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Description of the final instar larva of *Calopteryx exul* Sélys, 1853 (Zygoptera: Calopterygidae)

Rassim Khelifa*

Département d'Écologie et du Génie de l'Environnement, Faculté des Sciences de la Nature et de la Vie et des Sciences de la Terre et de l'Univers, Université 08 Mai 1945, Guelma 24000, Algeria

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The last instar larva of *Calopteryx exul* Sélys is described and illustrated based on larvae collected from the Seybouse River (northeast Algeria) and reared in the laboratory. A comparative analysis of three other congeneric species is presented.

Keywords: Odonata; damselflies; Calopterygidae; endemic species; endangered; exuvia; taxonomy

Introduction

Calopteryx exul Sélys, 1853 is one of the most threatened zygopterans in the Mediterranean basin with a geographic distribution restricted to North Africa (Tunisia, Algeria, and Morroco) (Riservato et al., 2009). In Algeria, the species has not been found since Martin (1910), but recently a colony was discovered in the Seybouse River (northeast Algeria) (Khelifa et al., 2011). This represents the only population currently known in the country and the largest in the Maghreb (Khelifa, in press). The adult preferred habitat is large watercourses with relatively shallow and fast flowing water (Khelifa, in press).

To date, no description of the larvae has been published except for a general illustration (sketch) by Jödicke et al. (2000) of one exuviae collected in northern Tunisia, stating that the species is characterized by rather narrow forewing sheaths with caudal appendages rather long compared to the length of antennae or labium. Here, I present a detailed description of *C. exul* exuviae based on individuals collected from northeast Algeria.

Methods

Study area

The study was conducted in the Seybouse River, northeast Algeria. This river is formed by the junction of Cherf and Bouhamdane wadi at Medjez Amar (36°26′35″ N, 7°18′39″ E) and flows

*Email: rassimkhelifa@gmail.com

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Table 1. Physical characteristics of sampling sites.

Stations	Geographic coordinates	Current velocity (ms^{-1})	Depth (cm)	Course width (m)	Altitude (m)
Ain Makhouf	36°14′27.71″N 7°18′36.01″E	0.34	35	13	646
Salah Salah	36°27′41.00″N 7°20′22.75″E	0.58	42	19.5	219
El Fedjoudj	36°28′29.21″N 7°22′26.55″E	0.41	40	18	221

into the Mediterranean at Sidi Salem (36°52′3″ N, 7°46′25″ E) near Annaba. The hydroperiod is similar to that of Numidia with a wet season between October and May and a dry season between June and September. The annual rainfall varies from 450 mm upstream to 735 mm downstream (ABHCSM, 2009). The river edges are usually covered by *Typha angustifolia*, *Tamarix gallica*, *Nerium oleander*, and *Rubus ulmifolius*.

Larval sampling and rearing

I used previous information on adult distribution of *Calopteryx* species in the Seybouse watershed to guide collection of larvae (Khelifa et al., 2011). Forty-one larvae were collected in April 2010 and 2011 with a hand net of 0.5 mm mesh from 10 m stretches of the shore in three sites (Table 1). I chose only large larvae to reduce mortality risks during rearing. Samples were brought to the laboratory within 2 hours of collection.

In the laboratory, I followed Van Gossum et al. (2003) to increase rearing success. Larvae were reared individually in oxygenated water and kept at room temperature of 18 ± 3°C under natural light conditions. We submerged a few sticks in water in order to help larvae to climb and emerge. Aquaria were covered with a net so that tenerals could not fly away after emergence. A large range of prey was provided, namely daphniids, dipteran and mayfly larvae, amphipods, and small tadpoles. I checked the aquaria daily for the presence of exuviae and tenerals. To limit damage to the population, all the emerged adults were reintroduced to their original localities within 24 h of emergence.

To calculate ratios, I measured the scape and pedicel length, the distance between antennomere 2 and antennomere 7, the length of the prementum, posterior tibia, and posterior femur using the same limits as Heidemann and Seidenbusch (2002). Values are presented as mean $\pm$ SD.

Results

Habitat

Sites where *Calopteryx exul* larvae were collected were wide stretches with relatively shallow and fast flowing water (Table 1). Larvae were abundant at the edge where vegetation, dominated by *Schoenoplectus maritimus* and *Typha angustifolia*, was hanging over the bank. Other species of odonates found included *Gomphus lucasii*, *Onychogomphus costae*, *Platycnemis subdilatata*, and rarely *Calopteryx haemorrhoidalis*.

Description (Figures 1–8)

All larvae emerged between 23:00 and 04:00 except for one individual which emerged at 19:30. From 41 larvae collected only 32 emerged successfully. All measurements and ratios below are based on the final instar exuviae of these emerged individuals.

Body. Yellowish to brownish, or rarely darker, slender body, mean total length (excluding antennae and gills) of 21.61 ± 1.35 mm (Figure 1a). Almost totally covered by small setae (Figure 1b).

Head. Wider than long (mean width of 4.67 ± 0.33 mm) and almost totally covered by sparse patches of small setae. Vertex with three conspicuous ocelli. Prominent postocular projections (occipital tubercles) approximately hemispheric (bulge-like) in lateral view (Figure 2a) but blunt in dorsal view (Figure 2b). Antennal sclerites large, surrounded by rather long setae. Antennae 7-segmented. Scape (first antennomere) exceeding the length of all remaining antennomeres (ratio

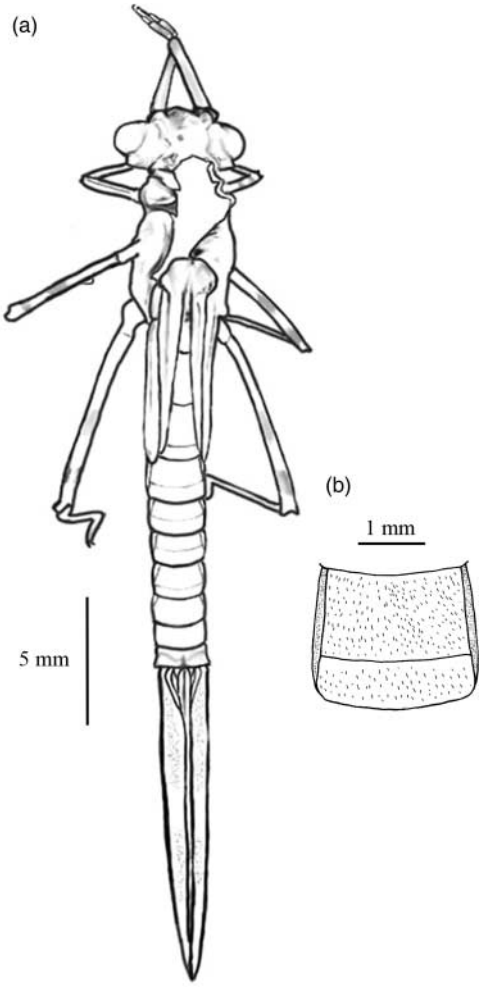

Figure 1. Body of *Calopteryx exul* final instar exuviae: (a) dorsal view; (b) enlarged dorsal view of abdominal segment 4 showing setae of body surface.

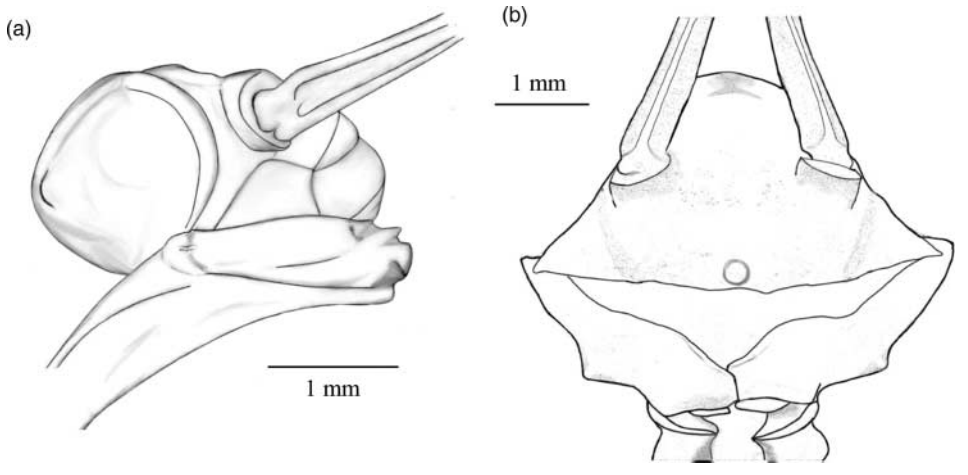

Figure 2. Head of *Calopteryx exul*: (a) lateral view; (b) dorsal view.

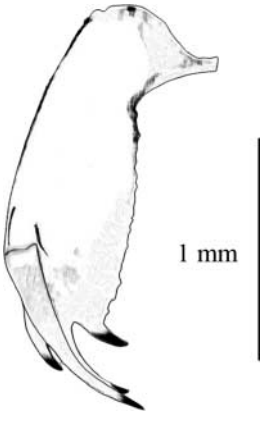

Figure 3. Left labial palpus. Because the intermediate hook crosses the movable hook, a medioventral view is shown so that all hooks are visible.

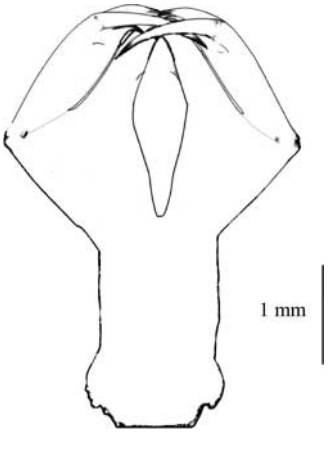

Figure 4. Prementum, view of inner surface.

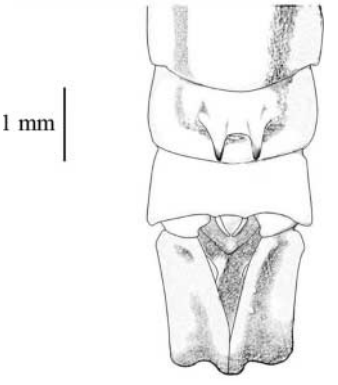

Figure 5. Male valves, ventral view.

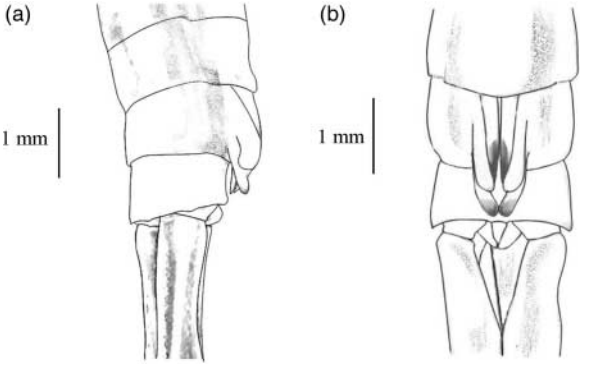

Figure 6. Female ovipositor and gonapophyses: (a) lateral view; (b) ventral view.

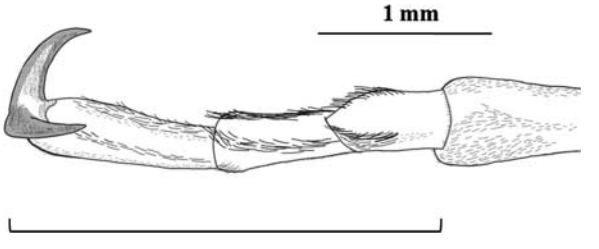

Figure 7. Left metatarsus, oblique ventral view.

1.5:1), triqueteral (3 edged) except distal part, which is cylindrical. Segments 2 to 6 cylindrical, segment 7 conical. Each scape with longitudinal mediodorsal pale stripe; Scape and pedicel (second antennomere) covered with furry layer of short setae. No gap between insertion of labial palpus to prementum. Two palpal setae close to insertion of long movable hook (Figure 3). Prementum deeply divided by long median cleft and wit pair of short premental setae ventrally disposed in its distal part (median lobes) (Figure 4).

Thorax. Mediodistal corners of pronotum relatively blunt. Wing cases with approximately semi-circular tips. Ratio of hind wing case length: width 3.6:1. Forewing cases reaching anterior margin of S4, hind wing cases exceed it and rarely reach its posterior margin.

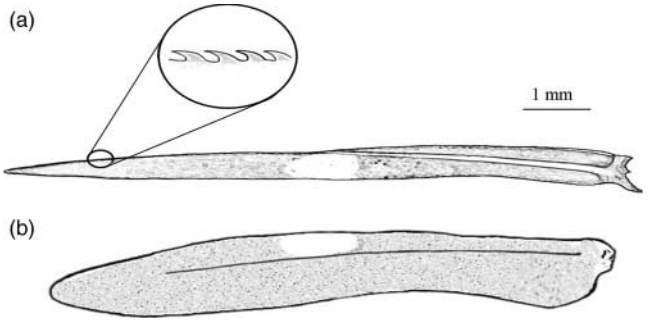

Figure 8. Caudal gills: (a) right lateral gill [–] a small part of the gill edge is enlarged showing the curved spines; (b) median gill.

Legs. Long with two dark bands on femur and tibia. Tibia always slightly longer than femur (ratio of posterior tibia:posterior femur 1.1:1). Tarsi 3 segmented, with dense, relatively long setae on first segment and 2 ventral parallel lines of setae on segments 2 and 3 (Figure 7).

Abdomen. Lateral flanges clearly evident. Male primary genitalia (valves) straight, slender, not exceeding posterior margin of 9th abdominal segment (Figure 5). In females, ovipositor not reaching posterior margin of final abdominal segment, both extremities of lateral gonapophyses in contact (Figure 6a, b).

Caudal gills. Triquetral lateral gills and lamellate median gill covered with short setae. Lateral gills always longer than the median (ratio 1.5:1). The three edges of lateral gills and the ventral and dorsal margins of the median gill with tiny, equidistant, curved spines (Figure 8a). Both lateral and median gill with blunt apex and are marked with one pale spot (sometimes two spots on lateral gill) usually in the middle of each gill (Figure 8a, b); second pale spot of lateral gill, if present, situated between first spot and the apex, obvious in larva but usually fainter or totally absent in final instar exuvia.

Discussion

In this paper I describe the last instar exuviae of the endangered, river-dwelling, *Calopteryx exul*. In Algeria, like in the rest of its geographic range, the species has undergone great habitat loss (Riservato et al., 2009) and the lack of data about its life history, ecology, and larval taxonomy has made it difficult to establish a regional conservation plan.

A comparative analysis of *C. exul* with three other Paleartic species described by Heidemann and Seidenbusch (2002), namely *C. splendens* (Harris, 1782), *C. haemorrhoidalis* (Vander Linden, 1825), and *C. virgo* (Linnaeus, 1758) is presented in Table 2. *C. exul* exuviae are most similar to *C. splendens* in a set of traits and ratios. They have the same body size and similar ratios of mentum:tibia, scape:pedicel, and scape:remaining antennomeres (Table 2). Also, females have a similar shape and disposition of the ovipositor and gonapophyses (Heidemann & Seidenbusch, 2002). One clear difference between these two species is that the male valves are short, thick, and have hemispheric extremities in *C. splendens*. Further taxonomic efforts are necessary to provide additional identification characters between these closely related species (Weekers et al., 2001). The distinction of both species should pose few taxonomic problems, and additionally they do not overlap in their geographic range; *C. exul* is endemic to the Maghreb whereas *C. splendens* is widely distributed over Europe and Western Asia. Two other *splendens*-like taxa, *C. waterstoni*

Table 2. Some measurements and ratios of *Calopteryx exul* with three congeneric species. Values are minima and maxima. Values of caudal gills present mediane gill (first value) – lateral gill (second value).

	C. splendens	*C. haemorrhoidalis*	*C. virgo*	*C. exul*
Body (mm)	18–24	17–21	19–23	18.5–24
Caudal gills (mm)	9–14	6–11	6–10	8.1–12.3
Mentum : Posterior femur	1:1.6–1:1.8	1:1.2–1:1.5	1:1.4–1:1.7	1:1.7–1:2.4
Mentum : Posterior tibia	1:1.7–1:2.1	1:1.4–1:1.8	1:1.6–1:2	1:1.7–1:2.4
Mentum : Body	1:4.6–1:5.2	1:3.4–1:4.3	1:4–1:4.8	1:4.6–1:6.4
Scape : remaining antennomers	1.3:1–1.5:1	1.3:1–1.5:1	1.1:1	1.3:1–1.8:1
Scape : Pedicel	4:1–4.9:1	3.2:1–4:1	3:1–4:1	3.5:1–5:1
Reference	Heidemann and Seidenbusch (2002)	Heidemann and Seidenbusch (2002)	Heidemann and Seidenbusch (2002)	This study

(Schneider, 1984) and *C. hyalina* (Martin, 1910), have fully hyaline wings similar to those of *C. exul*. According to recent data from Syria and Lebanon, *C. hyalina* is currently almost extinct (Riservato et al., 2009).

Regarding *C. virgo*, besides its larger body size, almost all ratios were different. Among the four species presented in Table 2, *C. virgo* is particularly characterized by conspicuous conical and acute postocular tubercles (Heidemann & Seidenbusch, 2002) and thus could not be confused with the three other species.

However, particular attention should be paid to differentiate *C. exul* from *C. haemorrhoidalis* because these species coexist and emerge at the same sites (personal observation). According to Heidemann and Seidenbusch (2002), female ovipositor and male valves are the most important traits that can be used in the identification of *Calopteryx* species. *Calopteryx exul* and *C. haemorrhoidalis* differ substantially in these two characters. Besides the fact that *C. exul* is longer and paler, the *C. haemorrhoidalis* ovipositor usually exceeds the final abdominal segment and the extremities of lateral gonapophyses do not touch (Heidemann & Seidenbusch, 2002). *Calopteryx haemorrhoidalis* males have rather acute slender valves that extend beyond the 9th abdominal segment (Heidemann & Seidenbusch, 2002). Using these traits might not be enough to accurately recognize the species in case of inter-population polymorphism, but adding the ratios in Table 2 and some characters illustrated and described above (see results) will yield reliable identification. However, future studies using larger sample sizes could lead to new measures and ratios slightly different from those reported by Heidemann and Seidenbusch (2002) for the three species of *Calopteryx*.

Furthermore, setae of tarsi of *C. exul* are similar to those of *C. haemorrhoidalis* (personal observation) and *C. maculata* (M. May, personal communication). Since neither species is closely related to *C. exul* (Weekers et al., 2001), this is probably a general pattern in *Calopteryx*. Another trait which could be an important identification key is the gill spines. Angle of curvature, length, and disposition of gill spines are most likely to vary between species and might be taken into account for future description of *Calopteryx* species.

It is well known that using the last instar exuviae in odonatological studies gives important information on species life history, ecology (Corbet, 1999), and genetics (Watts et al., 2005). Moreover, its occurrence at a given water body is a better indicator of reproduction than that of adults or larvae (Hardersen, 2008; Ott et al., 2007; Raebel et al., 2010; Samways et al., 2010).

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