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Revision of *Campsurus violaceus* species group (Ephemeroptera: Polymitarcyidae) with new synonymies and *nomina dubia* in *Campsurus* Eaton, 1868

C. MOLINERI[1], F. F. SALLES[2] & D. EMMERICH[1]

[1]*Instituto de Biodiversidad Neotropical - CONICET (National Council of Scientific Research), National University of Tucumán, Tucumán, Argentina. E-mail: carlosmolineri@gmail.com; danielemmerich07@gmail.com*
[2]*Laboratório de Sistemática e Ecologia de Insetos, Depto. de Ciências Agrárias e Biológicas, Universidade Federal do Espírito Santo, CEP 29.933−415, São Mateus, ES, Brazil. E-mail: ffsalles@gmail.com*

Abstract

The *violaceus* species group (formerly *notatus* species group) of *Campsurus* Eaton is revised. All the species in the *violaceus* group are diagnosed. A new species, *C. molinai* **sp. nov.** is described based on male imagos from Bolivia, characterized by their large and sclerotized penes. The *violaceus* group is proposed to include the following species: *C. assimilis* Traver, *C. truncatus* Ulmer (=*C. mahunkai* Puthz = *C. melanocephalus* Pereira & da Silva, new synonyms), *C. violaceus* Needham & Murphy (= *C. meyeri* Navás = *C. notatus* Needham & Murphy = *C. paranensis* Navás, new synonyms), *C. emersoni* Traver, *C. decoloratus* (Hagen), and *C. molinai* sp.nov. Additionally we consider the following species as *nomina dubia*: *C. longicauda* Navás, *C. pfeifferi* Navás, *C. zikani* Navás, *C. albicans* (orig. *Ephemera albicans* Percheron in Guerin & Percheron), *C. burmeisteri* Ulmer, *C. dallasi* Navás, *C. quadridentatus* Eaton, *C. claudus* Needham & Murphy, *C. corumbanus* Needham & Murphy, *C. dorsalis* (Burmeister), *C. mutilus* Needham & Murphy, and *C. striatus* Needham & Murphy. Given the results presented herein (five species synonymized and 12 proposed as *nomina dubia*), only 28 valid species remain in the genus *Campsurus*. Additionally, the nymphal stages of *C. violaceus* and *C. truncatus* are described and illustrated. Female adult genitalia (sockets) and eggs of *C. decoloratus* are described for the first time. Diagnoses, new country records, and redescriptions of selected characters of the imagos for the species of the *violaceus* group are given.

Key words: Campsurinae, Ephemeroidea, burrowing mayfly, taxonomy

Introduction

Campsurus Eaton, 1868 is a speciose genus of mayflies (Ephemeroptera: Polymitarcyidae) characterized by burrowing nymphs that live in soft substrates of lentic habitats (Domínguez *et al.* 2006). The relative large size and frequent presence of specimens at lights occasioned a lot of early descriptions of species, descriptions that most of the time are inadequate and made only from one or few adults (e.g., Guerin & Percheron 1838, Weyenbergh 1883, Eaton 1871, 1883, Navás 1927, 1931a, 1931b).

After recent taxonomic works (Domínguez *et al.* 2006, Molineri & Emmerich 2010, Emmerich & Molineri 2011, and Molineri & Salles 2013) the total number of valid species in *Campsurus* raised to 41, divided in four species groups. From this list, 13 species lack reliable diagnosis, description or drawings. Because of that, Domínguez *et al.* (2006) could not assign them to a particular species-group based on characters of male genitalia: *C. albicans* Percheron, *C. dallasi* Navás, *C. holmbergi* (Weyenbergh) (sic: it is known only from female), *C. nappii* (Weyenbergh), *C. paranensis* Navás, *C. pfeifferi* Navás, *C. quadridentatus* Eaton, *C. wappaei* (Weyenbergh), and *C. zikani* Navás, or because they were only known from females: *C. claudus* Needham & Murphy, *C. corumbanus* Needham & Murphy, *C. dorsalis* (Burmeister), *C. mutilus* Needham & Murphy, and *C. striatus* Needham & Murphy. *Campsurus paraquarius* Navás (1920) is now considered a *nomen nudum* in Asthenopodinae by Molineri *et al.* (2015). Domínguez *et al.* (2006) considered *Campsurus holmbergi, C. nappii* and C. *wappaei* as *nomina dubia*.

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Types of *C. paranensis* and *C. meyeri* were recently rediscovered and are here discussed and illustrated. Both species are considered junior subjective synonyms of *C. violaceus* (from the *notatus* group of *Campsurus* sensu Domínguez *et al.* 2006). The *notatus* group was proposed by Domínguez *et al.* (2006) to include: *C. assimilis* Traver, *C. mahunkai* Puthz, *C. melanocephalus* Pereira & da Silva, *C. meyeri* Navás, *C. notatus* Needham & Murphy, *C. truncatus* Ulmer, and *C. violaceus* Needham & Murphy.

Only two of the species groups were formally studied in a phylogenetic context (*major* and *albifilum*, Molineri & Salles 2013) and their monophyly appeared as strongly supported. The *notatus* group appears defined by autapomorphic changes in pedestal and penes (Domínguez *et al.* 2006) but this was not studied formally yet. The heterogeneous *segnis* group is under study and its monophyly is doubtful.

Additionally, in the present paper we describe and illustrate the nymphal stage of *C. violaceus* and *C. truncatus*, giving some characters to distinguish them from the other known nymphs of the genus. A new species, *C. molinai* is described from males from Bolivia. Female adult genitalia (sockets) and eggs of *C. decoloratus* are described for the first time. Diagnoses, new country records, and redescriptions of selected characters of the imagos for the species of the *violaceus* group are given.

Material and methods

All material is preserved in 96% ethyl alcohol. Dissected parts were mounted in Canada Balsam except wings, which were mounted dried. Sterna VIII of female adult were dissected and treated with KOH for 10−15 minutes before mounting them in ventral view in Canada Balsam. Pinned specimens were rehydrated following Alba-Tercedor (1987) before dissecting and mounting. The term "adult" is used in the text when the stage (imago or subimago) could not be determined with certainty.

Material is deposited in the following Institutions: CUIC (Cornell University Insect Collection, Ithaca, NY, USA), FAMU (Florida A&M University, Tallahassee, FL, USA), IBIGEO (Instituto de Bio y Geociencias del NOA, Salta, Argentina), IBN (Instituto de Biodiversidad Neotropical, Tucumán, Argentina), MACN (Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina), RBINS (Royal Belgian Institute of Natural Sciences, Brussels, Belgium); CZNC (Coleção Zoológica Norte Capixaba, ES, Brazil); ZMH (Zoologisches Museum Hamburg, Hamburg, Germany); FCE-Ep (Facultad de Ciencias, Entomología, Montevideo, Uruguay); MUSENUV (Museo de la Universidad del Valle, Cali); UMSA (Universidad Mayor de San Andrés (La Paz, Bolivia) and MZSP (Museu de Zoologia de São Paulo, São Paulo, Brazil).

Results

Validity of species (Tables 1 and 2). Three species inadequately described by Navás: *C. longicauda* Navás (1931a), *C. pfeifferi* Navás (1931b) and *C. zikani* Navás (1934), are proposed here as *nomina dubia* (Table 2) since the types were destroyed in 1951 on the return of the German Entomological Institute of Blücherhof to Berlin (Petersen & Gaedike 1968). Additionally, neither the figures nor the descriptions are useful to assign any specimen to them.

The following species known from males but with damaged types and inadequate descriptions and figures are also treated as *nomina dubia* (Table 2): *Campsurus albicans* (orig. *Ephemera albicans* Percheron in Guerin & Percheron 1838), *Campsurus burmeisteri* Ulmer (1942), *Campsurus dallasi* Navás (1927), and *Campsurus quadridentatus* Eaton (1871).

Finally, all the species only known from female adults very badly described and with lost or damaged types are also considered *nomina dubia* (Table 2): *C. claudus* Needham & Murphy (1924), *C. corumbanus* Needham & Murphy (1924), *C. dorsalis* (Burmeister, 1839), *C. mutilus* Needham & Murphy (1924), and *C. striatus* Needham & Murphy (1924).

The remaining 28 species are still considered as valid (Table 1).

TABLE 1. Valid species and species-groups in *Campsurus* (Polymitarcyidae, Campsurinae). Abbreviations: m (male imago), f (female imago), n (nymph).

Species-group	species and author	last revision	known stages	synonyms
albifilum	*C. albifilum* (Walker)	Molineri & Salles (2013)	m, f	
	C. homaulos Molineri & Salles	Molineri & Salles (2013)	m, f	
	C. gracilipenis Molineri & Salles	Molineri & Salles (2013)	m, f	
	C. yavari Molineri & Salles	Molineri & Salles (2013)	m	
	C. fuliginatus Molineri & Salles	Molineri & Salles (2013)	m	
major	*C. amapaensis* Molineri & Emmerich	Molineri & Emmerich (2010)	m	"sp. C" Traver
	C. major Needham & Murphy	Molineri & Emmerich (2010)	m, n	*C. brasiliensis* Traver
	C. argentinus Esben-Petersen	Molineri & Emmerich (2010)	m, f, n	*C. pallidus* Needham & Murphy
violaceus (*ex notatus)*	*C. assimilis* Traver	here	m, f	
	C. emersoni Traver	Traver (1947b)	m, f	
	C. decoloratus (Hagen)	Traver (1947b)	m	
	C. violaceus Needham & Murphy	here	m, f, n	*C. notatus* Needham & Murphy, *C. meyeri* Navás, *C. paranensis* Navás
	C. truncatus Needham & Murphy	here	m, f, n	*C. mahunkai* Puthz, *C. melanocephalus* Pereira & da Silva
	C. molinai **sp. nov.**	here	m	
segnis	*C. cuyuniensis* Traver	Traver (1947b)	m, f	
	C. cuspidatus Eaton	Eaton (1871)	m	
	C. duplicatus Spieth	Spieth, (1943)	m	
	C. essequibo Traver	Traver, (1947b)	m	
	C. evanidus Needham & Murphy	Emmerich & Molineri (2011)	m, f	*C. juradinus* Navás
	C. indivisus Ulmer	Ulmer (1942)	m, f	
	C. jorgenseni Esben-Petersen	Emmerich & Molineri (2011)	m, f	*C. scutellaris* Needham & Murphy
	C. latipennis (Walker)	Kimmins (1960)	m, f	
	C. litaninensis Spieth	Spieth (1943)	m, f	
	C. lucidus Needham & Murphy	Traver (1947b)	m	
	C. pedicellarius Spieth	Spieth (1943)	m, f	
	C. segnis Needham & Murphy	Traver (1947b)	m, f	
	C. ulmeri Traver	Traver (1950)	m	
	C. vulturorum Emmerich & Molineri	Emmerich & Molineri (2011)	m, f, n	

Violaceus species group

The following combination of characters defines this group: 1) in the male genitalia the pedestals (Figs. 1−8, 11, 28−33, 38−39) are subquadrate to subrectangular and somewhat flat, with the inner distal corner roundly projected posteriorly, always more developed than the outer corner (that may even be absent); 2) penes finger-like (Figs. 1−6, 8−11, 28−30, 38, 40), ventrally curved, and relatively well sclerotized except on a membranous portion ("t" in Figs. 3, 28 and 40); and 3) finger-like portion of penes arising from a single wide pyramidal base that extends somewhat to the outer margin (pb in Figs. 3, 7−8, 28, 40); 4) each foretarsal segment with apical margin sclerotized and slightly projected ventrally; 5) adults of both sexes present the mesofurcasternal protuberances with straight parallel inner margins; 6) female adults show a single anterior socket on sternum VIII (Figs. 34−35, 41−42, 45−46); 7) eggs with a large polar cap formed by many long threads coiled around each other (Figs. 43−44); 8) nymphs present long and slender mandibular tusks, with a row of pointed denticles on inner margin, the most basal one ("st" in Fig. 12) (called "subbasal tubercle" in other works, e.g. Domínguez *et al.* 2006) is larger than the others ("d" in Fig. 13).

TABLE 2. Species recognized as *nomina dubia* in Domínguez *et al.* 2006 (*), Molineri *et al.* 2015 (**), and this paper. Abbreviations: m= male adult, f=female adult.

Species	Author and year	Described stage
C. albicans	(Percheron) in Guerin and Percheron (1838)	m
C. burmeisteri	Ulmer (1942)	m
C. claudus	Needham & Murphy (1924)	f
C. corumbanus	Needham & Murphy (1924)	f
C. dallasi	Navás (1927)	m
C. dorsalis	(Burmeister 1839)	f
C. holmbergi *	(Weyenbergh 1883)	f
C. longicauda	Navás (1931a)	m
C. mutilus	Needham & Murphy (1924)	f
C. nappii *	(Weyenbergh 1883)	m
*C. paraquarius***	Navás (1920)	m
C. pfeifferi	Navás (1931b)	m
C. quadridentatus	Eaton (1871)	m
C. striatus	Needham & Murphy (1924)	f
C. wappaei *	(Weyenbergh 1883)	m, f
C. zikani	Navás (1934)	m

Campsurus violaceus Needham & Murphy
(Figs. 1−3, 5−11, 12−27, 41−43)

Campsurus violaceus Needham & Murphy, 1924: 18; Traver, 1947: 379; Domínguez *et al.* 2006: 580.
Campsurus meyeri Navás, 1934: 24; Traver, 1947: 371; Domínguez et al 2006: 576 NEW SYNONYM
Campsurus notatus Needham & Murphy, 1924: 20; Navás, 1926: 109; Traver, 1944: 39; Traver, 1947: 382; Demoulin, 1955: 30; Irmler, 1975: 348; Domínguez *et al.* 2006: 576 NEW SYNONYM
Campsurus paranensis Navás, 1932: 111; Domínguez et al 2006: 577 NEW SYNONYM

Type material. *C. meyeri*: 3 dried male imagos (in vial, not pinned), in good condition, accompanied by two labels: "*Campsurus meyerii* Long. Navás" (tipping-machine) and "nº 36958" (hand-written), without locality data. We rehydrated one male, dissected and mounted the genitalia, the body is preserved in ethyl alcohol. There is no indication in the vial that these specimens are types, and no collection data is present. The size and general aspect coincide with original description. Deposited in MACN.

C. violaceus: Holotype slides of male imago, one with two pairs of wings and the other with genitalia, both with a red small label and a white larger one that indicate: "Holotype Cornell U. No. 620" and "Cornell University No. 654, SUB. 4, SL♂, *Campsurus violaceus*, Date. Santa Fe Arg", respectively. Allotype slide with a pair of wings of a female adult, bearing two labels: a partially damaged small red one "Allotype, Cornell U., 620.2" and a larger white label including the following information: "Cornell University No. 654, SUB. 4, SL♀, *Campsurus violaceus*, Date. Santa Fe Arg". Deposited at CUIC.

Campsurus notatus holotype male imago slide with genitalia and a pair of wings bearing a white label with a small red label glued above: "Holotype Cornell U. No. 624.1" (red label) and Cornell University, SL♂, *Campsurus notatus*, Paraguay R. Brazil". Paratype male imago slides with a pair of wings and genitalia with two white labels with similar information except additional locality data: Paraguay R., above Porto Esperança, Brazil, and "Paratype Cornell U. No. 624".

Campsurus paranensis: 1 male imago, pinned, in good condition, from ARGENTINA: Santa Fé, 7.i.1927, Bridarolli. Deposited in IBIGEO.

Additional material. ARGENTINA: 2 male imagos, pinned, in good condition, from Delta Río Chana, Col. E.E. Blanchard (MACN); 2 male imagos, pinned, in good condition, one of them bearing a red-bordered hand-written label "*Campsurus holmbergi* Weyh." and a white label indicating "Rep. Argentina, Prov. de Bs As, 189, C. Bruch". The other specimen, with the subimaginal exuvia still attached to the cerci, bear the same information but in white labels (both in MACN); 23 nymphs, 2 reared male and 1 reared female adults from Corrientes, Esteros del Iberá, Colonia Pellegrini, x.2004, P. Pessaq col. (these nymphs were used for the description, drawings and pictures below); 36 male and 4 female adults (male parts on slides IBN70CM and IBN296CM, female IBN297CM) from Santa Fé, Santo Tomé, Salado river, nuptial flight (20 hs), 19.iv.1998, C. Molineri col.; 1 reared male (slide IBN647CM) from Santa Fé, Santo Tomé, Salado river, 14.iv.1997, F. Zilli col.; 20 male and 1 female adults from Corrientes, Mburucuyá National Park, Casco Central Estancia, light trap, 12−14.xii.1999, C. Molineri col.; 3 male imagos from Tucumán, Burruyacu, 3.xi.2008, M.J. Barrionuevo col.; 12 male and 25 female adults from Tucumán, Simoca, Bañados de Monteagudo, 27.iii.1997, light trap (21 hs), C. Molineri col.; 8 male and 12 female adults (IFML) from Santiago del Estero, Colonia Dora, 25.i.1983, A. Willink col.; 22 female adults from Córdoba, Yacanto de San Javier, 14.i.1982, E. Domínguez col.; 30 female adults from Santa Fe, Esperanza, town, light trap (20 hs), 12.iv.1998, C. Molineri col.; 10 male and 3 female adults from Formosa, near Ibarreta, 18.xi.1981, E. Domínguez col.; 6 male and 2 female adults from Formosa, 10 km South from Formosa, Torhue stream, 8.xii.1986, E. Domínguez col.; 12 male and 1 female adults from Santiago del Estero, Dpto. Figueroa, Caspi Corral, 27.xii.1982, E. Lavilla col.; 10 male and 2 female adults (IFML) from Tucumán, La Cocha, Los Pizarro dam, 10−13.xii.1982, R. Golbach col.; 4 male and 7 female adults from Santiago del Estero, Las Termas, Dique Frontal, 2.x.1981, E. Domínguez col.; 11 female adults from Misiones, 10 km NE from San Vicente, INTA Cuartel Victoria, 20.xi.1998, Domínguez, Molineri & Nieto cols.

BOLIVIA: 1 male imago from Cochabamba, río Ichilo floodplain lake, S 16º 4' 45"–W 64º 44' 20", E. Goitía col.

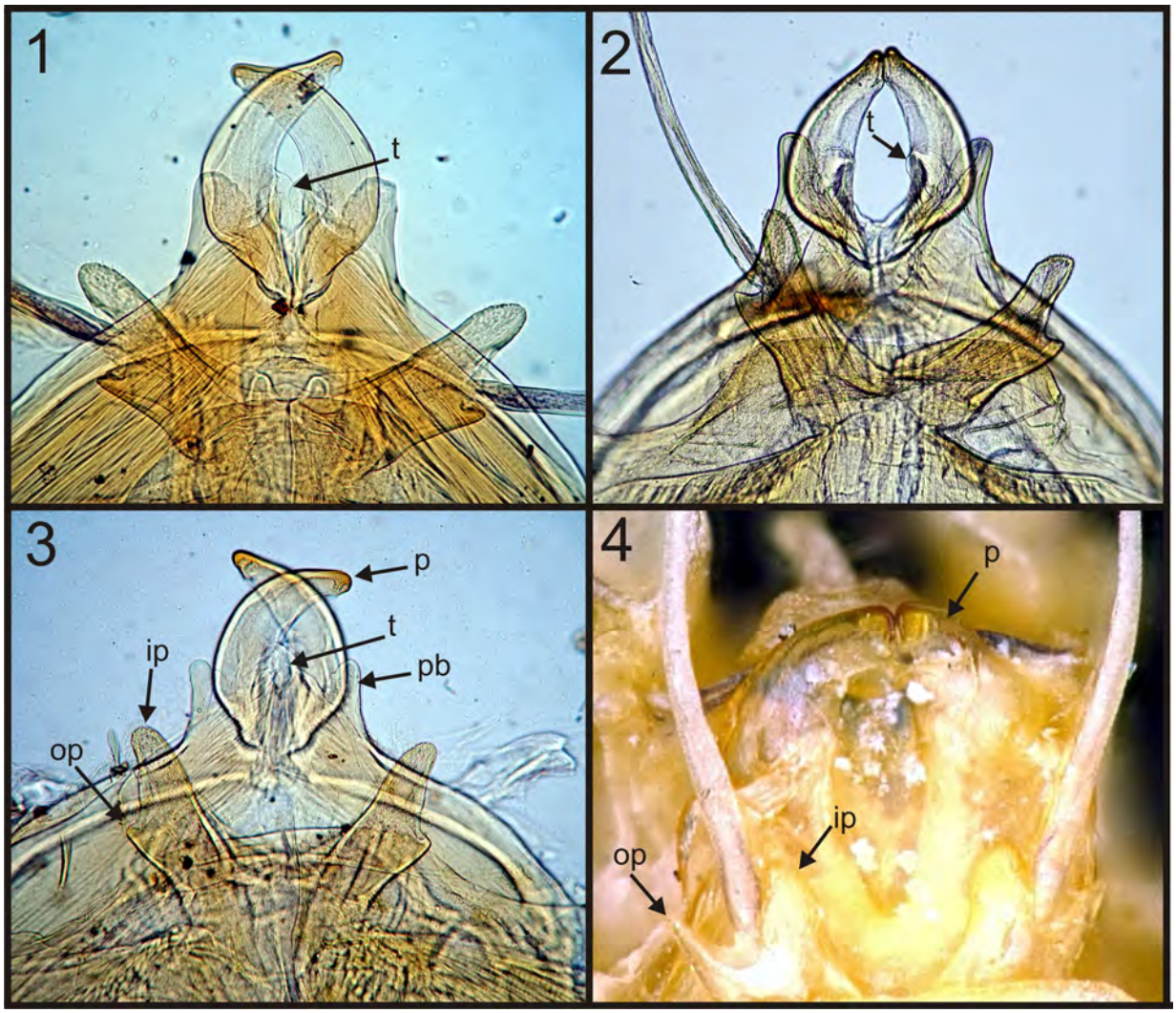
BRAZIL: 6 male imagos from Mato Grosso do Sul, Baia river, light trap, vi.2005, Sandra M. Melo col.; 2 male imagos from Guaraná lake, 28.xii.1997, aprox. S 22° 43' 26"–W 53º 18' 3" (CZNC); 1 male imago, 1 terminalia male imago (body missing) and 10 female adults from Mato Grosso, Transpantaneira rute, Porto Jofre, light trap, 6.v.1984, aprox. 17º 21' 46"–56º 46' 42", B. M. Mascarenhas *et al.* cols. (CZNC); 5 male imagos from Patos lake, 22.iv.1998, aprox. 22º 43' 12"–53º 17' 37" (CZNC); 23 male imagos from Amazonas, floodplain lake, 16−17.ix.2003, UV light trap, aprox S 3º 39' 29"–W 61º 29' 28" (CZNC); 2 male imagos from Brazil, Piauí, 01.vi.2011, Domingos Mourão, Vila Cachoeirinha, road to Domingos Mourão, S 4 º 10' 6"–W 41º 34' 55", P. V. Cruz Col. (CZNC).

COLOMBIA-PERU border: 1 male imago from Amazonas, Rondiña Island, S 4º 08' 23"–W 69º 59' 12", 9−10.ii.1999; M.C. Zúñiga & C. Molineri col (IBN). COLOMBIA: 1 male and 1 female imagos from Amazonas, Puerto Nariño, Loreto Yacu, 5.ii.1999, light trap 18−20 hs, E. Domínguez, M.C.Zúñiga & C. Molineri cols. (IBN); 6 male and 2 female adults same data except Tarapoto lake, 4.ii.1999 (MUSENUV); 2 male imagos from Amazonas, Natural Reserve Palmarí, Yabarí river, administration center, 120 m, 29.v.2002, light trap, S 4º 17' 10"–W 70º 17' 49", Zúñiga, Emmerich, Cardozo-Zúñiga AJ, Cardozo-Zúñiga RJ (MUSENUV); 1 male and 1 female adults (sternum VIII and eggs for SEM dissected from this female) Valle del Cauca, Ríofrío, Riofrío river, 5 km before Salónica, light trap 18−21 hs, N 4º 7' 39"− W 76º 22' 6", 1150 m, 22.ix.2002, Zúñiga, Ballesteros, Cardozo & Cardona cols. (IBN).

URUGUAY: 3 male imagos, Salto, Paso Yacaré, Itapebí stream, 9.i.1978, 21−22hs, Zolessi, Morelli &

Rodríguez cols. (FCE-Ep); 8 male imagos and 7 females imagos, Maldonado, rute nº 12, km 9, “La Chacra”, Laguna del Sauce, 23.xii.2002, ligth trap, D. Emmerich col. (IBN); 43 male imagos and 30 female imagos, Rivera, Santa Ernestina, rute nº 29, stream near Mina Corrales, S 31º 32' 23.8" −W 55º 33' 42", 146 m, 10.xi.2008, ligth trap, D. Emmerich col. (IBN); 7 female imagos, Lavalleja, Camping Arequita, Santa Lucía river, S 34° 17' 06" −W 55° 17' 02", 123 m, 3.iii.2008, ligth trap, D. Emmerich & S. Pérez cols. (IBN); 2 male imagos and 7 female imagos, Maldonado, rute nº 60 (km 23), El Rodeo stream, S 34° 40' 20"− W 55° 14' 15", 75 m, 7.xi.2008, ligth trap, D. Emmerich & S. Pérez cols. (FCE-Ep); 3 male imagos and 16 female imagos, Treinta y Tres, Quebrada de los Cuervos, Yerbal Chico stream, S 32º 55' 35.2" −W 54º 27' 39.6", 78 m, 25.iii.2010; ligth trap, D. Emmerich & C. Molineri cols. (FCE-Ep); 52 male imagos and 53 female imagos, Rocha, rute nº 15, Km 10, La Paloma, La Palma stream, S 34º 35' 10.6" −W 54º 10' 43.1", 5 m, 22.iii.2010, ligth trap, D. Emmerich & C. Molineri cols. (IBN).

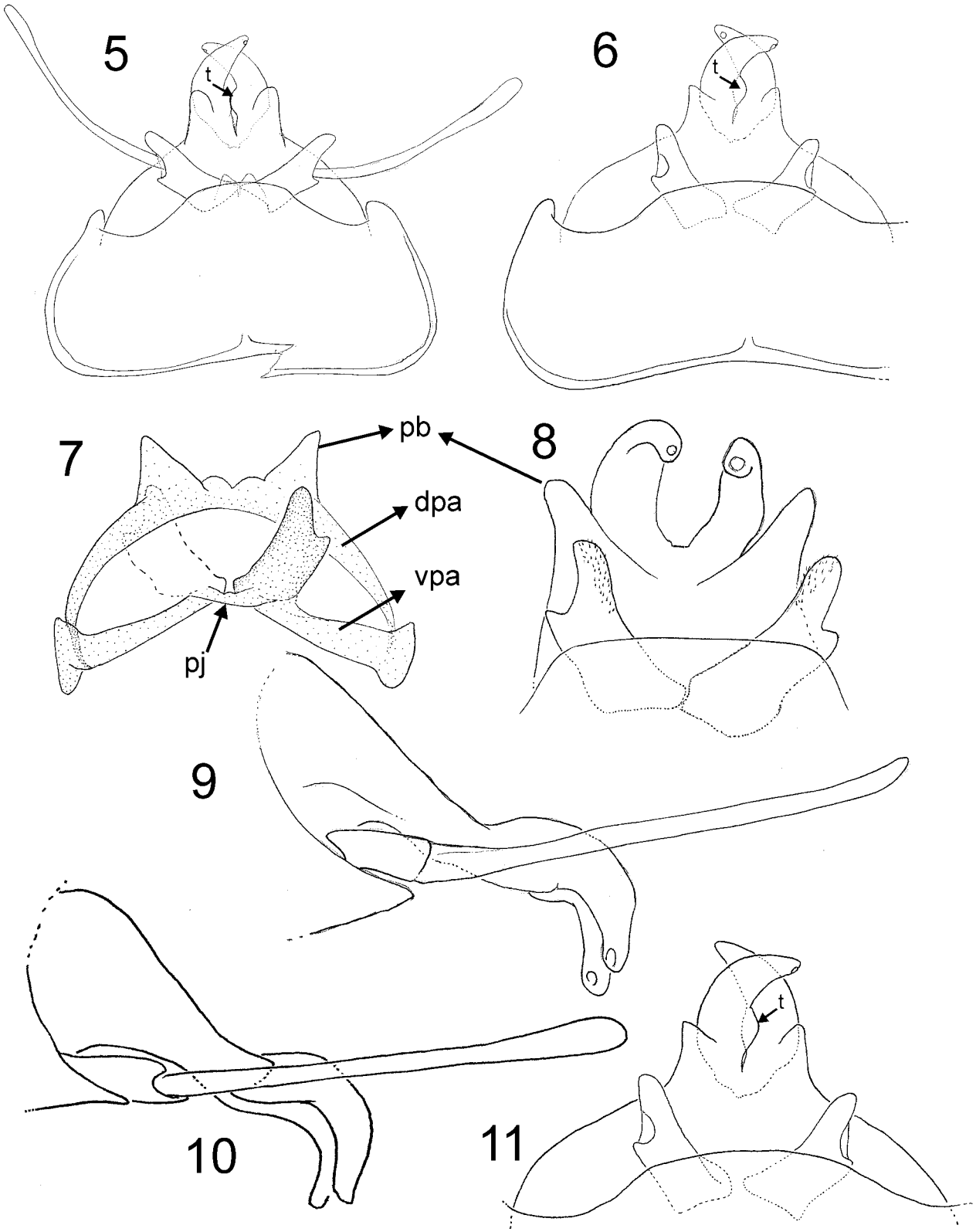
Distribution. Argentina, Bolivia, Brasil, Uruguay, Paraguay, Colombia, Peru.



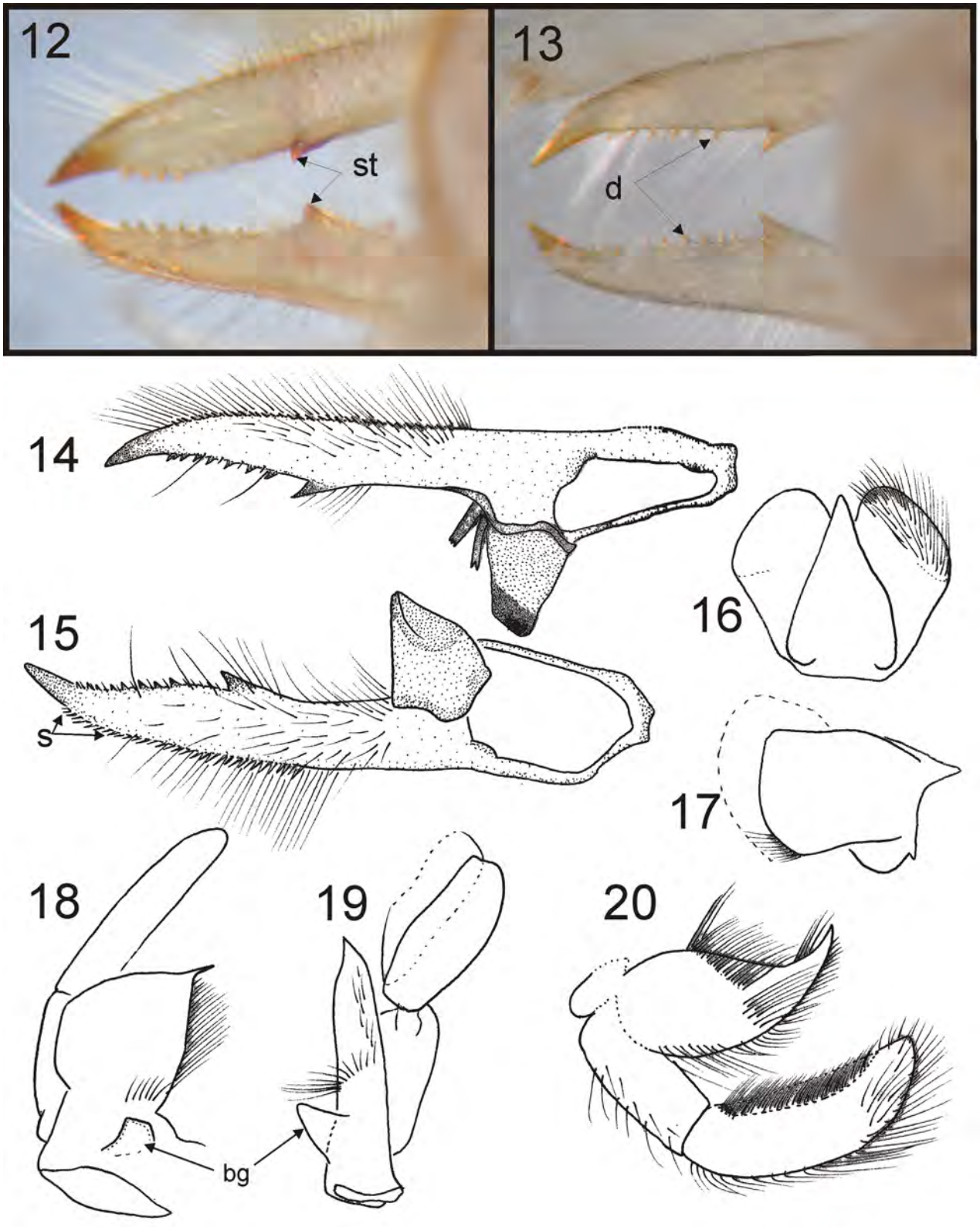
FIGURES 1−4. Photographs of male genitalia (types): 1, *C. violaceus* holotype slide (CUIC); 2, *C. meyeri* paratype (rehydrated and mounted on slide MACN); 3, *C. notatus* holotype slide (CUIC); 4, *C. truncatus* paratypoid (pinned, ZMH). Abbreviations: ip=inner projection (pedestal); op=outer projection (pedestal); p=penes; pb= pyramidal base (penes); t=”thumb” (penes).

Diagnosis. *Campsurus violaceus* can be separated from the other species of the *violaceus* species group by the following combination of characters: 1) pedestals elongate, with the outer corner slightly projected (Fig. 1−3, 5−8, 11); 2) penes relatively slender, with rounded "thumb" ("t" in Fig. 1−3, 5−6, 11); 3) female sternum VIII with relatively wide and short anterior furrow ("f" in Fig. 42) and single socket (Figs. 41−42). Eggs are not distinguishable from other species in the *violaceus* group. One character may be useful to distinguish nymphs of *C. violaceus* from *C. truncatus*, but this should be confirmed with the study of more material of the last species: in *C.*

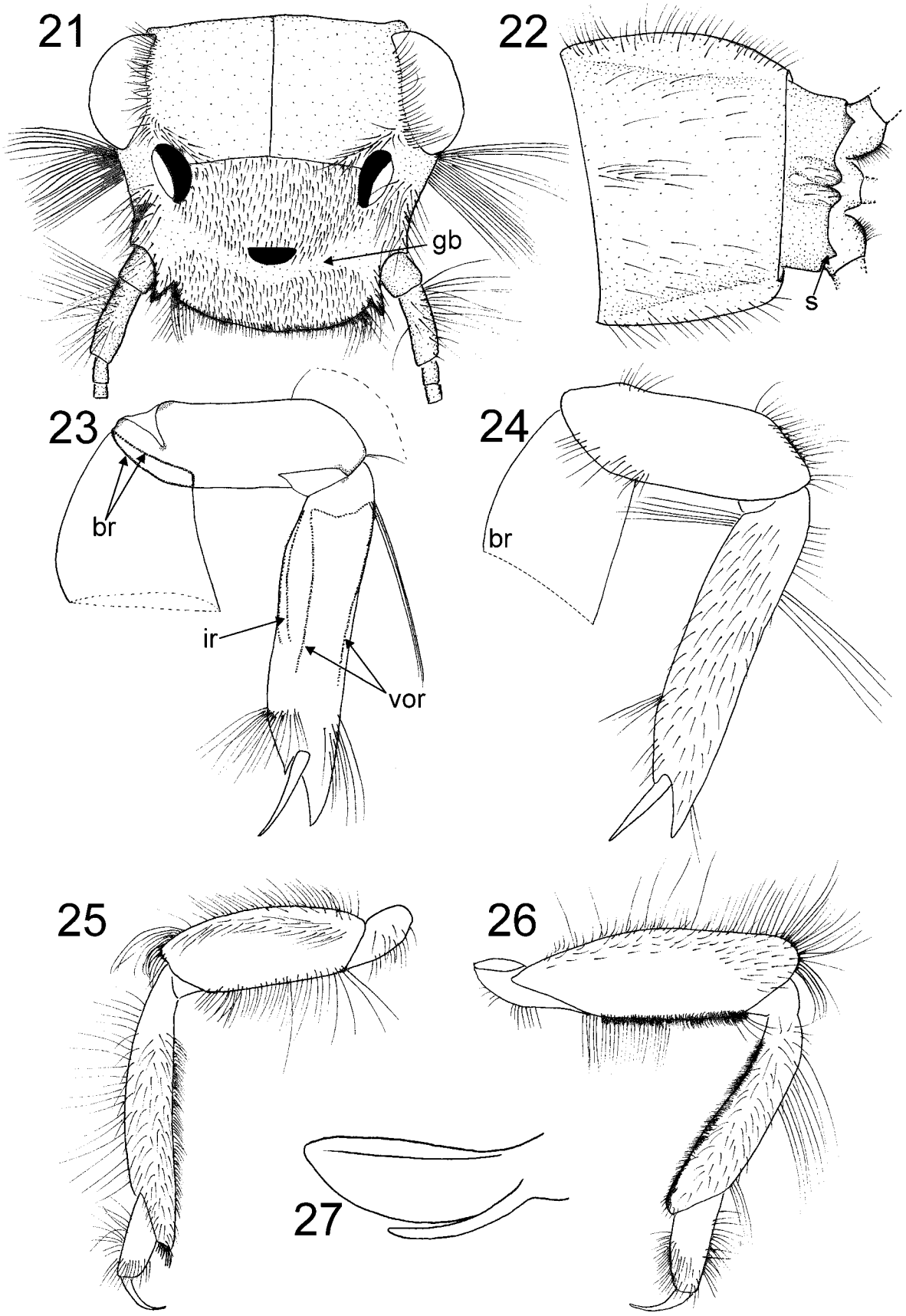
violaceus nymphs, the row of denticles on the inner margin of mandibular tusks is formed by 6−11 denticles that increase in size basally, except the most basal one that is as least three times larger than the previous one (Figs. 12−15); between each one of these denticles a stout seta is present (Figs. 14−15).



FIGURES 5−11. Male genitalia (types): 5, *C. violaceus*, v.v. (holotype); 6, *C. notatus*, v.v. (holotype); 7, *C. notatus*, v.v. (paratype); 8, *C. meyeri*, v.v. (holotype?); 9, same, lateral view; 10, *C. paranensis*, l.v. (holotype); 11, same, v.v. Abbreviations: dpa=dorsal portion of penean arm; pb=pyramidal base (penes); pj=pedestal joint; vpa=ventral portion of penean arm.



FIGURES 12−20. *C. violaceus*, mouthparts: 12−13, photographs of mandibular tusks (different specimens from Santa Fé, showing morphological variations), dorsal view; 14−15, mandibular tusks, d.v. (basal U-row of filtering setae omitted); 16−17, hypopharynx, ventral and lateral view; 18−19, maxilla, ventral and oclusal view; 20, labium, lateral view. Abbreviations: bg=basal gill; d=denticles; st=subbasal tubercle; s=stout spine-like setae.



FIGURES 21−27. *C. violaceus*, nymph. 21, head, d.v.; 22, abdominal sterna IX−X; 23, fore leg, v.v.; 24, same, d.v.; 25, middle leg, d.v.; 26, hind leg, d.v.; 27, gill I. Abbreviations: br= basal row (femoral filtering setae, most setae omitted); gb=glabrous band; ir=inner double row (filtering setae, tibia); vor= ventral-outer double row (filtering setae, tibia); s= spine of paraproct.

Male imago. Length (mm): body, 10.5−11.7; FW, 10.3−12.0; HW, 4.4−5.4; cerci, 29.0; foreleg, 5.0. Foreleg, ratio of segments in relation to femur (1.38 mm): femur (1), tibia (0.9−1.0), tarsomere 1 (0.1); tarsomere 2 (0.3−0.4); tarsomere 3 (0.4), tarsomere 4 (0.4), tarsomere 5 (0.4), short claw (0.2), long claw (0.3). Tarsal segments 2−4 subequal, slightly shorter than 5 (the longest), tarsomere 1 very short. Genitalia (Fig. 1−3, 5−11): sternum IX subtriangular with apical margin straight to slightly concave; pedestal slender, slightly flattened dorsoventrally, distally with large rounded inner corner ("ip" in Fig. 3) and short outer corner generally blunt ("op" in Fig. 3); forceps long and slender distally widened; penes finger-like, curved and ventrally directed, becoming thinner toward the rounded apex, "thumb" relatively well developed and rounded ("t" in Fig. 3).

Female imago. Length (mm): body, 14.0−19.0; FW, 13.6−16.0; HW, 5.5−7.0; cerci, 4.0−5.0. Forelegs generally present but one or both may be lost during the molt from nymph to subimago. Sternum VIII with anterior furrow relatively short and wide, and anterior single socket as in Figs. 41−42; sternum completely covered by microtrichia, except anteriorly and around the socket.

Egg. Length (µm), 210−220; width, 120−130. Ovate (ratio L/W: 1.7−1.8), with a strong concavity as in Fig. 43; the capped pole is slightly wider than the uncapped pole (Fig. 43). Polar cap of Type III (Koss & Edmunds 1974) formed by 12−15 very long filaments twisted around and coiled forming a subcircular cap (Fig. 43). Chorionic surface relatively smooth, very small grooves may be present on concave area (Fig. 43).

Mature nymph. Length of male (mm): body, 14.8−16.2; terminal filament, 7.0−8.0; cerci, 9.0−10.5. Length of female (mm): body, 16.0−19.5; terminal filament, 7.0−7.5; cerci, 6.0−7.0. General coloration whitish yellow with purplish gray shading dorsally. Head (Fig. 21) shaded grayish dorsally, except on whitish genae and yellowish frontal projection; darker between lateral ocelli, pigments forming a netted pattern on occipital area. Head capsule with rows of long setae on inner margin of eyes and lateral ocelli, on lateral edge of genae just anteriorly to eyes, and on anterior margin of frons (Fig. 21); a large area anterior to epicranial suture densely covered with shorter setae, a thin transverse band anterior to ocelli is smoother (with less setae or without setae at all, glabrous band "gb" in Fig. 21). Antennae whitish, the head is slightly elevated at the base of antennae and a strong spine-like projection is present on foremargin of frons, arising also as part of this elevated antennal base; pedicel twice as long as scape, scape with few setae dorsally, pedicel with many setae dorsally as in Fig. 21. Mouthparts whitish except sclerotized areas, spines and thick setae yellowish. Labrum subquadrate, small, covered with setae dorsally; clypeus with straight anterior margin. Mandibles with reduced 3-pointed outer incisor and 2-pointed movable incisor; ventrally with a double row of long filtering setae at base; distally with large and slender 1-pointed mandibular tusks. Mandibular tusks (Figs. 12−15) with a row of pointed denticles, the most basal one (or subbasal tubercle, "st" in Fig. 12) is larger (ca. 3x) than the others ("d" in Fig. 13); intercalated between each of these denticles a single stout seta is present; the number of denticles presents some variation (6−11 in each tusk) but is the same (or differ only by 1 or 2) in both mandibles. Tusks are covered by long simple setae, mainly on dorsum and outer margin; also on outer margin a row of short stout spine-like setae are present ("s" in Fig. 15). Maxillae with a subtriangular membranous gill at the base ("bg" in Figs. 18−19); apex of galea-lacinia thin and pointed, apex and inner margin covered with long setae; palpus with long setae on outer margin, and with a dense patch of setae on inner margin of palp segment 2. Hypopharinx with pointed lingua and rounded superlingua with setae distally (Figs. 16−17). Labium with pointed paraglossae, covered by numerous setae (Fig. 20). Thorax yellowish white shaded gray on pronotum and mesoscutum, darker on carinae. Wingbuds whitish shaded purplish gray to brownish along costal margin. Thoracic pleura and sterna without marks. Legs whitish except at joinings, yellowish. Forelegs with numerous fringed setae forming a basal group on femur ("br" in Figs. 23−24) and two double rows on tibio-tarsus ("ir" and "vor" in Fig. 23); suture between foretibia and tarsus not visible, apex with two points; middle legs (Fig. 25) and hind legs (Fig. 26) with long and short simple setae, and areas densely covered by short setae on inner margin of tibiae II−III and of femur III; all tarsal claws long and slender without denticles. Abdomen yellowish white shaded widely with purplish gray dorsally except pale transverse dash at each side of terga II−VI and paired smaller pale spots on VII−IX; terga VIII−IX with thin black mediolongitudinal line. Abdominal sterna paler, not shaded, or only slightly shaded on median zone of sterna; sterna with scattered long setae, on VIII more numerous around the anterior half of the mediolongitudinal axis (Fig. 22); short setae present on the paired protuberances bordering the anus (Fig. 22). Gills: vestigial gill I whitish, bilamellate with a short and thin ventral lobe and a larger rounded dorsal lobe (Fig. 27); gills 2−7 with ventral lobe slightly shorter than dorsal lobe but increasing in length posteriorly, so on gill 7 both lobes are subequal in length; lamellae and fringes of gills whitish completely shaded with light grayish purple. Caudal filaments whitish covered with thin yellowish setae.

Discussion. Type of *Campsurus violaceus* Needham & Murphy (1924) presents pedestals with a characteristic form (Figs. 1 and 5), a truncate to slightly concave hind margin of male sternum IX, finger-like penes with a roundish inner ventral protuberance at base (thumb), and an outer subtriangular outgrowth of the pyramidal base (pb in Fig. 3). These characters are present in the same form in other types of *Campsurus* that we are considering as subjective junior synonyms: *C. notatus* Needham & Murphy (Figs. 3, 6−7), *C. meyeri* Navás (Figs. 2, 8−9), and *C. paranensis* Navás (Figs. 10−11).

Nymphal description given above is, to our knowledge, the first formal description for the species. Reared nymphs from Iberá (Argentina, Corrientes) were used for descriptions and illustrations. The nymphs of *C. violaceus* are almost undistinguishable to *C. truncatus* (described by Pereira & Da Silva 1991 under *C. melanocephalus*), but see diagnosis for further comments. Both species are similar to the nymphs of *C. major* and *C. argentinus* (Molineri & Emmerich 2010), only differing because femora II−III present less developed setation on dorsum than *major-argentinus*. Nevertheless, microhabitat of both groups are completely different: the nymphs of *violaceus* group burrow tunnels in soft mud at the bottom of lakes or river pools, while nymphs of the *major* group live in silk cases above rocks in river pools (Molineri & Emmerich 2010).

Campsurus truncatus Ulmer

(Figs. 4, 28−37)

Campsurus truncatus Ulmer, 1920: 2 (male); Lestage, 1923: 123; Puthz, 1973: 94 (male).
Campsurus mahunkai Puthz, 1973: 94 (male, female, egg); Domínguez *et al.* 2006: 575. NEW SYNONYM
Campsurus melanocephalus Pereira & Da-Silva 1991: 322 (male, female, nymph); Domínguez *et al.* 2006: 575. NEW SYNONYM

Type material. *C. truncatus*: photographs of 1 male imago, pinned, in good condition, with four labels indicating: "Espirito-Santo, Brasil, ex. coll. Fruhstoffer" (green), "coll. Ulmer Eing.Nr. 6−63" (white), "Paratypoid" (red), and "Mus. Wein 1921" (white). Deposited in Zoologisches Museum Hamburg.

Additional material. BRAZIL (in CZNC, except otherwise indicated): 2 male and 1 female imagos from Espírito Santo, Sooretama, São José river, 23.i.2012, light trap; 5 male and 1 female imagos from Espírito Santo, Santa Teresa, Nova Lombardia, Capitel de Santo Antônio, Grande stream, 704 m, 24.x.2008, light trap, CEUNES col., 19º 55' 30.1"–40º 33' 21.9"; 5 male imagos from Espírito Santo, Santa Teresa, Nova Lombardia, Capitel de Santo Antônio, Grande stream, 705 m, 26.x.2008, light trap, CEUNES col., 19º 52' 31.7 "− 40º 31' 47.3"; 1 male and 1 female imagos from Espírito Santo, Alfredo Chaves, Nova Mantova, Sede, 371 m, 4.ix.2007, light trap, RB col., 20º 39' 41.7"–40º 50' 24.3"; 3 male and 1 female imagos from Espírito Santo, Sooretama, São José river, 9.ix.2011, light trap; 2 male and 10 female imagos from Restinga de Jurubatiba National Park, Quissamã, RJ, Lagoa Vergueiro, AL Netto-Ferreira; 20 male adults from Amazonas, Jacitara lake, da Paciência island, 19.ix.2003, UV light trap; 20 male adults from Amazonas, Jacitara lake, da Paciência Island, 19.ix.2003, UV light trap; 2 male and 1 female imago from Amazonas, Codajás, Urucurizinho, lake, light trap, 16.ix.2003; 4 male and 18 female imagos from Goiás, Mineiros, stream, 514 m, 24.ii.2012, Pennsylvania trap, LF Sgarbi, APM Santos, E. Raimundi, 17º 12' 35.9"–52º 39' 38.9"; 9 male and 21 female imagos from Goiás, Caiapônia, 1.iii.2012; 2 nymphs (1 pharate male subimago) from rio Grande dam, 27.vii.2011; 10 nymphs from Cachoeira de Cima dam, 18.viii.2011; 1 nymph from São Paulo, Billings dam, 26.viii.2010, 2 nymphs from Cachoeira de Cima dam, 18.viii.2011; 15 nymphs from São Paulo, Billings dam, 7.vii.2009; 15 nymphs from São Paulo, res. Salto Grande (americana), sublitoral, 16.vi.2009; 8 male imagos from Piauí, 01.vi.2011, Domingos Mourão, Vila Cachoeirinha, road to Domingos Mourão, S 04°10'06.2" W 41°34'55.0", 1.vi.2011, P.V. Cruz Col. (INPA); 2 male and 1 female adults from São Paulo, Riberão Preto, USP, Monte Alegre lake, 15.viii.2007, Mariano, Calor & Pinho cols.; 1 mature male nymph from Minas Gerais, Poço de Caldas, Águas Claras dam, 20.xi.2013, P. Z. Pamplin col. (IBN), and 1 female mature nymph same data except date, 11.vii.2013.

COLOMBIA-PERU border: 1 male imago (IBN) from Amazonas, Caballo Cocha, light trap, M.E. Rincón col. (without additional data). COLOMBIA: 1 male imago (IBN) from Amazonas, Puerto Nariño, Tarapoto lake, 93 m, 4.ii.1999, light trap 18−20 h, S 3º 43' 43"–W 70º 25' 17", Zúñiga, Domínguez, Molineri cols.; 3 male and 2 female adults (IBN) from Amazonas, Amacayacu National Park, 93 m, 1.ii.1999, S 3º 48' 47"–W 70º 17' 06", 93 m, light trap 17−19 h, Zúñiga, Domínguez, Molineri cols.; 2 male imagos (MUSENUV) from Amazonas, Leticia, road to

Tarapaca, stream at km 15, 93 m, S 4º 5' 41"–W 69º 59' 01", 11.ii.1999, light trap 4−6 h, Zúñiga, Domínguez, Molineri cols.

Distribution. Bolivia, Brazil, Colombia, Peru.

Diagnosis. *Campsurus truncatus* can be separated from the other species of the genus by the following combination of characters: 1) pedestals elongate, with projected acute outer corner ("op" in Figs. 4 and 28), generally as projected as the inner one ("ip" in Figs. 4 and 28), but variable (Figs. 31−33); 2) penes relatively stout, with rounded "thumb", and somewhat truncated apex (Figs. 28−30); 3) female socket with relatively long and narrow anterior furrow ("f" in Figs. 34−35). Nymphs may be distinguishable by the row of denticles on the inner margin of mandibular tusks formed by 6−8 denticles that increase in size basally, the most basal one is only 1.5 times larger than the previous one (Figs. 36−37); between each one of these tubercles two stout setae are present (Figs. 36−37). The eggs are not distinguishable from other species in the *violaceus* group.

Male imago. Length (n=7, mm): body, 9.0−16.5; FW, 9.0−14.0; HW, 4.1−6.5; cerci, 19.5−34.0; foreleg, 4.2−6.2 (total length without coxa). Foreleg, ratio of segments in relation to femur (1.4 mm): femur (1), tibia (0.8−1.1), tarsomere 1 (0.1); tarsomere 2(0.2−0.5); tarsomere 3 (0.3−0.5), tarsomere 4 (0.3−0.5), tarsomere 5 (0.3−0.5), short claw (0.1−0.3), long claw (0.2−0.4). Tarsal segments 2−4 subequal, slightly shorter than 5 (the longest), tarsomere 1 very short. Genitalia (Fig. 4, 28−33): penes stout, with rounded "thumb", apex truncated; pedestal subrectangular (but variable, Figs. 31−33), always the outer margin acutely pointed and subequal in length to the more rounded (and wider) inner margin; outer subtriangular outgrowth of the pyramidal base rounded as in Figs. 28−30.

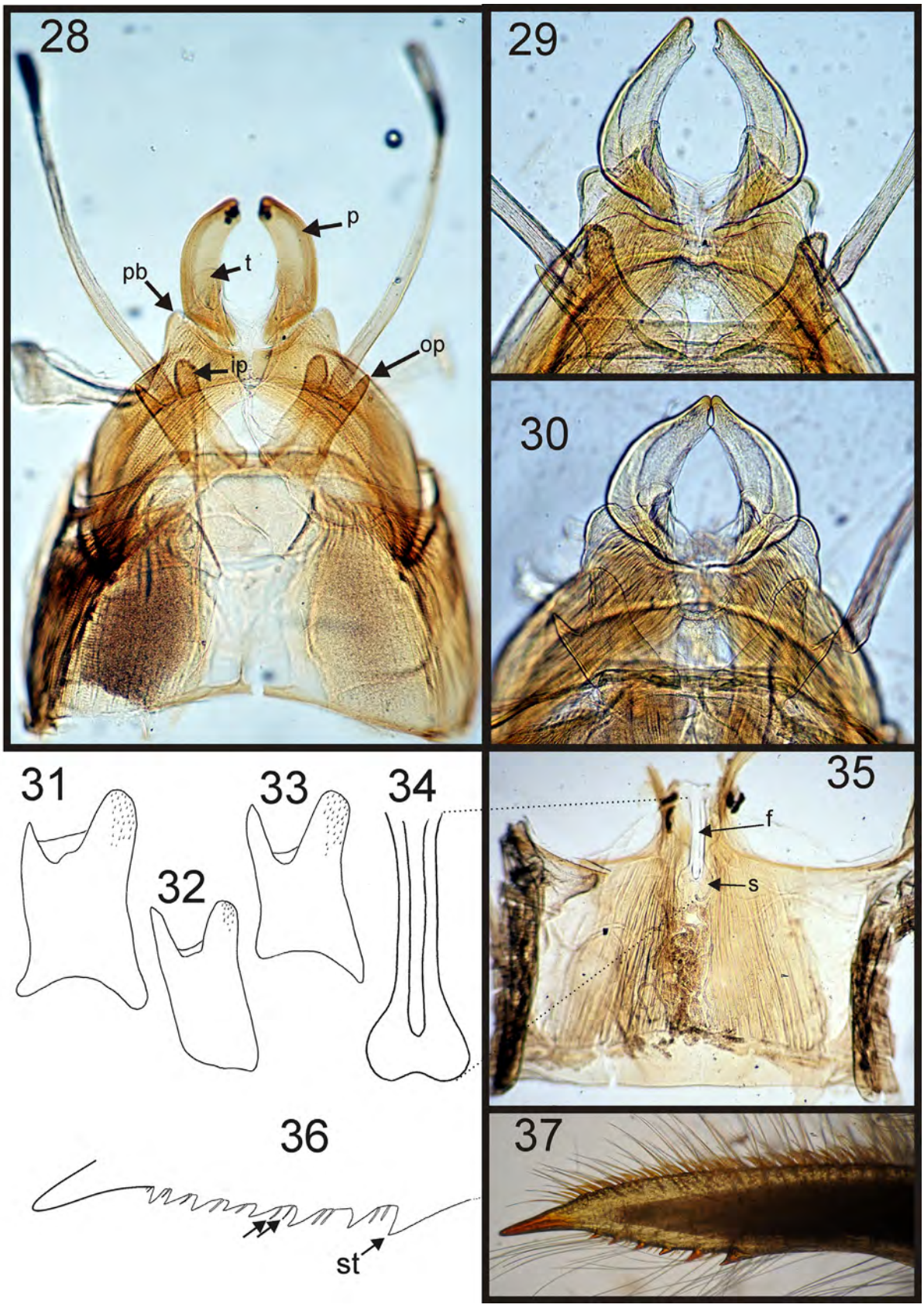
Female subimago. Length: body, 10.0−11.7; FW, 10.0−11.8; HW, 4.2−5.0; cerci, 2.5−3.0. Abdomen. Sternum VIII with single socket, anterior to it a long and slender furrow is present (Figs. 34−35).

Nymph. As in the description given for *C. violaceus*, exceptions follow:

Mature nymph. Length of male (mm): body, 14.5; terminal filament, 10.0; cerci, 13.5. Length of female (mm): body, 24.0; terminal filament and cerci broken off and lost. General coloration light brownish yellow (both individuals are pharate subimagos). Mandibular tusks with 6−8 denticles on inner margin, the most basal one slightly larger (1.5 x) than the others (Figs. 36−37); paired stout setae are intercalated between these denticles. Abdomen. Thin blackish medial line present on terga II−IX. Gills 2−7 with ventral lobe paler than dorsal one, fringes paler than lamella.

Discussion. *Campsurus truncatus* is here considered the senior synonym of *C. mahunkai* and *C. melanocephalus* because all of them share the same male genitalia, particularly the form of pedestals and forceps. *Campsurus truncatus*, known from all the stages, presents male genitalia similar to *C. violaceus*, except that penes are shorter and more robust with a truncate apex, pedestals are different in form, with both posterolateral corners similar in length, the outer thinner than the inner one. Characters given by Puthz (1973) and Pereira & da Silva (1991) to distinguish *C. mahunkai* and *C. melanocephalus* respectively, showed to be variable in a larger series from different localities studied by us. For example the black color on head and other dorsal portions of adult *C. melanocephalus* is the main defining character used by Pereira & da Silva to distinguish this species, but specimens showing pale to very obscure coloration but with identical genitalia are present in different series studied by us. Puthz (1973) differentiated *C. mahunkai* from *C. truncatus* (from which he studied the type) in the form of hind margin of sternum IX (truncate in the first, slightly concave in the second) and base of penis (more protruded in the second), but such differences were encountered by us in different males of the same population, thus proving to be inside the normal intraspecific variability. Even in *C. truncatus* "paratypoids" (two pinned male imagos at ZMH) the two conditions of the hind margin of sternum IX are present.

We have only studied two ready to molt nymphs that seems undistinguishable from *C. violaceus* at this time, except for the relative smaller most basal denticle on the inner margin of mandibular tusk of *C. truncatus*. Mandibular tusks of these nymphs present a regular denticulation on the inner margin, differing from the original description (as *C. melanocephalus*) where Pereira & da Silva (1991) characterize the species as having an "irregular denticulation".



FIGURES 28–37. *C. truncatus*. Imago: 28, male genitalia, v.v. (Colombian specimen); 29, same (slide IBN28CM); 30, same (slide IBN31CM); 31–33, pedestals, variations, v.v.; 34, detail of female sockets; 35, female sternum VIII. Nymph: 36, outline of inner edge of left mandibular tusk; 37, left mandibular tusk. Abbreviations: f=furrow; ip=inner projection (pedestal); op=outer projection (pedestal); p=penes; pb= pyramidal base (penes); s=socket; st=subbasal tubercle; t="thumb" (penes).

***Campsurus molinai* sp. nov.**
(Figs. 38−40)

Type material. Holotype male imago from Bolivia, Beni, La Granja lake, 2.v.2005, C. Molina col. (UMSA). Paratype male imago (slide IBN344CM), same data as holotype (IBN).

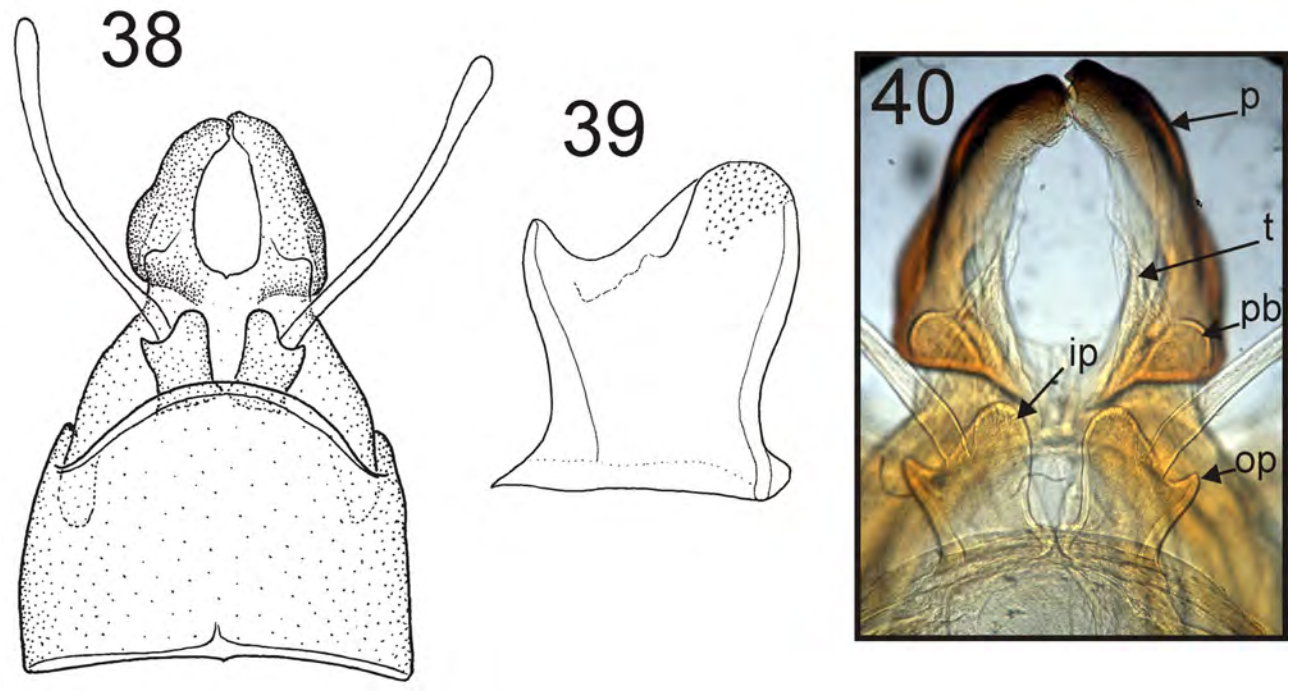
Distribution. Bolivia (Beni).

Etymology. The species is dedicated to Dr. Carlos Molina, Bolivian limnologist that collected and kindly offered the material of the species.

Diagnosis. 1) pedestals stout, subquadrate, inner distal corner larger and roundly expanded, outer corner thinner and acute (Figs. 38−40); 2) penis strongly developed and sclerotized, with a small spine-like projection at apex, basal 1/2 of penis strongly expanded dorsally (Figs. 38, 40); 3) thumb not finger-like, reduced to a basal membrane on inner ventral margin of each penis ("t" in Fig. 40).

Male imago. Length (mm): body, 13.0−13.5; FW, 11.0−11.2; HW, 5.0−5.2; cerci, 31.0; foreleg, 5.5−5.7. Body coloration completely faded. Foreleg ratio of segments in relation to femur (1.6 mm): femur (1), tibia (1.0), tarsomere 1 (0.1); tarsomere 2(0.3); tarsomere 3 (0.3), tarsomere 4 (0.3), tarsomere 5 (0.3), short claw (0.2), long claw (0.3). Tarsal segments 2−5 subequal, tarsomere 1 very short. Genitalia (Figs. 38−40): sternum IX subquadrate with rounded apical margin; pedestal stout, slightly flattened dorsoventrally, distally with large rounded inner corner and short acute outer corner (Fig. 39); penes strongly developed and sclerotized, curved ventrally and medially, finger-like on distal half, with small acute projection at apex; basal 1/2 of penes strongly projected dorsally (Fig. 38−40).

Discussion. This new species is similar to *C. truncatus* in genital morphology, but pedestals are stouter and penes much more developed (each lobe is very wide and large) and sclerotized. The same differences apply when compared with *C. mahunkai*, known also from Bolivia but here treated as synonym of *C. truncatus*.



FIGURES 38−40. *C. molinai* **sp. nov.**, male adult. 38, male genitalia, v.v.; 39, pedestal, detail, v.v.; 40, penes and pedestals, v.v. (photograph). Abbreviations: ip=inner projection (pedestal); op=outer projection (pedestal); p=penes; pb= pyramidal base (penes); t="thumb" (penes).

***Campsurus assimilis* Traver**

Campsurus assimilis Traver 1944: 39 (male, female); Domínguez *et al.* 2006: 567.

Material. Not studied.

Distribution. Brazil (Rio Grande do Sul).

Diagnosis. *Campsurus assimilis* can be separated from the other species of the *violaceus* group by the following combination of characters: 1) pedestal subrectangular with inner distal corner only slightly more developed than the outer, both small and rounded (figure 4 of Traver 1944); and 2) penes relatively longer and slender than the other species of the *violaceus* group, abruptly bent at middle, "thumb" apparently absent (figure 3c of Traver 1944).

Campsurus decoloratus (Hagen)

(Figs. 44−46)

Palingenia decolorata Hagen 1861: 43.
Campsurus decoloratus Eaton 1883−1888: 41.

Material. Two female adults from USA: Texas, Montgomery Co., San Jacinto river at US59, near Kingwood, 17.viii.1997, N. A. Wiersema col.

Distribution. Mexico, Nicaragua, USA (http://www.entm.purdue.edu/mayfly/).

Diagnosis. *Campsurus decoloratus* can be separated from the other species of the genus by the following combination of characters: 1) pedestals and penes similar to *C. violaceus*, with pedestals elongate with outer corner slightly projected and penes slender, except that "thumb" is finger-like (figures 22−23 of Traver 1947); 2) female socket with straight transverse opening and with an anterior longitudinal rib (Figs. 45−46).

Female. Abdominal sternum VIII with a subquadrate single socket on the anteromedian area, the anterior furrow presents a thin medial rib ("r" in Fig. 46); in both female adults studied the groove (socket`s opening) appears obtruded by a subespherical aglutinated material ("?" in Fig. 46). The sternum VIII is completely covered by microtrichiae, except anteriorly and around the groove (Figs. 45−46).

Eggs (Fig. 44). Length, 188−237; width, 145−175. L/W ratio (N=5): 1.2−1.6. Hemispherical to ovate, with convex and concave sides as usual, capped pole broader, cap formed by >15 very long threads coiled around each other in a single stronger filament, chorionic surface covered by small punctures, except below the polar cap. Micropylar devices unknown.

Campsurus emersoni Traver

Campsurus emersoni Traver 1947: 392.

Material. Not studied.

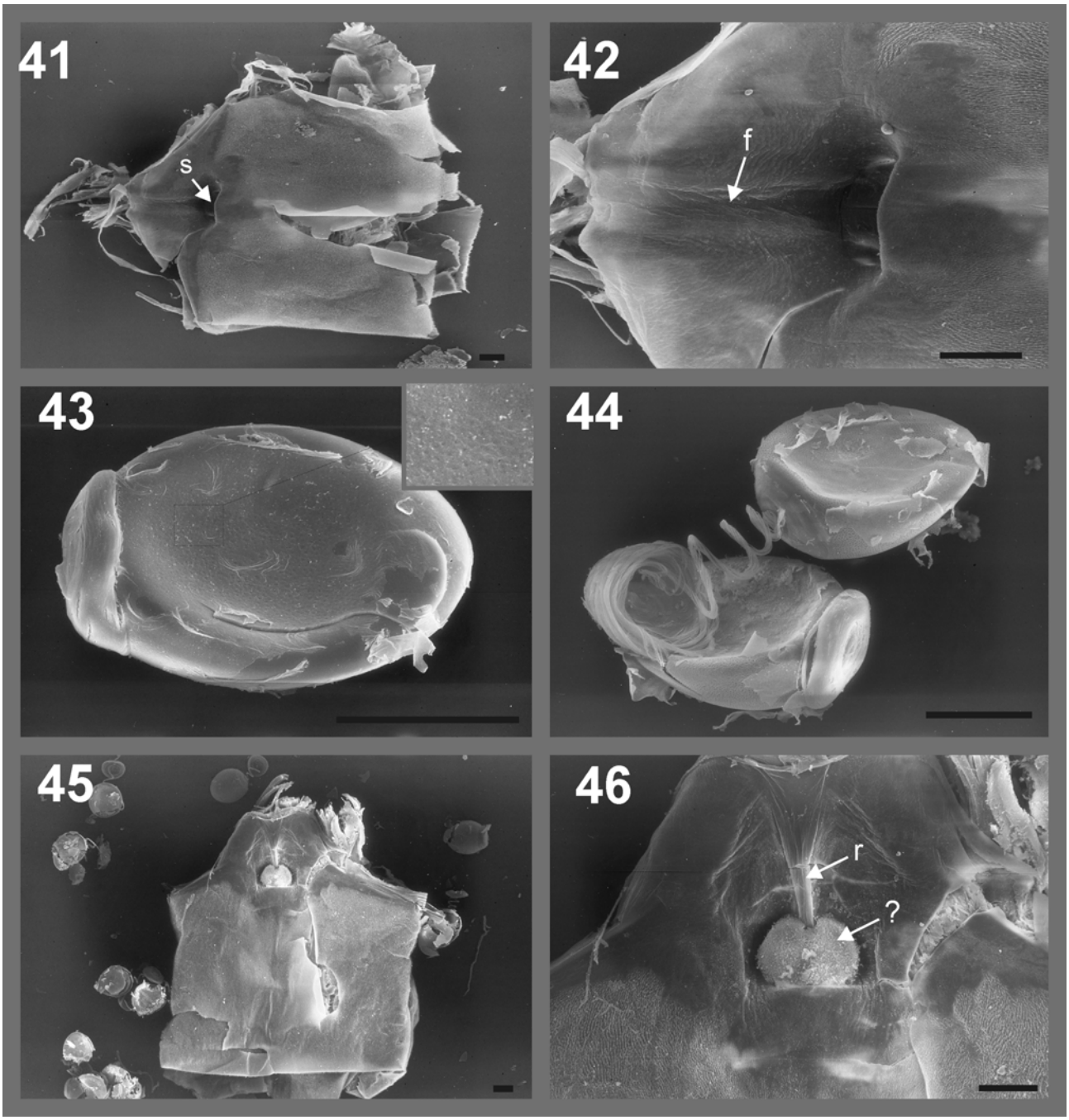
Distribution. Panamá.

Diagnosis and discussion. *Campsurus emersoni* can be separated from the other species of the genus by the following combination of characters: 1) pedestals and penes similar to *C. violaceus* (Figs. 1–3) except that "thumb" is apparently absent from figure 36 of Traver 1947). This species is most probably another junior synonym of *C. violaceus*.

Concluding remarks

The study of the types and fresh material support the *violaceus* group as composed of only six valid species: *C. assimilis*, *C. molinai* **sp. nov.**, *C. truncatus* (=*C. mahunkai* = *C. melanocephalus*), *C. violaceus* (= *C. meyeri* = *C. notatus* = *C. paranensis*), *C. emersoni* Traver and *C. decoloratus* (Hagen). As *C. notatus* is now considered a junior synonym of *C. violaceus*, we prefer to call this informal group as the *violaceus* group.

As a result of the present work *Campsurus* is composed by 28 valid species in four species-groups; and 17 species are synonymized or proposed as *nomina dubia*.



FIGURES 41−46. Female sternum VIII and eggs. *C. violaceus*: 41, sternum VIII (s=socket); 42, detail of socket; 43, egg. *C. decoloratus*: 44, eggs; 45, sternum VIII; 46, detail of socket. Abbreviations: f=furrow; r=rib; s=socket.

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