

## Evolution and Systematic Significance of Wing Micro-sculpturing in Termites (Isoptera)

### VIII. Subfamily Amitermitinae of Family Termitidae

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(1) Of the Amitermitinae, 9 genera and 40 species from various regions of the world were studied: *Eurytermes*, *Alyscotermes*, *Anoplotermes*, *Speculitermes*, *Doonitermes*, *Euhamitermes*, *Drepanotermes*, *Eremotermes* and *Microcerotermes*.

(2) Micro-sculpturing on both wing surfaces consists of a dense covering of two types of structures, viz., (i) thin, pointed papillae which are directed distally and are present on the anterior and posterior wing margins; and (ii) micrasters of both nonasteroid (1-6 arms) and asteroid (5-8 arms) types.

(3) Evolutionary trends are discussed. The presence of only the simple, nonasteroid micrasters in the majority of the Amitermitinae genera suggest the primitive nature of this subfamily within the family Termitidae.

(4) Micro-sculpturing is of assistance in distinguishing the lower taxa (genera and species) but is less helpful for the higher taxa (families and subfamilies).

**Key Words:** Wing micro-sculpturing, Amitermitinae, Termites, Isoptera, Evolution

#### Introduction

In the present series (Roonwal et al. 1967-1979 and in press, vide References at the end) on the evolution, etc. of wing micro-sculpturing in the Isoptera, several new types of structures have been discovered. The present part deals with the large and widespread subfamily Amitermitinae of the family Termitidae. It is the most primitive

of the Termitids and presents certain simplified features of micro-sculpturing especially regarding the micrasters.

For synonymies and taxonomic details of species names, Snyder's (1949) world catalogue is referred to. For species described later, the appropriate first reference and recent revisions are indicated. For sub-family

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classification, Snyder's (1949) simpler arrangement has been followed in preference to that of Sands (1972).

### Material and Methods

Winged imagoes from the following regions were examined: West, South and Southeast Asia, Africa, South America, Australia, New Guinea, the Pacific Ocean (Solomon Islands) and the Indian Ocean (Seychelles Islands). In all, 9 genera and 40 species were studied, as follows :—

*Eurytermes* (1 sp.), *Alyscotermes* (1 sp.), *Anoplotermes* (4 spp.), *Speculitermes* (3 spp.), *Doonitermes* (1 sp.), *Euhamitermes* (3 spp.), *Drepanotermes* (1 sp.), *Eremotermes* (4 spp.) and *Microcerotermes* (22 spp.). The previously used techniques were employed, and densities of micro-structures refer to the middle portion of wing on the dorsal surface.

### Results

The various genera and species of the sub-family Amitermitinae are now discussed in some details.

#### Genus (1) *Eurytermes* Wasmann

Of this small oriental genus, one species was available.

1. *Eurytermes boveni* Roonwal & Chhotani 1966 (Roonwal & Chhotani 1966, *Proc. natn. Inst. Sci. India*, New Delhi, **B31** [1965], p. 99; also revision of genus.) Imagoes from South Asia (India): Kanha National Park, Mandla District, Madhya Pradesh.

Wings (with scale): 10–11 × 2.5 mm; transparent, colourless, veins brown. Hairs: Anterior vein and margin with many hairs, 50–60 μm long; 1–2 rows on second vein, and a few small hairs on posterior margin; none on membrane.

Wing micro-sculpturing: Consists of papillae and micrasters. *Papillae*: 1–2 rows of pointed, thorny papillae on anterior margin, size 6 μm × 3 μm; a row of similar but smaller ones (4–5 μm × 1–2 μm) on posterior margin. *Micrasters*: Numerous nonasteroid (2–4 arms) micrasters present all over. Size 4–8 μm × 4–6 μm. Density 9280/mm<sup>2</sup>.

#### Genus (2) *Alyscotermes* Sands

This soldierless African genus contains but two species of which one was available.

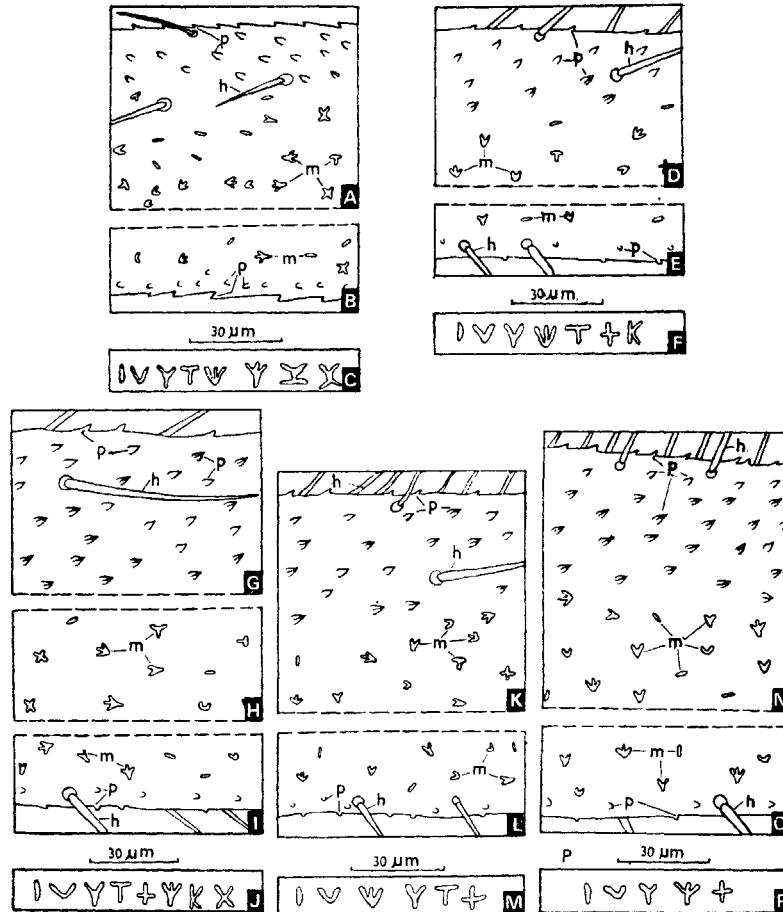
1. *Alyscotermes kilimandjaricus* (Sjöstedt 1907) (figures 1N–P). [Syns.: *Microtermes* (? *Procutitermes*) *mfolozii* Fuller; and *M. (Cubitermes) natalensis* Holmgren] (Snyder, 1949, p. 106, *Anoplotermes kilimandjaricus*; Sands, 1972, *Alyscotermes kilimandjaricus*, synonymy.) Imagoes from South Africa: “Canjeni on the south bank of White Mfolozi River, Zululand” (*mfolozii*); and “Rail, Natal” (*natalensis*).

Wings (with scale): 10–11 × 3 mm; transparent, pale brown to yellowish brown. Hairs: 3–5 rows (length 30–65 μm) on anterior margin and 1–2 rows on posterior margin; also a row on each vein and a few scattered hairs on membrane.

Wing micro-sculpturing: Consists of papillae and simple micrasters. *Papillae*: Of two types. On anterior margin 2–3 rows of simple, pointed papillae, and below them 3–5 rows of arrowhead-type papillae. Size 4–6 μm × 3–4 μm. Smaller and simple pointed papillae on posterior margin. *Micrasters*: Simple, thick, nonasteroid type (1–4 arms) present all over. Size 4–8 μm × 2–6 μm. Density 4000–6250/mm<sup>2</sup>. (Also see Roonwal & Rathore 1977.)

#### Genus (3) *Anoplotermes* F. Mueller

Of this moderate-sized, widespread, soldierless genus, four species from South America and Africa were available.



**Figure 1** A-P Micro-sculpturing on dorsal wing-surface in two soldierless genera (*Anoplotermes* and *Alyscoptermes*) of the Amitermitinae. A-C: *Anoplotermes brevipilus*, hindwing. A, anterior margin. B, posterior margin. C, micrasters enlarged and rearranged. D-F: *Anoplotermes pacificas*, forewing. D, anterior margin. E, posterior margin. F, micrasters enlarged and rearranged. G-J: *Anoplotermes* sp. 1 (S. Africa), forewing. G, anterior margin. H, middle of wing. I, posterior margin. J, micrasters enlarged and rearranged. K-M: *Anoplotermes* sp. 2 (Uganda, Africa), hindwing. K, anterior margin. L, posterior margin. M, micrasters enlarged and rearranged. N-P: *Alyscoptermes kilimandjaricus*, hindwing. N, anterior margin. O, posterior margin. P, micrasters enlarged and rearranged  
**h**, hairs; **m**, micrasters; **p**, papillae

1. *Anoplotermes brevipilus* Emerson 1925 (figures 1A-C; and pl. 1A) (Snyder 1949, p. 104.) Imagoes from South America: "Okó River, tributary of Cayumi R., 37th mile, British Guiana" (=Guyana).

Wings (without scale): 6.5-7×2 mm; transparent, yellowish brown, veins pale brown. Hairs: A row each on anterior and posterior margins; a few hairs on membrane. Length 35-60 μm.

Wing micro-sculpturing: Consists of papillae and micrasters. *Papillae*: 2-3 rows of pointed papillae (4-6 μm×3-4 μm) on anterior and posterior margins. *Micrasters*: Thick, simple, nonasteroid types (1-3 arms) present all over. Size 5-10 μm×1-7 μm. Density 5330-5660/mm<sup>2</sup>. (Also see Roonwal & Rathore 1977.)

2. *Anoplotermes pacificus* F. Mueller 1873 (figures 1D-F) (Snyder 1949, p. 107.) Imagoes from South America: Novo Horizonte, Sao Paulo Province, Brazil.

Wings and hairs as in *A. brevipilus* above.

Wing micro-sculpturing: Consists of papillae and micrasters. *Papillae*: 3-5 rows of pointed papillae on anterior margin, the deeper ones of the arrowhead-type; size 4-6 μm×3-4 μm; 2-3 rows of smaller, simpler ones on posterior margin. *Micrasters*: Almost as in *A. brevipilus*. Size 5-8 μm×1-6 μm. Density 6,000-6,250/mm<sup>2</sup>. (Also see Roonwal & Rathore 1977.)

3. *Anoplotermes* sp. 1 (figures 1G-J) (Mathur & Thapa 1962, p. 39, "*Anoplotermes capensis* (Emerson)", probably MS name only.) Imagoes from South Africa: Kentani, Cape Province.

Wings (without scale): 10-12×3 mm; transparent, yellowish brown, veins pale brown. Hairs: 4-5 rows on anterior and 2-3 rows on posterior margin; a few scattered hairs on membrane; length 50-70 μm.

Wing micro-sculpturing: Consists of papillae and micrasters. *Papillae*: 7-12 rows of pointed papillae on anterior margin, the deeper ones of arrowhead-type; size

6-8 μm×4-6 μm; 2-3 rows of smaller and simpler ones on posterior margin. *Micrasters*: As in *A. brevipilus*. Size 4-7 μm×2-6 μm. Density 5000/mm<sup>2</sup>.

4. *Anoplotermes* sp. 2 (figures 1K-M) (Mathur & Thapa 1962, p. 40, "*Anoplotermes luescheri* (Emerson)", probably MS name only.) Imagoes from Eastern Africa: Hoima, Uganda.

Wings (without scale): 11×3 mm; transparent, yellowish brown, veins pale brown. Hairs: 5-7 rows on anterior and 3-4 rows on posterior margin; a row on each vein, and a few scattered hairs on membrane, 20-70 μm long.

Wing micro-sculpturing: Consists of papillae and micrasters, as in *A. pacificus*. *Papillae*: 6-8 μm×4-6 μm. *Micrasters*: 4-6 μm×5-7 μm; density 5,000/mm<sup>2</sup>.

#### Genus (4) *Speculitermes* Wasmann

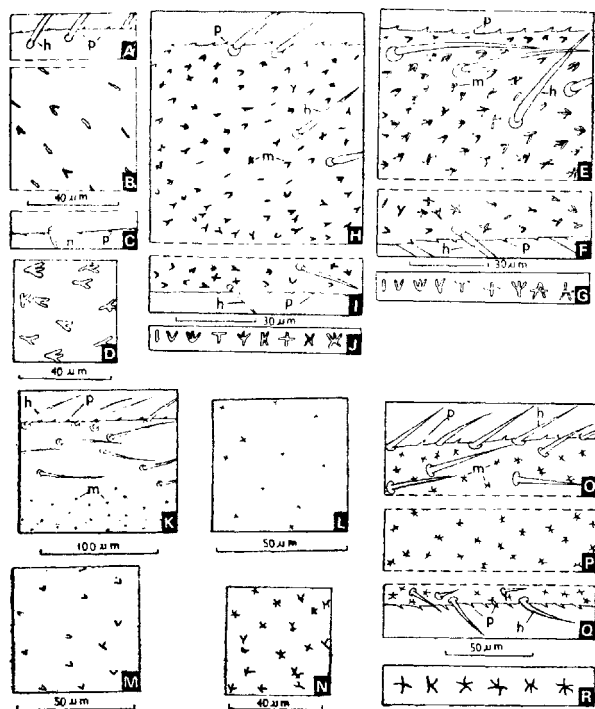
Of this small oriental and neotropical genus, three species were available.

1. *Speculitermes rongrensis*, Roonwal & Chhotani 1962 (figures 2A-C) (Roonwal & Chhotani 1962, p. 314, *S. cyclops rongrensis*.) Imagoes from South Asia: Bhutan.

Wings (with scales): 15×4 mm; transparent, glassy, colourless, veins dull white. Hairs: 1-3 rows on anterior margin, 65-70 μm long; a row on second vein and a row of smaller ones (40-50 μm long) on posterior margin; membrane hairless.

Wing micro-sculpturing: Consists of papillae and micrasters. *Papillae*: A row a minute (0.5 μm×0.5 μm), pointed papillae on anterior and posterior margins. *Micrasters*: Simple, nonasteroid type (with 1-2 arms, mostly 1-armed) all over. Size 3-4 μm×1-3 μm. Density 3200-4000/mm<sup>2</sup>.

2. *Speculitermes silvestrii* (Emerson 1925) (figure 2D; and pl. 1B, C) (Snyder 1949, p. 110.) Imagoes from South America: Ongeljik in Surinam (Dutch Guiana).



**Figure 2 A-R** Wing micro-sculpturing in some Amitermitinae (dorsal surface). A-C: *Speculitermes rongrensis*, forewing. A, anterior margin. B, middle portion highly magnified. C, posterior margin. D, *S. silvestrii*, hindwing, middle portion highly magnified. E-G: *Doonitermes capillosus*, forewing. E, anterior margin. F, posterior margin. G, micrasters enlarged and rearranged. H-J: *Euhamitermes lighti*, forewing. H, anterior margin. I, posterior margin. J, micrasters enlarged and rearranged. K-L: *E. urbanii*, forewing. K, anterior margin. L, middle part, to show micrasters. M, *E. wittmeri*, forewing, middle part with micrasters. N, *Eremotermes fletcheri*, hindwing, middle part with micrasters. O-R, *E. paradoxalis*, forewing. O, anterior margin. P, middle part. Q, posterior margin. R, micrasters enlarged and rearranged  
h, hairs; m, micrasters; p, papillae

Wing micro-sculpturing: *Papillae*: Not examined but probably present on anterior and posterior margins, as in *S. rongrensis*. *Micrasters*: Numerous thick, simple, non-asteroid type (2-4 arms) present all over; size  $7-11 \mu\text{m} \times 3-10 \mu\text{m}$ ; density  $3,330/\text{mm}^2$ . (Also see Roonwal & Rathore 1977.)

3. *Speculitermes sinhalensis* Roonwal & Sen-Sarma 1960 (pl. 1 D) (Roonwal & Sen-Sarma 1960, pp. 23-26, *S. cyclops sinhalensis*.) Imagoes from South Asia (India): Dharwar, Karnataka.

Wing micro-sculpturing: *Papillae*: Not examined but probably present, as in *S. rongrensis*. *Micrasters*: as in *S. rongrensis*, but with 1-3 arms; size  $5-12 \mu\text{m} \times 2-5 \mu\text{m}$ ; density  $3,850/\text{mm}^2$ . (Also see Roonwal & Rathore 1977.)

#### Genus (5) *Doonitermes* Chatterjee & Thakur

A single species was available of this small oriental genus.

1. *Doonitermes capillosus* Chatterjee & Thakur 1965 (figures 2E-G) (Chatterjee & Thakur 1965, *Sci. & Cult.*, Calcutta, 31, pp. 646-647; 1966, *Zool. Anz.*, Jena, 176, pp. 351-357.) Imagoes from South Asia (India): Asarori Forest near Dehra Dun, Uttar Pradesh.

Wings (without scale):  $15-17 \times 3.5-4 \text{ mm}$ ; transparent, colourless, veins pale yellowish brown. Hairs: 6-7 rows on anterior margin (length  $80-100 \mu\text{m}$ ), a row of scattered ones on second vein, and 2-3 rows of smaller hairs on posterior margin; membrane hairless.

Wing micro-sculpturing: Consists of papillae and micrasters. *Papillae*: 1-2 rows of thin or thick, pointed, spiny papillae on anterior margin ( $4-5 \mu\text{m} \times 3-4 \mu\text{m}$ ) and a row of small, pointed ones on posterior margin. *Micrasters*: Simple, thick, non-asteroid type (1-4 arms) present all over. Size  $5-8 \mu\text{m} \times 1-4 \mu\text{m}$ . Density  $7250/\text{mm}^2$ .

#### Genus (6) *Euhamitermes* Holmgren

Of this small oriental genus, three species were available.

1. *Euhamitermes lighti* Snyder 1933 (figures 2H-J) (Snyder 1949, p. 112.) Imagoes from South Asia (India): Asarori Forest near Dehra Dun, Uttar Pradesh.

**Wings** (without scale): 11–12 × 2–3 mm; transparent, colourless, veins dull white. **Hairs**: 2 rows on anterior margin (length 50–60 μm), a scattered row on second vein, and 1–2 rows of smaller ones on posterior margin; a few scattered hairs on membrane.

**Wing micro-sculpturing**: Consists of papillae and micrasters. **Papillae**: 1–2 rows of, small, pointed papillae on anterior margin (3–4 μm × 3–4 μm) and a row of similar but smaller ones on posterior margin. **Micrasters**: Small, simple, colourless, hyaline and non-asteroid type (1–4 arms) all over membrane. Size 4–6 μm × 1–4 μm. Density 7250/mm<sup>2</sup>.

2. *Euhamitermes urbanii* Roonwal & Chhotani 1977 (figures 2K–L) (Roonwal & Chhotani 1977, p. 53.) Imagoes from South Asia: Bhutan.

**Wings** (without scale): 11 × 3 mm; transparent colourless, anterior veins brown. **Hairs**: As in *E. lighti*; 70–75 μm long.

**Wing micro-sculpturing**: Consists of papillae and micrasters. **Papillae**: A row of small, pointed papillae on anterior margin (3 μm × 0.5–1 μm) and a row of similar but smaller ones on posterior margin. **Micrasters**: Simple, small, nonasteroid type (2–4 arms) present all over. Size 2–2.5 μm × 4–5 μm. Density 3600–4000/mm<sup>2</sup>.

3. *Euhamitermes wittmeri* Roonwal & Chhotani 1977 (figure 2M) (Roonwal & Chhotani 1977; p. 56.) Imagoes from South Asia: Bhutan.

**Wings**, **hairs** and **micro-sculpturing** (papillae and micrasters) generally as in *E. Urbanii*. **Micrasters** nonasteroid (2–3 arms); size 2–2.5 μm × 4–5 μm; density 4000–4800/mm<sup>2</sup>.

#### Genus (7) *Drepanotermes* Silvestri

Of this small Australian genus, a single species was available.

1. *Drepanotermes ruficeps* (Froggatt 1897) (Snyder 1949, p. 113.) Imagoes from Australia.

**Wings** (without scale): 16–17 × 5 mm; transparent, colourless. **Hairs**: Several on anterior margin and on the two front veins, and a few on the posterior margin and on membrane.

**Wing micro-sculpturing**: Consists of papillae and micrasters. **Papillae**: A row of thin, small, pointed, spiny papillae (3 μm × 0.5 μm) on anterior margin and a row of similar but smaller ones on posterior margin. **Micrasters**: Both nonasteroid (4 arms) and asteroid (5–6 arms) ones present all over, mostly the latter. Size 4–5 μm × 3–4 μm. Density 10500/mm<sup>2</sup>.

#### Genus (8) *Eremotermes* Silvestri

Of this small palaeartic and oriental genus, two species were available, and two others are discussed briefly but were not examined.

1. *Eremotermes dehradun*: Roonwal & Sen-Sarma 1960 (Roonwal & Sen-Sarma 1960, p. 63) mentioned the presence of "numerous micrasters" on wings of imagoes from Dehra Dun (India). We could not re-examine the examples for papillae, but they are probably present, as in *E. paradoxalis* below.

2. *Eremotermes fletcheri* Holmgren & Holmgren 1917 (figure 2N; and pl. 1E.) (Snyder 1949, p. 131; and Roonwal & Sen-Sarma 1960, p. 63, revision of genus.) Imagoes from South Asia (India): Coimbatore, Tamil Nadu.

**Wing micro-sculpturing**: **Papillae**: Probably present as in *E. paradoxalis* below, but not examined. **Micrasters**: Numerous brown, thin micrasters all over, mostly non-asteroids (3–5 arms) and a few (5%) asteroids (5 arms). Size 3–7 μm × 2–5 μm. Density 6330/mm<sup>2</sup>. (Also see Roonwal & Rathore 1977.)

3. *Eremotermes indicatus* Silvestri 1911 (Snyder 1949 p. 131.) Examples of this African species were not available to us,

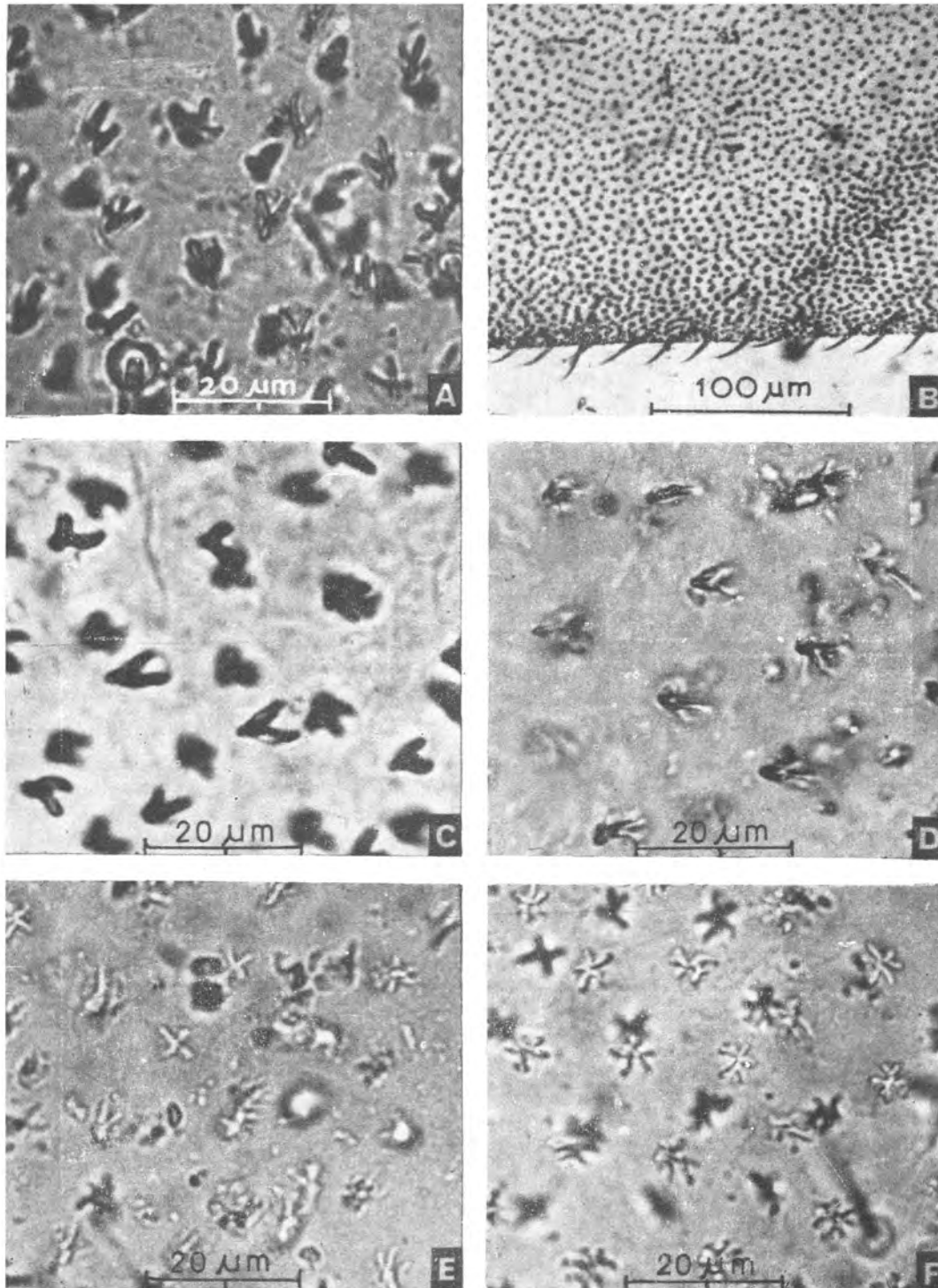


Plate 1 A-F Photomicrographs of wing micro-sculpturing in some Amitermitinae (views of dorsal surface of hindwings). A, *Anoplotermes brevipilus*; B, *Speculitermes silvestrii*, low magnification; C, Same, highly magnified; D, *Speculitermes sinhalensis*; E, *Eremotermes fletcheri*; F, *Eremotermes Paradoxalis*

but Menozzi (1940, *Bull. Lab. Zool. gen. agrar. Portici*, 31, pp. 248–250), who first described its imagoes, shows the figure of a wing as densely punctated, probably by micrasters.

4. *Eremotermes paradoxalis* Holmgren 1913 (figures 2 O–R; and pl. 1F). (Snyder 1949, p. 132; and Roonwal & Sen-Sarma 1960, p. 83, revision of genus.) Imagoes from South Asia (India): Jodhpur (Rajasthan) and Delhi.

Wings [(without scale): 6.5–8 × 1.5–2 mm; transparent, colourless, veins brown; membrane granular due to numerous brown micrasters. Hairs: 1–3 rows on anterior margin (length 35–50 μm), 1–2 rows of smaller hairs on posterior margin, and a few scattered ones on distal third of wing membrane.

Wing-micro-sculpturing: Consists of papillae and micrasters. *Papillae*: A row of small, thin, pointed papillae on anterior margin (size 4–6 μm × 3–4 μm), and a similar row of smaller ones on posterior margin. *Micrasters*: Thin, brown ones present all over, both nonasteroid (4–5 arms) and asteroid (5–6 arms), mostly the former. Size 3–8 μm × 3–8 μm. Density 5670–6000/mm<sup>2</sup>.

#### Genus (9) *Microcerotermes* Silvestri

Of this large, widespread genus, 22 species were available from West, South and Southeast Asia, South America, New Guinea, Australia and the Indian and Pacific Ocean islands. Wings are only moderately hairy, and micro-sculpturing consists of small, pointed, distally directed papillae on the anterior and posterior margins (the anterior ones being usually larger, but in a few cases, e.g., *M. palestinensis* and *M. serratus*, the posterior ones are larger) and micrasters on the rest of the wing membrane (described earlier in some species, vide Roonwal, Verma & Rathore 1974).

Micrasters are of both the nonasteroid and asteroid types, with 1–8 arms. Usually both types, in varying proportions, are present in different species, but in some the nonasteroid type alone is present (*M. cavus*, *M. diversus*). Sizes vary as about 4–9 μm × 1–9 μm. Micraster densities, per mm<sup>2</sup>, on a single wing surface vary from moderate (4455, *M. cavus*) to high (10870, *M. strunckii*).

1. *Microcerotermes annandalei* Silvestri 1923 (figures 3B, C) (Snyder 1949, p. 132.) Imagoes from South Asia (India): Barkuda Is., Chilka Lake, Orissa.

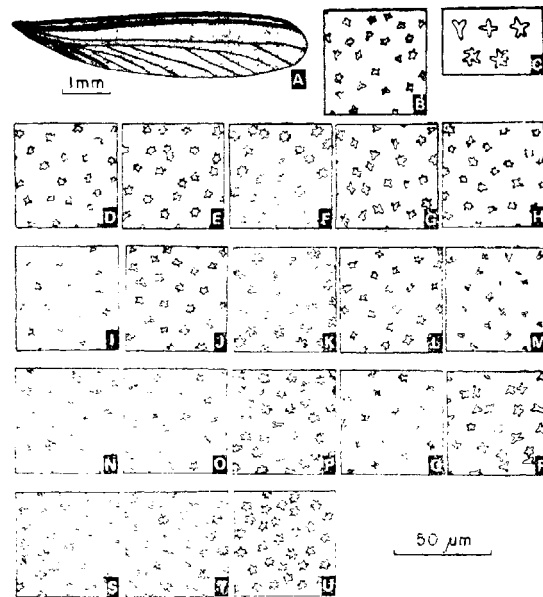


Figure 3 A–U Micrasters on wings of *Microcerotermes*, as seen on dorsal surface (those on the ventral surface are similar). A, *M. raja*, forewing, to show veins and the general distribution of micrasters (stippling). B–U, Small portions of hindwings, to show micrasters. B, *M. annandalei* C, same, types of micrasters more magnified and rearranged. D, *M. arborcus*. E, *M. beasoni*. F, *M. biroi*. G, *M. burmanicus*. H, *M. cameroni*. I, *M. cavus*. J, *M. crassus*. K, *M. depokensis*. L, *M. distinctus*. M, *M. diversus*. N, *M. los-banosensis*. O, *M. nervosus*. P, *M. nicobarenis*. Q, *M. palestinensis*. R, *M. raja*. S, *M. serratus*. T, *M. subtilis*. U, *M. turneri*.



Wing micro-sculpturing: 1-3 rows of pointed papillae on anterior margin and a row of similar but smaller ones on posterior margin. Both nonasteroid (3-6 arms) and asteroid (5-6 arms) micrasters present all over, mostly nonasteroids; size 5-8  $\mu\text{m} \times$  3-7  $\mu\text{m}$ ; density 6,075-6,615/ $\text{mm}^2$ .

2. *Microcerotermes arboreus* Emerson 1925 (figure 3D) (Snyder 1949, p. 133.) Imagoes from South America: Corupano, Venezuela.

Wing micro-sculpturing: 1-2 rows of pointed, spiny papillae on anterior margin and similar rows of smaller ones on posterior margin. Both nonasteroid (4-5 arms) and asteroid (5 arms) micrasters present all over, mostly nonasteroids; size 5-8  $\mu\text{m} \times$  3-8  $\mu\text{m}$ ; density 6,210/ $\text{mm}^2$ .

3. *Microcerotermes beesoni* Snyder 1933 (figures 3E and 4A, B) (Snyder 1949, p. 133.) Imagoes from South Asia (India): Dehra Dun and Chakrata, Uttar Pradesh.

Wings (with scale): 6  $\times$  1.5 mm; thin, transparent, veins dull white. Hairs: 2-3 rows on anterior margin, a few on second vein, and 1-2 rows on posterior margin, 40-60  $\mu\text{m}$  long.

Wing micro-sculpturing: 2-3 rows of short, pointed, spiky papillae on anterior margin (4-6  $\mu\text{m} \times$  3-4  $\mu\text{m}$ ) and a row of similar but smaller ones on posterior margin. Both nonasteroid (5 arms) and asteroid (5-6 arms) micrasters, mostly the latter, present all over; size 5-8  $\mu\text{m} \times$  5-8  $\mu\text{m}$ ; density 6075-6480/ $\text{mm}^2$ .

4. *Microcerotermes biroi* (Desneux 1905) (figure 3F) (Snyder 1949, p. 134.) Imagoes from the Pacific Ocean: Solomon Islands and New Guinea (Der Buab).

Wing micro-sculpturing: 1-2 rows of pointed, spiny papillae on anterior and posterior margins. Both nonasteroid (5-6 arms) and asteroid (5-8 arms) micrasters present all over, mostly asteroids; size 5-9  $\mu\text{m} \times$  5-8  $\mu\text{m}$ ; density 6885/ $\text{mm}^2$ .

5. *Microcerotermes bugnioni* Holmgren 1911 (figures 4C-E) Snyder 1949, p. 135.) Imagoes from South Asia: Colombo, Sri Lanka.

Wings (without scale): 6.5  $\times$  2 mm; transparent, pale yellow, veins dark brown. Hairs: 2-3 rows on anterior margin, a row on second vein and on posterior margin; a few hairs on membrane; length 60-80  $\mu\text{m}$ .

Wing micro-sculpturing: *Papillae*: 1-3 rows of spiny papillae on anterior margin (4-5  $\mu\text{m} \times$  3  $\mu\text{m}$ ) and a row of small ones on posterior margin. *Micrasters*: Dark brown; both nonasteroids (1-5 arms) and asteroids (5-6 arms) present all over, mostly the former. Size 4-8  $\mu\text{m} \times$  6-8  $\mu\text{m}$ . Density 9420/ $\text{mm}^2$ .

6. *Microcerotermes burmanicus* Ahmad 1947 (figure 3G) (Snyder 1949, p. 135.) Imagoes from South Asia: Moulmein Forest Division, Burma.

Wing micro-sculpturing: *Papillae* as in *M. biroi* above. Both nonasteroid (3-5 arms) and asteroid (5-6 arms) micrasters present, mostly asteroids; size 5-9  $\mu\text{m} \times$  5-8  $\mu\text{m}$ ; density 5805-6075/ $\text{mm}^2$ .

7. *Microcerotermes cameroni* Snyder 1934 (figure 3H) (Snyder 1949, p. 135.) Imagoes from South Asia (India): Cochin, Kerala.

Wing micro-sculpturing: *Papillae* as in *M. biroi* above. Both nonasteroid (4-6 arms) and asteroid (5-6 arms) micrasters present all over, mostly asteroids; size 5-8  $\mu\text{m} \times$  5-6  $\mu\text{m}$ ; density 5,670-6,210/ $\text{mm}^2$ .

8. *Microcerotermes cavus* Hill 1942 (figure 3I) (Snyder 1949, p. 135.) Imagoes from Australia: 70 miles west of Cobar, New South Wales.

Wing micro-sculpturing: Pointed papillae present on anterior and posterior margins. Only nonasteroid micrasters (3-5 arms) present all over, no asteroids; size 5-8  $\mu\text{m} \times$  3-6  $\mu\text{m}$ ; density 4455-4590/ $\text{mm}^2$ .

9. *Microcerotermes crassus* (Snyder 1934) (figure 3J) (Snyder 1949, p. 136.) Imagoes from South Asia: Meitkyina, Burma.

Wing micro-sculpturing: Pointed papillae present on anterior and posterior margins. Both nonasteroid (3–6 arms) and asteroid (5–6 arms) micrasters present all over, mostly nonasteroids; size 5–8  $\mu\text{m} \times 5\text{--}6 \mu\text{m}$ ; density 6,210–6,480/mm<sup>2</sup>.

10. *Microcerotermes depokensis* Kemner 1932 (figure 3K) (Snyder 1949, p. 137.) Imagoes from Southeast Asia: Depok, Java (Indonesia).

Wing micro-sculpturing: Papillae as in *M. biroi* above. Both nonasteroid (4–5 arms) and asteroid micrasters present all over, mostly asteroids; size 5–9  $\mu\text{m} \times 3\text{--}9 \mu\text{m}$ ; density 6885/mm<sup>2</sup>.

11. *Microcerotermes distinctus* Silvestri 1909 (figure 3L) (Snyder 1949, p. 137.) Imagoes from Australia.

Wing micro-sculpturing: Pointed papillae present on anterior and posterior margins. Both nonasteroid (3–5 arms) and asteroid (5–7 arms) micrasters present all over, mostly nonasteroids; size 5–8  $\mu\text{m} \times 3\text{--}8 \mu\text{m}$ ; density 6210/mm<sup>2</sup>.

12. *Microcerotermes diversus* Silvestri 1920 (figure 3M) (Snyder 1949, p. 137.) Imagoes from West Asia: Rustam Farm, Baghdad, Iraq.

Wing micro-sculpturing: Pointed papillae present on anterior and posterior margins. Nonasteroid micrasters (1–4 arms) present all over; no asteroids; size 3–6  $\mu\text{m} \times 2\text{--}5 \mu\text{m}$ ; density 4860–5130/mm<sup>2</sup>.

13. *Microcerotermes los-banosensis* Oshima 1914 (figure 3N) (Snyder 1949, p. 141.) Imagoes from Southeast Asia: Malata, Manila, Luzon Is. (Philippines).

Wing micro-sculpturing: 1–2 rows of small, pointed, spiky papillae on anterior margin, apparently none on posterior margin. Both nonasteroid (4–6 arms) and asteroid (5–6 arms) micrasters present all over, mostly nonasteroids; size 6–8  $\mu\text{m} \times 5\text{--}7 \mu\text{m}$ ; density 5535–5670/mm<sup>2</sup>.

14. *Microcerotermes minor* Holmgren 1913 (figures 4F–G) (Snyder 1949, p. 140,

*M. heimi* form *minor*.) Imagoes from South Asia (India): Rasur Reserve Forest, Chittoor District, Andhra Pradesh.

Wings (with scale): 6  $\times$  1.5 mm; transparent, colourless, front vein yellowish brown, other veins almost colourless. Hairs: 2–3 rows on anterior margin, a row on second vein, and a row on posterior margin; none on membrane; length 40–60  $\mu\text{m}$ .

Wing micro-sculpturing: *Papillae*: A row of small (3–4  $\mu\text{m} \times 2 \mu\text{m}$ ) ones on anterior margin; apparently none on posterior. *Micrasters*: Both nonasteroid (1–6 arms) and asteroid (5 arms) types, mostly the former, present all over. Size 4–6  $\mu\text{m} \times 1\text{--}6 \mu\text{m}$ . Density 7250/mm<sup>2</sup>.

15. *Microcerotermes nervosus* Hill 1927 (figure 3O) (Snyder 1949, p. 142.) Imagoes from Australia: Murrumbidgee, Northern Territory.

Wing micro-sculpturing: 1–2 rows of pointed papillae on anterior margin; a similar row of smaller ones on posterior margin. Both nonasteroid (3–5 arms) and asteroid (5 arms) micrasters present all over, mostly nonasteroids; size 5–8  $\mu\text{m} \times 3\text{--}6 \mu\text{m}$ ; density 4955–5130/mm<sup>2</sup>.

16. *Microcerotermes nicobarensis* Roonwal & Bose 1970 (figure 3P) (Roonwal & Bose 1970, *Rec. zool. Surv. India*, 62 [1964], p. 146.) Imagoes from Indian Ocean: Arong village, Car Nicobar Is. (the Nicobars group).

Wing micro-sculpturing: Pointed papillae present on anterior and posterior margins. Both nonasteroid (1–6 arms) and asteroid (5–8 arms) micrasters present all over, mostly asteroids; size 5–8  $\mu\text{m} \times 2\text{--}8 \mu\text{m}$ ; density 8775–9045/mm<sup>2</sup>.

17. *Microcerotermes palestinensis* Spaeth 1964 (figure 3Q) (Spaeth 1964, *Israel J. Zool.*, 13, p. 27.) Imagoes from West Asia: Ben-Shemen, Herzl Forest, Israel.

Wing micro-sculpturing: A row of minute, pointed papillae present on anterior margin and a similar row of somewhat *larger* ones

on posterior margin. Both nonasteroid (3–5 arms) and asteroid (5 arms) micrasters present all over, mostly nonasteroids; size  $6\text{--}8\ \mu\text{m} \times 3\text{--}6\ \mu\text{m}$ ; density  $4590\text{--}4860/\text{mm}^2$ .

18. *Microcerotermes raja* Roonwal & Bose 1964 (figures 3A, R) (Roonwal & Bose, 1964, *Zoologica*, Stuttgart, 40 (3) (Heft 113), p. 26, *M. championi raja*.) Imagoes from South Asia (India): Jodhpur, Rajasthan.

Wing micro-sculpturing: Pointed papillae present on anterior and posterior margins. Both nonasteroid (1–6 arms) and asteroid (5–6 arms) micrasters present all over, mostly nonasteroids; size  $5\text{--}9\ \mu\text{m} \times 2\text{--}8\ \mu\text{m}$ ; density  $6885\text{--}7695/\text{mm}^2$ .

19. *Microcerotermes serratus* (Froggatt 1897) (figure 3S) (Snyder 1949, p. 145.) Imagoes from Australia: Stapleton, Northern Territory; and Townsville, Queensland.)

Wing micro-sculpturing: A row of minute, pointed papillae present on anterior margin and a row of similar but larger ones on posterior margin. Both nonasteroid (4–5 arms) and asteroid (5–6 arms) micrasters present all over, mostly asteroids; size  $5\text{--}9\ \mu\text{m} \times 5\text{--}8\ \mu\text{m}$ ; density  $7560\text{--}8370/\text{mm}^2$ .

20. *Microcerotermes strunckii* (Soerensen 1884) (figures 4I–K) (Snyder 1949, p. 146.) Imagoes from South America: Matto Grosso, Brazil.

Wings (without scale):  $7\text{--}8 \times 2\text{--}2.5\ \mu\text{m}$ ; transparent, colourless, veins pale brown. Hairs: 3–4 rows on anterior margin, a row on second vein, and 1–2 rows on posterior margin; length  $60\text{--}80\ \mu\text{m}$ .

Wing micro-sculpturing: *Papillae*: A row of small, pointed papillae on anterior margin ( $3\text{--}4\ \mu\text{m} \times 2\text{--}3\ \mu\text{m}$ ) and a row of similar but smaller ones on posterior margin. *Micrasters*: Densely present all over; both nonasteroids (2–6 arms) and asteroids, mostly the latter. Size  $4\text{--}6\ \mu\text{m} \times 6\text{--}8\ \mu\text{m}$ . Density  $10870/\text{mm}^2$ .

21. *Microcerotermes subtilis* (Wasmann 1897) (figure 3T) (Snyder 1949, p. 146.)

Imagoes from Indian Ocean (Seychelles Is.): La Misera, Maha.

Wing micro-sculpturing: 1–2 rows of papillae on anterior margin and similar rows of smaller ones on posterior margin. Both nonasteroid (4–6 arms) and asteroid (5–7 arms) micrasters present all over, mostly nonasteroids; size  $6\text{--}9\ \mu\text{m} \times 5\text{--}8\ \mu\text{m}$ ; density  $8505\text{--}8640/\text{mm}^2$ .

22. *Microcerotermes turneri* (Froggatt 1897) (figure 3U) (Snyder 1949, p. 147.) Imagoes from Australia.

Wing micro-sculpturing: Papillae as in *M. subtilis* above. Both nonasteroid (4–5

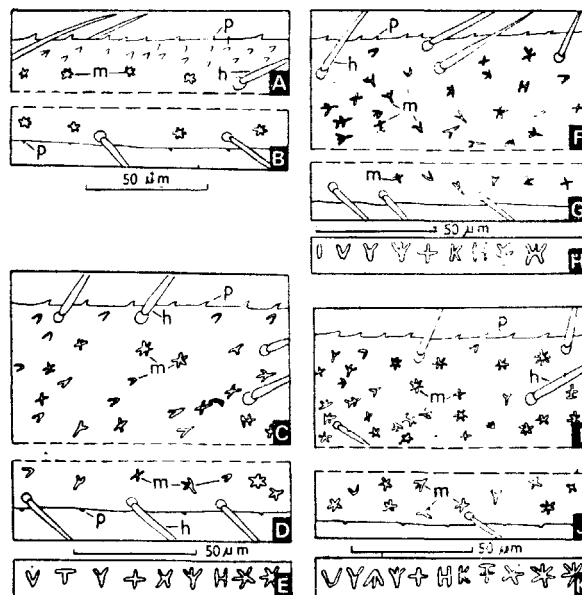


Figure 4 A–K Portions of dorsal surface of forewings of some *Microcerotermes*, to show micro-sculpturing (papillae and micrasters). A–B: *M. beasoni*, anterior and posterior margins respectively. C–D: *M. buginioni*, anterior and posterior margins respectively. E, Same, micrasters enlarged and rearranged. F–G: *M. minor*, anterior and posterior margins respectively. H, Same, micrasters enlarged and rearranged. I–J: *M. strunckii*, anterior and posterior margins respectively. K: Same, micrasters enlarged and rearranged  
h, hairs; m, micrasters; p, papillae.

arms) and asteroid (5-6 arms) micrasters present all over, mostly asteroids; size 6-8  $\mu\text{m} \times 5-6 \mu\text{m}$ ; density 7560-8235/ $\text{mm}^2$ .

**Discussion and Conclusions**

*Evolutionary trends*

Amitermitinae, which is the most primitive of the four subfamilies of the highly evolved family Termitidae, is characterised by the comparative simplicity of wing micro-sculpturing of which only two types are present, viz., the distally directed papillae and the nondirectional micrasters. Hairs are present in moderate numbers on the anterior and posterior wing margins, few occurring on the membrane.

The papillae are normally of a single type, e.g., pointed and spiky, but in the genus *Anoplotermes* the arrowhead-type is also present in some species (*A. pacificus*). Sizes of papillae vary from small (5-12  $\mu\text{m} \times 2-5 \mu\text{m}$ ) to minute (0.5  $\mu\text{m} \times 0.5 \mu\text{m}$ , *Speculitermes rongrensis*). Papillae occur only on the anterior and posterior margins of wings, the anterior papillae being generally larger than the posterior ones, but the reverse occurs in a few species (*Microcerotermes palestiniensis* and *M. serratus*). Occasionally, they seem to be absent on the posterior margin (*Microcerotermes los-banosensis* and *M. minor*).

Micrasters vary in size as about 3-10  $\mu\text{m} \times 1-7 \mu\text{m}$  and are usually thick except in *Eurytermes*, *Drepanotermes*, *Eremotermes* and some species of *Euhamitermes* where they are thin. Both nonasteroid and asteroid types occur, the former exclusively in the primitive genera and both in the higher ones (table 1). In structure and complexity (figure 5) they conform to the 10 types (I-X, with 1-8 arms) in two groups (nonasteroid and asteroid), as categorised by Roonwal, Verma and Rathore (1974). In *Speculitermes rongrensis* they are

SUBFAMILY	GENUS	NON- ASTEROID					ASTEROID					
		I	II	III	IV	V	VI	VII	VIII	IX	X	
AMITERMITINAE	ALYSCOTERMES	0	V	Y	T	X						
	ANOPLOTERMES	0	V	Y	T	X						
	SPECULITERMES	0	V	Y	T	X						
	EREMOTERMES			Y	V	X	T	X	X	X	*	*
	MICROCEROTERMES	0	V	Y	T	X						

Figure 5 Types of micrasters I-X occurring in some genera of the Amitermitinae

extremely simple, with only 1-2 arms, mostly "one-armed" (thick rods). Densities (per  $\text{mm}^2$ ) vary from low (3200-4000, *Speculitermes rongrensis*; 4400-6250, *Alyscotermes kilimandjaricus*) to high (10500, *Drepanotermes ruficeps*; 10870, *Microcerotermes strunckii*).

On the whole, the Amitermitinae retains its primitive character, in contrast to the next higher subfamily Termitinae where micrasters attain their greatest development.

*Systematic significance*

Generic differences are at once apparent in the micrasters, especially among distant genera. Thus, the lower genera, especially the *Anoplotermes* complex (*Alyscotermes*, *Anoplotermes*, *Speculitermes*) stand out by their having only very simple, nonasteroid micrasters (sometimes largely 1-armed and rod-like, *S. rongrensis*), in contrast to the higher ones (*Microcerotermes*) with more elaborate, asteroid micrasters as well. *Eurytermes*, *Eremotermes*, *Drepanotermes* and some Eutiamitermes are characterised by thin micrasters in contrast to thick ones in all the rest. Specific differences are also apparent. Thus, on the whole, micro-sculpturing provides good characters for separating the

**Table 1** Summary of types of wing micro-sculpturing in the subfamily *Amitermitinae* (of family *Termitidae*)

Genera	Papillae (directed distally)			Micrasters		Remarks
	Finger-shaped	Pointed and spiny	Arrow-head type	Non-asteroid	Asteroid	
<i>Eurytermes</i>	—	+	—	+	—	Micrasters thin
<i>Alyscotermes</i>	—	+	+	+	—	Micrasters thick
<i>Anoplotermes</i>	—	+	+	+	—	-do-
			(in some species)			
<i>Speculitermes</i>	—	+	—	+	—	-do-
		(minute)				
<i>Doonitermes</i>	—	+	—	+	—	-do-
<i>Euhamitermes</i>	—	+	—	+	—	Micrasters thick or thin
<i>Drepanotermes</i>	—	+	—	+	+	Micrasters thin
<i>Eremotermes</i>	—	+	—	+	+	-do-
<i>Microcerotermes</i>	—	+	—	+	+	Micrasters thick

—absent; +present

lower taxonomic categories but are less satisfactory for the higher ones (families and subfamilies), though phylogenetic trends are unmistakable.

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