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Evolution and Systematic Significance of Wing Micro-sculpturing in Termites (Isoptera) XI. Some Hitherto Unstudied Genera and Species in Five Families

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(1) The following six genera were studied (all except *Heterotermes* and *Stylotermes* for the first time): Kalotermitidae: *Ceratokalotermes*. Termopsidae: *Archotermopsis*. Rhinotermitidae (Heterotermitinae): *Heterotermes* and *Reticulitermes*. Stylotermitidae: *Stylotermes*. Termitidae (Macrotermitinae): *Ancistrotermes*. (2) The following micro-structures occur on the wings: *Ceratokalotermes*, papillae, tubercles and pimpules; *Archotermopsis*, papillae only; *Heterotermes*, papillae and micrasters; *Reticulitermes*, papillae and pimpules; *Stylotermes*, papillae, arrowheads and pimpules; and *Ancistrotermes*, papillae and simple, non-asteroid micrasters. (3) The evolutionary and systematic significance of these structures is discussed.

Key Words: Isoptera, Wing micro-sculpturing, Evolution, Termite genera

Introduction

In a recent series of studies (Roonwal et al, 1967-1980, vide the References), both surfaces of termite wings have been found to be covered with several different kinds of microscopic structures whose density is sometimes as high as over 12,000/mm^2. These structures assist in taxonomic differentiation of allied genera and species and in determining the phylogenetic position of families and subfamilies. In this part* of the series, data on the following genera and species, which have not been hitherto studied, are presented, and their evolutionary and systematic significance discussed:

Kalotermitidae: *Ceratokalotermes spoliator* (Australia)

Termopsidae: *Archotermopsis wroughtoni* (India)

*It is hoped to follow this up with the next part of the series in which the position in the order Isoptera as a whole will be reviewed.

Rhinotermitidae (Heterotermitinae): *Heterotermes longiceps* (Brazil) *Reticulitermes assamensis* (India)

Stylotermitidae: *Stylotermes fletcheri* (India)

Termitidae (Macrotermitinae): *Ancistrotermes latinotus* (Africa)

All genera (except *Heterotermes* and *Stylotermes*) are discussed here for the first time.

Material and Methods

Winged images from various regions of the world were studied, the precise localities being given under each species. The techniques followed were as in the previous parts. Densities refer to the dorsal wing surface, those on the ventral surface being similar. For taxonomic details and synonymies, Snyder's (1949) world catalogue is referred to, while for species and genera described later the appropriate sources are indicated.

Results

The genera and species studied here are now described in some detail.

FAMILY 1: KALOTERMITIDAE

Micro-sculpturing in several genera of the family Kalotermitidae were described by Roonwal and Rathore (1978). Three types of structures occur, viz., small, finger-like papillae (directed distally and confined to the anterior margin of wing), large subcrescentic and often granular tubercles (also directed distally but distributed irregularly all over the wing), and minute, glassy, rounded, non-directed pimpules found nearly all over. These types may occur simultaneously on a wing, or the tubercles may be present or absent in species of the same genus (e.g., *Neotermes*). Micro-sculpturing in *Ceratokalotermes* is described below.

Genus: Ceratokalotermes Krishna

This genus contains a single Australian species.

1. *Ceratokalotermes spoliator* (Hill) (figure 1 A, B). (Snyder 1949, p. 21, *Kalotermes spoliator*; Krishna 1961, p. 338, *Ceratokalotermes spoliator*.) Australia. Wings (without scale 8–9 × 2 mm) transparent, colourless, front veins thick and dark brown, the rest pale brown but their course marked by a single row of tubercles. Hairs: Wings hairless except for a few small, scattered hairs on the anterior margin. Micro-sculpturing consists of papillae, tubercles and pimpules.

Papillae: 5–6 rows of distally directed, fingerlike papillae on the front and other veins; size 7–9 μm × 5–6 μm, becoming smaller and shallower posteriorly, density on anterior vein 9400/mm^2.

Tubercles: Large, distally directed, shallow, subcrescentic, granular structures (size 20–40 μm × 6–9 μm) present in a single row on all veins (except the front one) and scattered on the membrane.

Pimpules: Minute, rounded, non-directed, refractile, glassy, colourless structures present all over membrane; are larger (2–3 μm × 2–3 μm) and more common in distal upper half of wing, smaller (1.5–2 μm × 1.5 μm) and less common elsewhere.

Discussion: The occurrence of these three types of structures in *Ceratokalotermes* confirms the uniformity of the family Kalotermitidae and its primitive nature. Micrasters, microsetae and rods, which characterise the higher families, are altogether absent here.

FAMILY 2: TERMOPSIDAE

One genus, *Zootermopsis*, in this small, primitive, Nearctic and Oriental family

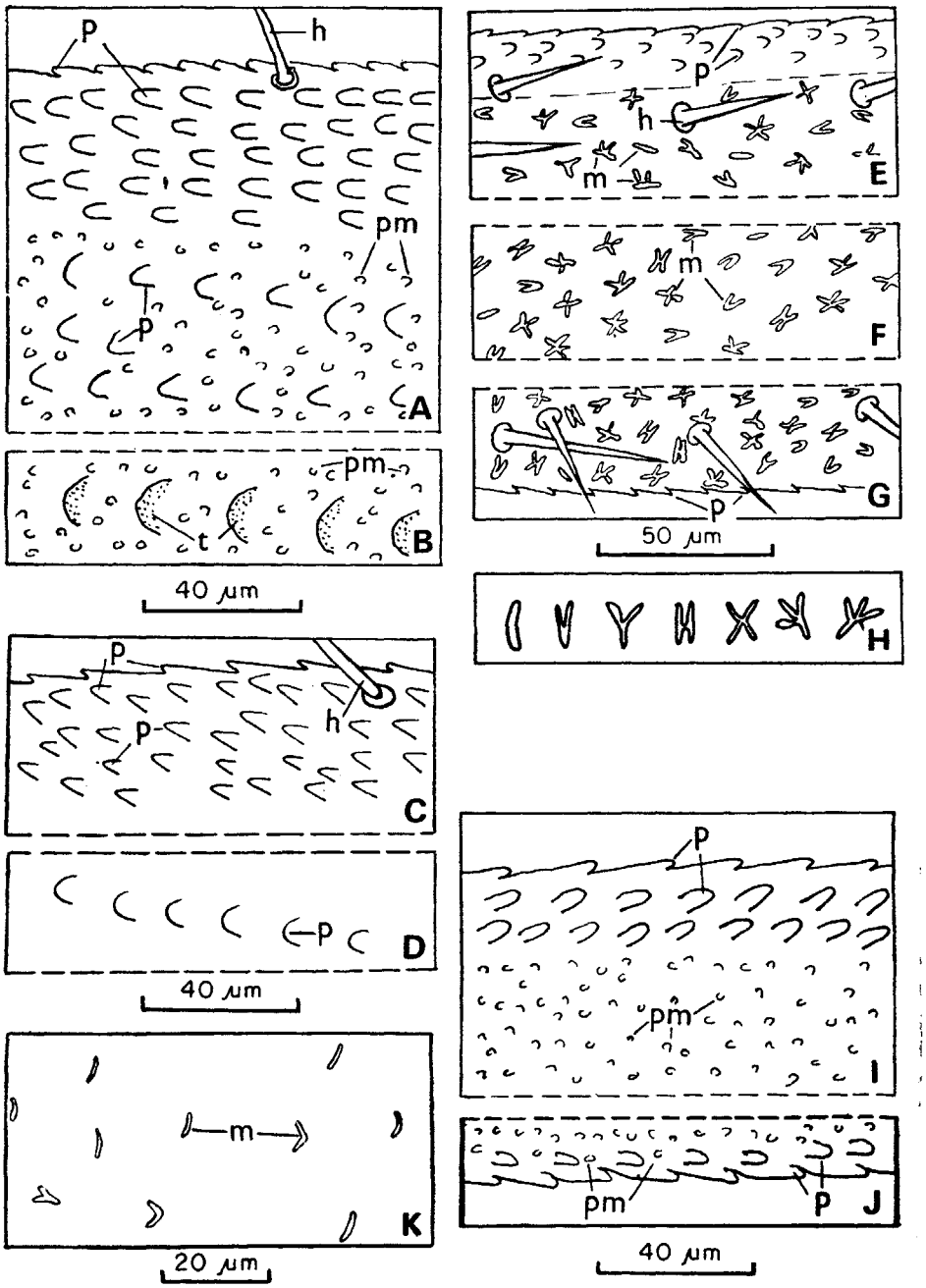

Figure 1 Portions of wings of some termites, highly magnified, to show micro-sculpturing. (**A-B**): *Ceratokalotermes spoliator* (Australia), forewing. *A*, anterior margin; *B*, middle. (**C-D**): *Archotermopsis wroughtoni* (India), forewing. *C*, anterior margin; *D*, middle. (**E-H**): *Heterotermes longiceps* (Brazil), forewing. *E*, anterior margin; *F*, middle; *G*, posterior margin; *H*, micrasters enlarged and rearranged. (**I-J**): *Reticulitermes assamensis* (India), forewing; *I*, anterior margin; *J*, posterior margin. (**K**): *Ancistrotermes latinotus* (South Africa), middle of forewing; **h.**, hairs; **m.**, micrasters; **p.**, papillae; **pm.**; pimpules; **t.**. tubercles

(regarded by some authorities as a subfamily, Termopsinae, of the family Hodotermitidae) was studied by Roonwal, Verma and Thakur (1979 a); micro-sculpturing here consists solely of papillae. Nothing was known of the other two genera, *Archotermopsis* and *Hodotermopsis*; micro-sculpturing in the first one is described below.

Genus Archotermopsis Desneux

This genus contains a single living species which is confined to high altitudes in the Northwest Himalayas.

2. *Archotermopsis wroughtoni* (Desneux) (figure 1 C, D). (Snyder 1949, p. 55.) South Asia (India): Yusimarg, 2286 m altitude (Kashmir). Wings (without scale 17–19 × 4–4.5 mm) transparent, colourless. Hairs: A few scattered ones on the anterior margins, the rest of the wing hairless. Micro-sculpturing consists solely of distally directed papillae: 4–5 rows of thorny, pointed papillae (6–8 μm × 4–6 μm) on the anterior margin and front vein, and rounded and subcrescentic ones, in single rows, on the thicker veins. [Earlier, Emerson and Krishna 1975, p. 16, stated that the wings of *Archotermopsis* "lack punctations." They did not explain 'punctations', which, however, seem to be different from micrasters since, later in the same paragraph these authors, in some other genera, speak of the presence of "rounded punctations or micrasters". Emerson and Krishna made no mention of papillae.]

Discussion: In *Archotermopsis* (as in *Zootermopsis*) only papillae are present, and both tubercles and pimpules are wanting. This feature suggests the very primitive nature of the family Termopsidae; in the Mastotermitidae both papillae and pimpules are present, and in the Kalotermitidae all three structures (papillae, tubercles and pimpules) are found.

FAMILY 3: RHINOTERMITIDAE

Several members of this family have already been studied (Roonwal & Rathore 1977, two species of *Heterotermes*, and Roonwal, Verma & Thakur 1979 b, several subfamilies and genera). A hitherto unstudied species of *Heterotermes* (from Brazil) and a representative of an unstudied genus (*Reticulitermes*) are described below.

Subfamily: Heterotermitinae

This subfamily contains two genera which are discussed below.

Genus: Heterotermes Froggatt

Two species (*H. gertrudae* and *H. indicola*) of this widespread genus were studied by Roonwal & Verma (1976, *H. gertrudae*, micrasters), Roonwal & Rathore (1977) and Roonwal, Verma and Thakur (1979 b). A third, from a different region, is described below.

3. *Heterotermes longiceps* Snyder (figure 1 E-H). (Snyder 1949, p. 68.) South America: Santa Ernestina (S.P., Brazil). Wings (with scale 10–11 × 2 mm) transparent, colourless, anterior veins pale brown. Hairs: 2–3 rows on the front vein, a row of scattered hairs on the second vein and posterior margin, and scattered ones on the membrane. Length 50–80 μm. Micro-sculpturing consists of papillae and micrasters.

Papillae: 3 rows of finger-like papillae (6–7 μm × 4–5 μm) on the anterior margin, and a row of very small, pointed ones (2–2.5 μm × 1–2 μm) on the posterior.

Micrasters: Both asteroid (5 arms) and non-asteroid (1–4 arms) types, mostly the latter, present almost all over wing; size 8–11 μm × 7–11 μm, density 7700/mm^2.

Genus Reticulitermes Holmgren

Of this hitherto unstudied genus, a single species is described below.

4. *Reticulitermes assamensis* Gardner (figure 1 I, J). (*R. chinensis* of authors. Synder, 1949 p. 71, *R. chinensis* Snyder, in part.) South Asia (NE India): Shaitan Bridge, Arunachal Pradesh (formerly NEFA). Wings (without scale 8 × 2 mm) transparent, colourless, front veins pale brown, the rest nearly colourless. Hairs apparently absent. Micro-sculpturing consists of papillae and pimpules; no micrasters.

Papillae: 3–4 rows of finger-like papillae (6–9 μm × 3–6 μm) on the anterior half of front vein, and 2 rows of similar but smaller ones on the posterior.

Pimpules: Numerous minute, rounded, glossy pimpules (1.5–2 μm × 1.5–2 μm) all over membrane except in the region of papillae; density in middle of wing 7000/mm^2.

Discussion: Emerson (1971: 273) stated that "*Heterotermes* is more primitive than *Reticulitermes*"; he further (p. 276) credited the latter genus with "fine and not dense punctations on the wing membrane", but did not say precisely what he meant by 'punctations'. Now that we have information on both the known genera of the Heterotermitinae, it seems that *Reticulitermes*, which possesses only papillae and pimpules (and no micrasters) is perhaps more primitive than *Heterotermes* which has papillae and the full range of both nonasteroid and asteroid micrasters. The absence of micrasters is a mark of primitiveness, as shown by recent surveys of micro-sculpturing in various termite families, including the Rhinotermitidae (Roonwal, Verma & Thakur 1979 b).

FAMILY 4: STYLOPERMITIDAE

Genus Stylotermes Holmgren and Holmgren

[Syns. *Sarvaritermes* Chatterjee & Thakur, and *Operculitermes* Yu & Ping]

Stylotermes dunensis was studied by Roonwal, Verma & Thakur (1979a) who reported the occurrence of distally directed papillae and arrowheads and the non-directional and minute pimpules. A second species is described below.

5. *Stylotermes fletcheri* Holmgren & Holmgren. (Snyder 1949, p. 75.) South Asia (India): Coimbatore (Tamil Nadu). Wings transparent and colourless, apparently hairless. Microsculpturing consists of the distally directed papillae and arrowheads and the nondirectional and minute pimpules.

Papillae: 3–4 rows of small, weakly pointed papillae (3–6 μm × 2–4 μm) on the anterior margin, and 1–2 rows of similar but smaller ones on the posterior.

Arrowheads: Several rows (up to 6 or 7) of large, pointed arrowheads (6–9 μm × 6–9 μm) present below the papillae of the anterior vein, and in 1–2 rows of smaller ones on other veins.

Pimpules: Minute, rounded, glassy and colourless; present in moderate numbers on the proximal half of wing, apparently absent elsewhere.

Discussion: The primitive nature of this small family is indicated by the presence, in the two species studied, of only papillae, arrowheads and pimpules, and the absence of structures which characterise the higher families (e.g., micrasters, rods and microsetae).

FAMILY 5: TERMITIDAE

This large family has been studied in a series of papers by Roonwal et al. (1967

onward, vide the References). An interesting genus (not hitherto studied) of the subfamily Macrotermitinae is described here.

Subfamily: Macrotermitinae

Several genera of this highly evolved, fungus-growing subfamily were studied by Roonwal & Chhotani (1967) and Roonwal, Verma & Rathore (1980). Two types of micro-sculpturings occur, viz., (a) by the distally directed papillae present in all genera at the anterior and posterior wing margins; and (b) by a second type which covers the rest of the wing surface and consists, according to genus, of either microsetae (*Pseudacanthotermes*), pimpules (*Macrotermes*), short, thick, stubby rods* (*Allodontermes*), or thin, stringy, sinuous, short to long rods (*Odontotermes*, *Hypotermes* and *Microtermes*). A member of the interesting Eithiopian genus *Ancistrotermes* is now described.

Genus: Ancistrotermes Silvestri

A single species of this medium-sized genus was available from Africa.

6. *Ancistrotermes latinotus* (Holmgren) (figure 1K). [Syn. *A. lebomboensis* Fuller; not *A. crucifer* Sjoestedt.] (Snyder, 1949, p. 246; and Bouillon & Mathot 1966, pp 8-9, synonymy.) Africa: Malanga, Angola (*latinota*); and Conjeni, White Umfolosi River, "Zululand" (=Natal), South Africa (*lebomboensis*). Wings (without scale 21–23×5—5.5 mm) transparent, colourless, veins pale brown. Haris: 2–3 rows of long (60–80 μm) hairs on the front vein and a row on the second vein, membrane hairless. Micro-sculpturing consists of papillae and simple, nonasteroid micrasters.

Papillae: 4–5 rows of small, spiny, distally directed papillae (3–5 μm × 3–4 μm) on the anterior margin, and 3–4 rows of similar but smaller ones on the posterior.

Micrasters: Numerous nonasteroid (1–3 arms), thick, glassy micrasters all over, generally rod-like, V-shaped and Y-shaped, but round on proximal part of wing. Size 6–8 μm × 2–6 μm, density 5070/mm^2.

Discussion: Apart from papillae, micro-sculpturing in the Macrotermitinae is marked by considerable variability, four types of structures being found as mentioned above. Micrasters, hitherto not found in the Macrotermitinae, are reported here in *Ancistrotermes*, but only the simple, non-asteroid (1–3 arms) types occur, ranging from thick rods (sometimes rounded and ball-shaped) to V and Y shapes. In view of this find, the "rods" in the Macrotermitine genus *Allodontermes* (reported earlier, vide Roonwal, Verma & Rathore, 1980), which resemble those of *Ancistrotermes*, should be regarded as belonging to the category of nonasteroid micrasters.

Discussion and Conclusions

The results obtained from the material studied here confirm and reinforce those obtained in the previous parts of this series. They also throw fresh light on the phylogenetic position of some genera, as discussed above under each family. To take but two examples: The extreme simplicity of micro-sculpturing (consisting of papillae only) in two genera of the Termopsidae (*Archotermopsis* and *Zootermopsis*) would suggest the very primitive nature of this family in comparison with the Mastotermitidae (where pimpules also occur) and the Kalotermitidae (where pimpules and tubercles occur in addition to papillae). In the Rhinotermitidae, genus *Reticulitermes* (where micrasters are absent) seems to be more primitive than

*Now interpreted as simple, one-armed micrasters (vide infra).

Heterotermes (where micrasters are well developed).

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