

Evolution and Systematic Significance of Wing Micro-sculpturing in Termites (Isoptera) XII. Sculpturing on Wing Scales

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Elaborate and dense micro-sculpturing occurs on both wing surfaces in termites (Roonwal et al. 1967-1981), but at the proximal end, especially on the wing scale, it becomes modified as compared with the 'typical' condition on membrane. Since complete wings are available only infrequently (at periodical swarmings and are cast away soon after, leaving behind only the stumps or scales), it is important for taxonomic purposes to know the condition on the scales.

In a pilot study, 15 species belonging to nine genera were examined: Hodo-termitidae: *Anacanthotermes*. Rhinotermitidae: *Heterotermes* and *Coptotermes*. Termitidae: *Eremotermes*, *Microcerotermes*, *Angulitermes*, *Odontotermes*, *Microtermes* and *Trinervitermes*.

Sculpturing on scales is markedly different from the membrane part. Papillae, though universally present on the membrane, are often absent on scales. Pimpules may be present or absent; micrasters and cuticular rods are present but are greatly modified. Thus, the atypical condition on the scale does not permit us to use it for discriminating between species, and the restriction applies even more so to the higher taxonomic categories.

Key Words : Termites, Isoptera, Wing scales, Micro-sculpturing

Introduction

In a series of studies (Roonwal & Co-workers 1967-1981) the occurrence of elaborate and dense (in some cases over 12500/mm²) micro-sculpturing on both upper and lower surfaces of termite wings has been established on the basis of the examination of all the major families and some 79 genera and over 238 species from all over the world.

At least seven different types of micro-structures have been identified, and they comprise an important systematic character, especially for differentiating the lower taxonomic categories, e.g. species and subspecies, sometimes even genera.

The isopteran wing is divided into two parts (figure 1): a small, proximal, basal *scale* and a large, distal *membrane*,

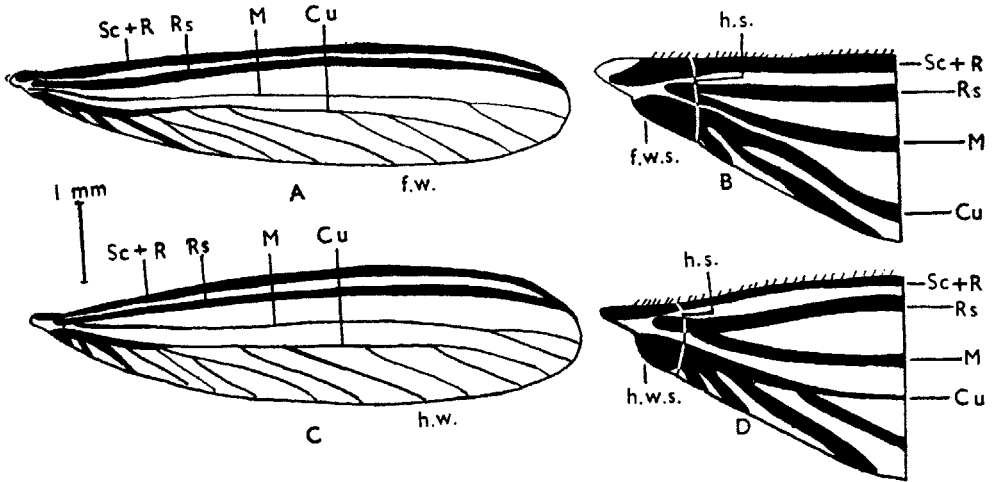


Figure 1 Right wings of *Microcerotermes raja*, to show venation and humeral suture. (A) Forewing. (B) Same, basal part enlarged. (C) Hindwing. (D) Same, basal part enlarged. *Cu*, cubitus; *f.w.*, forewing; *f.w.s.*, forewing scale; *h.s.*, humeral (or basal) suture; *h.w.*, hindwing; *h.w.s.*, hindwing scale; *M*, media; *Rs*, radial sector; *Sc + R*, subcosta + radius.

the boundary between the two being marked by the *humeral* or *basal suture*. Soon after the periodical nuptial flight, the membrane portion is cast away, leaving behind permanently a stump or scale which is found in all dealated reproductives (including the so-called kings and queens) in nests and mounds. Alates are collected infrequently (only at swarming time) whereas dealates can be collected more often, with the added advantage of being available with the associated soldiers and workers.

Micro-sculpturing studies carried out so far have been mainly concerned with the wing membrane whose sculpturing is regarded as 'typical' for a species. Since the scale is more commonly available and can possibly be taxonomically useful, a special pilot study was made to determine the extent to which scale micro-sculpturing can be used.*

Material and Methods

The techniques as given in the previous

parts were followed. Micro-sculpturing on wing scales was studied in 15 species belonging to 3 families and 9 genera, as follows:

- Fam. I. Hodotermitidae: *Anacanthotermes*.
- Fam. II. Rhinotermitidae
 - Subfam. Heterotermitinae: *Heterotermes*.
 - Subfam. Coptotermitinae: *Coptotermes*.
- Fam. III. Termitidae
 - Subfam. Amitermitinae: *Eremotermes* and *Microcerotermes*.
 - Subfam. Termitinae: *Angulitermes*.
 - Subfam. Macrotermitinae: *Odontotermes* and *Microtermes*.
 - Subfam. Nasutitermitinae: *Trinervitermes*.

All examples are from South Asia; the precise localities are indicated. For

* This part will be followed by the final one of the series, in which the evolutionary position in the Isoptera, as a whole, will be examined.

taxonomic position reference is made to Snyder's (1949) world catalogue, while for the species described later the appropriate references are given. For termite classification into families (Roonwal 1979).

Results

FAMILY I: HODOTERMITIDAE

GENUS (1) *Anacanthotermes* Jacobson

1. *Anacanthotermes macrocephalus* (Desneux) (figure 2)

(Snyder 1949 : 62.) Jodhpur (Rajasthan, India.)

Wings (with scale) : Forewings 23.0 × 5.3 mm, hindwings 22.0 × 6.0 mm. Forewing scale, L 1.25 – 1.50, W 1.2 – 1.3 mm. Hindwing scale, L 1.10 – 1.12, W 1.00 – 1.05 mm.

Micro-sculpturing: *On scale*: papillae minute (1–2 μm × 1–2 μm), somewhat pointed; in 3–4 rows on distal three-fourths of anterior margin. Pimpules absent. Hairs numerous, short to long (6–70 μm), stumpy and scattered all over, fewer on lower part. *On membrane*: Papillae finger-like; in 2–3 rows on anterior margin: size 3–6 μm × 2–4 μm; density c. 8750/mm². Pimpules all over; size 2–3 μm × 2–3 μm; density c. 2000–4000/mm². Hairs few or absent. (Also see Roonwal & Rathore 1978 and Roonwal et al. 1979 a.)

FAMILY II. RHINOTERMITIDAE

GENUS (2) *Heterotermes* Froggatt

Micro-sculpturing in *Heterotermes* has been studied by Roonwal and Verma (1976), Roonwal and Rathore (1977), Roonwal et al. (1977 b) and Roonwal (1981, and in press.)

2. *Heterotermes gertrudae* Roonwal (figure 3)

(Roonwal 1953, *Indian J. Ent.*, 15 : 115-

118; and in press.) Chamba District Himachal Pradesh, India.)

Forewing scale, L 0.7, W 0.47 mm; hindwing scale, L 0.62, W 0.44 mm.

Micro-sculpturing: *On scale*: Papillae absent (cf. membrane.) Micrasters present on distal half, patchy; nonasteriod type, with 2–5 arms; smaller (6 × 5 μm) but denser than on membrane; on either side of humeral suture, arms clumped into irregularly rounded shapes; density 7200/mm², higher than on membrane. Hairs numerous, short to long (30–130 μm). *On membrane*: Papillae finger-shaped with round apex; in 3–4 rows on front vein; size 3–6 μm × 2–3 μm; density 8200/mm². Micrasters all over; both nonasteroids and asteroids present, but rounded near suture; size 4–8 μm × 2–6 μm; density 4800/mm². Hairs in moderate numbers, 35–60 μm long.

3. *Heterotermes indicola* (Wasmann) (figure 4)

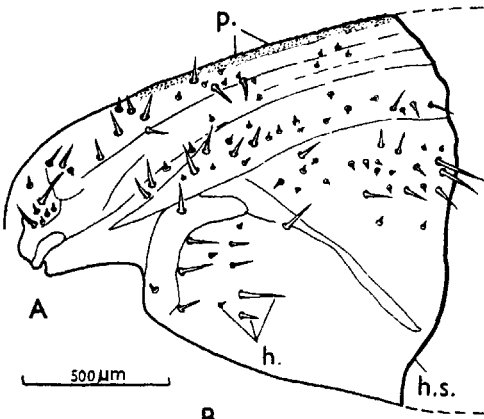
(Snyder 1949; 68; and Roonwal, in press.) Jodhpur (Rajasthan, India.)

Forewing scale, L 0.4, W 0.32 mm; hindwing scale, L 0.32, W 0.26 mm.

Micro-sculpturing: *On scale*: Papillae absent (cf. membrane.) Micrasters generally as in *H. gertrudae*; smaller but denser than on membrane; size 4–6 μm × 3–4 μm; density 8400/mm². Hairs numerous, 140–580 μm long. *On membrane*: Papillae pointed, spiky, in 3–4 rows on front vein; size 3.5–5.5 μm × 2–3 μm. Micrasters generally as in *H. gertrudae*; size 6–9 μm × 2–8 μm; density 5330/mm². Hairs in moderate numbers, 35–65 μm long.

GENUS (3) *Coptotermes* Wasmann

Micro-sculpturing in *Coptotermes* has been studied by Roonwal et al. (1979 b).



← **Figure 2** *Anacanthotermes macrocephalus*. Right forewing, dorsal surface. (A) Scale. (B) Hairs of various types on scale; enlarged and re-arranged. h., hairs; h.s., humeral suture; p., papillae.

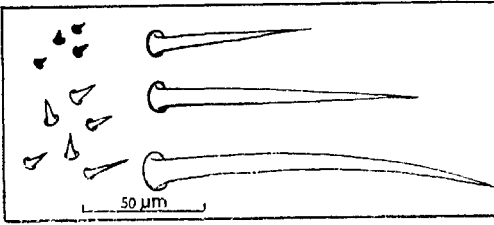
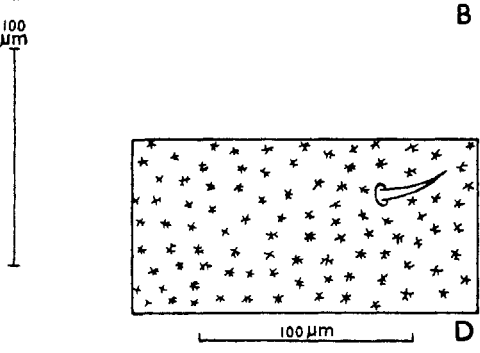
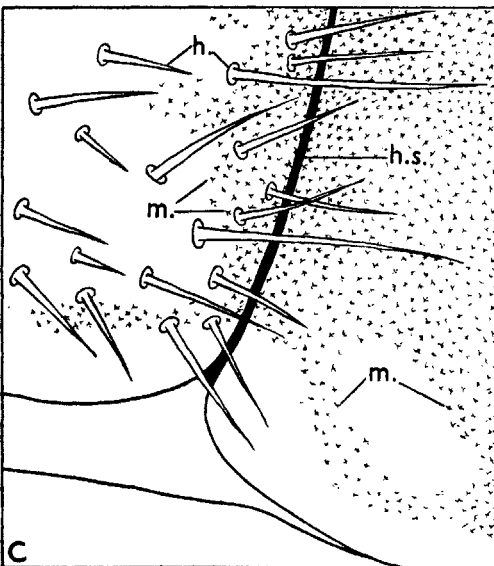
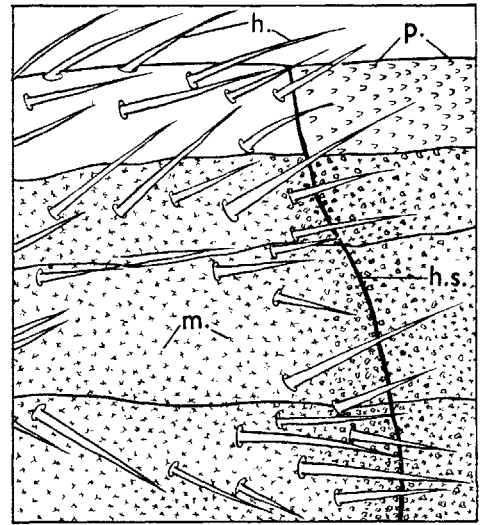
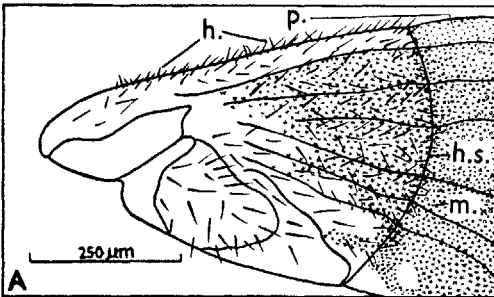


Figure 3 *Heterotermes gertrudae*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Same, upper portion, enlarged. (C) Same, lower portion, enlarged. (D) Middle of membrane, to show micrasters.

↓ h., hairs; h.s., humeral suture; m., micrasters; p., papillae.



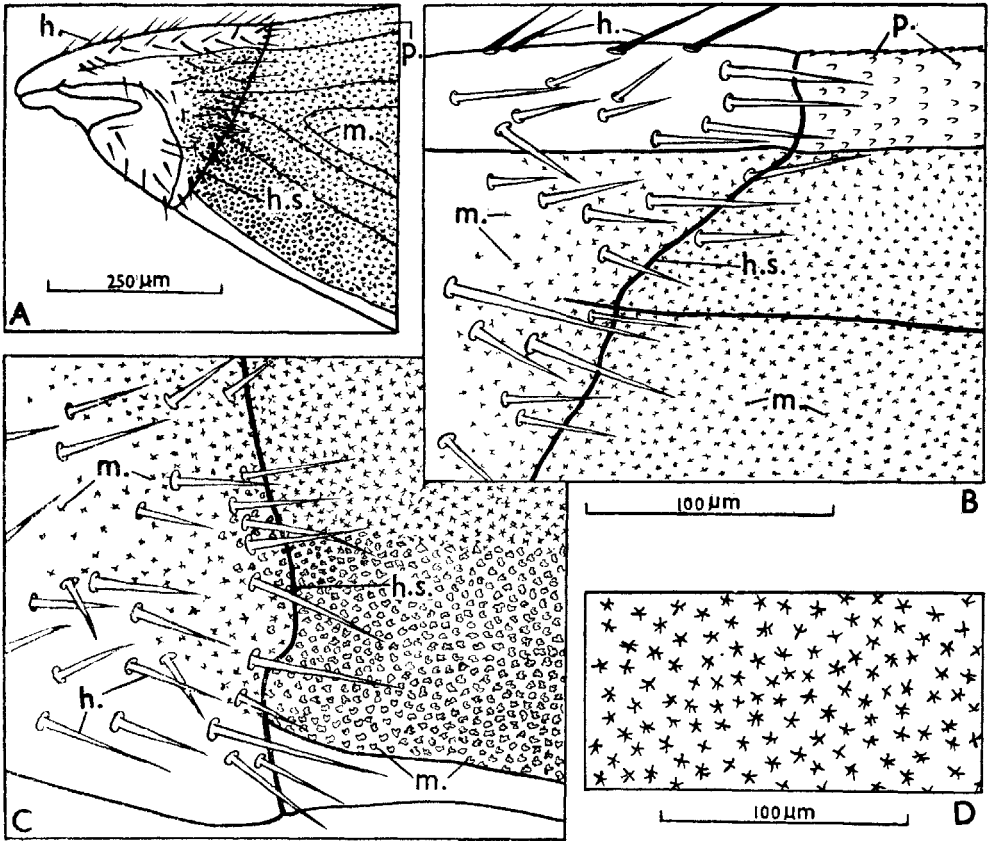


Figure 4 *Heterotermes indicola*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Same, upper portion, enlarged. (C) Same, lower portion, enlarged. (D) Middle part of membrane, enlarged, to show micrasters.

h., hairs; *h.s.*, humeral suture; *m.*, micrasters; *p.*, papillae.

4. *Coptotermes heimi* (Wasmann)

(figure 5)

(Snyder 1949: 79.) Jodhpur (Rajasthan, India.)

Forewing scale, L 0.97, W 0.82 mm; hindwing scale, L 0.9 mm, W 0.75 mm.

Micro-sculpturing: *On scale:* Papillae present in 3–4 rows in a small, narrow strip in distal one-fourth of anterior margin; somewhat pointed; size $4\text{--}6\ \mu\text{m} \times 3\text{--}4\ \mu\text{m}$. Pimpules numerous, present in distal half of scale; size $2\text{--}3\ \mu\text{m} \times 2\text{--}3\ \mu\text{m}$. Hairs numerous, $40\text{--}180\ \mu\text{m}$ long. *On membrane:* Papillae numerous; in 7–9 rows on anterior margin; size larger

than on scale, c. $5\text{--}8\ \mu\text{m} \times 4\text{--}6\ \mu\text{m}$. Pimpules present on proximal one-third of wing; are similar to those on scale. Hairs all over, shorter than on scale.

FAMILY III. TERMITIDAE

GENUS (4) *Eremotermes* Silvestri

Micro-sculpturing in *Eremotermes* has been studied by Roonwal and Rathore (1977) and Roonwal and Verma (1980 a).

5. *Eremotermes paradoxalis* Holmgren (figure 6)

(Snyder 1949 : 132; and Roonwal & Sen-Sarma 1960, *Contrib. Syst. Orient.*

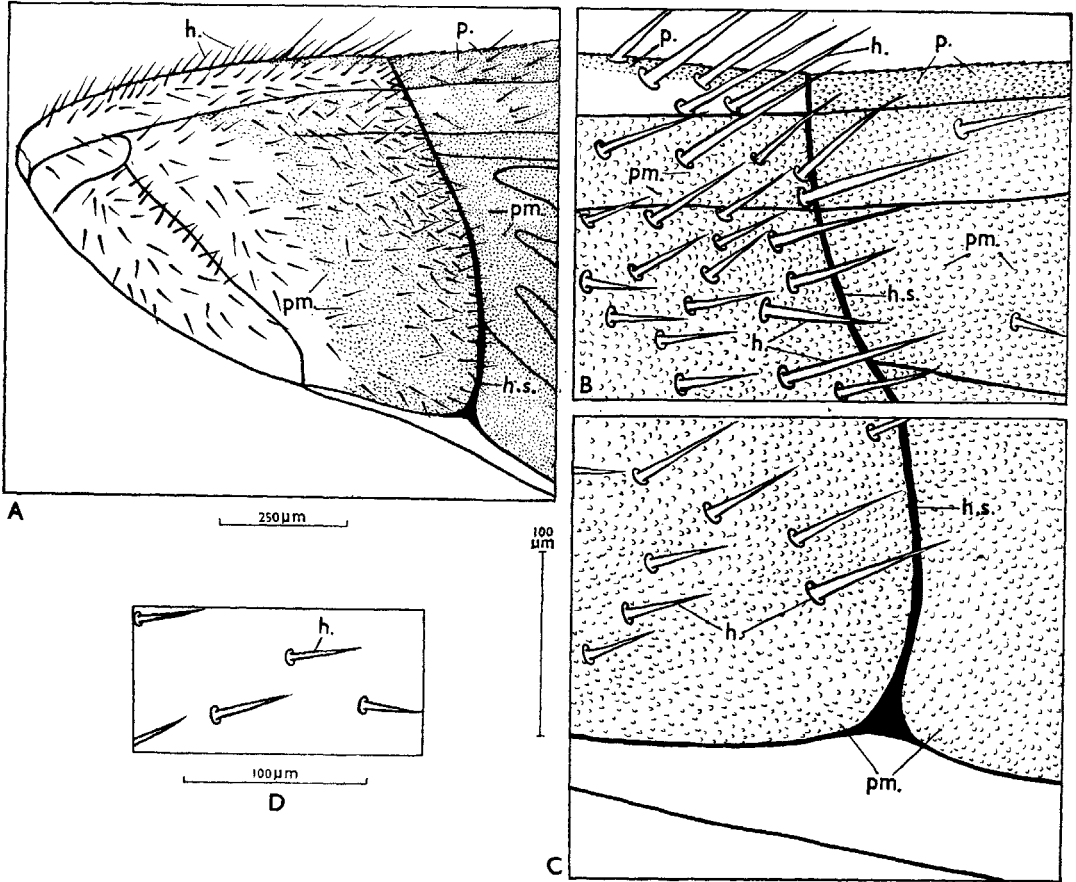


Figure 5 (A-D) *Coptotermes heimi*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Scale, upper part, enlarged. (C) Same, lower part. (D) Middle of wing, only hairs present. *h.*, hairs; *h.s.*, humeral suture; *p.*, papillae; *pm.*, pimpules

Termites, ICAR, New Delhi, p. 69.) Jodhpur (Rajasthan, India.) Forewing scale, L 0.44, W 0.38 mm; hindwing scale, L 0.38, W 0.33 mm.

Micro-sculpturing : *On scale :* Papillae in 2-3 rows on distal one-third of anterior margin; smaller than on membrane; size $4 \times 5 \mu\text{m}$. Micrasters small ($4-5 \mu\text{m} \times 3-4 \mu\text{m}$); present on most of the scale, except the extreme proximal part; non-asteroids, with 3-5 arms; density c. $5200/\text{mm}^2$. Hairs short to long (10-80 μm), present in proximal half. *On mem-*

brane : Large ($4-8 \mu\text{m} \times 3-5 \mu\text{m}$), pointed papillae present in 1-2 rows on anterior margin; a row of similar but smaller ones on posterior margin. Thin, brown nonasteroid and asteroid micrasters (4-6 arms) present all over; size larger ($3-8 \mu\text{m} \times 3-8 \mu\text{m}$), density c. $6000/\text{mm}^2$. Hairs few but longer, 30-50 μm .

GENUS (5) *Microcerotermes* Silvestri
Micro-sculpturing in *Microcerotermes* has been studied by Roonwal et al. (1974) and Roonwal & Verma (1980a).

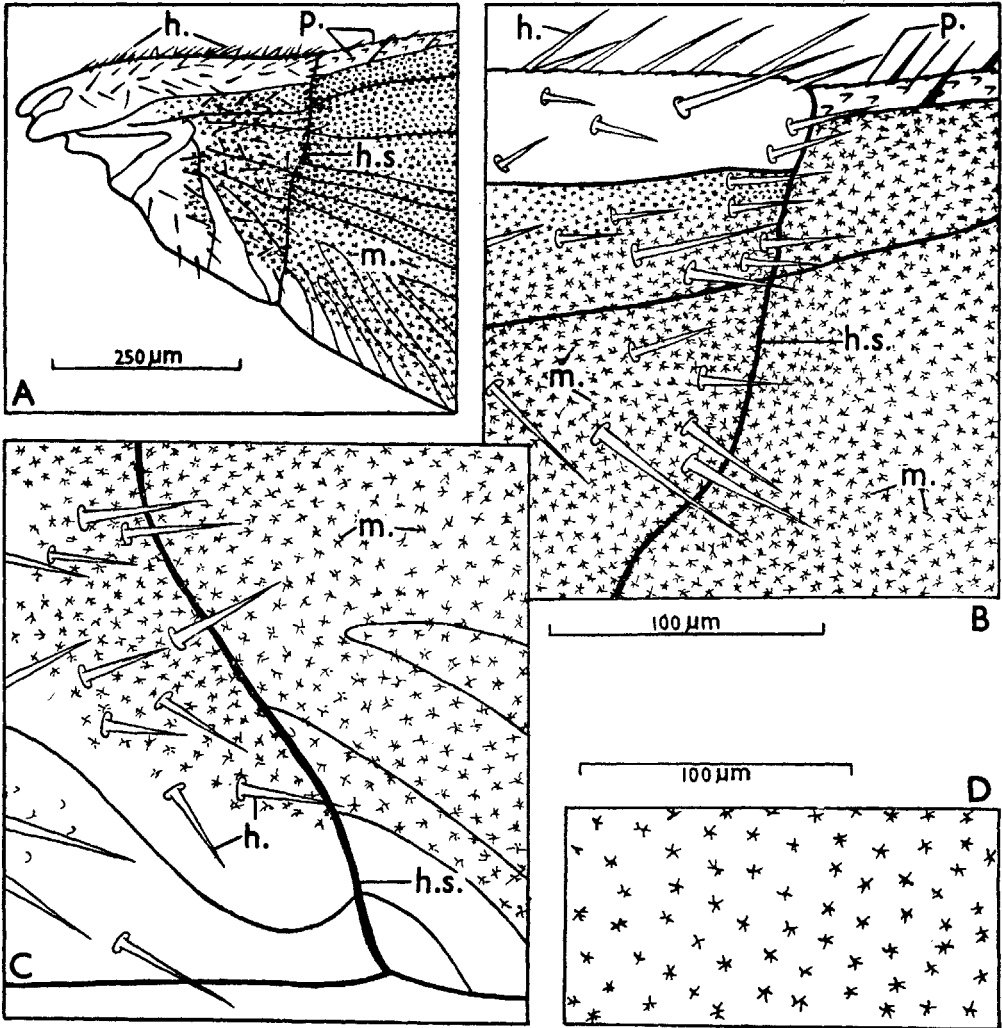


Figure 6 (A-D) *Eremotermes paradoxalis*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Same, upper portion, enlarged. (C) Same, lower portion, enlarged. (D) Middle part of membrane, enlarged to show micrasters.

h., hairs; *h.s.*, humeral suture; *m.*, micrasters; *p.*, papillae

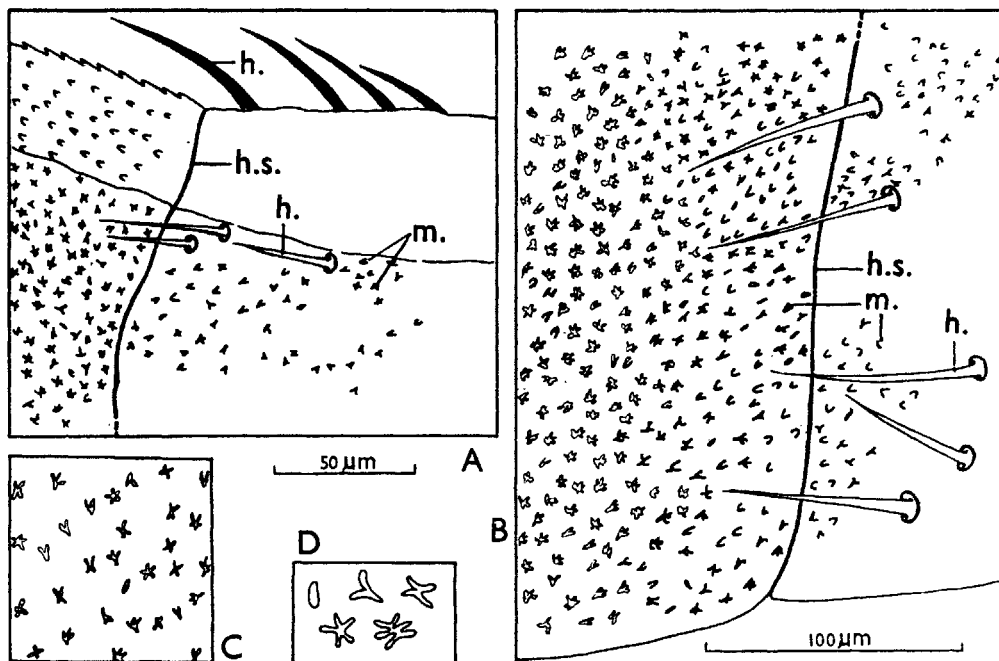


Figure 7 (A-D) *Microcerotermes raja*. Left forewing. (A) upper part of scale (right part) and of membrane (left part). (B) Same, lower part. (C) Micrasters on middle of wing membrane. (D) Same, enlarged, micrasters re-arranged. h., hairs; h.s., humeral suture; m., micrasters

6. *Microcerotermes raja* Roonwal & Bose (figures 1 & 7)

(Roonwal & Bose 1964, *Zoologica Stuttgart*, **40** (3), Heft 113, p. 26, *M. championi raja*.) Jodhpur (Rajasthan, India.) Forewing scale, L 0.46, W 0.32 mm; hindwing scale, L 0.42, W 0.28 mm.

Micro-sculpturing: *On scale:* Papillae absent. Micrasters scattered in patches, leaving large areas blank; mostly non-asteroids (1-5 arms); size smaller (3-5 μm × 2-3 μm) than on membrane; density higher (c. 10000/mm³ in patches). Hairs patchy, 17-86 μm long. *On membrane:* Papillae pointed, present in 5-6 rows on anterior margin; size 3-4 μm × 2-3 μm; a row of similar but smaller ones on posterior margin. Micrasters well developed, mostly nonasteroids; size 5-9 μm × 2-8 μm; density 6885-7695 mm³. Near the scale micrasters smaller, thinner and

denser (c. 19000-20000/mm³), distorted and clumpy.

GENUS (6) *Angulitermes* Sjöstedt

Micro-sculpturing in *Angulitermes* has been studied by Roonwal et al. (1974) and Roonwal & Verma (1980 b.)

7. *Angulitermes jodhpurensis* Roonwal & Verma (figure 8)

(Roonwal & Verma 1976: *Ent. monthly Mag.*, Oxford, **112** : 5.) Jodhpur (Rajasthan, India.)

Forewing scale, L 0.41, W 0.38mm; hindwing scale, L 0.39, W 0.32 mm.

Micro-sculpturing: *On scale:* Papillae absent. Micrasters present mostly on distal and lower half, absent elsewhere; small (3-4 μm × 2-3 μm) and denser (c. 16000/mm³). Hairs numerous but

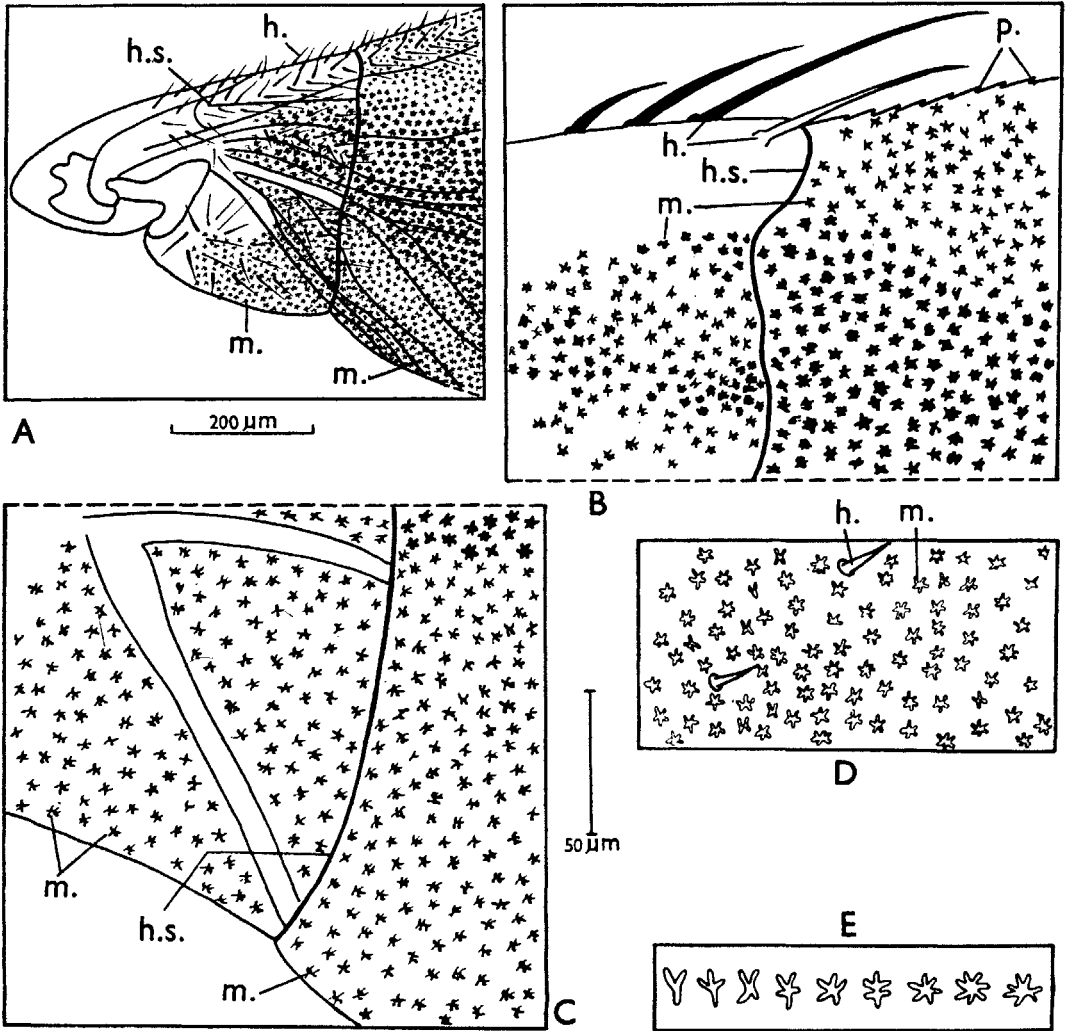


Figure 8 (A-E) *Angulitermes jodhpurensis*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Same, upper part enlarged. (C) Same, lower part. (D) Middle of membrane, to show micrasters. (E) Same, micrasters enlarged and re-arranged. *h.*, hairs; *h.s.*, humeral suture; *m.*, micrasters; *p.*, papillae

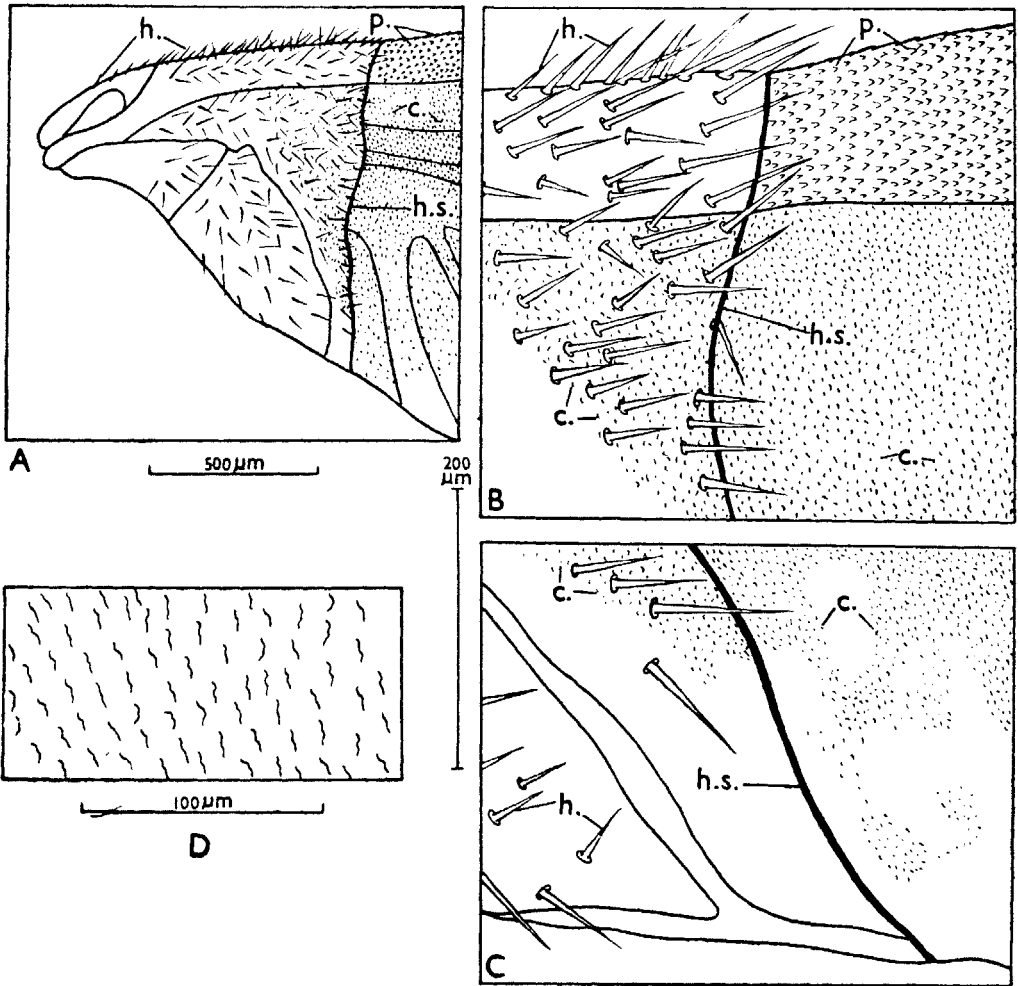


Figure 9 (A-D) *Odontotermes dehraduni*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Same, upper part, enlarged. (C) Same, lower part, enlarged. (D) Middle of membrane, to show cuticular rods.

c.r., cuticular rods; h., hairs; h.s., humeral suture; p., papillae.

patchy, 30–70 μm long. *On membrane*: A row of very small (1 μm \times 0.5 μm) papillae on anterior margin, and a row of similar but even smaller ones on posterior margin. Both nonasteroid and asteroid micrasters all over; size 5–8 μm \times 3–8 μm , density c. 7315–8100/ mm^2 . In parts adjacent to scale micrasters small (3–5 μm \times 2–4 μm), somewhat distorted, clumpy and denser (c. 17600/ mm^2). Hairs few, scattered, 30–90 μm long.

GENUS (7) *Odontotermes* Holmgren
Micro-sculpturing in *Odontotermes* has

been studied by Roonwal and Chhotani (1967) and Roonwal et al. (1980.)

8. *Odontotermes dehraduni* Snyder
(figure 9)

(Snyder 1949 : 224.) Jodhpur (Rajasthan, India.)

Forewing scale, L 1.10, W 1.05 mm; hindwing scale, L 1.05, W 0.99 mm.

Micro-sculpturing : *On scale*: Papillae absent (cf. membrane). Cuticular rods present in a small patch in distal part adjacent to humeral suture; rods short, stumpy, 8–12 μm long. Hairs numerous

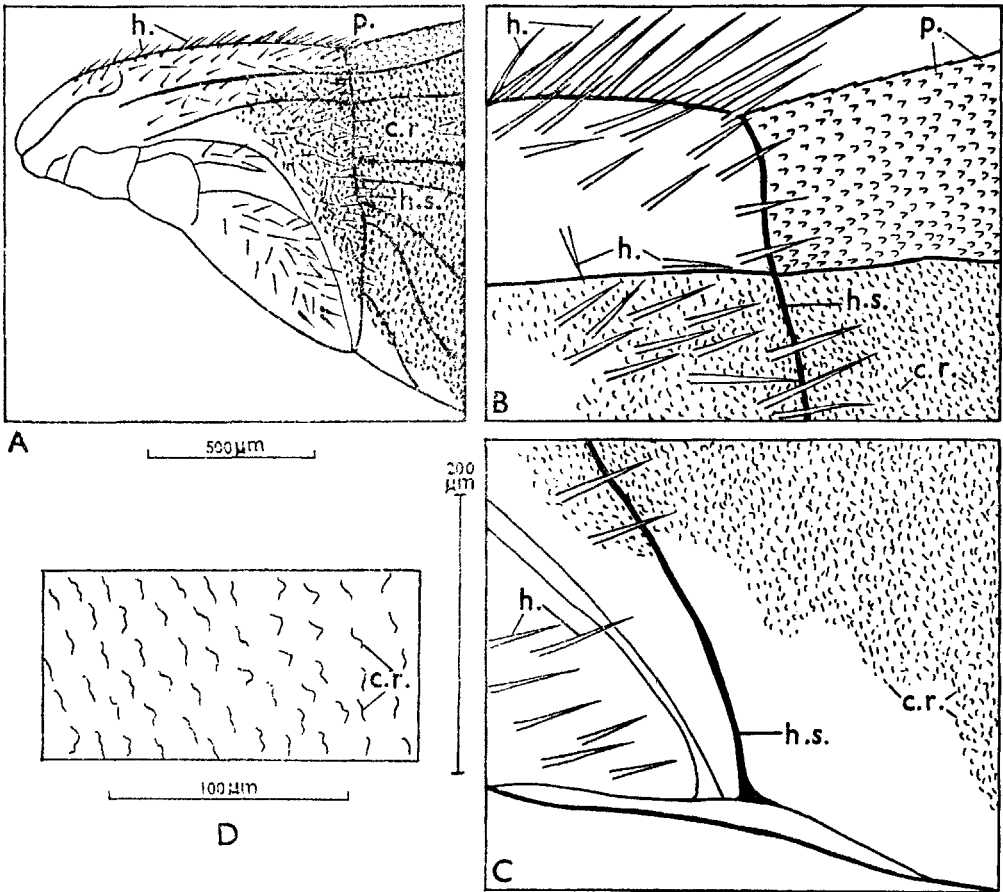


Figure 10 (A-D) *Odontotermes distans*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Scale, upper part, enlarged. (C) Same, lower part. (D) Middle of wing, to show cuticular rods.

c.r., cuticular rods; h., hairs; h.s., humeral suture; p., papillae

but patchy and long (100–180 μm). *On membrane*: Papillae tongue-shaped, in 4–13 rows on anterior margin (fewer rows in middle, more near humeral suture); size 7.0–7.5 $\mu\text{m} \times 6.8 \mu\text{m}$; 1–2 rows on posterior margin. Cuticular rods thin, substraight to weakly wavy (*obesus*-type), present all over; length 11–13 μm , density 6520/ mm^2 ; shorter (3–6 μm long) and stumpy near suture. Hairs few and scattered, 60–80 μm long.

9. *Odontotermes distans* (Holmgren & Holmgren) (figure 10)

[The correctness of Thakur's (1981b) relegating *O. parvidens* H. & H., etc., as synonyms of *O. distans* is open to serious question.*]

(Snyder 1949 : 225.) Khokari village near Jodhpur (Rajasthan, India.)

Forewing scale, L 1.27, W 1.12 mm; hindwing scale, L 1.12, W 1.05 mm.

Micro-sculpturing: *On scale*: Papillae absent (cf. membrane.) Cuticular rods present in a small patch in distal part; short, stumpy, substraight to weakly curved, 4–6 μm long, thicker than on membrane. Hairs numerous but patchy, 60–180 μm long. *On membrane*: Papillae pointed, present in 8–13 rows (fewer rows in middle, more near humeral suture) near anterior margin; 2–3 rows on posterior margin. Cuticular rods all over; as in *O. dehraduni*; length 12–14 μm ; density 5795/ mm^2 . Hairs present in moderate numbers, length 100–160 μm .

10. *Odontotermes obesus* (Rambur) (figure 11)

(Snyder 1949 : 235.) Jodhpur (Rajasthan, India.)

Forewing Scale, L 1.35, W 1.27 mm; hindwing scale, L 1.20, W 1.12 mm.

Micro-sculpturing: *On scale*: Papillae

absent (cf. membrane.) Cuticular rods present in a small patch in distal part; thin, substraight to weakly curved; short, 3–4 μm . Hairs numerous but patchy; short to long 40–210 μm . *On membrane*: Pappillae tongue-shaped to weakly pointed; in 5–10 rows on anterior margin (fewer rows in middle, more near humeral suture); size 6–8 $\mu\text{m} \times 5–6 \mu\text{m}$; fewer rows on posterior margin. Cuticular rods thin, weakly wavy; length 10–15 μm ; density c. 4000–5800/ mm^2 . Hairs present, fairly numerous.

11. *Odontotermes wallonensis* (Wasmann) (figure 12)

(Snyder 1949 : 243.) Near Bar (Ajmer District, Rajasthan, India.)

[Thakur's (1981b) treating *O. brunneus kushwahi* Roonwal & Bose 1964 (not Roonwal & Chhotani, as stated by him) as a synonym of *O. wallonensis* is almost certainly incorrect.]*

Forewing scale, L 1.41, W 1.35mm; hindwing scale, L 1.30, W 1.23 mm.

Micro-sculpturing: *On scale*: Papillae absent (cf. membrane.) Cuticular rods present in a patch in distal one-fourth of scale; short (3–5 μm), substraight to weakly wavy. Hairs numerous, 60–210 μm long. *On membrane*: Papillae tongue-shaped but pointed in proximal part near scale; in 8–13 rows on anterior margin (fewer rows in middle, more near humeral suture); 3–4 rows of smaller ones on posterior margin. Cuticular rods present all over; of the *obesus*-type; length 10–15 μm , density c. 5000/ mm^2 . Hairs numerous but patchy, 70–90 μm long.

GENUS (8) *Microtermes* Wasmann

Micro-sculpturing in *Microtermes* has been studied by Roonwal and Chhotani (1967) and Roonwal et al. (1980).

*Thakur's (1981b) account of the Indian *Odontotermes* is perfunctory and his synonymies should be treated with caution.

12. *Microtermes mycophagus* (Desneux)
(figure 13)

(Snyder 1949 : 252.) Jodhpur (Rajasthan,
India.)

Forewing scale, L 1.08, W 0.97 mm;
hindwing scale, L 0.97, W 0.86 mm.

Micro-sculpturing: On scale: Papillae
present in 4–6 rows in a small patch at
the anterior margin of distal two-thirds;
small, pointed; size $4 \times 3 \mu\text{m}$. Hairs

patchy, mostly at the anterior and distal
margins, absent elsewhere; $30\text{--}80 \mu\text{m}$ long.
On membrane: Papillae pointed; in
several rows (few rows in middle, 15–17
near humeral suture); size $6 \times 5 \mu\text{m}$; 1–2
rows on posterior margin. Cuticular
rods all over; small ($7\text{--}8 \mu\text{m}$ long), sub-
straight to slightly curved, a few almost
V-shaped; density $4350/\text{mm}^2$. Hairs
patchy, $60\text{--}90 \mu\text{m}$ long.

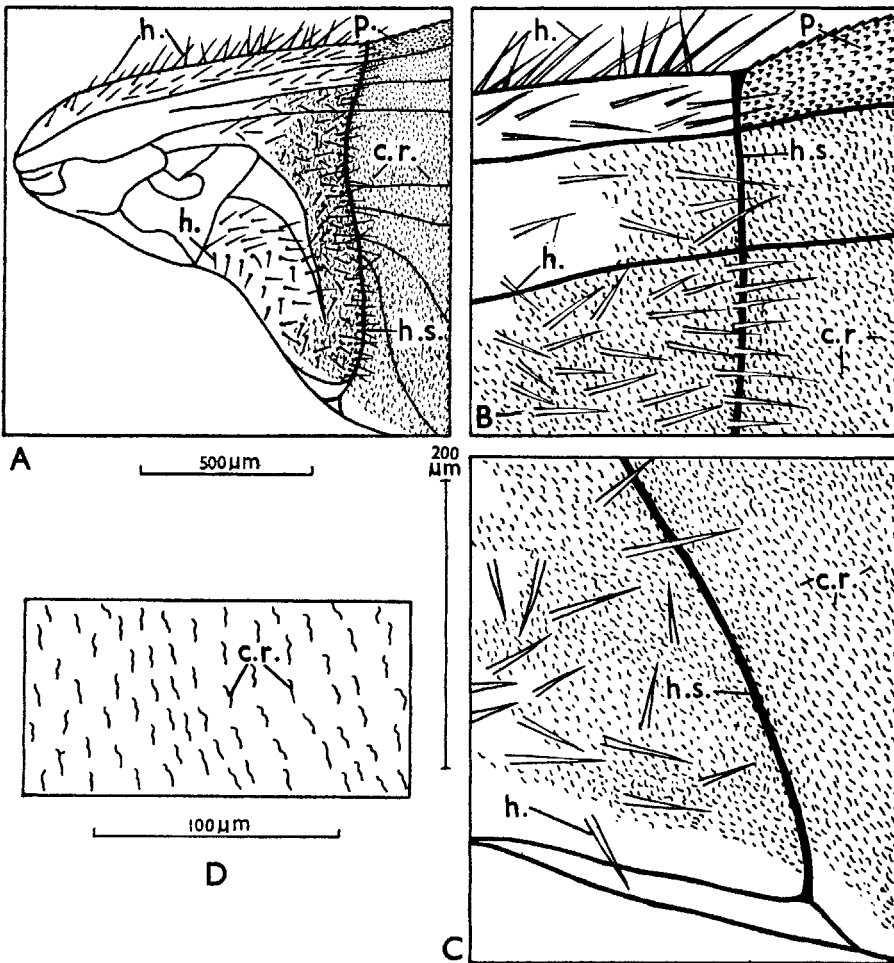


Figure 11 (A–D) *Odontotermes obesus*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Same, upper part, enlarged. (C) Same, lower part, enlarged. (D) Middle of membrane, to show cuticular rods.

c.r., cuticular rods; h., hairs; h.s., humeral suture; p., papillae

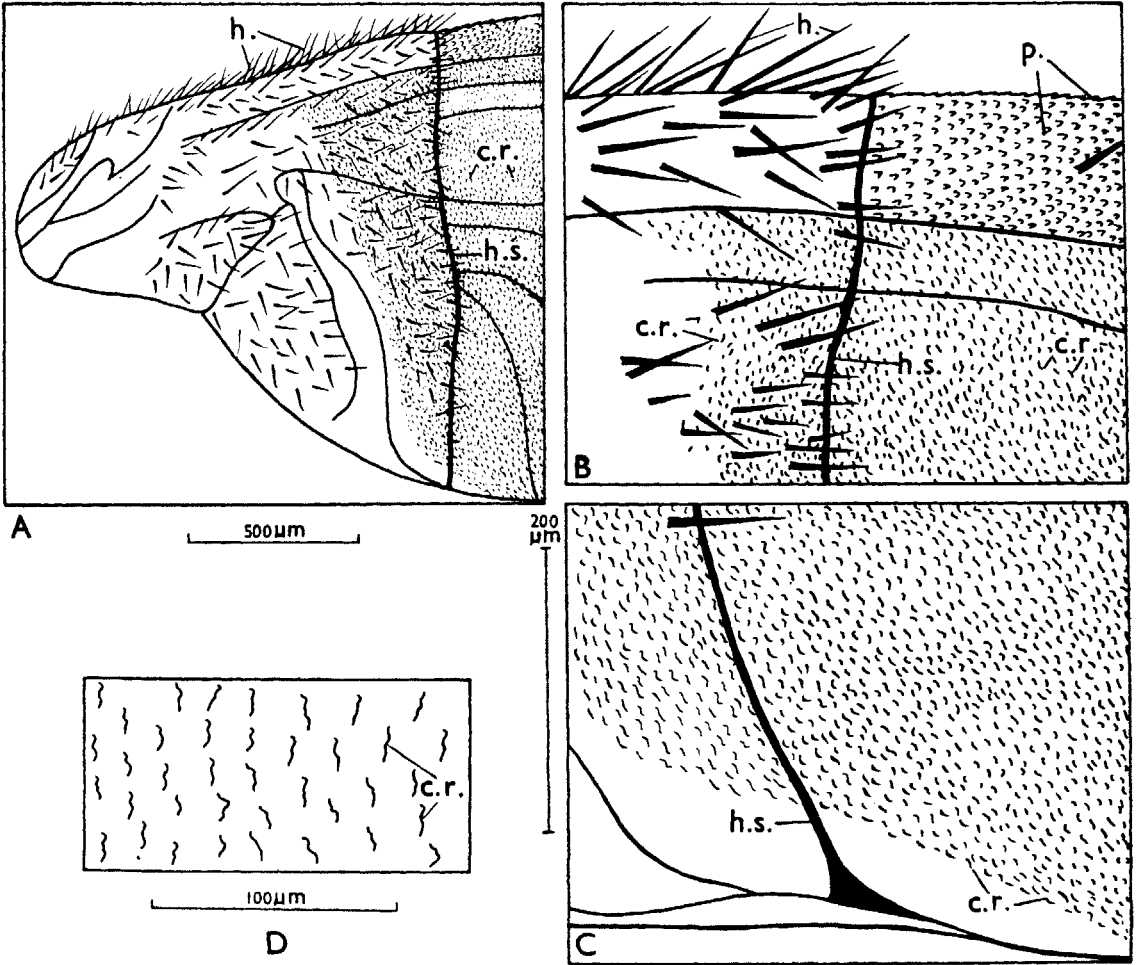


Figure 12 (A-D) *Odontotermes wallonensis*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Upper part of scale, enlarged. (C) Same, lower part. (D) Middle of membrane, to show cuticular rods.

c.r., cuticular rods; *h.*, hairs; *h.s.*, humeral suture; *p.*, papillae

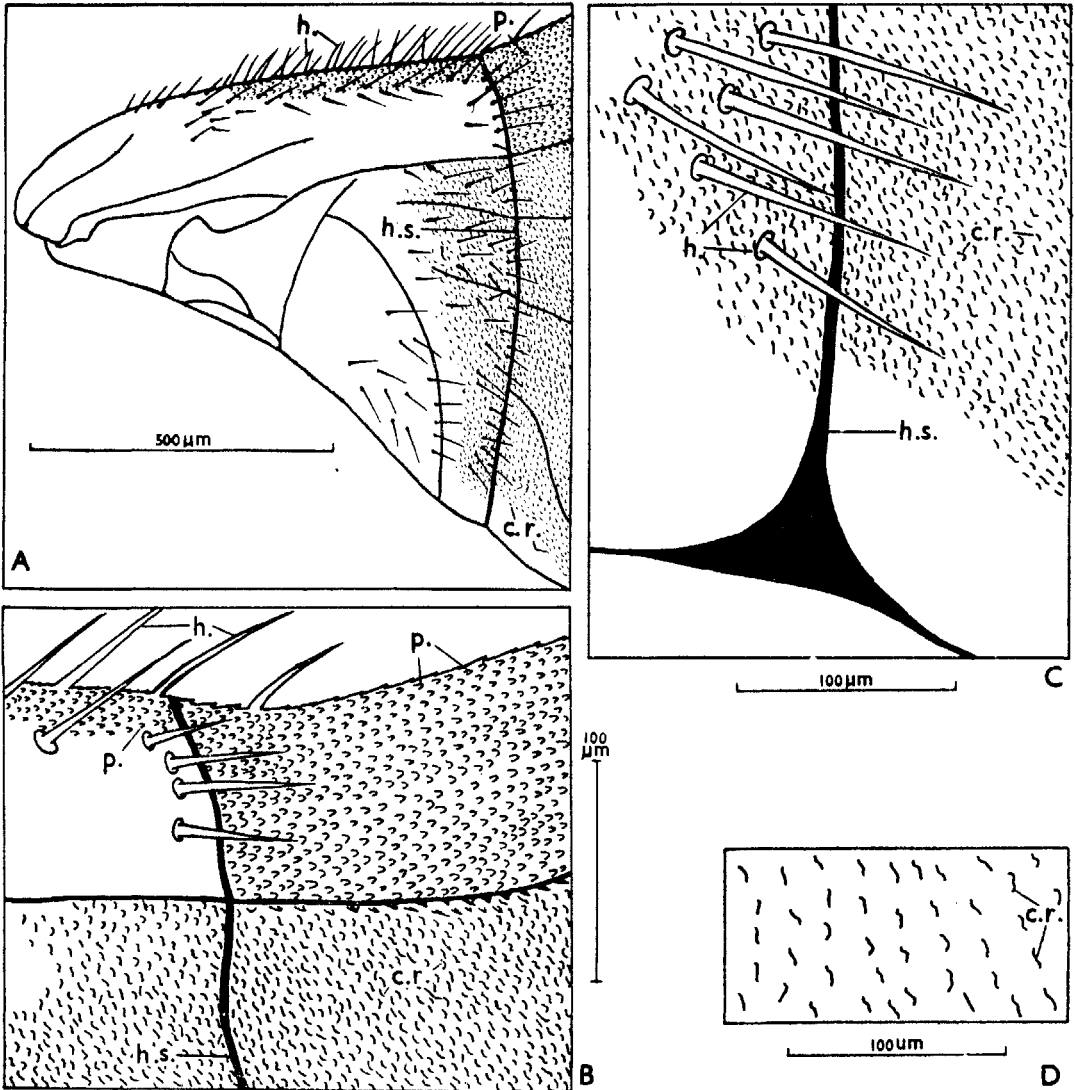


Figure 13 (A-D) *Microtermes mycophagus*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Scale, upper part, enlarged. (C) Same, lower part. (D) Middle of membrane, to show cuticular rods.

c.r., cuticular rods; *h.*, hairs; *h.s.*, humeral suture; *p.*, papillae

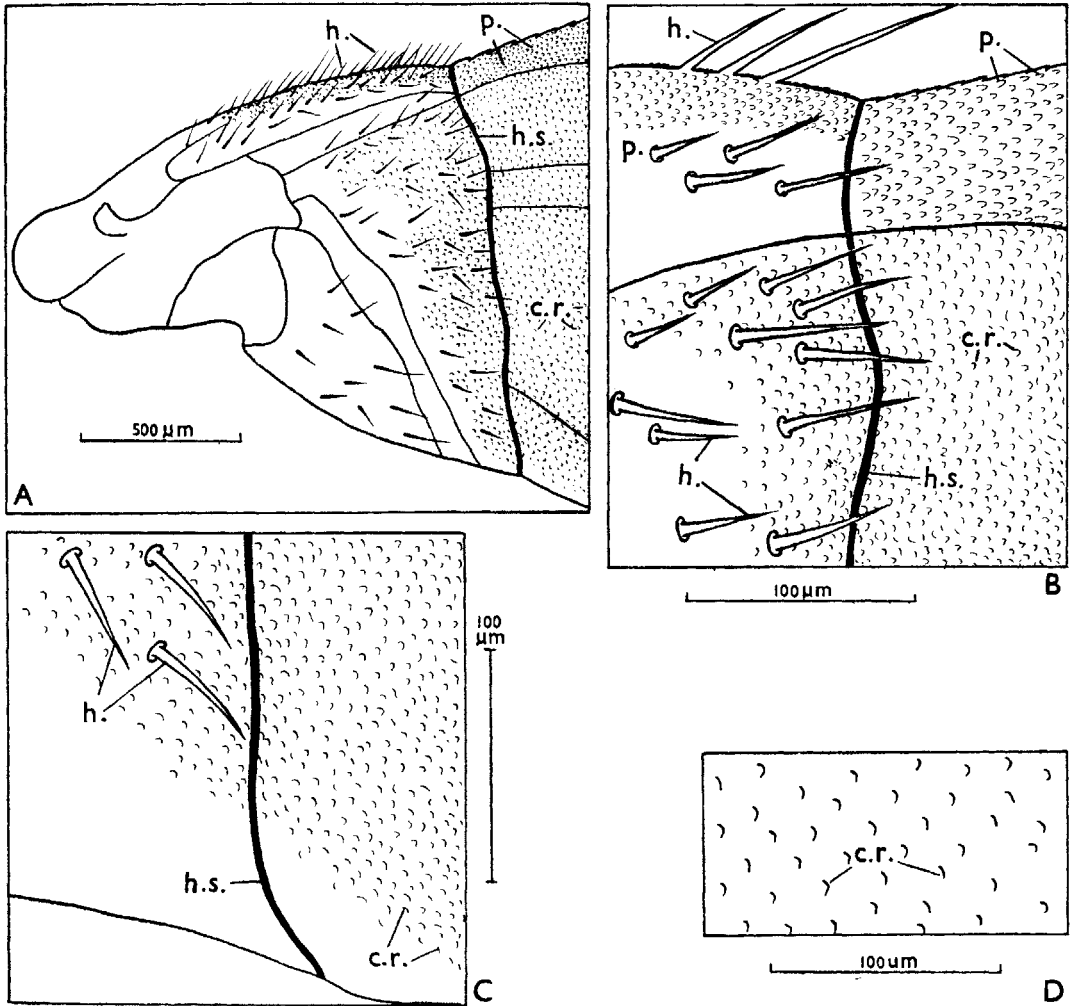


Figure 14 (A-D) *Microtermes obesi*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Scale, upper part, enlarged. (C) Same, lower part. (D) Middle of membrane, to show cuticular rods.

c.r., cuticular rods; h., hairs; h.s., humeral suture; p., papillae

13. *Microtermes obesi* Holmgren (figure 14) [Syn. *M. anandi* Holmgren] (Snyder 1949 : 252.) Jodhpur (Rajasthan, India.)

Forewing scale, L 0.83, W 0.75 mm; hindwing scale, L 0.70, W 0.63 mm.

Micro-sculpturing: On scale: Papillae present in 4-5 rows in a patch in distal half of anterior margin; small, $3 \times 5 \mu\text{m}$. Cuticular rods present in a patch in distal one-fourth; substraight to curved, many almost V-shaped; small, 2-4 μm long. Hairs few, scattered, 30-100 μm long. *On membrane:* Papillae tongue-shaped, mostly with pointed tip; in 4-12 rows (fewer rows in middle, more near humeral suture) on anterior margin; 1-2 rows on posterior margin; size $4 \times 6 \mu\text{m}$. Cuticular rods small, straight to weakly curved, a few V-shaped especially near suture; size 2-8 μm ; density 4800/mm². Hairs fairly numerous, 50-80 μm long.

14. *Microtermes unicolor* Snyder (figure 15)

(Snyder 1949 : 254.) Jodhpur (Rajasthan, India.)

Forewing scale, L 0.82, W 0.75 mm; hindwing scale, L 0.75, W 0.71 mm.

Micro-sculpturing: On scale: Papillae absent (cf. membrane.) Cuticular rods present in a patch on distal one-fourth; small ($4 \times 2 \mu\text{m}$), substraight to wavy. Hairs numerous, all over, 30-110 μm long. *On membrane:* Papillae in a wide strip of 10-15 rows at the anterior margin and 1-2 rows at the posterior; generally tongue-shaped and shallow, but deeper and pointed near scale; size $4 \times 6 \mu\text{m}$. Cuticular rods as in *M. mycophagus* but smaller (2-7 μm long) and with V-shape more common; density c. 4500/mm². Hairs smaller, scattered all over.

GENUS (9) *Trinervitermes* Holmgren

Micro-sculpturing in *Trinervitermes* has

been studied by Roonwal et al. (1981).

15. *Trinervitermes biformis* (Wasmann) (figure 16)

[Syns. *T. heimi* (Wasmann) and *T. longinotus* (Snyder)] (Snyder 1949 : 323.) Udaipur (Rajasthan, India.)

Forewing scale, L 1.2, W 1.05 mm; hindwing scale L 0.97, W 0.9 mm.

Micro-sculpturing: On scale: Papillae absent (cf. membrane.) Micrasters present as a patch on distal one-fifth; mostly nonasteroids (3-5 arms); several with arms fused into nodule-like bodies, especially on either side of humeral suture; size 3-5 $\mu\text{m} \times 3-4 \mu\text{m}$. Hairs fairly dense, present all over, 60-220 μm long. *On membrane:* Papillae pointed, in a wide band of 8-15 rows at the anterior margin and 1-5 rows at the posterior; size 6-8 $\mu\text{m} \times 4-6 \mu\text{m}$. Micrasters present all over; thin nonasteroid with 1-6 arms; clumped and nodule-like near the scale; size 4-7 $\mu\text{m} \times 3-6 \mu\text{m}$. Hairs numerous, present all over, 40-90 μm long.

Discussion and Conclusion

From this pilot study the following, briefly, are the conclusions which emerge:

1. There is a marked difference between the wing scale and the membrane as regards the presence or absence of the various types of micro-sculpturing elements (table 1).

2. Papillae, while being universally present on the membrane in the Isoptera, are often absent on the scale. When present, they are weakly developed and are confined to a small area.

3. Pimpules, when occurring in a species on the membrane, may be either present (*Coptotermes heimi*) or absent (*Anacanthotermes macrocephalus*) on the scale.

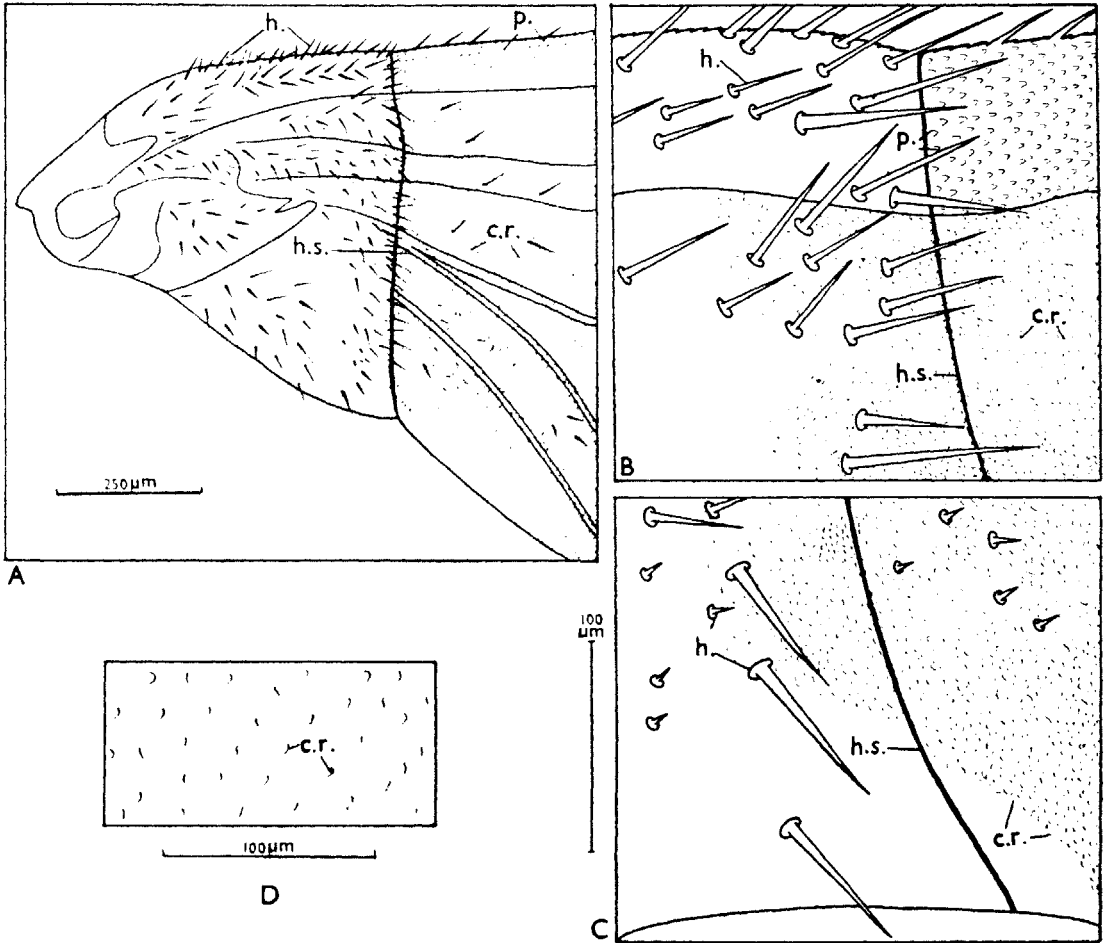


Figure 15 (A-D) *Microtermes unicolor*. Right forewing, dorsal view. (A) Scale and part of membrane. (B) Scale, upper part, enlarged. (C) Same, lower part. (D) Middle of membrane, to show cuticular rods.

c.r., cuticular rods; *h.*, hairs; *h.s.*, humeral suture; *p.*, papillae

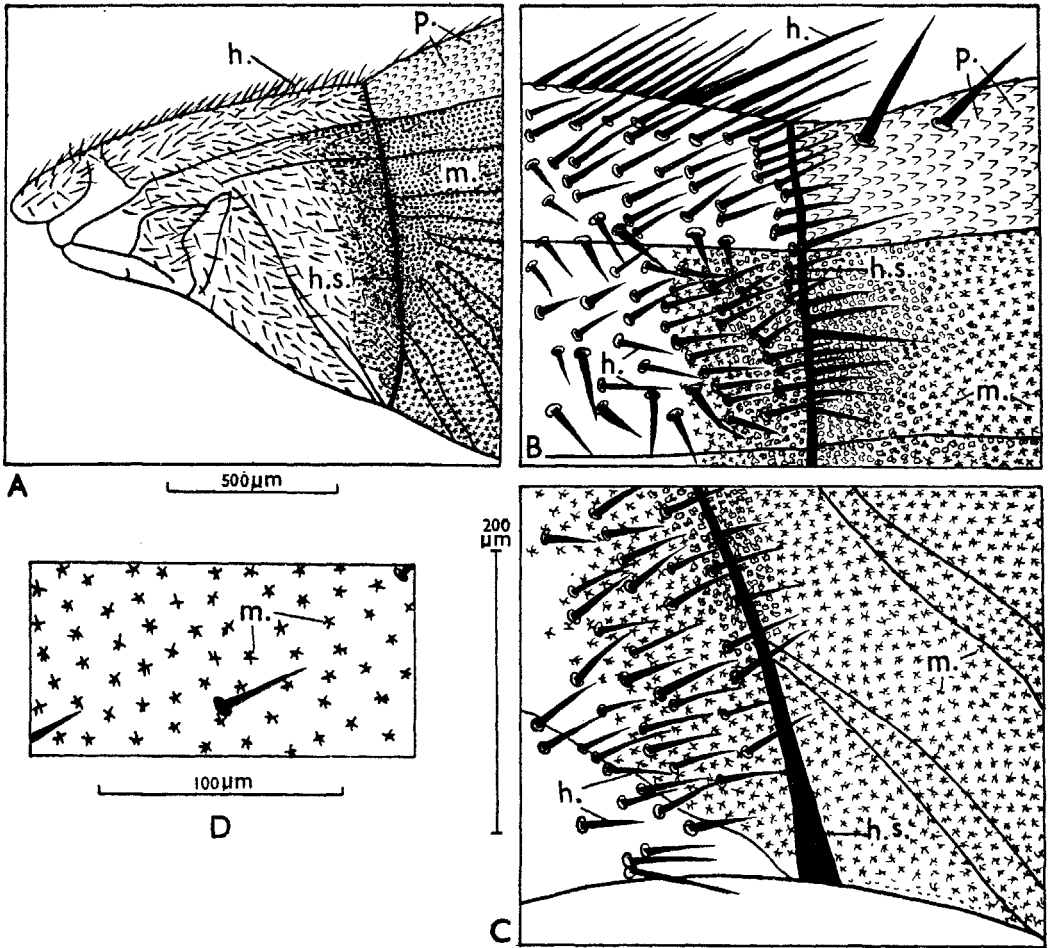


Figure 16 (A-D) *Trinervitermes biformis*. Right forewing, dorsal surface. (A) Scale and part of membrane. (B) Scale, upper part, enlarged. (C) Same, lower part. (D) Middle of wing, to show micrasters.

h., hairs; *h.s.*, humeral suture; *m.*, micrasters; *p.* papillae

Table 1 Summary of wing micro-sculpturing on the scale and membrane of wings in some termites. +, present; —, absent.

Family and species	On wing scale				On wing membrane			
	Papillae	Pimpules	Micrasters	Cuticular rods	Papillae	Pimpules	Micrasters	Cuticular rods
Fam. I. Hodotermitidae								
1. <i>Anacanthotermes macrocephalus</i>	+	—	—	—	+	+	—	—
Fam. II. Rhinotermitidae								
2. <i>Heterotermes gertrudae</i>	—	—	+	—	+	—	+	—
3. <i>H. indicola</i>	—	—	+	—	+	—	+	—
4. <i>Coptotermes heimi</i>	+	+	—	—	+	+	—	—
Fam. III. Termitidae								
5. <i>Eremotermes paradoxalis</i>	+	—	+	—	+	—	+	—
6. <i>Mitrocerotermes raja</i>	—	—	+	—	+	—	+	—
7. <i>Angulitermes jodhpurensis</i>	—	—	+	—	+	—	+	—
8. <i>Odontotermes dehraduni</i>	—	—	—	+	+	—	—	+
9. <i>O. distans</i>	—	—	—	+	+	—	—	+
10. <i>O. obesus</i>	—	—	—	+	+	—	—	+
11. <i>O. wallonensis</i>	—	—	—	+	+	—	—	+
12. <i>Microtermes mycophagus</i>	+	—	—	+	+	—	—	+
13. <i>M. obesi</i>	+	—	—	+	+	—	—	+
14. <i>M. unicolor</i>	—	—	—	+	+	—	—	+
15. <i>Trinervitermes biformis</i>	—	—	+	—	+	—	+	—

4. Micrasters, when occurring in a species on the membrane, are also present on the scale. But in the latter case they are markedly atypical, often becoming clumpy and nodule-like. A similar modification occurs in the proximal part of the membrane adjacent to the humeral suture.

5. Cuticular rods, when occurring in a species on the membrane, are also generally present on the scale but are somewhat atypical, being smaller and stubby.

6. Thus, since the condition of micro-sculpturing on the wing membrane, must be regarded as typical for a species, its atypical nature on the wing scale does not permit us to use the latter structure for discriminating between different species (the restriction applies even more so to the higher taxonomic categories) except that the occurrence of the type of non-papillate structures (e.g. micrasters, rods, etc.) in that species can be established.

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