

The neotropical damselfly genus *Cora*: new larval descriptions and a comparative analysis of larvae of known species (Odonata: Polythoridae)

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The final larval stadium of four species of *Cora* are described and compared with known species in the genus. *Cora skinneri* Calvert, 1907, *C. semiopaca* Selys, 1878 and *C. lugubris* Navás, 1934 are described and illustrated for the first time using material from Costa Rica for the first two and from Colombia for the latter. A redescription of *C. marina* Selys, 1868 from specimens collected in Costa Rica is also included for comparison. Although all species are very similar as larvae, two major groups can be differentiated based on the shape of the caudal gills. The three species here described for the first time are very similar, but can be separated from each other using a combination of characters.

Se describen los estadios finales de las larvas de tres especies de *Cora* y se comparan con las especies conocidas en el género. *Cora skinneri* Calvert, 1907, *C. semiopaca* Selys, 1878 y *C. lugubris* Navás, 1934 son descritas e ilustradas por primera vez usando material de Costa Rica para las dos primeras y de Colombia para la última especie. Se incluye además la descripción de la larva de *C. marina* Selys, 1868 de especímenes recolectados en Costa Rica para propósitos comparativos. Las especies de *Cora* son muy similares como larvas, pero se pueden diferenciar dos grandes grupos basado en la forma de las branquias caudales. Las tres especies que se describen pertenecen al mismo grupo y se pueden separar entre ellas usando una variedad de caracteres.

Keywords: Odonata; Zygoptera; Polythoridae; *Cora skinneri*; *Cora semiopaca*; *Cora lugubris*; *Cora marina*; taxonomy; larvae; Costa Rica; Colombia

Introduction

The Neotropical damselfly genus *Cora* has 22 species, making it the largest genus in the family Polythoridae (Garrison et al., 2010). *Cora* reaches its highest diversity in northern South America (Bick & Bick, 1986), with only six species reported for Central America, most of them only from Costa Rica and Panama. Only *C. marina* Selys, the most widespread species in the genus, reaches

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Mexico (González-Soriano & Novelo-Gutiérrez, 1996; Paulson, 1982). The larvae of Polythoridae are poorly known, with most genera having only two or three of their species described as larvae. *Cora* is no exception and only three of its 22 species have their larvae described: *C. chirripa chirripa* Calvert (Calvert, 1911) is restricted to Costa Rica, *C. cyane* Selys (De Marmels, 1982) occurs only in Venezuela, and *C. marina* (Novelo-Gutiérrez & Gonzalez-Soriano, 1985) is the only species with a wide distribution, from Colombia and Venezuela to Mexico.

In this study, we describe and illustrate the final larval stadium of three additional *Cora* species, *C. skinneri*, *C. semiopaca* and *C. lugubris*. For the sake of completeness, we provide a brief redescription of *C. marina*, as this species has been reported for the same countries as the three species described. All major characteristics that separate known larvae in the genus are discussed based on larval descriptions, in order to facilitate identification.

Material and methods

Morphological terminology follows Corbet (1953) for the labium and Snodgrass (1954) for remaining body parts. All measurements are in mm and were obtained by using an ocular micrometer mounted on a dissecting microscope.

Larvae described below were associated by collecting final stadia in the field and rearing them until emergence in the laboratory. Larval sampling was accompanied by adult collections and descriptions of the stream habitat. Specimens from Costa Rica are deposited at the Museo de Zoología, Universidad de Costa Rica (MZUCR), those from Colombia are at the Museo de Entomología Francisco Luis Gallego, Universidad Nacional de Colombia, Medellín (MEFLG), and those from Mexico at the Instituto de Ecología, Xalapa, Mexico (IEXA).

Results

Cora skinneri Calvert, 1907

(Figures 1b, 2a)

Material examined

Larvae: One F0 stadium male, Costa Rica, Cartago, Reserva Forestal Rio Macho, Universidad Nacional field station, 19 March 1992, A. Ramírez leg. One F0 stadium male and 1 early stadium female, Reserva Forestal Rio Macho, El Llano, 21 February 1993, 1600 m a.s.l. A. Ramírez leg.

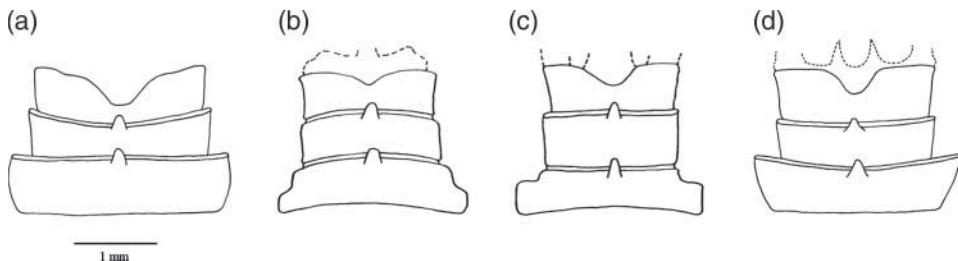


Figure 1. Abdominal segments 8–10 of *Cora* showing differences in the form and depth of the abdominal segment 10 indentation. (a) *C. lugubris*, (b) *C. skinneri*, (c) *C. semiopaca*, and (d) *C. marina*. Apparent differences in segments 8–9 are not considered consistent enough to be of use in species separation.

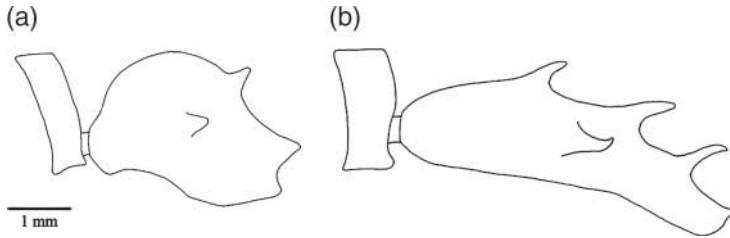


Figure 2. Caudal gills, lateral view, for (a) the generalized *C. lugubris*, *C. skinneri* and *C. semiopaca* group, and (b) for *C. marina*. See text for details on the number of projections, as not all are visible laterally.

Description

Larvae uniformly light brown, body short and robust, integument densely covered with small scales.

Head. Wider than long, occipital margin concave, cephalic lobes moderately developed, rounded, but not bulging, covered with small scales, except for nine clear areas: two in front of middle ocellus, a long one near margin of each eye, one on each cephalic lobe, and three along occipital margin. Frontal and ventral margins of eyes with row of small scales. Antennae 7-segmented, 2nd segment longest, relative length of antennomeres: 0.6, 1.0, 0.5, 0.4, 0.3, 0.2, 0.1; scape and pedicel covered with small scales and with row of long setae on both lateral margins. Flagellum mostly glabrous. Labrum with row of long setae, setae $0.7\times$ length of labrum. Labium with articulation of prementum–postmentum at level of posterior margin of procoxae; prementum two times as long as wide, without setae. Labial palp with 3 apical teeth, the middle one longest, innermost smallest, apex truncated. Ligula with border serrated and very narrow middle V-shaped incision with very small spine at each side.

Thorax. Pronotum covered with scales, except for clear area at each side. Anterior and posterior wing pads reaching basal half of abdominal segments 7 and 8, respectively. Femora compressed laterally, with one dorsal and two ventral crests with rows of scales; tibiae with four crests with scales. Tarsi 3-segmented, all covered with stout setae; tarsal claws simple, each with pulvilliform empodium.

Abdomen. Tergites covered with scales; segments 2–9 with well-developed obtuse dorsal protuberances; segments 3–10 with row of scales on posterior margin. Posterior margin of abdominal segment 10 with deep incision (Figure 1b). Lateral margins of segments 2–8 with lateral projection, best developed on 8. Segments 2–7 each with pair of digitiform ventrolateral gills. Male gonapophyses small, reaching posterior margin of segment 9; female gonapophyses well developed, but no last stadium female larvae were available to examine the final size. Caudal gills petiolate and inflated (Figure 2a), densely covered with scales; lateral gills larger than middle one. Lateral gills with four small projections, middle gill with five such projections (as in Figure 2a).

Dimensions (mm). Total length including gills, but excluding antennae: 17–19; abdomen 6–6.5; posterior femur 4.2–4.3; posterior tibia 4.1–4.2; maximum width of head 4.7; lateral gills 3.0–3.3, middle gill 2.5–3.0.

Cora semiopaca Selys, 1878

(Figures 1c, 2a)

Material examined

Larvae: One F0 stadium male and 2 F0 stadium females. Costa Rica, San José, El Rodeo Forest Reserve, 28 December 1990, 850 m a.s.l. A. Ramírez leg.

Description

Larvae uniformly dark brown, body short and robust, integument densely covered with small scales.

Head. As in *C. skinneri*, but with the following differences: Antennae 7-segmented, 2nd segment longest, relative length of antennomeres: 0.6, 1.0, 0.7, 0.5, 0.4, 0.3, 0.1; scape and pedicel covered with small scales and with row of long setae on both lateral margins, those of inner margin longer.

Thorax. As in *C. skinneri*, but with the following differences: anterior and posterior wing pads reaching basal and middle part of abdominal segment 6, respectively.

Abdomen. As in *C. skinneri*, but with the following differences: female gonapophyses well developed, clearly passing the posterior margin of segment 10. Posterior margin of abdominal segment 10 with deep incision (Figure 1c). Gills as in Figure 2a.

Dimensions (mm). Total length including appendages 14–16; abdomen 4–6; posterior femur 4; posterior tibia 3; maximum width of head 4; lateral gills 3, middle gill 2.

Cora lugubris Navás, 1934

(Figures 1a, 2a)

Material examined

Exuvia: One F0 stadium female. Colombia, Antioquia, Quebrada la Miel, Caldas, 8 October 2008, 1987 m a.s.l. M. Altamiranda leg. Cat. No. 19670.

Description

Larvae light brown with pale areas on the anterior vertex, between each lateral ocellus and corresponding antenna. Body robust and densely granulated.

Head. As in *C. skinneri*, but with the following differences: Relative length of antennomeres: 0.6, 1.0, 0.5, 0.3, 0.3, 0.3, 0.1; scape and pedicel covered with small scales and with a row of setae of similar length on both lateral margins.

Thorax. As in *C. skinneri*, but with the following differences: anterior and posterior wing pads reaching distal margin of abdominal segments 5 and 6, respectively.

Abdomen. As in *C. skinneri*, but with the following differences: posterior margin of abdominal segment 10 with deep incision, 2/3 length of segment (Figure 1a). Gills as in Figure 2a.

Dimensions (mm). Total length including appendages 13.6; abdomen 4.5; posterior femur 3.2; posterior tibia 3.5; maximum width of head 3.9; lateral gills 2.6, middle gill 2.3.

Cora marina Selys, 1868

(Figures 1d, 2b)

Material examined

One F1 stadium female, three F0 stadium male. Costa Rica, Alajuela, San Ramón, Río San Lorencito, Estación Biológica Alberto Manuel Brenes, February 1994, 860 m a.s.l., M. Springer leg. One F0 stadium female, four F0 stadium male, Costa Rica, Alajuela, San Ramón, Río San Lorencito, Estación Biológica Alberto Manuel Brenes, 30 December 1999, 860 m a.s.l., M. Springer leg. Three F0 stadium female, one F0 stadium male. Costa Rica, Alajuela, San Ramón, Río San Lorencito, Estación Biológica Alberto Manuel Brenes, 30–31 December 2000, 860 m a.s.l., M. Springer leg. One F0 stadium male, Costa Rica, Alajuela, San Carlos, Río La Vieja, PH Chocosuela I, 50 m below to site dam, 750 m a.s.l., 9 March 2002, M. Springer leg. One F0 stadium female, Costa Rica, Puntarenas, Coto Brus, afluyente Río Jaba, Las Cruces Field Station, 1000 m a.s.l., 14 July 1996, M. Springer & J.A. Álvarez leg. One F0 stadium male, Costa Rica, Puntarenas, Coto Brus, Río Jaba, Las Cruces Field Station, 1200 m a.s.l., July 1998, students OTS course leg. One F0 stadium male, Costa Rica, Puntarenas, Coto Brus, Río Jaba, Las Cruces Field Station, May 1995, A. Ramírez leg. One F0 stadium female, Costa Rica, Heredia, Parque Nacional Braulio Carrillo, confluencia Sucio-Hondura, 3 April 1992, A. Ramírez leg. Two F0 stadium males, 1 F0 stadium male exuvia. Costa Rica, Heredia, Río Tirimbina, Estación Biológica La Tirimbina, 4 April 2009, 180 m a.s.l., P. Gutiérrez-Fonseca leg. One F0 stadium male, Costa Rica, San José, Puriscal, Mastatal, Quebrada Grande, 27 May 2005, R. Chaves & S. Bolton leg. Two F0 stadium male, Mexico, Veracruz, Los Tuxtlas, Sta Marta, Arroyo Claro, 8 March 1991, R. Novelo leg. One F1 stadium male, Mexico, Veracruz, Los Tuxtlas, Sta Marta, Arroyo Claro, 8 March 1991, R. Novelo leg.

Description

Exuvia light brown, larvae dark brown or black. Body robust and densely granulated.

Head. As in *C. skinneri*, but with the following differences: Relative length of antennomeres: 0.7, 1.0, 0.5, 0.5, 0.3, 0.2, 0.1; scape and pedicel covered with small scales and with row of similar length setae on both lateral margins.

Thorax. As in *C. skinneri*, but with the following differences: anterior and posterior wing pads reaching distal margin of abdominal segment 6 and basal half of segment 7, respectively. Tarsi, in ventral view, with two spines at each side of distal margin, each with pulvilliform empodium.

Abdomen. As in *C. skinneri*, but with the following differences: Posterior margin of abdominal segment 10 with a deep incision (Figure 1d). Gills elongated and with long acute projections as in Figure 2b. Median gill with six projections. Lateral gills with five or six projections, the presence of an internal lateral projection varying with locality. All specimens from Mexico have lateral gills with five projections, lacking an internal projection. Specimens from Venezuela always have the internal projection and the lateral gills have six projections (J. De Marmels, personal communication). Specimens from Costa Rica were found with five and six projections. Even

specimens from the same locality varied in the presence and size of the internal projection. Of the 24 Costa Rican larvae analysed, 70% had six and 30% had five projections on their lateral gills.

Dimensions (mm). Total length including appendages 18–19; abdomen 8–8.5; posterior femur 4.5–5; posterior tibia 4; maximum width of head 4.5; lateral gills 3.5–4, middle gill 4–4.5.

Discussion

The family Polythoridae is known to have a high degree of similarity among its members, both as adult and larvae. Distinctions among taxa are somewhat difficult for species and even genera (Garrison et al., 2010). Few species of polythorids have been described as larvae and the larval stage of three of the eight genera are completely unknown (i.e. *Kalocora*, *Miocora* and *Stenocora*). Using the limited information available, the known genera have been divided into two groups: *Cora*, *Euthore* and *Polythore* have large larvae with rounded occipital lobes; and *Chalcothore* and *Chalcopteryx* have relatively small larvae with angled occipital lobes (De Marmels, 2007; Etscher et al., 2006). Separation of *Cora* from *Euthore* and *Polythore* is rather difficult at this point. De Marmels (2007) suggests the use of the shape of the wing sheaths as a distinctive character, with *Cora* having narrow and elongated ones.

Including the species described here, only a quarter of the total number of *Cora* species is known in its larval stage (i.e. six out of 22). Known larval *Cora* can be divided into two major groups based on the shape of the caudal gills and the number of projections present (Table 1). *C. marina* and *C. cyane* form one group, which is characterized by elongated gills armed with five or six long projections. These two species can be separated by the shape of the dorsal projections on the abdomen and the lateral gill projections, being pointed in *C. marina* and rounded in *C. cyane* (De Marmels, 2007). The presence of an empodium on the pre-tarsi appears to be a variable character in *C. cyane*, and perhaps should not be used for species separation (De Marmels, personal communication). The second group within *Cora* is composed of the remaining species (i.e. *semiopaca*, *skinneri*, *lugubris* and *chirripa*), all of which have rounded gills armed with four or five short projections (Table 1). The larvae of these four species are rather similar, but can be differentiated by a combination of characteristics. The dorsal margin of the abdominal segment 10 is deeply incised in some species (e.g. *C. lugubris*) and not as much in others (e.g. *C. skinneri*). Further details are provided in Table 1. It is clear that while two large groups can be delineated, differences among species within each group are very slight and further work is necessary to allow for proper separation of the species.

Table 1. Comparison of larval characteristics among species of *Cora* that are useful in separating the species.

Character	<i>Cora</i> species					
	<i>chirripa</i>	<i>lugubris</i>	<i>semiopaca</i>	<i>skinneri</i>	<i>cyane</i>	<i>marina</i>
Tarsal empodium	Present	Present	Present	Present	Present or absent	Present
Dorsal margin abdominal segment X	with a wide deep incision	with a deep incision	with a shallow incision	with a shallow incision	- - -	with a deep incision
Caudal gills and projections	Short	Short	Short	Short	Long	Long
Number of gill projections	4 - 5 - 4	4 - 5 - 4	4 - 5 - 4	4 - 5 - 4	6 - 6 - 6	5 - 6 - 5 or 6 - 6 - 6
Total larval length (mm, no gills)	16.5–20.5	11 (exuviae)	11–13	14–16	13.5 (exuviae)	18–20

Variability among localities in the number of projections present in the lateral gills of *Cora marina* deserves further attention. *C. marina* is a widespread species and adults are known to have some degree of variability in their morphological characteristics (Bick & Bick, 1986). The pattern we observed for the larvae indicates that populations at each end of the species distribution (e.g. Mexico and Venezuela) are clearly different, with those in the middle having a mixture of characters shared with both ends. This pattern in variability was previously discussed for adults of *C. marina*. Selys Longchamps (1873) proposed *C. alcyone* as a new species from Venezuela similar to *marina*. Later, De Marmels (1988) recognized the degree of similarity between *alcyone* and *marina* and treated it as a subspecies. Bick and Bick (1986) studied the amount of variability in *marina* and decided to consider *alcyone* as a synonym of *marina*. The pattern appears to be a case of isolation by distance, with populations at the edge of the species distribution showing marked phenotypic differences due to limited gene flow and those in the middle showing a mixture of characteristics (Wright 1943). Further larval sampling at different localities along the species range could shed light on the proper treatment (e.g. subspecies versus variability) of the different populations.

Polythoridae also occupy similar habitats. Most larval specimens have been collected from small to mid-size streams with continuous water flow, rocky substrates and abundant detritus. The habitat of known species of *Cora* fits well within that description. Larvae of *C. skinneri* were collected in a small (<1 m width) shaded stream, in areas of loose rocks with leaf litter accumulations. *Cora semiopaca* was collected from a similarly small stream, but with more organic matter in the bottom (e.g. wood and leaf accumulations). *Cora lugubris* and *C. marina* differed mostly on the fact that they inhabited somewhat larger streams (3–4 m width). Females of *C. lugubris* were observed ovipositing on dead wood at the stream margins in shaded areas with abundant detritus, and larvae were collected in areas of rocks and accumulation of leaf litter. In general, *Cora* larvae had been found living under or on the sides of rocks on the stream bottom in riffles or areas of continuous flow. Ecological studies on *C. marina* (Pritchard, 1996) and behavioural studies on *C. semiopaca*, *C. obscura* and *C. notoxantha* (Fraser & Herman, 1993) also agree with the general habitat here described for *Cora* species.

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