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Description of final stadium larva of *Erythrodiplax connata* and *E. basifusca* and redescription of that of *E. minuscula* (Odonata: Libellulidae)

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In this contribution the final stadium larvae of *Erythrodiplax connata* and *E. basifusca* are described and that of *E. minuscula* is redescribed. Diagnoses are provided for the larvae of the genus *Erythrodiplax* and for those included in the *connata* group. *E. connata* lacks lateral spines on abdominal segments, a character which has not been observed in any other larvae of the genus. Finally, due to the fact that the larvae of *E. connata* could not be reared successfully until emergence, differences with other sympatric Patagonic Libellulidae are discussed.

En esta contribución se describe el último estadio larval de *Erythrodiplax connata* y *E. basifusca* y se redescrive el de *E. minuscula*. Se provee una diagnosis de las larvas del género *Erythrodiplax* y de las larvas del grupo *connata*. Se destaca la ausencia de espinas laterales en las larvas de *E. connata*, caracter que no ha sido observado en ninguna otra especie del género. Por último, debido a que las larvas de *E. connata* no han podido ser criadas hasta su emergencia en el laboratorio, se discuten las diferencias con respecto a otros Libellulidae patagónicos encontrados en simpatria con esta.

Keywords: Odonata; dragonfly; final stadium larvae; *Erythrodiplax, connata*; Patagonia

Introduction

The American genus *Erythrodiplax* Brauer, 1868 comprises 56 species (Garrison, von Ellenrieder & Louton, 2006). The knowledge of its larvae is far from complete; to date the final stadium larvae of only 20 species have been described, which represents approximately 36%, i.e. *E. amazonica* Sjöstedt, 1918, *E. anomala* (Brauer, 1865), *E. atroterminata* Ris, 1911, *E. basalis* (Kirby, 1897), *E. berenice* (Drury, 1773), *E. corallina* (Brauer, 1865), *E. fervida* (Erichson, 1848), *E. funerea* (Hagen, 1861), *E. fusca* (Rambur, 1842), *E. juliana* Ris, 1911, *E. justiniana* (Selys in Sagra, 1857), *E. latimaculata* Ris, 1911, *E. lygea* Ris, 1911, *E. melanorubra* Borrer, 1942, *E. minuscula* (Rambur, 1842), *E. nigricans* (Rambur, 1842), *E. ochracea* (Burmeister, 1839), *E. pallida* (Needham, 1904), *E. paraguayensis* (Förster, 1905), *E. transversa* Borrer, 1957 and *E. umbrata* (Linnaeus, 1758) (Calvert, 1904, 1928; Carvalho, Ferreira & Nessiminian, 1991; Costa, Vieira & Lourenço, 2001; De Marmels, 1992a, 1992b; Garré, Muzón & Ardohain, 2008;

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Klots, 1932; Limongi, 1991; Muzón & Garré, 2005; Needham & Westfall, 1955; Needham, Westfall & May, 2000; Pritchard & Smith, 1967; Santos, 1956; Trapero Quintana & Reyes Tur, 2008; von Ellenrieder & Muzón, 2000). In Argentina this genus is represented by 21 species (von Ellenrieder & Muzón, 2008), and the final stadium larva of 13 is known.

Borror (1942) established 12 species groups for the genus (i.e. *acantha*, *attenuata*, *basalis*, *castanea*, *connata*, *famula*, *funerea*, *juliana*, *longitudinalis*, *nigricans*, *umbrata* and *unimaculata*); the *connata* group is the most speciose one and includes the following 13 species: *E. abjecta*, *E. atroterminata*, *E. bromeliicola*, *E. cauca*, *E. cleopatra*, *E. connata*, *E. fusca*, *E. justiniana*, *E. ines*, *E. media*, *E. melanorrhuba*, *E. minuscula* and *E. paraguayensis* (Borror, 1942; Paulson, 2003).

Borror (1942) in his revision of the genus *Erythrodiplax*, considered that the species *E. connata* (Burmeister) had three subspecies: *connata connata*, *c. minuscula* (Rambur) and *c. fusca* (Rambur). *Erythrodiplax connata connata* had an unusual disjunct distribution (southern USA to Mexico and western Argentina and Chile). According to Paulson (2003) these two populations correspond in fact to two distinct species, and he proposed the name *E. basifusca* (Calvert) for the northern population and *E. connata* for the southern one (as Chile is the type locality of *E. connata*).

Erythrodiplax connata is the southernmost member of the genus and is widely distributed in Patagonia, reaching approximately 44°S. It can be found on forested and on steppe areas as a common inhabitant of lentic environments, where adults can be found perching on short stems near the ground. It is known in Argentina (Neuquén, Río Negro and Chubut provinces) and in southern Chile (Paulson, 2003; Muzón, 2009; von Ellenrieder & Muzón, 2008).

In this contribution we describe the final stadium larvae of *Erythrodiplax connata* and *E. basifusca* and redescribe that of *E. minuscula*, which was first described by Needham (1904). It is important to mention that the final stadium larva of *E. basifusca* was keyed by Needham et al. (2000) but was never formally published. On the other hand, the larvae described by Santos (1967) as *E. connata fusca*, which Carvalho et al. (1991) considered to be *E. connata*, was re-identified by Costa et al. (2001) as *E. fusca*.

Material and methods

Measurements are given in millimetres. The mandibular formula follows Watson (1956). Drawings were made with the aid of a camera lucida and pictures were taken with a digital camera DFC 290, both coupled to a Leica MS5 stereomicroscope.

Examined specimens of *E. connata* are deposited in the collection of the Departamento Entomología, Museo de La Plata, Buenos Aires, Argentina; those of *E. basifusca* and *E. minuscula* are deposited in the Florida State Collection of Arthropods (FSCA), Gainesville, Florida, USA.

Genus *Erythrodiplax* Brauer

Diagnosis of larvae

The diagnosis of Garre et al. (2008) must be emended as follows: body lacking long hairs (except on prothorax); head longer than thorax; third segment of antenna the longest; mandibles with four incisor teeth, number of molar teeth variable (2–4) but lacking a molar crest; distal margin of prementum obtuse and crenulated; abdomen without dorsal hooks (some species with mid-dorsal tubercles bearing tufts of hairs); lateral spines on S8–S9 (absent only in *E. connata*), more rarely on S7; epiproct, paraprocts and cerci decurved (except in *E. umbrata*).

Description of final stadium larva of Erythrodiplax connata (Figures 1–3)

Specimens studied. Two ♀♀ final stadium larvae from Argentina, Neuquén province, Parque Nacional Lanín, Termas de Lahuenco, 870 m asl, (39°48'55.5"S, 71°37'27.8"W), 20 November 1994, leg. J. Muzón. Two ♀♀ and one ♂ final stadium larvae from Argentina, Río Negro, Estancia El Rincón, vertientes arroyo Valcheta, 620 m asl, (40°59'24.1"S, 66°40'35.7"W), 28–29 January 1999, leg. J. Muzón & N. von Ellenrieder.

Identification of specimens: Larvae assigned to *E. connata* were not successfully reared to metamorphosis. However, identification was possible because they were collected together with adults of *E. connata*. The other libellulids recorded at the collecting sites are *Sympetrum villosum* (Termas de Lahuenco) and *Dasythemis mincki* (Estancia El Rincón), whose larvae have already been described (Muzón & von Ellenrieder, 1997; von Ellenrieder, 2007) and can be easily separated from that of *E. connata* (see below).

Head. 2.17 times as wide as long, posterior margin slightly concave. Mandibular formula: L 1 2 3 4 0 a b / R 1 2 3 4 y a b d (Figure 1). Labium: reaching half the distance between first and second coxae. Prementum (Figure 2a): pale; ligula with 11–21 small setae; with 22–26 premental setae (11 + 11, 11 + 12, 12 + 12 or 13 + 13); ligula obtuse; ratio of maximum width to maximum length 1.23; lateral margin without setae; laterodistal margin with 3, 4, 5 or 7 spiniform setae (Figure 2a–b). Labial palp (Figure 2b): pale; with 7 palpal setae; anterior margin slightly crenulated with 14–19 spiniform setae, one on each concavity; inner margin with 4–8 spiniform setae on distal 0.70; movable hook 0.24 the maximum length of labial palp.

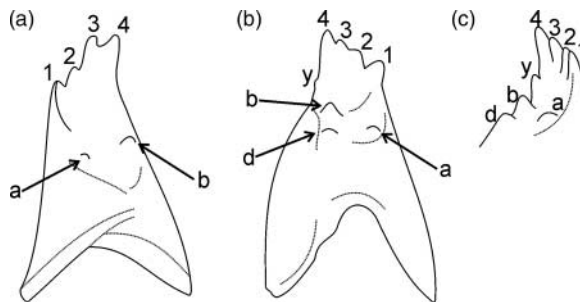


Figure 1. *Erythrodiplax connata*: (a) left mandible; (b) right mandible; (c) right mandible showing tooth y.

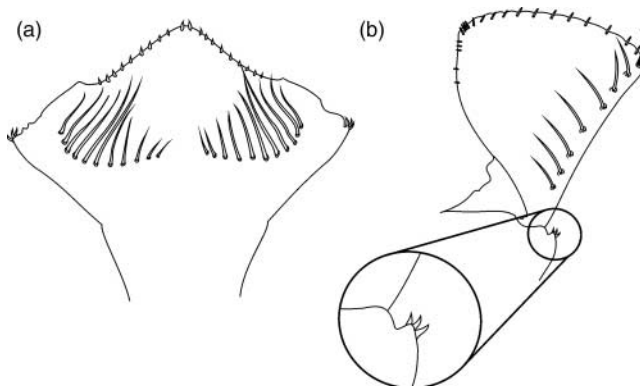


Figure 2. *Erythrodiplax connata*: (a) prementum, dorsal view; (b) right labial palp, inner view.

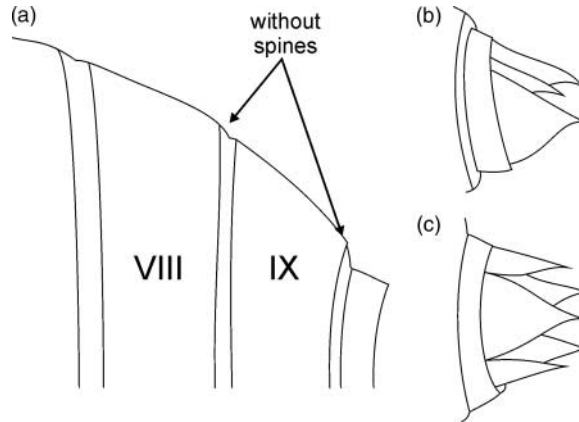


Figure 3. *Erythrodiplax connata*: (a) abdominal segments S8-S10, right half dorsal view; (b) terminalia, lateral view; (c) terminalia, dorsal view.

Thorax. Wing pads reaching posterior margin of abdominal segment V (except in one specimen in which they reach anterior margin of abdominal V).

Abdomen. Lateral spines absent from S8 and S9 (Figure 3a). Epiproct wide at base, apex acute. Paraprocts, epiproct and cerci tips slightly decurved (Figure 3b–c). Ratio relative to paraprocts: epiproct 1.03, cerci 0.74.

Measurements. Average and standard deviation, range in square brackets; N = 5 unless indicated otherwise. Total body length (including paraprocts): 14.60 ± 1.0794 [13.0–16.0]. Head maximum width: 4.12 ± 0.1095 [4.0–4.3]. Head maximum length: 1.90 ± 0.0707 [1.8–2.0]. Prementum maximum width: 3.58 ± 0.5404 [3.0–4.2]. Prementum maximum length: 2.90 ± 0.2915 [2.5–3.2]. Labial palp maximum width: 1.54 ± 0.1517 [1.4–1.7]. Labial palp maximum length: 2.12 ± 0.1643 [2.0–2.3]. Movable hook length: 0.50 ± 0.0707 [0.4–0.6]. Femur III length: 3.12 ± 0.3000 [3.3–4.0]. Tibia III length: 3.82 ± 0.3114 [3.5–4.2]. Width of abdominal terga S6: 4.86 ± 0.4506 [4.3–5.4]; S7: 4.58 ± 0.4087 [4.1–5.0]; S8: 4.02 ± 0.2864 [3.7–4.4]; S9: 3.28 ± 0.2588 [3.0–3.5]; S10: 1.62 ± 0.2280 [1.4–1.9]. Mid-dorsal length of abdominal terga S6: 0.96 ± 0.1517 [0.9–1.2]; S7: 0.82 ± 0.1095 [0.7–1.0]; S8: 0.76 ± 0.0894 [0.7–0.9]; S9: 0.54 ± 0.0894 [0.5–0.7]; S10: 0.24 ± 0.0548 [0.2–0.3]. Abdomen maximum width: 4.86 ± 0.4506 [4.3–5.4]. Abdomen maximum length: 8.44 ± 0.9607 [7.4–9.6]. Cercus length: 0.56 ± 0.0548 [0.5–0.6]. Paraproct length: 0.76 ± 0.0548 [0.7–0.8]. Epiproct length: 0.78 ± 0.0447 [0.7–0.8].

Description of final stadium larva of *Erythrodiplax basifusca* (Figures 4–6)

Specimens studied. One ♀ (reared) final larval stadium, USA, Arizona, Santa Cruz Co., Peña Blanca Lake, west of Nogales, 11 July 1958, coll. Westfall.

Head. 2.23 times as wide as long, posterior margin slightly concave. Mandibular formula: L 1 2 3 4 0 a b / R 1 2 3 4 y a b d (Figure 4). Labium: reaching half the distance between first and second coxae. Prementum (Figure 5a): pale; ligula with 26 small setae; with 22 premental setae (11 + 11); ligula obtuse; ratio of maximum width to maximum length 1.14; lateral margin without setae; laterodistal margin with 3 or 4 spiniform setae (Figure 5a–b). Labial palp (Figure 5b): pale; with 7 palpal setae; anterior margin slightly crenulated with 14 spiniform setae, one on each concavity; inner margin with 11 spiniform setae on distal 0.50; movable hook 0.27 the maximum length of labial palp.

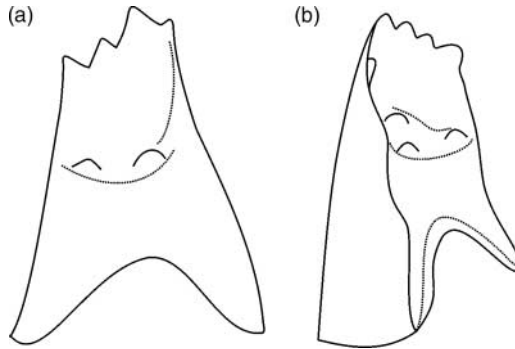


Figure 4. *Erythrodiplax basifusca*: (a) left mandible; (b) right mandible.

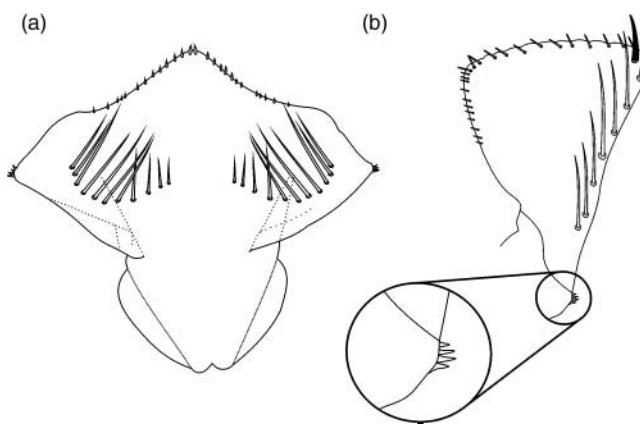


Figure 5. *Erythrodiplax basifusca*: (a) prementum, dorsal view; (b) right labial palp, inner view.

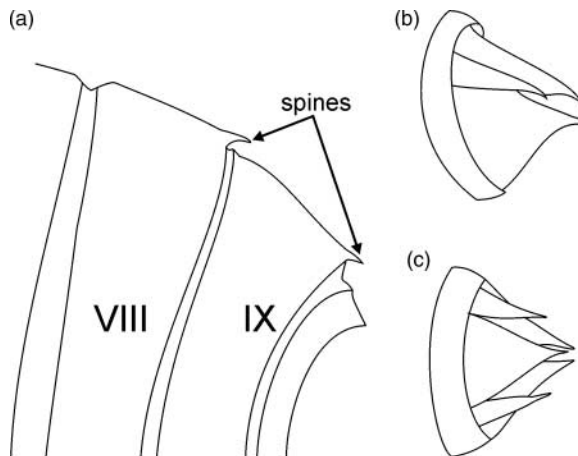


Figure 6. *Erythrodiplax basifusca*: (a) abdominal segments S8-S10, right half dorsal view; (b) terminalia, lateral view; (c) terminalia, dorsal view.

Thorax. Wing pads reaching anterior fourth of abdominal segment VI.

Abdomen. Lateral spines present on abdominal segments VIII and IX (Figure 6a); ratio of spine length of segment VIII and IX to maximum length of corresponding segments 0.14 and

0.18 respectively. Epiproct wide at base, apex acute. Paraprocts, epiproct and cerci tips slightly decurved (Figure 6b–c). Ratio relative to paraprocts: epiproct 1.08, cerci 0.66.

Measurements (N = 1). Total body length (including paraprocts): 12.64. Head maximum width: 3.97. Head maximum length: 1.78. Prementum maximum width: 3.50. Prementum maximum length: 3.08. Labial palp maximum width: 1.54. Labial palp maximum length: 2.27. Movable hook length: 0.61. Femur III length: 3.29. Tibia III length: 3.87. Width of abdominal tergum S6: 4.50; S7: 4.45; S8: 4.08; S9: 3.29; S10: 1.32. Middorsal length of abdominal tergum S6: 0.90; S7: 0.96; S8: 0.70; S9: 0.61; S10: 0.22. Lateral spines on abdominal segment S8: 0.10; on segment S9: 0.11. Abdomen maximum width: 4.54. Abdomen maximum length: 6.40. Cercus length: 0.53. Paraproct length: 0.80. Epiproct length: 0.86.

Redescription of final stadium larva of Erythrodiplax minuscula (Figures 7–9)

Specimens studied. One ♀ (reared) final larval stadium, USA, Florida, Alachua Co., Twin Oaks pond, 5 mi E Gainesville, 13 August 1946.

Head. 1.64 times as wide as long, posterior margin straight. Mandibular formula: L 1 2 3 4 0 a b / R 1 2 3 4 y a b d (Figure 7). Labium: reaching half the distance between first and second coxae. Prementum (Figure 8a): with dark brown specks on anterior half; ligula with 22 small setae; with 24 premental setae (12 + 12); ligula obtuse; ratio of maximum width to maximum length 1.12; lateral margin without setae; laterodistal margin with 4 spiniform setae (Figure 8a–b). Labial palp (Figure 8b): with dark brown specks as shown in Figure 8b; with 7 palpal setae; anterior margin slightly crenulated with 11 spiniform setae, one on each concavity; inner margin with 9 spiniform setae on distal 0.80; movable hook 0.33 the maximum length of labial palp.

Thorax. Wing pads reaching posterior fourth of abdominal segment V.

Abdomen. Lateral spines on abdominal segments VIII and IX (Figure 9a) present; ratio of spine length of segment VIII and IX to maximum length of corresponding segments 0.22 and 0.33 respectively. Epiproct wide at base, apex acute. Paraprocts, epiproct and cerci tips slightly decurved (Figure 9b–c). Ratio relative to paraprocts: epiproct 0.85, cerci 0.56.

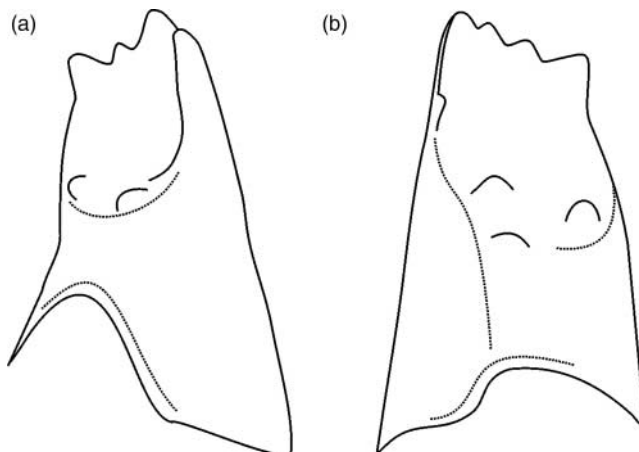


Figure 7. *Erythrodiplax minuscula*: (a) left mandible; (b) right mandible.

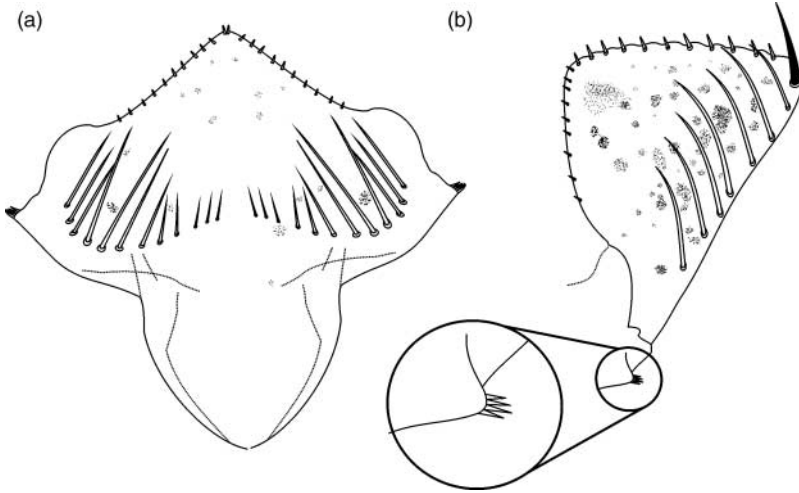


Figure 8. *Erythrodiplax minuscula*: (a) prementum, dorsal view; (b) right labial palp, inner view.

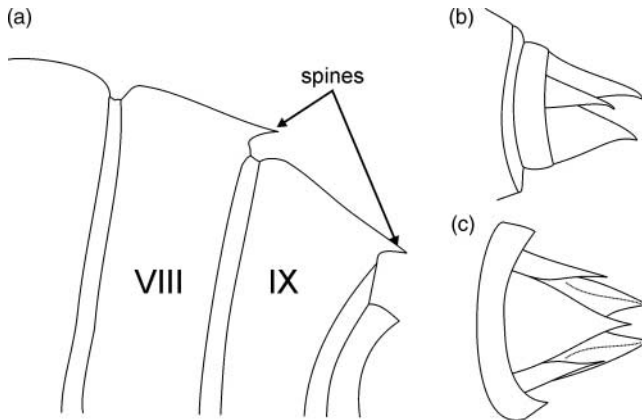


Figure 9. *Erythrodiplax minuscula*: (a) abdominal segments S8-S10, right half dorsal view; (b) terminalia, lateral view; (c) terminalia, dorsal view.

Measurements (N = 1). Total body length (including paraprocts): 11.50. Head maximum width: 3.73. Head maximum length: 2.27. Prementum maximum width: 2.62. Prementum maximum length: 2.33. Labial palp maximum width: 0.99. Labial palp maximum length: 1.82. Movable hook length: 0.61. Femur III length: 2.92. Tibia III length: 3.56. Width of abdominal tergum S6: 3.68; S7: 3.68; S8: 3.46; S9: 2.78; S10: 1.25. Mid-dorsal length of abdominal tergum S6: 0.59; S7: 0.75; S8: 0.59; S9: 0.43; S10: 0.14. Lateral spines on abdominal segment S8: 0.13; on segment S9: 0.14. Abdomen maximum width: 3.81. Abdomen maximum length: 6.48. Cercus length: 0.42. Paraproct length: 0.74. Epiproct length: 0.62.

Discussion

The final stadium larvae of the genus *Erythrodiplax* show a great uniformity of metric and morphological characters, making the distinction of species very difficult (Needham et al., 2000; von Ellenrieder & Muzón, 2000). This uniformity is greater in the *connata* group, from which almost

70% of its species are described or keyed (e.g. *E. atroterminata*, *E. basifusca*, *E. bromelicola*, *E. connata*, *E. fusca*, *E. justiniana*, *E. melanorubra*, *E. minuscula* and *E. paraguayensis*) (Carvalho et al., 1991; Costa et al., 2001; Garré et al., 2008; Muzón & Garré, 2005; Needham, 1904; Needham et al., 2000).

The final stadium larvae of the species included in the *connata* group are typical small to medium *Erythrodiplax*, with 9–13 premental setae (about 15 in *E. bromeliicola*), 6–10 palpal setae (about 11 in *E. bromeliicola*), mandibular formula as follows: L 1234 0 ab, R 1234 y abd (abc, in *E. atroterminata*), ratio of maximum width to maximum length of ligula from 1.0 (*E. paraguayensis*) to 1.8 (*E. atroterminata*), maximum length of femur III from 2.75 (*E. paraguayensis*) to 3.5 (*E. atroterminata* and *E. melanorubra*), abdominal lateral spines present on S8 and S9 (absent in *E. connata*); those on S8 from 0.10 (*E. basifusca*) to 0.4 (*E. paraguayensis* and *E. melanorubra*) and on S9 from 0.11 (*E. basifusca*) to 0.62 (*E. paraguayensis*).

The species previously considered as subspecies of *E. connata* (i.e. *E. minuscula*, *E. fusca*, *E. basifusca* and *E. connata*) are extremely difficult to distinguish both in morphology and size, with *E. minuscula* the smallest and *E. connata* and *E. fusca* the biggest. Some characteristics show greater intraspecific variability than interspecific, for example the number of labial palp setae (6–8 in *E. fusca* versus 7 or 8 in the rest). As stated before, the absence of lateral spines on abdominal S8 and S9 readily diagnoses *E. connata*, differentiating it not only from the other species in the *connata* group, but from all the other known *Erythrodiplax*.

Patagonian libellulids

Few of the Odonata species of Patagonia are widely distributed but *E. connata* is one of them; it is common in the two main Patagonian biomes, steppe and forest (Muzón, 2009). So far, the other libellulid sympatric with *E. connata* in woody areas is the Patagonian endemic *Sympetrum villosum* Ris, 1911 (final stadium larva described by Muzón & von Ellenrieder, 1997). These two can be easily distinguished because of a row of small setae on the upper side of the external surface of labial palp (absent in *E. connata*; present in *S. villosum*), and the number of palpal setae (7 in *E. connata*; 8 or 9 in *S. villosum*).

On the other hand, in the steppe, two other libellulids have been recorded in sympatry with *E. connata*: *Dasythemis mincki clara* Ris, 1908 and *Erythrodiplax atroterminata* (Muzón et al., 2005; 2010); *E. corallina* and *E. nigricans* have not yet been found in sympatry with *E. connata*, but this is likely. *Dasythemis mincki clara* lacks lateral spines on S8 and S9, as in *E. connata*, but it differs from the latter in the arrangement of premental setae: in *D. mincki clara* there are 3–5 long setae, followed by a group of 7–16 very short setae arranged in a convex line (von Ellenrieder, 2007), whereas in *E. connata* the premental setae decrease in size towards the midline and there are no short setae arranged in a convex line.

The absence of lateral abdominal spines in Odonata larvae has been interpreted as a possible result of evolution in fishless habitats (Corbet, 1999; Hovmöller & Johansson, 2004). As lateral abdominal spines are present in all known *Erythrodiplax* larvae, their presence can be interpreted as ancestral, so its secondary loss in *E. connata* could be correlated with a speciation process in Patagonia, an area with natural absence of fishes in small ponds.

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