

New species of *Psyllipsocus* from Brazilian caves (Psocodea: 'Psocoptera': Psyllipsocidae)

Charles LIENHARD¹ & Rodrigo L. FERREIRA²

¹ Muséum d'histoire naturelle, c. p. 6434, CH-1211 Genève 6, Switzerland.
Corresponding author. E-mail: charleslienhard@bluewin.ch

² Universidade Federal de Lavras, Departamento de Biologia (Zoologia),
CP. 3037, CEP. 37200-000 Lavras (MG), Brazil. E-mail: drops@dbi.ufla.br

New species of *Psyllipsocus* from Brazilian caves (Psocodea: 'Psocoptera': Psyllipsocidae). - Twelve new species are described from 42 caves situated in 10 Brazilian states: *Psyllipsocus angustipennis* Lienhard n. spec., *P. chunioventralis* Lienhard n. spec., *P. didymus* Lienhard n. spec., *P. falci-fer* Lienhard n. spec., *P. fuscistigma* Lienhard n. spec., *P. marconii* Lienhard n. spec., *P. proximus* Lienhard n. spec., *P. punctulatus* Lienhard n. spec., *P. radiopictus* Lienhard n. spec., *P. spinifer* Lienhard n. spec., *P. subtilis* Lienhard n. spec., *P. thaidis* Lienhard n. spec. A brief distributional analysis shows a high degree of regional endemism. Eight species are only known from a single cave each. Only one species, *P. spinifer*, can be considered as widely distributed in Brazilian caves; it is known from 20 caves situated in eight states. Some phylogenetic aspects are also briefly discussed.

Keywords: Brazil - cave fauna - endemism - male genitalia.

INTRODUCTION

This is the third contribution on the genus *Psyllipsocus* Selys-Longchamps resulting from a study of Brazilian cave psocids belonging to the families Psyllipsocidae and Prionoglarididae of the suborder Trogiomorpha (infraorders Psyllipsocetae and Prionoglaridetae). A new genus and four new species of prionoglaridids were described by Lienhard *et al.* (2010) and Lienhard & Ferreira (2013a). The first contribution on *Psyllipsocus* (Lienhard *et al.*, 2012) reported *P. yucatan* Gurney from several Brazilian caves and treated the still enigmatic phenomenon of microcrystal deposits on the wing membranes of some living individuals of this species. The second contribution on *Psyllipsocus* (Lienhard & Ferreira, 2013b) presented the description of three closely related new species characterized by several striking synapomorphies of male and female genitalia, in particular the presence of a novel accessory genital organ in the male.

At present, we are aware of twelve additional undescribed *Psyllipsocus* species inhabiting Brazilian caves; they are described herein. An identification key to all South American species of Psyllipsocidae and Prionoglarididae and an analysis of their distribution will be presented in a future review paper. For general remarks on the genus *Psyllipsocus* and on its distribution in South America, see Lienhard & Ferreira (2013b).

MATERIAL AND METHODS

The material examined was collected by RLF (unless other collector mentioned) by hand-collecting in 42 caves situated in 10 Brazilian states. In general only adults were studied. Nymphs are only mentioned if they were collected together with adults and therefore could be assigned to the same species as the latter. Dissection and slide-mounting followed the methods described by Lienhard (1998). The material examined is deposited in the following institutions: Universidade Federal de Lavras, Departamento de Biologia (Coleção de Invertebrados Subterrâneos), Lavras, Brazil (ISLA); Muséum d'histoire naturelle, Geneva, Switzerland (MHNG).

The pilosity of wing veins is usually heavily damaged in the material studied. For the drawings it was reconstructed on the basis of the insertion points of the hairs, which are always visible in slide-mounted wings, and of the few hairs on each wing which were not lost. The length of these hairs was considered as representative for the pilosity of the entire wing, based on the observation that in *Psyllipsocus* the length of wing ciliation is uniform over the whole wing.

In the descriptions the terms microspades organ (pedicel), coxal organ (hindleg), setal organ (paraproct), phallic cradle and endophallic tube (male genitalia) are used sensu Mockford (1993, 2011).

Abbreviations used in the descriptions: AP = areola postica (a marginal cell in forewing formed by veins CuA1 and CuA2); bcc = length of basal closed cell in forewing; BL = body length (in alcohol); dcc = length of distal closed cell in forewing; F = hindfemur (length); FW = forewing (length); FWw = forewing (greatest width); HW = hindwing (length); IO/D = shortest distance between compound eyes divided by longitudinal diameter of compound eye in dorsal view of head; P2 = second article of maxillary palp; P4 = fourth (terminal) article of maxillary palp; T = hindtibia (length); t1, t2, t3 = tarsomeres of hindtarsus (length, measured from condyle to condyle); v1, v2, v3 = first (ventral), second (dorsal) and third (external) ovipositor valvula respectively. Abbreviations of wing veins are used according to Yoshizawa (2005).

Abbreviations for Brazilian states: AL = Alagoas, AM = Amazonas, BA = Bahia, CE = Ceará, GO = Goiás, MG = Minas Gerais, MT = Mato Grosso, PI = Piauí, RN = Rio Grande do Norte, SP = São Paulo.

TAXONOMY

Psyllipsocus spinifer Lienhard n. spec.

Figs 1-2

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (CE), Ubajara, Gruta de Ubajara cave, 30.xii.2006, leg. R. L. Ferreira.

PARATYPES: ISLA and MHNG, slide-mounted or in alcohol; BRAZIL, leg. R. L. Ferreira (unless other collector mentioned), from the following municipalities. – 1 ♀, Campo Formoso (BA), Toca do Morrinho cave, i.1997. – 2 ♂, 3 ♀, 1 nymph, Campo Formoso (BA), Toca do Angico cave, 9.i.2008. – 1 ♂, 3 ♀, Curaçá (Patamutê) (BA), Toca d'agua de Patamutê cave, 6.i.2008. – 1 ♂, São Desidério (BA), Gruta do Sumidouro do João Baio cave, 29.vii.2006. – 3 ♂, 4 ♀, Araripe (CE), Gruta do Brejinho cave, 1.v.2007. – 1 ♂, 1 ♀, Tejuçuoca (CE), Gruta do Veado Campeiro cave, 16.ix.2008. – 4 ♂, 5 ♀ (one of them allotype), Ubajara (CE), Gruta de Ubajara cave, 30.xii.2006 (type locality). – 1 ♂, 1 ♀, Ubajara (CE), Gruta do Morcego Branco cave, 3.i.2007. – 1 ♂, 2 ♀, Ubajara (CE), Gruta do Araticum cave, 1.i.2007. – 1 ♂, 2 ♀, Damianópolis (GO), Lapa do Ribeirão dos Porcos cave, 5.x.2001. – 1 ♀, Januária (MG), Gruta Caboclo cave, 27.vii.2003. – 1 ♀, Januária/Itacarambi (MG), Gruta Janelão cave, 28.vii.2003. – 1 ♂, 2 ♀, Pains

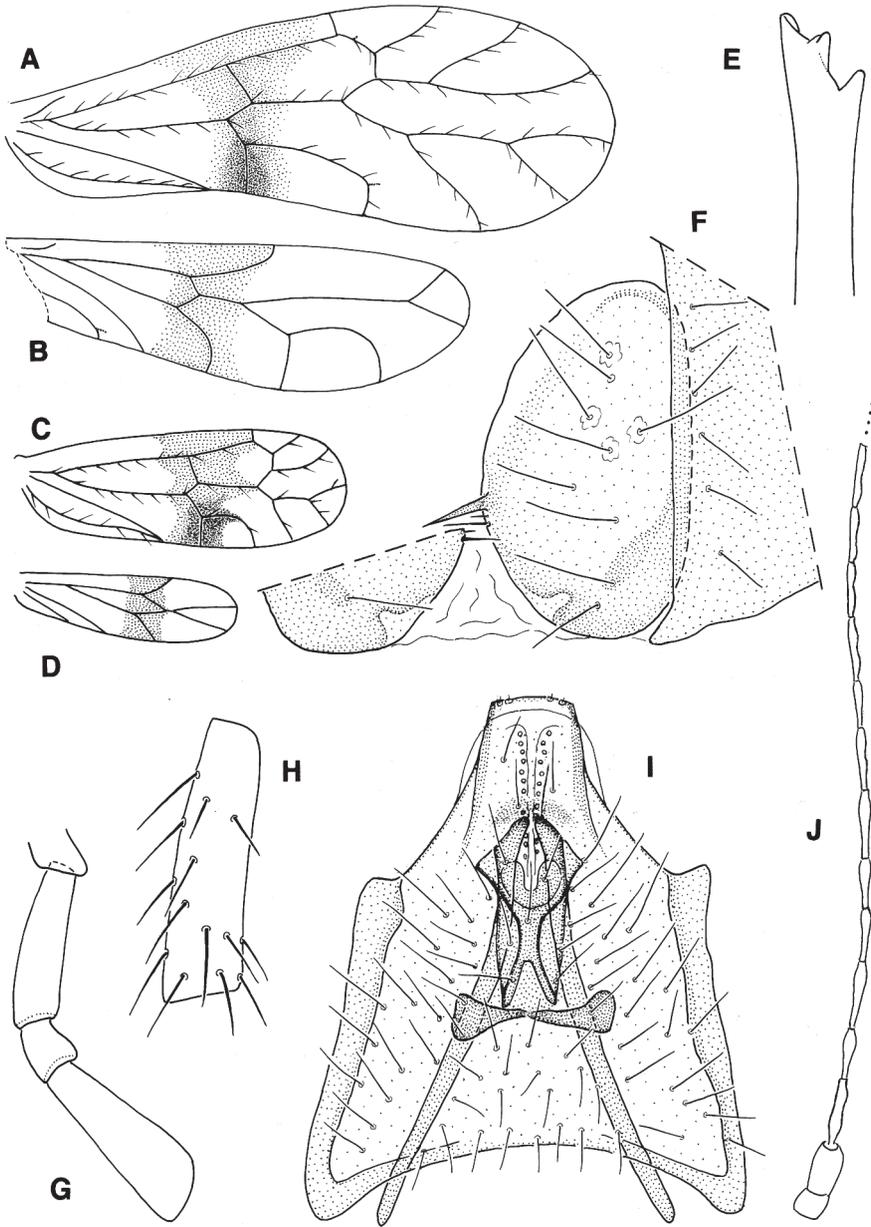


FIG. 1

Psyllipsocus spinifer Lienhard n. spec., male holotype (C-J) and female allotype (A-B). (A) Macropterous female, forewing. (B) Ditto, hindwing. (C) Brachypterous male, forewing. (D) Ditto, hindwing. (E) Lacinial tip. (F) Right paraproct, right postero-ventral part of clunium, ventral part of left paraproct. (G) Maxillary palp. (H) P2-chaetotaxy. (I) Hypandrium and phallosome, ventral view. (J) Antenna (scape, pedicel and basalmost 12 flagellomeres; pilosity not shown).

(MG), Gruta Paiol de Milho cave, 13.x.2003. – 2♂, Chapada dos Guimarães (MT), Gruta Kiogo Brado cave, 27.x.2006. – 1♀, 1♀, Coronel José Dias (PI), Toca das Moendas cave, 10.ix.2008. – 1♂, 2♀, Coronel José Dias (PI), Toca do Inferno cave, 12.ix.2008. – 2♂, 4♀, Governador Dix-Sept Rosado (RN), Gruta do Lagedo Grande cave, 21.vii.2010, leg. D. M. Bento. – 1♂, 1♀ Altinópolis (SP), Gruta do Paraná cave, 1.iii.2006. – 1♂, Altinópolis (SP), Gruta Olho de Cabra cave, 2.iii.2006. – 1♂, 1♀, Altinópolis (SP), Gruta Edgar 1 cave, 28.ii.2006.

DESCRIPTION: General colouration yellowish to light brown. Wings with a large brown transversal band (Fig. 1A-D), in brachypterous individuals usually more contrasting with the remaining hyaline membrane than in macropterous ones. Head dark brown around antennal base and in genal region; compound eyes dark brown; ventral half of postclypeus medium brown, darker than dorsal half; labrum dark brown; antenna and maxillary palpus brown. Scutum of mesothorax dark brown, mesoscutellum and metathorax yellowish; legs brown. Abdomen yellowish, with broad dark brown transversal band of hypodermal pigment in middle; terminalia medium to dark brown.

Both sexes usually brachypterous (Fig. 1CD) (venation often somewhat reduced, forewing at most reaching tip of abdomen), rarely macropterous (Fig. 1AB). Forewing of macropterous individuals (Fig. 1A): Rs and M fused for a length; distal closed cell longer than marginal length of pterostigma but slightly shorter than basal closed cell ($bcc/dcc \approx 1.3$); first portion of pterostigmal R1 longer than R1-Rs cross-vein, not parallel to wing margin but backwards directed; CuA1 almost straight basally, abruptly curved distally and meeting wing margin in an almost right angle. Hindwing of macropterous individuals (Fig. 1B): R1 originating basally of Rs-M fusion, thus closed cell quadrilateral. Female figured in Fig. 1AB with a minute spur-vein basally on R1 and distally on CuA1 of forewing and on vein A of hindwing. Three ocelli present. Pilosity of frons and vertex almost uniform. Antennal flagellomeres not strictly cylindrical but with uneven surface (due to insertion points of long and relatively thick setae) or slightly club-shaped (Fig. 1J), in basal half of antenna maximal length of flagellar hairs about 3x greatest width of their flagellomeres (NOTE: for comparison, cylindrical flagellomeres with almost even surface due to finer and shorter pilosity are figured by Lienhard & Ferreira, 2013b: fig. 4H; maximal length of their hairs about 2x width of flagellomeres). Pedicel lacking microspades organ. P2 chaetotaxy as in Fig. 1H, internal seta in basal half normal (i. e. not thicker than other setae of similar length), not differentiated as a stout sensillum; P4 slender hatchet-shaped (Fig. 1G). Lacinal tip as in Fig. 1E. Pretarsal claws simple, symmetrical, with a small preapical denticle; hind legs with well-developed coxal organ. Clunium, epiproct and paraproct simple in both sexes (Figs 1F, 2A); the latter bearing a relatively short anal spine and a setal organ consisting of a short fine seta and a longer, somewhat thicker seta; paraproctal sensorium with 4-5 fine trichobothria on basal florets and one normal seta.

Hypandrium and phallosome as in Fig. 1I. Hypandrium dorsad curved in lateral view, with bifid apical lobe (angulate ventral part of this lobe slightly longer than rounded dorsal part, see Fig. 1I); dorsal (inner) side of hypandrium with a conspicuous transversal sclerite (continuous or medially interrupted, see Fig. 1I) just basally of the complex phallosomal sclerotizations. Basal struts long and slender; endophallic tube on each side with a longitudinal pore-bearing zone; phallic cradle not clearly recognizable.

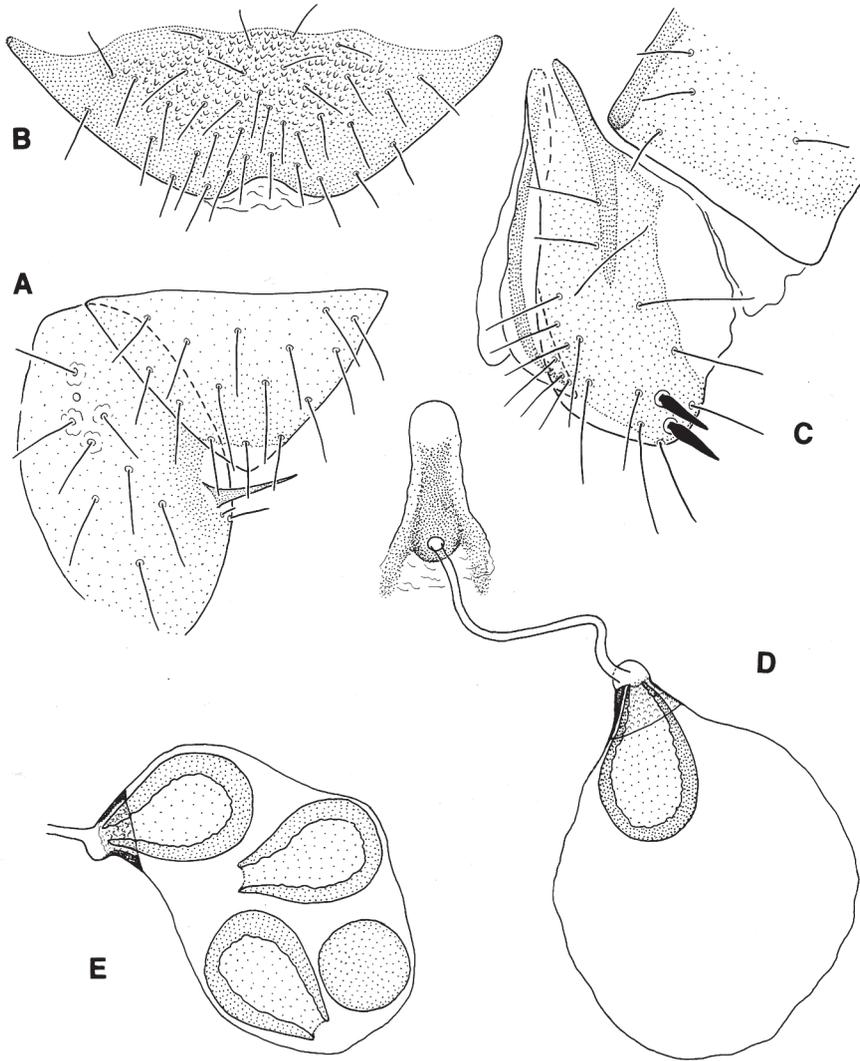


FIG. 2

Psyllipsocus spinifer Lienhard n. spec., female allotype (A-D), female paratype from type locality (E). (A) Epiproct and left paraproct. (B) Subgenital plate. (C) Left ovipositor valvulae and left hind corner of clunium. (D) Spermatheca and spermatheca containing one spermatophore. (E) Spermatheca containing four spermatophores (three of them in lateral optical section, one in terminal view).

Female genitalia as in Fig. 2B-E. Sclerotized zone of subgenital plate distally slightly bilobate (Fig. 2B). Ovipositor valvulae (Fig. 2C): v1 membranous, v2 with sclerotized median axis, v3 with two conspicuous stout apical spines. Spermatheca, spermatophores and spermatheca as in Fig. 2DE. Transition zone between spermathecal duct and sac slightly swollen, adjacent part of spermathecal wall sclero-

tized and thickened; spermatophore bulbous, strongly sclerotized, dark brown (usually already visible in undissected abdomen).

MEASUREMENTS: *Male holotype* (brachypterous): BL = 1.1 mm; FW = 750 μm ; FWw = 268 μm ; FW/FWw = 2.8; HW = 520 μm ; F = 248 μm ; T = 453 μm ; t1 = 200 μm ; t2 = 43 μm ; t3 = 54 μm ; IO/D = 1.7. – *Female allotype* (macropterous): BL = 1.2 mm; FW = 1380 μm ; FWw = 510 μm ; FW/FWw = 2.7; HW = 1060 μm ; F = 293 μm ; T = 515 μm ; t1 = 215 μm ; t2 = 45 μm ; t3 = 55 μm ; IO/D = 1.7.

ETYMOLOGY: The specific epithet refers to the presence of two stout spines on v3 (Latin: *spina* – spine; suffix *-fer*, *-fera*, *-ferum* from *ferre* – to bear, carry).

DISTRIBUTION AND HABITAT: *P. spinifer* is known from 20 caves situated in eight Brazilian states. It is one of the most common species of this genus in Brazilian caves. This wide geographic distribution in very different cave types may indicate that this species is opportunistic or euryecic.

DISCUSSION: *P. spinifer* differs from all other species of the genus by its wing pattern, by the presence of two stout spines on v3 of the female and by the characteristic male genitalia (in particular by the presence of a transversal internal hypandrial sclerite). 1-2 heavy setae on v3 are also known in the closely related genera *Dorypteryx* Aaron, *Pseudorypteryx* Garcia Aldrete and *Psocathropos* Ribaga (see Mockford, 1993 and Lienhard, 1998). Several spermatophores (4 observed in the paratype figured in Fig. 2E) may be present in the same female, indicating that the species is polyandrous.

***Psyllipsocus falcifer* Lienhard n. spec.**

Figs 3-4

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (MG), Pains, Gruta Ronco cave, 28.xi.1999, leg. R. L. Ferreira.

PARATYPES: ISLA and MHNG, slide-mounted or in alcohol; BRAZIL, leg. R. L. Ferreira, from the following municipalities. – 1 ♂, Cordisburgo (MG), Gruta Tão Lucas cave, 14.xi.2010. – 1 ♀, Cordisburgo (MG), Lapinha do Atamis cave, 13.xi.2010. – 2 ♀ (one of them allotype), 1 nymph, Pains (MG), Gruta Ronco cave, 28.xi.1999 (type locality). – 1 ♀, Pains (MG), Gruta Paiol de Milho cave, 13.x.2003. – 1 ♀, Pains (MG), Gruta dos Estromatólitos cave, 7.xi.2000. – 1 ♀, Sete Lagoas (MG), Gruta Rei do Mato cave, 3.+4.xi.2011. – 1 ♂, 1 ♀, Vazante (MG), Gruta da Escarpa cave, xi.2008. – 1 ♂, 1 ♀, Vazante (MG), Lapa das Urtigas cave, 16.ix.2010.

DESCRIPTION: General colouration yellowish, with some brown hypodermal pigmentation. Wings unmarked (Fig. 3A-C). Head with some small brown patches on frons between dark brown compound eyes and a patch at the antennal base. Legs whitish, tibiae with two light brown transversal bands (often weakly developed). Terminalia light brown.

Both sexes macropterous (Fig. 3AB). Forewing: Rs and M not fused for a length but joined by a crossvein (thus distal closed cell pentagonal); basal closed cell very much longer than distal closed cell (bcc/dcc \approx 3), the latter also much shorter than marginal length of pterostigma; pterostigma long and triangular, first portion of pterostigmal R1 longer than R1-Rs crossvein and almost parallel to wing margin; CuA1 weakly curved (AP long and flat). Hindwing (Fig. 3BC): R1 originating basally of Rs-M fusion, thus closed cell quadrilateral. Some variation of venation observed: vein A of hindwing simple or forked (Fig. 3BC); right forewing of the female from

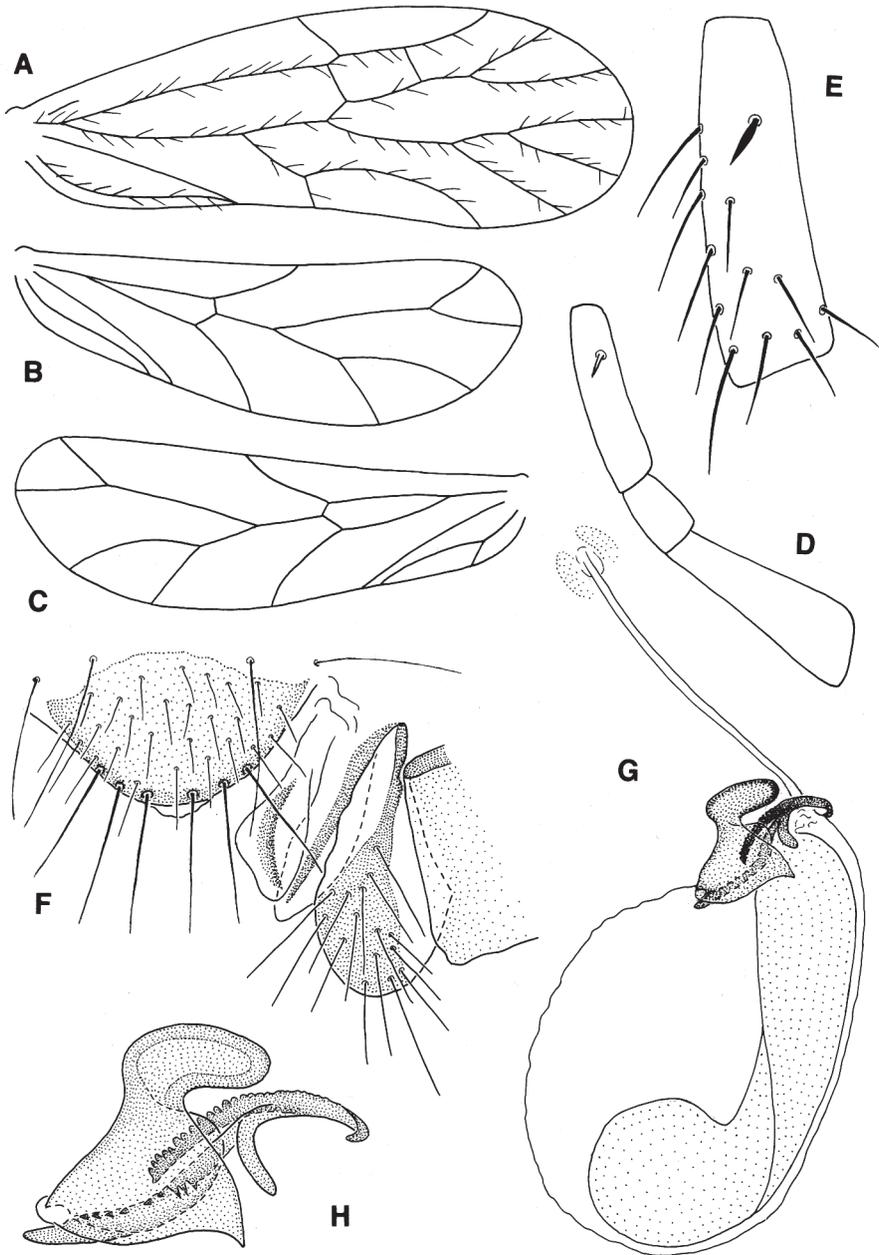


FIG. 3

Psyllipsocus falcifer Lienhard n. spec., female paratype from Gruta Paiol de Milho. (A) Forewing. (B) Right hindwing. (C) Left hindwing. (D) P2-P4 of maxillary palp. (E) P2-chaetotaxy. (F) Subgenital plate, left ovipositor valvulae and left hind corner of clunium. (G) Spermapore plate and spermatheca containing one spermatophore. (H) Spermathecal sclerotizations.

Gruta dos Estromatólitos cave (Pains, MG) lacking crossvein between pterostigma and Rs, thus lacking distal closed cell (left forewing with normal venation). Three ocelli present. Pilosity of frons and vertex almost uniform. Antennal flagellomeres with uneven surface (due to insertion points of long and relatively thick setae), in basal half of antenna maximal length of flagellar hairs about 5x greatest width of their flagellomeres. Pedicellar microspades organ weakly developed (at most with two units). P2 chaetotaxy as in Fig. 3E, stout sensillum well-differentiated; P4 slender hatchet-shaped (Fig. 3D). Lacinial tip as in Fig. 4C. Pretarsal claws simple, symmetrical, with a small preapical denticle; hind legs with well-developed coxal organ. Clunium and epiproct simple in both sexes (Fig. 4BD).

Male paraproct on its hind margin with two conspicuous non-articulated sickle-shaped spines in addition to the normal anal spine (Fig. 4D), setal organ consisting of a short fine seta and a longer, somewhat thicker seta, sensorium with some fine trichobothria on weakly differentiated basal florets. Hypandrium and phallosome as in Fig. 4E; basal struts very short, not reaching anterior margin of hypandrium; phallic cradle broadly rounded, laterally reaching sclerotizations of posterior margin of hypandrium; endophallus with a pair of slender pore-bearing lobes.

Female paraproct lacking sickle-shaped spines, other paraproctal structures as in male (Fig. 4B). Subgenital plate and ovipositor valvulae as in Fig. 3F, v1 and v2 each with a sclerotized median axis, subgenital plate simple, with a row of six very long and relatively thick setae on posterior margin. Spermatheca and spermapore plate as in Fig. 3G (the figured spermatheca contains one characteristically shaped spermatophore; see also discussion, below); sclerotizations of spermathecal wall near duct very complicated (Figs 3GH, 4A), characterized by a conspicuous digitiform prominence (the latter usually already visible in undissected abdomen). Spermapore plate simple, lacking conspicuous sclerotizations (Fig. 3G).

MEASUREMENTS: *Male holotype*: BL = 1.5 mm; FW = 1750 μ m; FWw = 650 μ m; FW/FWw = 2.7; HW = 1410 μ m; F = 342 μ m; T = 677 μ m; t1 = 265 μ m; t2 = 47 μ m; t3 = 60 μ m; IO/D = 1.3. – *Female allotype*: BL = 1.6 mm; FW = 1750 μ m; FWw = 663 μ m; FW/FWw = 2.64; HW = 1440 μ m; F = 360 μ m; T = 690 μ m; t1 = 270 μ m; t2 = 52 μ m; t3 = 60 μ m; IO/D = 1.4.

ETYMOLOGY: The specific epithet refers to the presence of two sickle-shaped spines on the paraproct of the male (Latin: *falx* – sickle; suffix *-fer*, *-fera*, *-ferum* from *ferre* – to bear, carry).

DISTRIBUTION AND HABITAT: *P. falcifer* is known from 8 caves situated in 4 municipalities in Minas Gerais state. All these caves are located in the Brazilian Savanna (“Cerrado” vegetation). Ecological conditions are not the same in these caves but all of them are dry and rather small (less than 100 meters long). Specimens were always observed on or near guano piles, most of them produced by haematophagous bats (*Desmodus rotundus*).

DISCUSSION: *P. falcifer* differs from all other species of the genus by the presence of two sickle-shaped spines on the male paraproct and of a sclerotized digitiform prominence on the spermatheca near the origin of the spermathecal duct. The absence of wing markings clearly distinguishes it from the other two Brazilian *Psyllipsocus* species having an Rs-M crossvein in the forewing (i. e. *P. marconii* and *P. thaidis*, see

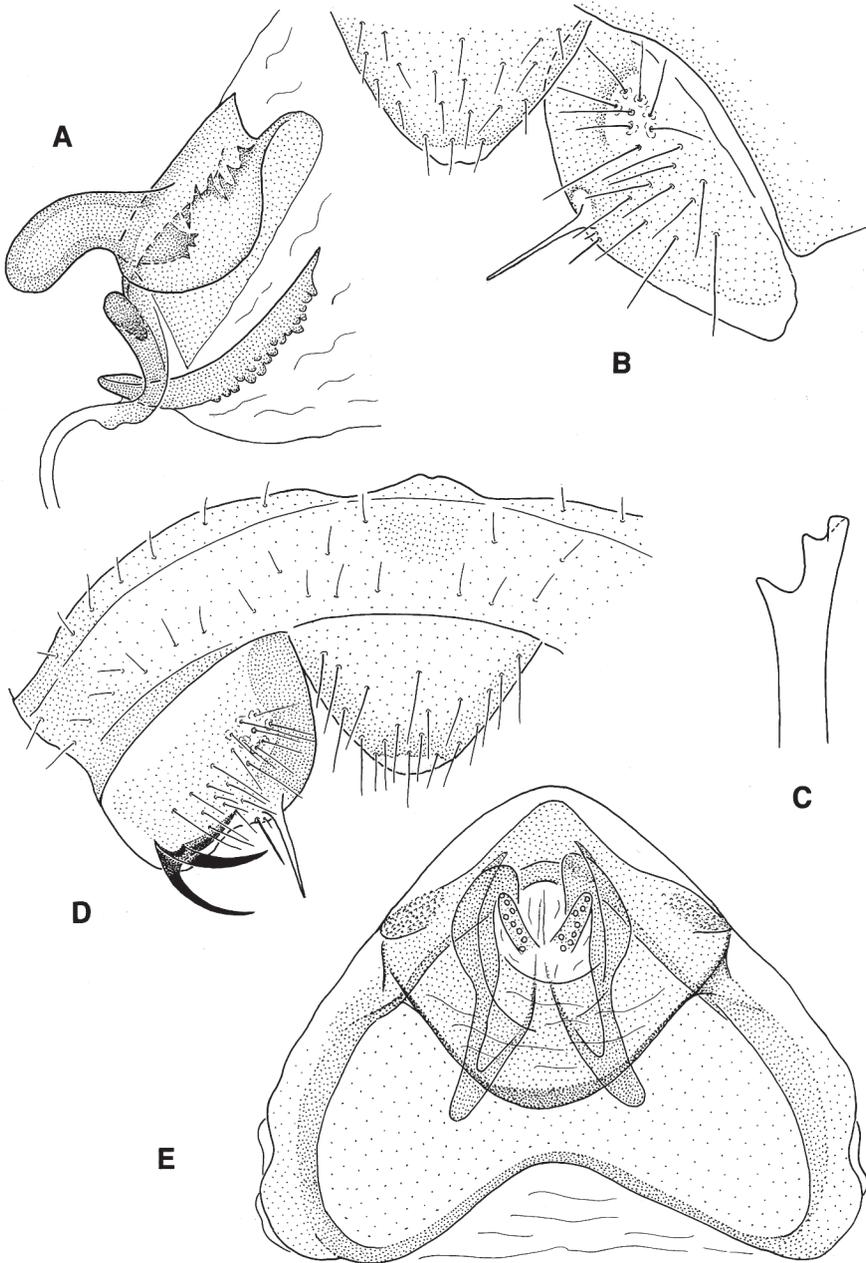


FIG. 4

Psyllipsocus falcifer Lienhard n. spec., female allotype (A-C) and male holotype (D-E). (A) Spermathecal sclerotizations. (B) Epiproct, right paraproct and right hind corner of clunium. (C) Lacinial tip. (D) Left and central part of clunium, epiproct, left paraproct. (E) Hypandrium and phallosome, ventral view (pilosity not shown).

below). In *P. falcifer* up to 3 spermatophores could be observed in the spermatheca of a single female; this indicates that the species is polyandrous. See also discussion on *P. thaidis*, below.

***Psyllipsocus marconii* Lienhard n. spec.**

Figs 5-6

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (MG), Montalvânia, Gruta Nossa Senhora do Perpétuo Socorro cave, 14.vii.2007, leg. R. L. Ferreira.

PARATYPES: ISLA and MHNG, slide-mounted and some parts in alcohol; 2 ♀ (one of them allotype), same data as for holotype.

DESCRIPTION: General colouration light brown. Forewing with characteristic colour pattern (Fig. 5A). Head with whitish frons and light brown vertex; compound eyes dark brown. Legs light brown, lacking any patches or transversal bands. Abdomen whitish, terminalia light brown.

Both sexes macropterous (Fig. 5A-C). Forewing: Rs and M not fused for a length but joined by a crossvein (thus distal closed cell pentagonal); basal closed cell very much longer than distal closed cell ($bcc/dcc \approx 4$), the latter also shorter than marginal length of pterostigma; first portion of pterostigmal R1 longer than R1-Rs crossvein and almost parallel to wing margin; CuA1 strongly curved, meeting wing margin in a right angle. Hindwing (Fig. 5BC): R1 originating basally of Rs-M fusion, thus closed cell quadrilateral. Some aberrations of hindwing venation observed in one female (Fig. 5B). Three ocelli present. Pilosity of frons and vertex almost uniform. Antennal flagellomeres with uneven surface (due to insertion points of long and relatively thick setae), in basal half of antenna maximal length of flagellar hairs about 5x greatest width of their flagellomeres. Pedicellar microspades organ weakly developed (at most with 2 units). P2 chaetotaxy as in Fig. 5D, with a stout sensillum in basal half; P4 slender hatchet-shaped. Lacinial tip as in Fig. 5E. Pretarsal claws simple, symmetrical, with a small preapical denticle; hind legs with well-developed coxal organ. Epiproct (Fig. 6A) and paraproct simple in both sexes, the latter with a long anal spine and a setal organ consisting of a short fine seta and a longer, somewhat thicker seta (Fig. 5H); paraproctal sensorium with six fine trichobothria on basal florets and one normal seta.

Male with a pair of conspicuous non-articulated spines near posterior margin of clunium (Fig. 6A). Hypandrium and phallosome as in Fig. 6B; basal struts short, not reaching anterior margin of hypandrium; phallic cradle well-developed, broadly rounded; endophallus with characteristic sclerotizations and a pair of broad pore-bearing internal lobes.

In female posterior margin of clunium without spines. Subgenital plate simple, with rounded margin. Ovipositor valvulae as in Fig. 5G, v1 and v2 each with a sclerotized median axis. Spermatheca and spermapore plate as in Fig. 5F (the spermatheca figured contains two characteristically shaped spermatophores); sclerotizations of spermathecal wall near duct complicated, characterized by a short rounded prominence close to the origin of the duct, an external vesicle and a heavily sclerotized ridge directed to the lumen of the spermathecal sac (the imprint of this ridge is visible on the corresponding side of the spermatophores, Fig. 5F); spermapore plate simple, lacking conspicuous sclerotizations.

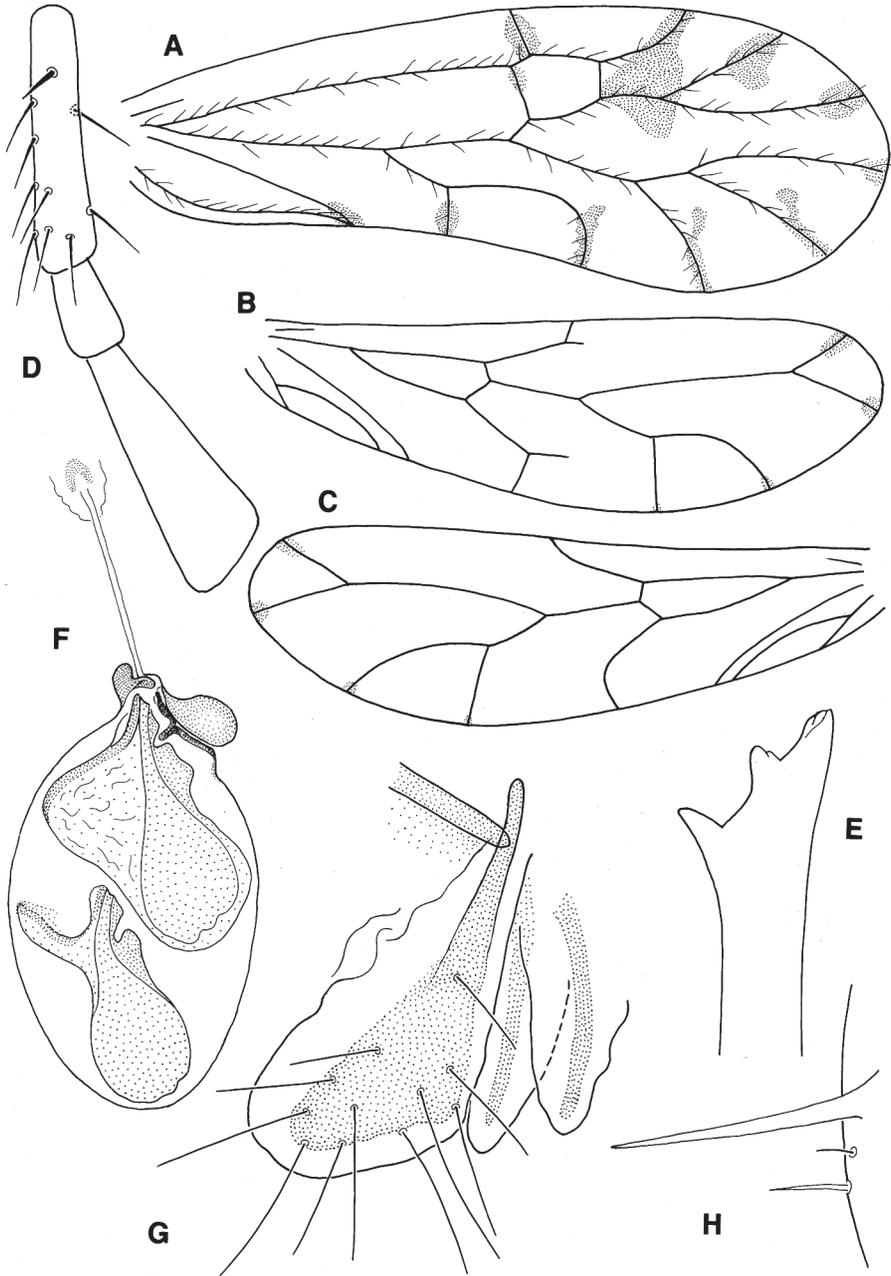


FIG. 5

Psyllipsocus marconii Lienhard n. spec., female allotype (A-F) and female paratype (G-H). (A) Forewing. (B) Right hindwing. (C) Left hindwing. (D) P2-P4 of maxillary palp, pilosity not shown except for P2. (E) Lacinial tip. (F) Spermapore plate and spermatheca containing two spermatophores. (G) Right ovipositor valvulae. (H) Hind margin of right paraproct.

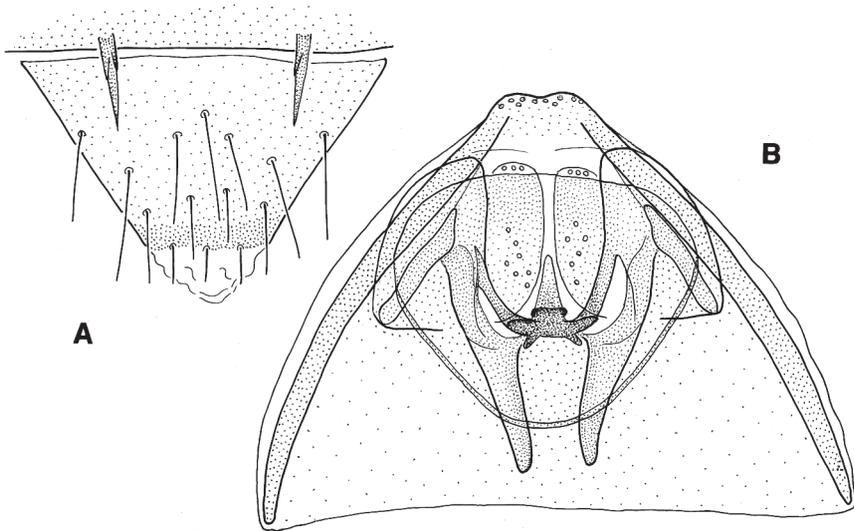


FIG. 6

Psyllipsocus marconii Lienhard n. spec., male holotype. (A) Epiproct and clunial spines. (B) Hypandrium and phallosome, ventral view (pilosity not shown).

MEASUREMENTS: *Male holotype*: BL = 1.6 mm; FW = 1790 μ m; FWw = 677 μ m; FW/FWw = 2.64; HW = 1466 μ m; F = 296 μ m; T = 663 μ m; t1 = 243 μ m; t2 = 47 μ m; t3 = 56 μ m; IO/D = 1.5. – *Female allotype*: BL = 1.9 mm; FW = 2030 μ m; FWw = 720 μ m; FW/FWw = 2.8; HW = 1664 μ m; F = 353 μ m; T = 705 μ m; t1 = 259 μ m; t2 = 52 μ m; t3 = 58 μ m; IO/D = 1.7.

ETYMOLOGY: The species is named after Marconi Souza Silva in recognition of his invaluable support to RLF, in the field and in the laboratory.

DISTRIBUTION AND HABITAT: *P. marconii* is only known from the type locality, the Gruta Nossa Senhora do Perpétuo Socorro cave situated in Montalvânia municipality, Minas Gerais state. This cave has been severely altered by humans for religious use. The entrance was modified (stairs were built and the natural topography was modified to prevent water flooding the cave) and a “skylight” was closed by the installation of a roof. The first metres of the main conduit were transformed into a church, and regular religious services occur in the cave. These alterations severely reduce the ingress of organic matter into the cave. The only visible resources in its deep parts are piles of bat guano, in which the specimens of *P. marconii* were collected. The species was only found in this cave, even though some other caves in the same area were investigated.

DISCUSSION: This species differs from all other species of the genus *Psyllipsocus* by its forewing pattern and by the presence of a pair of stout spines on the hind margin of the male clunium. The spermatheca of the allotype contains two spermatophores (Fig. 5F); this indicates that the species is polyandrous. See also discussion on *P. thaidis*, below.

***Psyllipsocus thaidis* Lienhard n. spec.**

Fig. 7

HOLOTYPE: ISLA; ♀ (slide-mounted); BRAZIL (PI), Coronel José Dias, Coroa de Frade cave, ix.2008, leg. R. L. Ferreira.

DESCRIPTION OF FEMALE: General colouration light brown. Forewing with a characteristic colour pattern (Fig. 7A), hindwing hyaline (Fig. 7B). Head with some brown patches (Fig. 7H); compound eyes dark brown. Legs light brown, lacking any patches or transversal bands. Abdomen whitish with narrow red-brown transversal bands (more distinct laterally than dorsally), terminalia light brown.

Macropterous (Fig. 7AB). Forewing: Rs and M not fused for a length but joined by a crossvein (thus distal closed cell pentagonal); basal closed cell very much longer than distal closed cell ($bcc/dcc \approx 5.5$), the latter also shorter than marginal length of pterostigma; first portion of pterostigmal R1 almost parallel to wing margin, slightly shorter than R1-Rs crossvein; CuA1 strongly curved, AP relatively short and high. Hindwing (Fig. 7B): R1 originating basally of Rs-M fusion, thus closed cell quadrilateral. Three ocelli present (Fig. 7H). Head pilosity not uniform, with numerous stout setae on vertex and frons in addition to normal thinner hairs (Fig. 7H: alveoli of dislodged stout setae shown and two stout setae, one of medium length, one of maximal length). Antennal flagellomeres with uneven surface (due to insertion points of long and relatively thick setae), in basal half of antenna maximal length of flagellar hairs about 5x greatest width of their flagellomeres. Pedicellar microspades organ weakly developed, with 2 units. P2 with a well-differentiated stout sensillum; P4 slender hatchet-shaped (Fig. 7D). Lacinial tip as in Fig. 7C. Pretarsal claws simple, symmetrical, with a small preapical denticle; hind legs with well-developed coxal organ.

Clunium, epiproct and paraproct simple, chaetotaxy of paraproctal hind margin as in Fig. 7E, paraproctal sensorium with six fine trichobothria on weakly differentiated basal florets and one normal seta. Subgenital plate simple, with a row of six long fine setae on posterior margin. Ovipositor valvulae as in Fig. 7F, v1 and v2 each with a weakly sclerotized median axis. Spermatheca as in Fig. 7G, empty (no spermatophore observed); spermathecal wall near duct with some complicated sclerotized yellowish structures; spermapore plate simple and membranous.

MEASUREMENTS: *Female holotype*: BL = 1.8 mm; FW = 2010 μm ; FWw = 790 μm ; FW/FWw = 2.54; HW = 1636 μm ; F = 338 μm ; T = 712 μm ; t1 = 254 μm ; t2 = 49 μm ; t3 = 62 μm ; IO/D = 1.7.

ETYMOLOGY: The species is named after Thais Oliveira do Carmo in recognition of her work on Brazilian cave psocids. The species epithet is invariable, it corresponds to the genitive case of the classical Greek name Thais.

DISTRIBUTION AND HABITAT: *Psyllipsocus thaidis* is only known from the type locality, the Coroa de Frade cave situated in Coronel José Dias municipality, Piauí state. This limestone cave is located in a semi-arid biome, called Caatinga. The external area was severely altered in the past decades by mining activities, which partially destroyed the entrance. Fortunately, the inner portion of the cave is isolated from the external environment by a constriction of the conduit near the entrance. The specimen was found on a relatively old pile of bat guano. Although there are caves and rock shelters in the entire area, most of them are in sandstones or conglomerate strata. Some

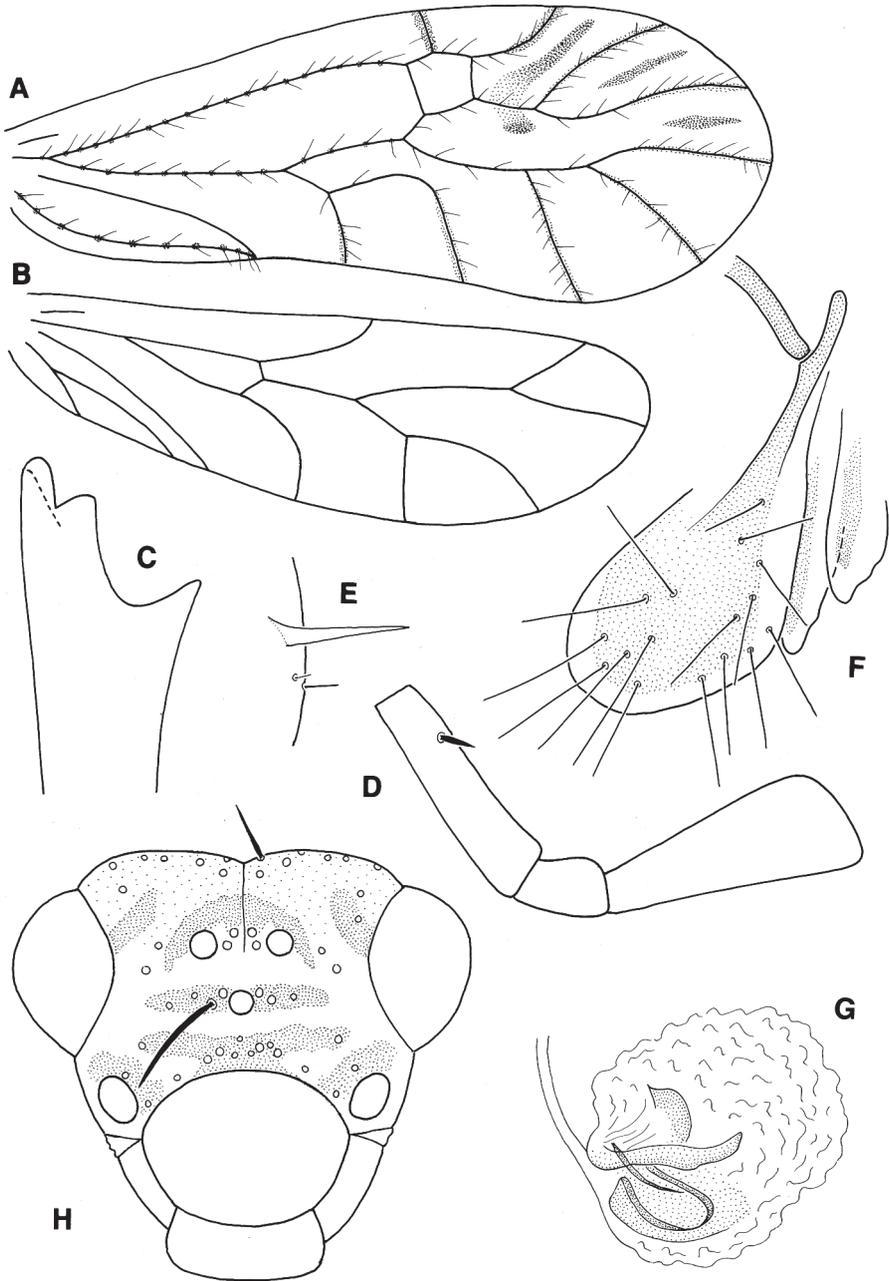


FIG. 7

Psyllipsocus thaidis Lienhard n. spec., female holotype. (A) Forewing. (B) Hindwing. (C) Lacinial tip. (D) P2-P4 of maxillary palp. (E) Hind margin of paraproct. (F) Right ovipositor valvulae. (G) Spermatheca. (H) Front view of head, showing frontal and vertical pigmentation and alveoli of particularly stout setae (alveoli of thinner hairs not shown).

of these caves were surveyed but *P. thaidis* was not found, perhaps indicating some habitat preference of this species.

DISCUSSION: *Psyllipsocus thaidis* belongs to a small group of species also comprising *P. falcifer* and *P. marconii*. Among Brazilian *Psyllipsocus* these species are characterized by the apomorphic presence of a Rs-M crossvein in the forewing. While *P. falcifer* has unmarked forewings, the other two species are clearly recognizable by their characteristic wing pattern. *P. thaidis* is also characterized by the presence of numerous stout setae on frons and vertex. The alveoli of these setae are clearly larger than those of normal setae (Fig. 7H, alveoli of normal setae not shown in this figure). Among Brazilian *Psyllipsocus* a similar non-homogeneous head pilosity has also been observed in *P. subtilis* and *P. fuscistigma*. In *P. falcifer* and *P. marconii* the head pilosity is almost uniform, lacking particularly thick setae on frons and vertex (often most setae dislodged in preserved material, but all alveoli relatively small and of almost equal diameter).

***Psyllipsocus clunioventralis* Lienhard n. spec.**

Figs 8-9

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (MT), Chapada dos Guimarães, Gruta Kiogo Brado cave, 27.x.2006. leg. R. L. Ferreira.

PARATYPES: ISLA and MHNG, slide-mounted and in alcohol; 2♂, 1♀ (allotype), same data as for holotype.

DESCRIPTION: General colouration yellowish to light brown, with some brown hypodermal pigmentation laterally on head, thorax and abdomen. P4 brown, compound eyes dark brown. Forewing with characteristic colour pattern, brown patches somewhat less extensive in male (Fig. 8A) than in female (Fig. 9A). Tibiae without transversal bands. Terminalia light brown.

Both sexes macropterous (Figs 8A, 9AB). Forewing: Rs and M fused for a length; distal closed cell longer than marginal length of pterostigma and slightly shorter than basal closed cell ($bcc/dcc \approx 1.2$); first portion of pterostigmal R1 about equal in length to R1-Rs crossvein; CuA1 almost semicircular (AP relatively short). Hindwing (Fig. 9B): Basal portion of Rs not differentiated and R1 originating from R-M fusion, thus closed cell triangular. Three ocelli present. Pilosity of frons and vertex almost uniform. Antennal flagellomeres with uneven surface (due to insertion points of long and relatively thick setae) (as figured for *P. didymus* in Fig. 10C), in basal half of antenna maximal length of flagellar hairs about 5x greatest width of their flagellomeres. Pedicellar microspades organ well-developed, with 5 units (as figured for *P. didymus* in Fig. 10B). P2 chaetotaxy as in Fig. 9C, with a long and slender stout sensillum in basal half; P4 broadly hatchet-shaped (Fig. 8C). Lacinial tip as in Fig. 8B. Pretarsal claws simple, symmetrical, with a small preapical denticle; hind legs with well-developed coxal organ. Epiproct and paraproct simple in both sexes (Figs 8D, 9F), anal spine very long, setal organ consisting of two fine setae, the ventral seta usually only slightly longer than the dorsal one, paraproctal sensorium with six fine trichobothria on basal florets and one normal seta.

In the male, postero-ventral corners of clunium prolonged into a ventro-mediad directed sclerotized rod-like extension with a truncate tip (Fig. 8DF). Hypandrium and phallosome as in Fig. 8E; basal struts not differentiated; phallosome with a compact

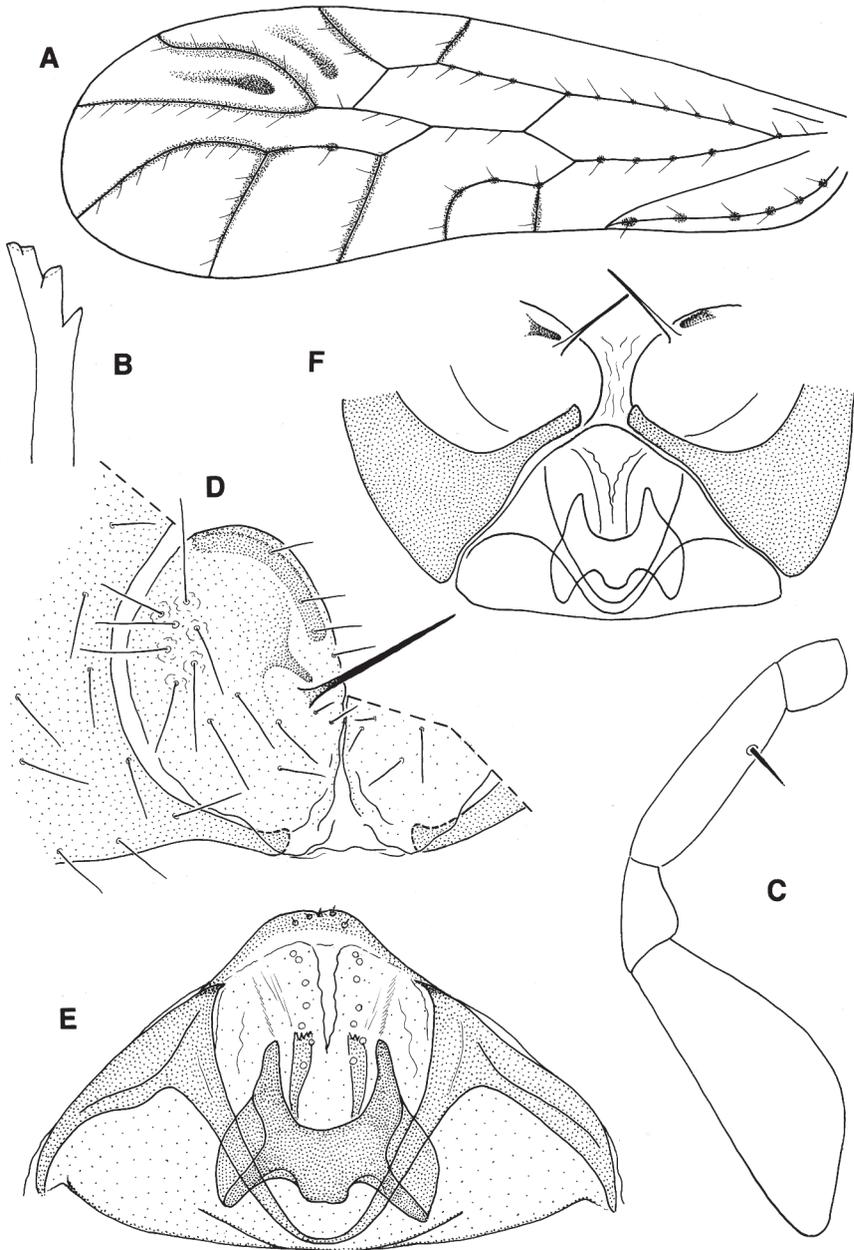


FIG. 8

Psyllipsocus clunioventralis Lienhard n. spec., male holotype (A-E) and male paratype (F). (A) Forewing. (B) Lacinial tip. (C) Maxillary palp. (D) Left paraproct and ventral extension (clunial rod) of left hind corner of clunium (and parts of right paraproct and clunial rod). (E) Hypandrium and phallosome, ventral view (pilosity not shown). (F) Schematic representation of paraprocts, hypandrium with phallosome and (dotted) ventro-lateral parts of clunium with clunial rods.

sclerite, posteriorly bifurcate, anteriorly trilobate with a truncate median lobe and a pair of broad lateral lobes; sclerotized posterior extensions of phallosome sclerite not reaching posterior margin of hypandrium; phallic cradle anteriorly rounded, postero-laterally broadly fused to lateral sclerotizations of the hypandrium.

In the female, postero-ventral corners of clunium as usual in the genus, i. e. lacking clunial rods (see Figs 4B, 12C, 14E). Subgenital plate simple, its hind margin slightly truncate, with a row of particularly long fine setae (Fig. 9D). Ovipositor valvulae as in Fig. 9E, v1 and v2 each with a slightly sclerotized median axis. Spermapore plate as in Fig. 9I, with a horseshoe-shaped sclerotization. Spermathecal duct and wall damaged, the latter with a characteristic strap-like sclerite, probably situated near origin of duct (Fig. 9H). Spermatophore with a slender, strongly curved and thick-walled basal neck (Fig. 9G).

MEASUREMENTS: *Male holotype*: BL = 1.4 mm; FW = 1607 μm ; FWw = 536 μm ; FW/FWw = 3.0; HW = 1354 μm ; F = 282 μm ; T = 656 μm ; t1 = 215 μm ; t2 = 49 μm ; t3 = 52 μm ; IO/D = 1.8. – *Female allotype*: BL = 1.2 mm; FW = 1690 μm ; FWw = 635 μm ; FW/FWw = 2.7; HW = 1450 μm ; F = 290 μm ; T = 635 μm ; t1 = 200 μm ; t2 = 49 μm ; t3 = 54 μm ; IO/D = 1.6.

ETYMOLOGY: The specific epithet (*clunioventralis*, -is, -e) refers to the presence, in the male, of a ventral extension of the clunium.

DISTRIBUTION AND HABITAT: *P. clunioventralis* is only known from the type locality, the Gruta Kiogo Brado cave situated in Chapada dos Guimarães municipality, Mato Grosso state. This sandstone cave is located near a Brazilian National Park, and so it is well preserved. The vegetation belongs to the Brazilian Savannah (“Cerrado”) which is little altered compared with other areas. Although the cave has a small watercourse, most substrates are dry, because the small stream runs in the lower part of the cave. The cave contains several bat guano piles (especially from the carnivorous bat *Chrotopterus auritus*), whereon the specimens were found. This cave lacks aphotic zones, since the only conduit is straight and has a big entrance at each extremity. Two other caves were sampled nearby, but *P. clunioventralis* was not found.

DISCUSSION: *P. clunioventralis* is characterized by its forewing pattern, the anteriorly rounded phallic cradle and the shape of the phallosome sclerite. The presence of a pair of clunial rods in the male of this species and of the closely related *P. didymus* clearly distinguishes these species from all other members of the genus *Psyllipsocus*. These two species also have a very characteristic compact and anteriorly trilobate phallosome sclerite. Its antero-lateral lobes are probably rudiments of the basal struts of a normal *Psyllipsocus* phallosome (see Fig. 11 and figures in Mockford, 2011).

The only other species of *Psyllipsocus* showing a sexually dimorphic structure of the postero-ventral clunial corners are the closely related species of the *clunjunctus* group (*P. clunjunctus* Lienhard, *P. serrifer* Lienhard, *P. similis* Lienhard) recently described from Brazilian caves (Lienhard & Ferreira, 2013b). However, in these three species the prolonged clunial corners of the male are medio-ventrally fused to each other, forming a complex sclerotized clunial bridge. See also General Discussion, below.

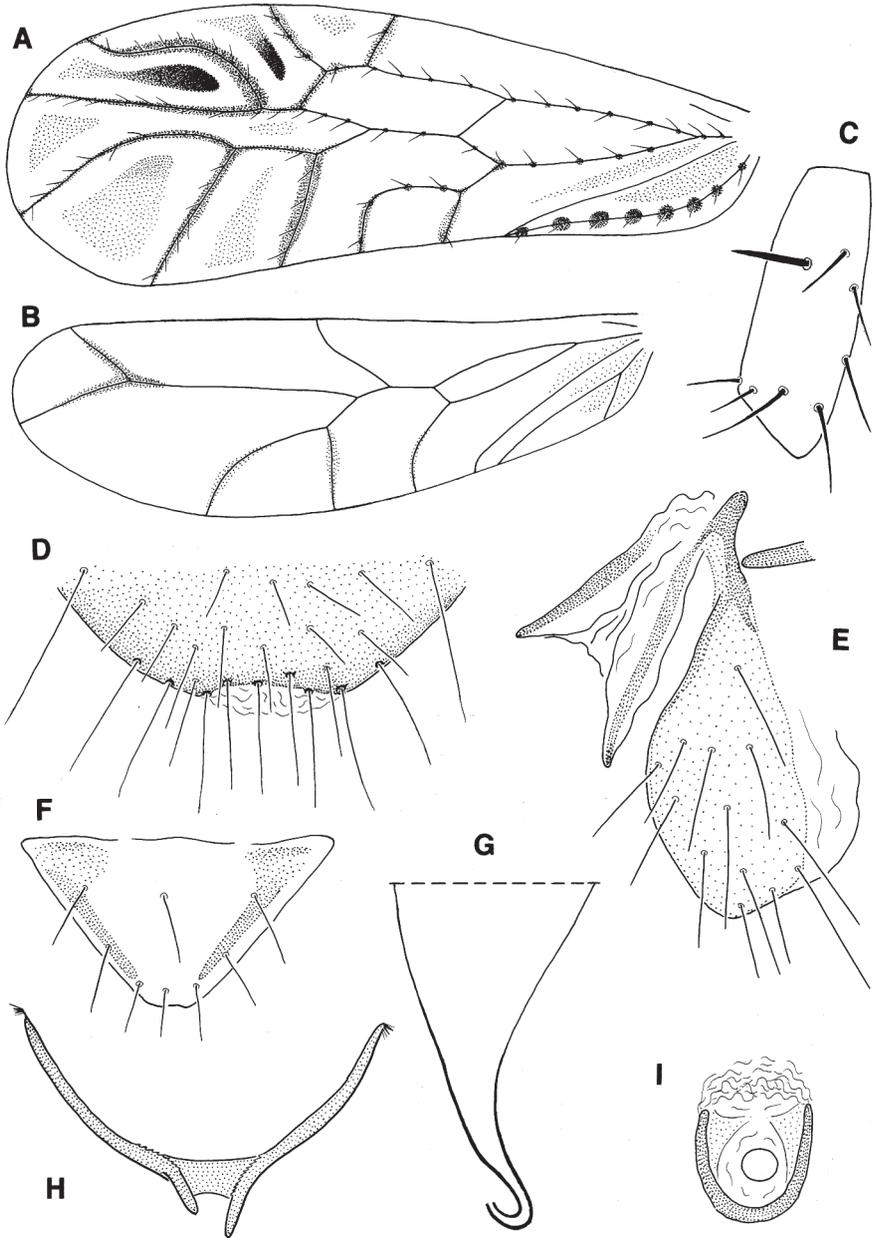


FIG. 9

Psyllipsocus clunioventralis Lienhard n. spec., female allotype. (A) Forewing. (B) Hindwing. (C) P2-chaetotaxy. (D) Subgenital plate. (E) Left ovipositor valvulae. (F) Epiproct. (G) Basal part of spermatophore. (H) Spermathecal sclerotization. (I) Spermapore plate.

The presence of three spermatophores in the spermatheca of the allotype of *P. clunioventralis* indicates that the species is polyandrous.

***Psyllipsocus didymus* Lienhard n. spec.**

Fig. 10

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (MT), Paranaíta, Gruta da Pedra Preta cave, 19.ix.2011, leg. R. L. Ferreira.

PARATYPE: MHNG, terminalia slide-mounted, rest in alcohol; 1♂, same data as for holotype.

DESCRIPTION OF MALE: General colouration light to medium brown. P4 brown, compound eyes dark brown. Forewing with characteristic colour pattern (Fig. 10A). Tibiae without transversal bands. Abdominal tergites with red-brown transversal bands of hypodermal pigment. Terminalia light brown.

Macropterous (Fig. 10A). General morphology as in *P. clunioventralis* (see description above). Male terminalia (Fig. 10D) as in *P. clunioventralis*, except for the following diagnostic details. Paraproct with a sclerotized ventro-basal strap (in *P. clunioventralis* at most a membranous fold at this place); tip of clunial rods not simply truncate but slightly expanded and lobed; phallic cradle anteriorly truncate; antero-medial lobe of phallosome sclerite narrowly rounded; sclerotized posterior extensions of phallosome sclerite reaching posterior margin of hypandrium.

MEASUREMENTS: *Male holotype*: BL = 1.0 mm; FW = 1340 µm; FW_w = 472 µm; FW/FW_w = 2.84; HW = 1100 µm; F = 230 µm; T = 490 µm; t1 = 170 µm; t2 = 43 µm; t3 = 47 µm; IO/D = 1.7.

ETYMOLOGY: The specific epithet refers to the close relationship to *P. clunioventralis* (Greek *didymos*, latinized: *didymus*, -a, -um; twin).

DISTRIBUTION AND HABITAT: *P. didymus* is only known from the type locality, the Gruta da Pedra Preta cave, Paranaíta municipality, Mato Grosso state. This granite cave comprises a huge crevice, enlarged due to erosion by water. The external vegetation was Amazonian forest, but this has been severely impacted by clearing for pasture. The main organic resources in the cave are plant debris, brought in by water or wind. Specimens of *P. didymus* were found on cave walls (in twilight zones) and may feed on algae. The species was not found in the only other cave visited nearby (Abrigo da Pedra Preta).

DISCUSSION: This species is very closely related to *P. clunioventralis* (see discussion on that species, above) from which it can be distinguished by the forewing pattern, the anteriorly truncate phallic cradle and the other details of male terminalia mentioned in the above description.

***Psyllipsocus subtilis* Lienhard n. spec.**

Fig. 11

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (RN), Felipe Guerra, Caverna Arapuá cave, 3.viii.2010, leg. D. M. Bento.

PARATYPES: ISLA and MHNG, slide-mounted or in alcohol; BRAZIL, leg. D. M. Bento, from the following municipalities. – 1♂, 3♀ (one of them allotype, one lacking head), Felipe Guerra (RN), Caverna Arapuá cave, 3.viii.2010 (type locality). – 1♂, Felipe Guerra (RN), Caverna Rumana cave, 5.viii.2010. – 1♀, Felipe Guerra (RN), Caverna Beira-Rio cave, 19.vii.2010. – 1♂, 2♀, Governador Dix-Sept Rosado (RN), Gruta do Lagedo Grande cave, 20.iii.2010. – 1♂, Governador Dix-Sept Rosado (RN), Caverna Capoeira do João Carlos cave, 3.vi.2010. – 1♀, Governador Dix-Sept Rosado (RN), Gruta do Marimbondo Caboclo cave, 20.vii.2010.

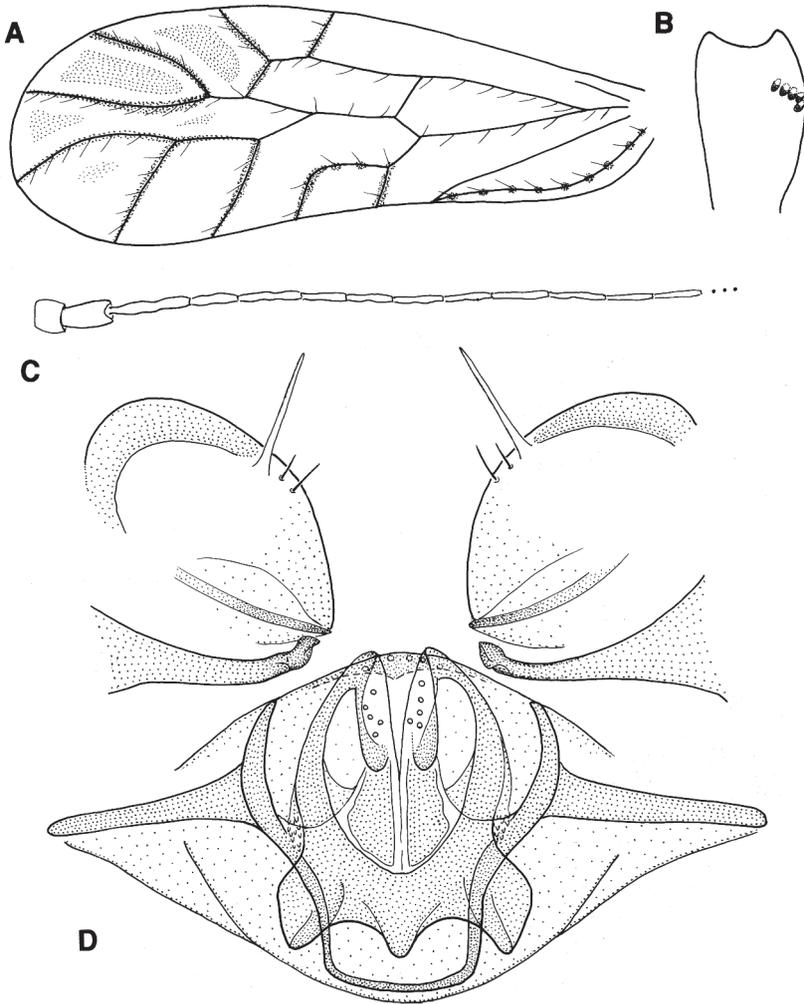


FIG. 10

Psyllipsocus didymus Lienhard n. spec., male holotype. (A) Forewing. (B) Pedicel with microspades organ (pilosity not shown). (C) Antenna (scape, pedicel and basalmost 11 flagellomeres; pilosity not shown). (D) Paraprocts, clunial rods and hyandrium with phallosome (pilosity not shown, except for anal spine and paraproctal setal organ).

DESCRIPTION: General colouration yellowish to light brown. Compound eyes dark brown. Forewing with characteristic but very subtle colour pattern (Fig. 11A), brown patches often weakly developed, almost invisible in the very pale male from the Caverna Rumana cave. Tibiae without transversal bands. Abdomen whitish, terminalia light brown.

Both sexes macropterous. Forewing (Fig. 11A): Rs and M fused for a length; distal closed cell very much longer than marginal length of pterostigma and also

slightly longer than basal closed cell ($bcc/dcc \approx 0.9$); first portion of pterostigmal R1 about equal in length to R1-Rs crossvein; CuA1 almost semicircular (AP relatively short, but its marginal length exceeding its height). Hindwing: Basal portion of Rs not differentiated and R1 originating from R-M fusion, thus closed cell triangular (as shown for *P. fuscistigma* in Fig. 12B). Three ocelli present. Head pilosity not uniform, with some stout setae on frons and vertex (almost all head setae dislodged in the material examined; however, a certain number of particularly large alveoli are present on frons and vertex, in addition to the small alveoli of normal hairs; pattern similar to that shown for *P. thaidis* in Fig. 7H). Antennal flagellomeres with uneven surface (due to insertion points of long and relatively thick setae), in basal half of antenna maximal length of flagellar hairs about 5x greatest width of their flagellomeres. Pedicellar microspades organ well-developed, with 5 units. Maxillary palp as in Fig. 11D, P2 with a stout sensillum about in middle of inner side, P4 broadly hatchet-shaped, externally concave and distally slightly tapered. Lacinial tip as in Fig. 11C. Pretarsal claws simple, symmetrical, with a small preapical denticle; hind legs with well-developed coxal organ. Clunium, epiproct and paraproct simple in both sexes; the latter with a very long anal spine and a setal organ consisting of a short fine seta and a longer, somewhat thicker seta; paraproctal sensorium with 6 fine trichobothria on basal florets and one normal seta (as shown for *P. fuscistigma* in Fig. 12C).

Hypandrium and phallosome as in Fig. 11B; hypandrium with a shallow apical lobe (as shown in Fig. 12D for *P. fuscistigma*), this prominence not visible in the holotype (Fig. 11B) due to slide-mounting; phallic cradle posteriorly fused to phallosome and joined by a postero-lateral arm to the lateral sclerotizations of the hypandrium; phallosome on each side with a broad granulate apical lobe and a weakly prominent denticulate internal lobe; the latter not reaching the tip of the granulate apical lobe; basal struts short; endophallic tube with a row of 4 pores on each side.

Female genitalia (Fig. 11E): Subgenital plate simple, with some long fine setae on posterior margin. Median axis of v1 and v2 very weakly sclerotized, v3 with a marginal row of 6-7 thick setae (these setae clearly thicker than other v3-setae of similar length). Spermapore plate simple, with some membranous folds and a weakly sclerotized area around spermapore; spermathecal duct thin-walled, of medium length and rather wide; spermathecal wall damaged by slide-mounting, very thin and lacking conspicuous sclerotizations; non-sclerotized spermatophore large and almost spherical.

MEASUREMENTS: *Male holotype*: BL = 1.5 mm; FW = 1590 μ m; FWw = 578 μ m; FW/FWw = 2.75; HW = 1340 μ m; F = 268 μ m; T = 564 μ m; t1 = 166 μ m; t2 = 39 μ m; t3 = 45 μ m; IO/D = 1.6. – *Female allotype*: BL = 1.3 mm; FW = 1636 μ m; FWw = 620 μ m; FW/FWw = 2.64; HW = 1354 μ m; F = 275 μ m; T = 592 μ m; t1 = 168 μ m; t2 = 41 μ m; t3 = 49 μ m; IO/D = 1.75.

ETYMOLOGY: The specific epithet refers to the characteristic but very subtle wing pattern of this species (Latin: *subtilis*, -is, -e).

DISTRIBUTION AND HABITAT: *P. subtilis* is known from six caves situated in two municipalities in the state Rio Grande do Norte. These caves belong to a Cretaceous limestone formation (Apodi group). Their environment comprises Brazilian “Caatinga” vegetation (semi-arid) and some areas have been altered by human acti-

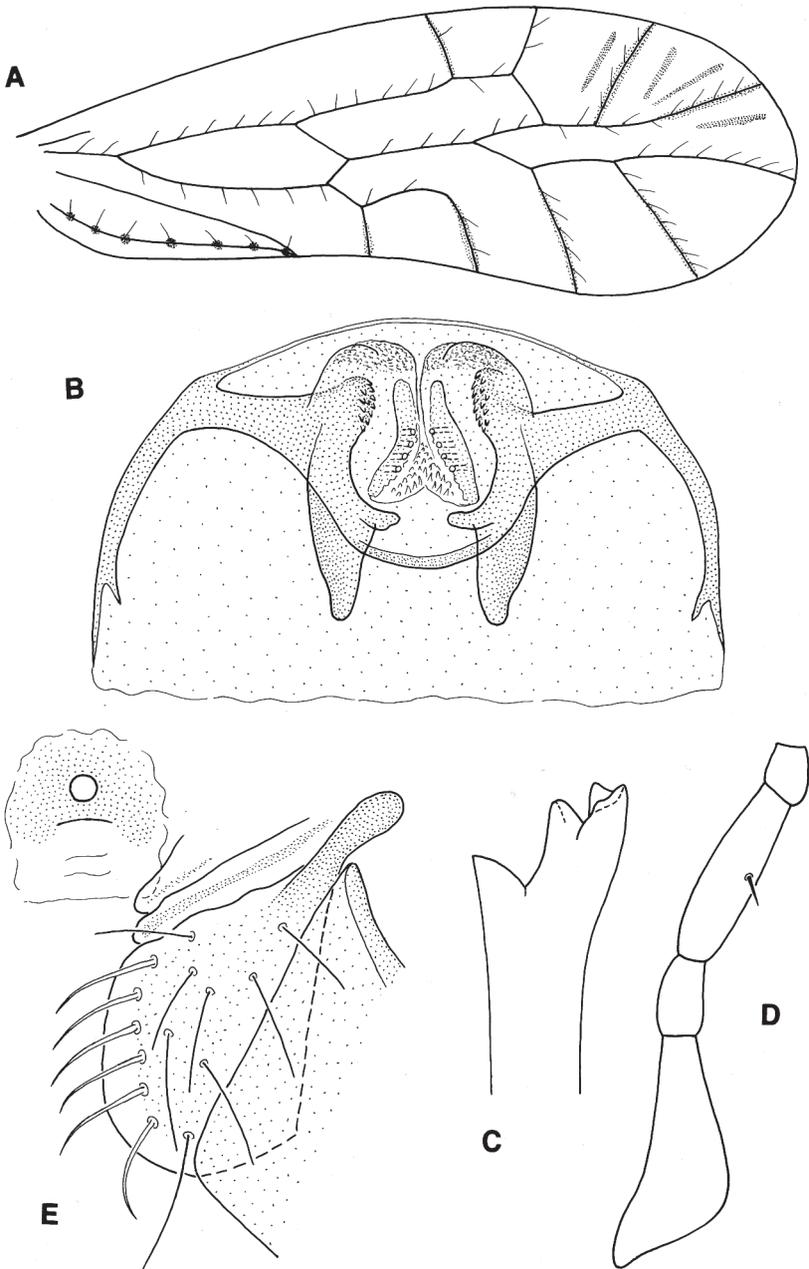


FIG. 11

Psyllipsocus subtilis Lienhard n. spec., male holotype (A-D) and female allotype (E). (A) Forewing. (B) Hypandrium and phallosome, ventral view (NOTE: apical prominence of hypandrium similar to that of *P. fuscistigma*, see Fig. 12D, here not visible due to slide-mounting). (C) Lacinal tip. (D) Maxillary palp. (E) Left ovipositor valvulae, left hind corner of clunium and spermapore plate.

vities, especially agriculture. The caves are predominantly dry, and their length mostly does not exceed 100 metres. Specimens were all observed on piles of old bat guano.

DISCUSSION: See discussion on *P. fuscistigma*, below.

***Psyllipsocus fuscistigma* Lienhard n. spec.**

Fig. 12

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (CE), Tejuçuoca, Gruta do Veado Campeiro cave, 16.ix.2008, leg. R. L. Ferreira.

DESCRIPTION OF MALE: General colouration light brown. Compound eyes black. Forewing with characteristic colour pattern (Fig. 12A). Tibiae without transversal bands. Abdomen whitish, with narrow light brown transverse bands; terminalia light brown.

Macropterous (Fig. 12AB). General morphology as in *P. subtilis* (see description, above). Forewing venation (Fig. 11A) very similar to that of *P. subtilis* but distal closed cell about equal in length to basal closed cell ($bcc/dcc \approx 1.0$) and first portion of pterostigmal R1 slightly shorter than R1-Rs crossvein. Hindwing as in Fig. 12B. Paraproct (Fig. 12C) and epiproct simple, as in *P. subtilis*.

Hypandrium and phallosome as in Fig. 12D. Hypandrium, phallic cradle and central sclerotizations of phallosome similar to *P. subtilis* but denticulate lobe larger, reaching tip of membranous apical zone which is not granulate; basal struts short; endophallic tube with a row of 3 pores on each side.

MEASUREMENTS: *Male holotype*: BL = 1.2 mm; FW = 1450 μ m; FWw = 520 μ m; FW/FWw = 2.8; HW = 1200 μ m; F = 240 μ m; T = 536 μ m; t1 = 170 μ m; t2 = 39 μ m; t3 = 43 μ m; IO/D = 1.4.

ETYMOLOGY: The specific epithet, a noun in apposition, refers to the dark brown patch at the distal end of the pterostigma (Latin: *fuscus* – dark brown).

DISTRIBUTION AND HABITAT: *P. fuscistigma* is only known from the type locality, the Gruta do Veado Campeiro cave, in Tejuçuoca municipality, Ceará state. This limestone cave is small and completely dry. The main resource observed was guano from frugivorous bats, whereon the specimen was found. There are also some other small caves in the same outcrop, which represents the only limestone outcrop in the region, these caves being isolated from other limestone formations. The external vegetation belongs to the Brazilian “Caatinga”, and the area was extremely dry during the collection period. All caves located in this outcrop were sampled, but only one specimen of *P. fuscistigma* was found.

DISCUSSION: *P. fuscistigma* is closely related to *P. subtilis* and *P. radiopictus*; the presence of four pigment stripes running parallel to forewing veins R2+3 and R4+5 (one in cells r1 and r5, two in cell r3), is here interpreted as a synapomorphy of these species. However, they are easily distinguishable by several details of the forewing pattern and by the shape of the AP (its height exceeding its marginal length in *P. radiopictus*, not reaching marginal length in the two other species). The genitalia of *P. radiopictus* are not known and for *P. fuscistigma* only male genitalia are known, which are very similar to those of *P. subtilis*, except for the details mentioned in the above description. The v3-chaetotaxy of *P. subtilis* is unique to the genus because of the presence of a row of thick marginal setae. Unfortunately this character could not be observed in *P. fuscistigma* and *P. radiopictus*; it might be a synapomorphy of all three species.

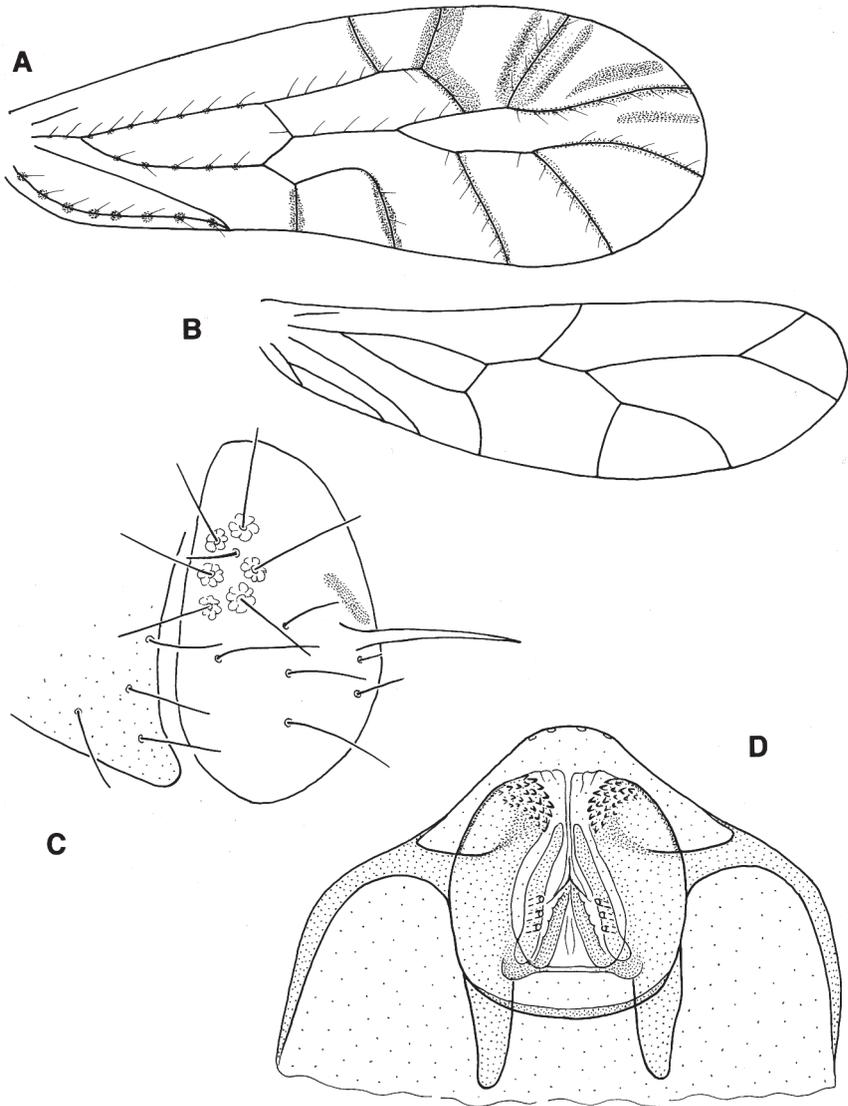


FIG. 12

Psyllipsocus fuscistigma Lienhard n. spec., male holotype. (A) Forewing. (B) Hindwing. (C) Left paraproct and left hind corner of clunium. (D) Hypandrium and phallosome, ventral view (pilosity not shown).

***Psyllipsocus radiopictus* Lienhard n. spec.**

Fig. 13

HOLOTYPE: ISLA; damaged specimen of unknown sex lacking head, prothorax and abdomen (slide-mounted); BRAZIL (AL), Murici, Toca da Raposa 1 cave (granite), 13.i.2007, leg. R. L. Ferreira.

PARATYPE: MHNG, damaged specimen of unknown sex lacking head, prothorax and abdomen (slide-mounted); same data as for holotype.

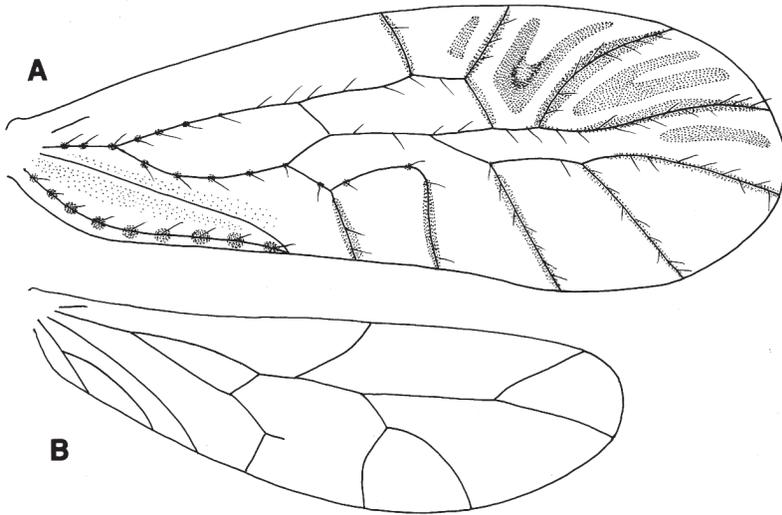


FIG. 13

Psyllipsocus radiopictus Lienhard n. spec., holotype. (A) Forewing. (B) Hindwing.

DESCRIPTION: Pterothorax light to medium brown. Forewing with characteristic colour pattern (Fig. 13A). Tibiae without transversal bands. Pretarsal claws simple, symmetrical, with a small preapical denticle; hind legs with well-developed coxal organ. Macropterous (Fig. 13AB). Forewing: Rs and M fused for a length; distal closed cell very much longer than marginal length of pterostigma and slightly shorter than basal closed cell ($bcc/dcc \approx 1.1$); first portion of pterostigmal R1 about equal in length to R1-Rs crossvein; CuA1 abruptly curved, its distal portion straight or slightly concave; AP short and high (its height exceeding its marginal length). Hindwing: Basal portion of Rs not differentiated and R1 originating from R-M fusion, thus closed cell triangular; in both hindwings of holotype CuA angulate and with a long spur vein in middle (Fig. 13B), in paratype CuA strongly bent in middle and the spurvein minute.

MEASUREMENTS: *Holotype*: FW = 1920 μm ; FWw = 733 μm ; FW/FWw = 2.62; HW = 1495 μm ; F = 310 μm ; T = 690 μm ; tarsus broken. – *Paratype*: FW = 1905 μm ; FWw = 740 μm ; FW/FWw = 2.57; HW damaged; F = 303 μm ; T = 684 μm ; t1 = 220 μm ; t2 = 49 μm ; t3 = 54 μm .

ETYMOLOGY: The specific epithet refers to the characteristic colour pattern in the radial region of the forewing (Latin: *pictus*, -a, -um; painted, coloured).

DISTRIBUTION AND HABITAT: *P. radiopictus* is only known from the type locality, the Toca da Raposa 1 cave, in Murici municipality, Alagoas state. This small granite cave is a typical “talus” cave (formed due to sediment removal by water leading to spaces between rock blocks), characterized by the presence of very dry sediments. The few resources observed were guano piles from insectivorous bats (on which the specimens were observed). The original external vegetation was Brazilian Atlantic

Forest, but the region is now almost completely deforested and mostly used for sugarcane plantations. There are few caves in the area, although many crevices may occur in the granitic outcrops. Therefore it is likely that *P. radiopictus* also occurs in other microhabitats in this area.

DISCUSSION: See discussion on *P. fuscistigma*.

***Psyllipsocus punctulatus* Lienhard n. spec.**

Fig. 14

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (PI), Coronel José Dias, Toca do Inferno cave, 12.ix.2008, leg. R. L. Ferreira.

DESCRIPTION OF MALE: Head medium to dark brown, compound eyes dark brown, thorax and legs light brown, tibiae without transversal bands, forewings with characteristic colour pattern (Fig. 14A), abdomen whitish, terminalia light brown.

Macropterous (Fig. 14AB). Forewing: Rs and M fused for a considerable length; distal closed cell longer than marginal length of pterostigma but slightly shorter than basal closed cell (bcc/dcc \approx 1.3); first portion of pterostigmal R1 slightly longer than R1-Rs crossvein; CuA1 moderately curved distally, AP relatively low. Hindwing: Basal portion of Rs not differentiated and R1 originating from R-M fusion, thus closed cell triangular. Three ocelli present. Pilosity of frons and vertex almost uniform. Antennal flagellomeres with uneven surface (due to insertion points of long and relatively thick setae), in basal half of antenna maximal length of flagellar hairs about 5x greatest width of their flagellomeres. Pedicellar microspades organ well-developed, with 6 units in both antennae (Fig. 14D). Maxillary palp as in Fig. 14C, P2 with a slender stout sensillum, P4 slender hatchet-shaped. Lacinal tip as in Fig. 14F. Pretarsal claws simple, symmetrical, with a small preapical denticle; hind legs with well-developed coxal organ. Clunium, epiproct and paraproct simple (Fig. 14E); the latter with a very long anal spine and a setal organ consisting of two short fine setae of about equal length; paraproctal sensorium with 6 fine trichobothria on basal florets and one shorter normal seta.

Hypandrium and phallosome as in Fig. 14G; hypandrium apically with 4 marginal setal sensilla and subapically on dorsal (inner) side with a median group of 4 placoid sensilla; phallosome on each side with a prominent denticulate postero-internal lobe; basal struts slender but short, fused to posterior sclerites of phallosome; endophallic tube on each side with a slender pore-bearing sclerite; phallic cradle differentiated as a sclerotized median arch, posteriorly fused to phallosome and joined by a postero-lateral arm to the lateral sclerotizations of the hypandrium.

MEASUREMENTS: *Male holotype*: BL = 1.5 mm; FW = 1680 μ m; FWw = 580 μ m; FW/FWw = 2.9; HW = 1380 μ m; F = 300 μ m; T = 606 μ m; t1 = 202 μ m; t2 = 43 μ m; t3 = 52 μ m; IO/D = 2.0.

ETYMOLOGY: The specific epithet (*punctulatus*, -a, -um) refers to the characteristic forewing pattern (Latin: *punctulum*; small spot).

DISTRIBUTION AND HABITAT: *P. punctulatus* is only known from the type locality, the Toca do Inferno cave, situated in Coronel José Dias municipality, Piauí state. This sandstone cave is located in a National Park (Parque Nacional da Serra da Capivara). The sandstone caves in this area were mainly formed by the expansion of

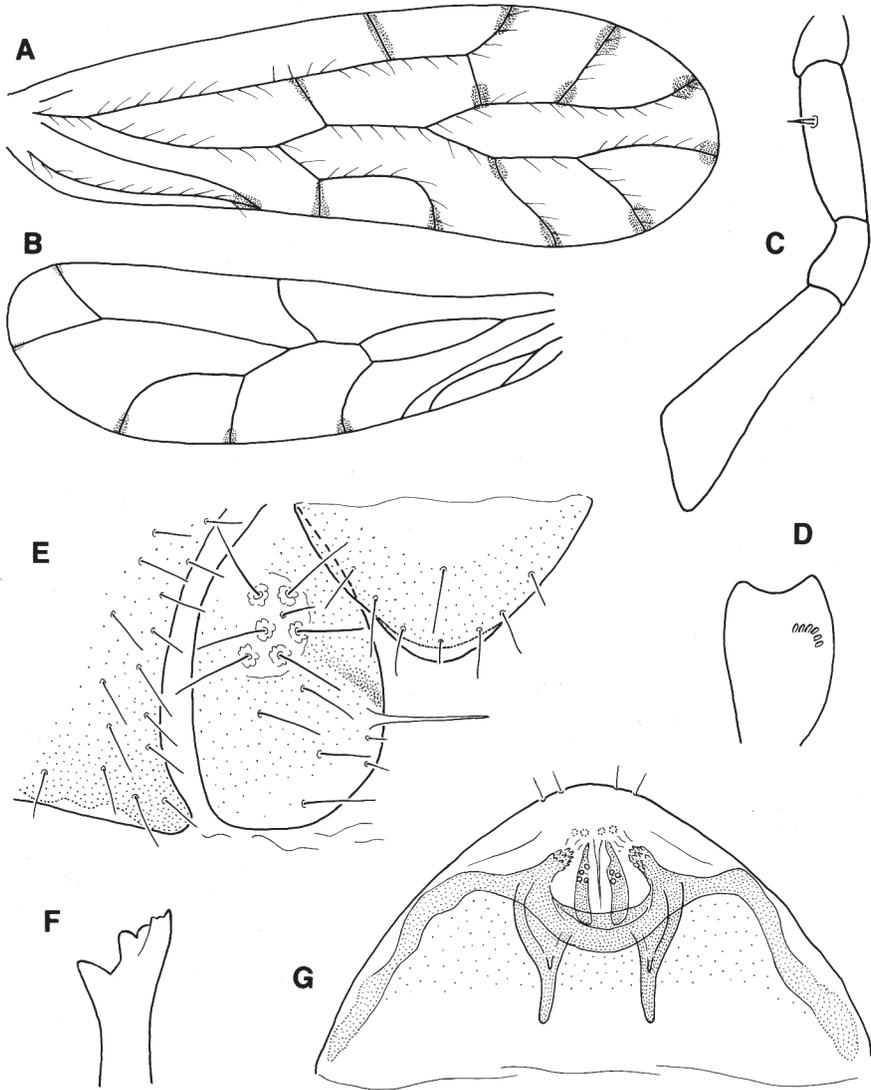


FIG. 14

Psyllipsocus punctulatus Lienhard n. spec., male holotype. (A) Forewing. (B) Hindwing. (C) Maxillary palp. (D) Pedicel with microspades organ (pilosity not shown). (E) Epiproct, left paraproct and left hind corner of clunium. (F) Lacinial tip. (G) Hypandrium and phallosome, ventral view (pilosity not shown except for distal marginal sensilla).

cracks in the rock by water, so most of them do not have true aphotic zones. *P. punctulatus* was observed on the cave wall, where it may feed on algae. There are many caves and rock shelters in this area, but only a few caves were surveyed.

DISCUSSION: This species is characterized by the arrangement of the brown pigment patches on the forewing and by the male genitalia. The presence of a pair of

denticulate posterior lobes of the phallosome and of a well-developed phallic cradle laterally fused to the phallosome and joined by a postero-lateral arm to the lateral sclerotizations of the hypandrium might be synapomorphies between *P. punctulatus*, *P. subtilis* and *P. fuscistigma*. See also discussion of the female cf. *punctulatus*, described below.

***Psyllipsocus* spec. cf. *punctulatus* Lienhard**

Fig. 15

MATERIAL EXAMINED: ISLA; ♀ (slide-mounted); BRAZIL (MG), Januária/Itacarambi, Gruta Brejal cave, 25.vii.2003, leg. R. L. Ferreira.

DESCRIPTION OF FEMALE: Head dark brown, compound eyes dark brown, thorax and legs medium brown, tibiae without transversal bands, forewing with characteristic colour pattern (Fig. 15A), abdomen yellowish brown, terminalia light brown.

General morphology as in the above described male of *P. punctulatus*, except for the following details. Forewing (Fig. 15A): distal closed cell almost equal in length to basal closed cell; first portion of pterostigmal R1 clearly longer than R1-Rs cross-vein; M1 strongly curved; CuA1 basally straight, strongly curved distally, AP slightly taller than in the above described male. Pedicellar microspades organ with 4 units in both antennae. Both maxillary palps broken off.

Subgenital plate simple, with some long fine setae on posterior margin. Ovipositor valvulae as in Fig. 15B, v1 and v2 each with a slightly sclerotized median axis. Spermapore plate with a roughly triangular sclerite (Fig. 15CD). Spermathecal duct of medium length; spermathecal wall very thin (damaged after slide-mounting), with a characteristic sclerite and a pair of oval granulate structures near duct; spermatophore not sclerotized (Fig. 15C).

MEASUREMENTS: *Female*: BL = 1.5 mm; FW = 1820 µm; FWw = 620 µm; FW/FWw = 2.94; HW = 1540 µm; F = 300 µm; T = 650 µm; t1 = 200 µm; t2 = 47 µm; t3 = 52 µm; IO/D = 1.6.

DISTRIBUTION AND HABITAT: The Gruta Brejal cave (MG), where this specimen was collected, is situated about 720 km from the type locality of *P. punctulatus* (Toca do Inferno cave, PI). These caves are very different: whilst Toca do Inferno cave is dry and light (the cave ceiling has a slit-like opening), Brejal cave is a large and voluminous cave (length about 1.5 km) traversed by a river, with most areas being aphotic zones. In Brejal cave, the specimen was collected on a bat guano pile, in a completely aphotic zone.

DISCUSSION: The specimen described above may be the female of *P. punctulatus* or of a closely related new species. It differs from the male holotype of *P. punctulatus* by some minor characters of colouration and general morphology: wing pattern not so clearly delimited to small spots, veins M1 and CuA1 somewhat more curved than in male, AP slightly taller and distal closed cell slightly longer than in male (Fig. 15A), pedicellar microspades organ with 4 units (6 in male, Fig. 14D), compound eyes somewhat larger than in male. Unfortunately this female lacks maxillary palps, thus the presence of the P2-sensillum could not be verified. At present we hesitate to assign this female definitively to *P. punctulatus*. This problem would be resolved when discovering the missing sex of at least one of these populations.

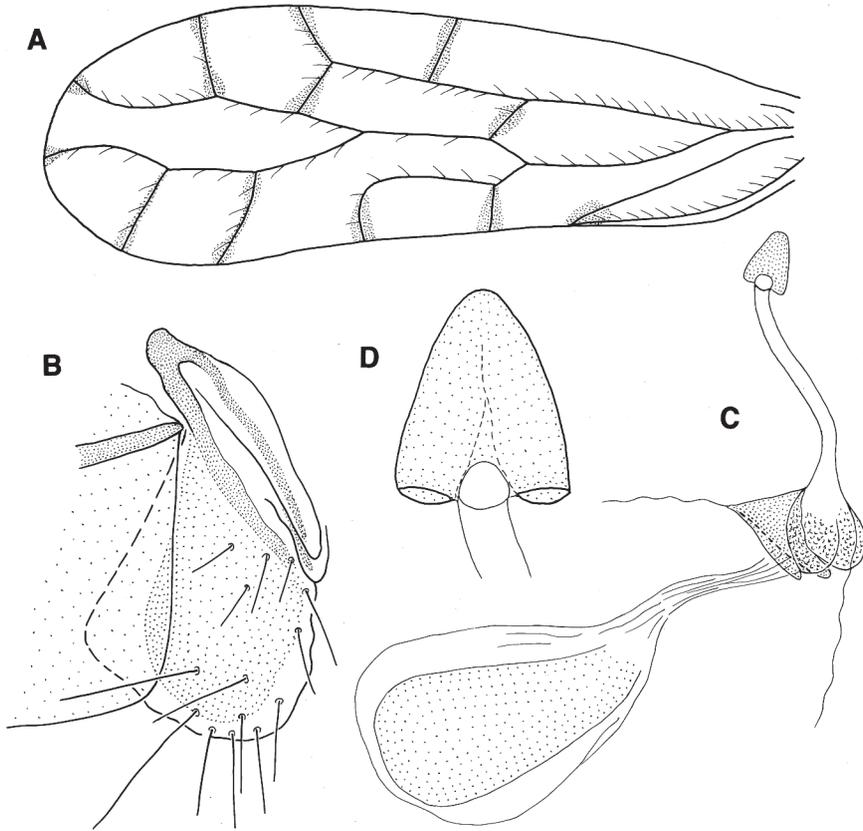


FIG. 15

Psyllipsocus spec. cf. *punctulatus*, female. (A) Forewing. (B) Right ovipositor valvulae and right hind corner of clunium. (C) Spermapore plate, spermathecal duct and basal part of spermathecal sac containing one spermatophore. (D) Spermapore plate, enlarged.

***Psyllipsocus angustipennis* Lienhard n. spec.**

Figs 16, 17AB

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (MG), Itacarambi, Gruta Bonita cave, 19.iii.2003, leg. R. L. Ferreira.

PARATYPES: ISLA and MHNG, slide-mounted or in alcohol; BRAZIL, leg. R. L. Ferreira, from the following municipalities. – 1♂, Itacarambi (MG), Gruta Bonita cave, 19.iii.2003 (type locality). – 1♀ allotype and 1♀ lacking abdomen (value of IO/D same as for allotype, clearly higher than in male, thus this specimen considered as a female), Januária/Itacarambi (MG), Gruta Preguiça cave, 26.vii.2003.

NON-TYPES: ISLA and MHNG, slide-mounted and some parts in alcohol; 2♂, BRAZIL (MT), Apiacás, Parque Nacional do Juruena, Casa de pedra do Navalha cave, 9.ix.2011, leg. R. L. Ferreira (see discussion below).

DESCRIPTION: General colouration whitish to light brown, with some red-brown hypodermal pigment, especially around antennal base, laterally on postclypeus and as a longitudinal band laterally on thorax. Compound eyes black. Forewing with characteristic colour pattern (Fig. 16A), membrane hyaline (slightly tinged with brown in the

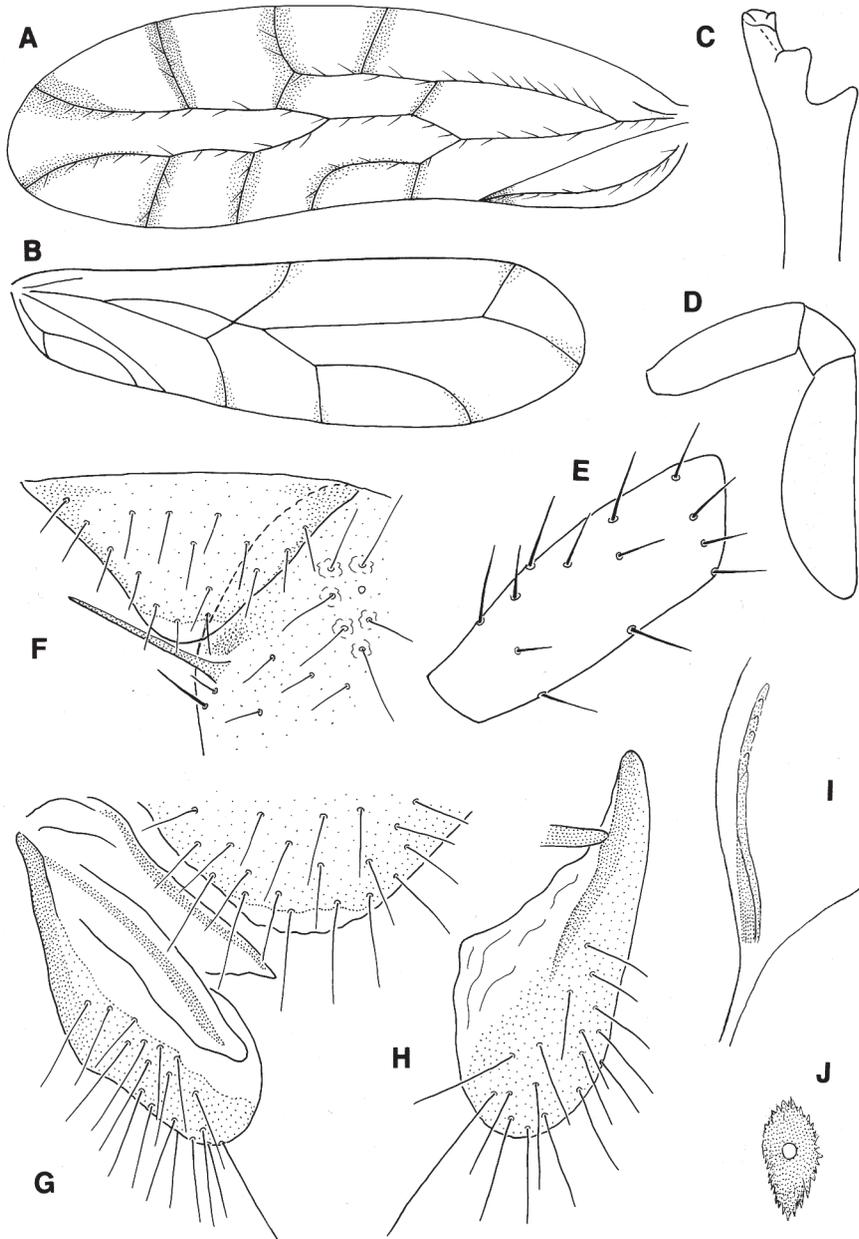


FIG. 16

Psyllipsocus angustipennis Lienhard n. spec., female allotype (A, F-J) and female paratype (B-E) from Gruta Preguiça. (A) Forewing. (B) Hindwing. (C) Lacinial tip. (D) P2-P4 of maxillary palp. (E) P2-chaetotaxy. (F) Epiproct and right paraproct. (G) Subgenital plate and right ovipositor valvulae (the latter slightly deformed by slide mounting). (H) Left v3 in normal sclerite. (I) Part of spermathecal duct and basal part of spermathecal sac with feather-like sclerite. (J) Spermapore plate.

non-type males). Legs whitish, with a brown ventral patch subapically on femora and two brown transversal bands on tibiae (tibiae light brown and lacking transversal bands in the non-type males).

Both sexes macropterous. Forewing (Fig. 16A): Rs and M fused for a length; distal closed cell longer than marginal length of pterostigma but shorter than basal closed cell ($bcc/dcc \approx 1.3$); first portion of pterostigmal R1 slightly longer than R1-Rs crossvein (about equal in length in the non-type males); AP relatively low. Hindwing (Fig. 16B): Basal portion of Rs not differentiated or very short, so R1 originating from R-M fusion or very slightly basally to it. Three ocelli present. Pilosity of frons and vertex almost uniform. Antennal flagellomeres with almost even surface, in basal half of antenna maximal length of flagellar hairs at most 2x greatest width of their flagellomeres. Pedicel lacking microspades organ. Maxillary palp as in Fig. 16D, P4 regularly rounded on internal side, P2 lacking stout sensillum (Fig. 16E). Lacinial tip as in Fig. 16C. Pretarsal claws simple, symmetrical, with a small preapical denticle; hind legs with well-developed coxal organ. Clunium, epiproct and paraproct simple in both sexes (Fig. 16F); the latter with a very long anal spine and a setal organ consisting of a short fine seta and a longer, somewhat thicker seta; paraproctal sensorium with 6 fine trichobothria on basal florets and one normal seta.

Hypandrium and phallosome as in Fig. 17A (holotype) and 17B (non-type); phallic cradle not clearly recognizable; phallosome compact, on each side with a group of 3 internal sense-pores (one pore of the holotype bearing a minute sense peg) and a slender anteriorly directed lateral lobe; basal struts short and posteriorly fused to median part of the phallosome, their anterior ends forming a pair of slender latero-basal extensions of the compact phallosome sclerite; posterior lobes of phallosome delimiting a median incision, these lobes broadly rounded in the holotype, somewhat slenderer and delimiting a clearly V-shaped incision in the two non-types.

Female genitalia (Fig. 16G-J): Subgenital plate simple, with some long fine setae on posterior margin; median axis of v1 and v2 well-sclerotized; spermatopore plate as in Fig. 16J, weakly sclerotized; spermatheca thin-walled and elongate (slightly damaged by slide-mounting), lacking sclerotizations except for a weakly sclerotized slender rod near opening of duct (Fig. 16I) (similar in shape to the corresponding feather-like structure in *P. proximus*, see Fig. 17D). Several elongate and very fragile spermatophores observed in the spermatheca of the allotype, their shape not clearly recognizable, probably similar to the spermatophore shown in Fig. 17D for *P. proximus*.

MEASUREMENTS: *Male holotype*: BL = 1.3 mm; FW = 1540 μ m; FWw = 480 μ m; FW/FWw = 3.2; HW = 1270 μ m; F = 250 μ m; T = 520 μ m; t1 = 200 μ m; t2 = 39 μ m; t3 = 47 μ m; IO/D = 0.9. – *Female allotype*: BL = 1.2 mm; FW = 1580 μ m; FWw = 490 μ m; FW/FWw = 3.2; hindwings and hindlegs damaged; IO/D = 1.25.

ETYMOLOGY: The specific epithet (*angustipennis*, *-is*, *-e*) refers to the characteristic shape of the forewing (Latin: *angustus* – narrow; *penna* – wing).

DISTRIBUTION AND HABITAT: The type material of *P. angustipennis* is known from two caves situated in the municipalities Januaria/Itacarambi (MG). Two non-type males are also known from the very different Casa de pedra do Navalha cave,

Apiacás (MT), which is situated about 1740 km from the type locality. *P. angustipennis* may be an euryecic species, or even a complex of more than one species (see discussion below). The huge distributional gap observed may be interpreted as a sampling artefact, since much of the area between was not sampled. All specimens were found on old bat guano piles.

DISCUSSION: *P. angustipennis* is very similar to *P. proximus* (see below); within the genus these species are characterized by their narrow forewings ($FW/FWw > 3$; this index ≤ 3 in *Psyllipsocus* species with normal wing shape) and the very distinctive structure of the phallosome. The two males from Apiacás are here considered as non-types of *P. angustipennis*. They belong to a population that is geographically very distant from the typical population of *P. angustipennis* (see above) but close to the typical population of *P. proximus* from Apuí municipality (distance between the two localities in Apiacás and Apuí municipalities: 92 km). The male genitalia of these non-types are somewhat intermediate between the types of the two species (see Fig. 17AB and F). However, the phallosome of *P. proximus* is characterized by a deeper V-shaped incision due to the presence of a pair of long and slender posterior prominences and by a pair of broad-based basal struts bearing a slender angulate anterior end. Though there is no doubt that the three populations are very closely related, we decided to assign provisionally the males from Apiacás to *P. angustipennis* and to consider the Apuí population as belonging to a species of its own. In addition to the above mentioned phallosome characters *P. proximus* differs also from *P. angustipennis* by its somewhat more extensive forewing pattern. In all specimens of *P. angustipennis* and *P. proximus* examined, compound eyes are clearly larger in relation to width of head capsule (IO/D 0.9-1.25) than in all other species treated in this study, which have values of IO/D varying between 1.3 and 2.0.

In *P. angustipennis* several spermatophores could be observed in the spermatheca of the allotype, this indicates that the species is polyandrous.

***Psyllipsocus proximus* Lienhard n. spec.**

Fig. 17C-F

HOLOTYPE: ISLA; ♂ (slide-mounted); BRAZIL (AM), Apuí, Parque Nacional do Juruena, Gruta Apiacá 1 cave, 13.ix.2011, leg. R. L. Ferreira.

PARATYPES: ISLA and MHNG, in alcohol and slide-mounted (allotype); 2 ♀ (one of them allotype), same data as for holotype.

DESCRIPTION: General colouration as in *P. angustipennis* (see description above). Forewing with characteristic colour pattern (Fig. 17C), membrane slightly tinged with brown, brown patches along M-branches clearly larger than in *P. angustipennis*. Brown ventral patch subapically on femora and tibial transversal bands distinct.

Both sexes macropterous (Fig. 17C). General morphology as in *P. angustipennis*. Forewing: FW/FWw 3.1-3.4; $bcc/dcc \approx 1.4$. Hindwing: Basal portion of Rs present but very short, origin of R1 slightly basal to Rs-M fusion.

Hypandrium and phallosome as in Fig. 17F, similar to *P. angustipennis*, except for following details. Basal struts with a slender angulate anterior end, posterior lobes of phallosome long and slender, delimiting a deep V-shaped median incision.

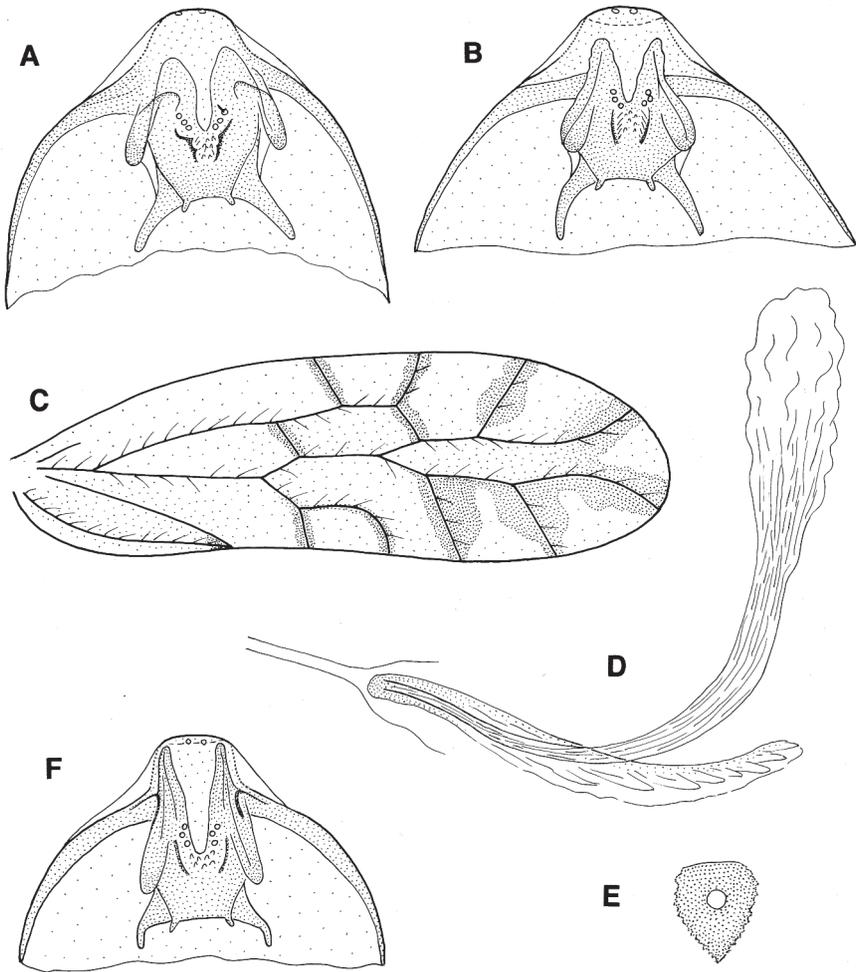


FIG. 17

Psyllipsocus angustipennis Lienhard n. spec. (A-B), hypandrium and phallosome, ventral view (pilosity not shown) of male holotype (A) and male non-type from Apiacás (B). – *Psyllipsocus proximus* Lienhard n. spec. (C-F), female allotype (C-E) and male holotype (F). (C) Forewing. (D) Part of spermathecal duct and basal part of spermathecal sac with feather-like sclerite and one spermatophore. (E) Spermatophore plate. (F) hypandrium and phallosome, ventral view (pilosity not shown).

Female genitalia similar to *P. angustipennis*. Spermatophore plate as in Fig. 17E, weakly sclerotized. Spermatheca thin-walled (damaged by slide-mounting), lacking sclerotizations except for a weakly sclerotized slender feather-like structure near opening of duct (Fig. 17D). One elongate and very fragile spermatophore present in the spermatheca of the allotype, its slender basal part situated near base of the feather-like sclerite (Fig. 17D).

MEASUREMENTS: *Male holotype*: BL = 1.2 mm; FW = 1200 μm ; FWw = 350 μm ; FW/FWw = 3.4; HW = 1000 μm ; F = 220 μm ; T = 430 μm ; t1 = 180 μm ; t2 = 39 μm ; t3 = 43 μm ; IO/D = 0.9. – *Female allotype*: BL = 1.4 mm; FW = 1330 μm ; FWw = 423 μm ; FW/FWw = 3.14; HW = 1130 μm ; F = 240 μm ; T = 475 μm ; t1 = 178 μm ; t2 = 39 μm ; t3 = 50 μm ; IO/D = 0.9.

ETYMOLOGY: The specific epithet refers to the very close relationship of this species to *P. angustipennis* (Latin: *proximus*, -a, -um; nearest).

DISTRIBUTION AND HABITAT: *P. proximus* is only known from the type locality, the Gruta Apiacá 1 cave situated in Apuí municipality, Amazonas state. This cave belongs to a group of small caves, all located on a steep part of a sandstone outcrop in Juruena National Park. The external vegetation consists of well-preserved Amazonian forest. Some other caves were sampled in this area, but *P. proximus* was only found in this cave, which was the only one with aphotic zones. Specimens were found on bat guano piles, in the aphotic area of the cave.

DISCUSSION: See discussion of *P. angustipennis*.

GENERAL DISCUSSION

DISTRIBUTION

A brief analysis of the distribution of the 12 new species described above shows that there is a high regional endemism of cave *Psyllipsocus* in Brazil. Only *P. spinifer* can be considered as a common species; it occurs in 20 caves situated in eight states (BA, CE, GO, MG, MT, PI, RN, SP). *P. falcifer* is known from eight caves (four municipalities) in the state of Minas Gerais and *P. subtilis* from six caves (two municipalities) in the state of Rio Grande do Norte. *P. angustipennis* is known from two caves (two neighbouring municipalities) in the state of Minas Gerais, and two specimens from a cave in the state of Mato Grosso are also tentatively assigned to this species. The remaining eight species are known from six states (AM, AL, CE, MG, MT, PI), each from a single cave. A detailed distributional analysis will be given in a future review paper (see Introduction).

PHYLOGENY

The three most common *Psyllipsocus* species in Brazilian caves are the cosmopolitan *P. ramburii* Selys-Longchamps (see Lienhard & Smithers, 2002), the widely distributed *P. yucatan* Gurney (see Lienhard *et al.*, 2012) and the above described *P. spinifer* (detailed collecting data for the former two species will be published in the review paper mentioned above). Each of these species has a rather isolated position in the large genus *Psyllipsocus*. However, the males of all three species have a phallosome with a pair of long and slender basal struts, as is typical for psyllipsocids (see Mockford, 2011) (NOTE: Male genitalia of *P. ramburii*, the usually parthenogenetic genotype of *Psyllipsocus*, are figured in Lienhard, 1998).

The remaining 14 *Psyllipsocus* species known from Brazilian caves are not closely related to one of these common species. However, at least five small monophyletic groups of related species can be recognized among them. The *clunijunctus* group, defined by Lienhard & Ferreira (2013b) for *P. clunijunctus*, *P. serrifer* and

P. similis, is characterized by autapomorphic male and female genitalia. Another group is formed by *P. falcifer*, *P. marconii* and *P. thaidis*, characterized by the apomorphic presence of an Rs-M crossvein in the forewing. *P. clunioventralis* and *P. didymus* form a small group defined by the presence of an apomorphic clunial rod in the male (see descriptions above). A fourth small group, formed by *P. angustipennis* and *P. proximus*, is characterized by very narrow forewings and a compact phallosome lacking a clearly differentiated phallic cradle. Another species group is formed by *P. subtilis*, *P. fuscistigma*, *P. radiopictus* and possibly *P. punctulatus*. The former three species are characterized by some elements of the forewing pattern (see descriptions above) and probably by the presence of a marginal row of thick setae on v3 (female only known in *P. subtilis*). These characters are not present in *P. punctulatus*. However, the male genitalia of that species are somewhat similar to those of *P. subtilis* and *P. fuscistigma* (male of *P. radiopictus* not known), possibly due to synapomorphy (see discussion on *P. punctulatus* in the taxonomic part).

In view of the morphological heterogeneity of these species groups, the following observation on male genitalia is rather surprising. In all males of these cave-dwelling species from Brazil the basal struts of the phallosome are clearly reduced and more or less fused to the medio-distal phallosome sclerites. None of these species has the typical long and slender basal struts which are present in all other psyllipsocids. However, the type of reduction and transformation of the phallosome structures is apparently not the same in all the above mentioned species groups. Thus, we hesitate to consider the character state “basal struts reduced” as a synapomorphy of this morphologically very heterogeneous assemblage of species. We tentatively interpret here this superficial similarity as due to homoplasy.

In some extreme cases, the phallosome sclerites are very strongly reduced (*P. clunijunctus*, *P. serrifer*, *P. similis*) or fused to form a single compact sclerite lacking basal struts (*P. clunioventralis*, *P. didymus*). In both species groups a novel structure of the male clunium has evolved, a pair of simple clunial rods in the latter group (see descriptions in the taxonomic part), a complex clunial bridge in the former (see Lienhard & Ferreira, 2013b). These authors have interpreted the clunial bridge as an accessory genital organ which functionally compensates the reduction of primary genitalic structures. In the *clunijunctus* group, the massive reduction of the phallosome is also accompanied by the evolution of a sclerotized “micropenis” in the female, a cone-shaped sclerotization of the spermapore plate (see Lienhard & Ferreira, 2013b). No similar specialization of female genitalia has been observed in *P. clunioventralis* (female of *P. didymus* not known).

In this context it is interesting to mention that in two cave-inhabiting genera of another trogiomorphan family, the prionoglaridids *Afrotroglia* Lienhard (South Africa and Namibia) and *Neotroglia* Lienhard (Brazil), the phallosome is also strongly reduced, while the spermapore region of the female bears some complex accessory structures which probably functionally replace the reduced intromittent organ of the male (Lienhard, 2007; Lienhard *et al.*, 2010).

These cave-dwelling prionoglaridids and psyllipsocids with reduced male genitalia generally live in dry and probably oligotrophic caves. They are the only trogiomorphan psocids showing some reduction of the phallosome. The correlation

between their subterranean mode of life and the evolutionary trend leading to a certain reduction of male primary external genitalia seems evident. We hope that future biospeleological research will be able to elucidate what kind of selection pressure might be at the origin of this phenomenon.

ACKNOWLEDGEMENTS

We thank Edward L. Mockford (Illinois State University, Normal, Illinois, USA) and John Hollier (MHNG) for critical reading of the manuscript and useful comments. RLF thanks all the members of the team from the Centro de Estudos em Biologia Subterrânea – Universidade Federal de Lavras (CEBS-UFLA) for their help in the field trips and collections, and especially Marconi Souza Silva (Lavras, MG, Brazil) for technical assistance. CL thanks John Hollier for interesting discussions. RLF also thanks the Centro Nacional de Pesquisa e Conservação de Cavernas (CECAV) and the Conselho Nacional do Desenvolvimento Científico e Tecnológico (CNPq grant 301061/2011-4).

REFERENCES

- LIENHARD, C. 1998. Psocoptères euro-méditerranéens. *Faune de France* 83: XX+517 pp.
- LIENHARD, C. 2007. Description of a new African genus and a new tribe of Speleketorinae (Psocodea: 'Psocoptera': Prionoglarididae). *Revue suisse de Zoologie* 114(3): 441-469.
- LIENHARD, C. & FERREIRA, R. L. 2013a. A new species of *Neotrogla* from Brazilian caves (Psocodea: 'Psocoptera': Prionoglarididae). *Revue suisse de Zoologie* 120(1): 3-12.
- LIENHARD, C. & FERREIRA, R. L. 2013b. Three new species of *Psyllipsocus* (Psocodea: 'Psocoptera': Psyllipsocidae) from Brazilian caves with description of a novel structure interpreted as a male accessory genital organ. *Revue suisse de Zoologie* 120(3): 421-443.
- LIENHARD, C. & SMITHERS, C. N. 2002. Psocoptera (Insecta): World Catalogue and Bibliography. *Instrumenta Biodiversitatis (Muséum d'histoire naturelle, Genève)* 5: xli+745 pp.
- LIENHARD, C., DO CARMO, T. O. & FERREIRA, R. L. 2010. A new genus of Sensitibillini from Brazilian caves (Psocodea: 'Psocoptera': Prionoglarididae). *Revue suisse de Zoologie* 117(4): 611-635.
- LIENHARD, C., FERREIRA, R. L., GNOS, E., HOLLIER, J., EGGENBERGER, U. & PIUZ, A. 2012. Microcrystals coating the wing membranes of a living insect (Psocoptera: Psyllipsocidae) from a Brazilian cave. *Scientific Reports* 2, 408 (8 figs); DOI: 10.1038/srep00408.
- MOCKFORD, E. L. 1993. North American Psocoptera (Insecta). *Flora and Fauna Handbook* 10: XVIII+455 pp. Sandhill Crane Press, Gainesville, Florida.
- MOCKFORD, E. L. 2011. New species of *Psyllipsocus* (Psocoptera: Psyllipsocidae) from North and Middle America with a key to the species of the region. *Transactions of the American Entomological Society* 137: 15-47.
- YOSHIZAWA, K. 2005. Morphology of Psocomorpha (Psocodea: 'Psocoptera'). *Insecta Matsumurana, New Series* 62: 1-44.

