A new species of *Languidipes* Hubbard (Ephemeroptera, Polymitarcyidae) from Borneo

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Abstract

The genus *Languidipes* is currently represented by three species distributed in southeastern Asia~~n~~, India, and Sri Lanka. *Languidipes corporaali* is the most widely distributed species, and both, male and female imagos, as well as nymphs, are known. In contrast, the other species, *L. ~~trapobanes~~taprobanes* and *L. lithophagus*, are only known from nymphs. Here, we describe a new species, *Languidipes janae* sp nov, based on male imagos collected from Borneo, Indonesia. This new species is characterized by the presence of ommation on mesonotum, and penis almost completely divided, with sub-quadrate base and a small outer projection basal to the long and slender distal arms. This constitutes the first record of the genus for Borneo. A cladistic analysis of the subfamily Asthenopodinae ~~corroborates~~ supports its taxonomic status.

Introduction

Polymitarcyidae (Ephemeroptera), with a worldwide distribution, includes large to medium-sized mayflies with burrowing nymphs (Kluge 2004, McCafferty 2004). The~~Strong~~ mandibular tusks

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of the immature forms are used to dig tunnels in a varietyd kinds of underwater sediments, including mud, clay and even siliceous rocks (Molineri, Salles & Peters 2015, Bolotov et al. 2022). InThe additional particularity of they produceing silk infrom the malpighian ducts, allowings them to coat their tunnelsburrowings with a thin mesh of this material (Sattler 1967), or even to construct silk cases where tunnels are impossible to dig (Molineri & Emmerich 2010, Pai et al. 2023). Furthermore, adults are so short-lived, that they do not present functional legs (except for the male forelegs, used to graspb females during copula), spending their entire life in flight. This forces them to make their subimaginal molt in a unique manner, not shading their cuticle in the classic form (as an entire piece) but in flakes that come off the body and wings (Molineri 2010). Because of their unique biology, including nymphs hidden in the substrates and extremely short-lived adults, specimens of this group are infrequently collected.

The genus *Languidipes* was originally described for *Asthenopus corporaali* Lestage, 1922 from Java, Indonesia. *Languidipes corporaali* (Lestage) was subsequently recorded from other Indonesian localities (Sumatra and Simeulue), as well as from Malaysia and Thailand (Baumgardner et al. 2012). The genus *Languidipes* also includes the species *L. trapobanestaprobanes* (Hubbard 1984) (Hubbard 1984, Rathinakumar et al. 2019, Pai et al. 2023), from India and Sri Lanka, and the recently described *L. lithophagus* (Bolotov et al. 2022) from Myanmar.

A phylogenetic framework has been proposed for the subfamily Asthenopodinae, where *Languidipes* is included together with partially sympatric *Povilla* and other three South American genera (Molineri, Salles & Peters 2015).

Here we describe a new species of *Languidipes* based on male imagos from Borneo, Indonesia, and test its phylogenetic relationships inside the subfamily.

Materials & methods

Specimens awere fixed in alcohol 70º70 % (v/v) ethanol., wings of one of them wereOne wing was removed and mounted dry oin microscope slides. Genitalia was dissected and temporarily mounted in gel alcohol for study and drawings with a camera lucida attached to an Olympus BX51 microscope. Photographs were taken with a Zeiss Axiocam ICc5 attached to a Zeiss Stemi 508 stereo microscope. Some images were processed with CombineZP software (Hadley, 2010) to improve focus.

Material is deposited in the following Institution: IBN (Instituto de Biodiversidad Neotropical, Tucumán), and FAMU (Florida A&M University, Tallahassee, FL).

The morphological matrix published in Molineri, Salles & Peters (2015) was revised, the new species amended, and some characters of *L. corporaali* were modified following the description of Baumgardner et al. (2012). All other taxa and characters in the matrix were not modified (Appendix 1).

The TNT program (Goloboff, Farris & Nixon 2008) was used to ~~searching most~~setup parsimonious trees. Heuristic searches were conducted under implied weights (Goloboff, Mattoni & Quinteros 2006) with k = 3 and 100 replicates of tree bisection and reconnection. All characters were treated as non-additive except for continuous characters (chars. 0 to 26), for additional details see Molineri, Salles & Peters (2015). Group support was calculated with the method of frequency difference (Goloboff et al. 2003), using 1000 replications of symmetric jackknifing.

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Results

Description

Languidipes janae sp. nov. (Figures 1 – 3)

Type material. Holotype male imago from Indonesia (Borneo): Kalimantan, Timur Prov., Lake Semayang, nr. Kota Bangun, attracted to light on boat, 3.vii.1985, M. Christensen, specimen number IBN – E 6370. Paratypes: 4 male imagos, same data, all deposited in IBN (IBN – E – 6371, IBN – E – 6372, IBN – E – 6373 and IBN – E – 6374).

Additional material. We also examined 1 larvae of *L. ~~trapobanes~~taprobanes*, paratype, FAMU E2109, from Ceylon, Kollonawe, iv.1954 (no more data).

Diagnosis. The male imago of this species is characterized by the presence of ommation on mesonotum, and penis divided almost completely, with sub-quadrate base, small outer projection basally to the long and slender distal arms; distal arms with pointed apex.

Male imago. Length (mm): body, 10.0–14.0; forewing, 12.2–13.0; hind wing, 4.0–5.0; cercus, 26.0, ~~terminal filament~~parecercus, 0.5-1.1. Head. Compound eyes large, black, covering most of head, separated in the middle of head by a distance equal to 1/3 of the width of an eye (Figs. 1~~A~~a, 1c~~C~~); lateral ocelli large and pedunculated (Fig. 1c~~C~~). Head brown dorsally, shaded with black mainly at the base of ocelli; ventrally much paler. Remnants of mouthparts whitish yellow. Antenna: scape and pedicel yellowish (flagellum broken-off and lost). Thorax. Pronotum reddish brown with black stippling on central area; anterior membranous portion blackish, posterior margin withish; sternum and pleura whitish. Mesonotum reddish brown slightly paler medially, shaded with black between the posterior scutal protuberances~~PSP~~; ommation (oval whitish median area in ~~basal~~ anterior ¼ of mesonotum) present (arrow in Fig. 1c~~C~~); pleura and sternum light yellowish brown, furcasternal median impression translucent. Metanotum reddish brown shaded with black on median area and posterior margin, pleura yellowish, sternum whitish translucent. Forelegs relatively short (slightly shorter than ½ of body length), yellowish white (Fig. 1b~~B~~). Middle and hind legs whitish, weak (Fig. 1d~~D~~). Forewings (Fig. 2a~~A~~) hyaline shaded with gray along costal margin and on membrane basal to vein A. Hindwings (Fig. 2a~~A~~) hyaline,

shaded with gray at costal and basal half of subcostal areas, and at base. Veins of both wings brownish, lighter toward apex, except cross veins on apical half of wing, translucent. Abdomen. Dorsum brownish shaded with black, ventrally whitish. Genitalia (Figs. 2bB to 2eE, 3A and 3bB): forceps one-segmented, robust, distally with a patch of short and curved setae along the inner margin. Penis divided almost completely, penis base sub-quadrate with a small outer projection (arrow in Figs. 2eE and 3bB), distal arms long and slender with pointed apex. Cerci: whitish, shaded with light gray basally. ~~Terminal filament~~ Paracercus as long as tergum X, whitish and thin.

Etymology. The specific name (noun in the genitive case) is a tribute to Janice Peters ("Jan"), who facilitated the material of the new species, and for her constant support.

Notes. In forewings, ICu veins presented variations among specimens. Frequently ICu1 is basally fused to CuA but may be basally free or joined to ICu2, additionally ICu2 may be basally free or fused to CuP.

Distribution. Data here presented constitute the first record of a *Languidipes* species in Borneo Island (Fig. 4).

Phylogenetic study

Only one shortest tree was recovered (Fig. 5), with a tree length of 270.8, a total fit of 5.8, and an adjusted homoplasy of 15.2. A high support was obtained for *Languidipes* (95%) and for the sister group *Languidipes* + *Povilla* (87%). The synapomorphies supporting the genus *Languidipes* (two species included) are: 1) ratio length second foretarsite / foretibia (char. 1 changes from 0.584-0.645 to 0.480), 2) ratio FW / foreleg length (char. 2, from 1.661-1.736 to 2.800), 3) ratio FW /cercus length (char. 3, from 0.339-0.347 to 0.375-0.464), 4) FW ratio length / width (char. 4, from 2.000-2.214 to 2.265), 5) ratio length FW / HW (char. 5, from 2.302-2.447 to 2.790), 6) penes, ratio basal width / subapical width (char. 17, from 1.300 to 2.000), 7) FW Cu sector, ICus joinning hind margin on different sides of tornus (char. 35): ICu1 close to tornus, ICu2 on basitornal margin, and 8) median plate of styliger (char 41) absent. The autapomorphies found for *Languidipes janae* are: 1) ratio subapical width of foretibia / subbasal width of tarsite 2 (char. 0, from 1.700 to 1.040), 2) ratio FW / cercus length (char. 3, from 0.375-0.464 to 0.500), 3) ratio marginal length between main longitudinal veins/imv length (mean of all values in a wing) (char. 9, from 1.653 to 1.745), 4) Rs stem length (FW male) / Rs from fork to margin (char. 10, from 0.235-0.241 to 0.220), 5) ratio total length of forceps / basal width (char. 13, from 4.545 to 4.300-4.500), 6) ratio length / basal width of penile lobe (char. 15, from 4.706-5.200 to 2.600), 7)

158 penes, ratio basal width / subapical width (char. 17, from 2.000 to 3.125), and 8) male foretarsite
159 1 subrectangular (char. 29).
160
161 ## Discussion
162 The species of *Languidipes* seem restricted to southeastern Asia (Fig. 4). The range of
163 *Languidipes corporaali* is the widest of the genus, being recorded in some Indonesian islands
164 (Java, Sumatra, and Simeulue), Thailand, and Malaysia; with a doubtful record for Assam, India
165 (Chopra 1927, cited in Hubbard 1984). Hubbard (1984) affirms that probably this last record will
166 be a new species.
167 Most species of *Languidipes* are only known from nymphs. *Languidipes* ~~*trapobanes*~~*taprobanes* is
168 known from Sri Lanka and the south of India, while *L. lithophagus* was recently described from
169 Myanmar (Bolotov et al. 2022). It is possible that the males described here as *L. janae* represent
170 the adult stage of one of them, but this seems unlikely. Nevertheless, we prefer to describe the
171 new species because it constitutes the unique record from Borneo, and its size is relatively
172 smaller than the other species (Hubbard 1984; Rathinakumar et al. 2019; Bolotov et al. 2022; Pai
173 et al. 2023).
174 Styliger in *Languidipes* is reduced to pedestals, which appear to be the basal segment of forceps.
175 Median plate of styliger is not present, contrary to *Povilla* and other Asthenopodinae, but similar
176 to Campsurinae (Kluge 2004; Molineri, Salles & Peters 2015). Following this interpretation,
177 forceps of *Languidipes* are one-segmented, and the diagnosis proposed by Baumgardner et al.
178 (2012) including the statement "male genitalia without a remnant of styliger plate" should be
179 amended to "male genitalia without a remnant of the median plate of styliger".
180 Surprisingly, a weak small circular area in the center of the mesonotum (Fig. 1c~~B~~) is present in
181 the specimens here studied. This structure, much resembling the ommation of Caenidae and
182 Neoephemeridae (Wang et al. 1997), is unique in the family Polymitarcyidae, and most probably
183 is an independent acquisition.
184 Among the species of *Languidipes*, only *L. corporaali* is known from the male adult, and it
185 presents a penis structure strongly different to *L. janae* sp. nov. The basal portion of the penis are
186 wide and laterodistally rounded in *L. corporaali*, but is sub-quadrate and with an acute projection
187 in outer margin in *L. janae*. Penis arms in *L. corporaali* ends more acutely than in the species
188 described here. Finally, penis is divided from the base of the arms to the apex in *L. corporaali*,
189 but *L. janae* presents a much deeper division including most of the basal portion of penis.
190 The previous phylogenetic hypothesis (Molineri, Salles & Peters 2015) is not modified by the
191 inclusion of *Languidipes janae*. As expected, this species is grouped with *L. corporaali* in a well-
192 defined group, sister to *Povilla*.
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Bibliography

Baumgardner, D. E., Peters, J. G., Ghani, I. A. & Hubbard, M. D. (2012). The adult stage of *Languidipes corporaali* (Lestage, 1922), new status and the validity of *Povilla* (Navas) (Ephemeroptera: Polymitarcyidae: Asthenopodinae). Aquatic Insects 34, 107–113. https://doi.org/10.1080/01650424.2012.713487

Bolotov, I. N., Kondakov, A. V., Potapov, G. S., Palatov, D. M., Chan, N., Lunn, Z., Bovykina G. V., Chapurina Y. E., Kolosova Y. S., Spitsyna E. A., Spitsyn V. M., Lyubas A. A., Gofarov M. Y., Vikhrev I. V., Yapaskurt V. O., Bychkov A. Y. & Pokrovsky, O. S. (2022). Bioerosion of siliceous rocks driven by rock-boring freshwater insects. npj Materials Degradation, 6(1), 3. https://doi.org/10.1038/s41529-022-00216-6

Chopra B. (1927). The Indian Ephemeroptera (mayflies). Part I. - The suborder Ephemeroidea: Families Palingeniidae and Polymitarcidae – Records of the Indian Museum 29, 91-138, pl. 8-10.

Goloboff P.A., Farris J.S., Kallersjo M., Oxelman B., Ramırez M.J., Szumik C.A. (2003). Improvements to resampling measures of group support. Cladistics 19, 324–332. https://doi.org/10.1111/j.1096-0031.2003.tb00376.x

Goloboff P.A., Farris J.S., Nixon K. (2008). TNT, a free program for phylogenetic analysis. Cladistics 24, 774–786. https://doi.org/10.1111/j.1096-0031.2008.00217.x

Goloboff P.A., Mattoni C., Quinteros S. (2006). Continuous characters analyzed as such. Cladistics, 22: 589–601. https://doi.org/10.1111/j.1096-0031.2006.00122.x

Hadley A. (2010). CombineZP software. http://www.hadleyweb.pwp.blueyonder.co.uk/CZP/Installation.htm

Hubbard, M. D. (1984). A revision of the genus *Povilla* (Ephemeroptera: Polymitarcyidae). Aquatic Insects 6, 17–35. https://doi.org/10.1080/01650428409361158

Kluge N.J. (2004) The phylogenetic system of Ephemeroptera. Kluwer, 442 pp.

Lestagje, J. A. (1922). Notes sur les genres *Asthenopus* - *Povilla* (Ephemeroptera) et description d'une espèce javanaise nouvelle (*Asthenopus corporaali*). Annales de la Société Entomologique de Belgique 62: 142-148.

McCafferty W.P. (2004). Higher classification of the burrowing mayflies (Ephemeroptera: Scapphodonta). Entomological News 115: 84–92.

Molineri C (2010) A cladistic revision of *Tortopus* Needham & Murphy with description of the new genus *Tortopsis* (Ephemeroptera: Polymitarcyidae). Zootaxa 2481: 1–36.

Molineri C, Emmerich D (2010) New species and new stage descriptions of *Campsurus* major species group (Polymitarcyidae: Campsurinae), with first report of silk-case construction in mayfly nymphs. Aquatic Insects 32: 265–280. doi: 10.1080/01650424.2010.533131

Molineri, C., Salles, F. F., & Peters, J. G. (2015). Phylogeny and biogeography of Asthenopodinae with a revision of *Asthenopus*, reinstatement of *Asthenopodes*, and the description of the new genera *Hubbardipes* and *Priasthenopus* (Ephemeroptera, Polymitarcyidae). ZooKeys, (478), 45. doi: 10.3897/zookeys.478.8057

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Pai, S. G., Kalleshwaraswamy, C. M., Varanashi, K., Ranjith, M., & Rajkumar, M. (2023). First record of Mayfly *Povilla* (*Languidipes*) *taprobanes* Hubbard from Karnataka. Indian Journal of Entomology, 610-616. https://doi.org/10.55446/IJE.2021.392

Rathinakumar, T., Kubendran, T., & Balasubramanian, C. (2019). New record of the Genus *Povilla* (Navas, 1912) (Ephemeroptera, Polymitarcyidae) from southern Western Ghats, India. Journal of Entomological Research, 43(1), 89-92. DOI: 10.5958/0974-4576.2019.00018.5

Sattler W. (1967). Über die Lebensweise, insbesondere das Bauverhalten, neotropischer Eintagsfliegen-Larven (Ephemeroptera, Polymitarcidae). Beiträge zur Neotropischen Fauna 5:89–110. doi: 10.1080/01650526709360399

Wang, T. Q., McCafferty, W. P., & Bae, Y. J. (1997). Sister relationship of the Neoephemeridae and Caenidae (Ephemeroptera: Pannota). Entomological News, 108, 1: 52-56.