

A New Species of *Glossotermes* (Isoptera): Reappraisal of the Generic Status with Transfer from the Rhinotermitidae to the Serritermitidae

by

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ABSTRACT

We describe a new species, *Glossotermes sulcatus*, based on samples collected in the Amazonian region with soldiers, workers, alates, and ergatoids. All the castes are described and illustrated, which is a novelty for *Glossotermes* Emerson as a whole, a genus described from a single soldier in 1950. The detailed study of the castes allowed us to redescribe the genus and discuss its status. There are many characters (in all castes) that reinforce our conclusion that *Glossotermes* is more closely related to *Serritermes* than to *Psammotermes*, contrary to what is so far accepted. Among these, mandibles of workers and alates of *Glossotermes* present the most conspicuous synapomorphy with *Serritermes serrifer*. We therefore propose to remove *Glossotermes* from Psammotermitinae and reassign it to the previously monotypic family Serritermitidae. We also provide a new definition for this family and the two new subfamilies (Glossotermitinae and Serritermitinae).

Keywords: Isoptera, *Glossotermes*, Serritermitidae, Rhinotermitidae, Systematics

INTRODUCTION

For the last fifteen years, many papers have been published on the phylogeny of Isoptera, considering some families or subfamilies or the entire order using morphological characters and a molecular approach (Thorne & Carpenter 1992; Khambampati *et al.* 1996; Kambhampati & Eggleton 2000; Donovan *et al.* 2000; Noirot 1995, 2001; Bitsch & Noirot 2002). Eggleton (2001) made a revision of most of these papers and concluded that there are many gaps in our understanding of the phylogenetic relationships inside Isoptera. The group composed of Serritermitidae, Rhinotermitidae, and Termitidae, stands as a good example of such gaps. While it is well accepted that these three families form a monophyletic assemblage (Noirot 1995; Donovan *et al.* 2000;

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Eggleton & Khambampati 2000), the relationships among them remain uncertain.

Holmgren (1911) placed *Serritermes serrifer* as the only species of the subfamily Serritermitinae inside Rhinotermitidae, while Ahamad (1955) placed it inside Termitidae. Emerson (1965) erected a new family – Serritermitidae — to accommodate *Serritermes serrifer*.

Rhinotermitidae, in its turn, also presents its own puzzles. In addition to being considered an artificial group (Eggleton 2001), this family holds genera whose systematic status are not firmly established. While properly describing the new family Serritermitidae, Emerson & Krishna (1975) shed serious doubts on the actual status of the rhinotermitid genus *Glossotermes*. By studying the morphology of all castes of *Serritermes serrifer* and making comparisons to other genera, these authors stated that "...] *Glossotermes* is more closely related to *Serritermes* than to the soldier of any other rhinotermitid genus ... The Neotropical distribution of both genera may not be coincidence". The absence of data, however, prevented Emerson & Krishna (*op.cit.*) to allocate *Glossotermes* into the Serritermitidae, keeping the previous decision of Emerson (1950), who tentatively ascribed it to Psammotermitinae (Rhinotermitidae). In fact, Emerson (*op.cit.*) himself was unable to make a firm determination of *Glossotermes*' phylogenetic affinities, since he had no more than a single soldier to describe the species-type of this genus (*Glossotermes oculatus*). But a warning was given: "When the imago of *Glossotermes* is discovered and compared, the relationships with *Serritermes* and other genera will be better understood" (Emerson & Krishna 1975). Samples of a new species of *Glossotermes* collected in the Amazonian region, by other colleagues and one of us (DeSouza), with soldiers, workers, alates, and ergatoids allowed us to redescribe the genus and discuss its status. This paper aims to present data and interpretations which support the hypothesis that *Glossotermes* belongs, in fact, to Serritermitidae. We also present a new definition of this family and the two subfamilies.

A preliminary version of this manuscript was presented by one of us (EMC) in the XIII International Congress of IUSI (International Union for the Study of Social Insects), held at Adelaide, Australia (Canello & DeSouza 1998-1999). Constantino (2003), in his online Catalog accepted *Glossotermes* as the second genus of Serritermitidae.

MATERIAL AND METHODS

All the samples of *Glossotermes sulcatus*, n.sp. are housed in MZUSP, INPA (Instituto de Pesquisas da Amazônia, Amazonas, Brazil), MEUV (Museu de Entomologia da Universidade Federal de Viçosa,

Minas Gerais, Brazil) and UFPB (Universidade Federal da Paraíba, João Pessoa, Paraíba, Brazil).

The holotype of *Glossotermes oculatus* came from AMNH and all the samples of *Psammotermes* and *Serritermes serrifer* belong to the MZUSP Collection.

The digestive tube description and comparisons follow Noirot (1995).

The morphometric characters here used are listed below and follow Roonwal (1970), except for “LH2: Length of head, in profile”, and “inter-eye distance”, for soldiers. In brackets, we include the page and the corresponding number in Roonwal (*op. cit.*).

1- For the soldiers:

LH: Length of head, dorsally (p. 19, nr.9, Fig.4, line JJ’);

LH2: length of head, in profile, as in Mathews (1977, p. 76, Fig. 15, L);

WH: width of head, dorsally (p. 23, nr. 17);

Hh: Height of head, in profile (p. 25, nr. 22, Fig.4);

IE: Inter-eye distance: distance between the eyes, excluding them.

WL: maximum width of labrum (p. 29, nr.33);

LM: length of left mandible (p. 30, nr. 37);

W mxP: maximum width of postmentum (p. 39, nr.62);

W mnP: minimum width of postmentum (p. 39, nr 63);

LPr: length of pronotum, dorsal (p. 40, nr.65);

W Pr: width of pronotum, dorsal (p. 42, nr. 68);

LT: length of hind tibia (p.45, nr. 85)

For alates:

LH: Length of head, dorsal (p.19, nr.8)

WH: width of head, dorsally (p. 23, nr. 17);

DE: Maximum diameter of compound eye (p.34, nr. 48)

IE: Inter-eye distance (p.36, nr. 52)

Mx. DO: Maximum diameter of ocellus (p.37, nr. 55)

Mn DO: Minimum diameter of ocellus (p.37, nr. 56)

MnE-O: Minimum eye- ocellus distance (p.37, nr. 57)

LPr: length of pronotum, dorsal (p. 40, nr.65);

WPr: width of pronotum, dorsal (p. 42, nr. 68);

LT: length of hind tibia (p.45, nr. 85);

LFW: length of forewing without scale (p.42,nr.74)

LHW: length of hindwing without scale (as the anterior)

LT: length of hind tibia (p.45, nr. 85)

For wing venation we follow the terminology used by Emerson (1965).

For the two ergatoids we used only length of head; width of head; length of pronotum; width of pronotum and length of hind tibia, as measured for the alates.

SERRITERMITIDAE HOLMGREN

Emerson & Krishna (1975) gave some diagnostic characters of Serritermitidae, based on the mandibles of the worker and soldier, plus the pronotum shape of *Serritermes serrifer*. We now propose to restrict such diagnostic characters to the subfamily Serritermitinae only. We also propose to include within Serritermitidae a new subfamily, Glossotermitinae, whose diagnostic characters are presented below.

Serritermitidae (Serritermitinae + Glossotermitinae)

Type genus: *Serritermes* Wasmann, 1897

Diagnostic characters:

The imago, workers and nymphs differ from all the other termite families by the proportionally elongated and sharp apical tooth of each mandible, reduced marginal teeth (one in Serritermitinae and two in Glossotermitinae), presence of third marginal on the left mandible, unique marginal of the right mandible close to the molar regions, and molar regions with well developed ridges. The soldier has long mandibles slightly curved upward when in profile. Relatively straight apical portions of both mandibles, in *Serritermes*, or slightly curved in *Glossotermes*. In *Serritermes*: both mandibles with numerous proportionally coarse, large serrations on the inner margins behind the tips, and in *Glossotermes*, inner edge of right mandible smooth and left mandible with a finely serrate inner edge behind the tip, becoming coarser near the lower portion towards the base, where a large groove occurs; edge below this groove coarsely serrate (with four distinct tooth-like projections) and a smooth edge above it. Pronotum proportionally narrow, elongated with both, front and hind margins, conspicuously bilobed, each deeply emarginated in *Serritermes* and, in *Glossotermes*, not so narrow, wider than long, with a not so deep emargination in the front margin and a slight emargination on the hind margin. Four tarsal articles, cerci short with two articles, styli absent.

Alates are small and delicate, with the mandibles as described for the workers. Venation reduced. Forewing: subcosta (Sc) and first radius (R1), second plus third radius (R2+3) absent; Radial sector (Rs) heavy and parallel to costal margin reaching the tip of wing; Media (M) very weak, with about seven to nine branches or M lacking as a distinct vein, possibly coalescent with cubitus (Cu). Cubitus weak with eight to nine branches (if M is present) or with 18 branches and extending to the apical portion of wing (in the absence of M); Anal vein absent. Hind wing scale smaller than forewing scale, not extending nearly to margin of metanotum. Hind wing venation very similar to the forewing, M

variable, sometimes joined to Rs near base, with 10 branches and Cubitus separate at suture with about eight branches. Anal vein (A) absent. Styli absent in both male and female; cerci short with two articles.

GLOSSOTERMITINAE

Type genus: *Glossotermes* Emerson, 1950

Diagnostic characters:

The imago and worker differ from all the other termite families by the elongated sharp apical tooth of each mandible, which is larger than marginal teeth and presents concave posterior margin. Molar regions are concave with very well developed ridges (13-15). Left mandible with two marginals (M1+2). Third marginal (M3) very large, much longer and narrower than M1+2, no gap between M3 and the molar prominence; molar tooth conspicuous and visible between M1+2 and M3. Right mandible with M1 large with posterior margin almost straight or very slightly concave; M2 absent, molar plate with an apical strong thickening in a way that seems another tooth.

Soldier: Head subretangular, somewhat flat, with distinct eyespot on each side with reduced facettes barely distinguishable and two light spots (reduced ocelli). A minute oval opening of the frontal gland visible well behind the level of the eyespots. Mandibles wide at the base and tapering to a sharp hooked tip. Both mandibles with a notch, inner edge of right mandible smooth with a tooth-like projection about one-third of the length of mandible (from the base condyle), a minute tooth at the inner portion of the notch, more evident in some specimens. Left mandible finely serrate at the inner edge below the tip, becoming coarser when approaching the lower half, where a groove begins; such groove enlarges itself, from this point to the base of the mandible; dorsal edge of the groove smooth; ventral edge coarsely serrate, bearing four distinct teeth-like projections. Mandibles slightly upward curved in profile.

***Glossotermes sulcatus* new species**

Etimology: *sulcatus* stands for “bearing a groove” in Latin. It was chosen in reference to the long narrow hollow space cut into the internal margin of the soldier’s left mandible.

Soldier (Figs. 1-4)

Head subretangular, somewhat flat; some specimens with slightly convex sides and some with base of head narrower than the anterior portion; in profile, with a slightly depressed area in the anterior portion

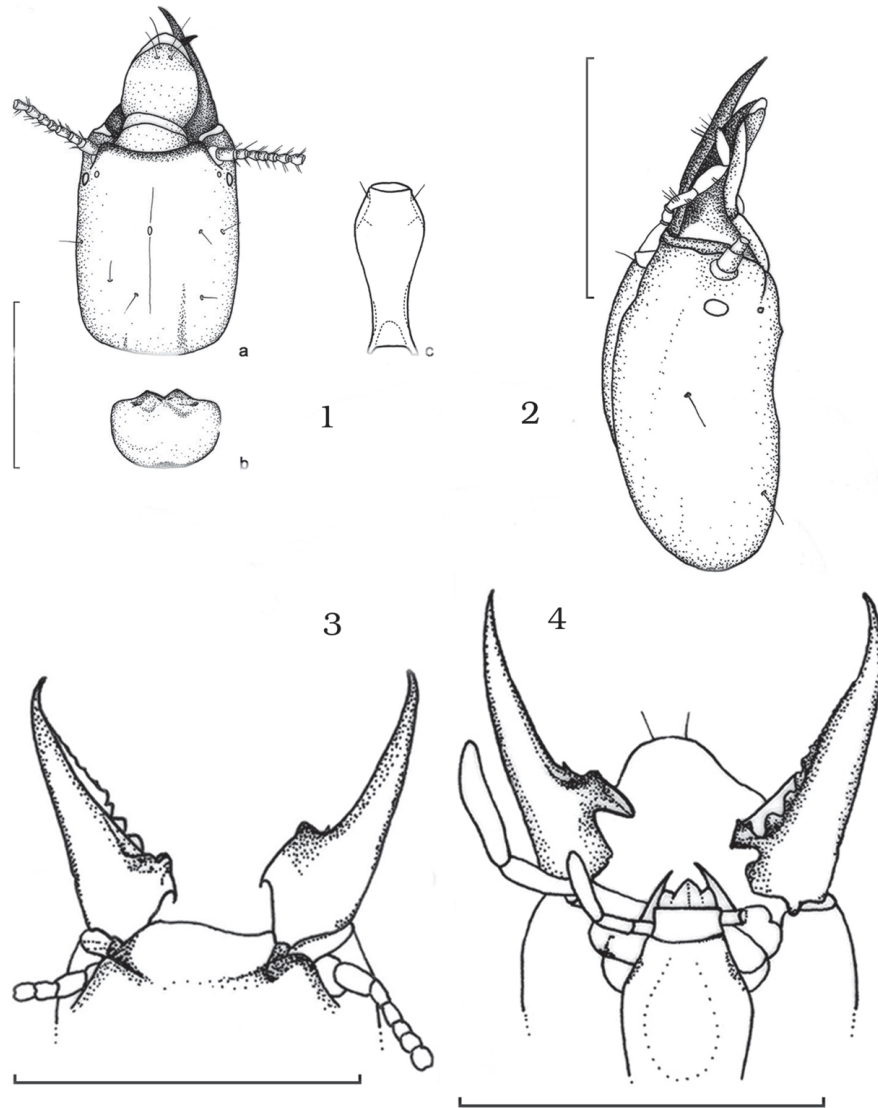


Fig. 1-4. *Glossotermes sulcatus* soldier: 1a, Head; b, Pronotum, (both in dorsal view); c, postmentum (ventral view), scale bar: 1mm.; 2. Head, in profile, scale bar: 1mm.; 3. mandibles, dorsal view, scale bar: 1mm.; 4. Mandibles, ventral view, scale bar: 1mm.

followed by a pimple-like protuberance in each side. Distinct eye spot a little smaller than the antennal socket, behind it on each side with reduced facettes barely distinguishable. One light spot (reduced ocel-

lus) on each side of the head, placed between the eyespot and the insertion of the antenna, far from the eyespot a little longer than the length of the eyespot. A minute oval opening of the frontal gland visible well behind the level of the eyespots. Postclypeus distinct. Labrum very wide, sides rounded; a thin hyaline lip at tip and a hyaline band in the central region. Labrum covering about 5/6 of the closed mandibles. Mandibles wide at the base and tapering to a sharp hooked tip or tapering to an almost straight tip. Both mandibles with a notch, inner edge of right mandible smooth with a tooth-like projection about one-third of the length of mandible (from the base condyle), a minute tooth at the inner portion of the notch, more evident in some specimens. Left mandible finely serrate at the inner edge below the tip, becoming coarser when approaching the lower half, where a groove begins. Such groove enlarges itself, from this point to the base of the mandible. Dorsal edge of the groove smooth; ventral edge coarsely serrate, bearing four distinct teeth-like projections. Mandibles slightly upward curved in profile. Antennae with 15 articles, 1st longer than 2nd, this equal to 3rd or longer, 4th the smallest one, 5th smaller than 6th, this smaller than 7th, from this to the last subequal; some specimens with 3rd and 4th not completely separate. Postmentum wide in the anterior portion and narrower in the posterior part; in profile somewhat convex. Pronotum wider than long, almost rectangular with middle of the front margin raised and strongly emarginated. Cerci with two articles, first much wider than second. Styli absent. Head with a few scattered bristles; postmentum with a few microscopic and short hairs, tip of labrum with four bristles, pronotum with a few erect bristles and microscopic hairs around the edges; abdominal tergites with erect bristles on the posterior margin and some microscopic hairs; abdominal sternites with many bristles, some short and microscopic hairs; legs with bristles, short hairs and some spines on the internal margin of the tibiae not organized in a row. Tibial spurs formula: 2:2:2. Head brownish yellow or yellow, mandibles pale brown, pronotum and postclypeus a little darker or same color of head, antennae and legs lighter.

Measurements of 10 soldiers, in millimeters: LH: 1.17- 1.28; LH2: 1.2- 1.34; WH: 0.93- 0.99; Hh: 0.64- 0.72; IE: 0.72- 0.85; WL: 0.4- 0.48; LM: 0.80- 0.83; WmxP: 0.35- 0.40; WmnP: 0.18- 0.19; LPr: 0.37- 0.42; WPr: 0.59- 0.64; LT: 0.86- 0.94

Worker (Figs.5-8):

Round head with somewhat inflated postclypeus, pronotum similar to that of soldier. Mandibles: both mandibles with apical tooth with

concave posterior margin, and larger than marginal teeth. Left mandible: first marginal tooth interpreted as M1+2 with posterior margin sinuous (it is possible to see the vestigial second tooth, Fig. 6 *); M3 very large, much longer and narrower than M1+2, no gap between M3 and the molar prominence; molar tooth conspicuous and visible between M1+2 and M3 (Figs. 5a and 6); molar prominence wide, the apex extends well beyond the point of the molar tooth, the inner surface concave with very well developed ridges (13 - 14). Right mandible: M1 large with posterior margin almost straight or very slightly concave, M2 absent, molar plate with many very well developed ridges, with apical strong thickening in a way that seems another tooth. Scattered bristles on head, tergites with erected bristles on the posterior margin and short hairs on surface; sternites with erected bristles on posterior marginal and many short hairs on surface. Head pale yellow or yellow white, legs, tergites and sternites paler than head, whitish.

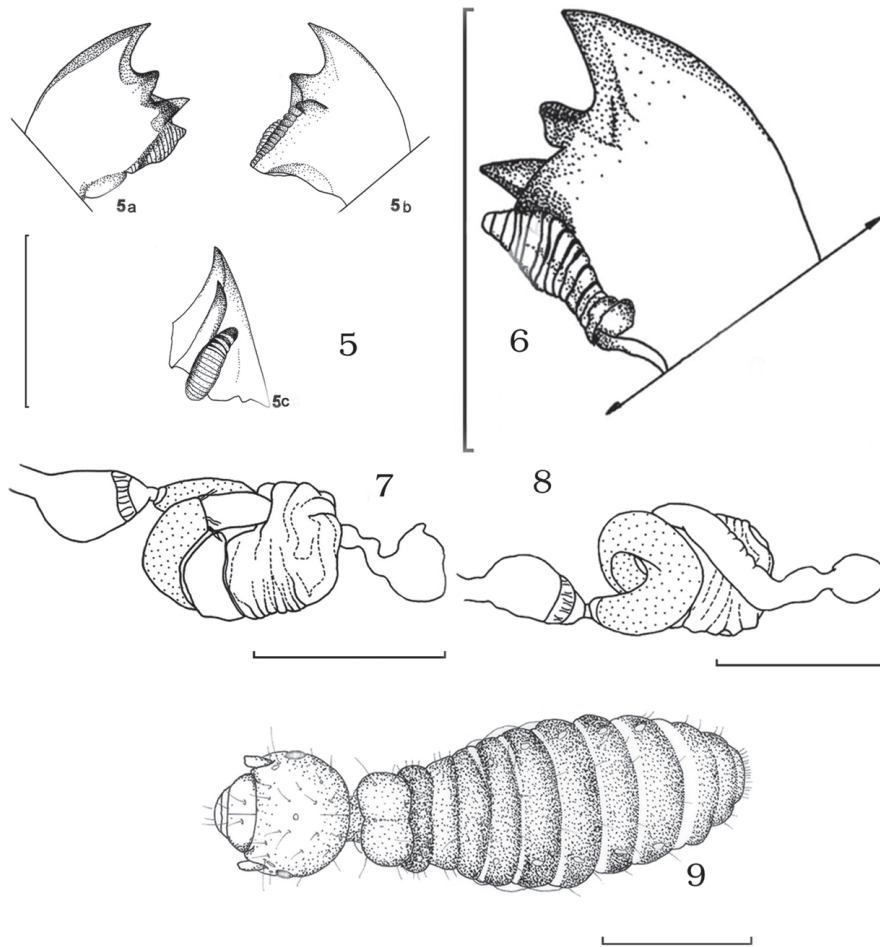
* In some individuals it is possible to see the vestigial second tooth on dorsal view.

Digestive tube* (Figs. 7 and 8): Gut with "untwisted pattern". Crop slightly dilated and asymmetric, as in the *Rhinotermitidae*. Gizzard (C/H=1:16) less developed than the usual C/H=1:8 to 1:11 of the *Rhinotermitidae*. Stomodaeal valve rather long as usual in termites. Midgut short without ceca, round limit with hindgut. Malpighian tubules: 8 from midgut to rectum. First part of the hindgut (P1+P2) very short, conical, no "limiting groove" is visible between P1 and P2. P2 (enteric valve) very different from the *Rhinotermitidae*; the six usual cushions are present with a triradial symmetry; cushions 2 barely visible, cushions 1 without a complex cuticular armature.

*We included here many observations kindly sent by Dr. Charles Noirot, from Université de Bourgogne, Dijon, France.

Ergatoid- female (Fig. 9):

Head rounded, eyes non pigmented, with some facettes, ocelli very small and far from the eyes. Fontanelle small, below the ocelli level and larger than ocelli. Postclypeus and labrum similar to those of the alates. Mandibles equal to those of workers. Antennae with 16 articles, 2nd longer than 3rd, this longer than 4th, 5th and 6th subequal and longer than 4th, 7th longer than 6th, from the 7th to 16th progressively increasing in size. Pronotum slightly arched, central region raised, anterior margin strongly emarginate. The 7th sternite of the ergatoid is enlarged as in the alate female, contrary to those narrow sternites of workers, all about the same size. Head with some scattered bristles of two sizes, only a few smaller ones. Pronotum with two erect bristles on



Figs. 5-8. *Glossotermes sulcatus* 5, Worker mandibles: a- left mandible, b- right mandible (both in dorsal view), c- right mandible, in frontal view dorsal view, scale bar: 0.5 mm; 6, worker: left mandible, in ventral view, scale bar: 0.5 mm; 7, Digestive tube, in situ, dorsal view, scale bar: 1mm; 8, Digestive tube, in situ, ventral view, scale bar: 1mm; 9, *Glossotermes sulcatus*, n.sp: ergatoid: female, dorsal view, scale bar: 1mm

the anterior margin and two on the posterior margin, two on the anterior corners short hairs on the anterior margin and some bristles near margins on the posterior corners. Mesonotum and metanotum with short bristles on the lateral margins and longer ones on the posterior margins. Abdominal tergites with bristles on the posterior margins and on the lateral portions along with a few short hairs, microscopic hairs on the surface. Abdominal sternites densely covered

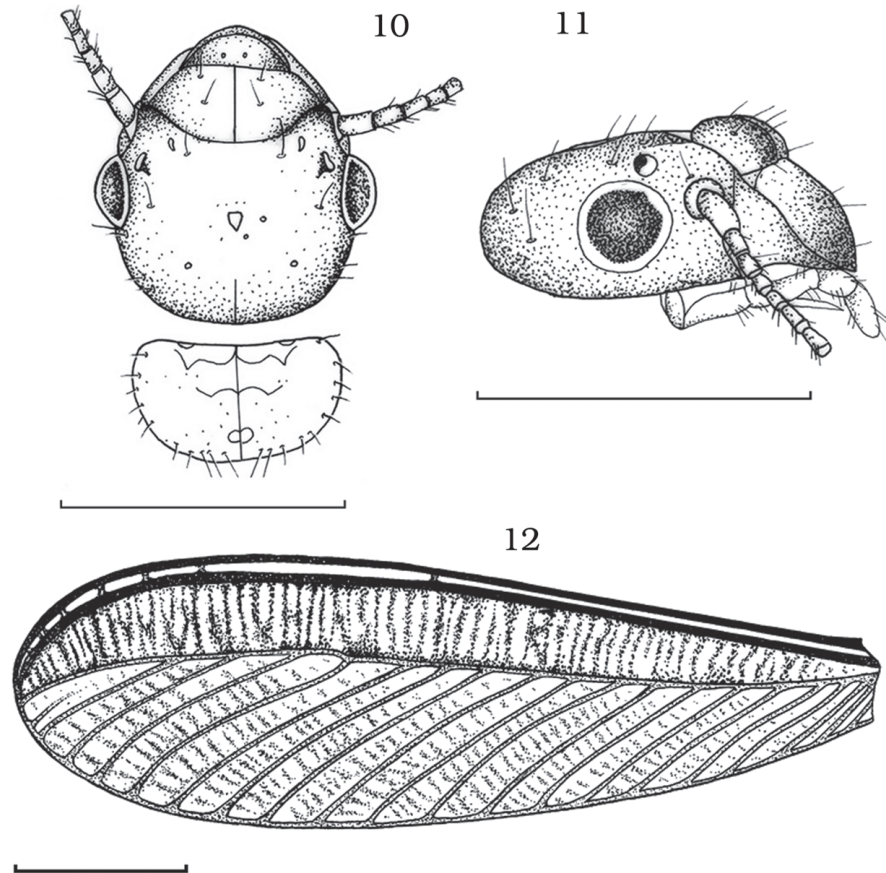
with short hairs and some bristles backward orientated on the posterior margins. Legs with many bristles and short hairs; tibiae with spines on the internal margin. Tibial spurs formula: 2:2:2. Pronotum and head brownish yellow, with lighter region around the fontanelle opening; antennae lighter than head; mesonotum, metanotum, the first four abdominal tergites and legs lighter than pronotum, other tergites same color as pronotum.

Measurements of two female ergatoids: LH (0.57-0.59); WH (0.94-0.99); LPr (0.34-0.39); WPr (0.57-0.62); LT (0.69-0.70).

Imagoes (Figs. 10-12):

Head rounded, eyes medium size, ocelli conspicuous, elevated, close to eyes (in profile), fontanelle opening sub triangular, in a depressed area (more depressed in the males), postclypeus arched, large labrum, with a light band at base. Antennae with 11 to 13 articles, 2nd subequal to 4th and 5th; third longer and subequal to 6th, increasing in size from seventh to tenth; 11-13th subequal and almost twice the second; when with 13, third subdivided. Mandibles as in the worker. Pronotum narrower than head, anterior margin not emarginate, posterior margin slightly emarginate. Forewing scale large, extending almost to posterior border of the mesonotum, overlapping the base of hind wing scale. The anterior scale is almost the double length of posterior. Humeral suture slightly convex between costal margin (C) and radial sector (Rs) and straight from Rs to inner margin. Wing membrane with irregular vertical and some slanting chitinizations, conveying a somewhat reticular appearance to whole wing between Rs and Cubitus, except at base near suture and a few cross reticulations between costal margin and Rs in apical fourth. Forewing with subcosta (Sc) and first radius (R 1); second plus third radius (R 2+3) absent. Radial sector (Rs) heavy and parallel to costal margin to the tip of wing. Vein M possibly* coalescent with cubitus (Cu). This vein with 18 branches and extending to the apical portion of wing. Hind wing with costal margin and Rs similar to forewing. M joined to Rs near base, with 10 branches reaching the inner margin within its apical two thirds. Cubitus separate at suture with about eight branches not extending beyond the first third of wing. Anal vein (A) absent. Some scattered bristles on head, four or six on the postclypeus, four on labrum. Pronotum with some bristles on margins, bristles and some very short hairs on the surface. Tergites and sternites with many bristles and hairs on the surface and longer bristles on the posterior margins. Legs covered by hairs and bristles, tibiae with many

* As suggested by Emerson & Krishna (1975)



Figs.10-12. *Glossotermes sulcatus* 10, Alate female: head and pronotum, dorsal view, scale bar: 1mm; 11. Alate female: head in profile, scale bar: 1mm; 12. Anterior wing, scale bar: 1mm

spines on the internal surface. Tibial spur formula: 2:2:2. In both wings: some bristles on the scale no hairs either on membrane or on veins beyond scale; margins smooth and hairless. Head brownish yellow or brown, with lighter region around the fontanelle opening and with lighter marks (more in males); pronotum and postclypeus lighter than head; antennae, labrum, legs, abdominal tergites and abdominal sternites lighter, brownish yellow (if head is brown) or pale yellow (if the head is brownish yellow).

Measurements of three alates, one with wings: LH (0.60-0.67); WH (0.96-0.99); DE (0.19-0.26); IE (0.70-0.72); MxdO (0.08-0.13); LPr

(0.35-0.38); WPr (0.61-0.67); LT (1.12-1.2); LFW (5.33); WFW (0.99); LHW (4.81); WHW (0.88).

Type material: Holotype: soldier, part of the lot MZUSP 10 000, kept separately and labelled: "MZUSP 10 000 *Glossotermes sulcatus* Cancellato & DeSouza; Brazil, Manaus, AM, [2°23'15" S- 59°51'07" W], 22.v.1986, Og F.F. de Souza coll."

Paratypes: workers and one soldier from the same colony of the holotype, with the same label (part of the lot MZUSP 10 000); MEUV: soldier and workers from the same colony of the holotype; MZUSP 11 275 *Glossotermes sulcatus*; Brazil, Manaus, AM (Reserva Ducke), 11/xii/90, F. Apolinário coll., alates, soldiers and workers; UFPB (Universidade Federal da Paraíba) nr.1935 *Glossotermes sulcatus*; with the same label as part of the lot MZUSP11 275, soldiers, workers; MZUSP 11 274 *Glossotermes sulcatus*; Brazil, Manaus, AM, (E. E.S.T., Estação Experimental de Silvicultura Tropical, km 44 of the road Manaus - Boa Vista, BR- 174), 5.iv.91, A.G. Bandeira coll., soldiers, workers, and one female ergatoid. INPA 882 *Glossotermes sulcatus*; with the same label as part of MZUSP lot 11 274, workers, soldiers, one male without wings and one female ergatoid.

Comparisons between the soldiers of *Glossotermes oculatus* and *Glossotermes sulcatus*

Soldiers of *Glossotermes sulcatus* are smaller than *G. oculatus* (although only the holotype of *G. oculatus* is known. *Glossotermes sulcatus* with posterior corners of head not so rounded as *G. oculatus* and different fontanelle position (anteriorly in *G. oculatus*); in profile, with a slightly depressed area in the anterior portion followed by a pimple-like protuberance in each side, while in *G. oculatus* this area is straight and there are no pimple-like protuberance. Labrum in a different shape, oval in the new species and pyriform in *G. oculatus*. Mandibles much more upward curved in profile in the new species than in the type of *G. oculatus*; the finely serrate inner edge behind the tip of the left mandible much more conspicuous in *G. oculatus*, with six more prominent teeth-like projections, at base; the tooth-like projection of the right mandible more prominent, and the minute tooth at the inner portion of the notch in another position and shape. Antennae with 15 articles in the new species and 13 in the description of *G. oculatus* (antennae broken in the holotype). Different shape of pronotum, elliptical in *G. oculatus* and almost rectangular with middle of the front margin raised and strongly emarginated in *G. sulcatus*, n. sp.

Comparisons with *Serritermes serrifer*

For the soldier caste we used both species of *Glossotermes*, but to

compare workers and imagoes only the *Glossotermes sulcatus*, n. sp. could be used, as these castes are unknown for *G. oculatus*.

Soldiers of *Glossotermes* and *Serritermes serrifer*

In both: soldier caste is monomorphic. There are some similarities: general aspect of body: small, delicate, slender legs, fontanelle small. Antennae with 12-13 articles in *Serritermes* and with 13-15 in *Glossotermes*. Head: thicker and shorter in *Serritermes*, more elongated (rectangular) in *Glossotermes*. Labrum: in both it is relatively large; wide and long in *Glossotermes*, and much longer than wide in *Serritermes serrifer*. Pronotum: in *Serritermes* it is peculiar, narrow and elongated with margins deeply emarginated while it is elliptical in *G. oculatus* and almost rectangular with the middle of the front margin raised in the new species.

Although the presence of distinct eye spot and ocelli may be interpreted as a symplesiomorphism, an interpretation of the most characters on soldier caste as plesiomorphic or apomorphic states are lacking by now.

Costa-Leonardo & Kitayama (1991) found that a dehiscence in the frontal gland of *Serritermes* allows its explosion, as a defense strategy. Our own data are not enough to assure it for *Glossotermes*, since all samples are preserved in alcohol. However, Dr. Reginaldo Constantino (Universidade de Brasília, Brasília, Brazil) has kindly allowed us to mention that, according to his own observations, *Glossotermes* also presents the same behavior in the field. In fact, several samples of *Glossotermes* deposited at MZUSP present soldiers bearing an exudate between the head and pronotum.

Workers

The mandibles of the worker of both *Glossotermes* and *Serritermes* present the most strong evidence of their relationship. In both, the mandibles have the apical tooth larger than marginal teeth and molar regions with very well developed ridges. In the left mandible of *Glossotermes* there are only two marginal teeth that we interpret as M1 fused with M2 (M1+2) and a very large M3, very close to the molar prominence (prm), filling the gap between M3 and prm, while in *Serritermes* the reduction is more evident, with only one marginal, interpreted by Emerson & Krishna (1975) as the third marginal, in the same position of the M3 in *Glossotermes*. In the right mandible of the worker of both genera there is also a reduction of marginal teeth to one, interpreted as M1, with posterior margin almost straight or very slightly concave (in *Serritermes*) and with a sharp toothlike projection above molar plate. Emerson & Krishna (1975) interpreted this as “possibly

extension of the upper side of molar plate on different level than marginal tooth..., perhaps adaptation for interlocking and fitting right mandible with left mandible". We agree with them for *Glossotermes*. The gut *in situ*, rolling up and torsion: very similar on worker of both genera. The description of the gut *in situ*, rolling up and torsion fits in general with the Noirot's description (1995) and Costa-Leonardo's description (1995) for *Serritermites serrifer*, except for the crop-gizzard more differentiated from esophagus (crop ovoid, in *Glossotermes*, as in other Rhinotermitidae) crop slightly dilated and asymmetric, as in Rhinotermitidae, and larger in *Glossotermes* than in *Serritermites*. In *Glossotermes* the gizzard is less developed than in the Rhinotermitidae, C/H=1:16, as in *Serritermites*. Stomodaeal valve of *Glossotermes* rather long as usual in termites, while this valve is very short in *Serritermites*. In *Glossotermes*, the first part of the hindgut (P1+P2) is very short, conical, without the limiting groove between P1 and P2, as in *Serritermites*. This groove is observed in all the other lower termites, except *Serritermites* (Noirot 1995). P2 (enteric valve) very different of the Rhinotermitidae; the six usual cushions are present with a triradial symmetry; cushions 2 barely visible, cushions 1 without a complex cuticular armature. In *Serritermites*, the structure is very similar and even more simple. The proportion of each part of the digestive tube is similar, with a slightly larger P1-P2 in *Glossotermes sulcatus*, n.sp.

Alates:

The shape of head are similar in both, shorter in *Serritermites serrifer*. Labrum similar in both. Fontanelle different, triangular in *Glossotermes* and with a peculiar shape in *Serritermites*, as showed by Emerson & Krishna (1975, Fig. 1). The ocelli closer to eyes in *Serritermites* than in *Glossotermes*. Eyes larger in *Serritermites* (in relation of the size of head). Pronotum similar in *Serritermites serrifer* and *Glossotermes sulcatus*, n.sp. The forewing scale overlaps the base of hind wing scale, in *Serritermites serrifer* contrary to Emerson & Krishna description (1975, p.3) and as it occurs in *Glossotermes sulcatus*, n.sp. Forewing scale twice the hindwing scale in *Glossotermes* while in *Serritermites* the anterior is almost one third the length of the posterior. The wing venation are also very similar, with a reduction relative to the most basal families, and both (*Serritermites* and *Glossotermes*) not very different from Rhinotermitidae. Among many alates of *Serritermites serrifer* examined from MZUSP collection none presented the situation figured by Emerson & Krishna (1975, Fig.3), that is, the first branch of M joining RS in about the middle. The mandibles of alates are very similar to those of workers, so the comparisons may be the same, and

again, these are the most conspicuous synapomorphies of this new group.

DISCUSSION

Examining the family (Rhinotermitidae) and subfamily (Psammotermitinae) where *Glossotermes* was tentatively included by Emerson (1950), we compared all the castes of *Psammotermes* and *Glossotermes*.

Even a preliminary examination of the general shape of femur and tibiae of *Psammotermes* and *Glossotermes* soldiers is enough to cast doubt on a close relationship of both. It's remarkable that Emerson & Krishna (1975) noted this difference, and affirmed: "the markedly swollen femora and tibia of *Psammotermes*, *Termitogenton* and *Stylotermes* are derivative and possibly an adaptation to fossorial burrowing. The tibiae of *Glossotermes* are more slender, less wide, and with far less convex margins than the robust tibiae of *Psammotermes*", and below: "*Psammotermes* is confined to arid steppe and desert soils, and the legs may be derivative adjustments to digging". *Glossotermes* occurs in Amazonian forest, in the soil and/or under logs. Despite our agreement to these statements, we think that these authors incurred in some misinterpretation. That is, such striking differences should be used to put both *taxa* apart from one another, not together.

Psammotermes presents an amazing variation in soldier size, ranging from minute, nanitic forms to very large, giant soldiers, while in *Glossotermes* and *Serritermes* the soldier caste is monomorphic.

Psammotermes has a soldier very different in general body aspect from *Glossotermes*. Probably, many of *Psammotermes* characters are adaptations to the arid habitats (as pointed out by Emerson & Krishna 1975), such as sclerotized body and the flat head, strong legs. Also the soldier antennae are very different, with a large first article and decreasing in size from the second to the last, which is very short. Following Emerson & Krishna (*op.cit.*) the soldier labrum is derivative in *Glossotermes*, which we agree, but they also affirmed that it is similar to *Psammotermes*, which we do not agree. The *Psammotermes* soldier has a large and very strongly sclerotized labrum, very different from that of *Glossotermes*, where it is large but very delicate (it seems to be "glandular", contrary to that in *Psammotermes*); both markedly differ in shape. The *Psammotermes* soldier's mandibles are very strong, robust, slightly curved with teeth much more similar to those of some Kalotermitidae than to *Glossotermes* and *Serritermes*. Mandibles of *Psammotermes* are not serrated and do not bear the internal groove typical of *Glossotermes* and *Serritermes*.

The morphology of the mandibles of workers and imagoes of *Glossotermes* constitute the definitive argument to take out this genus from Rhinotermitidae, as they are absolutely different from all other species of this family. While all the workers of Rhinotermitidae show a “complete” dentition of the mandibles, which can be interpreted as a plesiomorphic condition, *Glossotermes* present a very derivative condition, very similar to that of *Serritermes serrifer*, as compared above.

The characters of digestive tube are also very similar in *Glossotermes* and *Serritermes*, as seen before. These similarities could be another argument to place *Glossotermes* inside Serritermitidae, but we acknowledge that they are not very conclusive, as many homoplasies may occur in regressive evolution. According to Noirot (personal communication), the Rhinotermitidae, *Serritermes* and *Glossotermes* are similar regarding the gut only, forming probably a clade which could be the sister group of the Termitidae. Nevertheless, it is sure that, regarding the digestive tube, *Glossotermes* is closer to *Serritermes* than to Rhinotermitidae, its complex P1+P2 being especially significant. In other words, considering only this set of characters, *Glossotermes* could not be included into Rhinotermitidae.

The generic composition of the symbiotic protists of *Glossotermes* and *Serritermes* are identical: *Pseudotriconympha* sp., *Hexamastix* sp. and another species, possibly *Spirotriconympha* sp. This composition does not occur in any other Rhinotermitid species known so far (O. Kitade, personal communication). On the other hand, Costa-Leonardo & Kitayama (1991) mention that the “...*Serritermes serrifer* has the same protozoa found in the Rhinotermitidae: *Pseudotriconympha*, *Spirotriconympha* and *Holomastigotoides*”. Noirot (personal communication) thinks that on the whole, the Serritermitidae are not different than the Rhinotermitidae regarding the intestinal symbionts and that there is not a strict congruence between the systematics and the microfauna.

Also, an analysis of partial mitochondrial genes sequences (COI, COII and 16 Sr RNA) from some Rhinotermitidae, some Termitidae, Serritermitidae and *Glossotermes*, has showed that the clade (*Glossotermes* + *Serritermes*) was well supported both by neighbor-joining method and maximum parsimony method, by relatively high bootstrap values, although the resolution of branching order of (Rhinotermitidae + Serritermitidae + Termitidae) was still insufficient by the preliminary analysis (O. Kitade, personal communication).

Concluding, we are convinced that *Glossotermes* is not a Rhinotermitidae genus and *Psammotermes* is not its sister group based on the above characters analysis.

We agree with Emerson & Krishna (1975) when they considered the unique marginal tooth in the left mandible of *Serritermes* worker homologous with the third marginal based on its position and its backward pointed direction. They also considered the slight hump on cutting edge immediately anterior to marginal tooth (more visible in ventral view), possibly a greatly reduced second marginal. In Fig. 7 we may see that the third marginal (M3) of *Glossotermes* is exactly in the same position as the M3 of *Serritermes*, without any gap between the M3 and molar prominence (prm) We interpret the only marginal before M3 as the first marginal (M1) fused with second (M2), forming M1+2. A vestigial second is visible from ventral view (Fig.10). Still following Emerson & Krishna (*op. cit.*), the single marginal tooth of the right mandible of *Serritermes* is probably homologous with first marginal, because the faint hump anterior to the tooth is possibly a reduction of the subsidiary tooth of rhinotermitids. In *Glossotermes* the dentition is very similar, and we think the unique marginal may be homologous to the first marginal. The absence of a hump anterior to the tooth could be interpreted as an intermediate step, a fusion of the first and second, this one (M2) being reduced to the posterior straight margin of the unique marginal. It is worth noting also that the phrase: "Sharp toothlike projection above molar plate possibly extension of upper side of molar plate on different level than marginal tooth...", perhaps adaptation for interlocking and fitting right mandible with left mandible", from Emerson & Krishna (*op.cit.*), may well be applied to *Glossotermes*.

Concluding, the reduction of the marginal teeth with concomitant enlargement of the apical teeth of both mandibles represent apomorphic states, shared by *Serritermes* and *Glossotermes*, that is, synapomorphies of Serritermitidae in this new *sensu*. In *Serritermes* there is a more dramatic reduction as the left mandible has only one marginal tooth, and the molar regions have less ridges than in *Glossotermes*. In this way, we may interpret the left mandible of *Glossotermes* as an intermediate step, where there was a fusion of M1 + M2 and an enlargement of the third marginal, concomitant with an enlargement of the apical teeth.

Although we may recognize many morphological similarities between *Serritermes* and *Glossotermes*, it is not possible to state whether they actually are synapomorphies, without a thorough cladistic analysis with many *taxa*. Grassé (1986) affirmed and Eggleton (2001) reinforced that Rhinotermitidae is very heterogeneous, so, we think that a careful analysis of this family may show that it is not monophyletic.

While we think as plausible the monophyly of the group (Serritermitidae + Rhinotermitidae + Termitidae), as stated by many authors, the relationship within this group could only be established after a thorough reappraisal of all the characters, as mentioned above, followed by a careful cladistic analysis of all the castes involving many *taxa*.

Therefore, considering the amount of similarities between *Glossotermes* and *Serritermes*, coupled with the equally large amount of dissimilarities between *Glossotermes* and *Psammotermes*, we believe that transferring *Glossotermes* from Rhinotermitidae to Serritermitidae is the most parsimonious decision for now.

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