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Erythrodiplax ana sp. nov. (Odonata: Libellulidae) from Brazilian palm swamps

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Abstract

Erythrodiplax ana **sp. nov.** (male holotype, six male and three female paratypes), collected in Vereda wetlands (a unique Neotropical savanna environment) in Uberlândia (Minas Gerais) and Chapada dos Guimarães (Mato Grosso), Brazil, is described and illustrated. The new species fits in Borror's Basalis Group, and can be distinguished from other species by the combination of the following traits: blue pruinosity dorsally on thorax and third to eighth abdominal segments; sides of the thorax olive-green; face ivory or olive-green; wings hyaline with a small apical brown spot on all four wings, well defined in females; male genitalia with sclerotized erectile posterior lobe and inflatable sac-like median process. Last instar larvae were reared in the laboratory, resulting in the description of the larva. We also followed this population for 13 months and present resulting biological notes and comments on ontogenetic color change in males, as well as longevity.

Keywords: Dragonfly, new species, taxonomy, Cerrado, Brazil

Introduction

Erythrodiplax Brauer, 1868, is a genus of Libellulidae comprising 57 species (Garrison *et al.* 2006, Haber *et al.* 2015), of which 39 occur in Brazil. Here we describe a new species from Brazil, collected in Vereda, a wetland environment of the Brazilian savanna. This is the seventh *Erythrodiplax* species described after Borror's revision of the genus (Borror 1942), 16 years after the description of *E. bromeliicola* by Westfall (Needham & Westfall 2000) and concomitant with the recently described *E. laselva* breeding in bromeliads in Costa Rica (Haber *et al.* 2015). The species here described was classified in Borror's Basalis group because of the typical morphological features of the vesica spermalis: hood not developed, lateral lobes small and rounded, and a saclike erectile posterior lobe present.

Materials and methods

Specimens were collected in the Ecological Reserve of the Clube de Caça e Pesca Itororó de Uberlândia, Uberlândia, Minas Gerais State, Brazil (CCPIU) (15º57'S, 48º12'W; altitude 863 m; 640 ha) by RGF and DSV, and in the Chapada dos Guimarães National Park in Chapada dos Guimarães, Mato Grosso State, Brazil (15º 24'S, 55º 99'W; altitude 800m; 32,769.55 ha) by RGF. The species inhabits ponds in Vereda, which is an endemic Neotropical Savanna environment; also called palm swamps due to the common association with the palm tree *Mauritia flexuosa* L. (Arecaceae) (Figure 1a). This species could not be found anywhere else in surveys made around Uberlândia and Chapada dos Guimarães. The material is deposited in the Aquatic Insects collection of the Department of Hydrobiology, UFSCar, São Carlos, São Paulo State, Brazil. Single male (Figure 1b) and female

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(Figure 1c) paratypes are deposited in the Aquatic Insects collection of the Aquatic Biology Lab of the São Paulo State University in Assis, São Paulo State, Brazil. Single male and female paratypes are deposited at the Biodiversity Museum of the Federal University of Grand Dourados, MuBio UFGD, Dourados, Mato Grosso do Sul State, Brazil.

FIGURE 1. Photographs of (a) the study site and living habitat of *Erythrodiplax ana*: palm swamp pond typical of the Neotropical savanna; (b) male and (c) female.

Illustrations were made using digital camera photographs (Moticam and Canon EOS T5) attached to stereoscopic microscopes Zeiss Stemi SV 6 and Leica MZ95. Terminology for wing venation follows Riek and Kukalová-Peck (1984). Fw = forewing, Hw = hindwing, pt = pterostigma, Ax = antenodal cross vein, S = abdominal segments. Body measurements are shown in mm (range: minimum–maximum).

Adult males were marked in the field with a unique number on the right forewing and followed through consecutive days to note the color change in male thorax and the duration of each color stage. The population was followed biweekly between June 2011 and July 2012 from 10:00 to 14:00h, when males were captured, marked and released to estimate densities in rainy and dry seasons.We then analyzed male longevity with a Kaplan-Meier test.

The identity of the larva was ascertained by rearing two larvae in the laboratory. Exuviae were preserved in 80% alcohol, and adults were placed in a plastic container allowing hardening of the exoskeleton. Mandibular formulae follow Watson (1956).

Results

Erythrodiplax ana sp. nov. Guillermo-Ferreira & Vilela

Specimens examined. Holotype (1♂) BRAZIL, Minas Gerais: Uberlândia (Vereda of CCPIU, 840m), 10-VII-2012**,** Guillermo-Ferreira, R., Vilela D. S. Paratypes (5♂ and 2♀ adults) and final instar larvae, 1♂ and 1♀ (reared), collected at the same location and date;(1♂ and 1♀) collected at BRAZIL, Mato Grosso: Chapada dos Guimarães (Rio do Manso, 800m), 04-XI-2015 by the same collectors.

Etymology. This species is named after RGF's wife Ana.

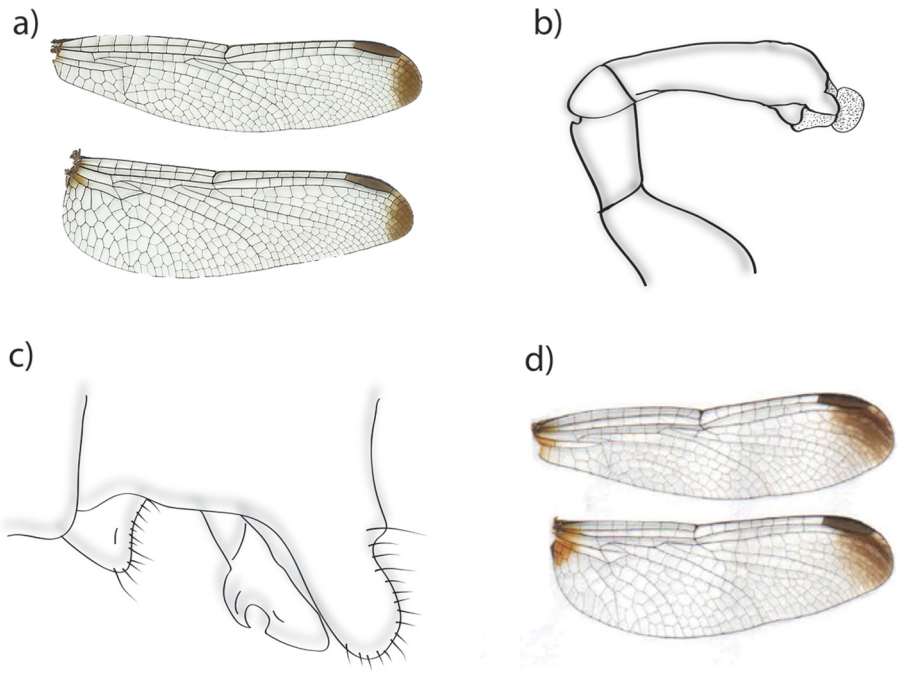

FIGURE 2. *Erythrodiplax ana*: (a) male wings; (b) vesica spermalis; (c) hamule; (d) female wings.

Description. Male Holotype. *Head*. Labrum, labium, clypeus and antefrons olive-green to ochraceous. Postfrons and vertex metallic blue. Occipital triangle black.

Thorax. Prothorax black, with long white hair-like setae on posterior lobe margins and middle lobe protrusions. Mesepisternum covered dorsally with light blue pruinosity, small spines and white hair-like setae, mesepisternum green ventrally; metepisternum olive-green, slightly covered dorsally with blue pruinosity, with a set of small spines dorsally, with a dark brown spot and small spines medially near the spiracle, a light brown spot posteriorly covered with small spines; metepimeron olive-green. Legs mostly dark brown, covered ventrally with a thin layer of white pruinosity; coxae and trochanters yellowish brown, femora dorsal surface yellowish brown and ventral surface dark brown; tibiae dark brown with a longitudinal yellow stripe; tarsi black; posterior femur with 14 short spines and one distal long spine on the ventro lateral surface.

Wings: hyaline, with small basal and apical brown spots on all four wings; venation brown to black, pt brown (Figure 2a).

Venation: 10–11 Ax in Fw, distal incomplete; 7–8 Ax in HW.

Vesica spermalis: first two segments similar to other *Erythrodiplax*; V3 long and sclerotized, with a truncated distal process, ventral portion less sclerotized; V4 with sclerotized lateral lobes, which are quadrate with rounded angles; an erectile and sclerotized posterior lobe; and a median process carrying an inflatable sac-like structure extending lateral lobe (Figure 2b).

Abdomen. S1 olive-green heavily covered with long white hair-like setae; S2 olive-green with blue pruinosity posteriorly in a small spot and long white hair-like setae dorsally; S3–7 covered dorsally with blue pruinosity, blue pruinosity fading in S3 anteriorly to carina; S8 black posteriorly and with blue pruinosity anteriorly; S9–10 totally black. Genital lobe quadrangular with long setae on margins, hamule concave, not higher than genital lobe (Figure 2c). Cerci yellow with black margins, lanceolate posteriorly, ventral margin with a row of 6 spines. Epiproct yellow, foliaceous with bifid tip.

*Measurements.*Total length (including caudal appendages) (28.2); abdomen length (excluding caudal appendages) (16.8); head maximum width (4.5); Fw length (24.6); Hw length (23.3); Hw width 6 (proximal to costal nodus); pt length (3.2) in Fw, (3.3) in Hw; length of metathoracic femur (4.4); metathoracic tibia (4.6); total length of cercus in lateral view (1.5); length of epiproct in lateral view (0.9).

Male paratypes. *Head*. Labrum and labium ivory (N=2) or olive-green (N=4). *Thorax*. Prothorax entirely black (N=3), with yellow marks (N=1) or covered by blue pruinosity (N=2). Metepimeron dark brown to black (N=3) or olive-green (N=3). *Abdomen*. S1–2 and S9–10 yellow (N=3) or dark brown (N=3). S1–10 entirely dark

brown to black ventrally (N=5) or with yellow marks (N=1). S1–8 dorsally covered by a thick layer of blue pruinosity. Older individuals present scratches on the blue pruinosity, revealing the black color beneath. *Venation:* 9 to 11 Ax in Fw, distal incomplete; 7 to 8 Ax in HW. Four males have no spots on the wingtips.

Measurements. Total length (including caudal appendages) (28.6–30.1); abdomen length (excluding caudal appendages) (15.6–16.4); head maximum width (4.5–5.1); Fw length (23.4–24.8); Hw length (21.0–23.0); Hw width (6.0–7.1) (proximal to costal nodus); pt length (3.5) in Fw, (3.7) in Hw; length of metathoracic femur (3.2–4.0); metathoracic tibia (4.0–4.5); total length of cercus in lateral view (1.31–1.40); length of epiproct in lateral view (0.8–0.92).

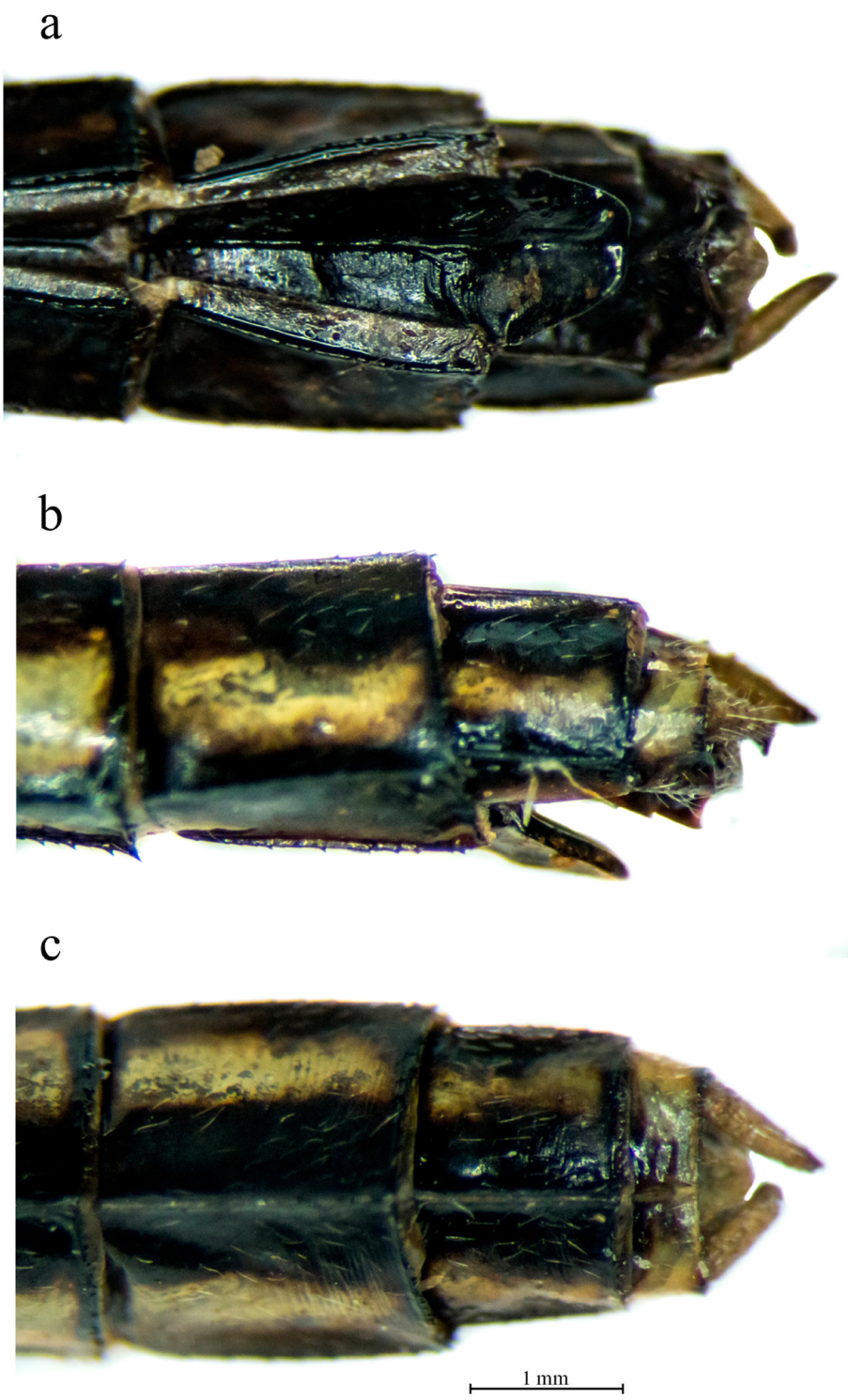

FIGURE 3. *Erythrodiplax ana* female final abdominal segments: (a) ventral view; (b) lateral view; (c) dorsal view.

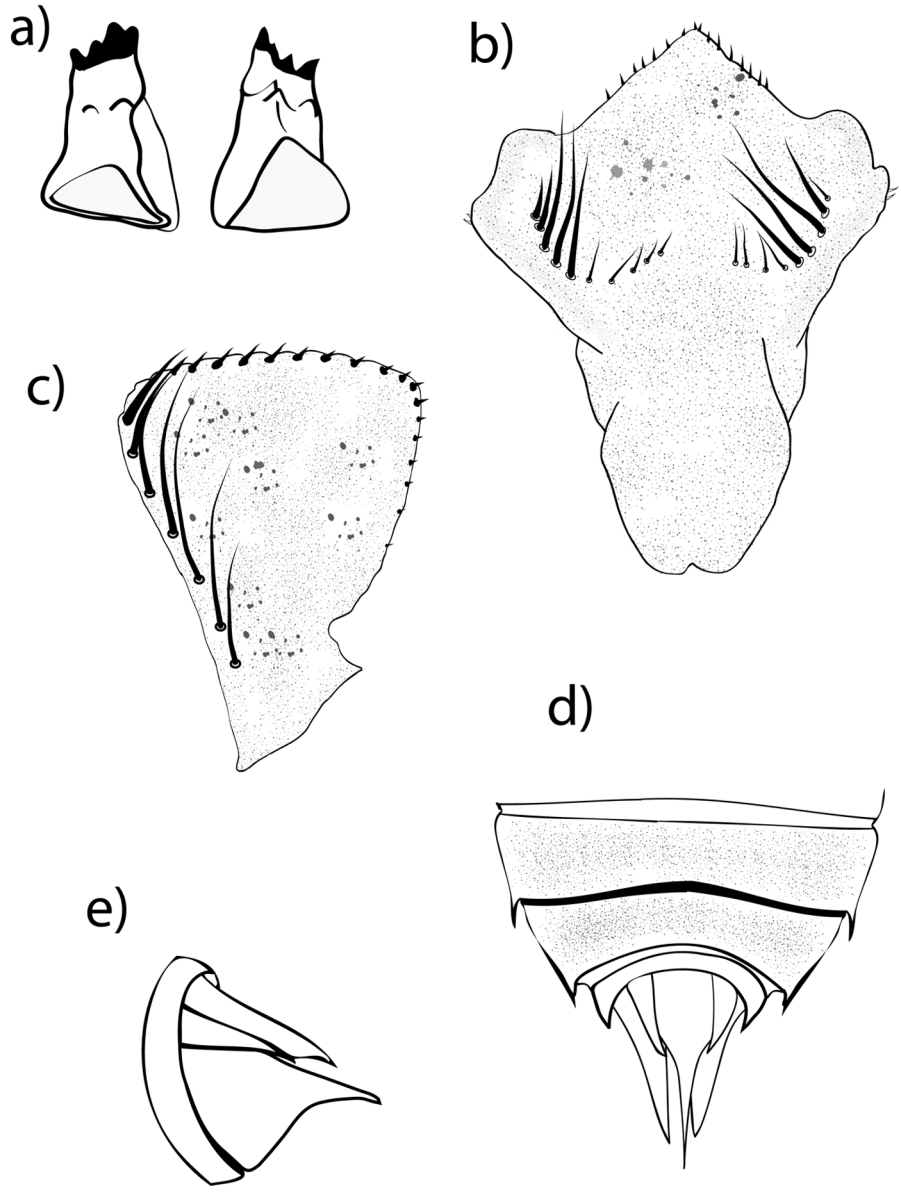

FIGURE 4. *Erythrodiplax ana* last instar larva: (a) left and right mandibles; (b) prementum; (c) labial palp; (d) lateral spines on abdominal segments 8–10; (e) paraproct and epiproct in lateral and dorsal views.

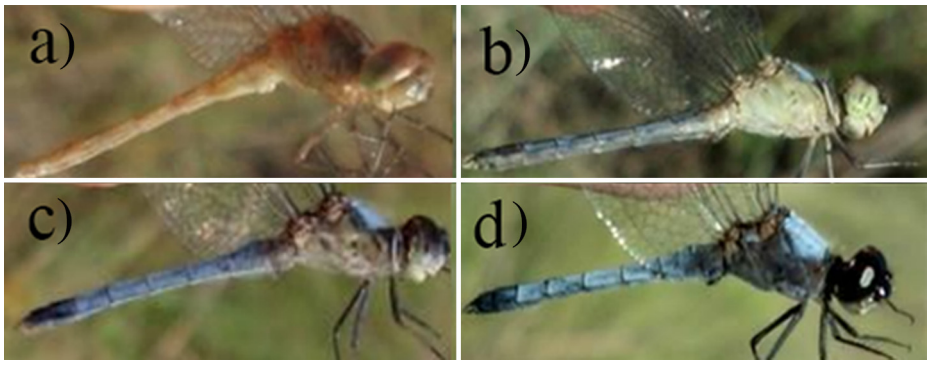

FIGURE 5. Color change according to the age of the male during six days of recapturing. (a) Teneral individual; (b) young male with green olive eyes and thorax; (c) male with darkened green eyes and thorax; (d) male with black eyes and thorax.

Female paratypes (N=3)**.** *Head*. Labrum and labium ochraceous, eyes dark brown. *Thorax*. Prothorax and metepimeron ochraceous to yellow. *Wings*: hyaline, with small basal spots and large apical brown spots on the four wings, reaching the middle of pterostigma; venation brown to black, pt brown (Figure 2d). *Abdomen*. S1–7 yellow with black segment margins, S8–10 black dorsally and in segment margins with lateral yellow stripes; cerci are blunt with brown coloration; vulvar lamina black, scoop-shaped and diagonally directed, almost as long as S9 (Figure 3). *Venation*: 11 Ax in Fw, distal incomplete; 9 Ax in HW. *Measurements.* Total length (24.31–25.88); head maximum width (4.03); Fw length (24); Hw length (22.6); Hw width (6.6) (proximal to costal nodus); pt length (3.36) in Fw, (3.4) in Hw; length of metathoracic femur (3.4–3.75); metathoracic tibia (3.8–4.0).

Description of the final instar larva. *Head.*About 1.3x as wide as long; occipital margin slightly concave; third segment of antenna the longest. Mandibular formula L 1 2 3 4 0 a b / R 1 2 3 4 y a b d (Figure 4a). Labium (Figure 4b) with 18 premental setae; ligula with 16 small setae; latero-distal margin with two spiniform setae; dorsal outer margin of labial palp (Figure 4c) with 6 palpal setae; anterior margin slightly crenulated with 10 spiniform setae, one on each concavity; inner margin with 10 spiniform setae; movable hook 0.22x maximum length of labial palp. *Thorax.* Wing pads reaching posterior margin of S5. *Abdomen.* Brown, no dorsal spines, posterior margins of S8–9 with lateral spines (Figure 4d). Epiproct wide at base, apex acute. Paraprocts, epiproct and cerci tips slightly curved (Figure 4e). Ratio relative to paraprocts: epiproct (1.03), cerci (0.74).

Measurements (in mm, N=4). Total length (12.0–14.0). Head: max. length (2.5–2.7), max. width (3.3–3.5). Prementum: max. length (2.35–2.5), max. width (1.8–2.0). Thorax: femur III (3.7–4.3), tibia III (3.5–4.0). Abdomen: total length (7.0–8.5), S8 length (0.7–0.8), S9 length (0.5–0.62), S10 length (0.40–0.45). Length of lateral spines (0.31) on S8, (0.30) on S9. Paraproct (0.42), epiproct (0.44).

Biological and ecological data. Males are territorial and defend perches on the pond against rival intruders (N=18). Females oviposit while the males guard them without contact, warding off other males during oviposition (N=10). The densities of males collected, marked and released during the rainy (N=165) and the dry (N=41) season varied (Vilela *et al.* 2016). The rainy season covered the months between the end of July (2010) and March (2011) with rains more concentrated between November and February. The dry season of 2011 occurred between early April and the end of June.

We marked 71 males and followed them for 67 days between September and November 2013, to document the ontogenetic color change. Males vary greatly in body coloration with age. Within a week, the eyes and thorax darken until they are dark brown or black (Figure 5). The thorax of young males is olive-green, turning brown/ black with age, sometimes completely covered by blue pruinosity. The blue pruinosity on dorsal thorax and abdomen may be scratched with age, when old males can be found with some blackened abdomen segments. The wings are often parasitized by *Forcipomyia* (Pterobosca) *incubans* (Diptera: Ceratopogonidae) (Guillermo-Ferreira & Vilela, 2013). Males may live up to 14 days, with the probability of survival decreasing to 90% in three days and to 50% in eight days (Figure 6).

Discussion

Erythrodiplax ana fits in Borror's (1942) Basalis Group, since the terminal segment of vesica spermalis has small and rounded lateral lobes; hood not developed; an erectile posterior lobe; median process well developed and extending lateral lobes, inflatable and sac-like; apical lobe small and trough-shaped. This species can be diagnosed by the combination of male genitalia and the following traits: blue pruinosity dorsally on thorax and S3–8 of abdomen; sides of thorax olive-green; face ivory or olive-green; wings hyaline with a small apical brown spot on all four wings, well defined in females.

Females of *Erythrodiplax* usually exhibit ventrally directed vulvar lamina (e.g. Nobre 2016). For instance, females of the Basalis group usually have the vulvar lamina with a rounded apex and often projected diagonally, as in *E. tenuis* Borror, 1942. Nevertheless, the main feature of *E. ana* females is the less pronounced, slightly less scooped and flattened apex of the vulvar lamina. Moreover, the vulvar lamina in *E. ana* is posteriorly directed (i.e. horizontal). Thus, although *E. ana* females may resemble other species, such as *E. atroterminata* Ris, 1911, from the Connata group, *E. ana* females can be distinguished by the combination of traits: flattened and horizontal vulvar lamina, no large basal spots on the wings, wing tips with brown spots and lanceolate cerci.

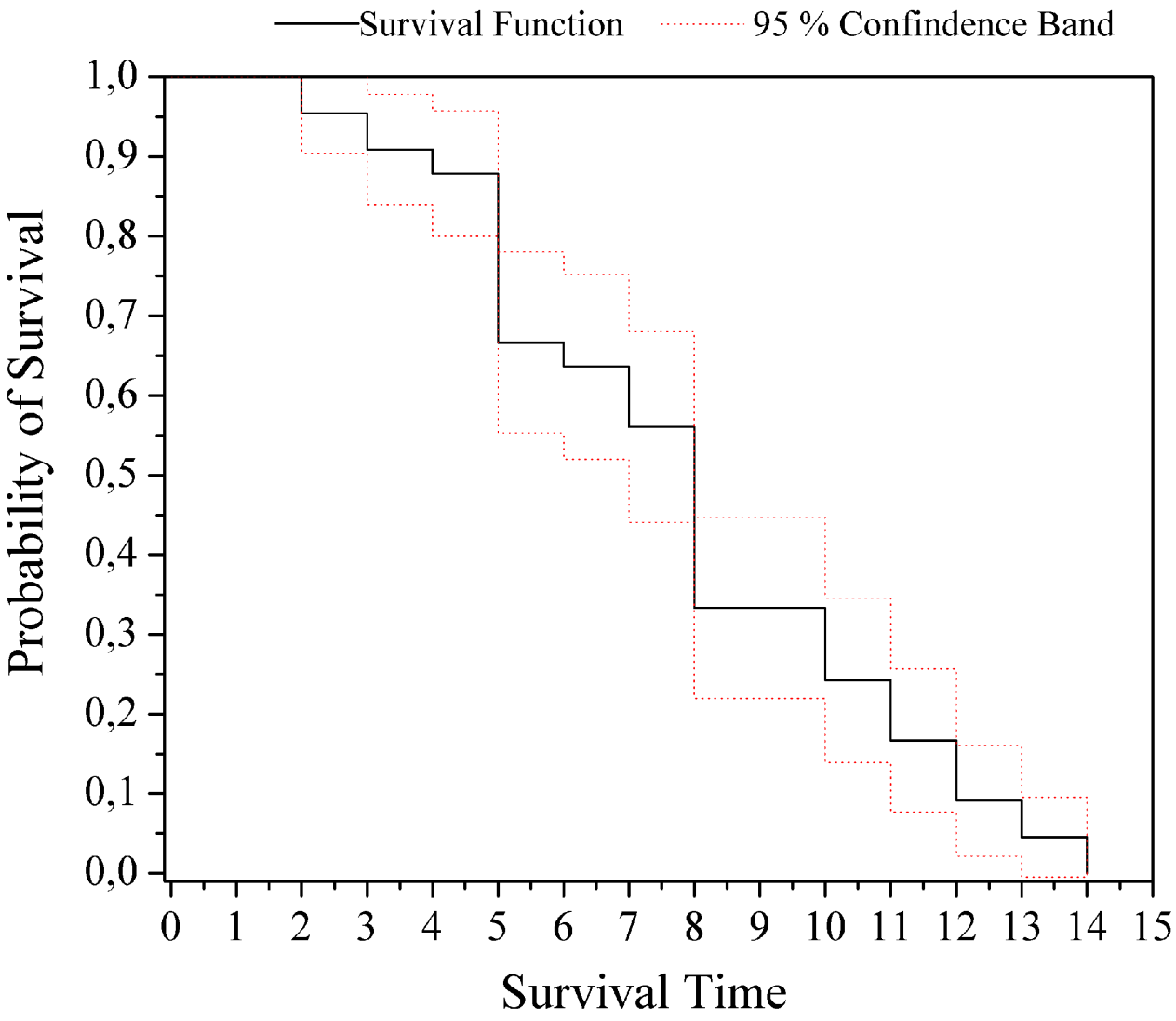

FIGURE 6. Cumulative proportion of surviving males.

Males of six additional *Erythrodiplax* species also have the wing tips a defined dark brown: *E. anatoidea* Borror, 1942, *E. andagoya* Borror, 1942, *E. angustipennis* Borror, 1942, *E. atroterminata*, *E. lygaea* Ris, 1911, and *E. tenuis*. *E. ana* distinction from these species is clearly indicated by the combination of the ivory face and the structure of the second-segment genitalia of the male. *E. ana* is similar to other species such as *E. avittata* Borror, 1942,*E. anomala* (Brauer, 1865), *E. pallida* (Needham, 1904), *E. nivea* Borror, 1942, and *E. nigricans* (Rambur, 1842) in its pruinose blue dorsal thorax and abdomen and similar vesica spermalis. However, *E. ana* can be distinguished from the others because it lacks basal spots on the wings. The description of *E. luteofrons* Santos, 1956, resembles *E. ana,* but these two species can be separated because of differences in the length of posterior and lateral lobes in male genitalia.

The larva can be diagnosed by having six palpal setae, 18 premental setae (9+9), and lateral spines on S8–9. The unique combination of these traits can also be used to distinguish *E. ana* from other *Erythrodiplax* species (Table 1). The presence of six palpal setae in the larva agrees with the adult classification, as the larva of *E. basalis* also exhibits this trait.

TABLE 1. Characters of labium and abdomen of the last instar larvae of *Erythrodiplax* species.

Species	Palpal setae	Premental setae	Lateral spines (segments)	Premental spines	Reference
amazonica	11	18	0	0	De Marmels 1992
ana	6	9	8, 9	2	This study
anomala	7	11, 12	7–9	1	Carvalho *et al.* 1991
atroterminata	8	12	8, 9	2	Garré *et al.* 2008
basalis	6	10	8, 9	2	Costa *et al.* 2001
basifusca	7	11	8, 9	3, 4	Lozano & del Palacio 2011
berenice	9, 10	10, 11	8, 9	3, 4	Needham & Westfall 1955
bromeliicola	7–9	12–14	8, 9	3	Trapero-Quintana & Novelo-Gutiérrez 2012
connata	7	11–13	0	4–8	Lozano & del Palacio 2011
corallina	8	11, 12	8, 9	4	Garré *et al.* 2008
fervida	6	10	8, 9	6	Trapero-Quintana & Reyes-Tur 2008
funerea	9, 10	10, 11	8, 9	1	Needham & Westfall 1955
fusca	6, 8	9,10,11	8, 9	1	Santos 1967
juliana	9	11	9	1	Carvalho *et al.* 1991
justiniana	10	12, 13	8, 9	1, 2	Needham & Westfall 1955
latimaculata	7	10	8, 9	2	Costa *et al.* 2001
lygaea	6	10	7–9	0	Costa *et al.* 2001
melanorubra	7	11	9	1, 2	Limongi 1991
minuscula	7, 8	11–12	8, 9	4	Lozano & del Palacio 2011
naeva	9, 10	10–13	8, 9	3, 4	Klots 1932
nigricans	8, 9	11–13	8, 9	3	Von Ellenrieder & Muzón 2000
ochracea	9	12	8, 9	1, 2	Carvalho *et al.* 1991
pallida	6	9	9	3	Needham 1904
paraguayensis	7, 8	10	8, 9	2	Muzón & Garré 2005
umbrata	10–13	13–16	8, 9	2, 3	Carvalho *et al.* 1991

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