

Description of a putative hybrid between *Ischnura cyane* and *I. capreolus* from Colombia (Odonata: Coenagrionidae)

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Abstract. Putative hybrids between the sibling species *Ischnura capreolus* and *I. cyane* from the Colombian Cordillera Oriental are reported from the department of Cundinamarca, central Colombia, where species are known to occur sympatrically. *Ischnura capreolus* is quite widespread in South America, from sea level to 1 750 m a.s.l., while *I. cyane* is a Colombian endemic restricted to altitudes between 1 300 and 2 200 m a.s.l.. Hybridisation may be a result of the changes in distribution of both species leading to increasing sympatry. The putative hybrid is described and illustrated and compared with both putative parental species.

Further key words. Damselfly, Zygoptera, hybridisation, heterospecific matings, Andes, Eastern Ranges, endemic

Introduction

Worldwide, more than 70 *Ischnura* species are known, amongst which six pairs of species (10 taxa) are known to hybridise (Table 1) (WELLENREUTHER & SÁNCHEZ-GUILLÉN 2016). In many cases, hybrid identification is based on the morphology of the male caudal appendages, and the tubercle on the male and female prothorax. It is believed that the comparatively high number of known hybridization cases in *Ischnura* is due to the existence in this genus of several recently radiated clades in which prezygotic and postzygotic reproductive barriers between sibling species are weak, thus allowing hybrid formation (WELLENREUTHER & SÁNCHEZ-GUILLÉN 2016). Range shifts resulting from local climate change are thought to facilitate hybridization (SÁNCHEZ-GUILLEN et al. 2014b; SÁNCHEZ-GUILLÉN et al. 2016). This has been reported in e.g., *I. elegans* which has extended its range in the Iberian peninsula in response to rising temperatures, resulting in increased sympatry with its sibling species *I. graellsii*. In areas where both species overlap unidirectional hybridization takes places, which might lead to progressive introgression and local extinction of *I. graellsii* (SÁNCHEZ-GUILLEN et al 2011; WELLENREUTHER et al 2011).

Colombia is a biologically megadiverse country (ARBELÁEZ-CORTÉS 2013) which is also reflected in odonate species richness (URRUTIA 2005; TORRES PACHÓN & REALPE 2016). Ten out of the 12 South American *Ischnura* species are known from the country, including four which have been described as new to science during the last

Table 1. *Ischnura* hybrids worldwide reported.

Species	Continent	Authors
<i>I. denticollis</i> × <i>I. gemina</i>	North America	JOHNSON (1975); SÁNCHEZ-GUILLÉN et al. (2014b)
<i>I. damula</i> × <i>I. demorsa</i>	North America	KENNEDY (1917); SÁNCHEZ-GUILLÉN et al. (2014b)
<i>I. fontaineae</i> × <i>I. elegans ebneri</i>	Africa	SCHNEIDER & KRUPP (1996)
<i>I. graellsii</i> × <i>I. elegans</i>	Europe	SÁNCHEZ-GUILLÉN et al. (2005)
<i>I. graellsii</i> × <i>I. saharensis</i>	Africa	SÁNCHEZ-GUILLÉN et al. (2014a)
<i>I. genei</i> × <i>I. elegans</i>	Europe	SÁNCHEZ-GUILLÉN et al. (2014a)

Table 2. Origin of *Ischnura* specimens analysed.

Specimen	Locality	Altitude [m a.s.l.]	Latitude	Longitude
<i>I. capreolus</i>	Mesitas	1 507	4°32'.615"N	74°26.243'O
<i>I. cyane</i>	San Francisco	1 627	4°59.228'N	74°17.107'O
Hybrid	Anolaima	1 669	4°45'35.024"N	74°28'5.069"O
Hybrid	Anolaima	1 669	4°45'35.024"N	74°28'5.069"O
Hybrid	Anolaima	1 669	4°45'35.024"N	74°28'5.069"O
Hybrid	Silvania	1 443	4°23'08.5"N	74°22'58.3"O
Hybrid	Silvania	1 443	4°23'08.5"N	74°22'58.3"O

ten years, ranging from sea level to 3 600 m a.s.l. (REALPE 2010; MACHADO 2012; BOTA-SIERRA et al. 2019).

In Colombia, two sibling *Ischnura* species, *I. capreolus* (Hagen, 1861) and *I. cyane* Realpe, 2010, occur sympatrically. *Ischnura capreolus* is a widely distributed species, ranging from Mexico to Argentina in the lowland (0–1 750 m a.s.l.), whereas *I. cyane* is a Colombian endemic restricted to the Cordillera Oriental at altitudes between 1 300–2 200 m a.s.l. (PÉREZ-GUTIÉRREZ & PALACINO-RODRÍGUEZ 2011). Where both species breed sympatrically, morphologically and genetically intermediate individuals occur (unpublished data). The aim of our study was to describe the putative hybrid between *I. cyane* and *I. capreolus*.

Study area and methods

Specimens of the parental species (Figs 2 A–F) and of putative hybrids examined (Figs 2 G–I) were from the Museo de Historia Natural at Universidad de los Andes, Bogotá-Colombia. (ANDES-E). Hybrid individuals were collected at the towns of Anolaima-Cundinamarca (4.761738, -74.464018; 1 669 m a.s.l.) and Silvania-Cundinamarca (4.38568, -74.382857; 1 443 m a.s.l.) (cf. Fig. 1).

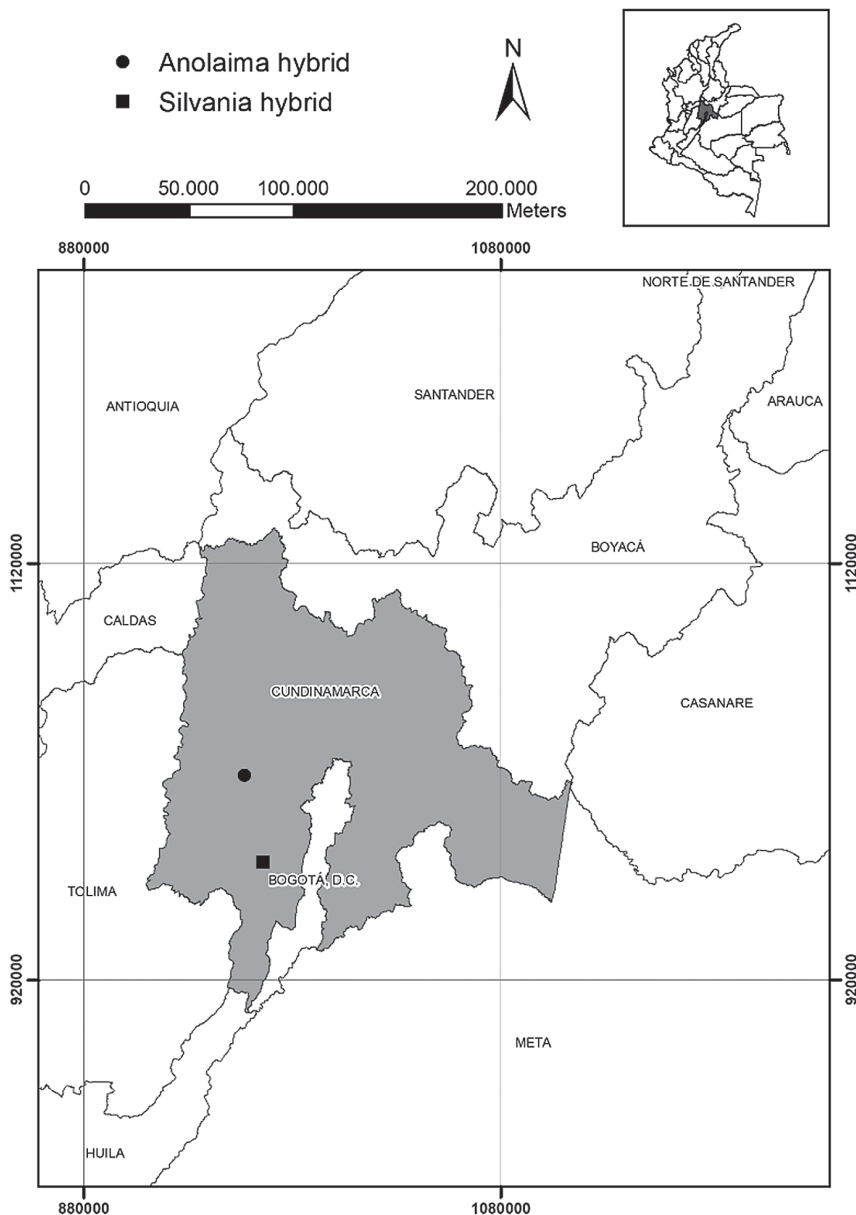


Fig. 1. Geographical position of the collecting sites of the putative hybrids between *Ischnura cyane* and *I. capreolus* at the two towns Anolaima-Cundinamarca (indicated as Anolaima hybrid) and Sylvania-Cundinamarca (indicated as Sylvania hybrid) in Colombia.

For the description of the male hybrid we examined one male of each parental species, and five hybrid males (three from Anolaima and two from Silvania) (Table 2), in order to report variation among the morphotype. Abbreviations for structures used throughout the text are as follows: FW – fore wing; HW – hind wing; Px – postnodals; Pt – pterostigma. Terminology of wing venation follows RIEK & KUKALOVÁ-PECK (1984). All specimens were measured with the aid of a Zeiss Stemi 1000 stereomicroscope. Images were made using a scanning electron microscope JEOL,

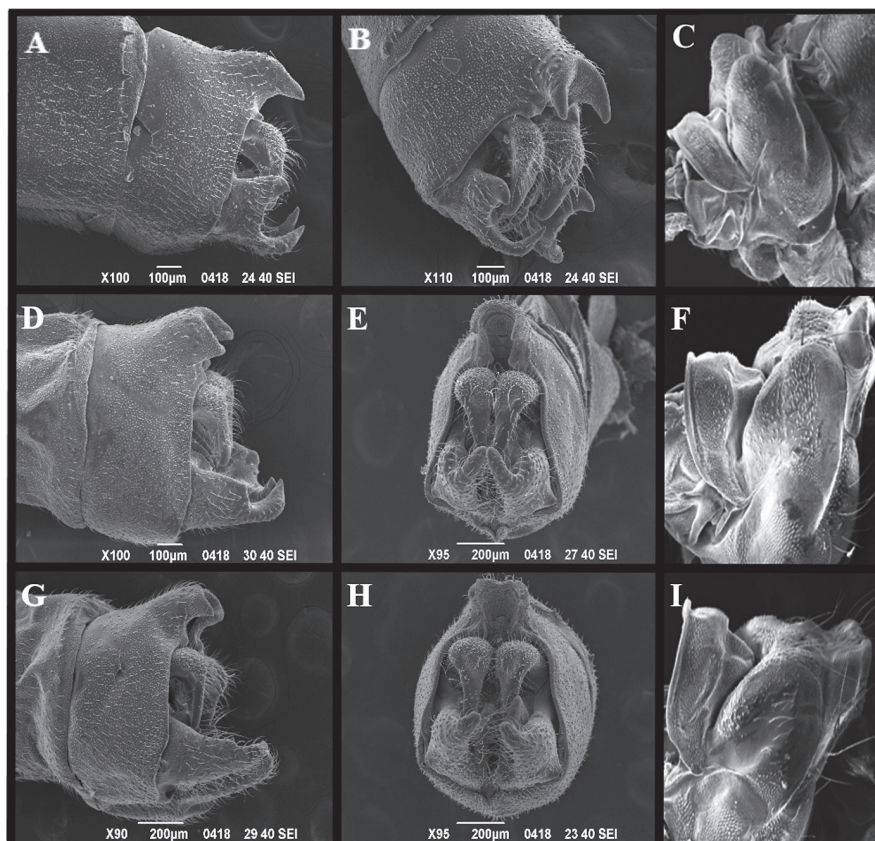


Fig. 2. Terminalia and prothoraces of *Ischnura cyane*, *I. capreolus* and their putative hybrid. *Ischnura capreolus* (from Mesitas-Cundinamarca): A) lateral view of epiprocts and paraprocts, B) distal view of epiprocts and paraprocts, C) prothorax. Putative hybrid (from Anolaima-Cundinamarca): D) lateral view of epiprocts and paraprocts, E) distal view of epiprocts and paraprocts, F) prothorax. *Ischnura cyane* (from San Francisco-Cundinamarca): G) lateral view of epiprocts and paraprocts, H) distal view of epiprocts and paraprocts, I) prothorax.

model JSM 6490-LV, at Universidad de los Andes and with an EPSON scanner, and fixed with GIMP – GNU 2.10.8 (GIMP Team 2019).

Results

Male hybrid

Head – Labium white; labrum greenish yellow with a basal black stripe; anteclypeus greenish yellow, postclypeus dark green with metallic reflections; antefrons greenish yellow and postfrons dark green; epicranium black, with light blue postocular spots. Compound eyes dark above and light red below; genae greenish yellow, and mandibles white (Fig. 3).

Thorax – Prothorax black with a light blue stripe on anterior lobe and posterolateral angles of posterior lobe light blue. Posterior lobe narrow. Pterothorax light blue except: black mid-dorsal stripe, black humeral stripe, black spot on posterior fourth of metapleural suture (Fig. 3). Pectum pale. Legs pale with spurs and the external

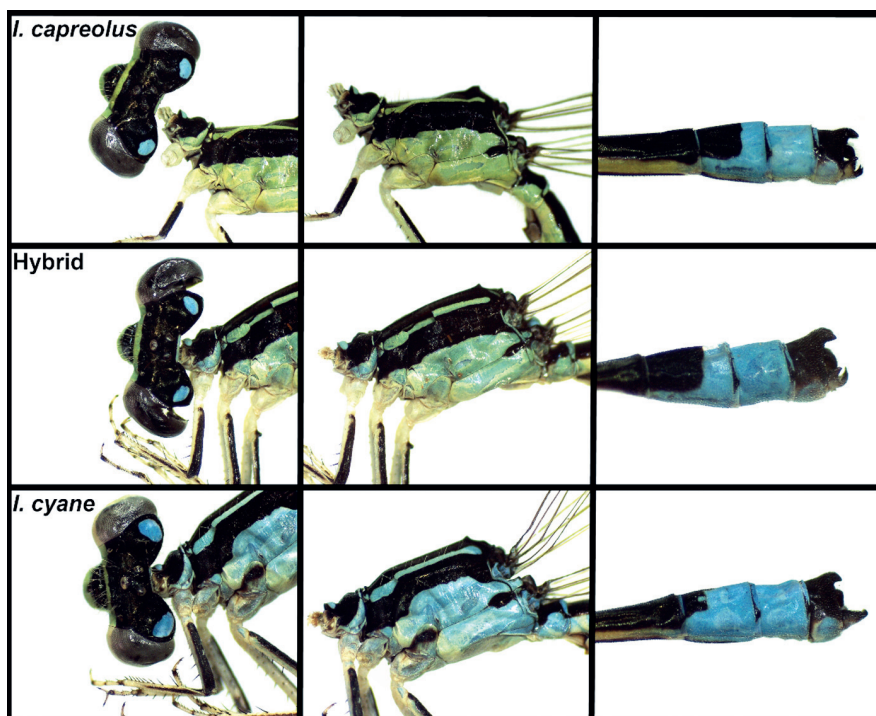


Fig. 3. Body colour variation among *Ischnura cyane* (upper row), *I. capreolus* (lower row) and their putative hybrid (middle row) from Colombia.

surface black. Tarsi with black rings at articulations, claws long dark yellow with black tip and a small subapical tooth. Wing hyaline. Pt black, Px 8 in FW, Px 6 in HW, R3 arising in FW near Px4 in HW near Px3.

Abdomen – Venter pale. S1–S7 dorsally black, S1–S2 laterally blue, S3–S6 laterally yellowish blue, anterior half of S8 black and posterior half blue, S9 light blue, S10 dorsally black and laterally blue (Fig. 3). Hind border of S10 with a large black spine with bifid tip projected posteriorly. Cerci black, hook-shaped, with distal half turned downward almost at a right angle. Paraprocts in lateral view pale with black tip, subquadrate, curving inwards forming a small C-shape at the end, not higher than the paraproct base (Fig. 2D). Genital ligula with distal segment narrow and deeply bifid, forming two curved spines slightly sclerotized.

Body dimensions (Mean \pm SE) – Total length 23.4 ± 0.5 mm. Abdomen length 19.2 ± 0.4 mm (without caudal appendages). FW length 12 ± 0.5 mm. HW length 11.2 ± 0.4 mm.

Discussion

Although all individuals examined were hybrids from crosses between *I. cyane* and *I. capreolus*, we found a shape gradient that ranged from hybrids with the paraproct morphologically close to *I. capreolus* to hybrids with the paraproct morphology close to *I. cyane* (cf. Figs 2D–E). In lateral view, the paraprocts of some hybrids had a pronounced “C-shape” terminally, similar to the *I. capreolus* paraproct (Figs 2A–C), in combination with the dark blue thoracic coloration (Fig. 3). At the other extreme, some hybrids had long and a poorly defined terminal “C-shape” in the paraprocts, in combination with light blue thoracic coloration; that is, closer to *I. cyane* paraproct shape (Figs 2F–H) and coloration (Fig. 3). The observed gradient in the paraproct morphology of the studied hybrids is consistent with successive backcrosses between hybrids and each parental species, however it has not yet been possible to test in the laboratory the possible mating crosses between both parental species and hybrids.

One of the consequences of climate-induced range shifts is the formation of new overlapping distributions. In the last 40 years, many odonate species have changed their latitudinal distribution ranges in response to climate change (HICKLING et al. 2005). When two closely related species (that have evolved in allopatry, and thus have not reinforced reproductive isolation) come into secondary contact, or increase their current sympatry, the natural balance in the occasional formation of hybrids and their removal by natural selection can be altered (SÁNCHEZ-GUILLÉN et al. 2013). Observed hybrids between *I. capreolus* and *I. cyane* in the studied sympatric zone could be due to a recently increased range overlap induced by local climate change. Distributional changes could have allowed the two species to stay in contact for longer periods, thus facilitating heterospecific matings and the production

of hybrids exhibiting unusual levels of variation and with intermediate paraproct morphology and thorax coloration.

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