below), occurs in soils which have a little clay or loam or gravel and on which some natural vegetation can subsist in the presence of irrigation or natural water and where the land is capable of being cultivated.

Family RHINOTERMITIDAE

Subfamily (i) PSAMMOTERMITINAE

3. Genus *Psammotermes* Desneux

This is a small genus of arid zone or sand termites occurring from North Africa across West Asia to Western India, including the drier western parts of the Indian Desert. Its 8 known species largely occur in the Ethiopian region, with one species going north to the fringe of North African temperate desert (Mediterranean belt of the Palaearctic) and one to the dry steppe zone in Madagascar. Thus, the genus is essentially Ethiopian and desertic, and Emerson (1955, pp. 483, 484) had concluded that this situation "indicates a dispersion from Africa at least by Eocene times."

The single Rajasthan species, *P. rajasthanicus* Roonwal & Bose, is essentially a desertic and sand species, occurring in Western Rajasthan (Barmer, Jaisalmer and Bikaner districts) and the adjoining parts of Pakistan (Sind, coastal Baluchistan, Punjab). Its soldiers are trimorphic.

It is Oriental in distribution but is not endemic to Rajasthan. Essentially, it is an extension of the Ethiopian element, as already suggested by Roonwal and Bose (1960, 1962, 1964) and Roonwal, Chhotani and Bose (1962), into the Palaearctic-Oriental border area. West of it is found *P. hybostoma* Desneux, from Southern Arabia (Muscat) to the Sahara in North Africa (Desneux, 1904, p. 25).

Subfamily (ii) HETEROTERMITINAE

4. Genus *Heterotermes* Froggatt

This genus, with numerous species, is cosmopolitan, occurring throughout the tropical and subtropical termite belt, and its species, are present in the Nearctic, Neotropical, Ethiopian (poor), Oriental and Australian regions. Its phylogenetic and geographical origins are not clear. It is a rather primitive genus among the Rhinotermitidae, and is, according to Emerson (1955, pp. 483, 499), "presumed to have arisen in the tropics before the Cretaceous separation of Australia from Indomalaya"; but its exclusion from the greater portion of the Ethiopian region is puzzling, and odd representatives there, and elsewhere, are probably later introductions.

The sole Rajasthan species, *H. indicola* (Wasmann), is widespread (Afghanistan, Pakistan, North India and Bangla Desh.) It is not endemic to Rajasthan but is broadly Oriental and belongs to the group of four oriental species which occur in the Indian Subregion, viz., *ceylonicus* Holmgren (Sri Lanka); *gretrúdae* Roonwal (the western sub-Himalayas), *indicola* (Wasmann) (*supra*) and *malabaricus* Snyder (South India).

Subfamily (iii) COPTOTERMITINAE

5. Genus *Coptotermes* Wasmann

Like *Heterotermes*, this genus too is widespread. Some 54 living species are known and are distributed in the Papuan, Australian, Oriental, Ethiopian and Neotropical regions, and introduced in some others. About half the number of known species are Oriental, and that region is generally regarded as its place of origin, from which it has spread elsewhere (Emerson, 1955, p. 484).

Of the 24 Oriental species, 8 are found in the Indian Sub-region (Roonwal and Chhotani, 1962 *b*). The sole species occurring in Rajasthan viz., *C. heimi* (Wasmann) (synonym *C. parvulus* Holmgren) is widespread in Pakistan, India and Bangla Desh and should be regarded as broadly Oriental.

Family TERMITIDAE

Subfamily (i) AMITERMITINAE

6. Genus *Speculitermes* Wasmann

This genus, which is characterised among other things by the extreme rarity of the soldier caste (formerly believed to be altogether absent), is closely allied to the mainly Neotropical *Anoplotermes* (a soldierless genus) with which it forms a close complex. *Speculitermes* occurs in South America (4 species) and the Oriental region (10 species) and may, on the basis of the richness of the species, be regarded as Oriental, though the *Anoplotermes-Speculitermes* Complex as a whole probably arose in the Neotropics, and thence got dispersed in the early Mesozoic, or somewhat later, to the Orient before the three southern continents drifted apart in Wegener's (1922) sense (as already suggested by Roonwal, Chhotani and Bose, 1962; and Roonwal and Chhotani, 1966), though its absence in Africa remains a puzzle.

S. cyclops cyclops Wasmann occurs in the whole of India (except Assam where *S. c. rongrensis* Roonwal & Chhotani is found) and Pakistan (submontaneous parts of the Punjab). Its Burmese records need confirmation. It is Oriental and is restricted to the Indian Sub-region; it is not endemic to Rajasthan. Ecologically it occurs in moderately moist forests, with or without gravelly or stony soil, and where there is some decaying vegetable matter on which it feeds; it avoids open, arid areas.

7. Genus *Amitermes* Silvestri

This large genus, with some 115 species, is widespread, occurring in the following regions : Australian (56), Oriental (6), Ethiopian (32), Palearctic (6), Nearctic (8) and Neotropical (7). Its two principal

centres, viz., Australia and Tropical Africa, are wide apart, and the intervening Oriental Region is poor. Emerson (1955, p. 472) considered it "mainly tropical", but he was not then aware of the exceptional richness of the Australian fauna (*vide* Gay, 1968).

The origin of *Amitermes* is not clear. Its primitive relatives are Oriental, and this feature, viewed in conjunction with its present areas of abundance, would suggest an Oriental-Australian origin on the one hand and an almost equally feasible Oriental-Ethiopian origin on the other.

Ecologically, the genus seems to be versatile, equally at home in tropical forests and more open habitats and even in hot deserts. This feature is well illustrated by the six Oriental species half of which occur in tropical forests (Malaya, Thailand, Sumatra) and the other half in deserts (Pakistan and western Rajasthan). The sole Rajasthan species, *A. belli* (Desneux), occurs in both arid and wet habitats in Rajasthan and adjoining Pakistan. Zoogeographically, it is Oriental but not endemic to Rajasthan.

8. Genus *Synhamitermes* Holmgren

This small, fairly advanced amitermitine genus contains only four species and has a discontinuous distribution—in the Neotropics (South America, one species) and the Orient (India, Bangla Desh and Sri Lanka, 3 species), a discontinuity which can best be explained, as in so many other cases, on the basis of Wegener's (1922) Continental Drift Theory. The genus probably arose in the Oriental region where it is best represented today. The sole Rajasthan species, *S. quadriceps* (Wasmann), is widespread in India (Maharashtra, Rajasthan and Bangla Desh), and is found in moist forested areas. It is Oriental but not endemic to Rajasthan.

9. Genus *Eremotermes* Silvestri

This small genus, with only 10 species, occurs from North and Central Africa *via* West Asia to Pakistan and India. The zoogeographical distribution is : Palaearctic 3, Ethiopian 1, and Oriental (Pakistan and India) 6. It is a genus of small, whitish desert termites which live a subterranean life in small colonies. It probably arose in the Oriental region where its greatest concentration lies, and thence migrated west to Africa. The two Rajasthan species are distributed as follows:—

(i) *E. neoparadoxalis* Ahmad : Pakistan (Sind, Baluchistan, N.W.F.P.) and Western India (western Rajasthan and Delhi). It is a dry and semi-dry zone species.

(ii) *E. paradoxalis* Holmgren : Widely distributed in India (Western India, e.g., Rajasthan including both dry and moist districts east up

to Kota; Delhi; east up to Bihar; Madhya Pradesh; and Peninsular India down to Kerala); and Pakistan (Sind, Punjab, N.W.F.P.). It is ecologically more versatile and is found both in arid, desertic areas as well as in the more moist forest belts.

Both species are Oriental, but not endemic to Rajasthan.

10. Genus *Microcerotermes* Silvestri

This large genus, with some 117 species, is widespread, occurring in all the major zoogeographical regions except the Neotropical, but the majority of the species (73%) are concentrated almost equally in the Oriental and the Ethiopian regions. The distribution is briefly as follows : Papuan (5 species), Australian (11), Oriental (40), Ethiopian (45), Malagasy (5), Palaearctic (6), and Neotropical (5). The genus probably originated in tropical Africa in the Mesozoic period before it separated from South Asia by Continental Drift, and thence spread to other areas, both moist and dry, and today an appreciable number of species are found in both arid and semi-arid areas too.

The five Rajasthan species have the following distribution; ecologically, they occur largely in arid and semi-arid areas, but some also in moist zones:—

(i) *M. laxmi* Roonwal & Bose : Western India (Bikaner District, Rajasthan). (ii) *M. palestinensis* Spaeth : Western India (Rajasthan : Jodhpur and Udaipur districts) and West Asia (Israel). (iii) *M. raja* Roonwal & Bose : Western India (Rajasthan : Jaipur District) and Pakistan (Punjab, N.W.F.P.). (iv) *M. sakesarensis* Ahmad : Western India (Rajasthan : Jaipur District) and Pakistan (Punjab, N.W.F.P.). (v) *M. tenuignathus* Holmgren : Western India (Gujarat and Rajasthan) in both semi-dry and moist areas) and Pakistan (all over).

Thus, all the five are Oriental and only two of them, *M. laxmi* and *M. raja*, are endemic to Rajasthan.

Subfamily (ii) TERMITINAE

11. Genus *Angulitermes* Sjöstedt

This small genus, formerly regarded as mainly Ethiopian, has now been found to be abundant in the Orient, especially in the Indian Sub-region, and the zoogeographical distribution of its 20 known species is as follows:— Ethiopian 5; Palaearctic (Israel) 1 and Oriental (Pakistan, India, Bangla Desh, Burma) 14. According to Emerson (1955, pp. 480, 485), the subfamily Termitinae, where *Angulitermes* belongs, probably arose in the Ethiopian region (where it is best represented) in the early Mesozoic period, before the Cretaceous, and thence spread elsewhere. *Angulitermes*, however, is a medium-specialised

genus, and is much better represented in the Oriental than in the Ethiopian region, and its origin in the Oriental region is more feasible. Ecologically, the genus is wholly subterranean, occurring in dry as well as moist areas.

The sole Rajasthan species, *A. jodhpurensis* Roonwal & Verma, has hitherto been found only in Jodhpur, situated on the eastern fringe of the Indian Desert. It is Oriental, and is endemic to Rajasthan.

Subfamily (iii) MACROTERMITINAE

12. Genus *Odontotermes* Holmgren

This is a large and specialised genus, with some 169 species, confined to the Ethiopian (90 species) and the Oriental (79) regions, one of the latter ones also extending to the Papuan. Its members cultivate fungi and several of them build conspicuous earthen mounds. Ecologically, the genus is versatile and its representatives occur in both tropical rain forests as well in open grasslands and even semi-deserts; in very arid areas, e.g., western Rajasthan, the mound-building species do not as a rule construct mounds.

According to Emerson (1955, p. 486), "the fungus-growing termites or Macrotermitinae are clearly of Ethiopian origin from some extinct group that shared the primitive characters of both the Macrotermitinae and the Nasutitermitinae and was itself probably derived from the primitive Amitermitinae. All ten genera of the Macrotermitinae are Ethiopian."

Odontotermes, the majority of whose species are Ethiopian, may thus well be regarded as having originated in tropical Africa, and thence spread to the Orient relatively late (Micoene or Pliocene?) through some ecologically suitable corridor. At present the Oriental species occur throughout South and South-east Asia from Pakistan *via* India, Nepal and Bangla Desh to South China, Indonesia and the Philippines.

The 12 Rajasthan species are distributed as follows:—

- (i) *O. brunneus* (Hagen) : Widely distributed in India and Sri Lanka.
- (ii) *O. dehraudni* (Snyder) : North India (Uttar Pradesh, Delhi, Rajasthan) and Pakistan.
- (iii) *O. distans* Holmgren & Holmgren : Widely distributed all over India.
- (iv) *O. feae* (Wasmann) : Widely distributed in India and further east: (Nepal, Bangla Desh, Burma, Thailand).
- (v) *O. giriensis* Roonwal & Chhotani : India (western part, e.g., Rajasthan; and eastern part, e.g., Meghalaya and Arunachal Pradesh); and Bangla Desh.
- (vi) *O. guptai* Roonwal & Bose : Rajasthan, in both dry and moist districts. Endemic to Rajasthan.
- (vii) *O. gurdas-*

purensis Holmgren & Holmgren : North India (Rajasthan, Haryana, Punjab, Kashmir); and Pakistan. (viii) *O. kushwahi* Roonwal & Bose : India (western part, e.g., Rajasthan and Gujarat; and southern part, e.g., Tamil Nadu. (ix) *O. latiguloides* Roonwal & Verma : Rajasthan (absent in very dry western desert; occurs elsewhere). Endemic to Rajasthan. (x) *O. obesus* (Rambur) : Widespread in Pakistan, India and Bangla Desh. (xi) *O. parvidens* Holmgren & Holmgren : Widespread in South Asia (Pakistan, India, Bangla Desh, Burma). (xii) *O. wallonensis* (Wasmann) : Widespread in India. All these 12 species are Oriental and only two of them, *O. guptai* and *O. latiguloides*, are endemic to Rajasthan.

13. Genus *Microtermes* Wasmann

This genus contains some 58 species which are confined to the Ethiopian (40 species), Malagasy (5) and Oriental (13) regions. Its representatives share many of the ecological characteristics of *Odontotermes* and often live in the mounds of, or in close association with, the latter; and they also grow fungi. Like *Odontotermes*, this specialised genus also probably had an Ethiopian origin and thence spread to India rather late (Miocene of Pliocene ?) through some ecologically suitable corridor.

The three Rajasthan species are distributed as follows:—

(i) *M. mycophagus* (Desneux) : Western India (Rajasthan and Delhi); and Pakistan. (ii) *M. obesi* Holmgren : South Asia (Pakistan, all India, Bangla Desh, Sri Lanka). (iii) *M. unicolor* Snyder : Pakistan, western and north-western India (Rajasthan and Uttar Pradesh); and Bangla Desh. All the three species are Oriental, and none is endemic to Rajasthan.

Subfamily (iv) NASUTITERMITINAE

14. Genus *Trinervitermes* Holmgren

This medium-sized genus with nasute soldiers, which are often dimorphic or even trimorphic, is mainly Ethiopian and contains some 63 species as follows:— 56 Ethiopian, 1 Palearctic (Arabia), and 6 Oriental. As suggested by Emerson (1955, p. 481), it probably arose in the "Ethiopian region when a tropical savanna was established in the Miocene..." and "invaded India from Africa in the Miocene, or more probably, in the Pliocene, through a tropical savanna or steppe corridor." The sole Rajasthan species, *T. biformis* (Wasmann), is widespread in India (western and Peninsular India) and also occurs in Pakistan and Sri Lanka. It is Oriental, but not endemic to Rajasthan.

4. Discussion

(a) Zoogeographical composition :

From the analyses given above (also Table 2), it will be seen that the 32 Rajasthan termites are composed of two zoogeographical elements,

viz., an overwhelmingly Oriental element (31 species, or 97%) alone with a tiny Palaearctic one (one species, or 3 %) The following six species (19%) are endemic:—

KALOTERMITIDAE :

Incisitermes didwanaensis

TERMITIDAE :

AMITERMITINAE : *Microcerotermes laxmi* and *M. raja*.

TERMITINAE : *Angulitermes jodhpurensis*.

MACROTERTITINAE : *Odontotermes guptai* and *O. latiguloides*.

The phylogenetic distribution of the 32 species is as follows:—

KALOTERMITIDAE	1 species, or 3.1 %
HODOTERMITIDAE	1 species, or 3.1 %
RHINOTERMITIDAE	3 species, or 9.4 %
PSAMMOTERMITINAE	1 species, or 3.1 %
HETEROTERMITINAE	1 species, or 3.1 %
COPTOTERMITINAE	1 species, or 3.1 %
TERMITIDAE	27 species, or 84.4 %
AMITERMITINAE	10 species, or 31.3 %
TERMITINAE	1 species, or 3.1 %
MACROTERTITINAE	15 species, or 46.9 %
NASUTITERMITINAE	1 species, or 3.1 %

The primitive families (the first three) are poorly represented (15.6%), the higher one, the Termitidae, constituting the remaining 84.4 %. Among the Termitidae itself, the more primitive subfamilies, the Amitermitinae and the Termitinae, constitute 34.4 %, and the other two 50 %. This distribution would suggest that the bulk of the fauna is probably of more recent origin (Miocene or Pliocene ?), and since these subfamilies are probably of Ethiopian origin, this part is probably an immigrant from Africa relatively late.

Among the primitive families, a single species, *I. didwanaensis*, is endemic, the remaining five endemics being from the higher groups.
(b) *Origins* (Tables 2 and 3)

It will be seen from the above analyses that the Rajasthan termite fauna (which is today overwhelmingly Oriental in its facies) is, *in origin* largely Ethiopian (68 %), and to a much lesser extent Oriental (15.6 %); it has tiny fractions which are Palaearctic (1 species, *Anacanthotermes macrocephalus*) and distantly Neotropical* (1 species, *Speculitermes cyclops*), and a small proportion (9.4 %) of doubtful origin (Table 3).

* In distant origin (the *Anoplotermes-Speculitermes* complex).

TABLE 3.—Summary of zoogeographical origins of the Rajasthan termite fauna.

Present-day status (and number of species)	Origins	
	Number of species	Percentage
Palaeartic : 1	Palaeartic : 1	3.1 %
Oriental : 31	Ethiopian : 22	68.8 %
	Oriental : 5	15.6 %
	Neotropical : 1	3.1 %
	Doubtful : 3	9.4 %

The present-day geographical situations of termite genera and species depend upon numerous factors of origin operating through long geological periods—such as land configurations (emergences and submergences), climates, ecological changes, adaptations, migrations, rates of evolution, etc. For Rajasthan termites we have material to discuss only some of these factors, especially migrations (dispersals), local evolution (endemism) and ecological adaptations.

(c) *Paucity of geological evidence*

The origin of termites from blattoid type ancestors is widely accepted on the basis of morphological similarities in blattids and primitive termites (such as the Mastotermitidae) and the degenerative reduction in the imagoes and workers of the higher termites of such primitive characters as the anal lobe of the hindwing, the number of antennal segments, the Y-suture of the head, the two lateral ocelli, the styli, the external genitalia, etc.; and on the development of social organisation.

Fossil evidence from geological history is not helpful since the earliest known termites are from periods as late as the early Tertiary or the late Cretaceous and such fossils are indistinguishable from modern isopteran genera (Imms, 1937; Weidner, 1966, 1970). The Problattodea (long extinct), which are regarded as the distant ancestors of both the Blattodea and the Isoptera, arose in the late Carboniferous or early Devonian.

A portion of western Rajasthan was, in pre-Mesozoic times (from the Permian onward) under the sea which withdrew by the Pliocene so that some termites might have invaded the dried up land in more recent times. No termite fossils have been found in Rajasthan, and geological evidence thus provides little guidance in zoogeographical matters. It may be presumed (*vide* Roonwal, Chhotani and Bose, 1962) that the primitive elements which were evolved earlier (e.g., *Anoplotermes-Speculitermes* complex), came from South America before the southern continents separated from one another in terms of the Continental Drift Theory of Wegener (1922). Those higher ones (Termitidae) which came from Africa, and were evolved later, probably also came

later (Miocene or Pliocene?) through some ecologically suitable corridor between Africa and South Asia; that was also the time when the sea receded from western Rajasthan.

(d) *Ecological considerations and migrations*

The present-day ecological characteristic of Rajasthan—its desiccation—is a recent feature, less than 10,000 years old. Before that event the land was well forested and verdant and presumably sustained a richer, more varied and a more tropical fauna than today. Dessication probably resulted in (i) the early elimination of the inadapted species; and (ii) the intrusion, mainly from the western desertic and savanna regions on the west, e.g., Iran, West Asia and even the Sahara, of such arid zone species, or allies, as *Eremitermes neoparadoxalis*, *Microcerotermes palestinensis*, *M. sakesarensis* and *M. tenuignathus*. This was a second series of intrusions, the first ones having occurred in geological times mainly from Africa (for the Ethiopian elements) and from South India-Malaya area (for the Oriental elements). The sole Palaearctic element, *Anacanthotermes*, probably came from the Iran-Central Asia region quite early (Miocene or Pliocene?) so as to allow it enough time to reach South India where it has evolved into a second species, *A. viarum*; the other species stopped short at the eastern border of the Indian Desert.

(e) *Endemism* (Table 4)

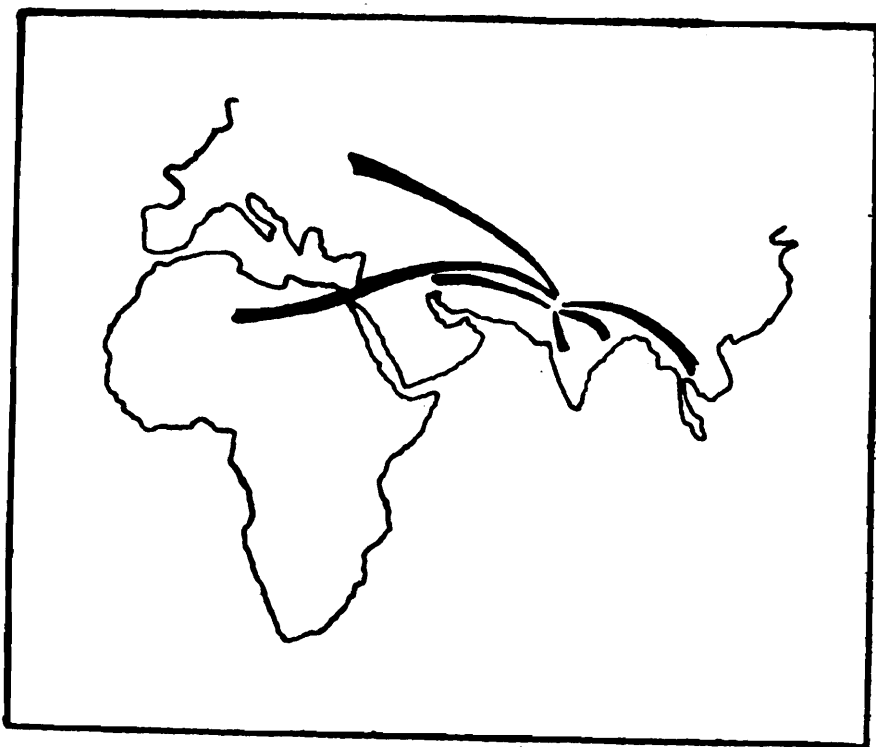
Six endemic species are presumed to have evolved locally. None of the genera concerned is endemic—some have an Ethiopian origin (*Microcerotermes*, *Odontotermes*), one an Oriental origin (*Angulitermes*), while for the primitive genus *Incisitermes* the origin is uncertain. Termite endemism in Rajasthan, a dry area, is only 19%. This is in contrast to some of the tropical rain-forest areas in India where high endemism (58.8%) occurs (Table 4).

TABLE 4.—Degree of endemism in the termite fauna in some arid and rain-forest areas in Indian Region.

Area	Percentage of endemism	Source
Rajasthan (mostly arid)	16 %	Present account
Assam region (tropical rain-forest)	58.8 %	Roonwal & Chhotani (1962, 1965)
Andaman & Nicobar Islands (tropical rain-forest)	58.8 %	Roonwal & Bose (1970)

(f) Comparison with other animals

No information is available on the zoogeographical status of the Rajasthan fauna of other groups of insects or indeed other animal groups except mammals. According to Prakash (1963, 1973), in origin the Rajasthan mammals are 49 % Palearctic, 51 % Oriental and 2.6 % endemic. Earlier writers (e.g., Blandford, 1901) also stated the presence of a substantial Palearctic element in the Indian Desert. According to Prakash, the Palearctic element varies with the group, from zero (Primates, etc.) to 44 (Rodentia) and 100 (Insectivora). Prakash postulates a wide source of immigration of the western (Palearctic) elements from the Sahara, Iran, Central Asia and even farther west, and for the eastern (Oriental) elements from Peninsular India and South-east Asia (Text-fig. 23). In the absence of detailed analyses, it is difficult to say to what extent this postulate of widespread intrusion is justified.



Text-fig. 23. Postulated immigration routes of the intrusive mammals in the Indian Desert. (After Prakash, 1973.)

ACKNOWLEDGEMENTS

We are indebted to the Officer-in-Charge, Desert Regional Station, Zoological Survey of India, Jodhpur, for kindly placing the Station's termite collections at our disposal. Our thanks are also due to Mr. N. S. Rathore for general help in various ways; and to the Council of Scientific and Industrial Research, New Delhi, for financial assistance.

SUMMARY

1. The taxonomic portion of account is based on an extensive collections (some 187 vials), made during the years 1964-73 from 60 localities in 16 districts of Rajasthan (6 never covered before), and forms a supplement to the earlier monograph of Roonwal and Bose (1964).

2. Several new additions of species and extensions of distributional range have been made to the termite fauna of Rajasthan. The additions are : One family (Kalotermitidae), one subfamily (Termitinae), 2 genera (*Incisitermes* and *Angulitermes*) and the following 14 species:—

1. *Incisitermes didwanaensis* Roonwal & Verma
2. *Microcerotermes palestinensis* Spaeth
3. *M. sakesarensis* Ahmad
4. *Angulitermes jodhpurensis* Roonwal & Verma
5. *Odontotermes brunneus* (Hagen)
6. *O. dehraduni* (Snyder)
7. *O. distans* Holmgren & Holmgren
8. *O. feae* (Wasmann)
9. *O. giriensis* Roonwal & Chhotani
10. *O. gurdaspurensis* Holmgren & Holmgren
11. *O. latiguloides* Roonwal & Verma
12. *O. parvidens* Holmgren & Holmgren
13. *O. wallonensis* (Wasmann)
14. *Microtermes unicolor* Snyder

3. The total number of species from Rajasthan has now risen from 19 in the earlier monograph (Roonwal and Bose, 1964) to 32. (Of the two species of *Trinervitermes* mentioned in the earlier account, *T. heimi* is now regarded as a junior synonym of *T. biformis*.)

4. In many species, new distributional records are given.

5. Measurements and illustrations are given for those species and castes which were not covered in the earlier monograph of Roonwal and Bose.

6. A phylogenetic analysis shows that the primitive families (Kalotermitidae, Hodotermitidae and Rhinotermitidae) are poorly represented (with 15.6 %, 3.1 % and 9.4 % representation respectively). The specialised family, Termitidae, accounts for the remainder (84.4 %).

7. A zoogeographical analysis shows that the *present-day* composition is overwhelmingly Oriental (97%), with only a small Palaearctic element (1 species, 3 %). Six species (19 %) are endemic to Rajasthan.

8. *In origin*, the fauna is largely Ethiopian (68.8 %), to a much lesser extent Oriental (15.6%), and there are tiny fractions of the Palaearctic and Neotropical elements (1 species each), while 3 species (9.4 %) are of doubtful origin.

REFERENCES

- AHMAD, M. 1955. Termites of West Pakistan.—*Biologia*, Lahore, 1 (2) : 202—264.
- BEAUFORT, F. L. DE. 1951. *Zoogeography of the Land and Inland Waters*.—London.
- BHARADWAJ, O. P. 1961. The arid zone of India and Pakistan. Pp. 143—174. In *A History of Land Use in Arid Regions*.—Paris (Unesco).
- BLANFORD, W. T. 1901. The distribution of vertebrate animals in India, Ceylon and Burma.—*Philos. Trans. roy. Soc. Lond.*, London, (B) 194 : 335—436.
- CHATTERJEE, P. N. and THAKUR, M. L. 1964. Revision of the termite genus *Microtermes* Wasmann (Isoptera : Termitidae : Macrotermitinae) from the Indian Region.—*Indian Forest Rec. (N.S.) (Entom.)*, Delhi, 10 (11) : 4+219—260.
- CHAUDHRY, M. I. and AHMAD, M. 1972. *Termites of Pakistan. Identity, Distribution and Ecological Relationships. (Final Technical Report.)* xiv+70 + 3 pp.+2 pp. (errata), 15 pls., 81 figs.—Peshawar (Pakistan Forest Inst.).
- DESNEUX, J. 1904. *Isoptera, Family Termitidae*. In *Genera Insectorum*, Fasc. 25, 52 pp., 2 pls.—Brussels.
- DESNEUX, J. 1906. Varietè termitologiques.—*Ann. Soc. Ent. Belg.*, Brussels, 49 (12) : 336—360.
- EMERSON, A. E. 1955. Geographical origins and dispersions of termite genera.—*Fieldiana (Zool.)*, Chicago, 37 : 465—521.
- GAY, F. J. 1968. A contribution to the systematics of the genus *Amitermes* (Isoptera : Termitidae) in Australia.—*Aust. J. Zool.*, Melbourne, 16 : 405—457.
- GHOSH, A. 1952. The Rajputana Desert—its archaeological aspects.—*Bull. natnl. Inst. Sci. India*, New Delhi, No. 1 : 37—42, 1 pl.
- HARRIS, W. V. 1970. Termites of the Palaearctic Region. Pp. 295—313. In *Biology of Termites*, Vol. 2 (Ed. by K. Krishna & Weesner).—New York (Academic Press).
- HORA, S. L. and MATHUR, B. B. L. 1952. On certain palaeographical features of Rajasthan as evidenced by the distribution of fishes.—*Bull. natnl. Inst. Sci. India*, New Delhi, No. 1 : 32—36.
- IMMS., A. D. 1937. *Recent Advances in Entomology*. (2nd Ed.). x + 431 pp.—London (J. & A. Churchill Ltd.).

- KRISHNA, K. 1961. A generic revision and phylogenetic study of the family Kalotermitidae (Isoptera).—*Bull. Amer. Mus. nat. Hist.*, New York, 12 : 303—408.
- KRISHNAN, M. S. 1952. Geological history of Rajasthan and its relation to present day conditions.—*Bull. natnl. Inst. Sci. India*. New Delhi, No. 1 : 19—31.
- MATHUR, R. N. and THAPA, R. S. 1962. A revised catalogue of Isoptera (white ants) of the Entomological Reference Collection at the Forest Research Institute, Dehra Dun. *Indian Forest Leaflet*, Delhi, No. 167, (Entom.) : 1—122. (Also *Errata* : 1—9, 1963).
- MISRA, V. C. 1967. *Geography of Rajasthan*. ix+168 pp., 27 pls, 24 flagged maps.—New Delhi (National Book Trust of India).
- PRAKASH, I. 1963. Zoogeography and evolution of the mammalian fauna of Rajasthan desert —*Mammalia*, Paris 27 (3) : 342—351.
- PRAKASH, I. 1973. The ecology of vertebrates of the Indian Desert. Pp. 369—420. In *Ecology and Biogeography in India* (Ed. by M. S. Mani).—The Hague (W. Junk).
- PRASHAD, B., THAPA, R. S. and SEN-SARMA, P. K. 1967. Revision of the Indian species of the genus *Microcerotermes* Silvestri (Isoptera : Termitidae : Amitermitinae).—*Indian Forest Bull.* (N.S.), Delhi, No. 246 : II+56.
- ROONWAL, M. L. 1968. Rajasthan termites (Insecta : Isoptera).—*Abstr. Papers Sympos. nat. Resources Rajasthan* (Jodhpur, Oct. 1968), Jodhpur, p. b6.
- ROONWAL M. L. 1969. Fauna of Rajasthan, India. Part 1. General Introduction, with a list of collecting localities and a bibliography of Rajasthan zoology.—*Rec. zool. Survey India*, Delhi, 61 (3 & 4) (1963) : 291—376j, 9 pls.
- ROONWAL, M. L. 1970a. Measurement of termites (Isoptera) for taxonomic purposes.—*J. zool. Soc. India*, Calcutta, 21 (1) : 9—66.
- ROONWAL, M. L. 1970b. Termites of the Oriental Region. Pp. 315—391. In *Biology of Termites*, Vo. 2 (Ed. by K. Krishna and F. M. Weesner).—New York (Academic Press).
- ROONWAL, M. L. 1973a. Mound-structure, fungus combs and primary reproductives (king and queen) in the termite *Odontotermes brunneus* (Termitidae) in India.—*Proc. Indian natnl. Sci. Acad.*, New Delhi, (B) 39 (1) : 69—76 (4 pls.).
- ROONWAL, M. L. 1973b. On a new phylogenetically significant ratio in termite eggs (Isoptera).—*Abstr. Sympos. Orient. Entom.* Calcutta, Nov. 1973), Calcutta : 10—11.

- ROONWAL, M. L. 1974. Nomenclatural status of a Palestine termite, *Microcerotermes palestiniensis* (Termitidae : Amitermitinae).—*J. zool. Soc. India*, Calcutta, **24** (2) (1972) : 193—194.
- ROONWAL, M. L. and ALI, S. 1965. Fauna (of India). Pp. 231—287. In the *Gazetter of India*, Vol. I. *Country and People*.—Delhi (Publ. Div., Ministry of Inform. & Broadcast., Govt of India).
- ROONWAL, M. L. and BOSE, G. 1960. A new termite, *Psammotermes rajasthanicus* sp. nov., from Rajasthan, India.—*Sci. & Cult.*, Calcutta, **26** (1) : 38—39.
- ROONWAL, M. L. and BOSE, G. 1962a. A redescription of the Indian termite, *Odontotermes bellahunisensis* Holmg. & Holmg., with description of a new subspecies from Rajasthan.—*J. Bombay nat. Hist.*, Bombay, **58** (3) (1961) : 580—594, 2 pls.
- ROONWAL, M. L. and BOSE, G. 1962b. An African genus, *Psammotermes*, in Indian termite fauna, with fuller description of *P. rajasthanicus* from Rajasthan, India.—*Rec. Indian Mus.*, Delhi, **58** (3 & 4) (1960) : 151—158, 2 pls.
- ROONWAL, M. L. and BOSE, G. 1964. Termite fauna of Rajasthan India.—*Zoologica*, Stuttgart, **40** (3) (Heft 113) : VI+58, 5 pls.
- ROONWAL, M. L. and BOSE, G. 1969. Fauna of Rajasthan India. Part 4. A check-list of Rajasthan termites (Insecta : Isoptera).—*Rec. zool. Surv. India*, Delhi, **61** (3 & 4) (1963) : 437—450d, 4 pls.
- ROONWAL, M. L. and BOSE, G. 1970. Taxonomy and zoogeography of the termite fauna of Andaman and Nicobar Islands, Indian Ocean.—*Rec. zool. Surv. India*, Delhi, **62** (3 & 4) (1964) : 109—107d, 4 pls.
- ROONWAL, M. L. and BOSE, G. 1973. Vegetational distribution of termites of Rajasthan (India) and their economic importance.—*Abstr. Papers Winter School Develop. Rajasthan Desert* (Jodhpur, Febr. 1973), Jodhpur, pp. 53—54. (Fuller paper in press.)
- ROONWAL, M. L. and CHHOTANI, O. B. 1960. Soldier caste found in the termite genus *Speculitermes*. — *Sci. and Cult.*, Calcutta, **26** (3) : 143—144.
- ROONWAL, M. L. and CHHOTANI, O. B. 1962a. Termite fauna of Assam Region, eastern India.—*Proc. natnl. Inst. Sci. India*, New Delhi, (B) **28** (4) : 281—406, 26 pls.
- ROONWAL, M. L. and CHHOTANI, O. B. 1962b. *Indian Species of Termite Genus Coptotermes*. ix+115 (18 pls.).— Delhi (Indian Counc. Agric. Res., Entom. Monogr. No. 2; Manager of Publ., Govt. of India).

- ROONWAL, M. L. CHHOTANI, O. B. 1965. Zoogeography of termites of Assam Region, India, with remarks on speciation.—*J. Bombay nat. Hist. Soc.*, Bombay, **62** (1) : 19--31.
- ROONWAL, M. L. and CHHOTANI, O. B. 1966. Soldier caste in the termite genus *Speculitermes* and the phylogeny of *Anoplotermes-Speculitermes* Complex.—*Biol. Zbl.*, Leipzig, **85** : 189--210.
- ROONWAL M. L., CHHOTANI, O. B. and BOSE G. 1962. Some recent zoogeographical findings in Indian termites. In *Termites in the Humid Tropics (Proc. New Delhi Sympos., 1960)* : 51—54, 1 pl. (Pl. 2).—Paris (Unesco).
- ROONWAL, M. L. and RATHORE, N. S. 1972. Sex ratios, sexual dimorphism, body-weight and moisture-content of two desert termites, *Anacanthotermes macrocephalus* (Hodotermitidae) and *Microtermes mycophagus* (Termitidae), from India.—*Ann. Arid Zone*, Jodhpur, **11** (1 & 2) : 92—110.
- ROONWAL M. L. and RATHORE, N. S.—Swarming of primary reproductives, egg-laying and hatching in the Indian Desert harvester termite, *Anacanthotermes macrocephalus* (Hodotermitidae) (*In press, a.*)
- ROONWAL, M. L. and RATHORE, N. S. — Swarming, egg-laying and brood-care in termites of genus *Microtermes* (Termitidae) in the Indian Desert. (*In press, b.*)
- ROONWAL, M. L. and RATHORE, N. S.—Biological observations on three Indian Desert termites, *Eremotermes paradoxalis*, *Microcerotermes raja* and *Angulitermes jodhpurensis* (Termitidae). (*In press, c.*)
- ROONWAL, M. L. and SEN-SARMA, P. K. 1960. *Contributions to the Systematics of Oriental Termites*, xiv+407 pp. (65 pls.). New Delhi (Entom. Monogr. No. 1, Indian Counc. Agric., Res.; Publ. by Manager of Publ., Govt. of India, Delhi).
- ROONWAL, M. L. and VERMA, S. C. 1973a. Observations on sex ratios, sexual dimorphism, weight and moisture-content in two termites from Indian Desert, *Microcerotermes raja* and *Microtermes obesi* (Termitidae).—*Ann. Arid Zone*, Jodhpur, **12** : 107--124.
- ROONWAL, M. L. and VERMA, S. C. 1973b. Broad-postmentun *latigula*-group species of termite genus *Odontotermes* (Termitidae) from the orient, with a new Indian species.—*J. Indian Acad. Wood Sci.*, Bangalore, **4** (2) : 88--91.

- ROONWAL, M. L. and VERMA, S. C. 1973c. First record of termite genus *Incisitermes* Krishna (Ka'otermitidae) from Indian Region, with description of a new species from Rajasthan.—*Zool. Anz.*, Leipzig, 191 (5 & 6) : 390—397.
- ROONWAL, M. L. and VERMA, S. C. A new species of termite genus *Angulitermes* (Termitidae : Termitinae) from the Indian Desert, with some observations on biology. (*In press.*)
- ROONWAL, M. L. VERMA, S. C. and RATHORE, N. S. 1973. Imago of the termite *Microcerotermes raja* (Termitidae : Amitermitinae) from the Indian Desert, with observations on the gallery system, swarming and tandem behaviour.—*J. Indian Acad. Wood Sci.*, Bangalore, 4 (1) : 22—30.
- ROONWAL, M. L., VERMA, S. C. and RATHORE, N. S. 1974. On a new systematic character in termites, the micrasters.—*Z. zool. System. u. Evolutionsforsch.*, Berlin, 12 (1) : 55—76.
- SCLATER, P. L. 1858. On the general geographical distribution of the members of the class Aves.—*J. Proc. Linnaen Soc. Lond. (Zool.)*, London, 2.
- SHARMA, S. K. 1967. Annual Progress Report for 1966—67 of Coordinated Scheme for Research Investigation on Termites Infesting Field Crops and Fruit Trees in Rajasthan. (Cyclostyled: 5+2 pp.)—Jodhpur (Agric. Dept. Rajasthan).
- SNYDER, T. E. 1949. Catalog of termites (Isoptera) of the world.—*Smiths. misc. Coll.*, Washington, 112 : 2+1—490.
- SPAETH, VIRGINIA A. 1964. Three new species of termites from Israel (Termitidae : Amitermitinae).—*Israel J. Zool.*, Jerusalem, 13: 27—33.
- SPATE, O. H. K. and LEARMONTH, A. T. A. 1967. *India and Pakistan. A General and Regional Geography.* (3rd ed.) : xxxiii + 877 pp.—London (Methuen & Co.).
- VAN DER GRACHT, W. A. J. M. (Ed. by). 1928. *Theory of Continental Drift*, x + 240 pp. Tulsa, U.S.A. (Amer. Assoc. Petrol. Geol.).
- VISHNOI, H. S. 1957a. Preliminary observations on the incipient primary colonies of the termite *Microtermes mycophagus* (Desneux).—*Proc. 44th Indian Sci. Congr.*, Pt. 3, Abstracts, Calcutta : 304.
- VISHNOI, H. S. 1957b. The swarming termites of Delhi.—*J. Bombay nat. Hist. Soc.*, Bombay, 54 (3) : 792—793.
- WADIA, D. N. 1955. *Deserts of Asia. Their Origin and Growth in the Late Pleistocene Times.* (Second Sir Charles Seward Memorial Lecture at the Birbal Sahani Institute of Palaeobotany.), 8 pp., 1 pl.—Lucknow (Sahani Inst. Palaeobot.).

- WADIA, D. N. 1960. The post-glacial desiccation of Central Asia.—*Monogr. natnl. Inst. Sci. India*, New Delhi, No. 1 : 4 + 25, 10 pls.
- WEGENER, A. 1922. *Die Entstehung der Kontinente und Ozeane*. (3rd Ed.) : viii + 144. Braunschweig.
- WEIDNER, H. 1966. Betrachtungen zur Evolution der Termiten.—*Deutsch. entom. Z.*, Berlin (N. F.), 13 (4 & 5) : 323—350.
- WEIDNER, H. 1970. Isoptera (Termiten). In *Handb. d. Zool.*, Vol. 4 (Arthropoda), Sec. 2 (Insecta), Pt. 2 (Special), Lief. 13, No. 14, pp. 1—147.—Berlin (W. de Gruyter & Co.).