

The Neotropical species of *Notalina*, a southern group of long-horned caddisflies (Trichoptera: Leptoceridae)*

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ABSTRACT. The leptocerid trichopteran genus *Notalina* is recorded from the South American continent for the first time. Seven new species are described in it and placed in a new subgenus, *Neonotalina*: *N.brasiliana*, *N.morsei*, *N.cipo* and *N.hamiltoni* from southeastern Brazil, comprise the *brasiliana* species-group, and *N.roraima* from Venezuela, *N.nanay* from Peru and *N.matthiasi* from Colombia form the *roraima* species-group. *Notalina* (*Neonotalina*) is identifiable by the presence of a long, slender baso-mesal process on the male inferior appendage. The two species-groups may be distinguished by the morphology of the male phallus. The historical biogeography of the genus in South America is discussed.

Introduction

The trichopteran family Leptoceridae, or long-horned caddisflies, contains forty-five genera and almost 1000 species, making it one of the largest families in the order. The family is divided into two subfamilies, the cosmopolitan Leptocerinae and the mainly Australasian and Neotropical Triplectidinae. The family-group taxonomy of the Leptoceridae was reviewed by Morse (1981). The present paper is the third in a series on the taxonomy, systematics and biogeography of the family in the Neotropics.

Mosely (1936) erected the genus *Notalina* and included in it three species: the generotype *N.parkeri*, *N.delicatula* (Ulmer), and *N.flava* (Ulmer). Since that paper eight additional

species have been added to the literature: *N.bifaria* Kimmins, *N.dwellinga* Neboiss, *N.fulva* Kimmins, *N.gungarra* Neboiss, *N.moselyi* Kimmins, *N.nigra* (Mosely), *N.pseudodelicatula* Neboiss and *N.tillyardi* Kimmins. These eleven species are restricted in distribution to Australia and Tasmania.

Recently, I have had the opportunity to examine caddisfly material on loan from the United States National Museum (Natural History), the Museu de Zoologia, Universidade de São Paulo, and the Instituto de Zoologia Agrícola, Universidad Central de Venezuela, Maracay, containing several new species of *Notalina* from South America. The seven new Neotropical species form a distinct subunit within the genus. The purpose of this paper is to describe these species, to place them in a new subgenus, to record the genus from the South American continent for the first time, and to discuss its historical biogeography.

Terminology for genitalia, upon which the species level taxonomy of the family is usually based, and wing venation follows the review by

*Studies in Neotropical Leptoceridae (Trichoptera) No. 3.

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Schmid (1980). Genitalic structures referred to in the text and key are labelled in Figs. 3, 4 and 5. A, B and C in Figs. 3–12 are lateral, dorsal and ventral views respectively of the terminal abdominal segments. In males, C is a ventral view of the left inferior appendage only. D and E are lateral and dorsal views respectively of the male phallic apparatus (except 8E is a ventral view). Types will be deposited in the United States National Museum (Natural History) (USNM), the Museu de Zoologia, Universidade de São Paulo (MZSP), the Instituto de Zoologia Agrícola, Universidad Central de Venezuela, Maracay (UCV), and the Clemson University Entomological Collection (CLEM) as indicated below.

***Notalina* Mosely**

Notalina Mosely, 1936: 114. Generotype: *Notalina parkeri*, by original designation. Mosely & Kimmins, 1953: 248. Neboiss, 1977: 136.

Triplexina Mosely, in Mosely & Kimmins, 1953: 231. Generotype, monobasic: *Triplexina nigra*. Neboiss, 1977: 136 (as a synonym of *Notalina*).

DIAGNOSIS: Tibial spur formula 2–2–4. Male forewing with forks I and V present (Fig. 1A); forks I, III and V present in female forewing (Fig. 2A). Hindwing of both sexes with forks III and V always present; fork I absent or, when present, very narrow; female hindwing narrower than male's (Figs. 1B, 2B). Second article of male inferior appendage seemingly absent, although the small, meso-ventral spine on the inferior appendage may be the remnant of that structure. The larval and pupal stages have not been described in the literature, although reared material for several Australian species has been obtained by R. St. Clair, Monash University.

A key to the Tasmanian species and a checklist of the previously known species were provided by Neboiss (1981, 1983, respectively). The seven new Neotropical species agree with the Australian species in overall plan of the male and female genitalia and wing venation. They form, however, a distinctive subunit within the genus differing from the Australian

subunit in several striking features of the male genitalia, especially the long, baso-mesal process of the inferior appendage. I am recognizing this difference by placing the Neotropical species in a new subgenus. The nominate subgenus and the new subgenus each appear to be monophyletic. Unique homologues implying monophyly are, for the nominate subgenus, the sharply pointed, ventrally-directed, lateral extensions of the male phallobase (Ross & Morse, 1975, Figs. 1D, 2D) and the deeply excised nature of the male abdominal segment X (Ross & Morse, 1975, Figs. 1A, 1B). For the new subgenus, homologues implying monophyly include the long, slender, baso-mesal process of the male inferior appendage and the lateral, flange-like extensions of the male phallobase.

***Notalina* (*Neotalina*) subgen.n.**

TYPE-SPECIES: *Notalina brasiliiana*, sp.n.

DIAGNOSIS: Similar to the nominate subgenus except male genitalia with inferior appendages each bearing a long slender baso-mesal process; abdominal segment X usually broad, saddle-shape, and not as deeply excised as in *N. (Notalina)*. The phallobase of the phallic apparatus has lateral, dorsally-directed, acuminate or spatulate flanges. In the female genitalia, sternum IX has a smooth, rectangular, slightly concave plate; segment X forms a dorsal shelf; the vulval scale is prominent and bears many minute setae; and the vaginal apparatus is oval and with central keyhole-shaped sclerites.

Key to the males of *Notalina* (*Neotalina*)*

- 1 Phallobase with paired, lateral, acuminate flanges; phalloretral sclerite well developed, large (Figs. 3D, 3E) *brasiliiana* group...2
- Phallobase with paired, lateral, spatulate flanges; phalloretral sclerite underdeveloped, small (Figs. 9D, 9E) *roraima* group...5
- 2 Abdominal segment X bearing a single pair of terminal processes..... 3

*The females of only *N. brasiliiana*, *N. morsei* and *N. matthiasi* are known and can be identified by referring to the descriptions and illustrations in the text.

- Abdominal segment X bearing 2 pairs of terminal, finger-like processes (Figs. 3A, 3B).....*N. brasiliiana*
- 3 Terminal processes of segment X large, quadrate in dorsal view (Figs. 5B, 7B)..... 4
- Terminal processes of segment X small (Fig. 8B)
N. hamiltoni
- 4 Segment X saddle-shaped in lateral view; inferior appendage narrow basally and bearing 2 sclerotized points mid-ventrally (Fig. 5A)*N. morsei*
- Segment X not as above; inferior appendage with basal region massive and bearing a lateral ridge (Fig. 7A).....*N. cipo*
- 5 Segment X with apex entire or with a very slight mesal cleft; without heavy setae (Figs. 9B, 10B) .. 6
- Segment X with a deep apico-mesal cleft and bearing heavy setae (Figs. 11A, 11B)
N. mathiasi
- 6 Inferior appendage with basal and apical portion long and slender; bearing a sharply pointed mid-ventral projection (Figs. 9A, 9C)
N. roraima
- Inferior appendage with basal portion broad; lacking pointed mid-ventral projection (Figs. 10A, 10C) *N. nanay*

***Notalina brasiliiana* sp.n.** (Figs. 1-4)

I am placing *N. brasiliiana* and the following three species in the *brasiliiana* species-group. The members of this group all possess lateral, acuminate flanges on the male phallobase and well-developed phallosclerites. *N. brasiliiana* can be distinguished from its relatives by the possession of two pairs of processes on abdominal segment X and by the complex nature of the basal half of the inferior appendage in the male genitalia.

Male. Length of forewing 10-11 mm. Colour brown in alcohol. Genitalia as in Figs. 3A-3E. Abdominal segment IX annular; broadest laterally. Segment X more or less rectangular in dorsal and lateral views and bearing a pair of dorso-mesal and ventro-lateral processes apically. Dorso-mesal processes finger-like and bearing long hair-like setae. Ventro-lateral processes shorter and stouter. Preanal appendage long and slender. Inferior appendage bearing a long, slender, baso-mesal process. Basal half of inferior appendage complex, with a broad baso-mesal process and a thin, vertically-situated, blade-like process. Apical half of inferior appendage long and finger-like. Phallic apparatus with phallic apodeme and phallobase well developed. Phallobase with a

pair of dorsally-directed, acuminate flanges. Phallosclerite very large and well developed; roughly U-shaped in dorsal view and divided apically into a pair of pointed processes and a pair of rounded processes.

Female. Size, colour and structure similar to male. Genitalia as in Figs. 4A, 4C. Abdominal sternum IX a smooth, rectangular, slightly concave plate. Pleuron IX with a shallow C-shaped concavity. Segment X forming a dorsal shelf; pointed in lateral view, emarginate in dorsal and ventral views. Appendage of segment X flat and thumb-shaped. Valve broad, fan-shaped. Vulval scale rounded apically and bearing many minute setae. Vaginal apparatus oval and with central keyhole-shaped sclerites.

Material examined

Holotype, ♂, BRAZIL: Minas Gerais, Serra do Caraça, 27.xi.1972 (*Exp. Mus. Zool.*) (MZSP).

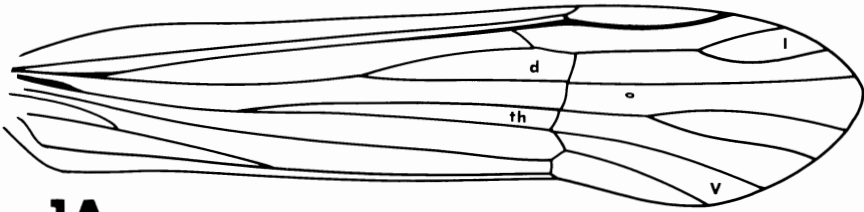
Paratypes. Same data as holotype, except 3.xii.1972, 2♂, 1♀ (MZSP). Same, except 30.xi.1972, 2♂, 2♀ (MZSP). Same, except 4.xii.1972, 4♂, 1♀ (USNM). Same, except 27.xi.1972, 2♀ (USNM). Same, except 29.xi.1972, 2♂ (CLEM). Serra do Cipó, Caminho da Usina, Rio Capivara, 21.ix.1976 (*Froehlich et al.*), 1♂, 2♀ (MZSP). Same, except 20.xii.1974, 5♂, 1♀ (MZSP). Same, except 19.iv.1975, 1♂ (MZSP). Serra do Cipó, km 116, Rio Brauninha, 19.xii.1974 (*Froehlich*), 1♀ (MZSP). Same, except km 110, 19.xii.1973, 1♂, 1♀ (MZSP). Same, except 29.x.1974, 1♂ (MZSP).

Etymology. Named for the type locality.

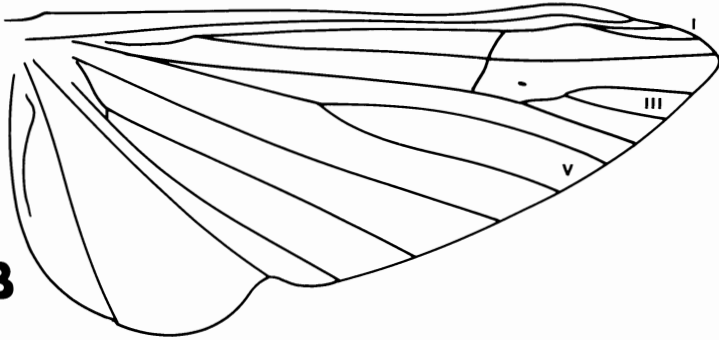
***Notalina morsei* sp.n.** (Figs. 5-6)

This species most closely resembles *N. cipo*. Its male can be separated from *N. cipo* and those of other members of the *brasiliiana* group by the shape of abdominal segment X, with its mound-like protuberance; the short, stubby, preanal appendage; and the structure of the inferior appendage.

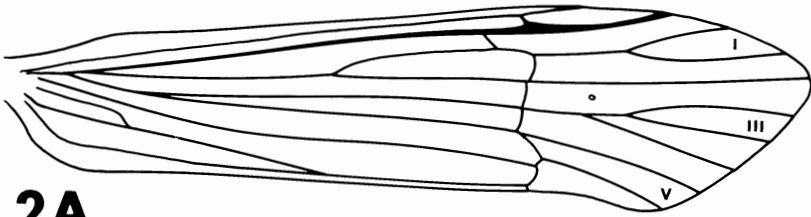
Male. Length of forewing 10 mm. Colour brown in alcohol. Genitalia as in Figs. 5A-5E.



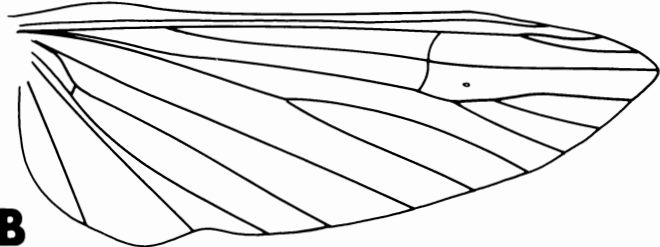
1A



1B



2A



2B

FIG. 1. *Notalina brasiliana*, male wings: A, forewing; B, hindwing.

FIG. 2. *Notalina brasiliana*, female wings: A, forewing; B, hindwing.

Abdominal segment IX annular; broadest laterally. Segment X saddle-shaped; apex divided into a pair of broad lobes and with a setose, mound-like protuberance mid-dorsally. Preanal appendage short and stubby. Inferior appendage bearing a long, slender, pointed, baso-mesal process; a ventro-mesal, thumb-like process; two sclerotized points mid-

ventrally; and a finger-like apical portion. Phallic apparatus with phallic apodeme and phallobase well developed. Phallobase with a pair of dorsally directed, acuminate flanges, hooked and upturned at their ties. Phallosomal sclerite well developed; bifid at apex and with an anteriorly-directed projection when viewed dorsally.

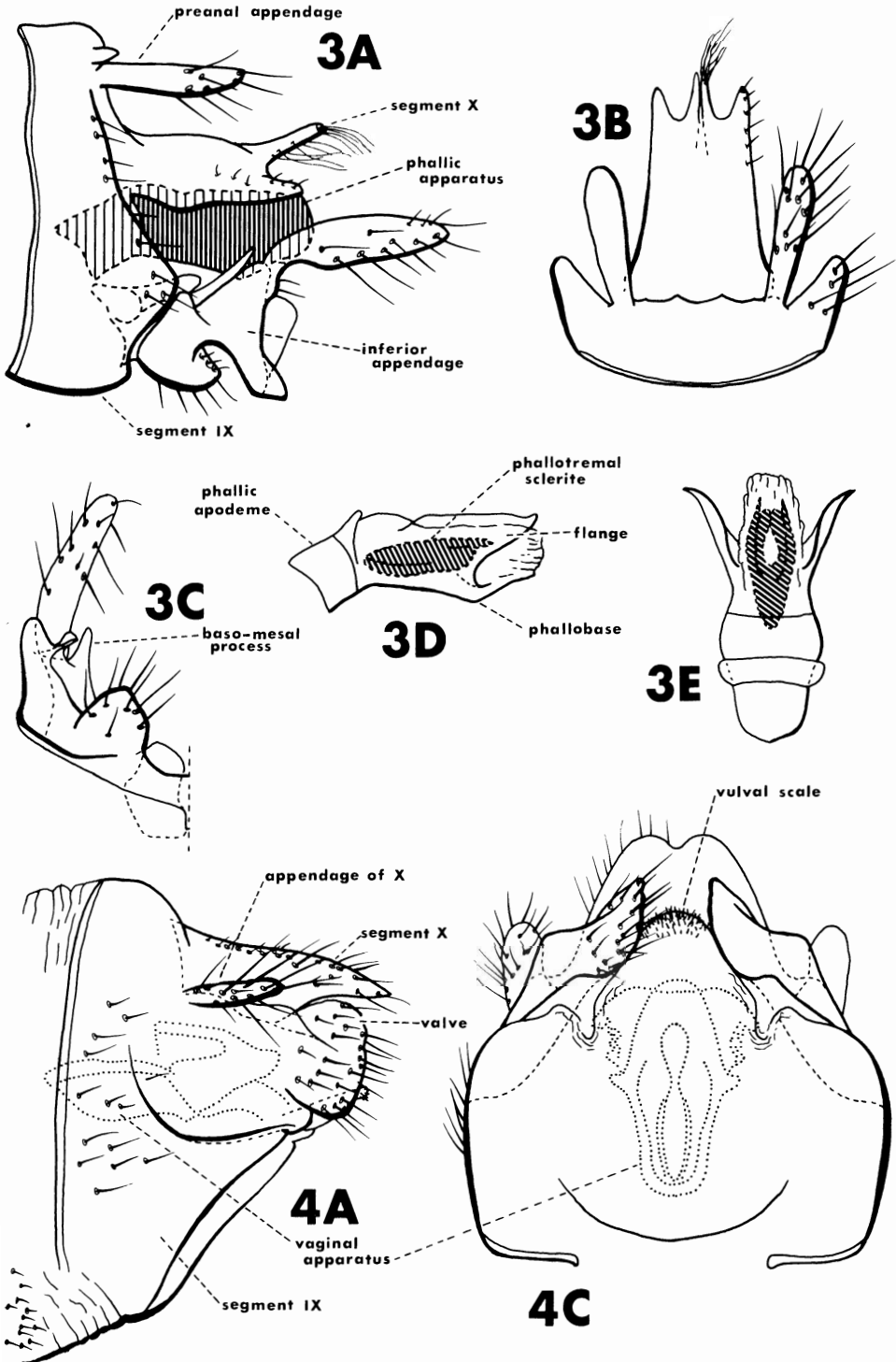


FIG. 3. *Notalina brasiliensis*, male genitalia: A, lateral; B, dorsal; C, left inferior appendage, ventral; D, phallic apparatus, lateral; E, same, dorsal.

FIG. 4. *Notalina brasiliensis*, female genitalia: A, lateral; C, ventral.

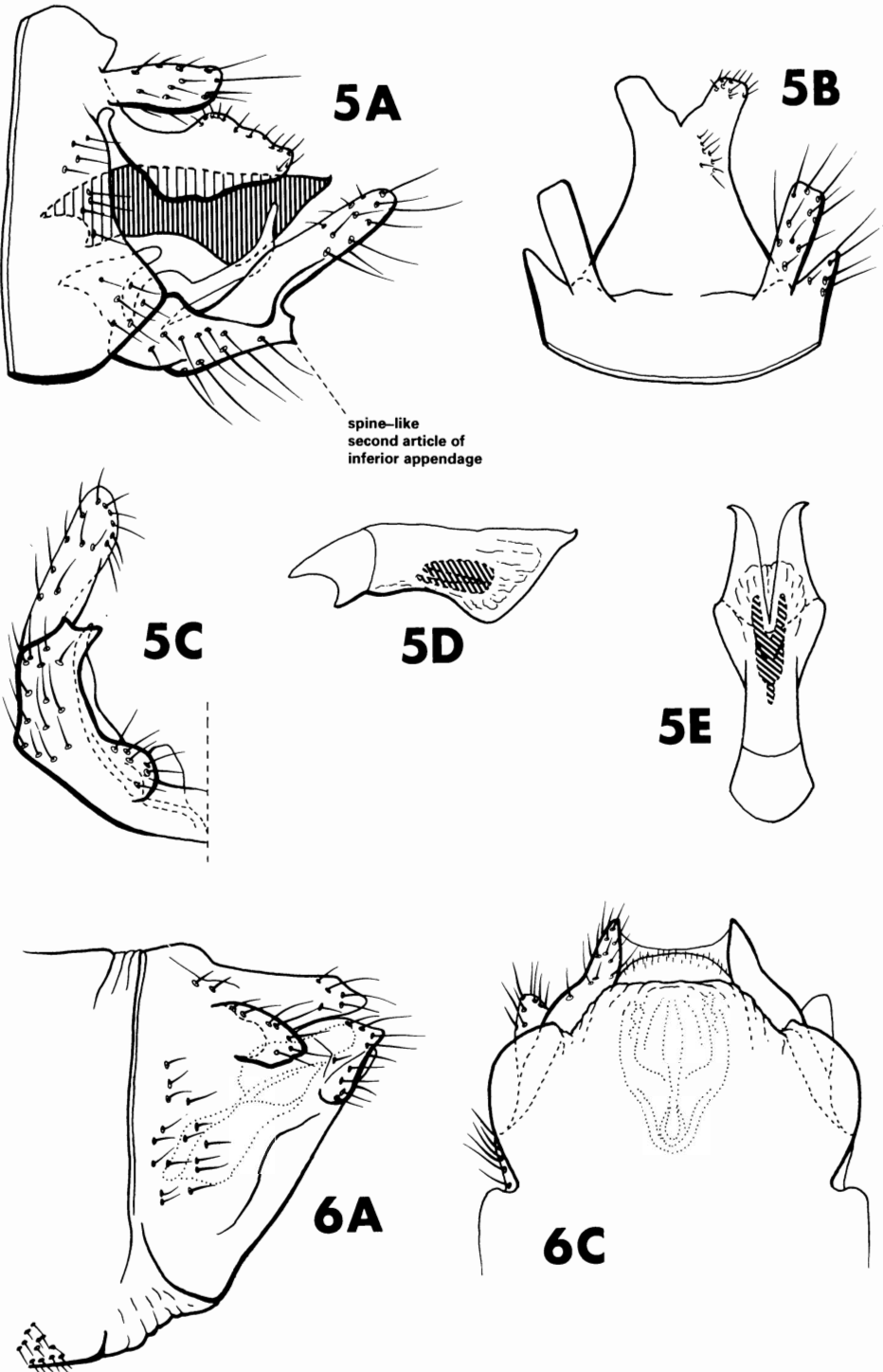


FIG. 5. *Notalina morsei*, male genitalia: A, lateral; B, dorsal; C, left inferior appendage, ventral; D, phallic apparatus, lateral; E, same, dorsal.

FIG. 6. *Notalina morsei*, female genitalia: A, lateral; C, ventral.

Female. Size, colour and structure similar to male. Genitalia as in Figs. 6A, 6C. Sternum IX a smooth, rectangular, slightly concave plate. Segment X forming a dorsal shelf; apex acute in lateral view, broadly rounded in dorsal or ventral views. Appendage of segment X ear-shaped. Valve acute, ventral margin rounded. Vulval scale rounded apically and bearing many minute setae. Vaginal apparatus oval and with central keyhole-shaped sclerites.

Material examined

Holotype, ♂, BRAZIL: Minas Gerais, Serra do Cipó, 17.xii.1974 (*Froehlich*) (MZSP).

Paratypes. Some data as holotype, 3♂, 1♀ (USNM). Same, except 17.iv.1975 (*Froehlich, de Carvalho, Shimuzu*), 4♂, 3♀ (CLEM).

Etymology. I take great pleasure in naming this species in honour of Dr John C. Morse, in recognition of his contributions to trichoperology and for his guidance and encouragement.

Notalina cipo sp.n. (Fig. 7)

This member of the *brasiliana* group is most similar to *N. morsei*. The deeply excised apex of the male abdominal segment X and the massive basal portion of the inferior appendage render it distinct.

Male. Length of forewing 9 mm. Colour brown in alcohol. Genitalia as in Figs. 7A–7E. Abdominal segment IX annular; broadest laterally. Segment X in lateral view with basal half broad and parallel sided, tapering to a pair of truncate processes; apex deeply excised in dorsal view; a pair of small, lateral protuberances present mid-dorsally. Preanal appendage long and slender. Inferior appendage broad and massive basally; with a long, slender, baso-mesal process, a lateral ridge, and a sharply pointed process at middle of mesal face; apical portion short and finger-like. Phallic apparatus with phallic apodeme and phallobase well developed. Phallobase with a pair of dorsally-directed, acuminate flanges, hooked and downturned at their tips. Phallosclerite well developed; bifid at apex, with tips overlapping.

Female. Unknown.

Material examined

Holotype, ♂, BRAZIL: Minas Gerais, Serra do Cipó, km 126, 27.x.1974 (*Froehlich*) (MZSP).

Etymology. Named for the type locality.

Notalina hamiltoni sp.n. (Fig. 8)

Notalina hamiltoni, the fourth member of the *brasiliana* group, differs most from its relatives in the structure of male abdominal segment X. In *N. hamiltoni* segment X is a lightly sclerotized shelf, notched at its apex. The shapes of the inferior appendage and phallic apparatus are also distinctive.

Male. Length of forewing 9 mm. Colour brown in alcohol. Genitalia as in Figs. 8A–8E. Abdominal segment IX annular; broadest laterally; tergum IX slightly produced posteriorly. Segment X a lightly sclerotized shelf, slightly notched at apex. Preanal appendage short. Inferior appendage broad basally; with a long, thick, baso-mesal process, a mid-ventral scoop-like projection, and a sharply pointed process at middle of mesal face; apical portion long and finger-like. Phallic apparatus with phallic apodeme and phallobase well developed. Phallobase with a pair of dorsally-directed, acuminate flanges, hooked at tips; ventral portion of phallobase forming a shelf. Phallosclerite well developed; U-shaped.

Female. Unknown.

Material examined

Holotype, ♂, BRAZIL: São Paulo, Estación Biol. Boraceia, xi.1963 (*Papauro & Rand*) (MZSP).

Etymology. This species is named in honour of Mr Steven W. Hamilton, in recognition of his contributions to our knowledge of Nearctic caddisflies.

Notalina roraima sp.n. (Fig. 9)

This species and the following two comprise the *roraima* species group, defined by the paired, spatulate flanges of the male phallosclerite.

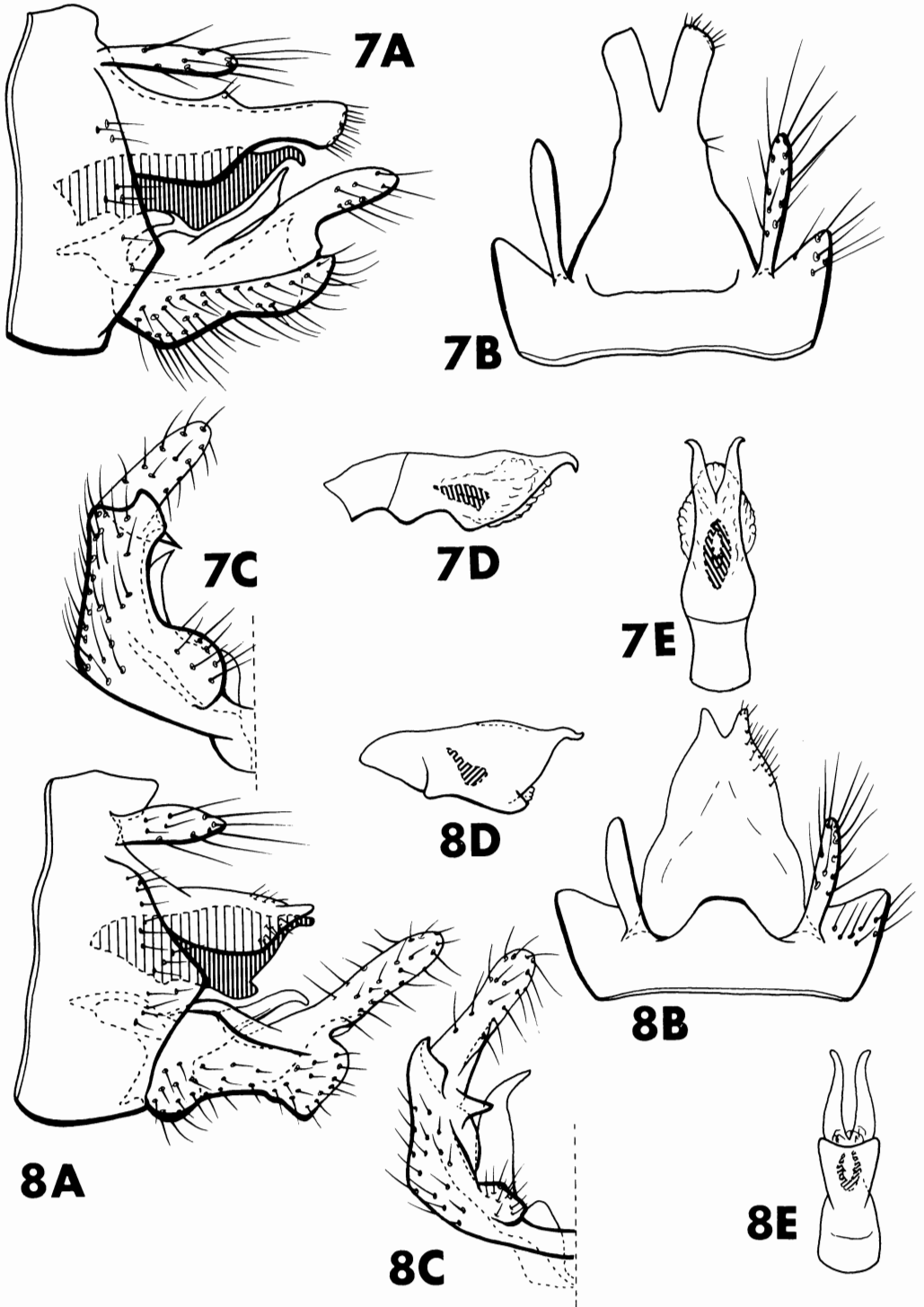


FIG. 7. *Notalina cipo*, male genitalia: A, lateral; B, dorsal; C, left inferior appendage, ventral; D, phallic apparatus, lateral; E, same, dorsal.

FIG. 8. *Notalina hamiltoni*, male genitalia: A, lateral; B, dorsal; C, left inferior appendage, ventral; D, phallic apparatus, lateral; E, same, ventral.

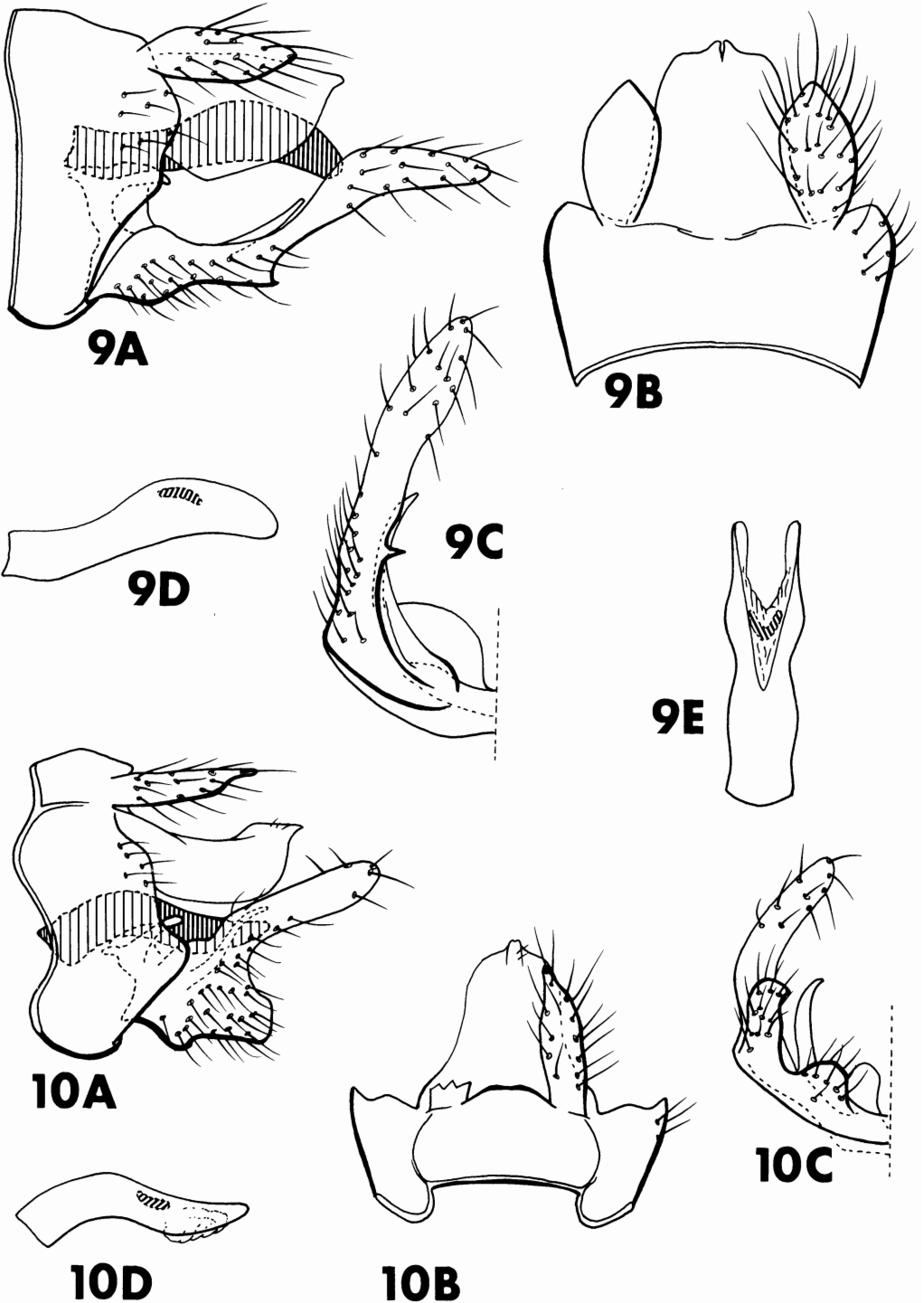


FIG. 9. *Notalina roraima*, male genitalia: A, lateral; B, dorsal; C, left inferior appendage, ventral; D, phallic apparatus, lateral; E, same, dorsal.

FIG. 10. *Notalina nanay*, male genitalia: A, lateral; B, dorsal; C, left inferior appendage, ventral; D, phallic apparatus, lateral.

base and by the underdeveloped phallotremal sclerite. The male of *N. roraima* is easily separated from that of other members of the group by its long, slender, inferior appendage and broad, flat, preanal appendage.

Male. Length of forewing 7 mm. Colour brown in alcohol. Genitalia as in Figs. 9A–9E. Abdominal segment IX annular; broadest dorsally and laterally. Segment X broad, hood-shaped; slightly cleft at apex. Preanal appendage broad and flat. Inferior appendage with basal and apical portion long and slender; bearing a long, slender, baso-mesal process and a sharply pointed, mid-ventral projection. Phallic apparatus simple; with phallobase divided into a pair of spatulate flanges. Phallotremal sclerite lightly sclerotized; U-shaped.

Female. Unknown.

Material examined

Holotype, ♂, VENEZUELA: Bolivar, Cumbre Roraima, Cerra Hitogeographica, 2800 m, 18.ii.1978 (*Joly*) (UCV).

Etymology. Named for the type locality.

Notalina nanay sp.n. (Fig. 10)

The broad basal region of the inferior appendage and the shape of abdominal segment X in the male separate this species from *N. roraima* and the following one.

Male. Length of forewing 7 mm. Colour brown in alcohol. Genitalia as in Figs. 10A–10D. Abdominal segment IX annular; anterior and posterior margins sinuate. Segment X saddle-shaped; with a small, apical, dorso-mesal ridge. Preanal appendage with apex acuminate. Inferior appendage with a long, slender, baso-mesal process; basal half broad and with a prominent ventral lobe; apical half long and finger-like. Phallic apparatus simple; with phallobase divided into a pair of spatulate to bill-shaped flanges. Phallotremal sclerite lightly sclerotized, U-shaped.

Female. Unknown.

Material examined

Holotype, ♂, PERU: Loreto, Callicebus Res. Station Mishana, Río Nanay, 25 km SW

Iquitos, 120 m, 10–17.i.1980 (*Heppner*) (USNM).

Etymology. Named for the Río Nanay.

Notalina matthiasi sp.n. (Figs. 11, 12)

This member of the *roraima* group is easily recognizable by the presence of numerous, small, spine-like setae on abdominal segment X and by the shape of the inferior appendage in the male.

Male. Length of forewing 10 mm. Colour brown in alcohol. Genitalia as in Figs. 11A–11D. Abdominal segment X annular. Segment X broad, saddle-shaped; with a deep, apical, dorso-mesal cleft; many small, spine-like setae present along sides and ventral edge, and a pair of spine-like setae at apex. Preanal appendage broad, slightly acuminate. Inferior appendage with a long, slender, baso-mesal process; basal portion with a broad, truncate process and with a quadrate process bearing sharply pointed corners; apical portion long, slender and finger-like. Phallic apparatus simple, with phallobase divided into a pair of broad, spatulate flanges. Phallotremal sclerite lightly sclerotized, U-shaped.

Female. Size, colour and structure similar to male. Genitalia as in Figs. 12A, 12C. Abdominal sternum IX a smooth, rectangular, slightly concave plate. Segment X forming a broad, thin, dorsal shelf; pointed in lateral view, gently emarginate in dorsal and ventral views. Appendage of segment X flat, ear-shaped. Valve broad, rounded. Vulval scale somewhat acute and bearing many small setae. Vaginal apparatus oval and with central keyhole-shaped sclerites.

Material examined

Holotype, ♂, COLOMBIA: Antioquia, Quebrada del Cebolla, W of La Fe, 25 km E Medellín, 2500 m, 21.iii.1984 (*Matthias*) (USNM).

Paratype. Same data as holotype, except 13.x.1983, 1 ♀ (USNM).

Etymology. Our knowledge of the caddisflies of Colombia has increased greatly through the efforts of Dr Uwe Matthias. This species is named in recognition of his contributions.

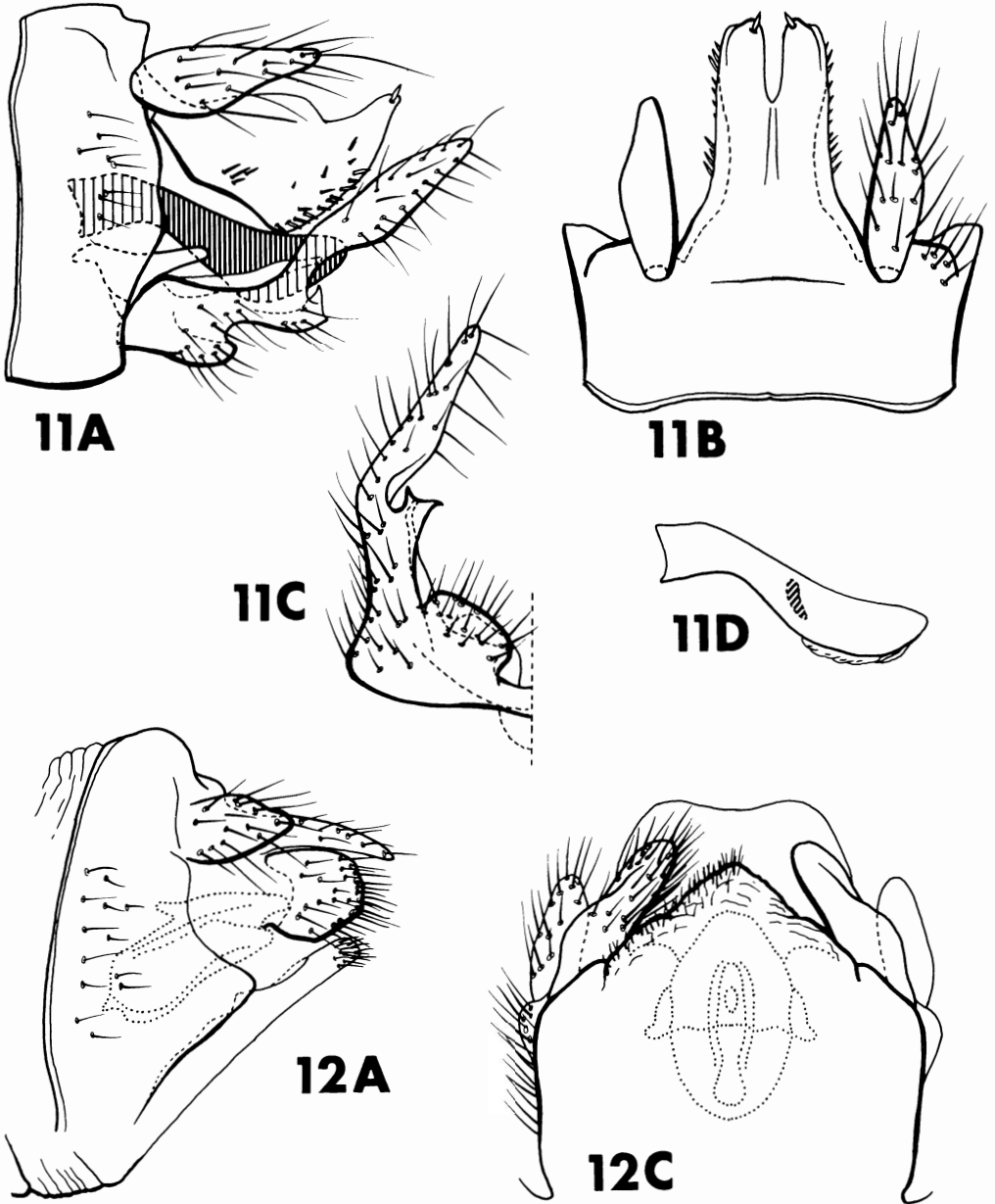


FIG. 11. *Notalina mathiasi*, male genitalia: A, lateral; B, dorsal; C, left inferior appendage, ventral; D, phallic apparatus, lateral.

FIG. 12. *Notalina mathiasi*, female genitalia: A, lateral; C, ventral.

Historical biogeography

The subfamily Triplectidinae is very speciose in Australia and South America. At least fourteen genera and almost 100 species occur in those two regions. No species are known to

occur in Africa, North America or Europe. The few widespread species of *Triplectides* found in India, Southeast Asia, Japan and Indonesia appear to be recent dispersalists from the Australian region. Based on these distributional data and the phylogenetic rela-

tionships of the subgenera and species groups of *Notalina* presented above, the following biogeographic hypotheses were developed using the vicariance approach to historical biogeography of Rosen (1978) and Nelson & Platnick (1981).

The Triplectidinae appear to be Gondwanian and apparently became isolated on Australia–Antarctica–South America when that landmass and Afroindia separated during the late Cretaceous, approximately 85 m.y. B.P. (Rosen, 1978). More or less direct genetic panmixis by ancestral triplectidines between Australia and South America via Antarctica may have been possible until about 45 m.y. B.P. (Raven & Axelrod, 1974). This time-table concurs with Morse's (1978, 1981) estimates that the Leptoceridae arose at least by 65 m.y. B.P. and that the Leptocerinae and Triplectidinae lineages became distinct by 40 m.y. B.P. The well-documented trans-Antarctic track is reflected in the distributions of many taxa of aquatic insects, including chironomid midges (Brundin, 1966) and mayflies (Edmunds, 1975), as well as the caddisfly families Helicophidae, Kokiriidae, Philorheithridae and Tasmiiidae (Wiggins, 1984). Apparently, the ancestral trans-Antarctic biota was adapted to temperate climates (Cracraft, 1975). Since the late Eocene epoch, the gradual separation of Australia and South America from Antarctica and the latter continent's migration to its present position over the South Pole effectively divided the ancestral triplectidine fauna into two isolated groups. Within *Notalina* this isolation resulted in the differentiation of the genus into the subgenera *N. (Notalina)* and *N. (Neonotalina)*, restricted in distribution to Australia–Tasmania and South America, respectively.

Diversification within the Neotropical subgenus may be the result of Quaternary geologic and climatic events, summarized by Simpson (1979). It is assumed that the ancestral *Neonotalina* was distributed throughout South America after the separation from Australia. With the onset of Pleistocene glaciation, opportunity occurred for the fragmentation of the ancestral population into northern and southeastern populations by the intervening increased aridity of the Amazon Basin and Colombian and Venezuelan Llanos during interglacial cycles (Simpson, 1979, especially

Figs. 7.4 and 7.7). This is reflected in the distributions of the species-groups of *Neonotalina*: *roraima* group species occur in the upper Amazon basin, the northern Andes, and the Guiana Highlands; *brasiliiana* group species seem to be limited in distributed to the highlands of southeastern Brazil. Alternatively, the two species-groups could have become isolated much earlier as a result of the formation of the Amazon Basin in Miocene–Pliocene times. The contemporary composition and distribution of *Neonotalina* species could then be the result of the interaction of more recent, Late Tertiary orogenic and Pleistocene glacial perturbations.

Scientific hypotheses, no matter how well corroborated, are always subject to falsification (Popper, 1965). Even so, the leptocerid phylogenetic hypotheses, upon which these biogeographic hypotheses are based, are founded on a particularly small number of apparent homologues. Therefore, corroboration of the phylogenetic hypotheses through further character analysis is needed in order to improve these biogeographical inferences.

Acknowledgments

I am especially grateful to Dr Oliver S. Flint, Jr, Smithsonian Institution, and to Drs C. Froehlich and C. Costa, Museu de Zoologia, Universidade de São Paulo, for allowing me to examine material. Thanks also to Dr Flint and to Dr John C. Morse, Clemson University, for useful discussions concerning this work. Partial funding for this research was provided by the R. Brice Waters Fellowship, College of Agricultural Sciences, Clemson University. This support is gratefully acknowledged. This is Technical Contribution 2334 of the South Carolina Agricultural Experiment Station.

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Accepted 27 October 1984