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The larva of *Mecistogaster linearis*, with notes on its abundance in lowland rainforest of Costa Rica (Odonata: Pseudostigmatidae)

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Abstract

The larva of *Mecistogaster linearis* is described and illustrated from specimens collected within or near the Río Dantas Wildlife Refuge at the north-western border of the Barbilla National Park on the Costa Rican Caribbean slope. Characters of F-0 larvae permit easy separation from *Megaloprepus caerulatus*, a species co-existing with *M. linearis*. Diagnostic characters include overall colour, shape of head, prementum and caudal gills. Exuviae may be determined using shape of mandibles. Two types of branched setae are present on tibiae and tarsi. Most are 3-branched but on front tarsi they are instead feather-shaped. It is suggested that these setae are used for eye-cleaning. *M. linearis* was a relatively rare but regularly occurring species in the study area throughout the 3-year study period.

Introduction

As is the case with most tropical species, many of the larvae in the family Pseudostigmatidae are still unknown. Although the adults in this family are easily detected, conspicuous animals, their larvae, which inhabit tree holes and phytothelmata, are generally difficult to find. In Costa Rica, however, the situation is not so problematic. Of the five species occurring in the country (Ramírez et al. 2000; Hedström & Sahlén 2001), four – *Mecistogaster ornata* Rambur, *M. modesta* Selys, *Pseudostigma aberrans* Selys and *Megaloprepus caerulatus* (Drury) – are formally described (Calvert 1911a, 1911b; Novelo-Gutiérrez 1993; Ramírez 1995, 1997; Hedström & Sahlén 2003). The larva of *M. modesta* has, like the remaining species, *M. linearis* (Fabricius), been used in quite a few ecological studies (e.g. Fincke 1992a, 1992b, 1997; Melnychuk & Srivastava 2002). *M. linearis*, however, is not formally described.

M. linearis is primarily a South American species, distributed from Argentina and Brazil to Venezuela and Ecuador (Tsuda 1991). The northernmost known populations are found in Costa Rica and Panama, in non-seasonal tropical wet lowland forest, and tropical moist forest (Fincke 1992a; Hedström & Sahlén 2001). In Costa Rica, *M. linearis* is present almost all the year around, but is uncommon, and only a total of six localities are known from the country. All findings are from the lowlands north-east of the mountains, the northernmost locality fairly close to the Nicaraguan border (Hedström & Sahlén 2001). Only a few previously reported findings of the larva of this species are known to us: on Barro Colorado Island in Panama, and at La Selva Biological Station, Costa Rica, where Fincke (1992a; 1992b; 1997) found larvae in natural tree-holes on a few occasions. The larva was not depicted, nor described in these works.

During field work in Costa Rica starting in June 2000, we found single larvae of *M. linearis* on three occasions in artificial tree-holes, adapted principally for egg-laying *M. caerulatus* (cf. Hedström & Sahlén 1998). The sample location was near Río Dantas, close to the northern border of Barbilla National Park, at ca 350 m altitude. One larva emerged within a few days, thus enabling us to confirm species identity. It then became evident that some larvae collected in 1998 also belonged to this species. On several later visits to the area between December 2000 and January 2004, more larvae of *M. linearis* were found, although never in any numbers.

In this paper we present a description of the larva of *M. linearis*, focusing on the F-0 stadium. As we have only one sample area, the variation in characters is probably greater than presented here, but we feel that knowledge of the morphology along with some short notes on the observed ecology of the species might be useful for other workers on the Central and South American odonate fauna.

Materials and methods

To assess the abundance of *Mecistogaster linearis* larvae, plastic egg-laying traps (n = 75; cf. Hedström & Sahlén 2001), were set within and near Río Dantas Wildlife Refuge, north of Barbilla National Park, Limón Province, Costa Rica. Traps were secured to living or fallen trees in eight light gaps at a height of 1-2 m, which corresponded to the observed distribution of water-filled holes on fallen tree-trunks in the area. Monitoring of *M. linearis* larvae (along with *Megaloprepus caerulatus)* was conducted from September 2000 to January 2004, and 2-3 visits per year were made. Apart from the preserved material (below), most specimens were returned to the traps after identification. In total, on 10 sampling occasions, 61 larvae were found (Fig. 1), numbers varying between two and ten on each visit. Two peak periods were observed, May-September 2001 and May-September 2003.

The Rio Dantas Wildlife Refuge and neighbouring Barbilla National Park on the Caribbean slope of Costa Rica had an annual rainfall of 3,000-6,000 mm (data from 1992-2003, Instituto Costarricense de Electricidad, ICE). The sampling area was within the tropical wet forest zone (Holdridge et al. 1971) and consisted of a mosaic of primary forest, natural light gaps and small streams, with a high closed canopy, and palms dominating the understory (Hedström & Sahlén 2001).

The description was based on the following specimens: 3 F-1 and 2 "small", 26-28 i 1998, leg. IH; 1 F-2, 05 vi 2000, leg. O. Fincke, GS and IH; 1 F-0, 03 ix 2000, leg. IH (hatched to adult on 18 ix 2000); 1 F-0, 28 x 2000, leg. IH; 3 F-0 and 2 "small", 04 xii 2000, leg. IH; 2 "small", 10-13 ii 2001, leg. IH; 1 exuvia, 28 iv 2001, leg. IH; 1 "small", 28 v 2001, leg. IH; 2 F-0, 10-15 i 2002, leg. IH; 1 F-1, 06 i 2004, leg. GS and IH; 1 F-0, 1 F-1 and 1 F-2, 07 i 2004, leg. IH.

All larvae were fixed soon after collecting, either in 80% ethanol or 80% ethanol with an additive of 4% formaldehyde and a few drops acetic acid. Larvae fixed in the latter solution were within one week transferred into 80% ethanol for storage. Larvae in stadia F-0 to F-2 normally need to be punctured ventrally with a fine needle early in the fixation process in order to be preserved without fermentation-caused deformation of the body (Norling & Sahlén 1997), but this was not done with our material and yet no visible deformation could be observed. The fixatives, however, reduced the size of the caudal lamellae quite visibly and air-dried lamellae of larvae from stadium F-0 were thus used to produce line drawings of their outer shape. The fixation method seems to preserve epidermal pigmentation, although some colour loss occurred. All larvae remain in the collection of GS.

The line drawings were produced by GS using a Nikon SMZ800 stereo microscope fitted with a camera lucida and a Sony digital video camera. The image analysis programme Easy Image 2000® by Bergström Instrument AB, Lund, Sweden, was used for measurements and some illustrations, particularly of small structures (e.g. mandibles). A Nikon Labophot 2 trinocular microscope and the same equipment were used to produce images of branched setae.

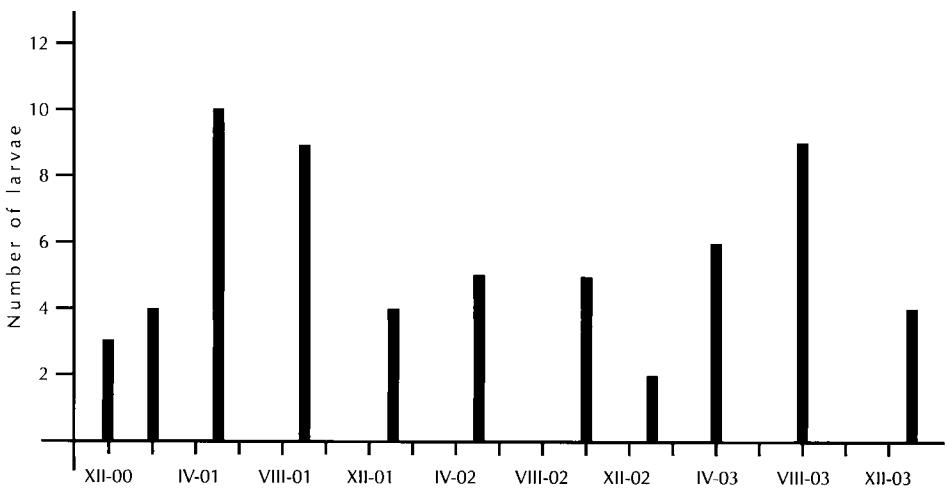


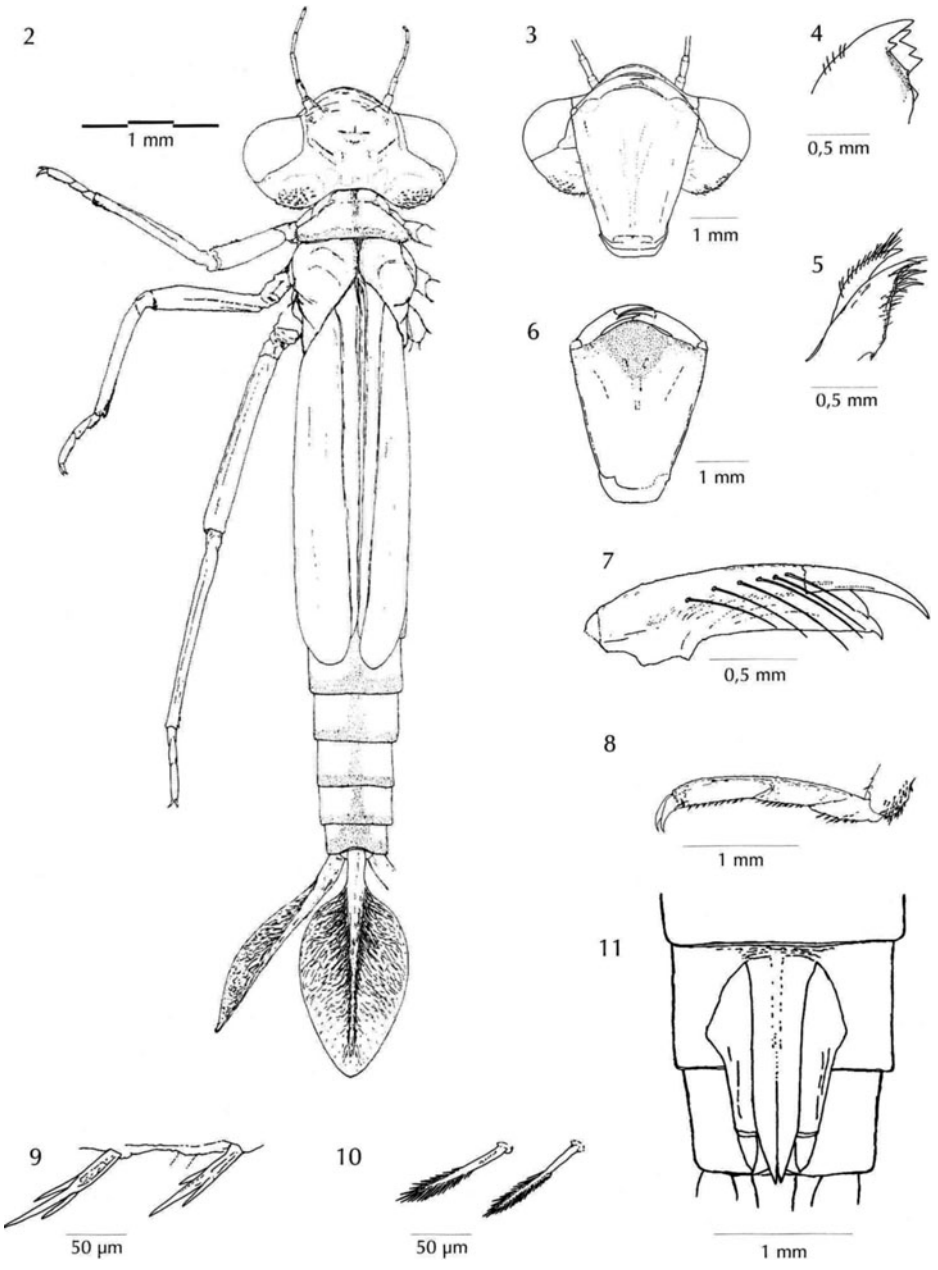
Figure 1: Total number of larvae of *Mecistogaster linearis* (n = 61) in plastic egg-laying traps (n = 75) during a 3-year sampling period between December 2000 and January 2004 within or near Rio Dantas Wildlife Refuge, north of the Barbilla National Park, Limón Province, Costa Rica. Traps were installed in February 1999 in eight light gaps.

Description

Colour pattern: In general dark brown on the dorsal side, yellowish brown on the ventral side. Legs yellowish brown, except in stadium F-0 where they are dark brown. Living larvae have a shining blue-grey hue which distinguishes them from other known larvae in the family. This blue-grey colouration quickly fades when larvae are killed. In particular, the tips of the caudal gills are "shining" in this colour. Ocelli with very little pigment (Fig. 2) clearly stick out against the dark brown head capsule. Eyes dark brown to black with darker pigmentation than rest of head. Labium and labial palpi light brown. Legs uniformly light to medium brown. Wing sheaths dark brown. A light brown stripe stretches mid-dorsally from the front margin of pronotum to end of wing sheaths (when small and separated, not visible in F-0). The rest of thorax darker brown. Some individuals lack this stripe but have several more narrow light brown markings on the dorsal side of pronotum. Abdomen medium brown with lighter colour ventrally. Some specimens have a darker brown, almost blackish colour dorsally. Tergites with a dark stripe mid-dorsally, extending somewhat irregularly to the sides. The posterior margins of all segments in the same colour. Smaller larvae (head width [Hdw] < 3.5 mm) often lack dark brown markings and have in general a lighter colouration. Caudal gills greyish, slightly transparent, especially towards the tip. A slight bluish tinge visible in most specimens. Central tracheae dark brown and clearly distinguished from rest of gills. Some specimens have dark greyish caudal gills, but always with a slight glimpse of blue colour.

Head: Hdw in stadium F-0 is 4.65 - 5.12 mm. Head ca 1.75 times wider than long. Antennae with a 5-sectioned flagellum (= "7-segmented"; Fig. 2, the fifth section of the flagellum very small). Neck line concave with distinct neck muscle attachment areas (Fig. 2). Setae on head only in the posterior part of the area behind the compound eyes (Figs 2, 3). Some wrinkles are visible in the cuticle lateral and anterior of ocelli. Posterior margin of compound eyes slightly undulating. – Mandibles with four large external teeth, the apical one with a small additional tooth at its base. Ventral side with a tiny tooth along the rounded edge. A few soft setae present on lateral side (Fig. 4). Maxillae with lacinia ending in four slightly curved teeth, one of which is on the ventral side. Many long setae cover the inner surface, spreading slightly ventrally. Galea curved and sharp with a dense fringe of long setae on the outer side (Fig. 5). – Folded labium reaches back to anterior base of median coxa. Length to width ratio of prementum is 1.3 in large larvae, slightly less in smaller larvae. Prementum wedge-shaped, tapering evenly towards posterior end (Figs 3, 6). A series of tiny lateral setae present from the base of the labial palpi reaching about one third back towards posterior end. Between 16 and 25 setae were present on each side in F-0 larvae, very few in smaller larvae. Prementum with a diffuse darker area extending from the anterior portion towards central area (Fig. 6). Number of palpal setae always six in F-0 and F-1 larvae (Fig. 7), five in the few examined larvae with Hdw < 3.5 mm. – Ontogenetic changes include larger occipital lobes and a slightly less concave neck line.

Thorax, wing sheaths and legs: Thorax flattened dorsoventrally in smaller specimens (Hdw < 3.5 mm). Wing sheaths reach half way on S6 in F-0 larvae. Male abdomens have somewhat longer S2, wing sheaths thus reaching somewhat shorter than in Figure 2. Ontogenetic changes include inflated wing sheaths which then shorten about the length of one abdominal segment. – Legs with two ventral rows



Figures 2-11: Larval details of *Mecistogaster linearis* — (2) general appearance; (3) labium in situ; (4) mandible in ventral view; (5) maxilla in ventral view; (6) prementum in dorsal view; (7) labial palp in dorsal view; (8) right hind tarsus and lower part of tibia showing positions of normal and branched setae; (9) shape of branched setae on middle and hind tarsi; (10) shape of branched setae on front tarsi; (11) female external genitalia in ventral view.

of spines or setae. Femora with four additional rows of small setae, two dorsal and two lateral. In some specimens setae are only present in some areas of these rows; the rest is merely a fold in the cuticle. Lower part of tibiae with a dense accumulation of setae (Fig. 8), especially on the ventral side, but often with a smaller cluster on the dorsal side. Many of these setae are branched. Tarsi with two rows of branched setae ventrally (Fig. 8) although some normal setae are irregularly interspersed. The branched setae are of two types: 3-branched (Fig. 9) on tibiae, mid and hind tarsi, and feather-shaped (Fig. 10) on front tarsi.

Abdomen and external genitalia: All tergites smooth, covered in fine, short setae. No spines present. Female ovipositor (Fig. 11) visible in larvae with a Hdw of 3.0 mm. The ovipositor extends behind S10 in F-0 larvae. Male accessory genitalia seen as a slight swelling in the cuticle in specimens with a Hdw from 4.0 mm forming a Y-shaped depression in F-1; no male F-0 was available.

Caudal lamellae: Lamellae oval, leaf-shaped, sometimes more rounded than in Figure 2. Length to width ratio is 2 in most larvae, but can be slightly less in some specimens. Smaller larvae have more narrow and pointed lamellae. Lamellae divided into a stalk-like proximal part and a leaf-shaped distal part, with an unclear nodus. Edges of the lamellae in the proximal part with a line of tiny setae, which are frequently missing from the somewhat notched edge.

Discussion

As *Mecistogaster linearis* is a tree-hole dweller, it should have all the characteristic larval traits for that particular habitat (cf. Ramírez 1997). Those traits are: relatively short, stocky body shape and stalked caudal lamellae ending in a wider part held close to the water surface, an adaptation for respiration in an oxygen-poor environment (Fincke 1992; de la Rosa & Ramírez 1995; Ramírez 1997; Hedström & Sahlén 2003). As pointed out in the paper by Hedström & Sahlén (2003), a similar morphology is found in the East African *Coryphagrion grandis* Morton which also breeds in containers (Clausnitzer & Lindeboom 2002).

M. linearis is in F-0 stadium easily separated from *Megaloprepus caerulatus*, with which it shares habitat in this study. Easily visible characters and general habitus (Fig. 2) are possible to use, e.g. head shape, premental shape, colouration and gills. The head of *M. linearis* is less heavily built than that of *Megaloprepus*, the margin of the occipital lobes being more evenly rounded and not as angular as in the other species (cf. Hedström & Sahlén 2003: figs 3, 4). Prementum is wedge-shaped rather than parallel sided as in the other species. Colouration of live larvae also differs, although general body colour with different shades of brown is the same in both species. *M. linearis* never possesses the white markings on thorax and caudal gills typical of medium sized and large larvae of *Megaloprepus* (Hedström & Sahlén 2003). The gills and often also the rest of the body in *M. linearis* instead have a hint of grey-blue in the colours, not violet as in *Megaloprepus*. The caudal gills are narrower, leaf-shaped and not round as in the other species.

On exuviae, where head shape and caudal gills are distorted and colour cannot be used, the shape of the mouthparts may be a good character. Whereas the maxillae (Fig. 5) are similar to that of *Megaloprepus*, the mandibles (Fig. 4) differ considerably (cf. Hedström & Sahlén 2003).

The branched setae of *M. linearis* have for the most part the 3-branched appearance found also in *Megaloprepus* (Hedström & Sahlén 2003) and most likely also in *Pseudostigma aberrans* (Novélo-Gutierrez 1993). The position of these setae is the same in all known species in the family and also in *C. grandis* (Clausnitzer & Lindeboom 2002) and *Coenagrion intermedium* Lohmann (Battin 1991). The most striking branched setae are the feather-shaped setae which are present in two rows ventrally on the front tarsi. The difference in shape between these setae and the 3-branched must be due to different use. Three-branched setae on the tarsi might e.g. be a way of increasing the grip on the substrate in a soft-walled container. The feather shape might, on the other hand, be designed for grooming. As only the front tarsi have this kind of setae and only the front legs are used for eye cleaning, our suggestion is that the feather-shape is optimal for removing algae and other objects from the surface of the ommatidia.

The population size of *M. linearis* in the study area seemed to be stable during the years 2001-2004. Hence we conclude that natural breeding sites must be abundant in the area, be it water holes on fallen tree tanks or water in the leaf axis of large tank bromeliads. As we added 75 new potential breeding sites for the species, the population in the study area was not altered and there was no observed increase in larval numbers over time (Fig. 1).

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