

Records of the Zoological Survey of India

The Harvester Termites (*Anacanthotermes*)
of the Indian Region. Identity, Distribution
and Biology (Isoptera, Hodotermitidae)

M.L. Roonwal, G. Bose

Issued by the Director
Zoological Survey of India, Calcutta

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THE HARVESTER TERMITES (*ANACANTHOTERMES*)
OF THE INDIAN REGION. IDENTITY, DISTRIBUTION
AND BIOLOGY (ISOPTERA, HODOTERMITIDAE)

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सत्यमेव जयते

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INTRODUCTION

The harvester termites belong to three genera referable to the subfamily Hodotermitinae (of the family Hodotermitidae). But the composition of the family Hodotermitidae varies with authors. Synder (1949, world catalogue) included in it four subfamilies, viz. Termopsinae, Stolotermitinae, Porotermitinae and Hodotermitinae. Grassé (1949) on the other hand, regards the Termopsinae as a separate family Termopsidae, including the subfamilies Termopsinae, Porotermitinae and Stolotermitinae) and the Hodotermitinae is raised to family rank. Later, however, Grassé (1986) has included the fossil subfamily Cretatermitinae, described by Emerson (1967) under Hodotermitidae, in Termopsidae. We consider the Termopsidae a separate family because of its primitiveness, but regard the subfamilies Porotermitinae, Stolotermitinae, Hodotermitinae and Cretatermitinae as referable to the family Hodotermitidae. Since the Porotermitinae and Stolotermitinae are aberrant groups, they do not fit in easily, and any arrangement which includes them must remain artificial.

Our Hodotermitidae includes the Porotermitinae (*Porotermes*), Stolotermitinae (*Stolotermes*) and Hodotermitinae and Cretatermitinae (fossil).

To the Hodotermitinae belong the harvester termites which are referable to three genera, *Hodotermes* (E. and S. Africa), *Microhodotermes* (the mediterranean region of N. Africa and S. Africa) and *Anacanthotermes* (N. Africa, Egypt, W. Asia, Arabia, Central Asia, to W. and S. India). The harvester termites of the Indian Region belong to the genus *Anacanthotermes*.

Abbreviations used : coll., collected by, collection; Im., imago; Ny., nymph; S., soldier; W., worker.

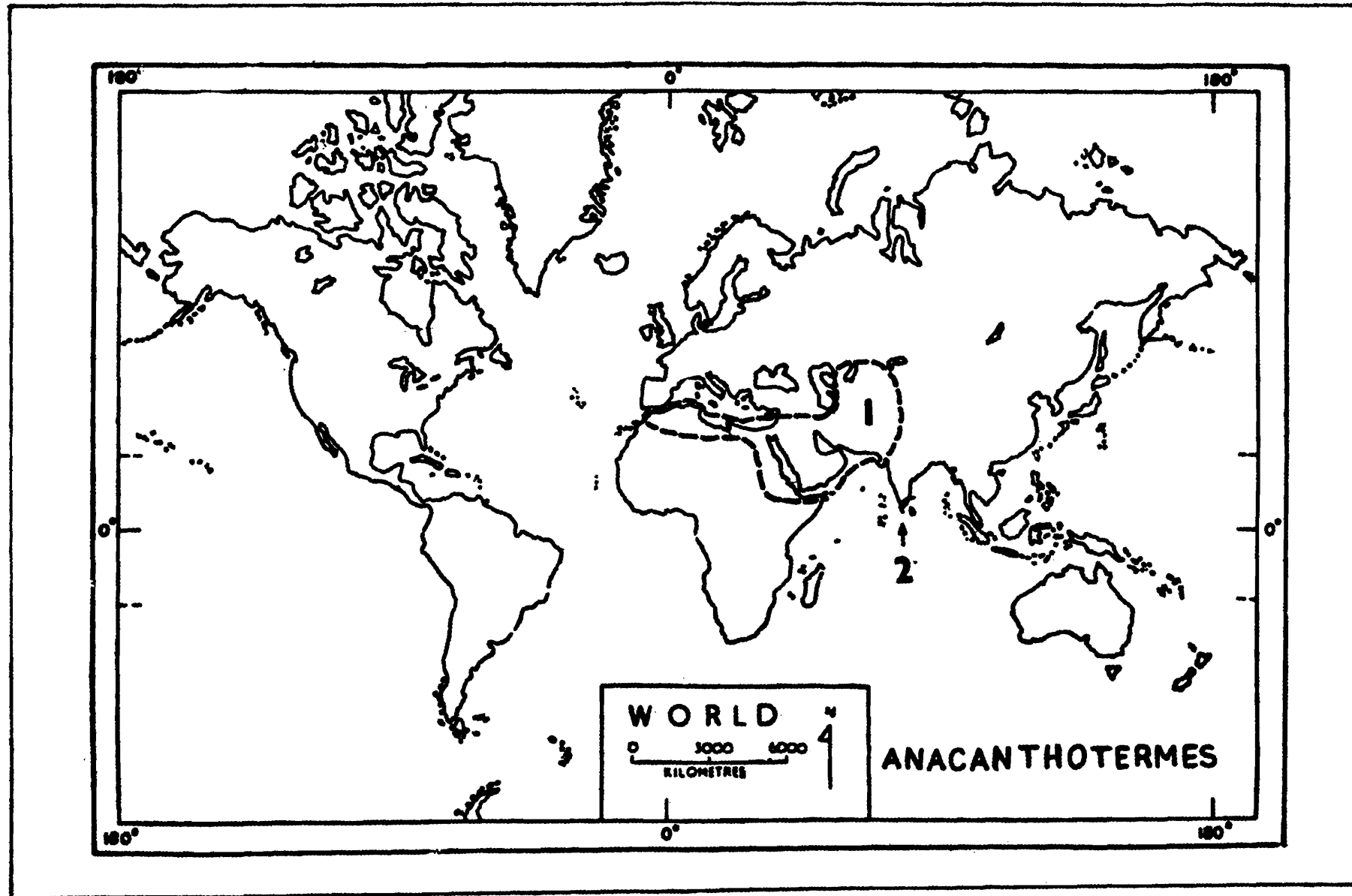


Fig. 1. World map, to show the distribution of genus *Anacanthotermes*. 1. North Africa, West and Central Asia to Western India (several species) 2. South India (*A. viarum*).

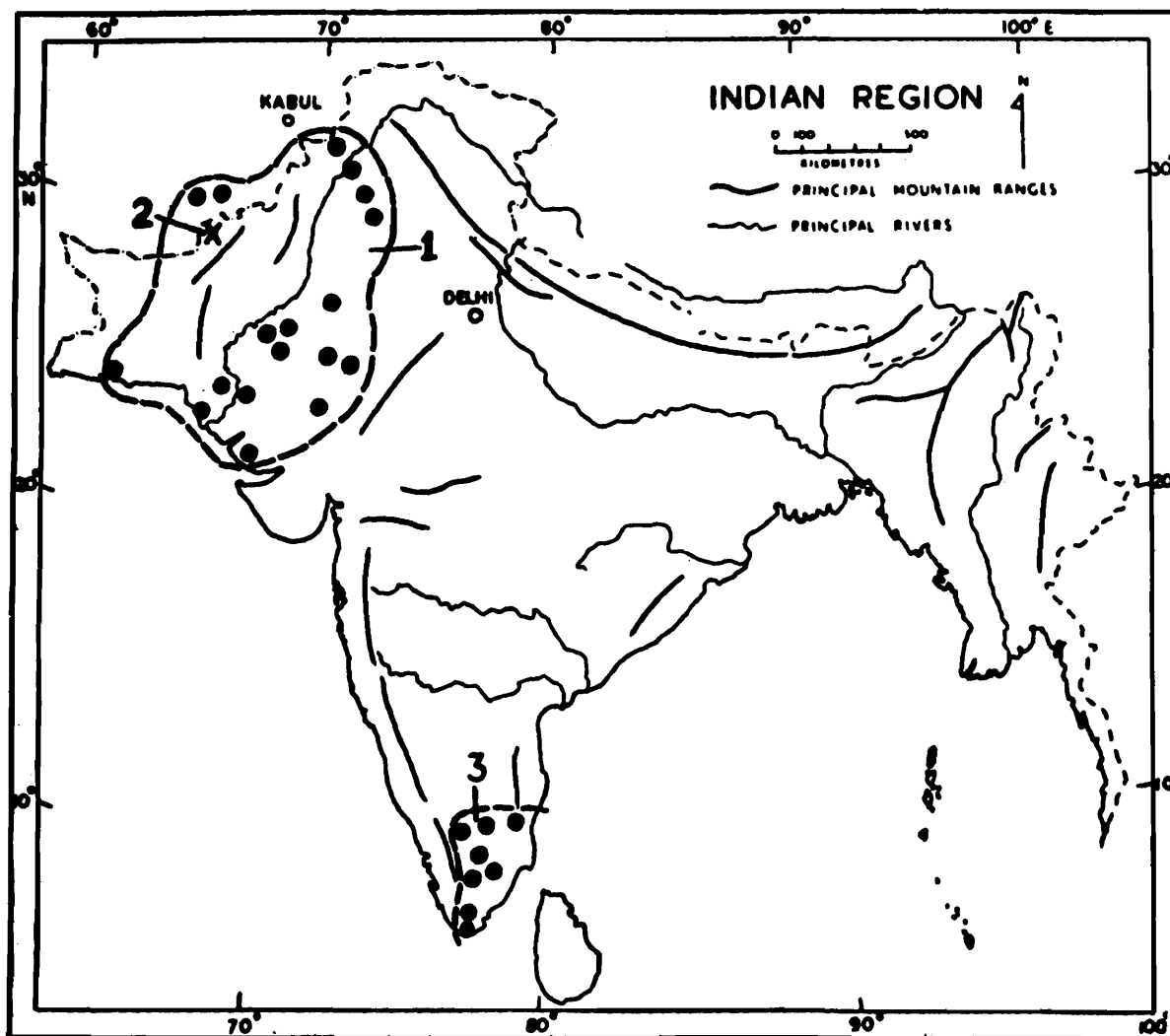


Fig. 2. Map of the Indian Region, showing distribution of the species of *Anacanthotermes*. 1. *A. macrocephalus*. 2. *A. baluchistanicus*. 3. *A. viarum*.

SYSTEMATIC ACCOUNT AND BIOLOGY OF INDIAN REGION SPECIES

Genus *Anacanthotermes* Jacobson

1905. Subgenus *Anacanthotermes* (of genus *Hodotermes* Hagen), *Ann. Mus. Zool. Acad. imp. Sci. st. Petersburg*, 9 (1904): 75-78.
1926. Genus *Anacanthotermes*, Sjöstedt, *K. Sv. Vet. Akad. Handl.*, (3) 3(1) (1925): 9, 10, 21.
1949. Genus *Anacanthotermes*, Snyder, *Smithson. misc. Colls.*, 112: 62.

Distribution (Figs. 1 & 2): Mainly palaeartic Coastal N. Africa west to Algeria; Palestine, W. Asia, Turkestan, Iran, Transcaspia, Afghanistan; also oriental (W. Pakistan, W. India and extreme S. India) and ethiopian (Egypt, Arabia).

Composition : It has twelve species of which the following four occur in the Indian Region and are dealt with below: *baluchistanicus*, *macrocephalus*, *vagens* and *viarum*.

Keys to Indian Region Species

IMAGOES

Imagoes are known in three species only.

- 1 (4). Labrum bulged in middle
- 2 (3). Larger species (length without wings 14.4-15.4; maximum head-width with eyes 3.20-3.42; maximum eye-diameter 0.63-0.70; maximum pronotum - width 2.53 - 2.90 mm). Antennal segments more numerous, 29-31. Eyes more widely separated from antennae (minimum distance 0.13-0.16 mm)..... *A. viarum*
- 3 (2). Smaller species (length without wings 12.5-15.0; maximum head-width 2.70-3.40; maximum eye-diameter 0.48-0.61; maximum pronotum-width 2.13 - 2.41 mm). Antennal segments fewer, 26 - 29, mostly 27 (24 in Afghanistan example only). Eye nearer antennae (minimum distance 0.05-0.08 mm)..... *A. macrocephalus*
- 4 (1). Labrum not bulged in middle. [Smallest species (length without wings 11-13; maximum head-width 2.80-3.07; maximum eye-diameter 0.47-0.59, maximum pronotum-width 2.05-2.33 mm). Antennal segments 24-27]..... *A. vagans*

SOLDIER

- 1 (2). Pronotum with posterior margin deeply notched in middle (soldier major; wavy in minor). [Postmentum with sides of posterior third weakly depressed, not forming a waist. Maximum head-width 2.91-3.53 mm. Antennae with 23-25 segments]..... *A. baluchistanicus*
- 2 (1). Pronotum with posterior margin either not notched or only weakly depressed.
- 3 (4). Pronotum with posterior margin not notched. Postmentum with no marked waist in posterior third. [Small species. Head-length to mandible base 2.44-2.91; maximum head-width 2.50-3.78 mm]. *A. vagans*
- 4 (3). Pronotum with posterior margin weakly notched. Postmentum with a strong waist in posterior third.
- 5 (6). Frons rugose, with several transverse ridges in middle. Mandibles larger and less incurved apically (index Left mandible-length/ Head-length to mandible-base 0.66-0.76)..... *A. viarum*
- 6 (5). Frons with no transverse ridges, either smooth or only weakly wrinkled. Mandibles shorter and strongly incurved (index Left mandible-length/Head length to mandible-base 0.53-0.66)..... *A. macrocephalus*

*Account of Species***1. *Anacanthotermes baluchistanicus* Akhtar**

(Figs. 3 and 4; and Table 2)

Anacanthotermes baluchistanicus Akhtar :1972. Chaudhry and Ahmad, *Termites of Pakistan*, etc. : 10. Chaman (Baluchistan, Pakistan), *Nomen nudum*.1974a. Akhtar, *Biologia* (Lahore), 20: 17-40, S.W., Chaman (Baluchistan, Pakistan).1974b. Akhtar, *Pakistan J. Zool.*, 6: 90.1979. Akhtar, *Biologia* (Lahore), 25: 161, 162.

The following description is based on Akhtar (1974a).

IMAGO : Unknown.

SOLDIER (Figs. 3 and 4; and Table 2): Dimorphic. *Soldier Major*: Head reddish brown; squarish, slightly elongate; sides subparallel with a weak depression in middle (length to mandible base 4.17 mm, maximum width 3.53 mm); with many moderately long hairs. Anteclypeus trapezoid. Postclypeus not well marked. Epicranial suture present. Labrum wider than long, with many hairs all over, the anterior ones longer. Antennae with 23 segments. Eyes and Ocelli small. Mandibles stout (length 2.71 mm), with well developed marginal teeth. Postmentum long (length 2.91; width maximum 1.02, minimum 0.87 mm); flat, sides subparallel. Pronotum weakly raised and convex anteriorly, posterior margin with a deep median notch. Tarsi 4-segmented.

Soldier Minor : Generally like soldier major, but smaller (head length to mandible-base 3.20, maximum width of head 2.91 mm). Antennae with 25 segments. Postmentum with wavy sides. Pronotum with only a weak notch on posterior margin.

WORKER (Fig. 3 E) : Not described by Akhtar but mandibles illustrated. Mandibles with 2 marginal teeth (Widely separated on left and close together on right mandible).

Types, etc. : Holotype (soldier) in Zoology Department, Punjab University, Lahore. *Type-locality*: Chaman (Baluchistan).

Geographical distribution (Fig. 2) : PAKISTAN: Known only from the type-locality (Chaman, Baluchistan).

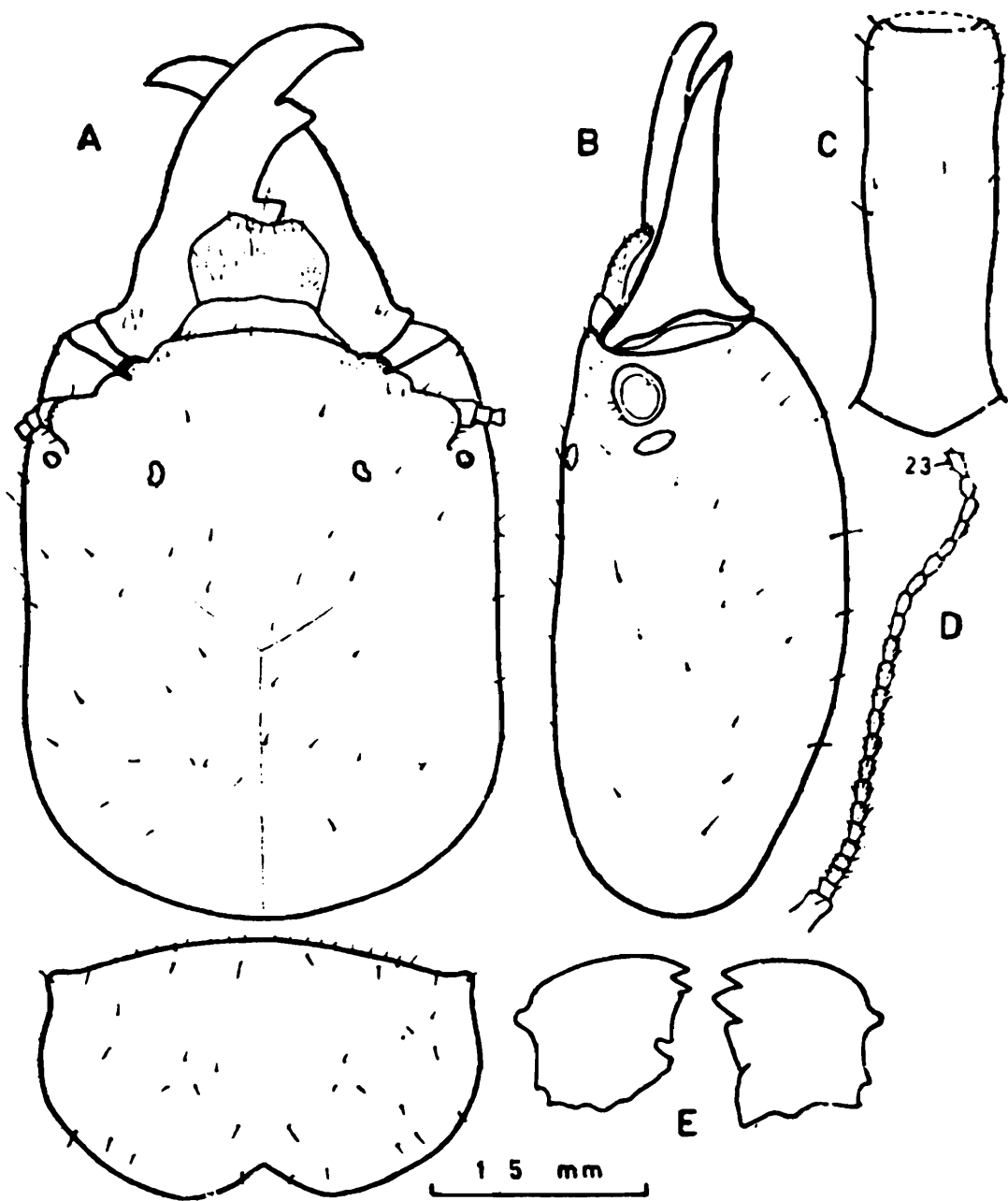


Fig. 3. *Anacanthotermes baluchistanicus*. Soldier Major (A-D) and Worker (E). (A) Head and pronotum, dorsal view. (B) Head, side view. (C) Postmentum. (D) Antenna. (E) Worker mandibles. (After Akhtar, 1974).

Biology

Little is known of its biology. The species seems to be rare. Only a single small colony was found feeding on logs of the mulberry, *Morus alba* which the workers has covered with a mud plaster. Larvae, irregular, longitudinal tunnels were made in the log. It lived in close association with another termite, *Amitermes* sp. which tunnelled the inner portions of the log while *A. baluchistanicus* was working on the outer portions.

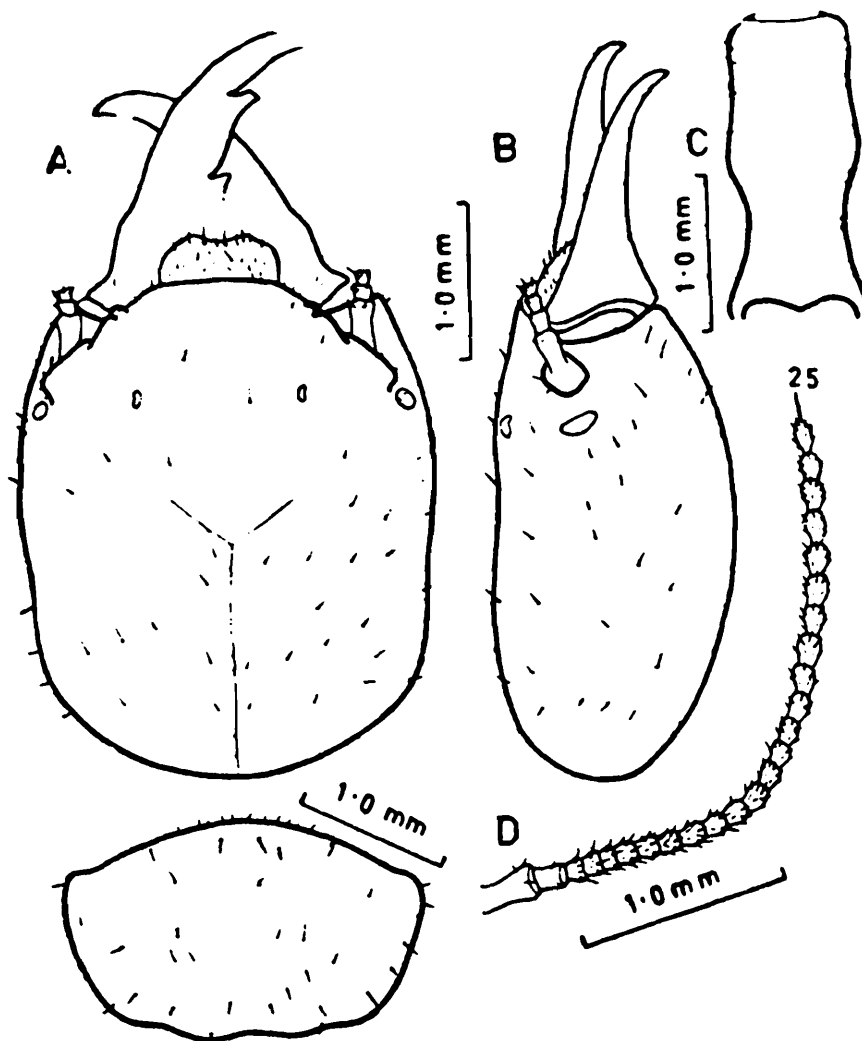


Fig. 4. *Anacanthotermes baluchistanicus*. Soldier Minor (A) Head and pronotum, dorsal view. (B) Head, side view. (C) Postmentum. (D) Antenna. (After Akhtar, 1974).

2. *Anacanthotermes macrocephalus* (Desneux)

(Syn. *A. peshawarensis* Akhtar)

(North Indian Harvester Termite)

(Figs. 5-9; Pl. I-IV; and Tables 1-3)

1. *Hodotermes macrocephalus* Desneux :

1906. Desneux, *Ann. Soc. ent. Belg.*, 49 (12) [1905]: 344-348. Im., S., W. *Type-locality*: Sind (Pakistan): Karachi and vicinity and whole of Sind, both upper and lower. We restrict it to Karachi. (T.R. Bell. in Desneux, 1906, *Ibid*: 346-347).

1909. Lefroy, *Indian Insect Life*, 1: 120. Sind.

1914. Bugnion, *Bull. Mus. Hist. nat.*, 20 (4): 174. Karachi (Pakistan) and Trichinopoly (S. India). [Confuses *H. viarum* König of S. India with *H. macrocephalus* Desn. of Sind and regards them as conspecific. Trichinopoly examples must be *Anacanthotermes viarum*.]

1941. Beeson, *Ecology & Control Forest Insects in India*: 541. Punjab and Sind plains. (Reprint ed., 1961 : 416).

2. *Hodotermes macrocephalus* Holmgren :

1960. Rao, *The Desert Locust in India*, New Delhi (I.C.A.R.): 286. Pasni reks (sand dunes) (Baluchistan coast, Pakistan). [No doubt Rao means 'macrocephalus Desneux' and not Holmgren; Rao also wrongly puts it in the family "Calotermitidae" instead of Hodotermitidae].

3. *Hodotermes (Anacanthotermes) macrocephalus* Desneux :

1911. Holmgren, *K. Sv. Vet. Akad. Handl.*, 46 (6): 43; Pl. 1, Fig. 10. India.

1913. Holmgren, *K. Sv. Vet. Akad. Handl.*, 50 (2): 35; Pl. 1, Fig. 2. Karachi (Sind).

1917. Holmgren and Holmgren, *Mem. Dept. Agric. India (Ent.)*, 5: 139. W. Sind ("Mile 120 on railway from Badin to Hyderabad").

1932. Kirby, *Univ. Calif. Publ. (Zool.)*, 37: 387-388, 444. Protozoa in gut.

1934. Margabandhu, *J. Bombay nat. Hist. Soc.*, 37 (3): 701. Sind.

4. *Anacanthotermes macrocephalus* (Desneux):

1944. Kirby, *Univ. Calif. Publ. (Zool.)*, 49 (8): 186-188. Sargodha (Punjab, Pakistan). Protozoa in gut.

1949. Snyder, *Smiths. misc. Colls.*, 112: 62. India.

1953. Rattan Lal and Menon, *Catal. Indian Insects*, Pt. 27, *Isoptera*: 3. Sind; Punjab. [Also gives Ceylon, based on Bugnion, 1914. But Bugnion did *not* record it from Ceylon; and his record from S. India (Trichinopoly) was due to confusion with *A. viarum*, vide supra.]

1953. Roonwal and Pant, *Indian Forest Leaflet (Ent.)*, No. 121 (3): 46. Pakistan (Punjab: Dipalpur, Montgomery Dist.; and Miranpur).

1955. Ahmad, *Biologia (Lahore)*, 1 (2): 210-212. Im., S. and W. Pakistan (Punjab, Sind, Baluchistan).

1960. Weidner, *Abh. u. Verh. naturwiss. Verein Hamburg*, (N.F.) 4 [1959]: 45 (map), 51 (Fig. B, soldier) and 56-57. SE Afghanistan.

1961. Harris, *Termites: Their Recognition and Control*: 49, 107. (Record from "north-east India," p. 49 incorrect.).

1962a, b. Gupta, *Rec. Indian Mus.*, 58 (3-4) [1960]: 169-194; and *Ibid*: 195-222. Bikaner and vicinity (Rajasthan). External morphology.

1962. Mathur and Thapa, *Indian Forest Leaflet (Ent.)*, No. 167: 4. Bikaner (W. Rajasthan); Pakistan (Punjab).

1964. Roonwal and Bose, *Zoologica (Stuttgart)*, 40 (3) (Heft 113): 9-12. India (W. Rajasthan), Pakistan and SE Afghanistan.

1969. Roonwal and Bose, *Rec. zool. Surv. India*, 61 (1963): 438.

1970. Roonwal, In *Biol. of Termites* Vol. 2 (Eds. Krishna and Weesner): 330-332.

1972. Roonwal and Rathore, *Annals arid Zone*, 11: 4-10, Jodhpur and vicinity. Biology.

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1974. Akhtar, *Pakistan J. Zool.*, **6**: 90-91, Pakistan.
- 1975a. Roonwal, In *Environm. Analysis of Thar Desert* (Eds. Gupta and Prakash): 400-401. Distribution.
- 1975b. Roonwal, *Z. angew. Ent.*, **78** (4): 424-440. W. Rajasthan. Biology.
1976. Roonwal, *Zool. Jahrb. (Syst.)*, **103**: 481-482. Distribution, biogeography.
- 1977a. Roonwal, In *Natural Resources of Rajasthan* (Ed. Roonwal): 377. W. Rajasthan.
- 1977b. Roonwal and Verma, *Rec. zool. Surv. India*, **72**: 433. Distribution.
1978. Roonwal and Bose, *Proc. Indian natnl. Sci. Acad., (B)* **44**: 321-322. Food, etc.
1979. Akhtar, *Biologia* (Lahore), **25**: 161, 162.
1979. Roonwal, Verma and Thakur, *Proc. Indian natnl. Sci. Acad., (B)* **45**: 123. Wing microsculpturing.
1979. Roonwal and Rathore, *J. zool. Soc. India*, **27** (1978): 2-4. Egg-wall and micropyle.
1982. Grassé, *Termitologia* vol 1: 11, 17, 22, 31, 37, 39, 40, 44, 56, 58, 62, 63, 67, 69, 70.
1982. Roonwal, In *Desert Resources and Technol.* (Ed. Alam Singh), vol. 1: 36. Ecology.
1982. Roonwal and Rathore, *Proc. Indian natnl. Sci. Acad., (B)* **48**: 324-325. Wing microsculpturing.
1983. Roonwal, *Proc. Indian natnl. Sci. Acad., (B)* **49**: 378. Wing microsculpturing.
1984. Bose, *Occ. Pap. Rec. zool. Surv. India*, No. 49: 72.
1984. Roonwal, *Mem. ent. Soc. India*, No. 9: 14. Abdomen and genitalia.
1984. Weidner, *Anz. Schadlingskd.*, **57**: 5. Distribution.
1986. Grassé, *Termitologia*, vol. 3: 374, 375, 507, 611, 651, 692.

5. *Anacanthotermes peshawarensis* Akhtar :

1972. Chaudhry and Ahmad, 1972, *Termites of Pakistan*, etc., p. 10. Pakistan. (N.W.F.P.: Peshawar, Bara). *Nomen nudum*.
- 1974a. Akhtar, *Biologia* (Lahore), **20**: 40-44. Peshawar (Type-locality). *Syn. nov.*
- 1974b. Akhtar, *Pakistan J. Zool.*, **6**: 90.
1979. Akhtar, *Biologia* (Lahore), **25**: 161, 162.

Material Examined :

(A) *At the Zoological Survey of India, Calcutta* : (1) 4 tubes, S., W., Shivbari near Bikaner, 8 and 9.ix.52. *M.L. Roonwal* coll., ex. underground galleries. (2) One tube, Im., Lalgahar near Bikaner. 8. viii.52, *Y.K. Srivastava* coll., ex at light, (3) One tube, S.W., Shivbari near Bikaner, 3.ix.52, *S.D. Gupta* coll., ex galleries in ground. (4) 8 tubes, S., W., Jodhpur District (Kailana, Beriganga, Bhagat-ki-Kothi all near Jodhpur), 12-21.xii.56, *B. Biswas* coll., ex soil or under cowdung. (5) 12 tubes, S., W., Bikaner and

Table 1. Body-measurements (mm), etc. of imagoes of *Anacanthotermes* of Indian Region.

Items	<i>macrocephalus</i> (Syn. <i>peshawarensis</i>)	<i>viarum</i> (syn. <i>koenigi</i> and <i>rugifrons</i>)	<i>vagans</i> (from Baluchistan, Hagen 1958; and Choudhry & Ahmad, 1972)
1. Total length with wings	27.2 27.5	27.5 30.0	24 26
2. Total length without wings	12.4 - 15.0	14.4 15.4	11 - 13
3. Head length to base of mandibles	2.37 - 3.00	2.70 2.90	2.37 2.54
4. Head length to tip of labrum	3.19 - 3.81	—	—
5. Max. width of head (with eyes)	2.70 - 3.40	3.20 3.42	2.82 3.07
6. Max. height of head	1.15 - 1.20	1.43 1.85	—
7. Labrum (length × width)	0.60 - 0.65 × 1.23	1.35 0.80 1.05 × 1.30 - 1.53	—
8. Max. diameter of eyes	0.48 - 0.61	0.63 - 0.70	0.47 - 0.59
9. Diameter of ocelli (max. × min.)	0.20 - 0.23 × 0.10	0.13	—
10. Min. eye-ocellus distance	0.43 - 0.45	—	—
11. Min. eye-antennal distance	0.05 - 0.08	0.13 0.16	—
12. Pronotum (max. length × max. width)	1.39 - 1.55 × 2.13 - 2.41	1.70 1.73 × 2.53 - 2.90	width 2.05 - 2.33
13. Length of forewing	23.0	—	20 - 23
14. Length of forewing scale	1.15 - 1.36	1.38 - 1.55	—
15. Length of hindwing scale	0.90 - 1.15	1.15 1.35	—
16. Number of antennal segments	24 29 mostly 27 (24 in Afghanistan examples only)	29 31	24 27 mostly 25

Table 2. Body-measurements (mm), etc. of soldiers of *Anacanthotermes* of the Indian Region.

Items	<i>macrocephalus</i> (syn. <i>peshawarensis</i>)	<i>viarum</i> (syn. <i>koenigi</i> and (<i>rugifrons</i>))	<i>Neotype</i>	<i>vagans</i> (1960; Chaudhry & Ahmad, 1972)	<i>baluchistanicus</i> Soldier Major	<i>Soldier Minor</i>
1. Total length (to tip of mandibles)	10.0 -16.7	8.0 -17.8	15.0	14	—	—
2. Head-length (to base of mandibles)	3.00- 4.90	2.40- 4.85	4.30	2.44- 2.91	4.17	3.20
3. Head-length (to tip of mandibles)	4.60- 7.30	—	—	6.5	—	—
4. Max. width of head	2.70- 4.56	2.40- 4.65	4.20	2.50- 3.78	3.53	2.91
5. Max. height of head	2.00- 2.60	1.20- 2.40	2.20	—	—	—
6. Head Index Width/Length	0.87- 0.92	0.92- 0.98	0.98	0.78	0.81	0.91
7. Labrum (max. length × max. width)	0.40- 0.60 × 0.95- 1.10	0.30- 0.78 × 0.75- 1.38	0.63 × 1.20	—	—	—
8. Length of mandibles	2.15- 2.60	1.80- 3.15	2.90	1.96- 2.76 (left)	2.71 (left)	2.25 (left)
9. Postmentum (min. median length × max. width)	2.40- 2.80 × 1.18- 1.40	1.29- 2.70 × 0.80- 1.45	2.0 × 1.30	2.6 × 1.0	2.91 × 1.02	1.99 × 0.87
10. Pronotum (width × length)	1.82- 3.25 × 0.98- 1.80	1.60- 3.60 × 0.90- 1.95	3.23 × 1.80	2.13- 3.22 × 1.18- 1.68	3.22 × 1.63	2.50 × 1.43
11. Index Pronotum Width/Head Width	0.73- 0.77	0.68- 0.86	0.77	0.77	0.91	0.86
12. No. of antennal segments	25-31	29-32	32	over 22	23	25

Table 3. Body-measurements (mm), etc. of workers of *Anacanthotermes* of Indian Region.

Items	<i>macrocephalus</i> (syn. <i>peshawarensis</i>)	<i>viarum</i> (syn. <i>koenigi</i> and <i>rugifrons</i>)
1. Total length	6.1 -10.6	8.5 -13.3
2. Head-length to base of mandibles	1.40- 2.85	2.50- 3.40
3. Head-length to tip of labrum	1.78- 4.00	--
4. Max. width of head	1.60- 3.30	3.00- 3.75
5. Max. height of head	0.90- 1.60	.
6. Labrum (length × width)	0.30- 0.85 × 0.66-1.38	—
7. Pronotum (length × width)	0.65- 1.00 × 0.90-1.75	1.15-1.50 × 1.85-2.18
8. No. of antennal segments	25-31	28-33

vicinity), 8-16.i.57, *B. Biswas* coll., ex ground; building 7-10 cm. high "mounds" (6). 3 tubes, S., W., Jaisalmer Dist. (Badebagh, and around Jaisalmer), 24.xii.57 and 21.1.58, *K.K. Tiwari and B. Biswas* coll., ex below stones. (7) 9 tubes, S., W., Barmer Dist. (Bhap tank near Barmer; and Pachpadra), *K.K. Tiwari and B. Biswas* coll., 6-16.ii.58, ex "ant hill" (= mound). (8) 2 tubes, S., W., Jodhpur Dist. (Agolai and Salawas), 28.v.63, *R.C. Sharma* coll. (9) One tube, S., W., Jodhpur Dist. (Satlana near Luni village), *R.N. Bhargava* coll., 22.x.63. (10) 2 tubes, S., W., Jodhpur Dist. (Kuni village; and near Mathania), 29.x.63 and 12.xii.63, *K.C. Kansal* coll. (11) One tube, S., W., Kailana near Jodhpur, *M.L. Roonwal* coll., ex ground near a mound. (12) Several tubes, S., W., Pakistan: Baluchistan (Pishin, *S.A. Taher* coll., 3.vii.50); Sind (Karachi, *M. Ayub* Coll., 30.vii.50; Lalukhet near Karachi, *M. Hussain* Coll., 29.xi.54). (13) 2 tubes, S., W., Karachi, *Shorab Ali* coll., 13.x.60, ex underground. (14) 3 tubes, S., W., Karachi, *M.L. Roonwal* coll., 14.ix.60, ex ground (one lot mixed with *Micro-termes* sp.).

(B) *At the Desert Regional Station, Zoological Survey of India, Jodhpur:*

(1) 3 tubes, Im., Jodhpur and vicinity, *N.S. Rathore* coll., ex swarms, at light, 9.viii.70; 16.viii.72 (9 P.M.); 18.viii.72 (8.30 P.M.). (2) 2 tubes Im., Jodhpur, *S.C. Verma* coll., ex swarms, at light, 16.viii.72 (8 P.M.), (3) 10 tubes, S., W., Jodhpur and vicinity, 1964-1972, several collectors. (4) 2 tubes, S., W., Beriganga, 12 Km N of Jodhpur, 15.iv.65 (*V.C. Agarwal*) and 3.vii.73 (*R.C. Sharma*), ex ground. (5) 2 tubes, S., W., Bilaspur, 30 km SW

of Jodhpur, 19.viii.65 (*V.C. Agarwal*), 26.xi.69 (*S.C. Verma*) (6) One tube, W., Salawas, 18 km W of Jodhpur, 28.ix.72, *R.C. Sharma* coll., ex. ground. (7) One tube, W., Kalyanpur, 68 km W of Jodhpur, 19.xi.72, *R.C. Sharma* coll., ex ground. (8) 1 tube Arnaji, 33 km SW of Jodhpur, 12.iii.68, *V.C. Agarwal* coll., ex under stone. (9) 9 tubes, S., W., Agolai, 45-50 km W of Jodhpur, 1964-1973, several collectors, ex mound, or ex ground. (10) One tube, S., W., Mathania, 20 km N of Jodhpur, 27.vii.70, *M.L. Roonwal* coll. (11) 2 tubes, S., W., Balotra and mewanager (Nakhora), (Barmer Dist.), ca. 60-65 km SW of Jodhpur, 4.viii.73, *R.C. Sharma* Coll. (12) one tube. S., W., Borunda ca. 70 km E of Jodhpur (Jodhpur Dist.), 15.xii.72, *R.C. Sharma* coll. (13) One tube, S., W., Shivbari near Bikaner, 3.ix.52, *S.D. Gupta* coll. (14) One tube, W., Chava village, 20 km from Bhuj (Kutch, Gujarat), 10.xi.78, *N.S. Rathore* coll., ex. under stone.

(C) *At the Indian Agricultural Research Institute, New Delhi* : (1) One tube, W., Pakistan (Sind: Milestone 120, SW from Hyderabad, on Badin road), T.B. Fletcher coll., 2.i.11.

(D) *At the Forest Research Institute, Dehra Dun*: (1) One vial, Im., S., W., W. Rajasthan (on Bikaner-Gajner Raod). (2) One vial, Im. S., W., Pakistan (Punjab : Dipalpur). (3) One vial, Im., S., W., Pakistan (Punjab Miranpur).

(E) *At the American Museum of Natural History, New York* : (1) One tube, 1 Im. (headless but with wings), 1 S., 1 W., Karachi (Sind), *T.R. Bell* coll., det. J. Desneux, "*H. [= Hodotermes] macrocephalus*" *Cotypes*. (2) One tube, S., W., "India (? Toholai)" (3) One tube, S., W., Pakistan (Sargodha, Punjab), *Light* coll., 22.x.28.

IMAGO (Fig. 5-7 and Table 1) Moderately pilose. Head yellowish to brownish-yellow; mandibles darker. Total length with wings 27.2-27.5 mm; without wings, 12.5-14.8 mm. Head subcircular, broader than long (maximum width 2.70-3.40 mm., length to lateral base of mandibles 2.40-3.00 mm); posterior margin rounded; epieramial suture present Fontanelle absent. Eyes large, suboval, the side facing antenna with substraight margin. Ocelli small, almost flush with head surface. Antenna with 26-29, mostly 27, segments (Afghanistan examples have only 24 segments, Weidner 1970); segment 1 longest, 2 less than half of 1; 3-5 subequal and shortest. Frons weakly striated. Anteclypeus large, apilose. Postclypeus narrower and with a few hairs near anterior margin. Labrum much broader than long, sides bulging out in middle; anterior margin substraight with a weak

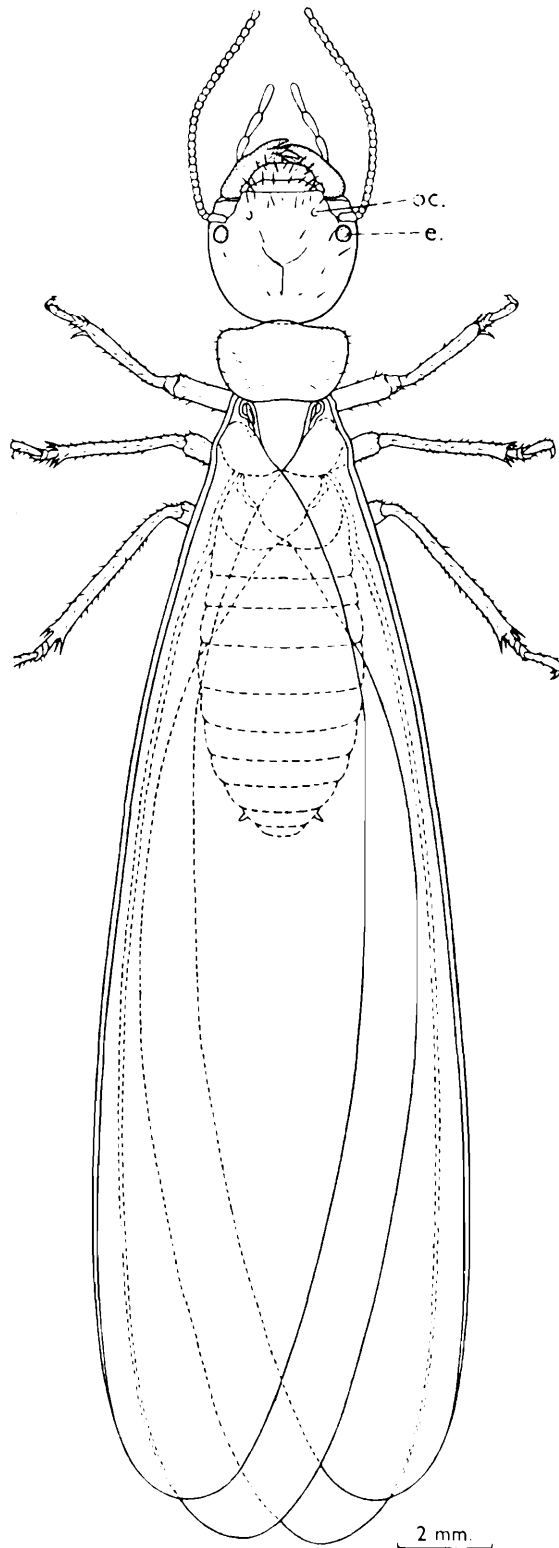


Fig. 5. *Anacanthotermes macrocephalus*. Imago, in dorsal view. e., eye; oc., ocellus.

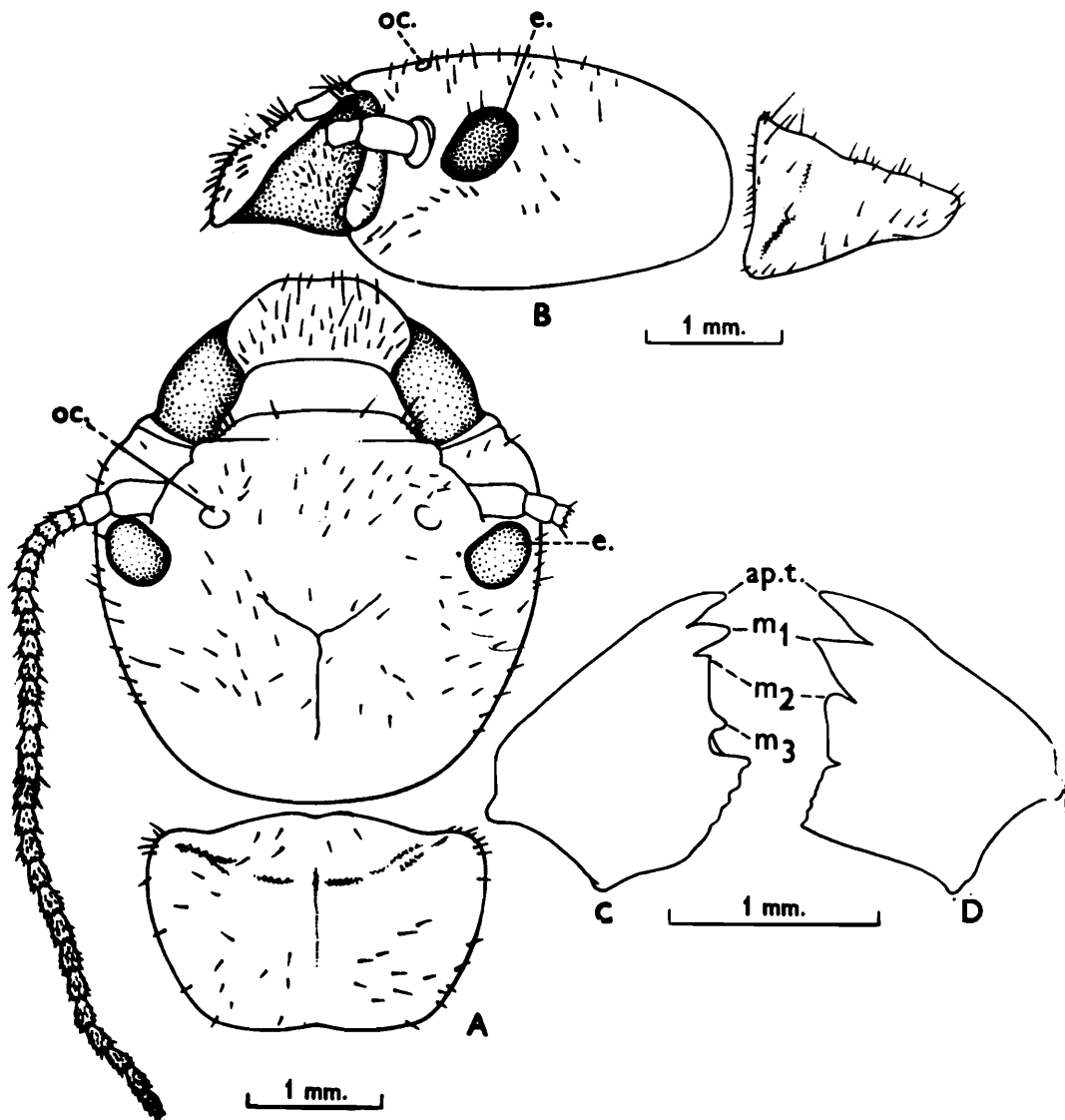


Fig. 6. *Anacanthotermes macrocephalus*. Imago. (A) Head and pronotum, in dorsal view. (B) Same, in side view. (C) Left mandible. (D) Right mandible. ap. t., apical tooth of mandible; e., eye; m1, m2 m3, 1st, 2nd, 3rd marginal teeth of mandibles; oc., ocellus.

medial depression; with several longish hairs on anterior margin and on body. Left mandible with an apical and three marginal teeth; 2nd very small, widely separated from 3rd; right mandible with an apical and two marginals, the latter close together. Pronotum narrower than head; weakly saddle-shaped; anterior margin convex, with a small median notch; posterior margin weakly convex, with a small median notch. Legs stout, pilose; tarsi 4-jointed; apical tibial spur formula 3: 4: 4. Wings reticulated; Wing microsculpturing consists of numerous papillae ($3-6 \mu\text{m} \times 2-4 \mu\text{m}$) and pimpules ($2-3 \mu\text{m} \times 2-3 \mu\text{m}$); no micrasters (Roonwal and Rathore 1978, Roonwal, Verma and Thakur 1979, and Roonwal 1983). In both wings the roots of principal veins lying within the basal scale. Sc short, R 4-branched, Rs. 6-branched, M 3-branched, Cu with 4 main branches, anal absent. Hindwing generally like forewing. Cerci one-jointed, small, subconical,

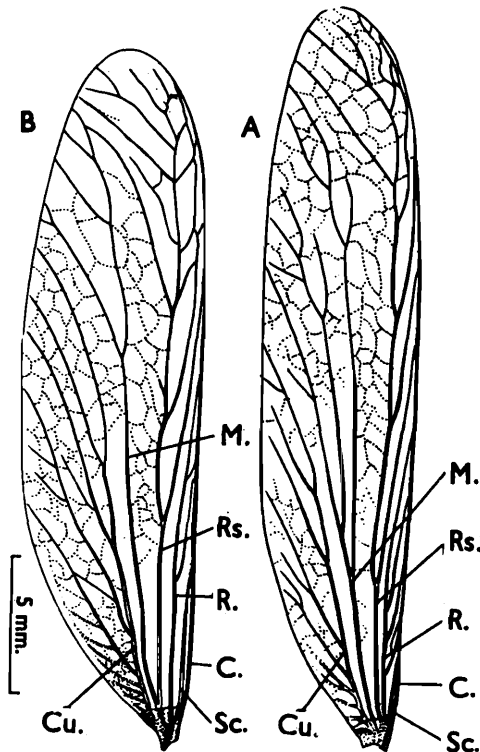


Fig. 7. *Anacanthotermes macrocephalus*. Wings. (A) Forewing. (B) Hindwing. C., costa; Cu., cubitus; M., media; R., radius; Ra., radial sector; Sc., subcosta. (After Roonwal and Bose, 1964).

0.28-0.30 mm long. Styli short one-jointed, 0.08-0.10 mm long, present in both sexes.

SOLDIER (Fig. 8 and Table 2) : Sparsely pilose. Head yellow to brownish yellow. Total length with mandibles 10.0-16.7 mm. Head subsquarish, slightly longer than broad (length to lateral base of mandibles 3.00-4.90; maximum width 2.70-4.56 mm); broadest posteriorly, posterior margin rounded. Fontanelle absent. Frons either smooth or only weakly wrinkled. Eyes small, subcircular. Ocelli as small subround spots. Antennae with 25-31 segments; segment 1 longest; 2 about half of 1; 3 subequal to 2; 4 smallest. Anteclypeus a narrow, trapezoidal, apilose, hyaline strip. Postclypeus not well differentiated; with a few hairs anteriorly. Labrum broad, subrectangular; much broader than long; with several hairs on anterior part and on body; anterior angles rounded; anterior margin substraight, with a slight median depression. Mandibles long, stout incurved at apex; each with two large marginal teeth. Postmentum club-shaped, broadest in anterior third; anterior margin substraight to wavy; posterior margin straight to weakly convex. Pronotum weakly saddle-shaped; much broader than long (width 1.82-3.25, length 0.98-1.80 mm); anterior margin convex, with a weak median notch; posterior margin convex, with a strong median notch; a few hairs on margins and body. Mesonotum much broader

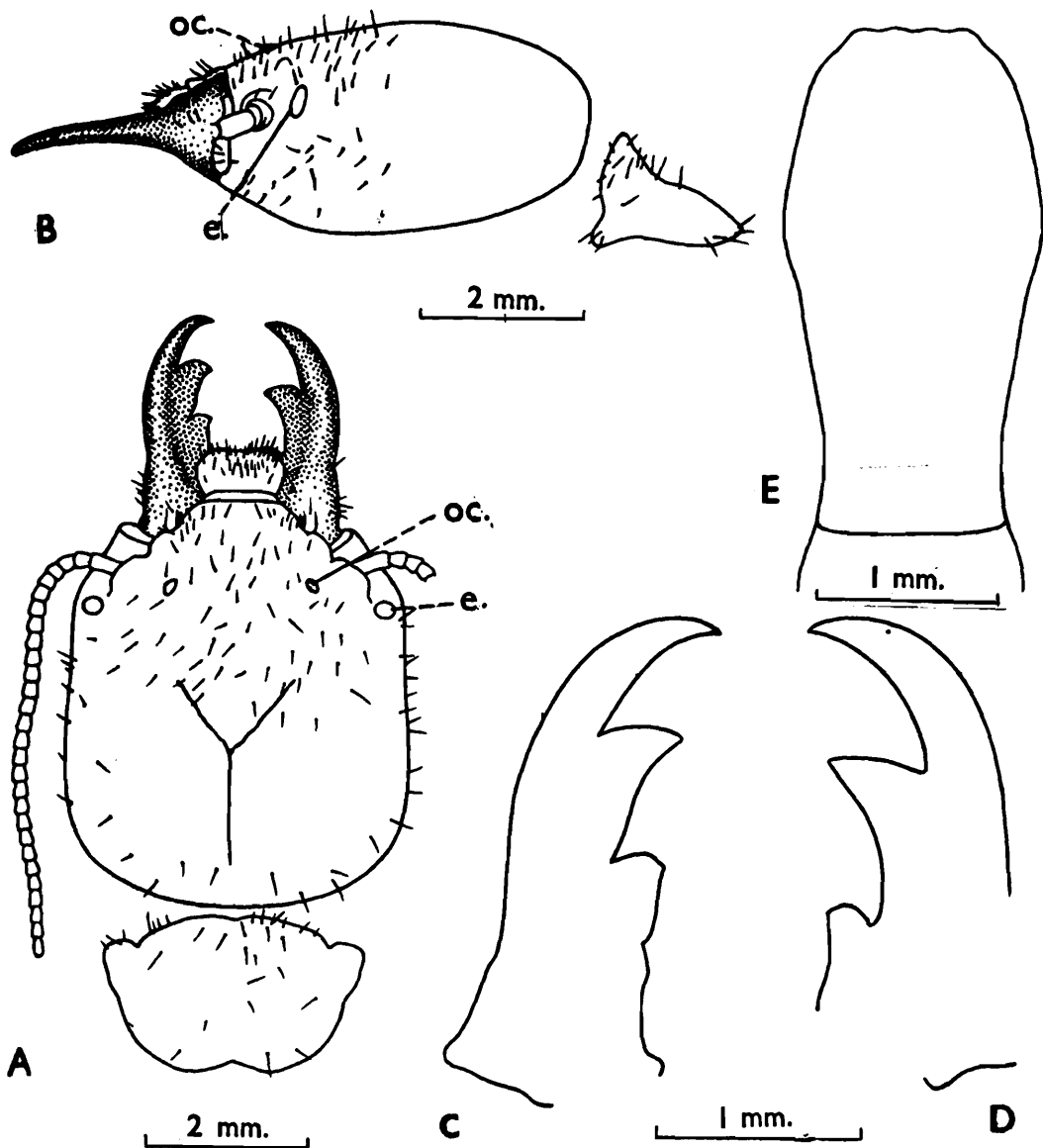


Fig. 8. *Anacanthotermes macrocephalus*. Soldier. (A) Head and pronotum, in dorsal view. (B) Same, in side view. (C) Left mandible. (D) Right mandible. (E) Postmentum. e., eye; oc., ocellus.

than long; sides straight; posterior margin slightly convex. Metanotum with straight sides; posterior margin weakly convex. Legs long, stout, sparsely pilose; tarsi 4-jointed; apical tibial spur formula 3 : 4 : 4. Cerci short, one-jointed, 0.18-0.25 mm long. Styli short, one-jointed. 0.10-0.15 mm long.

WORKER (Fig. 9 and Table 3) : Head brownish yellow. Total length 6.1-10.6 mm. Head subsquarish, somewhat broader than long (width 1.6-3.3, length 1.4-2.9 mm); epierianial suture present. Fontanelle absent. Eyes round, moderately large (diameter ca 0.4 mm). Ocelli very small. Antennae with 25-31 segments; 5 smallest. Anteclypeus rather small; postclypeus very narrow, not always distinct. Labrum and mandibles as in imago. Pronotum much narrower than head; sparsely pilose, subtrapezoidal, strongly convex

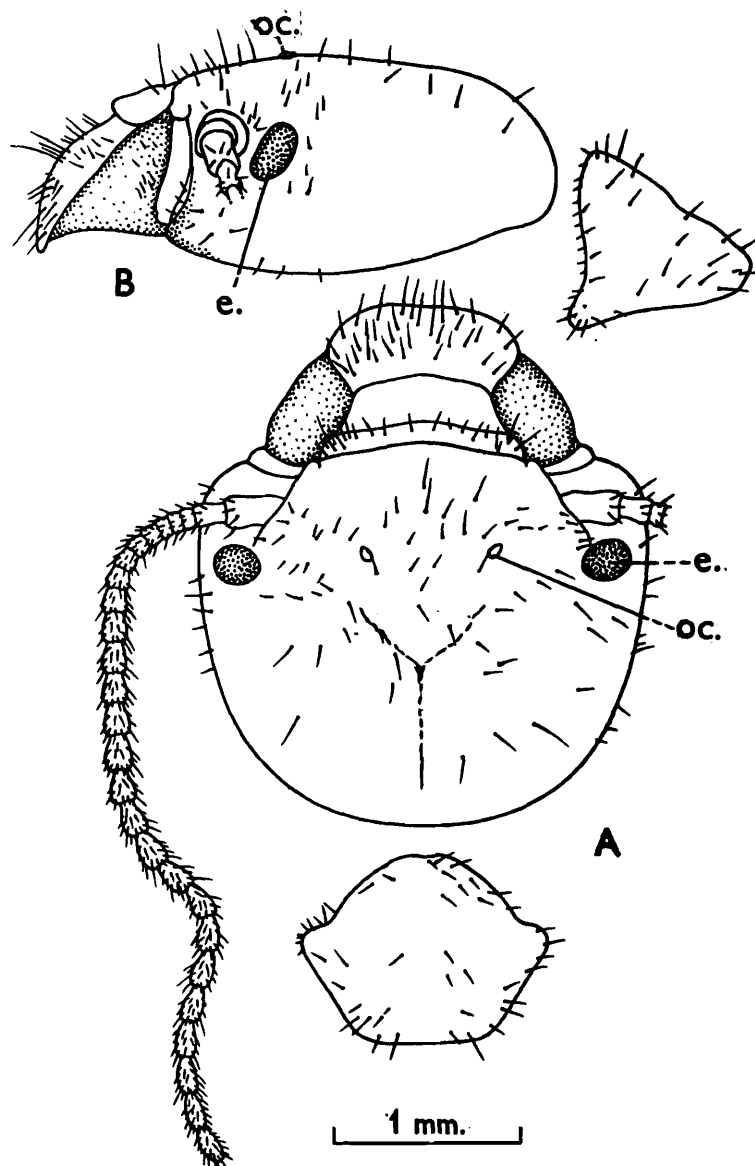


Fig. 9. *Anacanthotermes macrocephalus*. Worker. (A) Head and pronotum, in dorsal view. (B) Same, in side view. e., eye; oc., ocellus.

anteriorly; much broader than long; anterior margin strongly convex, with a weak median notch; posterior margin substraight without a median notch. Mesonotum narrower than pronotum; much broader than long, with a few rows of hairs near the convex posterior margin. Metanotum much broader than long; with rows of hairs near posterior margin. Legs long, slender; tarsi 4-jointed; apical tibial spur formula 3 : 4: 4. Carci short, (0.15-0.20 mm long, faintly 3-jointed vide Gupta 1962b) Styli short, one-jointed, 0.13-0.15 mm long.

Types, etc. : Of *A. macrocephalus* : Cotypes (an imago, a soldier and worker, in the American Museum of Natural History, New York), examined; Karachi (Sind), *T.R. Bell* coll. Cotypes also probably present in

Institute Royal des Sciences Naturelle de Belgique, Brussels. *Type-locality* : Karachi (Sind, Pakistan), as restricted here.

Of *A. peshawarensis* : Holotype (soldier) in Zoology Department, Punjab University, Lahore. *Type-locality* : Peshawar.

Geographical distribution (Fig. 2) : The desert parts of Western India (W. Rajasthan, east to Borunda, ca. 26-20 N. lat., and 73.13 E long., ca. 70 km east of Jodhpur; south to Bhuj area (Kutch-Bhuj, Gujarat), and west to nearly the whole of Pakistan (Punjab, Sind, Baluchistan, N.W.F.P.) and SE Afghanistan (Kandhar, etc.). Details are as follows :-

INDIA : The desert area in Western Rajasthan (east-up to Borunda, ca. 70 km E of Jodhpur) north to Bikaner and south up to Bhuj in Gujarat, thus: *Rajasthan* : Districts of Bikaner (Bikaner, Lalgah, Shivbari, Bikaner-Gajner Road); Jaisalmer (Jaisalmer and vicinity, and 28 km on road to Josirasar, Badebagh); Barmer (Lalyanpur, Bhap, Pachpadra, Balotra, Mevanagar); Jodhpur (Jodhpur and vicinity, Kailana, Pratapsagar, Salawas, Satlana, Sangania, Rohila, Beriganga, Mathania, Tiwari (Teori), Bjimsar tank, 5 km from Mathaida, Norwa, Arnaji, Agolai, Bilaspur, Borunda ca. 70 km E of Jodhpur). *Gujarat* : Kutch-Bhuj area (Chadva, 26 km from Bhuj).

PAKISTAN : Almost the whole of Pakistan, as follows : *Baluchistan* : Quetta, Sharia, Chaman, Pishin, Pasni (on coast). *Sind* : All over, both upper and lower Sind (Bell in Desneux 1906), Karachi and vicinity, Hyderabad, near Badin ca. 150 km SE of Hyderabad. *Punjab* : Districts of Montgomery (Dipalpur), Shahpur (Sargodha) and Mianwali (Mianwali); Miranpur. *N.W.F.P.* : Peshawar (*A. peshawarensis*).

AFGHANISTAN : SE part (1045-1240 m); Char Safa between Kolat and Kandahar; Kandahar; Kadjhakai, 70 km N of Gureck; and Arghandah, 22 km N of Kandahar.

Note : The records of Bugnion (1914) and, following him, of Rattan Lal and Menon (1953), from Sri Lanka are incorrect. The record of the genus from "north-east India", by Harris (1961, p. 49) is also an error.

Biology, etc.

(Figs. 10-20; and Pla. I-IV)

The external morphology of *A. macrocephalus* has been described by Gupta (1959, 1962a, b) and the abdomen and genitalia by Roonwal (1984). Awasthy (1973) has studied its neuro-endocrine system (he has erroneously assigned the species to the family Termitidae). Wing microsculpturing has

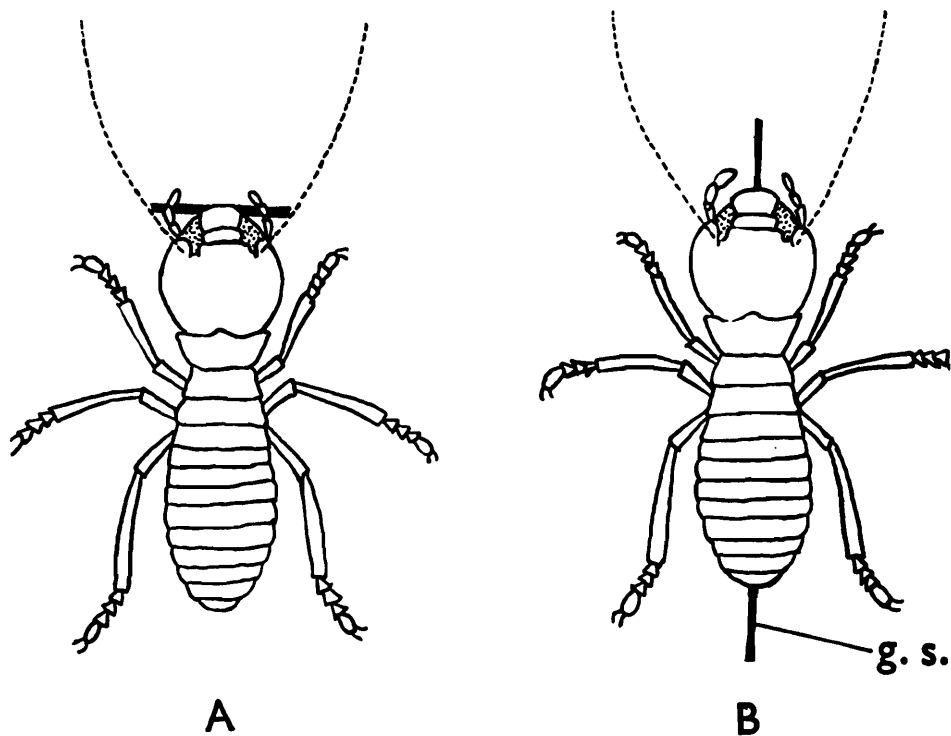


Fig. 10. *Anacanthotermes macrocephalus*. Foraging workers. (A) Normal method of carriage (horizontal) of foraged plant material when it is not too long. (B) Longitudinal carriage, when the plant material (a grass stem, etc.) is too long; this method is for ease of carriage and also facilitates entry into the entrance holes of the colony. g.s., grass stem. (After Roonwal, 1975b).

been examined by Roonwal and Rathore (1978), Roonwal, Verma and Thakur (1979) and Roonwal (1983b, c). Considerable work has been done on its biology and ecology, mainly by Gupta (1959) and Roonwal and coworkers (1970-1983).

Sexual dimorphism :

There is a wide range of body-size variation in all castes, especially in soldiers and workers, and the separation into minor and major soldiers as claimed by Ahmad (1955) does not exist. On the basis of 200 soldiers, Gupta (1962a) obtained a unimodal distribution curve in respect of total length with mandibles (range 10.0-16.7 mm, greatest concentration, 57.5%, within the range 13.00-14.99 mm); and similar results for all castes were obtained by Roonwal (1975b) in respect of maximum head-width with eyes (soldiers 2.70-4.56, workers 1.8-3.3, imagoes 2.70-3.40 mm).

A limited degree of sexual dimorphism is noted in freshly swarmed imagoes in respect of the maximum width of abdomen which is significantly greater in females (mean females 3.95 ± 0.07 mm) (Roonwal 1975b, d). In addition, there is, of course, the well known difference in the size of the

seventh abdominal sternum which is larger in females than in males (Roonwal 1984). In total length (without wings) (12.43-14.34 mm) and in wet body-weight (47.0-59.8 mg) in freshly swarmed imagoes there is no significant difference between the sexes (Roonwal and Rathore 1972).

Weight and moisture content : These have been studied by Roonwal (1975b), and are as follows :

	Soldiers	Workers	Imagoes (freshly swarmed)
Wet weight (mg)	15.1-70.9	8.6-36.5	47.0-59.8
Dry weight (mg)	5.4-21.7	2.4- 6.7	—
Moisture (absolute, mg)	7.6-53.0	6.2-29.8	—
Moisture (absolute, %)	50.3-78.7	72.1-85.1	—

Soldiers are larger in size and about twice as heavy (wet weight) as workers. Freshly swarmed imagoes, on the other hand, are only about 15% heavier than soldiers and about two-and-a-half times heavier than workers. The difference between soldiers and workers is even more pronounced in dry weight, the former having about three-and-a-half times the dry matter of workers. This difference is evidently due to the soldiers possessing larger quantities of relatively dry matter such as the thick head cuticle and the massive mandibles. Soldiers hold about twice the *absolute* amount of water as workers. But in the percentage content of water (in relation to weight) the two castes approximate, and workers (78.3 %) have only about 6% more water than soldiers (72.39 %).

In both size and weight, the non-reproductive castes (soldiers and workers) show much greater variability than imagoes, but this enhanced variability has not produced any polymorphism as, for example, in another desert termite, *Psammotermes rajasthanicus*, where soldiers are trimorphic (Roonwal, in press).

Sex ratios :

The sex ratio in swarming individuals varies from 53.5-68.0% in males and 32.0-46.5% in females. Chi-square tests show that males predominate slightly over females in the proportion 9: 7.7 (Roonwal and Rathore 1972). Both equal and unequal sex ratios (with either sex predominating) occur in termites, and some authors have attributed a selective value to unequal sex ratios (for a review, vide Roonwal 1975d).

Habitat (Plate I) :

Its habitat in Western India and Pakistan is characterised by hot, dry condition, with high summer temperatures (mean above 34° C) and cold or very cold winters (mean below 18° C). But at the western extremity it also occurs in areas of high humidity (e.g. Pasni on the Mekran Coast). As a whole the species is confined to a belt characterised by average winter (January) isotherms of 10° - 20° C and average summer (July) isotherms of 30° C, though actual temperatures may go well below zero degrees in winter (Jaisalmer, Quetta, Kandahar) and rise to about 50° C in summer. Aridity is probably more important than temperature as a factor in its biogeography. For instance, in Rajasthan, the species is restricted to the western third or arid zone (annual rain fall below 30 cm) and is absent from the semi-arid and wet areas further east. It also seems to have a preference for gravely or semigravely areas rather than sand dunes, but near the sea-shore it occurs among sand dunes which are consolidated by grasses and low bushes such as *Heliotropum*. It does not avoid even stony areas or salty soils. It lives in fairly deep and extensive underground galleries where it is protected from extremes of temperature and low humidity, and comes out for foraging during the cool hours.

It seems to undergo a seasonal vertical migration in the soil (Pal and Sharma 1971, western Rajasthan), In July they are found within a depth of 30 cm from the ground surface; in August and September they go deeper and occur mostly at about 60 cm depth from the surface; and in January (the coldest month) they are found only at a depth of about 90 cm.

Food and Foraging :

Food (Sharma, 1967, Roonwal 1975b, 1976, 1979, Parihar 1978-1980b) Plate II: It collects food during foraging excursions to the surface, and takes it back to the underground galleries where it is stored in small side chambers of varying sizes all along the gallery system (vide infra). The quantity so stored varies from chamber to chamber. Generally, the larger chambers have more material than the smaller ones, but some chambers may be empty. In the Great Indian Desert this stored food-stuff consists of stem pieces of grasses (*Cenchrus biflorus*, *C. ciliaris*, *C. setigerus*, *Lasiurus indicus*, *Aristida mutabilis*, *Cymbopogon jwaraneusa*, *Eleusine compressa* and *Dactyloctenium indicus*); stem pieces and bark of *Copparis decidua* and *Leptadenia pyrotechnica*, and bits and coats of the seeds *Zizyphus nummularia*, *Prosopis cineraria*, *P. juliflora* and other unidentified desert plants. In Sind and Baluchistan, besides wild grasses, *Heliotropum* and other

plants are eaten. It attacks wheat, maize and other food grains in storage (partly eating them and carrying some to the storage chambers) and also jute bags. Young *Prosopis* transplants and bark of mulberry, eucalyptus and willows are also attacked (Roonwal 1979, 1980). During the later part of the monsoon rains and the post-monsoon months, the stored plant bits are found mixed with the low earth mounds which the termite throws up and also in the large, trough-like cavity which is found just below the mound in the older colonies. This stuff presumably has been brought out from the storage chambers for drying and to prevent fungus growth (Roonwal 1975b).

Foraging : Foraging activity has been studied by Gupta (1959) and Roonwal (1975b). Foraging is a daily activity in which as a rule only the workers take part. For doing so, they emerge in numbers from tiny holes in the ground surface which mark the termite area. Occasionally, a few soldiers also emerge but apparently for guard duty only. When the foraging party is disturbed, the workers start streaming in frantically, and if soldiers are out nearby, they take up positions around the entrance hole; when most of the foraging workers have gone in, the soldiers also enter. Sometime two streams of foraging workers are met with - those coming in and those emerging from the hole for foraging.

Foraging takes place in the close vicinity of the exit holes, usually within 10 or 15 cm, occasionally up to 40 or 50 cm, depending upon the proximity of the food bushes. In hot summer months, foraging occurs during the cool night period, beginning about 9 or 10 P.M., and may continue in spurts from different exit holes, throughout the night and in the early morning. With the arrival of the summer monsoon rains in late June or early July, the atmospheric temperature declines, and foraging now begins earlier, starting at dusk; and on cloudy days and in winter months it occurs during daytime. There appear to be two types of foraging the quick, frenzied type and the leisurly type. In the former type, which lasts for 10 or 15 minutes, a few workers, about 10 or 20, emerge from an exit hole and move quickly to the nearby bushes. A worker may pick up in its mouth some food-stuff (a seed, a tiny bit of wood or a thorn) lying on the ground and return to the exit hole at a run; or it may climb a low bush or grass stem, cut a small bit of dry or semi-dry stem (soft green stems are not cut as a rule), and return quickly to the hole. For cutting the worker gets hold of a stem with the mandibles and goes round it, neatly biting off the bit. In the leisurly type of foraging, more workers are involved and the process may last an hour or so. Two modes of carrying the stem-piece in the mouth have been observed (Fig. 10), short bits are carried horizontally, while long bits are carried longitudinally between

the legs. At the mouth of the hole a few *duty workers* are waiting for the foragers. If the load is short the duty workers let the forager in quickly; but if it is long and cannot be taken in easily, the duty workers immediately take it off from the forager and push it in. The forager, now free of its inconvenient load, then moves in easily. When all the foragers are in, the duty workers also move into the hole and close it from the inside, with wet earth moulded into clods with their mouth-parts and saliva. The closing process may sometimes begin before all the foragers are back, and the returning foragers have to struggle in. To assist them, the duty workers may temporarily *reopen* the hole, and soon, when all the foragers are in, the entrance is finally sealed in 15 or 20 second, after which all is quiet again at the surface. (Roonwal 1975b).

Underground Galleries and Surface Mounds :

Underground galleries (Figs. 11-13) : *A. macrocephalus* lives in underground colonies, and their presence is marked by numerous hardly visible, small, round (diameter ca. 5-8 mm) exit holes scattered widely, and a number of small but conspicuous, conical mounds or earth heaps which cover some of these holes. The exit holes are also normally closed with earth and are opened only to let the foraging workers out.

A nest or colony (Bell in Desneux 1906, in Sind) consists of a succession, of groups of low, horizontal, flat, chambers, one below the other, but not necessarily immediately above each other; a group of chambers is spread over an area of about 4 square metres. Often there are two or three such chambers, one leading off the other, at the same level. The total depth of a nest may reach about two metres. Many of these numerous chambers, which are of all shapes and sizes, are filled with stored food material (cf. the storage chambers along the tunnels) and also contain many soldiers, workers and winged imagoes and a few larvae. Further down, many more such groups of chambers are found, along with more larvae, but there are no imagoes or stored food-stuff. Finally, the bottom chambers of the nest contain eggs and larvae. The lower earth strata are damp and sticky. Usually, a nest is built in relatively soft soil, but sometimes it may be found in mud flats and in sand-stone hills as well. The underground galleries in the latter case usually run in the crevices between stone slabs, but sometimes the tunnels are excavated for short lengths in the stone itself.

From the nest, narrow galleries lead horizontally in several directions and, after running for short or long distances, open on the ground surface by means of tiny, round holes. The galleries are subcylindrical (diameter 5-10 mm) and vertically slightly flattened; run zig-zag about 20-80 cm

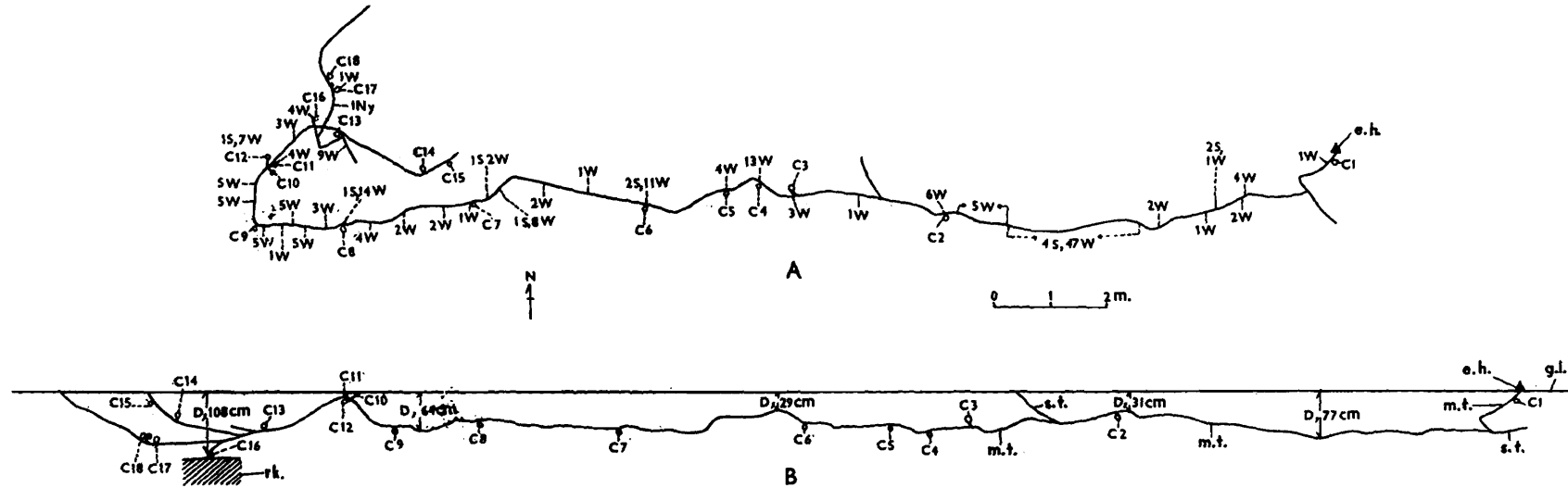


Fig. 11. *Anacanthotermes macrocephalus*. (Mathania near Jodhpur). Subterranean galleries. Diagrammatic. Length of excavated gallery ca. 28 m; diameter 5-7 mm; maximum depth from ground-surface 108 cm. (A) Surface view from above; (B) In vertical section. C1-C18, storage chambers; D, Depth from ground-surface; e.h., mound (earth heap); g.l., ground-level; m.t., main tunnel or gallery; rk., rock; S, soldiers; s.t. side tunnel; W, workers. (After Roonwal, 1975b).

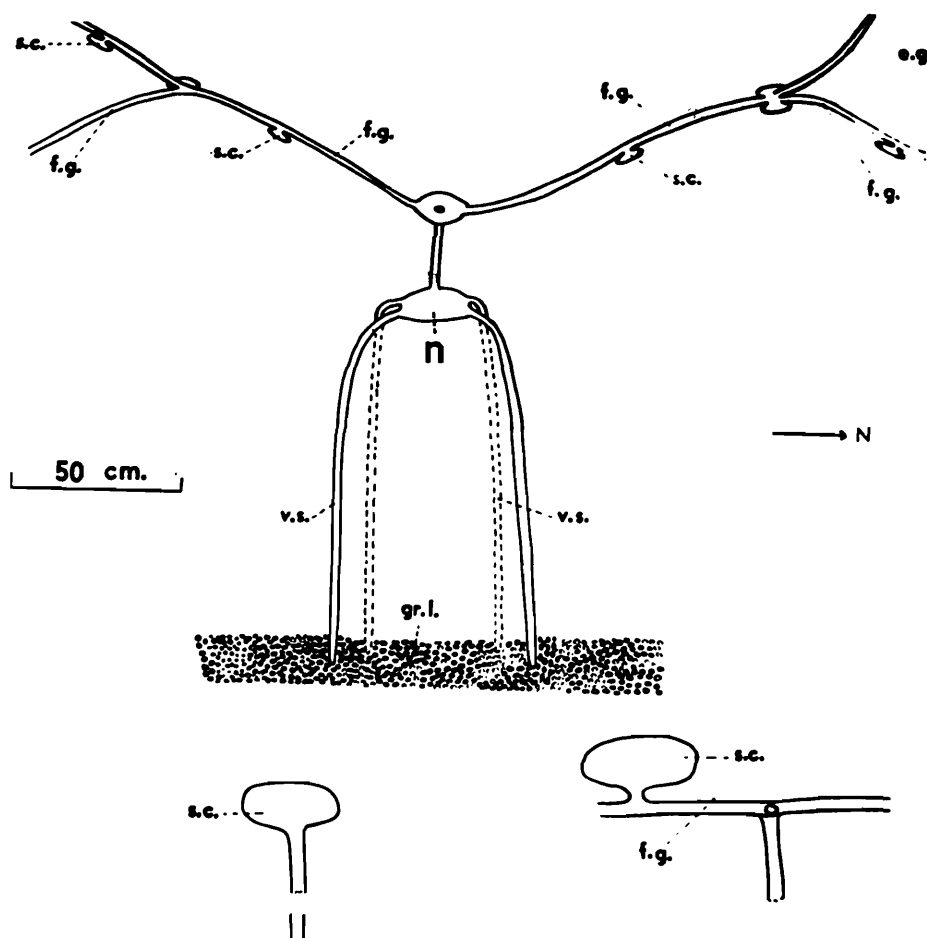


Fig. 12. *Anacanthotermes macrocephalus*. (Bikaner.) A part of the gallery system (main figure), with vertical shafts. Two smaller figures below: storage chambers enlarged. Diagrammatic. e.g., "exploratory gallery"; ex.h., exit hole; f.g., "foraging gallery"; g.l., ground-level; gr.l., layer of gravel; n, the so-called "central nest" of Gupta (it is not a true nest, *vide* Text); s.c., storage chambers; v.s., vertical shafts. (After Gupta, 1959).

below the ground surface, and for long distances, 40 metres or more. In Sind, Bell (in Desneux 1906) mentioned the occurrence sometimes of a second horizontal gallery "always immediately beneath the superficial one" Occasionally, the galleries plunge down vertically for a metre or so; the shafts end blindly in a bed of gravel or rock and probably serve to tap subsoil moisture.

All along the length of the galleries, saccular, smooth-walled, rounded chambers of various shapes and sizes (2×3 cm to 7×12 cm) are to be found; they generally open into the gallery through a short neck. They lie along the gallery at irregular intervals varying from 25 to 320 cm, but are sometimes almost contiguous. The chambers are used for the storage of food material. In the galleries one comes across many workers and a few soldiers (the latter forming not more than about 10% of the population) moving about; an occasional larva is also met with.

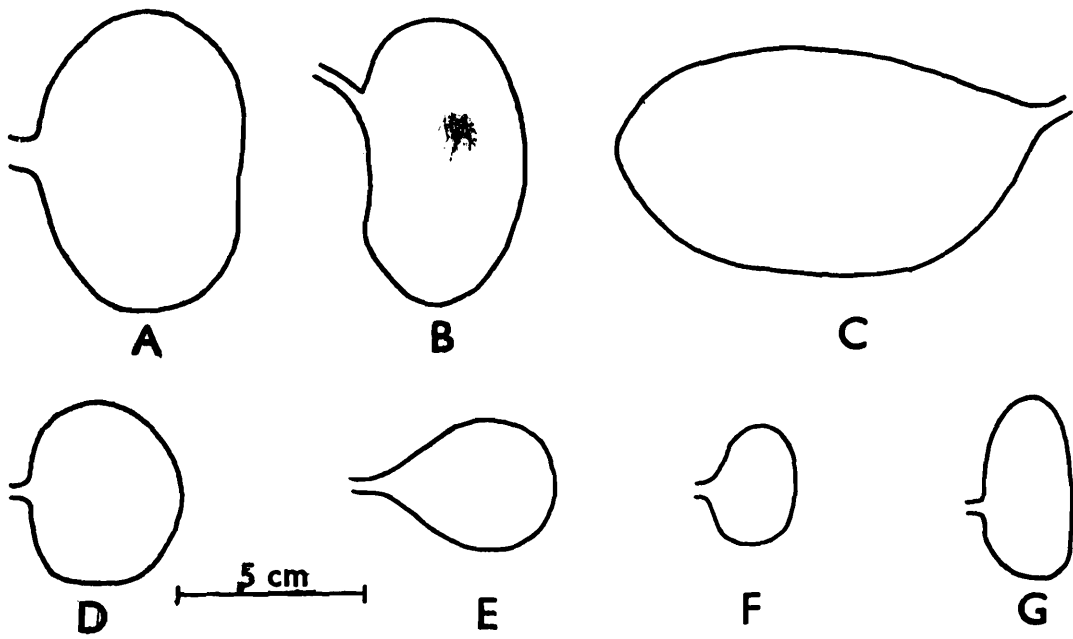


Fig. 13. *Anacanthotermes macrocephalus*. (Mathania near Jodhpur) Storage chambers along galleries in a single colony. Note size variation: diameter c 2 × 3 cm to 7 × 12 cm.

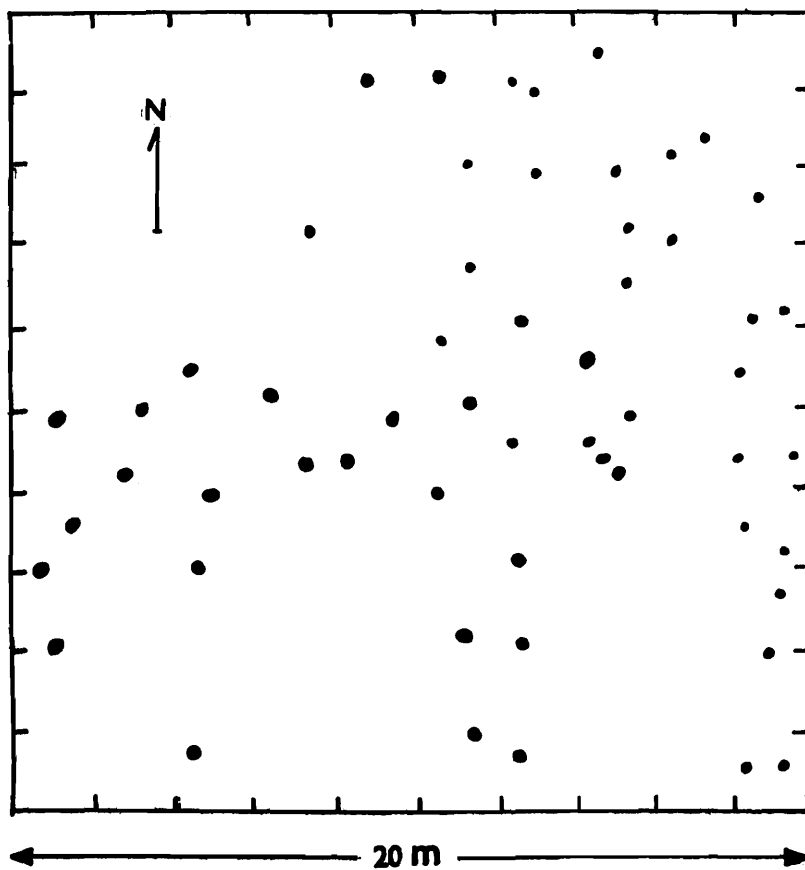


Fig. 14. *Anacanthotermes macrocephalus*. Distribution of mounds (solid circles) in a patch near Agolai village (Jodhpur District).

Mounds (Figs. 14-17: and Pls. I, III and IV) :

Many of the galleries open to the surface beneath low, conical mounds of excavated, granulated earth, the mound being topped with a small, cylindrical, compacted plug. Mounds vary in height* from quite small ones (early constructions to 25 cm (including the top plug) and a basal diameter of upto about 80 cm*; the base is irregularly subround. They are not random earth-heaps of excavated earth but discrete constructions with a simple but well defined architecture. During construction the mound height increases directly with the basal diameter, the Height/Diameter ratio varying from 0.14-0.71 in a straight line relationship.

Young mounds have two constituent parts, viz. the cone made up of loose earth globules and tiny stones; and the top plug which is a hardened, subcylindrical structure. The loose, conical part consists of two principal elements, viz. agglutinated earth globules of varying shapes and sizes (2 = 1.5 mm to 5 = 5 mm) composed of numerous tiny sand particles and a few tiny stones (also of varying shapes, sizes, 2 = 4 mm to 5 x 7 mm) and colours (translucent white, green, reddish, buff, etc.). The plug (height ca. 5 cm, diameter 1.5-2 cm) is a subcylindrical structure of hard, compacted earth globules of the same type as the cone. Its top is closed, and the inside may be solid or hollow. It usually lies at the apex of the cone, but occasionally it is found in the centre of the base. Sometimes a gallery leads into the plug from below but does not open to the outside. In larger and older mounds, the cone consists of a hardened central core and a loose outer mass. From the centre of the mound-base a small, round hole (diameter 6-12 mm) leads to the underground gallery system.

The volume and dry weight of the mound-earth of course increases with mound-size, as illustrated by the following figures :

Height	Basal diameter	Dry weight of earth
5 cm	12.5 cm	135 gm
32 cm	77 cm	2685 gm

Chemical analyses of mound-earth and the neighbouring subsoil showed a markedly higher proportion of water-soluble sodium salts in the mound-

*In the expressions in Roonwal and Bose (1964, p. 12) of mound height "60-150 cm" and basal diameter "100-150 cm", the "cm" is a misprint for "mm".

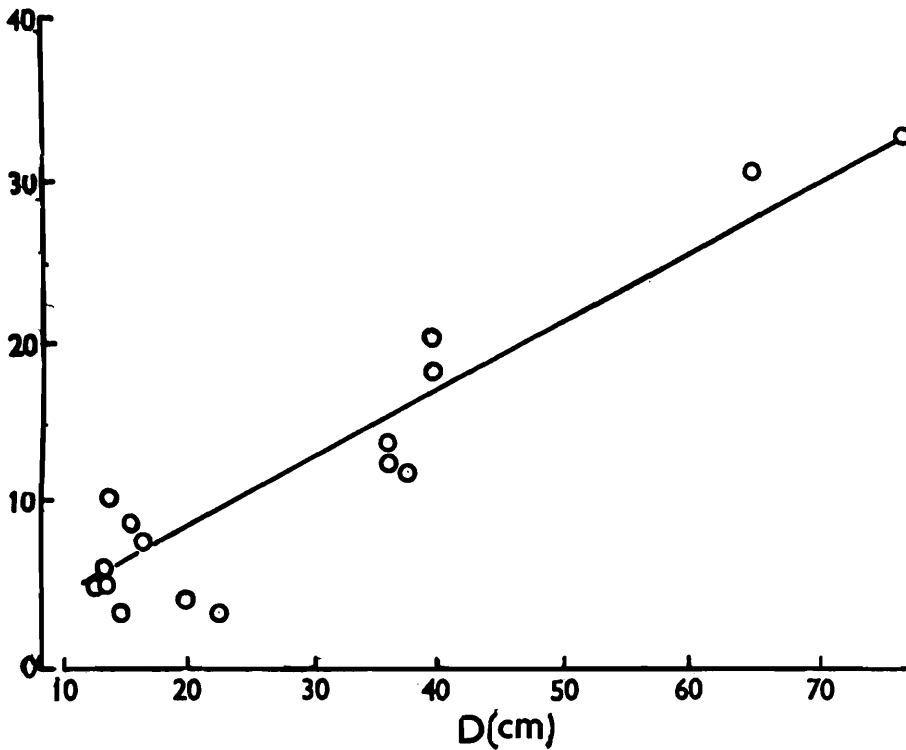


Fig. 15. *Anacanthotermes macrocephalus*. (Jodhpur District.) Graph showing relationship between height with plug (H) and maximum basal diameter (D) of mounds. (After Roonwal, 1975b).

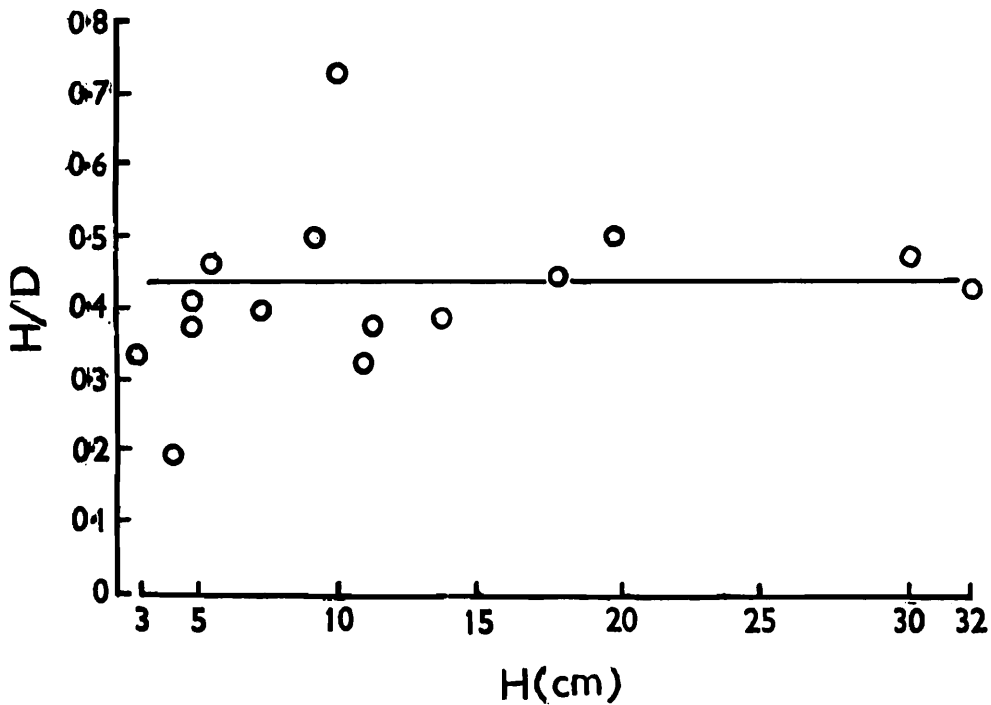


Fig. 16. *Anacanthotermes macrocephalus*. (Jodhpur District.) Graph showing relationship between height (H) of mound and the ratio Height/Maximum basal diameter (H/D)

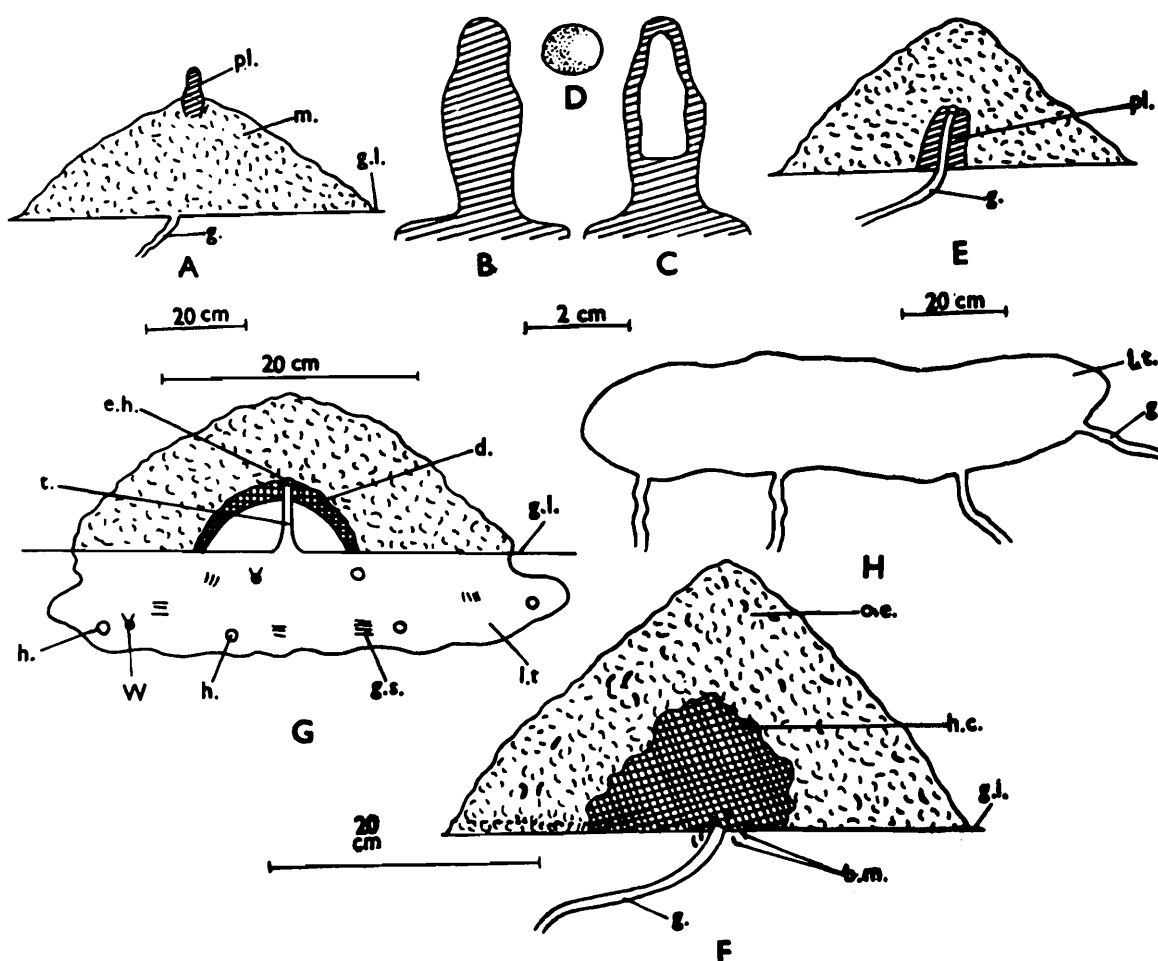


Fig. 17. *Anacanthotermes macrocephalus*. (Jodhpur District.) Mounds, showing variability (A) A mound in vertical section. Note the earthen plug at the apex and the underground gallery or tunnel below. (B) Earthen plug, from outside. (C) Same, in vertical section. (D) Entrance/exit hole of tunnel, at ground-level, in surface view. (E) Another mound in vertical section; the earthen plug is at the base. (F) A large mound (Mathania-Tewari Road) in vertical section, with a central hard core and blackish masses (? excreta) scattered about in excavated earth. (G) Another mound (Mathania-Tewari Road), with a central dome of hard earth; the main tunnel opens into a large, shallow trough immediately beneath the mound. (H) The large trough in Fig. G, in (b.m., small blackish masses (? excreta): d., dome of hard earth; e.h., entrance/exit hole; g., gallery; g.l., ground level; g.s., bits of grass stem; h.c., hard central earthen core; Lt., large, shallow trough; m., mound; o.e., outer loose granular mass of excavated earth; pl., earthen plug; W., workers). (After Roonwal, 1975b).

earth; values for potassium were inconclusive and no other differences were noticeable (Roonwal 1975b).

New mounds begin to be formed in late October and continue throughout the winter months, but enlargement of the older mounds continues throughout the year. The addition of fresh earth to a mound is

always noticeable by its darker colour due to wetness. The building of a new mound takes place as follows : An existing exit hole (diameter 6-10 mm; it is normally kept closed by means of earth clods) is first opened from the inside by workers. Then one by one in their mouth-parts they bring out, compacted, globular clods of earth (diameter 2 = 2 to 5 = 5 mm) which are wet with saliva, and place them around the edges of the exit hole to form a circular rim. More clods are brought up and placed on the rim, and gradually a *plug* takes shape. After a small plug has been formed, fresh clods are rolled over the rim and gradually, within a few days, a conical mound takes shape, and then grows in size week by week. As a rule, four or five workers take part in the process simultaneously. In the hot summer months the mound-construction activity begins in the later part of the night, about 3 or 4 A.M. When the soil surface becomes too hot, and construction work ceases, the workers move deeper into the galleries to avoid the heat. On cloudy days and in the winter months, however, construction activity can be seen even during day-time.

Swarming and breeding (Figs. 18-20) :

In the Great Indian Desert (Roonwal and Rathore 1975) swarming of winged reproductives occurs during the middle period of the monsoon months, in the first three weeks of August in the early part of the night, 8-30-11 P.M. In neighbouring Sind it occurs earlier, in the third week of July. Swarming is always preceded by heavy rain fall in the preceding 24 or 48 hours; actual swarming generally occurs in clear weather, but may also occur during a light drizzle (Roonwal 1976, 1983a). Alates are strongly attracted to light, and hundreds can be seen flying around electric lamps. After flying for an hour or so, they come down. Within a minute or two of landing, the alates shed their wings, leaving only basal stumps. The dealated individuals run about fast on the ground in an agitated manner and after one, two or several hours of this apparently aimless wandering, they tend to congregate in small groups of 15 or 20 individuals instead of forming pairs as in most other termites. Further behaviour was observed in breeding cages in the laboratory by releasing freshly swarmed individuals in the cages. Within two or three days, all the dealates had buried themselves under the cage soil by digging tunnels, the excavated earth being collected on the surface in small, conical heaps. Individual pairs separated in glass dishes quickly excavated a brood chamber in the soil and sat there quietly for hours. During the days which followed several such chambers (which were interconnected by narrow galleries) were excavated by the pair.

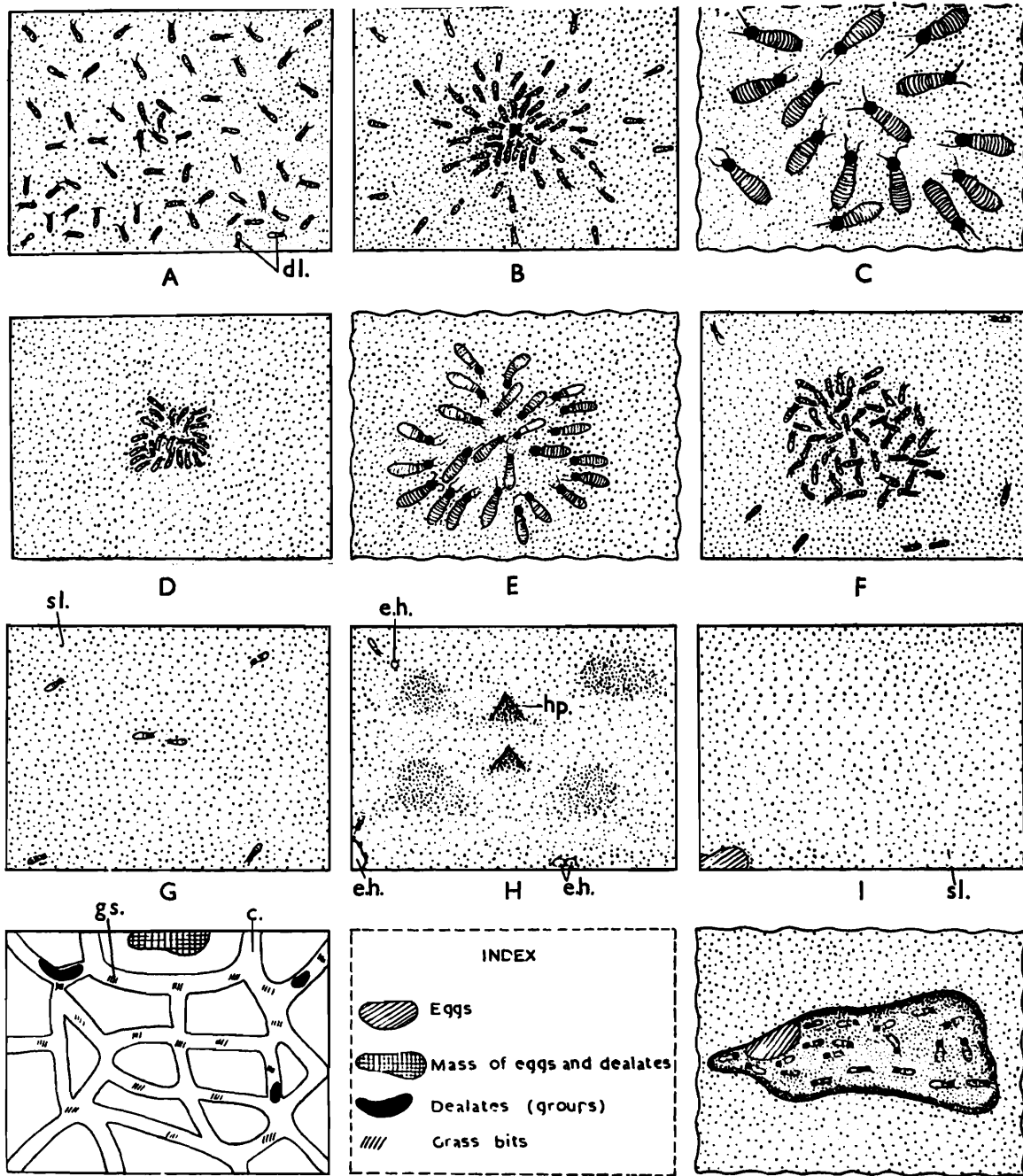


Fig. 18. *Anacanthotermes macrocephalus*. Post swarming activities of dealated imagoes (in cement breeding cages, ca. 25 cm × 35 cm, vide fig. J). From a swarm at Jodhpur, 18 August, 1972, 8.30 PM. (A) 2nd day; 56 dealates, released in cage 21 hours after swarming, wandering about. (B) Ten minutes later. Dealates congregate towards a single point (marked ×) and start digging. (C) Same as Fig. B; a part enlarged. (D) 4th day. Most dealates are already inside soil; the remaining few are digging in. (E) Same as Fig. D; a portion enlarged. (F) 5th day. Dealates have made tunnels (not shown in figure) beneath the soil and are continually going in and out; a few are again congregating in centre and are sitting quietly or moving about slowly. (G) 6th day. Most are again inside soil and digging tunnels; a few wander on the surface. (H) 8th day. Dealates have collected small heaps of excavated earth; most are now inside. (I) 11th day. All dealates are under soil. A →

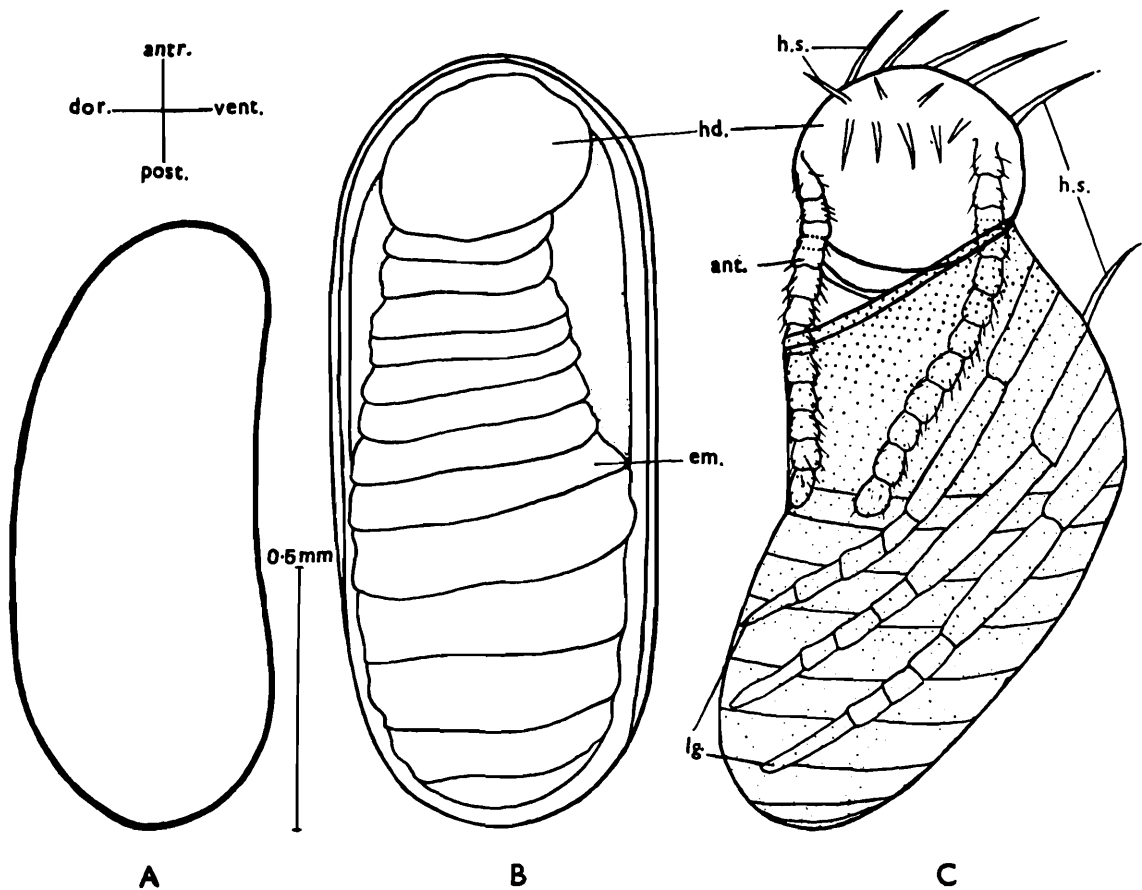


Fig. 19. *Anacanthotermes macrocephalus*. Eggs, from oviposition to hatching. (A) Outline of freshly laid egg. (B) Egg 16 days old, with the embryo seen through the translucent egg wall; the embryonic head is at the top. (C) Egg during the process of hatching; head and antennae are already partly out. (ant., antenna, antr., anterior; dor., dorsal; em., embryo; hd., head; h.s., hatching spines; lg., legs; post., posterior; vent., ventral). (After Roonwal and Rathore, 1975).

cluster of 13 eggs laid in one corner; a pair (a male and a female) found sitting near eggs. Several more batches of eggs are laid in the next few days. (J) 14th day (31 Aug.). Entire cage searched; Straw pieces found in small heaps. Eggs, now collected at a point near the edge of cage in a mass of about 150, with a group of 20 dealates huddled together nearby in the brood chamber. Other dealates have also gathered in small groups of 10-20 each. (K) Same as Fig. J. Egg masses, with associated dealates sitting in the brood chamber; enlarged. (c. channels on floor of cement cage; dl., dealates; e.h., entrance hole in soil; gs., pieces of straw; hp., heaps of soil excavated by dealates; sl., soil). (After Roonwal and Rathore, 1975).

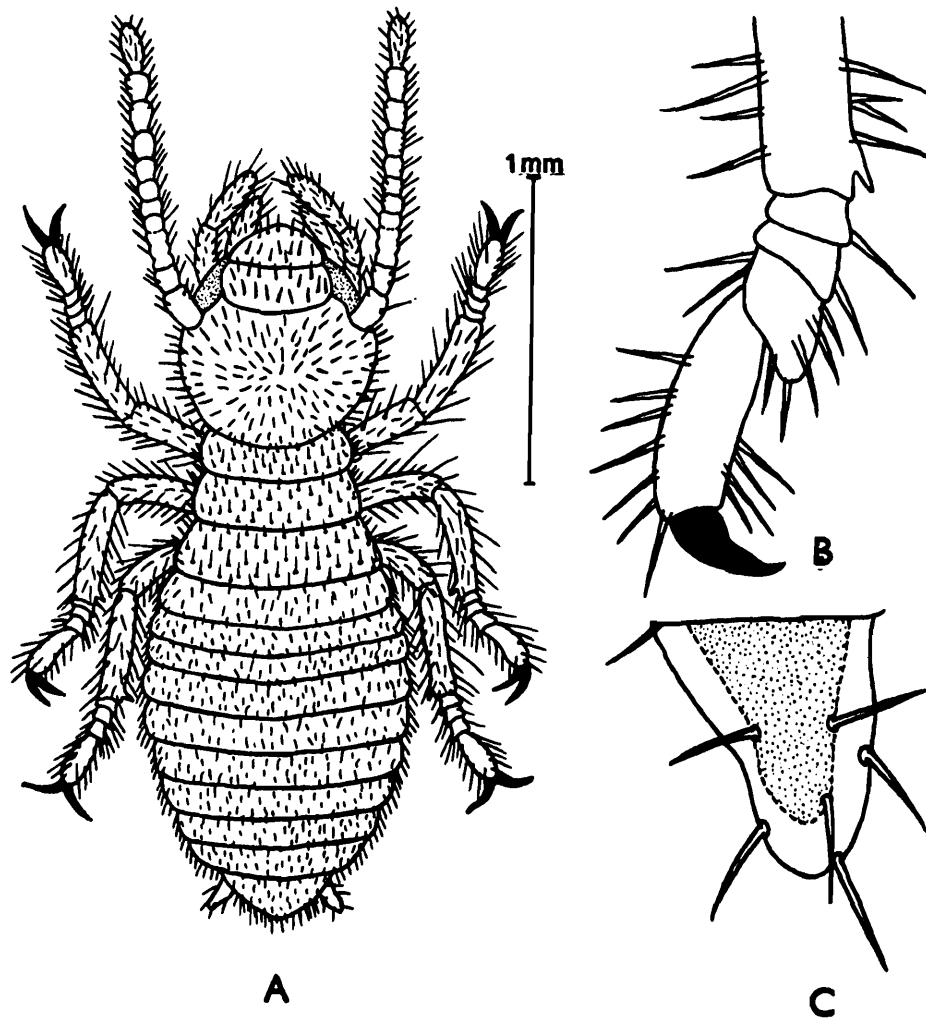


Fig. 20. *Anacanthotermes macrocephalus*. Freshly hatched larva. (A) Larva, in dorsal view. (B) Left foreleg, distal end, enlarged. (C) Left cercus, enlarged. (After Roonwal and Rathore, 1975).

The first batch of eggs is laid 10-16 days after swarming, a female laying 5-18 eggs. The second oviposition occurs 2-9 days after the first, a female laying 13 eggs (2 cases). After the two initial ovipositions, a rest period apparently intervenes, and no eggs are laid for about a month. In mass-breeding cages, eggs are collected in masses of upto 150 eggs which are lightly glued together and there is no brood care by individual pairs. The egg masses and several dealates are found together in large brood chambers where the dealates sit quietly for long hours, but occasionally come out to forage and collect the straw provided in the cage for food. When the dealates are disturbed, by striking the cage or simply by the ingress of strong light, they rush towards the eggs, each lifting an egg in its mouth-parts, and then wander about the cage in an agitated manner for a long time. When the disturbance ceases, the dealates return to the brood chamber and re-deposit the eggs in a heap.

Egg size and structure (Roonwal and Rathore 1979): The freshly laid egg is elongate-oval, with rounded ends; the outer surface is shiny, dirty white, with a brownish tinge dorsally. Its size is about 1.18 mm long and 0.52 mm in maximum diameter. With development, its size increases to about 1.42 = 0.63 mm, presumably by the imbibition of water, as occurs in several other insects.

The chorion covering the egg shows externally (presumably in the exochorion) a pattern of fine polygonal ridges which are well marked near the anterior and posterior ends, and fainter elsewhere. The micropylar apparatus is of the "diffuse type" and consists of a scattered group of 11-15 micropylar canals in the middle portion of the convex dorsal surface of the egg. Each micropyle consists of a complete suboval funnel (minimum and maximum diameters 9-12 μ and 10-13 μ , respectively) and a posteriorly directed, tubular canal (length 13-16 μ , width at base 3 μ , the canal narrowing as it penetrates deeper into the egg). Besides these, there are also present one or two suboval structures, the pseudomicropyles, (diameter 11 \times 16 μ), of the same size and shape as the micropyles proper but devoid of canals.

Termite eggs have been grouped, on the basis of the ratio Maximum Width/Length, into three phylogenetically significant categories, viz., narrow; medium and broad, the width increasing in the more highly evolved families. The eggs of *A. macrocephalus* belong to the 'medium' category, the Width/length ratio being 0.44 (as against 0.39 and below in the narrow category and 0.45 and above in the broad category) (Roonwal 1975c).

Hatching occurs during the second half of September (19th-29th), the incubation period of eggs being 23-26 days. About a day before hatching, the embryo shows peristaltic movements in the thoracic and neck regions, the waves running forward (posteriorly to anteriorly), each wave being repeated at intervals of about 30 second. Under the pressure so mounted, the head bursts out of the egg-shell at the anterior end of the egg. The process of egg-wall rupture is assisted by the long 'hatching spines' present on the head and thorax. The peristaltic waves continue, and the embryo remains in this half-emerged position for several hours before the entire body slowly wriggles out of the egg-shell.

The first stage larva is pure white in colour and is about 2.5-3 mm long. The body is covered all over with numerous small hairs which are much longer on the legs and cerci than elsewhere; there is now no trace of the hatching spines. The antennae have 13 segments, but segments 3, 4 and 5 are not yet fully differentiated.

Protozoa in the alimentary canal :

The following flagellate has been found in the alimentary canal of *A. macrocephalus* (vide Kirby 1932, 1944) :

Order Hypermastigida
Trichonympha turkestanica Bernstein

3. *Anacanthotermes vagans* (Hagen)

(Figs. 21-23; and Tables 1 & 2)

1. *Hodotermes vagans* Hagen :

1858. Hagen, *Linn. Ent.*, 12 : 88, Im., W. Pl. 2, figs. 18 and 19 (Im.). South Iran: Shiraz; and Karak Is. in Persian gulf.

1923. Silvestri, *Trans. ent. Soc. Lond.*, 1923: 261. Raz, NE of Baghdad (Iraq).

2. *Hodotermes (Anacanthotermes) vagans* Hagen :

1905. Jacobson, *Ann. Mus. Zool. Akad. imp. Sci. St. Petersburg*, 9 (1904): 66.

1911. Holmgren, *K. Sv. Vet. Akad. Handl.*, 46 (6): 43.

3. *Anacanthotermes vagans* (Hagen) :

1949. Snyder, *Smithson. misc. Colls.*, 112 : 63. Persia.

1967. Harris, *Proc. R. ent. Soc. Lond.*, 36 (5-6) : 80, 83-84.

1958. Weidner, *Ent. Mitt. zool. Staatsinst. u. zool. Mus. Hamburg*, No. 17 : 6-8. Iraq.

1960. Weidner, *Abt. u. Verh. naturwiss. Vereins Hamburg*, (N.F.) 1 (1959) : 45, 49-53. Iraq, Iran, Afghanistan.

1962. Mathur and Thapa. *Indian Forest Leaflet*, (Ent.), Dehra Dun, No. 167: 4. Afghanistan.

1970. Harris, In *Biol. of Termites* (Eds. Krishna and Weesner), Vol. 2 : 301.

1972. Chaudhry and Ahmad, *Termites of Pakistan, etc.* : 11 Pakistan (Baluchistan)

1974. Akhtar, *Pakistan J. Zool.*, 6: 90. Pakistan.

1979. Akhtar, *Biologia* (Lahore), 25: 161-162.

1983. Chhotani and Bose, In *Fauna of Saudi Arabia* Vol. 5: 122-123.

1984. Weidner, *Anz. Schadlingskd.*, 57: 4-6. Distribution.

Descriptions based on Hagen (1858) and Weidner (1960).

IMAGO (Fig. 21 a-c; and Table 1) : Head and thorax brownish red, venter and legs paler; antennae and labrum pale yellow; clypeus whitish; wings greyish yellow, not transparent; veins of costal field reddish yellow. Total length with wings 24-26, without wings 11-13 mm; wing expanse 42 mm. Head large, round, slightly narrowed near eyes; epicranial suture

well marked, no transverse grooves in front of the suture, but area between eyes irregularly and shallowly rugose; length to mandible-base 2.37-2.54, maximum width 2.8-3.07 mm. Eyes black, well developed, straight in front, round behind; maximum diameter 0.47-0.59 mm. Ocelli present as round fairly large, yellowish spots well raised from the surface (interpreted by Weidner as 'antennal spots'). Antennae thin, shorter than head, with 24-27 segments, mostly 25; segment 1 longest, 2 as long as wide, 3 smallest, ring-like (but in 26-segmented antennae, 3 is longer than 4). Labrum rounded, almost circular. Pronotum narrower than head (2.05-2.33 mm wide), width about twice the length; anterior margin of the bent front half strongly convex; sides narrowing posteriorly; posterior margin with distinct median notch. Legs with no lateral spines. Wings long and narrow; reticulated. Forewing (length 20-23, width 4.2-4.8 mm) with short Sc; R reaching the middle of C, and giving 2 or more branches; Rs with 5 branches to C and 3 to M; M with 2 main branches; Cu with 9 branches; anal absent. Hindwing almost like forewing; a weak anal present. Abdomen ovoid, somewhat wider than thorax. Cerci small, conical. Styli very small, smaller than cerci, present in both sexes.

SOLDIER (Fig. 21 d, e; and Table 2) : Head reddish brown, smooth, with a few hairs; mandibles blackish; antennae, labrum and pronotum reddish yellow; rest yellowish white. Total length with mandibles ca. 14 mm; size varies considerably. Head subrectangular, with rounded posterior margin (length with mandibles 4.6-6.5, to base of mandibles 2.44-2.91, maximum width 2.50-3.78 mm); epicranial suture well marked. Eyes blackish, well marked, but smaller than in imago; with front margin substraight; length about twice the width; Ocelli small, rounded, raised from surface (Weidner interprets them as 'antennal spots'). Mandibles large, straight but incurved and pointed near apex (length of left mandible 2.5 mm); with two large, pointed marginal teeth. Labrum large, subrectangular, narrowing posteriorly. Clypeus strip-like. Antennae thin, shorter than head; number of segments not known (but in his figure, Weidner shows a *broken* antennae with 22 segments). Postmentum band-like, with subparallel sides only very weakly incurved (cf. *A. macrocephalus*, etc.) Pronotum a little narrower than head; weakly saddle-shaped (the anterior end being upcurved); anterior margin strongly convex, not notched; posterior margin not notched. Abdomen translucent, with the gut contents showing through.

WORKER : Head orange; rest pale reddish yellow; eyes and mandibles darker. Total length 6-10 mm. Head rounded, almost ovoid. Eyes dark

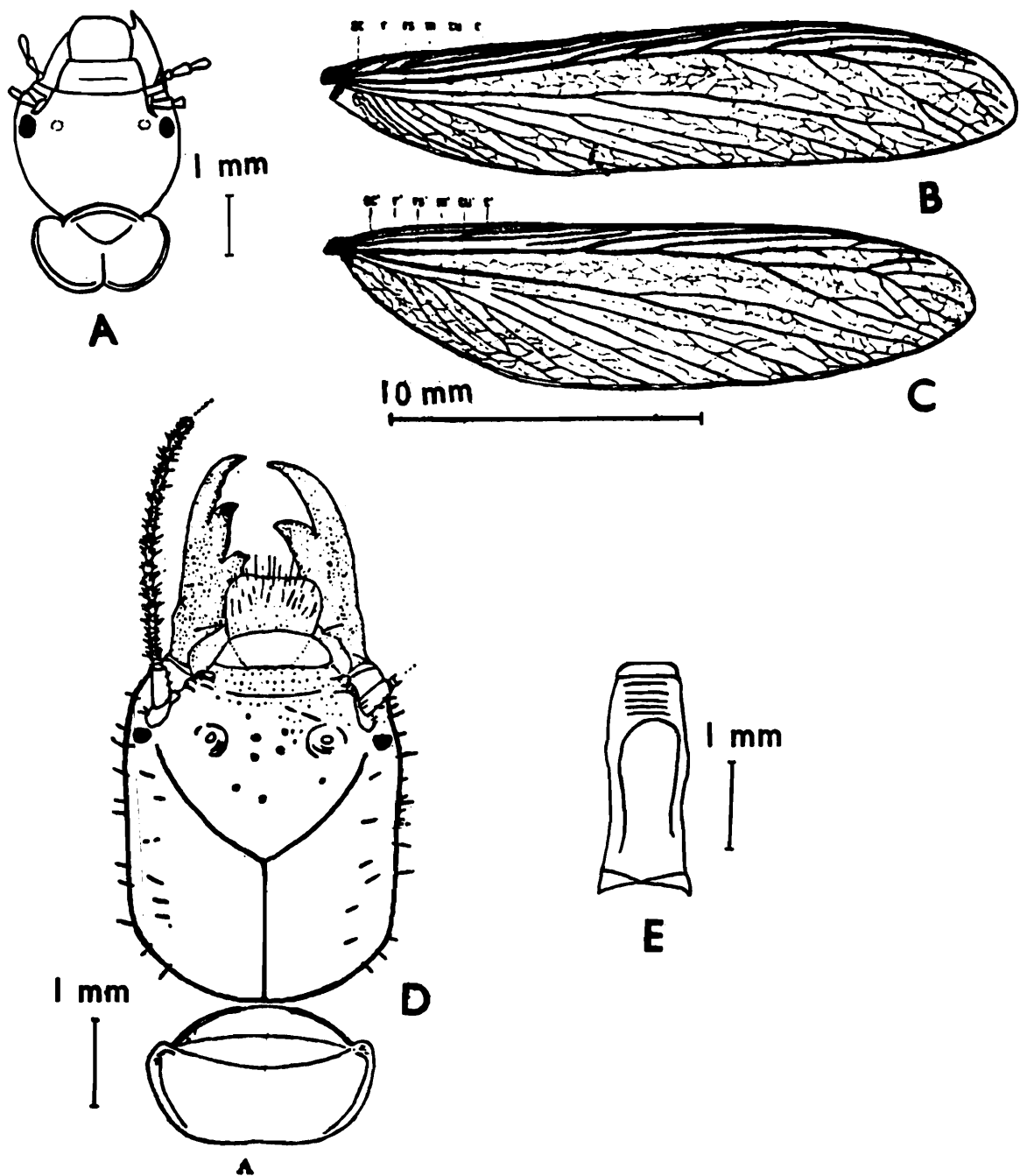


Fig. 21. *Anacanthotermes vagans*. (A) Imago, head and pronotum. (B) Forewing (C) Hindwing. (D) Soldier, head and pronotum. (E) Same, postmentum. (After Weidner 1960).

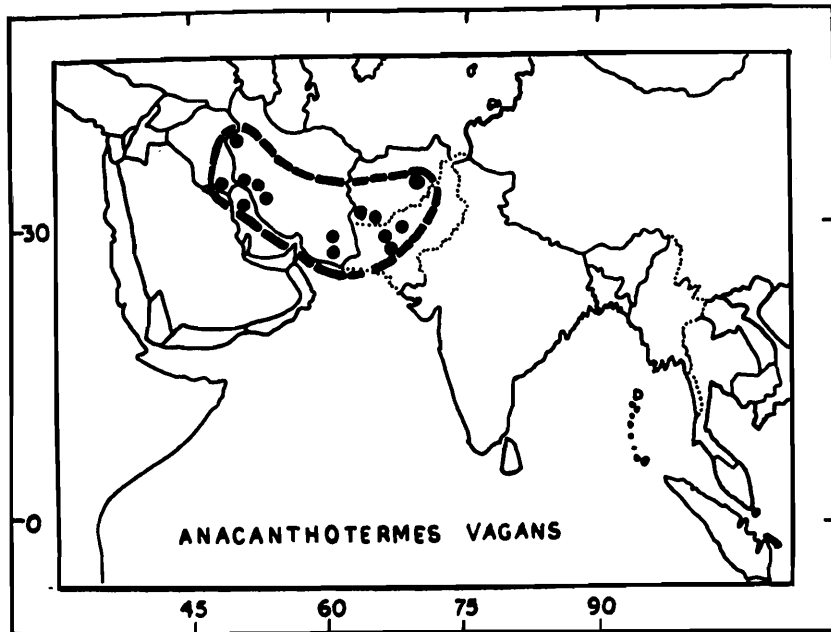


Fig. 22. Map of West and South Asia showing the geographical distribution of *Anacanthotermes vagans*.

brown. Ocelli small, marked by dark spots. Antennae with 24-25 segments. Pronotum saddle-shaped, divided by a transverse groove into two halves. Cerci present; styli short, pointed.

Types, etc. : Type (imago) in Natural History Museum, Vienna. Type-localities: Shiraz and Karak Island (S. Iran, *Hagen*).

Geographical distribution (Fig. 22) : Southern Iraq in the west, almost the whole of Iran (especially common in southern part), Kuwait, east to southern Afghanistan and southern Pakistan (*Hagen* 1858, *Weidner* 1958, 1960, *Mathur and Thapa* 1962, *Harris* 1967, *Chaudhry and Ahmad* 1972, *Akhtar* 1974, and *Chhotani and Bose* 1983); no records from India. Details are as follows :

IRAQ : Ruz near Baghdad, Basra.

IRAN : Shiraz, Karak Is., road between Shiraz and Bushair, Khuzistan (Shadegan), Kangadj, Abadan, Ahwaz, Seistan (Feisabad near Farah), Kasi Shirin in NW Iran, Iranshahr, Bampur, Hamadan, Yengedjeh.

KUWAIT : No specific locality given.

AFGHANISTAN : Pirzada, Koh Dana Ouat near Pakistan border, Obah.

PAKISTAN : All over Baluchistan where recorded from the following localities : Surkhab forest (Quetta-Pishin Dist.), Chaman, Mastung, Loralai, Nokundi (Noshki Dist.).

Biology, etc.

(Fig. 23)

Little is known about its biology. In Iran, swarming occurs from early February to the end of March. The species attacks woodwork in houses. In Baluchistan (Pakistan) the species occurs at considerable altitudes (1200-2450 m). It prefers dry areas with very low annual rain fall (hardly 5 cm) and scanty vegetation, as in Nokundi on the border between Pakistan and Iran. It feeds on dry grass, dead stumps and twigs, dead portions of trees (*Morus alba*, *Dalbergia sissoo*, *Populus* sp., *Prunus amygdale*, *Fraxinus excelsior*); it also feeds on tree bark under covered earthen galleries. It makes large tunnels in wood, connected by narrow galleries. Nesting occurs deep underground and the nest consists of a series of large and small chambers in the soil with inter communicating galleries. Foraging occurs above ground. It makes small, low amorphous mounds above ground (Fig. 23) from excavated earth; the mounds may sometimes be quite large, ca. 15 cm high and 210 cm wide at the base. Swarming dates are not known, but imagoes were obtained in a nest on 15th October.

The species is of considerable economic importance as it freely attacks woodwork in small rural timber houses. In the small Nokundi village (Baluchistan), for example, almost every house was attacked.

Protozoa in the alimentary canal :

The following flagellate has been found in the alimentary canal of *A. vagans* (vide Kirby 1944 , pp. 186-188).

Order Hypermastigida

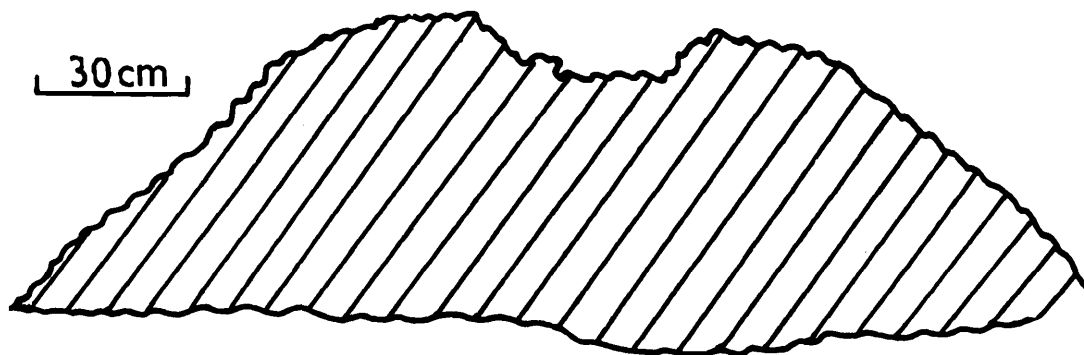
Trichonympha turkestanica Bernstein

Fig. 23. *Anacanthotermes vagans*. A large, granular, earthen mound (basal width 210 cm., height 15 cm.) Quetta (Baluchistan). (Adapted from photograph in Chaudhry and Ahmad 1972).

4. *Anacanthotermes viarum* (König) (nec Smeathman)
 (Syns. *Anacanthotermes koenigi* Holmgren and Holmgren; and
A. rugifrons Mathur and Sen-Sarma)
 (South Indian Harvester Termite)
 (Figs. 24-28; and Tables 1-3.)

1. *Termes viarum* König :

1779. König, *Beschr. berlin. Ges. naturf. Freunde*, 4: 24, W. only; Pl. 1, Figs. 12-14 (W).
 Type-locality : ? Tranquebar (Tamil Nadu, S. India).

2. *Hodotermes viarum* (König) :

1858. Hagen, *Linn. Ent.*, 12 : 90. "Trankebar" (= Tranquebar, Tamil Nadu, S. India).

1911. Holmgren, *K. Sv. Vet. Akad. Handl.*, 46(6): 43. Not identifiable; regards it as
 "species negligendae"

1912. Fletcher, *Agric. J. India*, 7(3): 224 (Fig. 1, S. head). India.

1914. Bugnion, *Bull. Mus. Hist. nat.*, 20 (4): 175. (Confuses *H. viarum* and *H. macrocephalus*, regarding them as conspecific.)

1920. Fletcher, *Proc. 3rd ent. Mtg. (Pusa 1919)*, 1 : 314. Coimbatore (S. India).

1920a. De Mello, *Proc. 3rd ent. Mtg. (Pusa, 1919)*, 3 : 1010-1019. Protozoa in gut.

1920b. De Mello, *Ann. Sci. Acad. Polytech. do Porto*, 14 : 44-48. Protozoa in gut.

1921. Fletcher, *Rept. Proc. 4th Ent. Mtg. (Pusa, 1921)* : 330; and Pl. LII, Figs. 12-14.
 (opp. p. 312). (English translation of König's paper of 1779.).

1932. Kirby, *Univ. Calif. Publ. (Zool.)*, 37 (15): 407. Protozoa in gut.

1934. Margabandhu, *J. Bombay nat. Hist. Soc.*, 37 (3): 701. Coimbatore (S. India).

3. *Hodotermes (Anacanthotermes) viarum* (König) :

1913. Holmgren, *K. Sv. Vet. Akad. Handl.*, 50 (2): 35, footnote. Regards it as
 conspecific with *A. macrocephalus* "on geographical grounds", but adds that the
 species is not morphologically identifiable and should be removed from the
 literature.

4. *Anacanthotermes viarum* (König) :

1942. De Mello and G. Monterio, *Arqu. Esc. med.-cirurg. Nova Goa*, (A), Fasc. 18 :
 1-14. Coimbatore, S. India. Protozoa in gut.

1944. Kirby, *Univ. Calif. Publ. (Zool.)*, 49 (8) : 186-187. Coimbatore, S. India. Protozoa
 in gut.

1949. Kirby, *Univ. Calif. Publ. (Zool.)*, 45 (5): 381. Protozoa in gut.

1949. Snyder, *Smithson. misc. Colls.*, 112 : 63. South India.

1953. Rattan Lal and Menon, *Catal. Indian Insects*. Pt. 27. *Isoptera* : 4. S. India
 (Tranquebar and Coimbatore). (Also gives Ceylon, based on Bugnion, 1914, but
 the latter author did *not* record it from Ceylon).

1953. Roonwal and Pant, *Indian Forest Leaflet. (Ent.)*, No. 121 (3): 46. Coimbatore
 (S. India).

1970. Roonwal, In *Biol of Termites* (Eds. Krishna and Weesner), Vol. 2 : 332. S. India.
1977. Chhotani, *Proc. 8th int. Congr. int. Un. Study soc. Ins.* (Wageningen), p. 116. Sri Lanka. (Species not mentioned, but presumably *A. viarum*.)
1983. Chhotani and Bose, In : *Fauna of Saudi Arabia* vol. 5 : 123.
1984. Weidner, *Anz. Schadlingskd.*, 57 : 5. Sri Lanka (based on Chhotani, 1977, supra).
1984. Bose, *Occ. Pap. Rec. zool. Surv. India*, No. 49 : 72-74.
5. *Hodotermes (Anacanthotermes) koenigi* Holmgren and Holmgren :
1917. Holmgren and Holmgren, *Mem. Dept. Agric. India (Ent.)*, 5: 138-139 (Im., S., W.)
Type-locality : Coimbatore (Tamil Nadu, S. India).
1934. Margabandhu, *J. Bombay nat. Hist. Soc.*, 37 (3) : 701. Coimbatore.
6. *Hodotermes Koenigi* Holmgren and Holmgren :
1953. Rattan Lal and Menon, *Catal. Indian Insects*, Pt. 27 (*Isoptera*) : 3. Coimbatore.
7. *Anacanthotermes rugifrons* Mathur and Sen-Sarma :
1958. Mathur and Sen-Sarma, *Entomologist* (1958) 91 (1146) : 233-241 (S., W.),
Figs. 1 and 2. Type-locality : Pallyamcottah, lat. 0.8.04 N, long, 77.44 E,
(Tinnevelly [Tirunelveli] District, Tamil Nadu, India).
1970. Roonwal, In *Biol. of Termites* (Eds. Krishna and Weesner), Vol. 2: 332. S. India
1983. Chhotani and Bose, In *Fauna of Saudi Arabia* vol. 5 : 123.
1984. Bose, *Occ. Pap. Rec. zool. Surv. India*, No. 49 : 71, 72, 74. (Treated it as conspecific with *A. viarum*).
8. Species named "*viarum*", but status doubtful (vide Hagen, 1858, *Linn. Ent.*, 12 : 93-94; and Snyder, 1949. *Smithson. misc. Colls.*, 112 : 351):
1781. *Termes viarum* Smeathman, *Philos. Trans. roy. Soc. Lond.*, 71 : 189. S. and W. Cameran Koes (Kamaranka) River, Sierra Leone (W. Africa).
- 1858a. *Hodotermes viarum* (Smeathman), Hagen, *Linn. Ent.*, 12 : 93-94 (Says status doubtful, and the type seen by him in the Banks Collection is not *Hodotermes* but a *Termes*!).
- 1858b. *Hodotermes viarum* (Smeathman), Hagen, *Catal. Neuropt. Insects Brit. Mus.*, Pt. 1, *Termitina* : 14, No. 6, W.
1900. *Hodotermes viarum* (Smeathman), Sjostedt, *K. Sv. Vet. Akad. Handl.*, 34 (4): 27. (Same remarks as for Hagen, 1858a, supra.).
1911. *Hodotermes viarum*, Holmgren, *K. Sv. Vet. Akad. Handl.*, 46(6) : 43. (Says *H. viarum* König and *H. viarum* Smeathmen are not identifiable and should be regarded as "species negligendiae".)

Note on nomenclature :

König's (1779) description of the worker of his *Termes viarum* was inadequate, but his illustrations (Pl. 1, Figs. 12-14) of workers (reproduced in Fletcher 1921, Pl. LII, Figs. 12-14) are excellent and the insect is undoubtedly an hodotermitid. Some authors regard the name *viarum* as

unidentifiable, but though the type is lost (we have designated a *neotype*, vide infra), we consider the species *viarum* as quite recognisable and accept the name as valid. There is a single *Anacanthotermes* species in South India, the two described later, e.g. *koenigi* Holmgren and Holmgren 1917, and *rugifrons* Mathur and Sen-Sarma 1958 being junior synonyms. The *viarum* of Smeathman (1781) from Sierra Leone, W. Africa is unidentifiable (vide also Hagen 1858, p. 93, and Snyder 1949, p. 351.).

Material examined :

(A) *At the Zoological Survey of India, Calcutta :* (1) A tube, Z.S.I. Reg. No. 4209/H8, 2 S. and 4 W., Coimbatore, (Tamil Nadu) (S. India), *Fletcher* coll. (YX), 2.ii.1913. [*Neotypes* and *paraneotypes* selected from this lot, vide infra, and given new Reg. Nos.] (2) Two tubes, Im., Coimbatore (Tamil Nadu), 6.x.1913, *Fletcher* coll. (3) A tube, Im. (and Loose wings), Coimbatore, *Fletcher* coll., 30.x.1913, on wings after 11 p.m., after heavy rain. (4) A tube, Im., S., W., Coimbatore, *Fletcher* coll. (5) A tube, S., W., Mannadipet, 20 miles SW of Pondicherry (S. India), *Menon* coll., 9.ii.1958. (6) A tube, S., W., Idumbaumalai, one km E of Palni Temple, Madurai District, Tamil Nadu, *Sen* coll., 23.ii.1965. (7) A tube, S., W., Gandhi Ghat, Kanniyakumari (Tamil Nadu), *R.K. Kacker* coll., 10.i.1971. (8) A tube, 1 S., 2 W., Palayamcottah [Palayamkottai], Tirunelveli Dist., Tamil Nadu, 18.i.1958, *Mathur* coll., ex small mound ca. 5 inches high. (Paratype soldier and paramorphotype workers from holotype colony of *A. rugifrons*.). (9) A tube, S., W., Kanniyakumari (Tamil Nadu), 27.ii.1969, *Chhotani* coll., ex sandy shore. (10) A tube, S., W., ditto. (11) A tube W., Satayanpathai, Palayamkottai (Tirunelveli District, Tamil Nadu), 26.ii.1969, *Chhotani* coll., ex soil. (12) A tube, W., Road between Uslempatti and Theni (Madurai District, Tamil Nadu), *Chhotani* coll., ex soil.

(B) *At the Indian Agricultural Research Institute, Delhi :* (1) A tube, Im., Coimbatore, 6.x.1912, *Fletcher* coll. (2) A tube, W., Coimbatore, 11.xii.1912, *Fletcher* coll. (3) A tube, Im., S., Coimbatore, 7.x.1913, *Fletcher* coll., (ABG). (4) A tube, Im., W., Coimbatore, 7.x.1913, *Fletcher* coll. (APF). (5) A tube, Im. (and loose wings), Coimbatore, *Fletcher* coll. (6) A tube with two lots from Tamil Nadu : (a) S., South Arcot Dist., on road between Vrindhachalam and Parur, *P.S.* coll., 12.x.1912, "throwing up mounds" (b) S., W., Coimbatore, *Fletcher* coll., 2.ii.1912. (7) A tube, S., W., Central Farm, Coimbatore, 12.v.1913, *C.N.* coll., "foraging on grass" (8) A tube, W., Coimbatore, *T.B.F. (T.B. Fletcher)* coll., 1.ii.1912, "throwing up mounds"

(C) *At the Forest Research Institute, Dehra Dun* : (1) A tube, S., W., Coimbatore, *Fletcher* coll., 26.vii.1912, det. as *koenigi* H. and H. (2) A tube, Im., Coimbatore, 6.x.1912, *Fletcher* coll. (3) A tube, S., W., Coimbatore, 2.ii.1913, *Fletcher* coll. (4) A tube, Im., W., Coimbatore, 1916, *Fletcher* coll. (5) A tube, 1 S., 1 W., Palayamcottah [Palayamkottai] (Tirunelveli District, Tamil Nadu), 18.i.1958, *Mathur* coll., ex small mound ca. 5 inches high (*Holotype* soldier and paramorphotype worker, of *A. rugifrons*.) (6) A tube, 7 S., 20 W., ditto, paratype soldiers and paramorphotype workers of *A. rugifrons*.

(D) *At the American Museum of Natural History, New York* (Formerly with Prof. A.E. Emerson, Chicago University, Chicago.) : (1) A vial, Im., S., W., Coimbatore, 1916, *Fletcher* coll. (2) A vial, 1 S., Coimbatore, 11.v.1912, *Fletcher* coll. (Cotype of *A. koenigi* H. and H.; ex Holmgren Collection, Stockholm). (3) A vial, Im., Coimbatore, 6.x.1912, *Fletcher* coll.

Note : No adequate description of *A. viarum* exists and following is the first such account.

IMAGO (Figs. 24, 25; and Table 1) : Posterior part of head, basal part of antennae, postclypeus, mandibles, pronotum and legs creamish yellow to golden brown; anterior part of head, labrum and apical segments of antennae paler; thorax, wing-scales and abdomen darker; wings hyaline, veins deep golden yellow; mandibular teeth dark brown. Head and body sparsely pilose. Total length with wings 27.5-30.0, without wings 14.4-15.4 mm. Head rounded, a little broader than long (length to mandible base 2.70-2.90; maximum width 3.20-3.42 mm); broadest near base of antennae, narrowing posteriorly, posterior margin rounded. Fontanelle absent. Eyes suboval, moderately large, anterior margin substraight, posterior one rounded; maximum diameter 0.63-0.70 mm. Ocelli present, small (interpreted by some authors, e.g. Holmgren 1911, as 'antennal spots'). Antennae with 29-31 segments; segment 1 largest, cylindrical; 2 less than half of 1, 3 a little smaller than 2 and subequal to 4; 5 shortest; from 6-19 gradually increasing in size; 20 to the penultimate one gradually becoming slender; the last ovate. Anteclypeus hyaline, apilose; anterior margin projected in front medially. Postclypeus not well differentiated; slightly depressed, rhomboidal, and with a few long bristle-like hairs on anterior margin. Labrum broad, flap-like, rounded, widest in middle; much broader than long; with many long and short hairs especially on anterior one-third. Mandibles subsquarish. Left with an apical and 3 marginal teeth; apical thin, finger-like; 1st marginal slightly shorter than apical and finger-like; 2nd

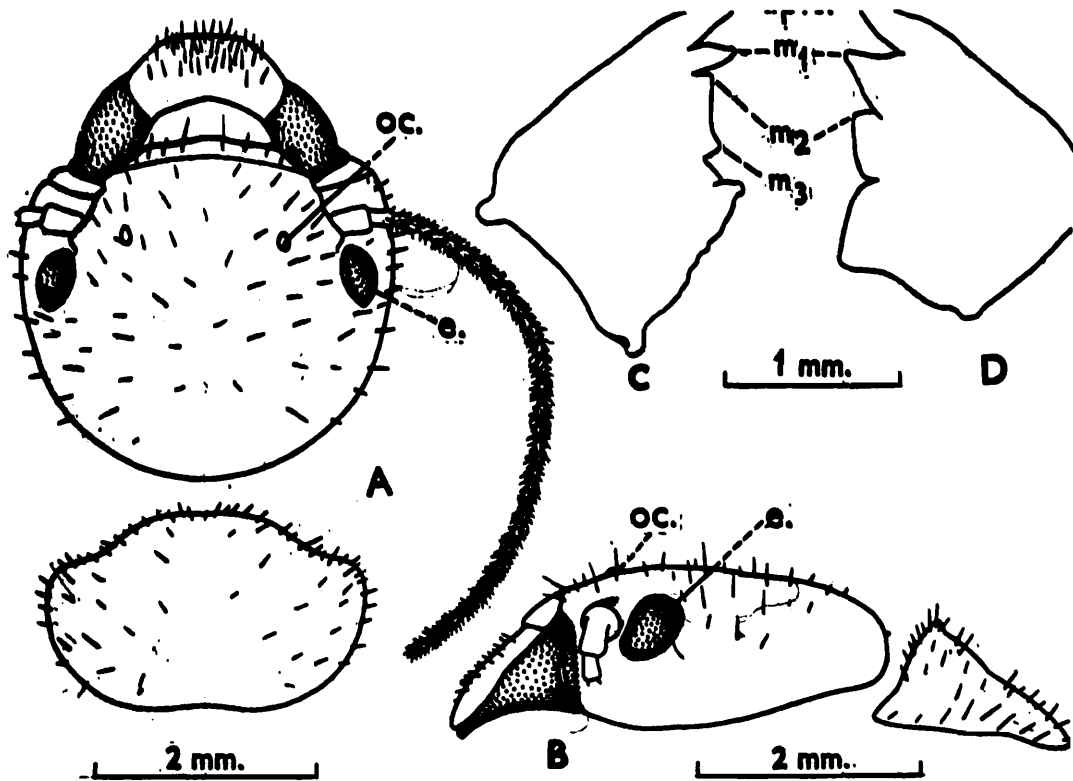


Fig. 24. *Anacanthotermes vagans*. Imago. Coimbatore, S. India. (A) Head and pronotum in dorsal view. (B) Same, in side view. (C) Left mandible. (D) Right mandible. ap.t., apical tooth; e., eye; m1, m2, m3, 1st, 2nd and 3rd marginal teeth; oc., ocellus.

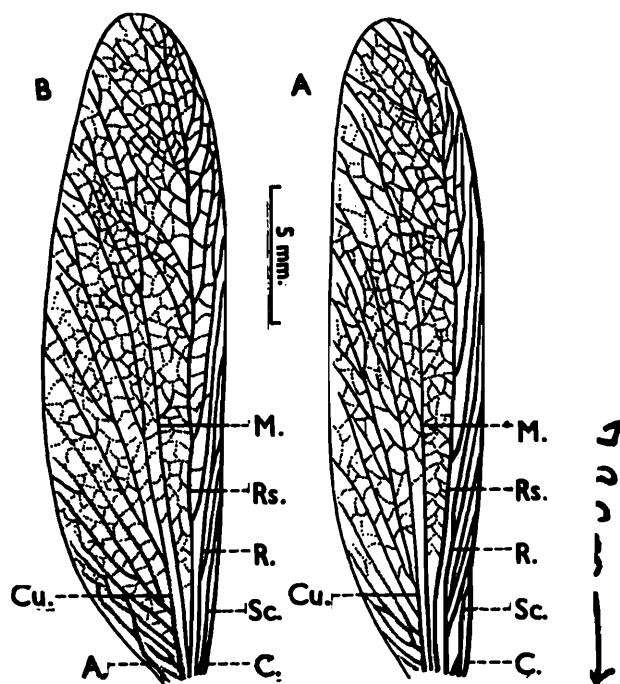


Fig. 25. *Anacanthotermes viarum*. Coimbatore, S. India. (A) Left forewing. (B) Left hindwing. A., anal; C., costa; Cu., cubitus; M., media; R., radius; Rs., radial sector.

very small, close to 1st; 3rd smaller than 1st and widely separated from 2nd. Right mandible with the apical finger-like; 1st marginal subtriangular, slightly shorter than apical, and with a small subsidiary tooth at its anterior base; 2nd much smaller than 1st and with a weakly convex, longer posterior margin. Pronotum narrower than head; subsemicircular with substraight sides; with short hairs on margins and on body, posterior angles rounded; posterior margin substraight with a weak median depression; anterior margin bulged forward and without a median notch. Mesonotum and metanotum lightly pilose; posterior margins with a weak median notch. Legs long, strong, with long setae-like hairs; apical tibial spur formula 3 : 4 : 4; tarsi 4-segmented. Wings long, narrow, reticulated. Wing microsculpturing not known, but presumably similar to *A. macrocephalus* (supra) where papillae are present but no micrasters. In forewing roots of all veins lie within scale; suture fairly complete and well marked. C running all along anterior margin; Sc small, joining C shortly after emergence from scale; R arising jointly with Rs. separating from it while still within scale, and the two emerging as strong, distinct veins; R 3-branched the 2nd branching into two and running up to costal margin; Rs running up to nearly apex of wing and branching on way into four or more branches with several sub-branches; M simple, giving off a branch about the middle of wing and running almost to wing-margin; Cu giving off 8 branches, all running to posterior edge of wing; anal small, unbranched. In hindwing basal scale smaller than in forewing; all principal veins arise inside scale; suture well marked; C running the entire length of wing-margin; Sc small, meeting C at about one-fifth of wing-length; R arising separately from Rs outside scale; branching out into two large veins, the 2nd again branching into two; Rs arising jointly with M, separating from it just outside scale and giving off about 7 large and a few smaller branches; M simple, with 3 branches; Cu hyaline, weak giving off about 7 larger and a few smaller branches; anal small, 2 branched. Abdomen oval, elongate, weakly pilose. Cerci one-jointed, 0.25-0.35 mm long. Styli one-jointed, 0.05-0.13 mm long.

SOLDIER (Figs. 26, 27; and Table 2) : Head anteriorly golden to reddish yellow, posteriorly deep golden yellow to reddish brown; postclypeus and mandibles bases darker; labrum, antennae, thorax and legs pale to brownish yellow; anteclypeus and abdomen pale creamish white to deep yellow; distal parts of mandibles dark brown, teeth darker. Head and body lightly pilose. Size range wide; total length with mandibles 8.0-17.8 mm. Head subsquarish, a little longer than broad (length to mandible base 2.40-4.85; maximum width 2.40-4.65 mm); sides subparallel, weakly incurved in

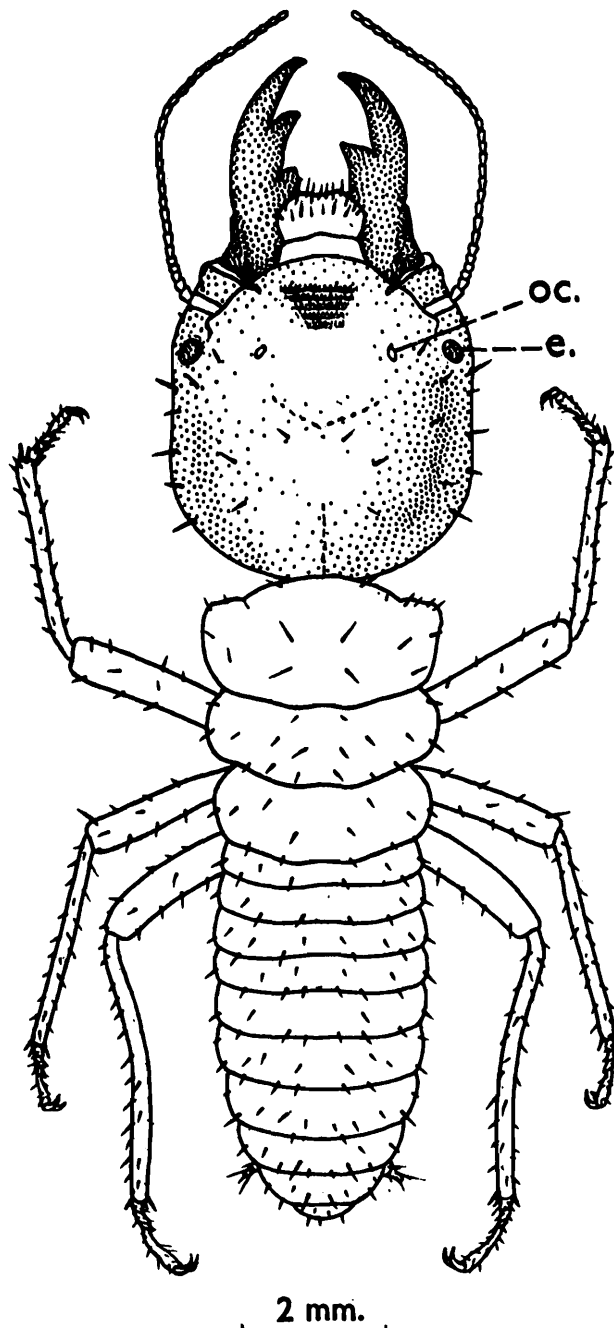


Fig. 26. *Anacanthotermes viarum*. Coimbatore, S. India. Neotype. Soldier, in dorsal view. e., eye; oc., ocellus.

middle; anteriorly slightly narrowing, posterior margin rounded. Frons rugose, with several transverse ridges in middle. Fontanelle absent. Eyes rather small; suboval. Ocelli: Small, almost flush with surface. Antennae with 29-32 segments; segment 1 longest, cylindrical; 2 about one-half of 1; 3 about one-half of 2 and shortest; 4 and 5 slightly longer than 3; 6 onward gradually increasing in size to the last. Anteclypeus narrow, hyaline, trapezoidal, apilose. Postclypeus not well differentiated. Frons slightly depressed; rugose, weakly striated with transverse striae. Labrum subpentagonal, much broader than long, broadest in anterior one-third; with several hairs present near anterior margin and a few on body; anterior margin with a shallow median depression. Mandibles long (length 1.80-3.15 mm), thick,

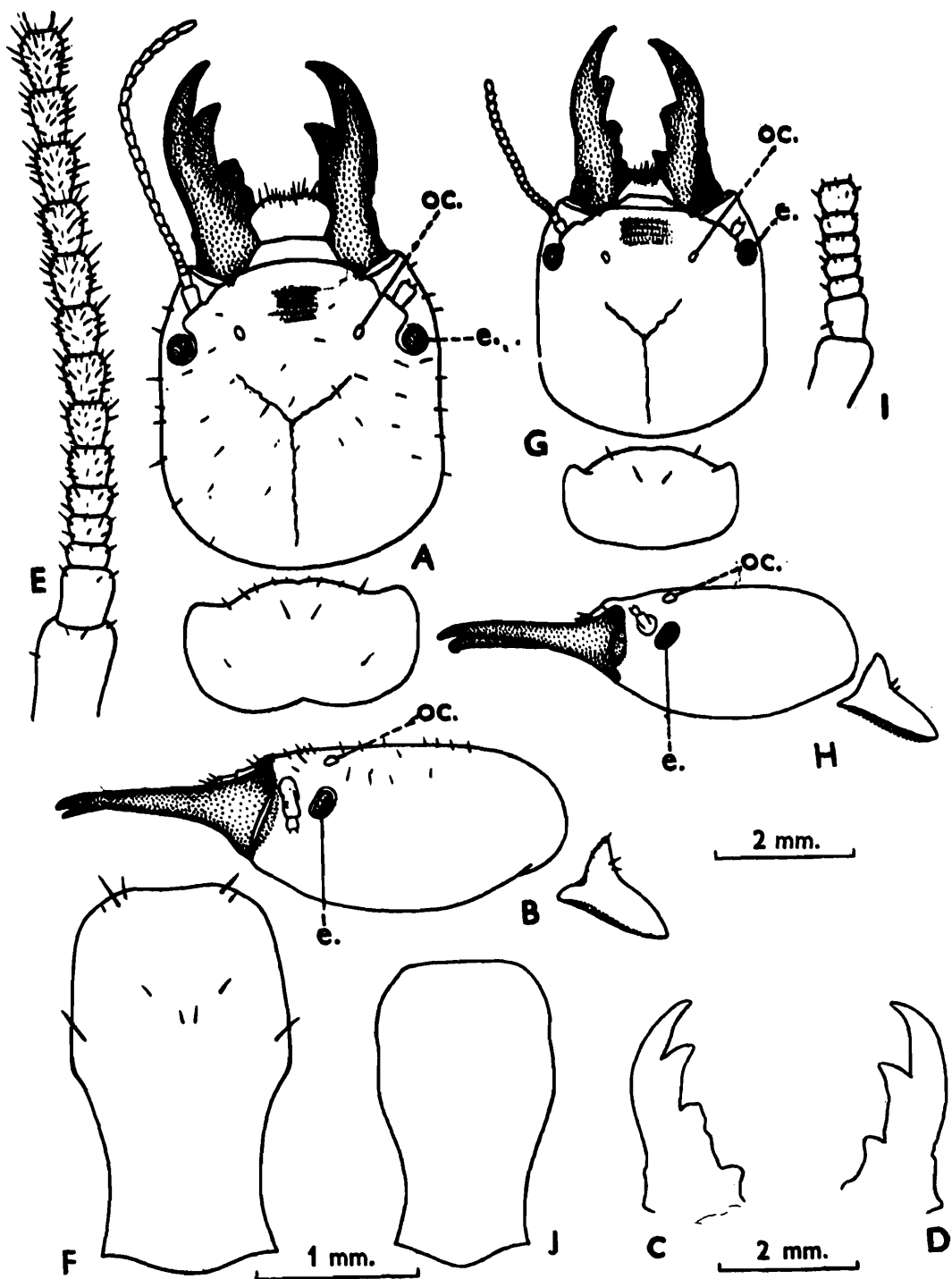


Fig. 27. *Anacanthotermes viarum*. Coimbatore, S. India. Soldiers. (A-F) Large soldier. (A) Head and pronotum, in dorsal view. (B) Same, in side view. (C) Left mandible. (D) Right mandible. (E) Basal part of antenna. (F) Postmentum. (G-J) Small soldier. (G) Head and pronotum, in dorsal view. (H) Same, in side view. (I) Basal part of antenna. (J) Postmentum. e., eye., oc., ocellus.

slightly incurved at the apices; with large, well developed teeth. Left mandible with a thin pointed, apical tooth and 2 marginal teeth; 1st marginal triangular; 2nd short, blunt, triangular, with a curved anterior and a long, sinuous posterior margin; molar plate with a big tooth-like projection near base. Right mandible with a stout, bluntly pointed apical tooth and 2 marginal teeth; 1st marginal triangular; 2nd bluntly triangular, widely separated from 1st. Postmentum club-shaped, sparsely pilose; broadest above middle; sides converging posteriorly to a narrow waist; anterior margin substraight with a slight medial depression; posterior margin convex, in middle and depressed laterally. Pronotum narrower than head; much broader than long, with substraight sides; anterior margin convex, with a weak median notch; posterior margin also convex, but with a strong median notch. Mesonotum suboval, broader than long; posterior margin with a median notch. Metanotum suboval, broader than long, posterior margin rounded, with a weak medial depression. Legs long, thin, sparsely pilose; apical tibial spur formula 3 : 4 : 4; tarsi 4-jointed. Abdomen oval, elongate, sparsely pilose. Cerci one-jointed, 0.18-0.28 mm long. Styli one-jointed, 0.10-0.15 mm long.

WORKER (Fig. 28 and Table 3) : Head, clypeus, labrum and mandibles pale golden yellow; mandibular teeth dark brown; antennae, legs and abdomen pale creamish white, thorax darker. Head and body sparsely pilose. Total length 8.5-13.3 mm. Head subsquarish, a little broader than long (maximum width 3.00-3.75 mm). Eyes oval, much broader than long. Antennae with 28-33 segments. We counted up to 30 segments; Holmgren and Holmgren, 1917, in their *A. koenigi* counted 32 segments in the larger specimens; and König, 1779, in his Pl. 1, Fig. 13 showed 33 clear segments in the left antenna; in *A. rugifrons* Mathur and Sen-Sarma, 1958, gave the number as 30-33. Pronotum subtrapezoidal, with convex anterior margin; sides converging to a rounded posterior margin. Meso- and metanotum suboval, broader than long. Legs thin, long; tarsi 4-segmented; apical tibial spur formula 3 : 4 : 4. Abdomen elongate, oval.

Types, etc. : (1) *Of A. viarum* (König) : From our own enquiries from European Museums, and the extensive researches of the termitologist, the late Professor A.E. Emerson (his letters dated 7th August 1958 and 10th April 1965) we are certain that König's types (workers) are lost. Accordingly, we designate as a *neotype* a soldier present in spirit in a tube in the Zoological Survey of India, Calcutta and with the following details : Z.S.I. Reg. No. 4355/H8, Coimbatore (Tamil Nadu, S. India), *T.B. Fletcher*

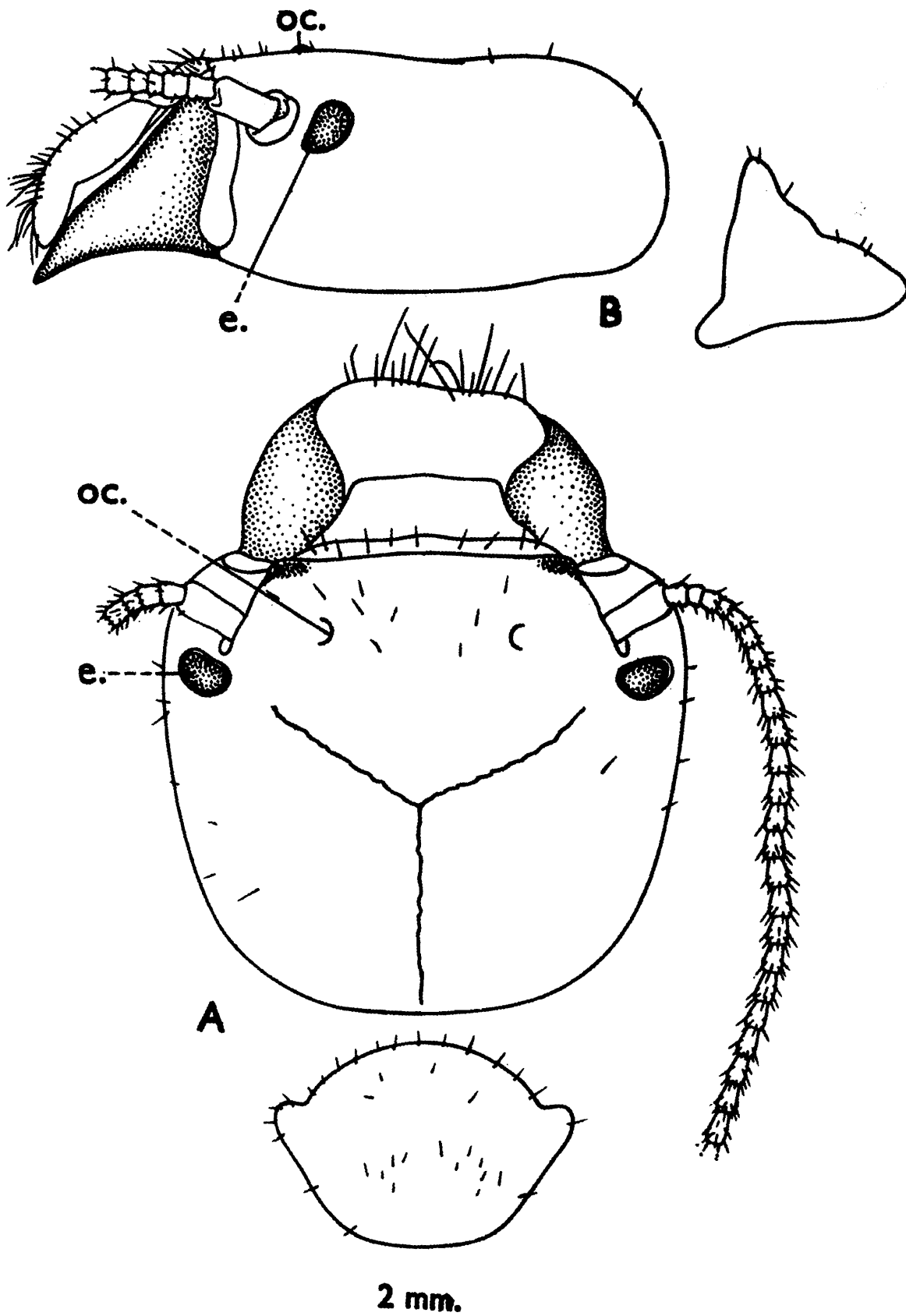


Fig. 28. *Anacanthotermes viarum*. Coimbatore, S. India. Worker. (A) Head and pronotum, in dorsal view. (B) Same, in side view. e., eye; oc. ocellus.

coll. (YX), 2 Febr. 1913. Also *paraneotypes* (a soldier and 4 workers), from the same lot as the neotype; Z.S.I. Reg. No. 4350/H8.

2. *Of A. koenigi Holmgren and Holmgren* : A cotype soldier in the American Museum of Natural History, New York (ex Holmgren Collection, Stockholm). Coimbatore (S. India), *T.B. Fletcher* coll., 11 May 1912. [Cotype soldiers from this lot may also be present in the Holmgren Collection in Stockholm Hogscola, now with the National Natural History Museum, Stockholm.].

3. *Of A. rugifrons Mathur and Sen-Sarma* : (A) In the Forest Research Institute, Dehra Dun : (i) In a vial, a *holotype* soldier and a *paramorphotype* worker, Field No. R.N.M. 86, Reg. No. MC-20120/1, Palayamcottah [Palayamcottai] (Tirunelveli District, Tamil Nadu, S. India), *R.N. Mathur* coll., 18 Jan. 1958. (ii) In a tube, 7 paratype soldiers and 20 paramorphotype workers, from the *holotype* colony, Reg. No. MC-20120/2. (B) In the Zoological Survey of India, Calcutta : A paratype soldier and a paramorphotype worker, from the *holotype* colony. (C) In American Museum of Natural History, New York : A paratype soldier and 2 paramorphotype workers, from the *holotype* colony.

Type-localities (all in Tamil Nadu, S. India) : (i) *Of A. viarum* : Coimbatore (of *Neotype*). (ii) *Of A. koenigi* (Cotypes) : Coimbatore. (iii) *Of A. rugifrons* : Palyamcottai (Tirunelveli District). [Konig, 1779, had not specified the localities of his collections and observations, but they are believed to be Tranquebar, Coromandal Coast and Madras proper, all in Tamil Nadu, South India.].

Geographical distribution (Fig. 2) : Peninsular India : Southern and southeastern portions of Tamil Nadu (the drier parts, apparently, not extending to the wetter western parts of Kerala), as follows : South Arcot District (Mannadipet, ca. 30 km SW of Pondicherry, 11.30 N lat., 79.40 E long., the northern limit; and on road between Vidhachalam and Parur). Coimbatore District (Coimbatore, 11.00 N lat., 77.00 E long., the *type-locality* and the western limit). *Madurai District* (Idumbaumalai near Palni Temple; road between Uslempatti and Theni). *Tirunelveli District* (Palayamkottai; Satyenpathi). *Kanniyakumari District* (Gandhi Ghat, Kanniyakumari extreme southern tip of India, ca. 8.02 N lat., 77.30 E long.; Nagercoil).

Biology

A. viarum is apparently not common. Its general habits are as in the North Indian Harvester Termite, *A. macrocephalus*. It lives in narrow underground tunnels and comes out to forage. It makes low, subconical earthen mounds of granular, excavated earth ca. 7-13 cm high and 40-50 cm in basal diameter. It eats grasses and probably also other plant material. König's (1779) early observations are of interest: They "live together in small societies on footpaths in grassy localities, and usually obliquely over and near small paths. They build no mounds unlike the foregoing [a species of *Odontotermes*, probably *O. redemanni*] they are very scarce and I have found them only in out-of-the way places. The Tamils call them sign-post ants." According to Chhotani and Bose, 1979, however, they make small (height 12 cm, basal diameter 30 cm) subconical, surface mounds of granular excavated earth; they found such mounds common near the sea-shore at Kanyakumari. The so-called nests mentioned by these authors are not mounds but simply underground galleries. Imagoes have been found in early October; and swarming recorded on 30th October at night (after 11 P.M.) following heavy rain.

Protozoa in alimentary canal :

Several flagellate Protozoa, as follows, have been found in considerable numbers in the alimentary canal of *A. viarum* (De Mello 1937-1949, De Mello and De Mello 1942, De Mello and Monterro 1942, and Uttangi and Joseph 1962, summary):-

Order Hypermastigida:

1. *Spirotrichonympha mirabilis* Grassi
2. *S. mirabilis indica* De Mello
3. *S. coimbatorensis* De Mello
4. *Trichonympha fletcheri* De Mello (Kirby 1944, p. 194, regards this as a junior synonym of *T. turkestanica* Bernstein.)
5. *Holomastigotoides proboscifer* De Mello
6. *H. sphaeroidalis* De Mello
7. *H. sp.* (3 forms) De Mello

Order Polymastigida:

8. *Trichomonas egasmonizi* De Mello
9. *Triceromitus sokheyi* De Mello
10. *Strobilonympha serpentiformis* De Mello

11. *S. schizophyla* De Mello

12. *S. pisciformis* De Mello

DISCUSSION

Anacanthotermes is mainly a palaeartic genus, with incursions into the ethiopian and oriental regions. Twelve species are known, as follows :

1. *A. ahngerianus* (Jacobson). Central Asia (Turkestan, N. Iran)
2. *A. baeckmannianus* Vasiljev). Middle Asia.
3. *A. baluchistanicus* Akhtar. Baluchistan (Pakistan). Rare, not adequately known.
4. *A. macrocephalus* (Desneux) (syn. *peshawarensis* Akhtar). W. India, Pakistan, Afghanistan.
5. *A. murgabicus* (Vasiljev), Middle Asia : Transcaspia.
6. *A. ochraceus* (Burmeister). Widespread. N. Africa (Algeria, Libya, Palestine, N. Egypt, Ethiopia), Arabia.
7. *A. saudiensis* Chhotani and Bose. Arabia.
8. *A. septentrionalis* (Jacobson), N. Iran, Transcaspia.
9. *A. turkestanicus* (Jacobson). Turkestan.
10. *A. ubachi* (Navas). W. Asia (Jordan, Israel, Iraq, Syria, S. Turkey).
11. *A. vagans* (Hagen), Iraq, Iran, Kuwait (Arabia), Afghanistan, Pakistan.
12. *A. viarum* (Konig) (synonym : *A. koenigi* Holmgren and Holmgren and *A. rugifrons* Mathur and Sen-Sarma). S. India (Tamil Nadu).

Zoogeographically, the most interesting aspect of their distribution is that this predominantly palaeartic and aridity-loving species should be found deep south in the tropical part of Peninsular India, removed from its nearest northern distribution (western Rajasthan) by a straight line gap of about 1100 km in which there is no other species of the genus, or of any other harvester termite (Hodotermitinae). It is difficult to explain this discontinuity.

SUMMARY

The identity, descriptions of the various castes, geographical distributions and biology and ecology of the following four species of *Anacanthotermes* are discussed in considerable detail :-

1. *A. baluchistanicus* Akhtar. Baluchistan (Pakistan). Rare.
2. *A. macrocephalus* (Desneux) (syn. *A. peshawarensis* Akhtar). W. India (Rajasthan), Pakistan, Afghanistan.
3. *A. vagans* (Hagen). Iraq, Iran, Kuwait (Arabia), Afghanistan, Pakistan.
4. *A. viarum* (König) (synonyms : *A. koenigi* Holmgren and Holmgren and *A. rugifrons* Mathur and Sen-Sarma). Tamil Nadu (India). The present is the first adequate description of the species, earlier descriptions being vague and incomplete. As the original type is lost, a neotype and paraneotypes have been selected and so designated.

A great deal is known about the biology and ecology of *A. macrocephalus*, and these aspects (especially swarming, sex-ratios, breeding behaviour, food, foraging, underground gallery system) are discussed. About the biology of the other species little information is available. Finally, the attention is called to the discontinuity (with a gap of about 1100 km) of distribution of the genus in India.

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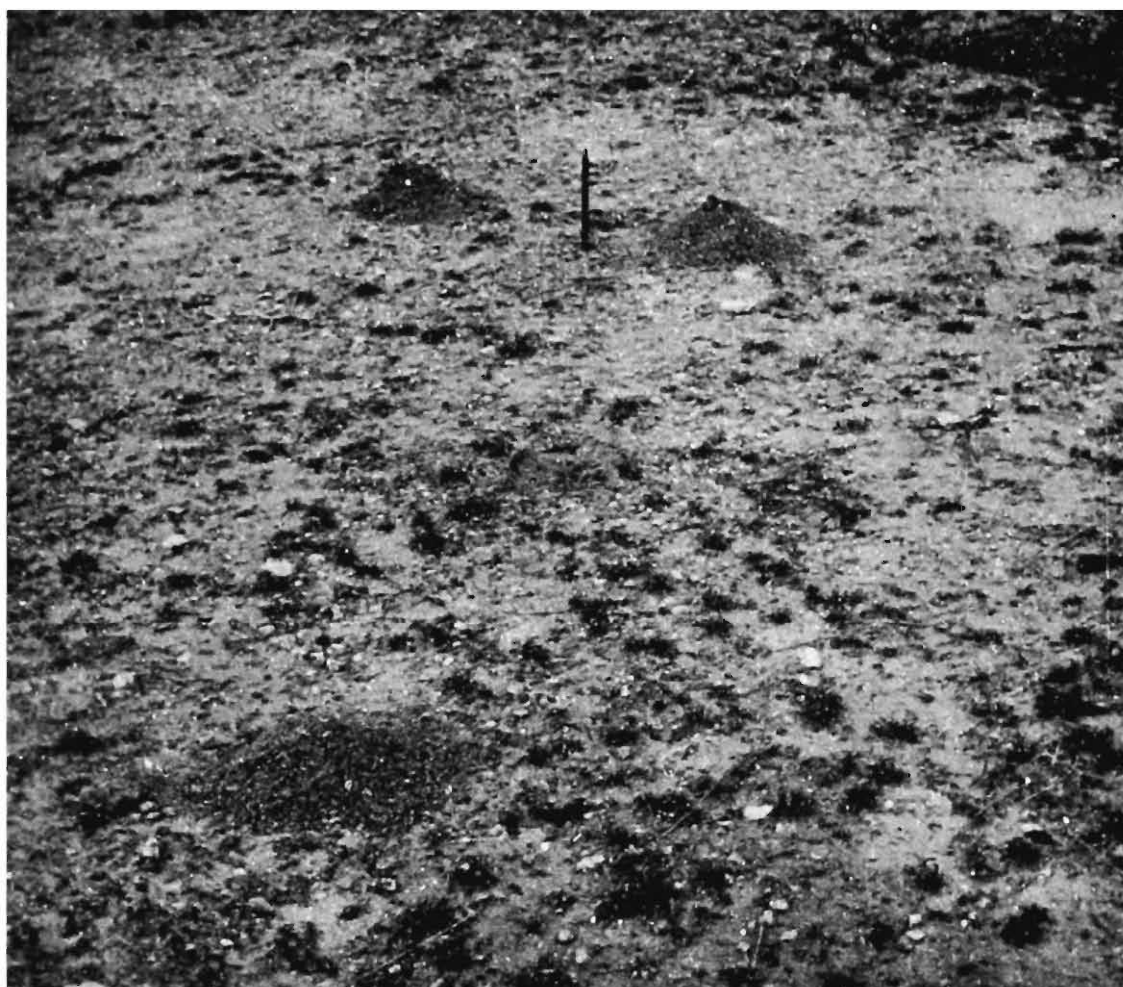
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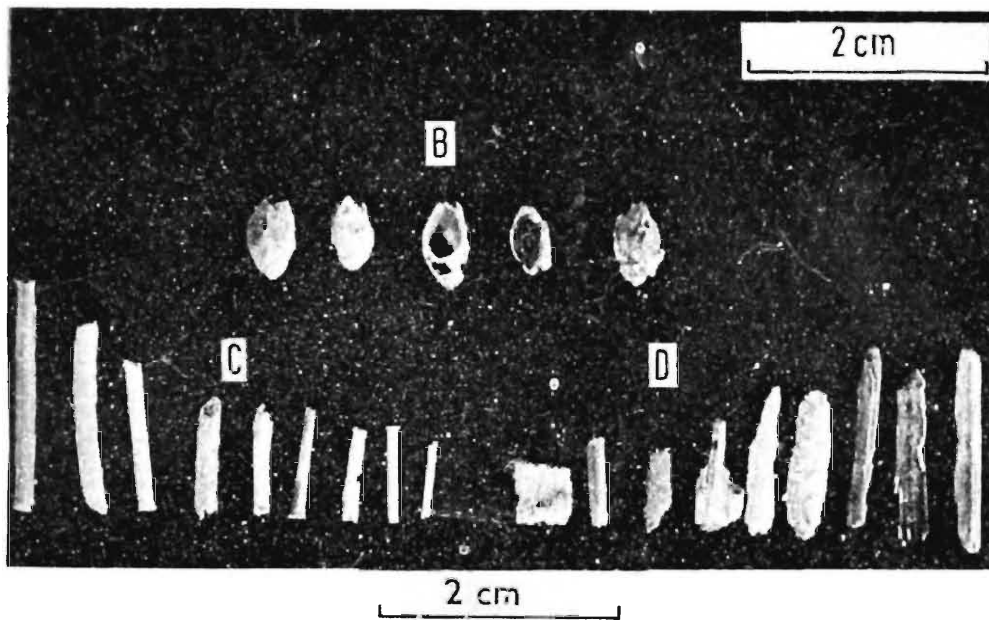
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Views of the habitat of *Anacanthotermes macrocephalus* in the Great Indian Desert.

TOP : A model reconstructed from original material obtained on the outskirts of Bikaner; one mound is shown in vertical section.

BOTTOM : Landscape near Jodhpur, with three mounds. (The black vertical pencil is 16 cm high).



Anacanthotermes macrocephalus (Jodhpur).

Plant material gathered in storage vaults or chambers along a subterranean gallery. Photographs. (A) The entire lot from a single chamber. (B-D) Samples of the principal constituents, sorted out; B, seeds; C, grass stems; D, bark and wood pieces. (After Roonwal, 1975b).



Anacanthotermes macrocephalus. (Jodhpur).

Two mounds, in near view. In the foreground mounds, note granular nature of mound-earth and the two 'plugs' at the apex. (The black pencil is 16 cm long.) (After Roonwal 1975b).