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LARVAL MORPHOLOGY OF THREE SPECIES OF THE GENUS *HADROTHEMIS* KARSCH (ANISOPTERA: LIBELLULIDAE)

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The larval morphology of *H. scabrifrons*, *H. coacta* and *H. camarensis* is described for the first time from specimens collected in East Africa, and a comparison among the species is given.

INTRODUCTION

The African genus *Hadrothemis* Karsch, 1891 includes seven species, and is widespread in the forests of West Africa, the Congo basin, Uganda and west Tanzania (DAVIES & TOBIN, 1985). Two of the species (*H. scabrifrons* Ris, 1909 and *H. camarensis* Kirby, 1889) are known for their dendrolimnetic oviposition behaviour (COPELAND et al., 1996; CORBET & McCRAE, 1981). 24 genera and 47 species are known worldwide to reproduce in phytotelmata (CORBET, 1999), about 2/3 being Zygoptera. In the afrotropical region only larvae of three species have been recorded from phytotelmata so far: the Zygoptera *Coryphagrion grandis* Morton, 1924 (LOUNIBOS, 1980; CLAUSNITZER & LINDEBOOM, 2002) and the afore mentioned two Anisoptera species of the genus *Hadrothemis*.

In this paper we describe the larvae of the two tree-hole dwelling species *H. camarensis* and *H. scabrifrons* together with the larvae of *H. coacta* Karsch, 1891. The latter reproduces in small ponds on the rainforest floor (CLAUSNITZER, 2002).

METHODS AND TERMINOLOGY

The material described here was partly collected in the field and reared to emergence for species

Table I
Summary of dimensions (in mm) of three *Hadrothemis* species

	H. scabrifrons final stadium larva	*H. scabrifrons* penultimate stadium larva	*H. camarensis*	*H. coacta*
total body length	26.8	23.6	26.0	
head width	7.0		6.2	
distance between antennae insertions	2.3-2.4	2.2	2.1-2.2	1.6
prementum length	5.4		4.7-5.6	4.3
prementum width	6.2		5.4-5.5	5.0
anterior tibiae length	5.2-5.3	4.3	5.2	
abdomen width	8.5-9.2	8.1	7.4	5.6
distance between tips of abdominal spines at S8			5.8	4.7
distance between tips of abdominal spines at S9	4.3	3.9	3.7	3.1
anal pyramid length	1.6	1.6	1.8	1.6
cerci length	0.8	0.7	0.8	0.7
epiproct length	1.4	1.3		1.5

identification, and partly identified in the field being the only species occurring in the area with dendrolimnetic behaviour. Both larvae and exuviae were stored in 75% ethyl alcohol and drawn using a stereomicroscope and a camera lucida (50× magnification). All measurements were to the nearest 0.02 mm using a micrometric eyepiece. The following measurements were made: total body length, head width, distance between antennae insertions, prementum length and width (after being cut and not flattened), anterior tibiae length, abdomen width, distance between apices of lateral spines at S8 and S9, anal pyramid length, cerci length and epiproct length. Because part of the material was damaged (e.g. stretched exuviae, flattened prementum), it was not possible to obtain all measurements for each specimen. For this reason, some measurements reported in Table I are lacking, some are referred to a single specimen, some to two only. CORBET's (1953) terminology for the mask was adopted. Abdominal segments are indicated as S1-S10. We adopted the term "stadium" instead of "instar" following CORBET (2002). For SEM observations, the glutaraldehyde-fixed sample (one final stadium larva) was washed three times with phosphate buffer (PB) pH 7.2, post fixed with 1% (w/v) osmium tetroxide overnight at 4°C, washed three times with PB, and dehydrated in a ethanol series. The sample was then critical point dried, gold sputtered and observed in a scanning electron microscope (LEICA STEREOSCAN S 440) and digitalized pictures were taken.

MORPHOLOGICAL DESCRIPTION

HADROTHEMIS SCABRIFRONS RIS

Figures 1, 2b, 3a, 4-9

M a t e r i a l. – 2 final instars and 1 penultimate exuviae from the Makadara forest, coastal Kenya, 29-IX-1979, P.S. Corbet leg.; – 4 final stadium exuviae from the Arabuko Sokoke forest, Kenya 15-XII-2000, V. Clausnitzer leg.; – 1 final stadium larva from Arabuko Sokoke forest, coastal Kenia, 12-XII-2000, V. Clausnitzer leg.

Habitus resembling species of the genus *Libellula* (Fig. 1a-b). Larvae uniformly dark brown-blackish but exuviae not so dark. Very long hairs cover the whole body, hiding almost completely sides of abdomen and anal pyramid (Fig. 5a-b). However, penultimate stadium exuviae much less hairy. Head short and wide, transverse, with small, prominent eyes and bands of stout spiniform setae on occipital angles (Figs 1a, 4a). Antennae 7-segmented (Fig. 4a-b, in the latter the first segment is not visible). Articulation between prementum and postmentum not reaching mesocoxae (Fig. 2a). Mask stout, prementum wider than it is long, with long and thin premental setae and lots of spiniform setae on lateral margins (Figs 2b, 7a). A field of numerous thin needle-like setae on central area of prementum (Fig. 6a-b). Apex of the prementum without setae, but with scattered sensilla, mainly conical (Fig. 7b), which are aligned in a thick line along the premental distal margin (Fig. 7c). Palpi with stout spiniform setae on external (i.e. dorsal) margin near articulation (Figs 3a, 8b); palpal setae very thin; movable hook short and sharp (Figs 3a, 8a-b); distal margin with shallow teeth, each with a group of spiniform setae (Figs 3a, 8a); the first two teeth are deeper and smaller with an evident asymmetry between right and left sides (Figs 8a,

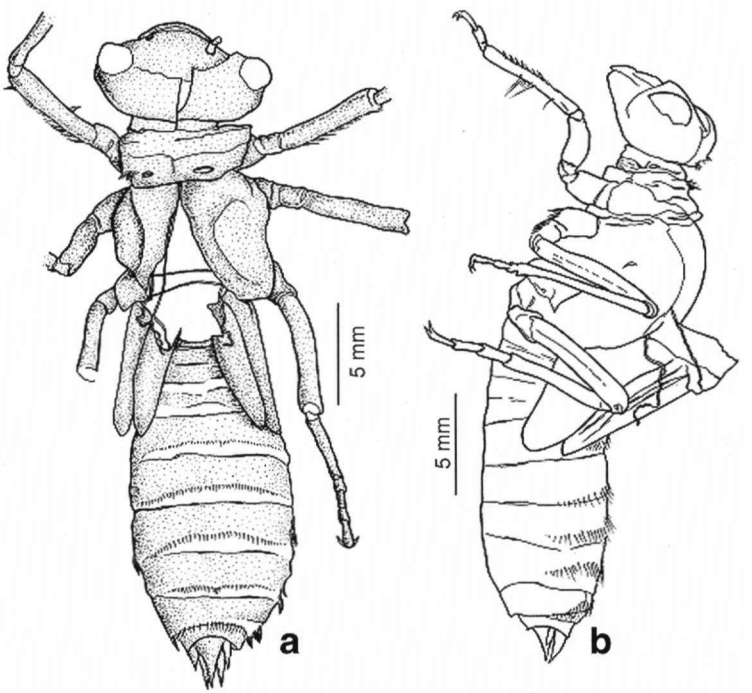


Fig. 1. *Hadrothemis scabrifrons*, schematic drawings of final exuviae, mask removed: (a) dorsal view; – (b) lateral view.

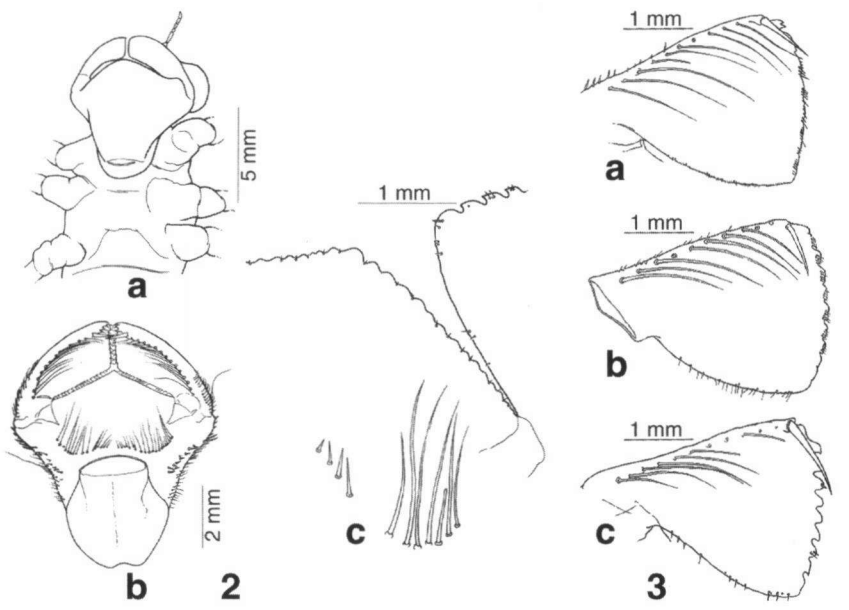
9a); margin of the teeth serrated (Figs 9 a-b); palpal inner (i.e. ventral) margin almost smooth and with a row of small and long spiniform setae (Figs 3a, 8c). Legs stout, fringed with long setae. Articulation between femura and tibiae of hind legs reaching S6. Wing sheaths on ultimate stadium larva reaching the distal margin of S6 and bearing rows of spiniform setae on main veins (Fig. 5a). Abdomen ovoid, widest segment S6. Small and sharp lateral spines on S8 and S9, hidden by tufts of hair-like setae; dorsal spines from S3 to S4/S6, hidden by wing sheaths. Anal pyramid small, about as long as S9+S10. Larvae show white spots on the eyes (see photo in CLAUSNITZER, 2002, p. 22), but these spots are only visible in living specimens and not in the exuviae or dead larvae.

HADROTHEMIS CAMARENSIS KIRBY

Figure 3b

M a t e r i a l. – 3 final stadium exuviae from Mpanga forest, Uganda, 1959, P.S. Corbet leg.; – 1 final stadium exuviae and 1 final stadium larva from Kakamega forest, western Kenya, 1-X-1990, R. Copeland leg.

Larval habitus similar to previous species, but less robust and not so hairy and dark. Prementum similar to *H. scabrifrons*, with a field of thin needle-like setae,



Figs 2-3. *Hadrothemis* structural features: (2) (a) *H. scabrifrons*, head and thorax, ventral view; (b) *H. scabrifrons*, mask; (c) *H. coacta*, details of prementum and palpus; – (3) palpal morphology: (a) *H. scabrifrons*; (b) *H. camarensis;* (c) *H. coacta.*

but lacking in spines on lateral margins. Palpus also similar, but distal margin with bigger, protruding teeth each with serration, whose lower element appears as a sharp point; inner margin with fewer, longer spiniform setae (Fig. 3b). Abdomen with evident lateral spines on S8 an S9 and very thin and long dorsal spines from S3 to S5/S6.

HADROTHEMIS COACTA KARSCH

Figures 2c, 3c

Material. – 2 final stadium exuviae from Busoga forest, Uganda, 2-XII-1954, P.S. Corbet leg.

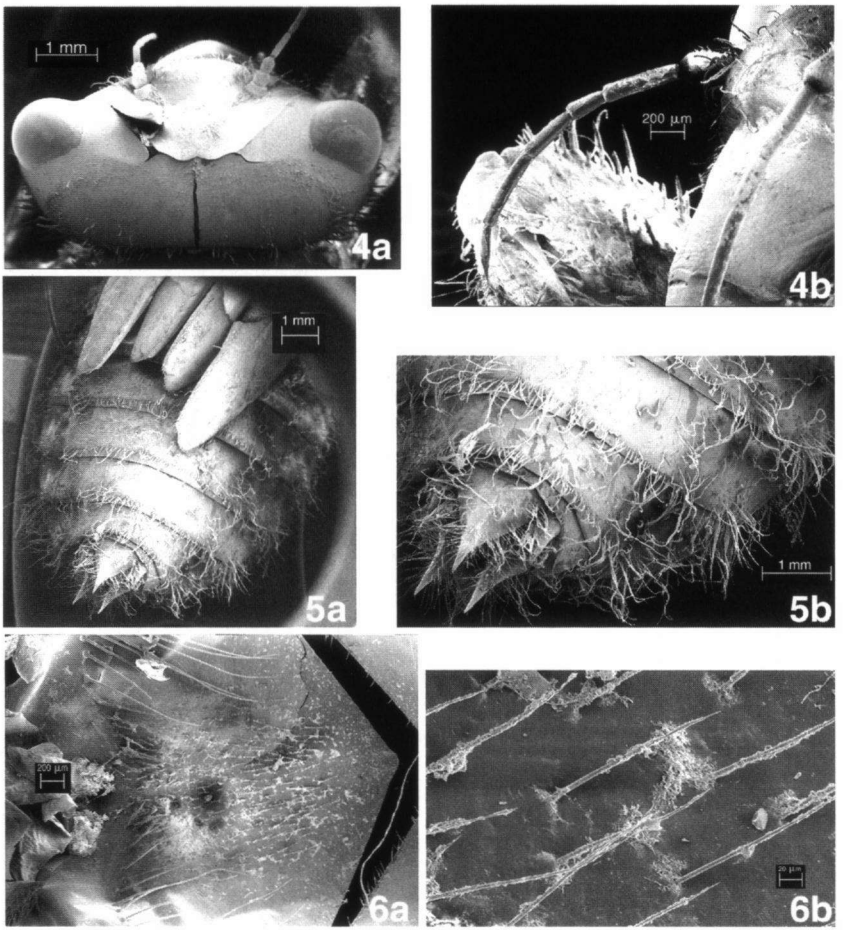
Larval habitus quite different to previous species, smaller (Tab. I), paler and glabrous. Distal margin of prementum toothed, and with a single spiniform seta between teeth (Fig. 2c), less dense field of needle-like setae on prementum central area. Palpus showing much longer movable hook than previous species, and distal margin with very big teeth, more or less pointed, with spiniform setae. Teeth smooth, not serrated. Inner margin with stout spiniform setae (Fig. 3c). Tibiae fringed with long setae, while femura with only a few setae near articulation with tibiae. Wing sheaths glabrous. Abdomen bearing very small conical lateral spines on S8 and S9; dorsal spines from S3 to S9, all large and pointed backwards, except that on S3, thin and vertical. Anal pyramid as long as S9+S10.

Table II
Comparison between premental and palpal features of three *Hadrothemis* species
(* penultimate stadium larva)

	H. scabrifrons	*H. camarensis*	*H. coacta*
premental setae	8+8*/ 14+11	8+8 / 10+11	7+7
spiniform setae on lateral margins of prementum	numerous and stout	few and small	no
palpal setae	13&13* / 15&15	10&11 / 11&12	11&11
teeth on distal margin of palpus	shallow and rounded	shallow and hook-like	big and irregular
shape of first two teeth of palpus	bigger and deeper than the other teeth	as in *H. scabrifrons*	similar to the other teeth
margin of teeth	serrated	serrated	smooth
spiniform setae on distal margin of palpus	numerous, irregularly spaced	numerous, regularly spaced	very scarce and stout
spiniform setae on inner margin of palpus	numerous, small and short	numerous, thin and long	scarce and stout
movable hook length	1/3 palpal distal margin	1/3 palpal distal margin	1/2 palpal distal margin

DISCUSSION

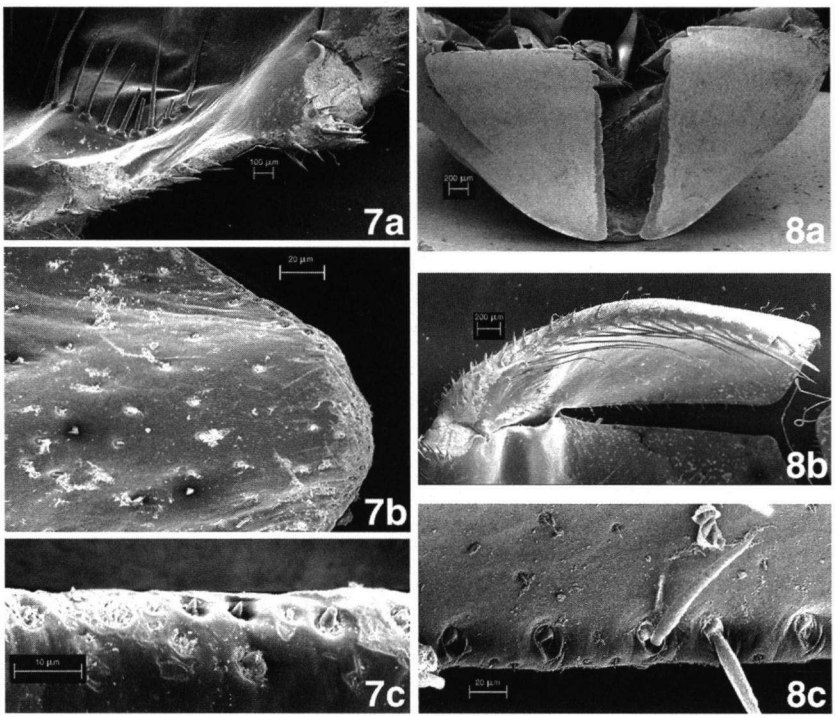
Hadrothemis species described here show a lot of differences between *H. coacta* and the two dendrolimnetic species, *H. scabrifrons* and *H. camarensis*, which are substantially similar in most features: they are stout and more or less hairy as in other Libellulinae genera (*Libellula*, *Orthetrum*), abdominal spines are small, there is no dorsal abdominal carina, legs are short and robust, eyes small and prominent. All these characters are typical of shallow burrowing species, living in mud or detritus in dark habitats. On the other hand, *H. coacta* is smaller, less



Figs 4-6. *Hadrothemis scabrifrons*, final stadium larva: (4) (a) head (mask removed); (b) right antenna, first segment not visible; – (5) (a) abdomen and wing sheaths; (b) details of the last segments and anal pyramid; – (6) (a) prementum, dorsal view; (b) detail of the needle-like setae on the central field.

stout, glabrous, but with more and bigger spines on the abdomen. Particularly useful for identification appears the shape of distal margin of palpi and prementum, even if the double-pointed first tooth of the palpus, particularly evident in *H. scabrifrons*, is common to the three species and very peculiar in comparison with other libellulid species. For a comparison of palpal and premental features, see Table II.

The dendrolimnetic *H. scabrifrons* and *H. camarensis* are both dark pigmented and at least *H. scabrifrons* has white spots on the upper part of the eyes. It is not known whether this occurs in the other species of the genus as well, or if these features respond to the different ecology. But it is more likely that white spots on the dorsal surface of tree-hole dwelling species represent an adaptation to phytotelmata as larval habitats. Dorsal white spots on the eyes are also described from the dendrolimnetic larvae of the libellulid *Lyriothemis cleis* Brauer, from Sulawesi (KITCHING, 1986), while the Zygoptera *Megaloprepus coerulatus* (Drury) has prominent white spots on the wing sheaths and on the caudal appendages (RAMIREZ, 1997).



Figs 7-8. *Hadrothemis scabrifrons*, final stadium larva: (7) (a) lateral margin of prementum; (b) detail of apex of prementum; (c) detail of sensilla on distal margin of prementum; – (8) (a) palpi, frontal view; (b) palpus, dorsal view; (c) detail of the inner margin of palpus.

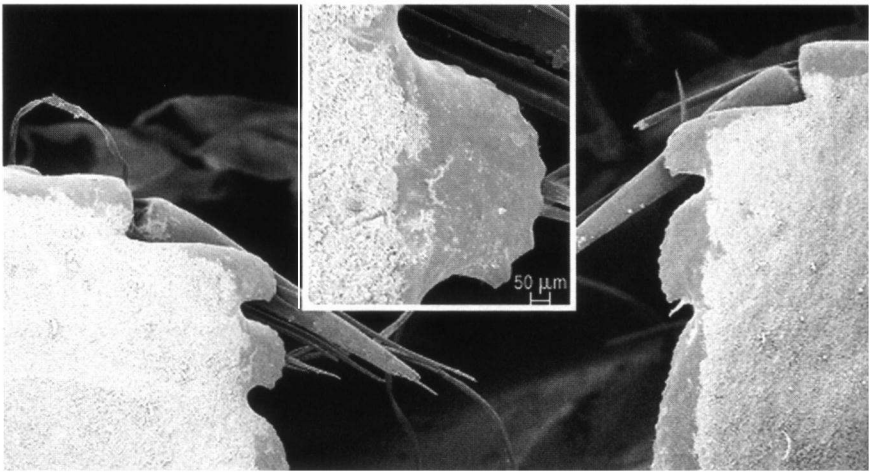


Fig. 9. *Hadrothemis scabrifrons*, final stadium larva: movable hooks and first teeth of distal margin of palpi and detail of the second right tooth.

Some notes on the adult ecology and adaptations to the habitats of *Hadrothemis* species were given by CLAUSNITZER (2002). Nevertheless, further studies on the eco-morphology of *Hadrothemis* species are needed to get an insight on adaptive traits linked to dendrolimnetic larval habitat.

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