

Evolution and Systematic Significance of Wing Micro-sculpturing in Termites (Isoptera)*. VII. Subfamily Macrotermitinae of Family Termitidae

M L ROONWAL¹ FNA, S C VERMA² and N S RATHORE³

¹, ³Desert Regional Station, Zoological Survey of India, Paota B Road, Jodhpur

²Northern Regional Station, Zoological Survey of India, Dehra Dun

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(1) Micro-sculpturing (in addition to hairs), consisting of a dense covering (density 900-10870/mm²) of microscopic (2-15 μ m) cuticular structures on both the wing-surfaces, is described in 30 species belonging to six genera of the highly evolved, fungus-growing subfamily Macrotermitinae of the family Termitidae: *Pseudacanthotermes* (2 spp.), *Allodotermes* (2 spp.), *Macrotermes* (7 spp.), *Odontotermes* (14 spp.), *Hypotermes* (1 sp.) and *Microtermes* (4 spp.). (2) It consists, in each species, of two types of structures: (A) Papillae (size 3-4 μ m \times 6-8 μ m, density c. 4000-10870/mm²), which lie horizontally in several layers at the anterior and posterior wing-margins and are directed distally, are present in all genera. (B) The second type, which covers the rest of the wing-surface, consists, according to genus, of three different kinds of structures: (i) Microsetae, a new type found in *Pseudacanthotermes*; length 8-10 μ m density 5070/mm², (ii) Pimpules, found in *Macrotermes*: size 2-3 μ m \times 3-4.5 μ m; density 4570-7200/mm². (iii) Rods: Of two different types: (a) Thick, stubby rods (size 8-12 μ m \times 2-2.5 μ m; density 6895/mm²), found in *Allodotermes*. (b) Thin, thread-like, short to long rods (length 2-8 μ m to 10-15 μ m according to species; density 2910-6870/mm²), found in *Odontotermes*, *Hypotermes* and *Microtermes*. Thus, a total of a four types occur, apart from papillae. (3) Microsetae and the thick, stubby rods are associated with the primitive genera, and thin, hairy rods with the higher genera (*Odontotermes*, etc.). These various types of structures seem to have arisen polyphyletically. Micro-sculpturing provides good characters for differentiating between the lower systematic categories, e.g., between genera, and to a considerable extent also between species.

Key Words: Isoptera Wing, micro-sculpturing, Termites, Macrotermitinae.
Evolution Systematic significance

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Introduction

In the previous parts of this series of studies, wing micro-sculpturing in several families and subfamilies of the Isoptera has been examined (Roonwal & Chhotani 1967, Roonwal et al. 1974, Roonwal 1977, Roonwal & Rathore 1977, 1978, and Roonwal et al. 1979a, b).

The present part deals with the highly evolved, fungus-growing subfamily Macrotermitinae, which is a moderate-sized subfamily with a dozen genera, all of which are either Ethiopian or Oriental. Of these, the following six were available, the number of species studied being mentioned within brackets: *Pseudacanthotermes* (2), *Allodontermes* (2), *Macrotermes* (7), *Odontotermes* (14), *Hypotermes* (1) and *Microtermes* (4). In each species, two different types of cuticular structures, besides hairs, constitute the micro-sculpturing. The first type comprises the papillae which are directed distally and are found in all genera of termites. The second type of structures which cover the rest of the wing-surface are, according to genera, of three different kinds, viz., microsetae, pimpules and rods; of these, the microsetae are a new type of structure not hitherto reported in termites.

For taxonomy, Snyder's (1949) world *Catalogue* is referred to for names published earlier; for later names, the appropriate first reference is mentioned. (For the Oriental species, see particularly Roonwal 1970, and for the Ethiopian *Macrotermes*, see Ruelle 1970).

Materials and Methods

Wings of termites from South Asia and Africa were examined. Glycerine mounts provided a clearer differentiation than those in canada balsam. Density determinations were done from camera lucida drawings. Since both the wing surfaces are covered

with micro-sculpturing, and previous experience with the various genera and species of other families showed no marked difference between the surfaces, only the dorsal surface was used for recording the data.

Results

The various genera and species studied are discussed below in some detail.

Genus: (1) *Pseudacanthotermes* Sjöstedt

This is a small Ethiopian genus of which two species were available.

1. *Pseudacanthotermes militaris* (Hagen 1858) (figures 1 A-D, and Plate 1, figure 1) (Snyder 1949, p. 204).

Material: Imagoes from Africa (Sorati, Uganda).

Wings: Colourless, transparent; the front two veins dark brown, rest paler. Size with scales, forewings 20×5 mm, hindwings 19×5 mm. With 2-3 rows of hairs on the anterior, and a row on the posterior margin; rest of the membrane without hairs; hairs $50-65 \mu\text{m}$ long.

Micro-sculpturing :

Consists of two types of structures, viz., the usual papillae and a new type of non-directional structure, the *microsetae*.

Papillae: Are pointed and directed distally; 2-3 rows on both anterior and posterior margins. Size $6-8 \mu\text{m} \times 3-4 \mu\text{m}$; the posterior once smaller. Density $4000/\text{mm}^2$.

Microsetae: Constitute a new type of structure; the whole wing-surface covered with them, except where papillae are present. Thin, pointed, setae-like, hyaline structures, with basal articulation and pointing in different directions. Length $8-10 \mu\text{m}$; density $5070/\text{mm}^2$.

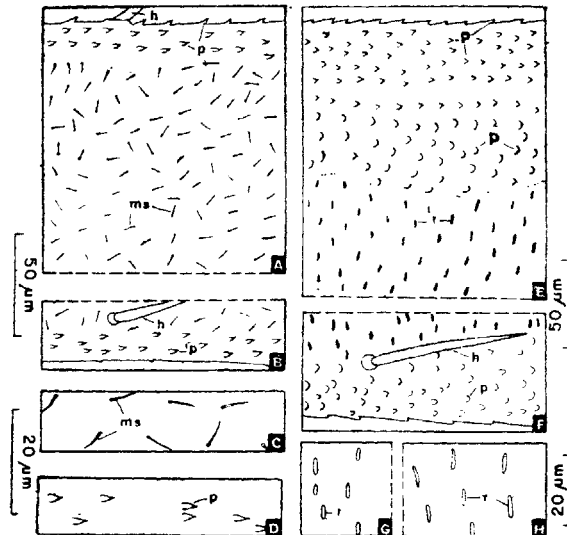


Figure 1 Wing micro-sculpturing on parts of dorsal surface of forewing in two Macrotermitinae species from Africa. A-D *Allodontermes militaris* (Sorati, Uganda), to show papillae and microsetae. A, Anterior margin; B, Posterior margin; C-D Parts of A, enlarged. E-H *Allodontermes schultzei orientalis* (Lozenzo Marques, Mozambique), to show papillae (of two types) and thick rods; E, Anterior margin; F, Posterior margin; G, Smaller rods on proximal one-fourth of wing. H, Longer rods elsewhere.

h, hairs; ms, microsetae; p, papillae; r, rods

2. *Pseudacanthotermes spiniger* (Sjöstedt 1900) (Snyder 1949, p. 204)

Material: Imagoes from Africa (Mable, Uganda).

Wings as in *P. militaris*, but larger, size without scale, forewings 27×6 mm, hindwings 25×5 mm. Micro-sculpturing with papillae and microsetae; generally as in *P. militaris* above.

Genus (2) *Allodontermes* Silvestri

This too is a small Ethiopian genus of which two species were available.

1. *Allodontermes rhodesiensis* (Sjöstedt 1914) (Snyder 1949, p. 207)

Wings and their micro-sculpturing are generally as in *A. schultzei orientalis* below:

2. *Allodotermes schultzei orientalis* Fuller 1922 (figures 1 E-H, and Plate 1, figure 2) (Snyder 1949, p. 207)

Material: Imagoes from Africa (Lorenzo Marques, Delgoa Bay, "Portugese East Africa" = Mozambique).

Wings: Transparent, colourless; veins pale brown. Size with scale, forewings 21×4 mm, hindwings 20×4 mm. With 2 rows of hairs on the front vein, a row on the next one, and 1-4 rows of scattered hairs on the posterior margin; hairs $80-100 \mu\text{m}$ long; rest of the membrane without hairs.

Micro-sculpturing:

Papillae: A wide band of 8-10 rows of papillae on the anterior margin, and 3-4 rows on the posterior. Papillae of two types viz., tongue-shaped and pointed; and shallower and rounded. Size $6-8 \mu\text{m} \times 4-6 \mu\text{m}$. Density $10870/\text{mm}^2$ (anterior region).

Rods: Thickly cover the entire membrane except where papillae are present. Are thick, straight, glossy and stubby structures with rounded ends (cf. the thin, hair-like rods of *Odontotermes* spp., etc. below); arranged subvertically antero-posteriorly). Those on the proximal one-fourth of the wing are smaller and more rounded (size $8-10 \mu\text{m} \times 2 \mu\text{m}$) than those elsewhere (size $10-12 \mu\text{m} \times 2-2.5 \mu\text{m}$). Density $6895/\text{mm}^2$. The rods may be interpreted as simple, one-armed, nonasteroid micrasters at Type I.

Genus (3) *Macrotermes* Holmgren

This is a moderate-sized Oriental and Ethiopian genus of which 7 species and subspecies were available. In all of them only papillae and pimpules are present (the presence of pimpules and the absence of rods found in several other genera of the subfamily Macrotermitinae recall similarity with the primitive family Kalotermitidae).

The rods may be interpreted as simple, one-armed, nonasteroid micrasters of type I.

1. *Macrotermes estherae* (Desneux 1908) (figures 2A-D, and Plate 1, figure 3) (Snyder 1949, p. 211)

Material: Imagoes from S. Asia (Palni Hills, Tamil Nadu, India).

Wings: Veins brown, heavily pigmented, especially in the anterior and proximal parts of wings; membrane colourless. Moderately hairy all over, specially on the anterior veins; length of hairs $60-150 \mu\text{m}$; density $150/\text{mm}^2$ in middle of wing.

Micro-sculpturing:

Papillae: Thickly present in 20-25 rows all over the width of the two anterior veins, and in 6-7 rows on the posterior margin. Size $3-7.5 \mu\text{m} \times 4.5-7.5 \mu\text{m}$. Density $8000/\text{mm}^2$ (on front vein).

Pimpules: Several rows thick on veins in the proximal part of wing; apparently absent in the distal part. Size $3-4.5 \mu\text{m} \times 3-4 \mu\text{m}$; density $4570/\text{mm}^2$ (on media).

2. *Macrotermes gilvus borneensis* Kemner 1933 (figures 2 E-H, and Plate 1, figure 4) (Snyder 1949, p. 211).

Material: Imagoes from S. E. Asia (Sarawak, E. Malaysia).

Wings: Transparent and pale yellow-brown; anterior two veins and proximal part golden brown. With dense covering of hairs all over, specially on the anterior veins; hairs $60-140 \mu\text{m}$ long; density $300/\text{mm}^2$ (in middle of wing).

Micro-sculpturing:

Papillae: Present in 7-8 rows on the front vein and in rows on the posterior margin. Size $3-7 \mu\text{m} \times 3-4 \mu\text{m}$ density $6400/\text{mm}^2$ (on anterior margin).

Pimpules: Present in broad strips on veins in the proximal part. Size $2-3 \mu\text{m} \times 2-3.5 \mu\text{m}$; density $7200/\text{mm}^2$.

The following five species generally resemble either of the two described above, and are considered very briefly.

3. *Macrotermes bellicosus* Smeathman 1781) Syn. *M. nigeriensis* (Sjöstedt) (Snyder 1949, p. 209; Ruelle 1970, p. 374)

E. Africa (Villagio-Ducadegli, Abruzzi, Somali Republic) Generally as in *M. gilvus borneensis* but hairs less dense.

4. *Macrotermes falciger* (Gerstäcker) Snyder 1949, p. 213, *M. goliath*; Ruelle 1970, p. 381, *M. falciger*.) Syn. *M. goliath* Sjöstedt)

E. Africa (Amani, Tanzania). Generally like *M. estherae*, but wings more hairy.

5. *Macrotermes gilvus gilvus* (Hagen 1858) S. E. Asia (Telawa, Java). Generally like *M. gilvus borneensis*. (Snyder 1949, p. 211)

6. *Macrotermes muelleri* (Sjöstedt 1898) (Snyder 1949, p. 215, *M. muelleri*; Ruelle 1970, p. 405, *M. muelleri*)

Central Africa (Medje, Zaire [formerly Belgian Congo]). A single damaged wing available. A few hairs present on the front vein; in addition, a row of round platelets (apparently the bases of broken hairs) present on other veins. Micro-sculpturing as in *M. estherae*.

7. *Macrotermes serrulatus serrulatus* (Snyder 1934) (Snyder 1949, p. 217, *M. serrulatus*; Roonwal & Sen-Sarma 1956, p. 21, *M. serrulatus serrulatus*)

S. Asia (Hsipaw, Burma). Wings transparent, colourless to pale yellow, veins yellow. Generally as in *M. estherae*, but papillae fewer and present only on anterior half of front vein.

Genus (4) *Odontotermes* Holmgren

This is a large Ethiopian and Oriental genus, members of which cultivate fungi and some of them build massive earthen mounds. Wing micro-sculpturing, by means of variously shaped thin, hair-like 'cuticular rods' was described by Roonwal and Chhotani (1967) in several species of *Odontotermes* as well as in a few species of

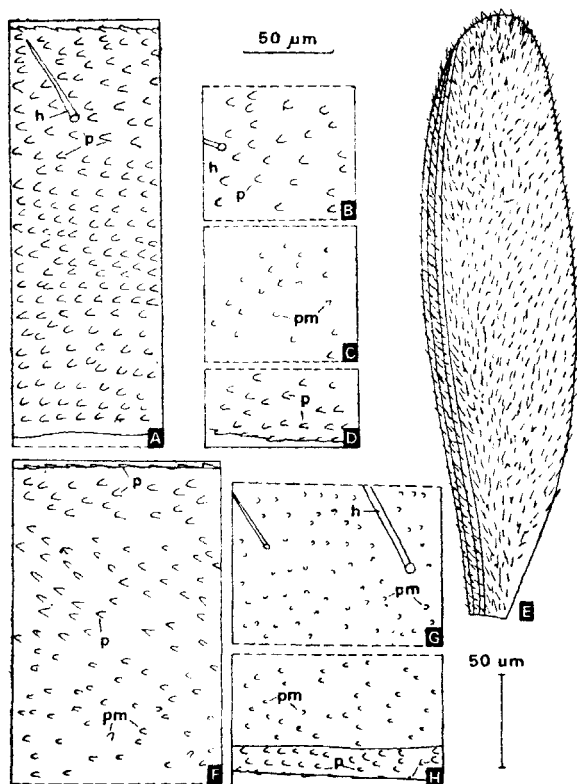


Figure 2 Micro-sculpturing on dorsal wing surface of *Macrotermes* from Asia. A-D *M. estherae* (Palni Hills, Tamil Nadu, India). A, Anterior margin, to show a wide belt of papillae on entire front vein; B, Next below, on second vein, with papillae. C, Much lower down on media, to show pimpules D, Posterior margin, to show papillae. E-H *M. gilvus borneensis* (Sarawak, E. Malaysia). E, Entire wing, to show distribution of hairs; F, Part of anterior margin in proximal region, to show papillae and pimpules; G, Part of second vein, to show pimpules. H, Posterior margin, to show papillae and pimpules
h, hairs; p, papillae; pm, pimpules

the allied genera *Hypotermes* and *Microtermes*. These authors also figured the papillae in *O. obesus* (their figure 1C), but gave no other details of their structure.

Here we discuss 14 species in all of which both papillae and thin rods are present. We confirm the occurrence of the two kinds of rods mentioned by Roonwal and Chhotani, e.g., (i) the *obesus*-type in which the rods are very thin, thread-like and substraight; and (ii) the *assmuthi*-type where they are thicker and serpentine. In both types they are dense (about 3200-8500/mm²) and are arranged subvertically (antero-posteriorly) with or without a slight tilt on either side.

1. *Odontotermes dehraduni* (Snyder 1933) (figures 3 A-E, and plate 1, figures 5 and 6) (Snyder 1949, p. 224).

Material: Imagoes from S. Asia (Jodhpur, Rajasthan, India).

Wings: Colourless, transparent, veins brownish yellow; length with scale, forewing 22 mm, hindwing 21 mm. With 2 or 3 irregular rows of hairs on anterior vein, a row on the next vein (Rs); and 1 or 2 rows on the posterior margin; rest of wing almost without hairs; hairs 60-80 μ m long.

Micro-sculpturing:

Papillae: Tongue-shaped and directed distally; 4-5 rows on the anterior margin, 1-2 rows on the posterior. Size 7-7.5 μ m \times 6-8 μ m; those on the posterior margin smaller.

Rods: Thin, thread like, substraight to weakly wavy rods (*obesus*-type) present all over membrane except in the region of the papillae. Length 11-13 μ m; density 6520/mm².

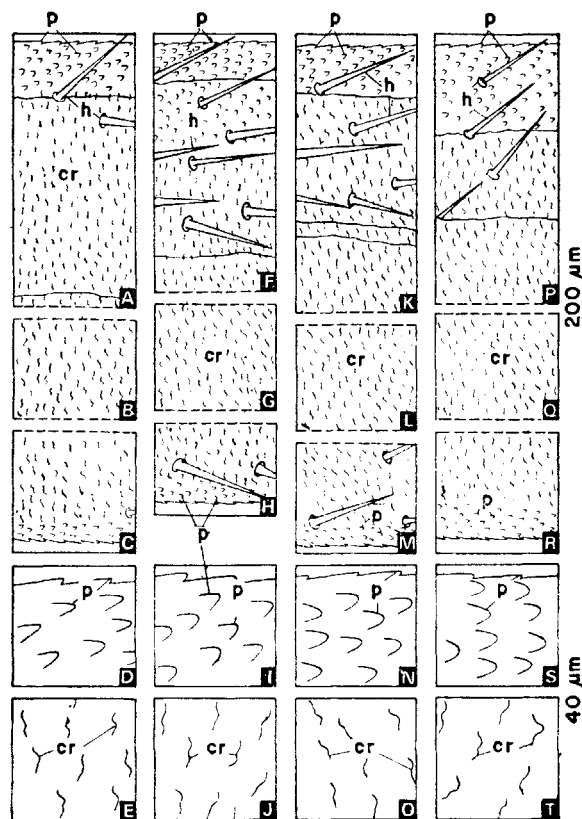


Figure 3 Parts of wings of *Odontotermes* (Rajasthan, India), to show micro-sculpturing. Upper three figures: Anterior, middle and posterior parts of wings. Lower two figures (more magnified): Above, anterior part; bottom, middle. A-E *O. dehraduni*, Jodhpur; right hindwing. F-J *O. distans*, Khokarid, near Jodhpur; right forewing. K-O *O. obesus*, Jodhpur; right hindwing. P-T *O. wallonensis*, Bar, Ajmer District; right forewing

c.r, cuticular rods; h, hairs; p, papillae

2. *Odontotermes distans* (Holmgren & Holmgren 1917) (figures 3 F-J, figure 7) and Plate 1 (Snyder 1949, p. 225).

Material: Imagoes from S. Asia (Khokaria village, 11 km E. of Jodhpur, Rajasthan, India).

Wings: Transparent, slightly pale brown; anterior vein dark brown, others colourless but fringed with brown. Length with scale, forewing 24 mm, hindwing 23 mm. Hairs as in *O. dehraduni*, but longer (100-160 μm) and more numerous.

Micro-sculpturing:

Papillae: Tongue-shaped; 8-11 rows on the anterior margin and 2-3 rows on the posterior. Among the anterior papillae, the lower rows are more rounded and shorter than the upper ones. Size 3-8 $\mu\text{m} \times 5-6 \mu\text{m}$.

Rods: Generally all over wings; as in *O. dehraduni*; of the *obesus*-type. Length 12-14 μm ; density 5795/mm².

3. *Odontotermes obesus* (Rambur 1842) (figures 3 K-O, 4A, J, and Plate 1, figure 8) (Snyder 1949, p. 235)

Material: Imagoes from S. Asia (Jodhpur, Rajasthan, India).

Wings: Generally as in *O. dehraduni*; length with scale, forewing 23 mm, hindwing 22 mm.

Micro-sculpturing:

Papillae: Generally as in *O. dehraduni*; 5-6 rows on the anterior margin, and 2-4 rows of smaller papillae on the posterior. Size 6-8 $\mu\text{m} \times 5-6 \mu\text{m}$.

Rods: Thin and of the *obesus*-type; all over wing except in the region of the papillae; length 10-15 μm . Density per mm², in forewings 3966-5550, in hindwings 4140-5795. (For some more details, see Roonwal & Chhotani 1967)

4. *Odontotermes wallonensis* (Wasmann 1902) (figures 3 P-T, and plate 2, figure 1) (Snyder 1949, p. 243).

Material: Imagoes from S. Asia (Bar, Ajmer District, Rajasthan, India).

Wings: Semitransparent, colourless; the anterior two veins thick and brown, the rest paler. Length with scale, forewing 26 mm, hindwing 25 mm. With a row of hairs on the two front veins and on the posterior margin, and several rows in the distal part; rest of wing without hairs; the hairs 70-90 μm long.

Micro-sculpturing:

Papillae: Tongue-shaped, apex rounded; 8-10 rows on the anterior margin, and 3-4 rows of smaller ones on the posterior.

Rods: Rest of the wing covered with rods of the *obesus*-type. Length 10-15 μm ; density 5075/mm².

5. *Other species with obesus-type rods* (figure 4)

The following 10 species, all from South Asia, have thin, *obesus*-type rods (for more details, see Roonwal & Chhotani 1967); we were unable to re-examine these species for papillae, but think that they are most probably present :—

bellahunisensis Holmgren & Holmgren 1917 (figure 4B)

ceylonicus (Wasmann 1902) (figure 4C)

flavomaculatus Holmgren & Holmgren 1917 (figure 4D)

gurdaspurensis Holmgren & Holmgren 1917 (figure 4E)

horni (Wasmann 1902) (figure 4F)

malabaricus Holmgren & Holmgren 1917 (figure 4G)

meturensis Roonwal & Chhotani 1960 (figure 4H)

microdentatus Roonwal & Sen-Sarma 1960 (figure 4I)

parvidens Holmgren & Holmgren 1917 (figure 4K)

redemanni (Wasmann 1893) (figure 4L)

The density varies as 3170—6870/mm².

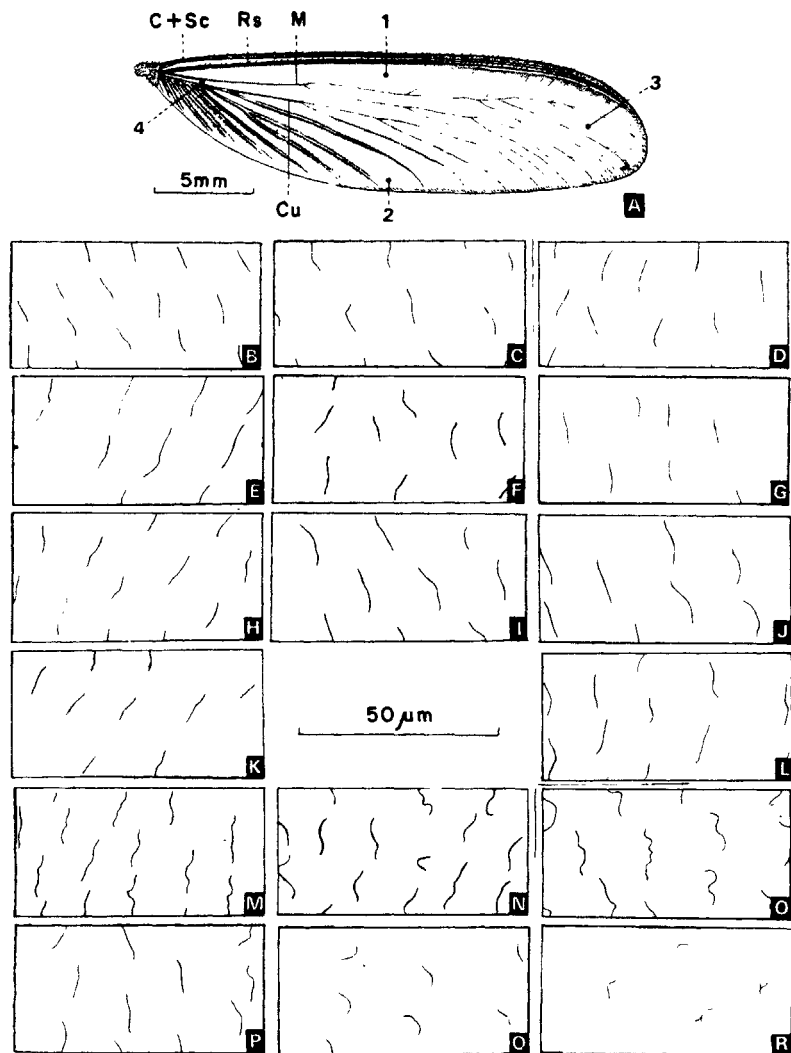


Figure 4 Wing micro-sculpturing in genera *Odontotermes* (A-O), *Hypotermes* (P) and *Microtermes* (Q, R). A, *O. obesus* Hindwing, to show venation and areas studied (locations 14 and the rectangles); B-Q Cuticular rods, in high magnification: B, *O. bellahunisensis*; C, *O. ceylonicus*; D, *O. flavonaculatus*; E, *O. gurdaspurensis*; F, *O. horni*; G, *O. malabaricus*; H, *O. meturensis*; I, *O. microdentatus*; J, *O. obesus*; K, *O. parvidens*; L, *redemanni* [B-L, the *obesus*-type of rods]; M, *Q. anceps amaniensis*; N, *O. assmuthi*; O, *O. formosanus*; [M-O, the *assmuthi*-type of rods] P, *Hypotermes obscuricops*; Q, *Microtermes imphalensis*; R, *M. unicolor*

C+Sc., costa-sub costa; cu, cubitus; M, Media; Rs, Radial sector

6. *Species with assmuthi-type rods* (figure 4, and plate 2, figures 2,3) are present; density of rods *c.* 2909-5553/mm².

The following species (two from S.Asia and one, *O. anceps*, from Amani, Tanzania, Africa) have the thick, serpentine, *assmuthi*-type rods, also arranged subvertically, with a slight tilt to either side. The length varies as 7-15 μm and the density per mm² as 4760-7670. (For more details, see Roonwal & Chhotani 1967.) Papillae were not mentioned, and we were unable to reexamine the material, but we suspect that they may be present as in other species of the genus.

O. anceps var. *amaniensis* Sjöstedt 1924 (figure 4M)

O. assmuthi Holmgren 1913 (figure 4N)

O. formosamus (Shiraki 1909) (figure 4O, and plate 2, figure 4)

Genus (5) *Hypotermes* Holmgren

In this small Oriental genus wings of *Hypotermes obscurieps* (Wasmann) from Sri Lanka (figure 4F) were examined by Roonwal and Chhotani (1967) and found to be covered all over with thin, cuticular rods; length 3-12 μm (shorter in hindwings than in the forewings), density 3966-5024/mm². Papillae were not mentioned. We were unable to re-examine the species but suspect that papillae are probably present.

Genus (6) *Microtermes* Wasmann

This medium-sized genus of very small termites occurs in the Ethiopian, Malagassy and Oriental Regions. Micro-sculpturing in four species from South Asia is discussed below; both papillae and thin, thread-like cuticular rods (the latter are generally shorter and less numerous than in *Odontotermes*)

1. *Microtermes imphalensis* Roonwal & Chhotani 1962 (figure 4 Q) (Roonwal & Chhotani 1962, p. 364)

Cuticular rods on wing-surface were described by Roonwal and Chhotani (1967) from Indian material (Imphal Valley, Manipur). General shape of rods as in *M. mycophagus* below; length 3-8 μm ; density 2909-5553/mm². Papillae were not mentioned; we were unable to re-examine the species, but suspect that they are present as in the other species of the genus examined by us (vide infra).

2. *Microtermes mycophagus* (Desneux 1906) (figures 5A-E, and plate 2, figures 5, 6) (Snyder 1949, p. 252)

Material: Imagoes from S. Asia (Jodhpur, Rajasthan, India).

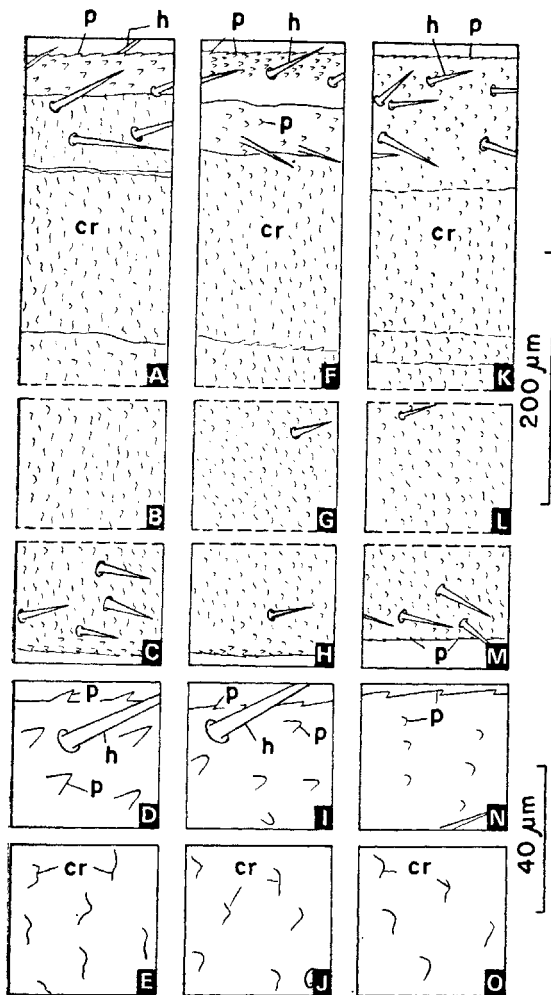
Wings: Transparent, colourless; two front veins brown, the rest paler. Length with scale, forewing 17 mm, hindwing 16 mm. With 2-3 rows of hairs on the front vein, and a single row on the next; posterior margin with 2-3 rows of smaller hairs; a few hairs on the membrane; hairs 60-90 μm long.

Micro-sculpturing:

Consists of papillae and rods.

Papillae: Pointed; 2-4 rows on the anterior margin, and 1-2 rows of smaller ones on the posterior. Size 6 μm \times 5 μm .

Rods: Wing-surface covered with small, thin, substraight to slightly curved (a few almost V-shaped), hairy rods which are arranged subvertically (antero-posteriorly), with or without a slight tilt on either side. Length 7-8 μm ; density 4350/mm² (on forewing).



Figures 5 Parts of right forewings of *Macrotermes* from Jodhpur, India, to show micro-sculpturing. Upper three figures: Anterior, middle and posterior parts of wings; Lower two figures (more magnified): Above anterior part; bottom, middle part. A-E *M. mycophagus*; F-J, *M. obesi*; K-O, *M. unicolor*

c.r., cuticular rods; h, hairs; p, papillae

3. *Macrotermes obesi* Holmgren 1913 (figures 5F-J, and plate 2, figure 7) [Syn. *M. anandi* Holmgren] (Snyder 1949, p. 252)

Material: Imagoes from S. Asia (India: Jodhpur, Rajasthan; and Hoshiarpur Punjab).

Wings: Generally as in *M. mycophagus* above, but smaller (length with scale, forewing 12 mm, hindwing 11.5 mm), the pigmented parts darker and the hairs rather more numerous.

Micro-sculpturing:

Papillae: Tongue-shaped with pointed apex; 4-5 rows at the anterior margin, and 1-2 rows of smaller ones at the posterior. Size $4\mu\text{m} \times 6\mu\text{m}$.

Rods: As in *M. mycophagus*, but mostly smaller. Length 2-8 μm ; density 2644:—4759/ mm^2 . (Also see Roonwal & Chhotani 1967.)

4. *Macrotermes unicolor* Snyder (figures 4R, 5K-O, and plate 2, figure 8) (Snyder 1949, p. 254)

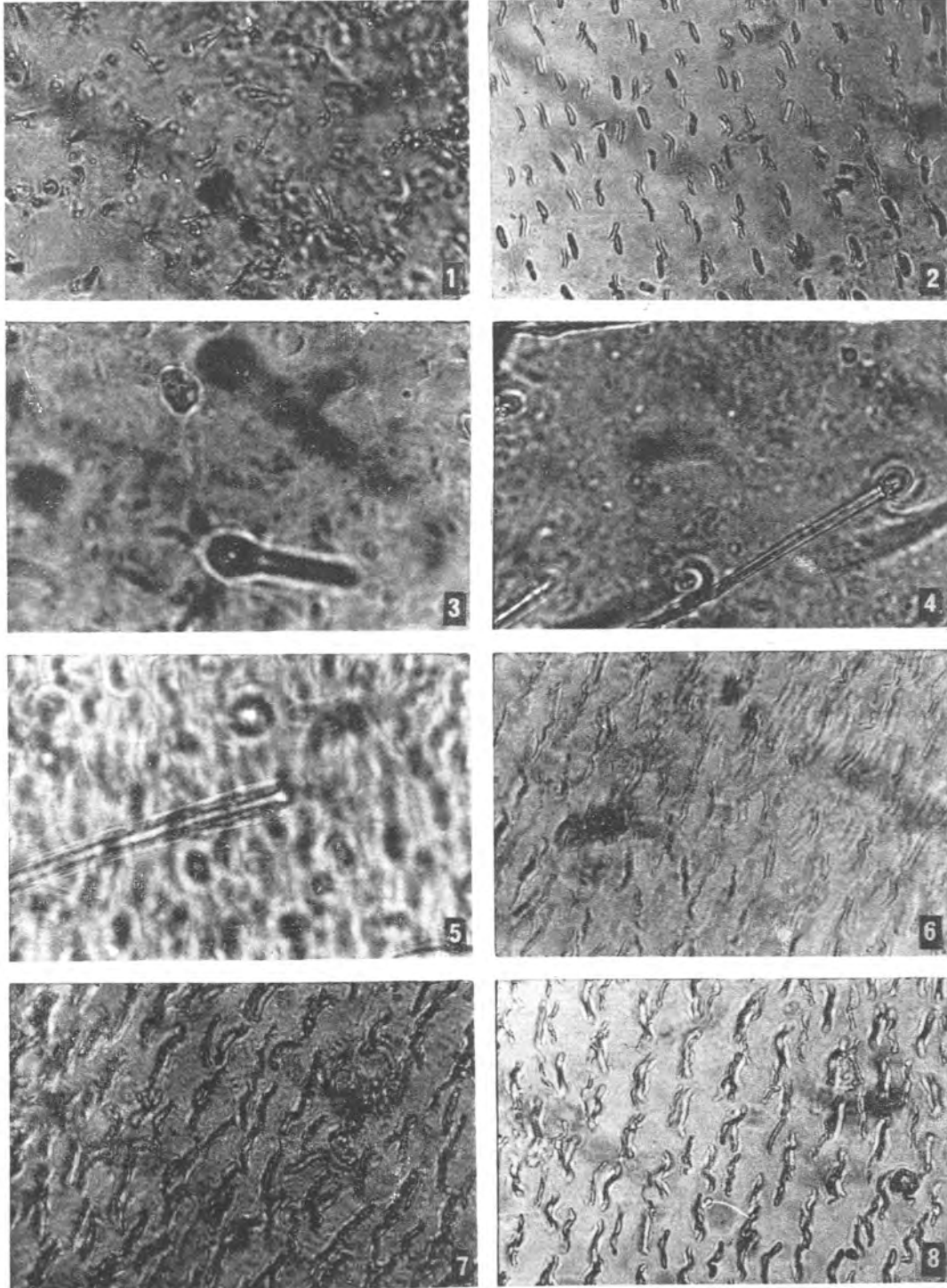
Material: Imagoes from S. Asia (India: Jodhpur, Rajasthan; and Dehradun, Uttar Pradesh).

Wings: Generally as in *M. mycophagus*, but smaller (length with scale 13.5 mm); hairs rather more numerous.

Micro-sculpturing:

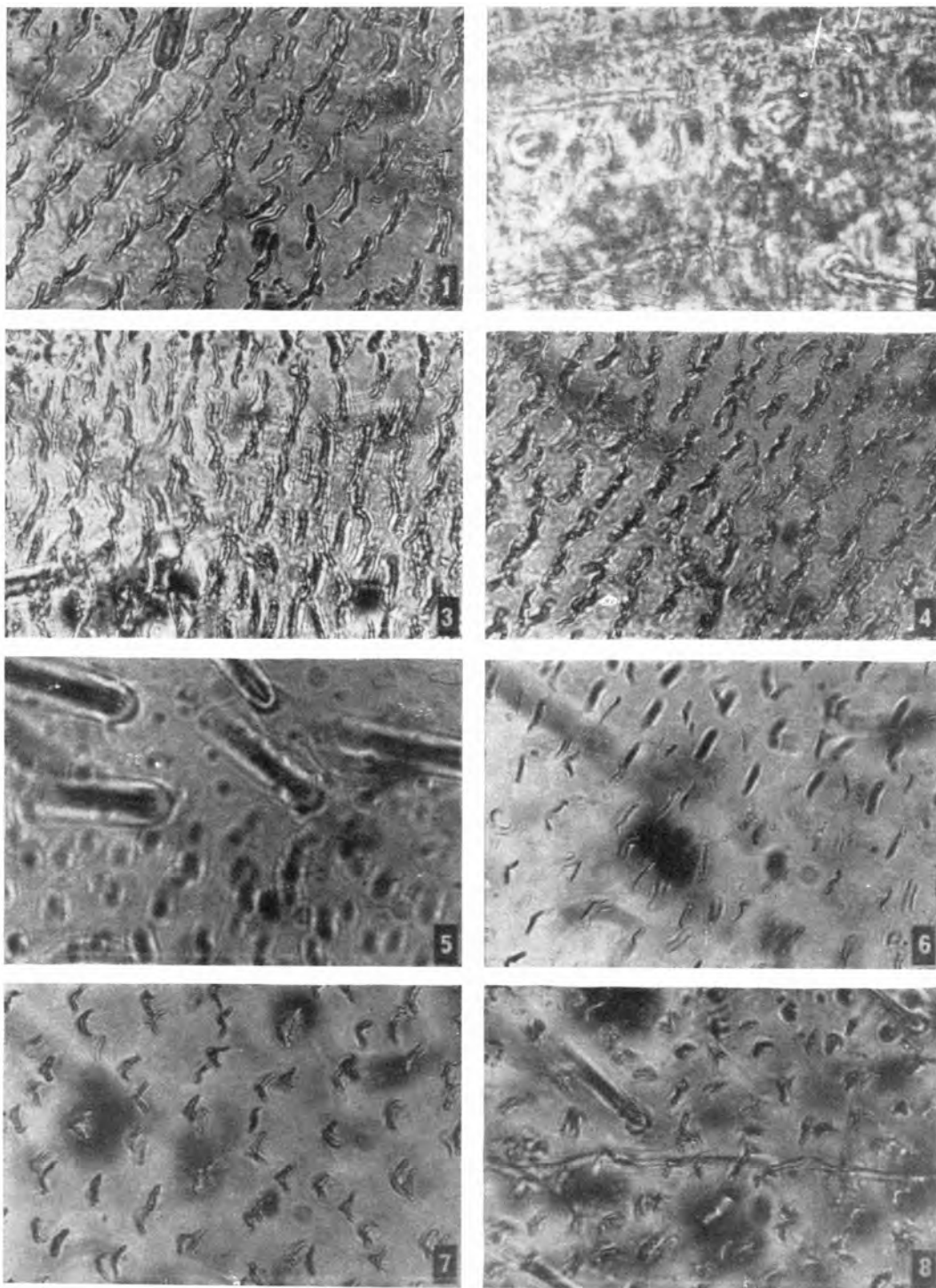
Papillae: Shallower and less pointed than in *M. mycophagus*. With a wide strip of 10-13 rows at the anterior margin, and 1-2 rows at the posterior, Size $4\mu\text{m} \times 6\mu\text{m}$.

Plate 1 Photomicrographs of wings of some Macrotermitinae, to show micro-sculpturing. (Also cf. the text-figures.) 1, *Pseudacanthotermes militaris*, middle portion, to show microsetae; 2, *Allodotermes schultzei orientalis*, middle portion, to show rods; 3, *Macrotermes estherae*, near anterior margin, to show papillae (near top); 4, *Macrotermes gilvus borneensis*, middle portion, to show pimpules (white, refractile dots) and hairs; 5, *Odontotermes dehraduni*, anterior margin, to show pointed papillae and two hairs; 6, middle portion, to show cuticular rods; 7, *Odontotermes distans*, middle portion, to show cuticular rods; 8, *Odontotermes obesus*, middle portion to show cuticular rods



50 μ m

Plate 1



50 μm

Plate 2

Rods: Generally as in *M. mycophagus* but smaller (length 2-7 μm). Density 2909—4495/mm². (Also see Roonwal & Chhotani 1967.)

Discussion and Conclusions

In the six Macrotermitinae genera studied here, micro-sculpturing consists of two main types, viz., of papillae and of a second type which varies with the genus (table 1).

Papillae are present universally, and this is in consonance with the condition in all families and genera of the Isoptera so far examined. Two main kinds of papillae are found (both kinds may occur in the same species), viz., finger-shaped or tongue-shaped (sometimes flatter and broader) but

the apex is round in some and sharply pointed in others. They are confined to the anterior and posterior margins of the wing, lie horizontally, always point towards the distal end of the wing, and are arranged in several vertical rows (a few to about 25 rows on the anterior margin, and 1-7 rows on the posterior). The size range is about 3-4 $\mu\text{m} \times 6-8 \mu\text{m}$ (the papillae on the posterior margin are generally smaller than those on the anterior), and the density about 4000-10870/mm².

The second type, which covers the rest of the wing surface, consists, according to genera, of three different kinds of structures as follows :

(i) Microsetae: They constitute a new type of micro-sculpturing not hitherto described

Table 1 Summary of wing micro-sculpturing in the genera of the Macrotermitinae

Genera (and number of species examined)	Known types of micro-sculpturing in isoptera					Rods	Remarks
	Papillae	Tubercles	Pimpules	Micro-setae	Micro-asters		
1. <i>Pseudacanthotermes</i> (2 spp.)	+	-	-	+	-	-	
2. <i>Allodotermes</i> (2 spp.)	+	-	-	-	-	+	Thick, stubby type
3. <i>Macrotermes</i> (7 spp.)	+	-	+	-	-	-	
4. <i>Odontotermes</i> (14 spp.)	+	-	-	-	-	+	Thin, long thread-like Either substraight or very sinuous
5. <i>Hypotermes</i> (1 sp.)	+	-	-	-	-	+	Ditto, but substraight
6. <i>Microtermes</i> (4 spp.)	+	-	-	-	-	+	Ditto, but short and substraight (some bent, V-shaped)

+ . present; - , absent

Plate 2 Photomicrographs of some more Macrotermitinae, to show micro-sculpturing. (Also cf. the text figures.) 1, *Odontotermes wallonensis*, middle portion, to show cuticular rods; 2, *O. assmuthi*, anterior margin, to show papillae; 3, Same, middle portion, to show cuticular rods; 4, *O. formosanus*, middle portion, to show cuticular rods; 5, *Microtermes mycophagus*, anterior margin, to show papillae, hairs and cuticular rods (the last two are rather out of focus); 6, Same, middle portion, to show cuticular rods; 7, 8, *M. obesi* and *M. unicolour* respectively, middle portions to show cuticular rods

in termites, and have been found in the genus *Pseudacanthotermes*. They are non-directional and have a basal articulation; they differ from hairs only in being very small. Length 8-10 μm ; density 5070/ mm^2 .

(ii) Pimpules: Minute non-directional structures which recall the pimpules of the Kalotermitidae (see Roonwal & Rathore 1977). Size 2-3 $\mu\text{m} \times 3-4.5 \mu\text{m}$. Density 4570-7200/ mm^2 . Found in genus *Macrotermes*.

(iii) Rods: These are arranged subvertically are of two kinds: (a) Thick, stubby rods (which recall the single-armed 'micrasters' of some termites, see Roonwal, Verma & Rathore 1974, Type I). Size 8-12 $\mu\text{m} \times 2-2.5 \mu\text{m}$; density 6895/ mm^2 . Found in genus *Allodotermes*. (b) Thin, short to long, thread-like rods. Length varying with genera from 2-8 μm to 10-15 μm . Density 2910-6870/ mm^2 . Found in genera *Odontotermes*, *Hypotermes* and *Microtermes*. (They were first described by Roonwal & Chhotani 1967.)

In addition to the micro-sculpturing mentioned above, the wings are covered with numerous hairs which are about 50-160 μm long. Their density and distribution varies with the genera and species; they are densest (125-300/ mm^2) in some species of *Microtermes* (see figure 2E).

A special feature of micro-sculpturing in the Macrotermitinae (apart from papillae which have been found to occur in all termites) is its great variability among the genera, and four types of structures

occur, thus: (i) Microsetae occur in the primitive genus *Pseudacanthotermes*; and (ii) thick, stubby rods (which may be interpreted as simple, one-armed, nonasteriod micrasters) in another primitive genus *Allodotermes*. The absence of these two types of structures in the more evolved genera of the Macrotermitinae suggest their association with primitiveness. (iii) The presence of pimpules in the relatively highly evolved genus *Macrotermes* is intriguing since these structures are a characteristic feature of the primitive family Kalotermitidae. (iv) The highly evolved and closely allied genera, *Odontotermes*, *Hypotermes* and *Microtermes*, have thin, thread-like rods which are not found anywhere else in the Isoptera, and this feature may, therefore, be associated with the highly evolved termites. Tubercles (found in some Kalotermitidae) and multi-armed micrasters (found in some Rhinotermitidae and some subfamilies of the Termitidae) are entirely absent in the Macrotermitinae. Since the four types of structures mentioned above in the Macrotermitinae vary with the genera and are difficult to derive one from the other, we may regard them as polyphyletic in origin.

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