

## **An extended description of the larva of *Megaloprepus caerulatus* from Costa Rica (Odonata: Pseudostigmatidae)**

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### **Abstract**

The larva of *Megaloprepus caerulatus* is described and illustrated from specimens collected near the northern border of Barbilla National Park on the Costa Rican Caribbean slope. Habits and characters of larvae of three different size classes obtained from artificial tree holes permit the identification of small (body length 4 mm, excluding the caudal lamellae) larvae up to the final stadium. New diagnostic characters include the shape of the prementum and head.

### **Introduction**

The larva of *Megaloprepus caerulatus* (Drury, 1782) is already known due to the extensive ecological work by O.M. Fincke on Barro Colorado Island, Panama (Fincke 1998, 1999). Ramírez (1997) described the larva mainly from final-stadium larvae and exuviae although several "intermediate instar" larvae were mentioned in the materials section. Large specimens, but not exuviae, seem to be easily identified by the conspicuous, white spots on the thoracic dorsum and on the tips of the caudal lamellae. The description by Ramírez (1997) did not enable us reliably to identify smaller specimens from Costa Rica. Here, we expand the larval description by Ramírez to include smaller size classes. Even though the diversity of odonate species coexisting in a Central American tree hole ecosystem is low (Fincke 1998), we hope that our inclusion of smaller larvae will allow others to discriminate among other species of pseudostigmatids from South America.

## Methods

Studies were conducted near the Nairi Field Station (9°59'40"N, 83°27'20"W) north of the border to Barbilla National Park, Costa Rica (Hedström & Sahlén 1998). Artificial water-containing tree-holes were made using the lower half of 1.5 l plastic bottles which were placed at a height of between 1 and 2 m above the ground which corresponded roughly to the natural position of water-containing holes on fallen tree-trunks. Twelve such artificial holes were placed at three different light gaps inside primary rain forest on 2 February 1998. By year's end (26-28 January 1999) traps in all three light gaps contained individuals of *Megaloprepus caerulatus*. These traps were emptied once every 3-4 months until mid 2001 and larvae retained for study.

Larvae were preserved either in 80% ethanol or 80% ethanol with an additive of 4% formaldehyde and a few drops of concentrated acetic acid. Larvae fixed in the latter solution were within a week transferred into 80% ethanol for storage. Larvae in stadia F-0 to F-2 were punctured ventrally to enhance preservation. We used photographic material of living larvae to illustrate caudal lamellae.

Growth rate of odonate larvae is dependent on food supply and other local conditions which can make it difficult to recognise different stadia (except for stadium F-0 on account of its large wing sheaths). We used head width (Hdw) to separate size classes. We discriminated among three Hdw classes: small (Hdw 1.2 - 1.3 mm), medium-sized (Hdw 2.6 - 2.7 mm) and large (Hdw 5.7 - 5.8 mm = stadium F-0) larvae. We only used stadium F-0 larvae which had not yet embarked on metamorphosis (wing sheaths not swollen, head shape not altered due to pharate adult head).

Line drawings were made by GS using a Nikon SMZ800 stereo microscope fitted with a camera lucida. A Sony digital video camera and the image analysis programme Easy Image 2000® by Bergström Instrument AB, Lund, Sweden, was used for measurements, and for illustrations of small structures (e.g. mandibles, external genitalia and setae).

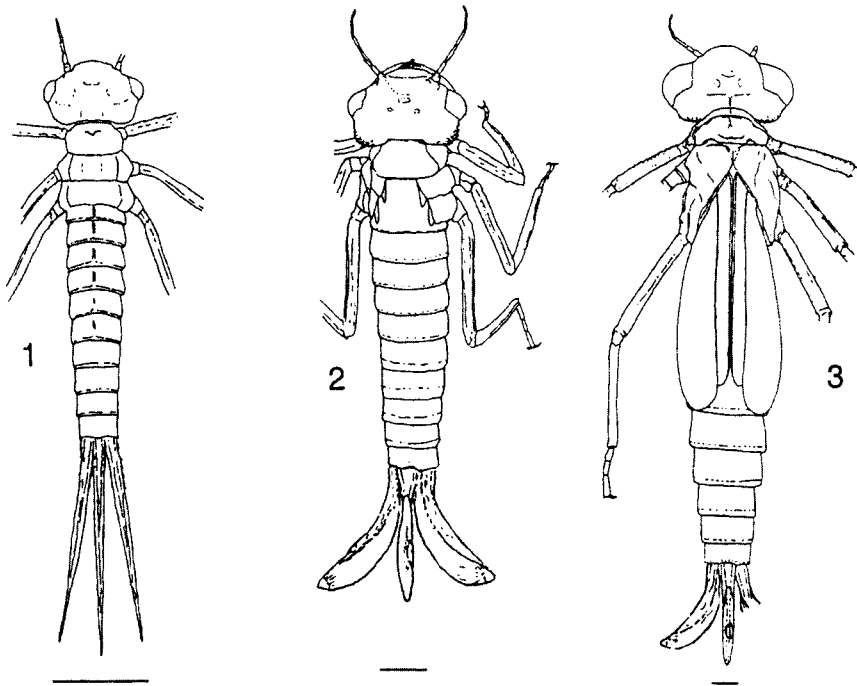
Larvae examined included: — 1 specimen Hdw 1.53 mm; 1 ♀ Hdw 3.16 mm; 1 ♂ Hdw 3.62 mm; 1 ♂ Hdw 4.03 mm; 1 ♀ Hdw 4.90 mm; 1 ♀ Hdw 4.96 mm; 1 ♀ stadium F Hdw 5.90 mm; 1 ♂ stadium F Hdw 5.97 mm; 1 ♂ stadium F Hdw 6.05 mm (5 June 2000); — 1 ♂ Hdw 2.70 mm; 1 ♀ Hdw 3.28 mm; 1 ♀ Hdw 3.92 mm; 1 ♀ Hdw 4.62 mm; 1 ♂ Hdw 4.28 mm; 1 ♀ Hdw 4.66 mm; 1 ♀ Hdw 4.91 mm; 1 ♀ Hdw 4.95 mm; 1 ♀ stadium F Hdw 5.41 mm; 1 ♀ stadium F Hdw 5.75 mm; 1 ♂ stadium F Hdw 5.81 mm; 1 ♂ stadium F Hdw 5.95 mm (7 June 2000); — 1 specimen Hdw 1.08 mm; 1 specimen Hdw 1.15 mm; 1 specimen Hdw 1.25 mm (21 May 2001); all specimens in coll. GS.

## Description

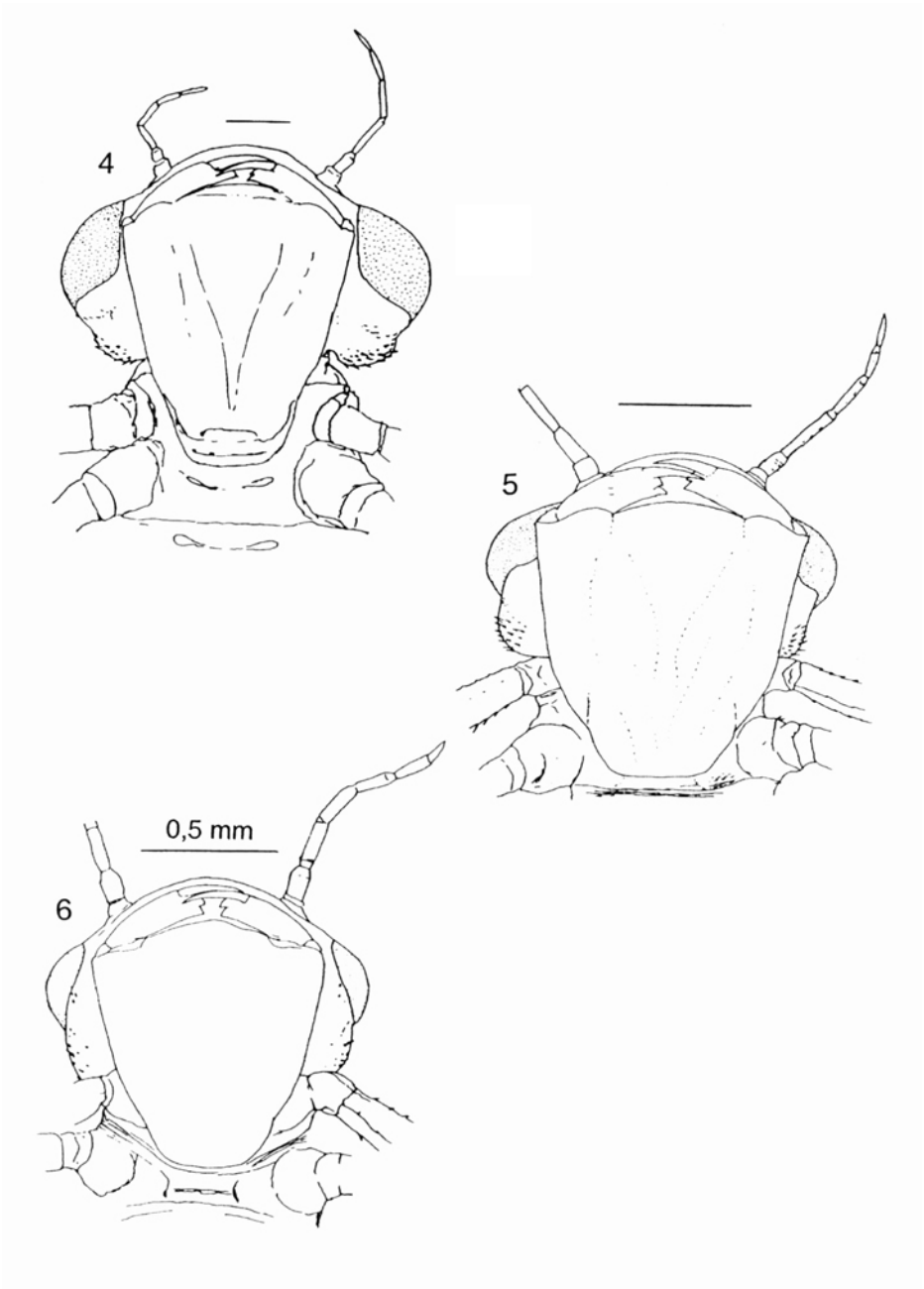
**Colour pattern:** Small and medium-sized larvae generally light to medium brown with darker pigmentation at joining surfaces of adjacent sclerites; caudal lamellae partially transparent — a darker pattern with a brownish-violet tinge in medium-size class; proximal area of the lamellae less pigmented than central part including the axial tracheae; medium-sized larvae with white tip on lamellae (cf. Fig. 22); white dorsal area on thorax anteroventrally to wing pads usually present on medium-sized specimens; large larvae

uniformly dark brown; lighter brown after a recent moulting; a white spot on mesothorax close to the mid-dorsal carina just proximal to Fw sheaths; caudal lamellae dark brown with violet tinge, tips white, surface mottled. The four white spots on lamellae and mesothorax diagnostic for this species but larvae with a Hdw of less than 2.70 mm lacking mesothoracic spot and small larvae lacking all four spots.

**Head:** Small larvae with slightly concave neck line (Fig. 1). Medium-sized and large larvae develop a very concave neck line (Figs 2-3). Head approx. 1.5 times wider than broad in small specimens; 1.7 times in large specimens. Antennae with a 5-segmented flagellum (= "7-segmented"; Figs 4-6). Some medium-sized and all small larvae having only a rudimentary 7th segment. Ocelli always with lighter pigmentation. Setae/hairs on head fewer and more spread out in small specimens, reaching the lower rim of the compound eyes ventrally (Fig. 6). Medium-sized and large specimens having setae only in the area behind the compound eyes, slightly more to the front on the ventral side (Figs 4-5). Mandibles in small larvae with three relatively sharp external teeth and one small bristle-like seta on outer surface (Fig. 11). Maxillae with lacinia and galea rather blunt, covered with setae, which are shorter, sparser and less bristle-like on the galea (Fig. 12). In large larvae, mandibles with five (two double and one single) external teeth, connected to a single ventral tooth. A thin fringe of setae is present on lateral side (Fig. 13). Maxillae are complex, the lacinia ending in four slightly curved teeth, and with a fringe of long and short setae basally; galea curved and sharp with a dense fringe of hair-like setae on the outer side (Fig. 14).



Figures 1-3. *Megaloprepus caerulatus* larva: general habitus of the three size classes examined. Legs only drawn in part — (1) small larva; (2) medium-sized larva; (3) large larva. Scale bars 1 mm.

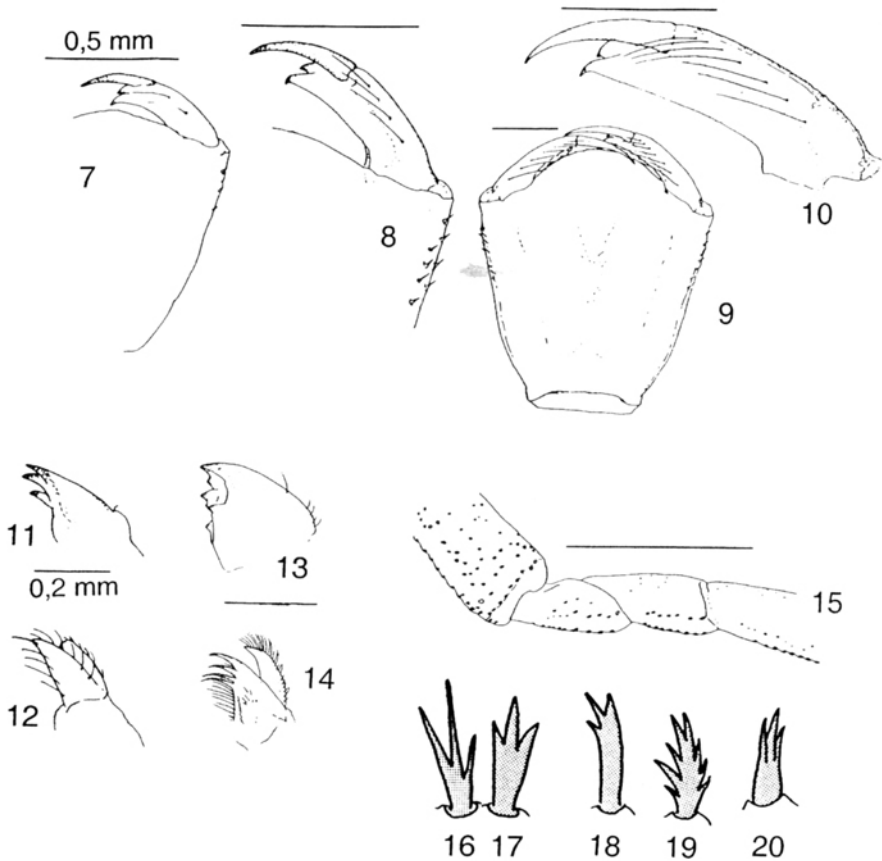


Figures 4-6. Labium of *Megaloprepus caerulatus* in situ — (4) large larva; (5) medium sized larva; (6) small larva. Scale bars 1 mm unless otherwise indicated.

**Labium:** Folded labium reaches back to anterior base of median coxae in small specimens (Fig. 6); less far in medium-sized and large specimens (Figs 4-5). Length-to-width ratio of prementum is 1.08 in small larvae, 1.02 in medium-sized larvae and 1.11 in large larvae. Lateral margins of prementum in medium-sized larvae are more parallel than in small and large ones (cf. Fig. 5 vs 4-6). The number of palpal setae increases from two in small larvae (Fig. 7) to four in medium-sized larvae (Fig. 8) and six in large larvae (Figs 9-10). The same increase also occurs in the number of lateral setae on the prementum. Only four or five such setae are present in small larvae (Fig. 7) whereas medium-sized and large larvae have at least eight (Figs 8-9).

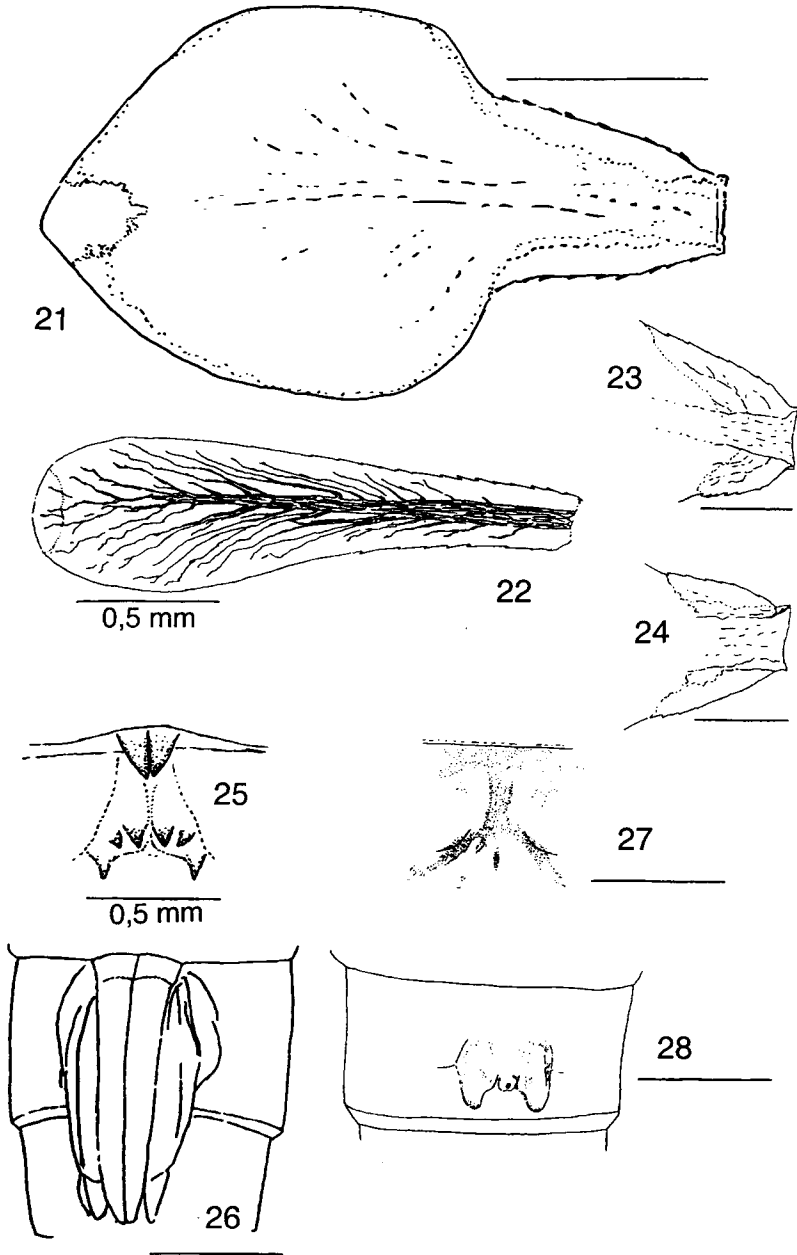
**Thorax, wing sheaths and legs:** All three segments of thorax flattened dorsally in small larvae (Fig. 1), becoming gradually more rounded in medium-sized and large specimens (Figs 2-3). Wing sheaths appear in medium-sized larvae, reaching back to between the 5th and 6th abdominal tergites in large larvae. Male abdomens have somewhat longer S2. Wing sheaths change shape during metamorphosis, becoming thicker and shorter. A larva close to emergence has wing sheaths at most reaching back to the middle of S5. Legs having two ventral rows of spiniform setae, these being small and inconspicuous in small larvae, and rather dense and pronounced in medium-sized and large larvae. Femora with four additional rows of setae, two dorsally and two ventrally. In small larvae the dorsal rows are well developed, the others not. Ventral part of tibiae (T) equipped with a dense accumulation of setae (Fig. 15) in all size classes, but in small specimens these setae are soft and hair-like. Tarsi with two rows of setae ventrally (Fig. 15) and scattered small hair-like setae on lateral and dorsal surfaces. At least part of the setae on the lower part of T1-3 and tarsi are branched. Branched setae present in medium-sized and large specimens in the two rows on all three tarsi and densely on T1, not on T2, and sparsely on T3. Most branched setae are 3-branched (Figs 16-17) a few having very short branches (Fig. 18), many branches (Fig. 19) or branches which are not quite separated (Fig. 20). In general, the larger the larva, the more branched setae are present. Small larvae lack them.

**Caudal lamellae:** Small and some medium-sized larvae with no clear nodus, the proximal area changing gradually into the distal area, the latter lacking the small spines or hair-like setae at the edge of the former (Fig. 22). Lamellae in small larvae about 3.5 times as long as wide, widest in outer third. Tracheae very dark. A whitish tinge evident at the tip of the lamellae, however is never particularly bright and is missing in about half of the specimens examined. Most medium-sized and large larvae have lamellae more rounded in appearance, only about 1.6 times as long as wide, the widest part being somewhat distal to the middle (Fig. 21). These lamellae are divided into a stalk-like proximal part and a rounded distal part, still with an unclear nodus. Edges of the lamellae in the proximal part with a spread out line of small setae, very short and frequently missing from the sparsely notched edge. Lamellae dark brown with a bluish tinge, the surface having a fine mottled structure of shallow, rounded depressions. Proximal area of the lamellae less pigmented, often light brown or yellowish brown to beige in colour. A distinct white patch is present at the tip of all lamellae in these size classes, together with a somewhat reduced dark pigmentation around the periphery of the rounded part. In large specimens, dorsal proximal area of the median lamella almost twice as long as ventral area (Fig. 23). Proximal area of lateral lamella reaching about the same distance both dorsally and ventrally (Fig. 24).



Figures 7-20. Larval details of *Megaloprepus caerulatus*. Prementum and labial palp(i) viewed dorsally — (7) small larva; (8) medium-sized larva; (9) large larva. Labial palp (10) in dorsal view; large larva. Mandible (11) and maxilla (12) of small larva in ventral view. Mandible (13) and maxilla (14) of large larva in ventral view. Lower part of tibia 1 and inner part of tarsus 1 of large larva (15); positions of setae indicated with rings/dots. Shape of branched setae (16-20) present on large larvae. Scale bars 1 mm unless otherwise indicated; no scale bars given for Figures 16-20.

**Abdomen and external genitalia:** Small larvae with indistinct mid-dorsal “ridge” on S1-6 (Fig. 1). Medium-sized and large larvae having all tergites smooth, covered in fine, short hair-like setae which are absent or difficult to distinguish in the smallest specimens. Male and female genitalia are first visible in medium-sized larvae. Male genitalia and female ovipositor (Fig. 25) seen as small, sharp projections in medium-sized larvae, being more clearly defined in large larvae (Figs 26, 28). Male accessory genitalia difficult to distinguish in medium-sized larvae but clearly visible as a Y-shaped depression in large ones (Fig. 27).



Figures 21-28. Larval details of *Megaloprepus caerulatus*: Caudal lamella — (21) large larva; (22) small larva. Inner, stalked part of caudal lamella in large larva — (23) median caudal lamella; (24) lateral caudal lamella. Female external genitalia — (25) medium-sized larva; (26) large larva. Male external genitalia in large larva — (27) accessory genitalia seen as shallow depressions ventrally on S2; (28) external genitalia ventrally on S9. Scale bars 1 mm unless otherwise indicated.

## Discussion

Ramírez (1997) noted that all known Central American larvae of the Pseudostigmatidae are adapted to a similar life mode exhibiting corresponding traits characteristic of tree-hole dwellers. Larvae of three different species can co-exist in the same tree-hole (Fincke 1992; de la Rosa & Ramírez 1995; Ramírez 1997). All are relatively short and stocky with stalked caudal lamellae ending in a rounded part which is held close to the water surface thereby facilitating respiration in an oxygen-poor environment. The tips of the lamellae are conspicuously white in *Megaloprepus caerulatus* and *Pseudostigma aberrans* Selys (Novélo-Gutierrez 1993). A similar morphology is found in the East African *Coryphagrion grandis* Morton (Clausnitzer & Lindeboom 2002), likewise a container breeder.

Smaller size classes have not been fully described in the other species. The small specimens in our study have a more long and slender appearance than the large larvae, and are equipped with long and slender caudal lamellae. Small larvae of this species are thus similar to a wide range of zygopteran larvae. Diagnostic characters are sparse in young larvae and hence we want to express a need for caution in using the characters presented in this paper on small larvae bearing in mind that no other related larvae are yet described in early stadia.

In larger size classes there are more similarities between known pseudostigmatids and *C. grandis* besides habitus and caudal lamellae as pointed out by Clausnitzer & Lindeboom (2002). One is the 2-pointed labial palpus (Figs 7, 8, 10), but the most useful distinguishing character is the presence of branched setae on tibiae and tarsi (Figs 15-20). Known from *M. caerulatus* (Ramírez 1997) and from *P. aberrans* (Novélo-Gutierrez 1993), branched setae may, as pointed out by Clausnitzer & Lindeboom (2002), serve as a diagnostic character when more species have been examined. As of today, they seem to connect Pseudostigmatidae with *C. grandis*, but are also present in the coenagrionid *Coenagrion intermedium* Lohmann (Battin 1991), as pointed out by Clausnitzer & Lindeboom (2002). In this study branched setae were found on all tarsi while present in high numbers on T1, in low numbers on T3 and not at all on T2. Branched setae were also absent from small specimens, which means that the diagnostic use of this character is limited to larger larvae.

To summarise: most characters change between the three different size classes of larvae examined in this study. Characters that are reliable in larvae belonging to the F-0 stadium will in most cases be absent or different in smaller stadia. There are few characters common to all size classes of this species, the shape of the prementum and to some extent also the general appearance of the head being the only exceptions. Positive identification of small larvae is therefore difficult, and may remain impossible should head shape and prementum shape turn out to be similar in small larvae of related species. For medium-sized and large larvae we suggest using general habitus and shape (and colour) of caudal lamellae as distinguishing characters. Characters like mandibles, maxillae, and the number of palpal setae change so much during ontogeny that only similar sized larvae should be used in comparisons among species.



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