Odonatologica 35(3): 233-241 *September 1, 2006*

DESCRIPTIONS OF THE LAST INSTAR LARVAE OF *NEODYTHEMIS HILDEBRANDTI* KARSCH AND *N. AFRA* (RIS) WITH COMMENTS ON THE STATUS OF THE GENUS AND SUBFAMILY (ANISOPTERA: LIBELLULIDAE, TETRATHEMISTINAE)

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Received February 16, 2006 / Reviewed and Accepted March 1, 2006

The larvae of *N. hildebrandti* (from Nosy Be, Madagascar) and *N. afra* (from Mt Kupe, Cameroon) are described, illustrated from exuviae, and compared with the larva of *N.* (*Allorrhizucha*) *klingi* (Karsch) from W Africa. Differences between the larva of *Neodythemis* and that of other known African Tetrathemistinae genera (*Malgassophlebia, Notiothemis* and *Tetrathemis*) are highlighted, and it is suggested that this provides support for the view that *Neodythemis* (including *Allorrhizucha*) and *Micromacromia* form a natural group, the 'neodythemistines', and that they are only distantly related to other genera in the subfamily. This provides additional evidence for the view that Tetrathemistinae is not a phylogenetically homogenous grouping within the Libellulidae.

INTRODUCTION

Neodythemis is an African genus which is conventionally placed within the Tetrathemistinae and considered to contain eight species, four of which are endemic to Madagascar and four are endemic to the African mainland (DAVIES & TOBIN, 1986). In a recent contribution, DIJKSTRA & VICK (2006), pointed out that the Tetrathemistinae as traditionally defined are a polyphyletic grouping and they identified the 'neodythemistines', a probably monophyletic group of genera, and showed that all the species described should be placed in two genera,

Neodythemis and *Micromacromia*. Using this definition, *Neodythemis* contains 12 species, of which four are Malagasy endemics.

MATERIAL AND METHODS

On 13 April 1999, during a six-day stay on Nosy Be (= Nosey Bey), an island off the north-west coast of Madagascar, the larva of a small libellulid was found in the Andranobe river. The river itself was fairly swift flowing through lowland forest and lightly shaded by tree canopy. Where the waters had been trapped by large boulders there were slower flowing marginal areas and many of the boulders were covered with the exuviae of *Zygonyx hova* (Martin, 1900). The larva of *N. hildebrandti* was dredged from amongst detritus in sandy substrate in such an area. Exuviae were found clinging to the larger boulders in the stream alongside exuviae of *Z. hova*. Larvae of other species found here included *Platycnemis malgassica* Schmidt, 1951, *Pseudagrion* sp., *Paragomphus* sp., *Orthetrum* sp., and *Trithemis* sp. The *Neodythemis* larva was brought back to the UK and it emerged on 17 June 1999. The adult was examined and determined by G.S. Vick and R.G. Kemp. Seven similar exuviae which had been found clinging to boulders in the same habitat were later compared with the exuviae of this larva and were assumed to be conspecific.

MORPHOLOGICAL DESCRIPTIONS

NEODYTHEMIS HILDEBRANDTI KARSCH, 1889

Figures 1, 3, 5, 7

Material. – 1 ♀ final instar exuviae, MADAGASCAR: Andranobe River, Nosy Be (13°20.33'S, 48°18.23'E), 13-IV-1999. S.G.Butler leg. Emerged UK 17-VI-1999.

HABITUS (Fig. 1). – Total length 17 mm, similar in appearance to *Palpopleura* spp., but rather larger and hairier and with stouter legs. There are few markings and the body colour is mid tan.

Head. – Sub-pentagonal in shape, the lateral margins of the occiput are somewhat rounded with a covering of both long and short setae, which are distributed from there to the central suture. The head is lightly marked on the occiput with a row of slightly pitted, inverted U-shaped patterns.

The labium (Fig. 3) is cup-shaped, the distal margin of the prementum being smooth without a median lobe and there are 24 (left) and 23 (right) setae on the distal margin itself.

The mental setae (Fig. 5) are small to minute and there are 17 (left) and 19 (right), arranged in an unusual pattern. Starting from the outer seta the line of setae arches up towards the distal lobe then gradually returns to the same level at the innermost seta, producing an almost symmetrical shape (anticlinal). This is in contrast to the normal line of setae in Libellulidae which usually curves basally from the outer edge and then curves back distally at the innermost portion (synclinal) and also consists of a group of outermost long setae declining in size inwardly. The labial palps also show an unusual arrangement (Fig. 3) as they have 2 large setae confined to the distal third of the palp, basal to these is a line of smaller setae 5

on right, 7 on left, these latter are distributed almost on the outer edge of the palp, thus producing a clearly discontinuous line. The distal margin of the palps has shallow crenulations each containing 3 setae, the basal is the longest of the three and the distal the shortest. The endhook is long and fine, and about 1/4 the length of the palps.

The antennae (Fig. 6) are 7 segmented, the ratios of length are as follows: seg. 1 = 0,5; seg. 2 = 0,6; seg. 3 = 0,9; seg. 4 = 0,5; seg. 5 = 0,6; seg. 6 = 0,8 and seg. 7 = 1,0. The surfaces are covered in fine setae, which are more noticeable on the basal segments.

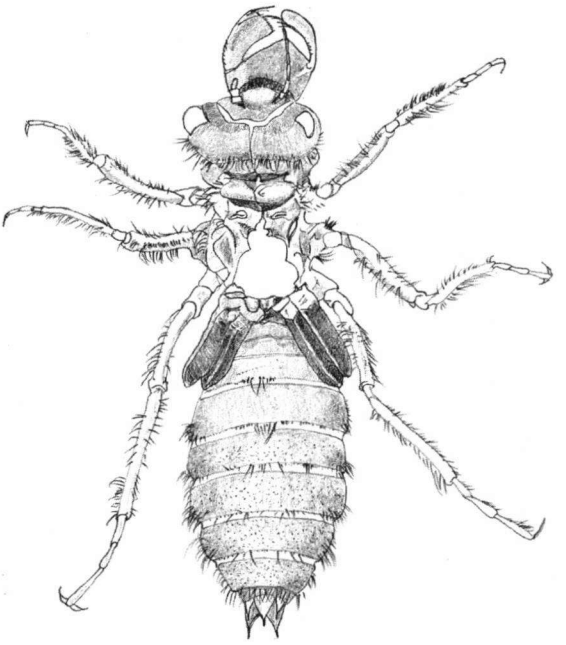


Fig. 1. *N. hildebrandti* Madagascar: habitus, dorsal view.

The eyes are small, not reaching halfway back to the occipital margin and the rear margin of the eye is angled towards the baso-lateral angle of the head.

T h o r a x. – The prothorax is sub-oval in shape, the outer margins bearing a small clump of setae; overall the thorax is slightly darker in colour than the rest of the body. The wing cases are divided and reach backwards to the distal margin of seg. 4.

The legs have femora which are stout with scattered setae dorsally and longer, finer setae ventrally. The fore and middle tibiae have longer setae dorsally and also a mixture of stout and finer setae. Ventrally the short tibial setae are arranged in a central row, which extends to the tarsal comb, with longer setae scattered amongst them. The rear tibiae (Fig. 7) have a distal row of long fine setae, plus several which are stouter. The ventral surface has finer setae, which graduate to 6 stout and curved setae, with 2 more on the edge of the articulation.

A b d o m e n (Fig. 1). – It is light brown in colour and has no visible markings. Fine short setae are noticeable on segs 8-10, but are sparser on the preceding segments. Long, fine setae are also present on the latero-distal margins of segs 5-9 and also on the centre of the dorsum at segs 4-8, they are also scattered irregularly over the rest of the dorsal surface. Also there is a row of short, fine

setae on the distal margin of segs 5-9. No dorsal or lateral spines are visible on any segment. Spines are present ventrally on the distal margins of segs 7, 8 and 9. Triangular sclerites are detectable on segs 3-5 and faintly on seg. 6.

The anal appendages are of the same pale colour, except at the tips, which are darkened. The epiproct is approximately the same length as seg. 9, the cerci reaching to ¾ of its length, whilst the paraprocts are approximately the length of segs 9 + 10 combined.

Comparative material. – 6 final instar exuviae from Andranobe R, Nosy Be and 1 from Moramanga, near Antananarivo in central Madagascar, 25-IV-99. M.J. Parr leg.

All the above exuviae found in situ at Nosy Be and Moramanga are slightly smaller, ranging in size from 13-14,5 mm. They are much darker in colour and appear slightly hairier and covered in a greater amount of detritus, though those differences could be accentuated by the cleaner artificial environment in which the bred specimen was reared. There is a definite central lobe on the ligula. The setae on the prementum appear smaller and fewer in number, however this is difficult to discern exactly, as the empty labium of each had filled with grains of sand, which are impossible to remove. As these differences are not significant enough to point to a different species, cohabiting at the same site, this material is to be assumed to be conspecific with the described larva.

Of the four Madagascan species, *N. hildebrandti* is the commonest species, recorded from most parts of the island, including Antananarivo, which is near to Moramanga. *N. arnoulti* Fraser, 1955 has only been recorded from eastern Madagascar (Mt Andohelo 1800m, 1 ♂), *N. trinervulata* (Martin, 1903) from eastern Madagascar (Col de Sakavalona, 1 ♂), whereas *N. pauliana* Fraser, 1952 is recorded only from central Madagascar (Forêt au Nord d' Anisobé, 1 ♂). The status of these last three species needs to be confirmed.

NEODYTHEMIS AFRA (RIS, 1909)

Figures 2, 4

Material. – 3 exuviae of final instar larvae, Mount Kupe, SW Cameroon (4°49.15'N, 9°41.48'E): 1 ♂ taken with adult (preserved dry and pinned, taken IV-1997), 1 ♀ found alone (preserved in 70% alcohol, taken II-1996) and in close agreement with first, Otto Mesumbe leg., 1 ♂ bred out by D.G. Chelmick 1998; all G.S.Vick det. All specimens are clean and not encrusted with mud.

The larvae resemble those of *Neodythemis hildebrandti*. Some differences are of course to be expected and we point out the following as being diagnostic of *afra*.

The setae on the lateral and hind margins of the head are longer (reaching 0.8 mm) and the rear angles of the head are more nearly square (Fig. 2). On the labium (Fig. 4) there is a suggestion of a median lobe and there are 14-15 setae per side on the distal margin (rather than 23-24); the extraordinary 'reverse-curve' of premental setae on the dorsal surface is if anything more prominent as each curve

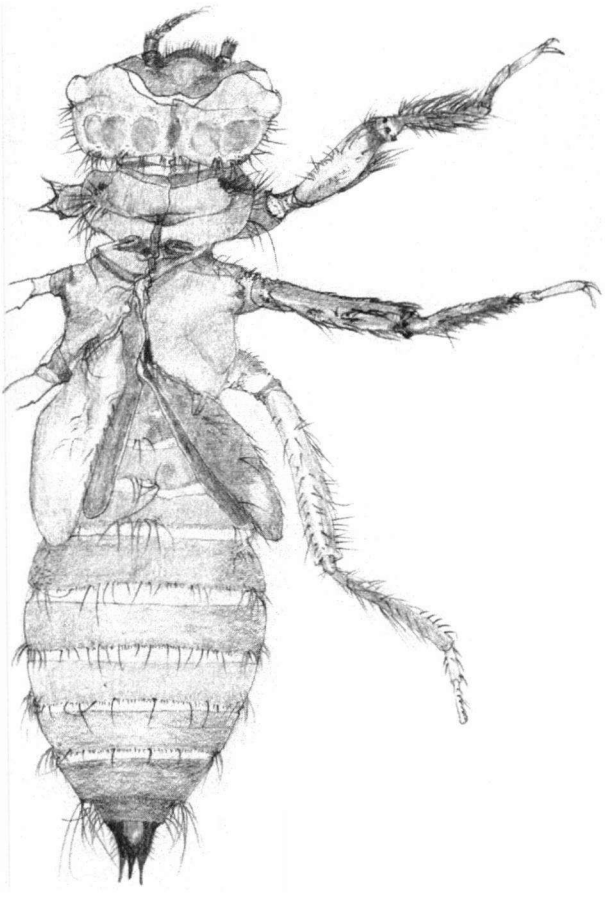


Fig. 2. *N. afra* Cameroon: habitus, dorsal view.

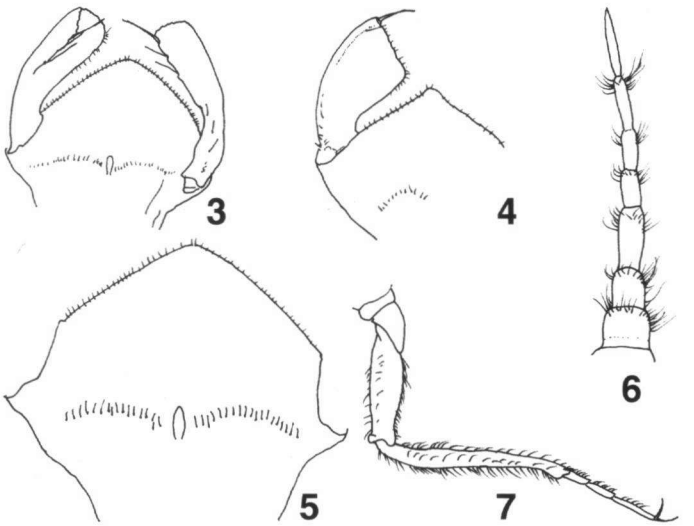
of setae has a smaller radius and there are fewer setae (13-14 per side rather than 17-19). The distal margins of the labial palps bear ten crenulations but only the basal six bear triple setae. The frons bears longer hairs, exceeding 1.0 mm, and they are noticeably yellow. The antennae are also 7-segmented but the ratios of lengths are as follows: seg. 1 = 0.5; seg. 2 = 0.6; seg. 3 = 1.2; seg. 4 = 0.7; seg. 5 = 0.8; seg. 6 = 0.8 and seg. 7 = 1.0 (note the greater relative length of seg. 3 in *afra*). In both species, the abdomen bears very long fine setae on the dorsum, arising near the distal margin of segments 4 to 8 (a few also on seg. 3 in *afra*) and these extend over the intersegmental membrane onto the next segment, but they are slightly longer in *afra* and the disposition is different as they are more evenly distributed across the dorsum in *afra*, and not most concentrated on the mid-line (cf. Figs 1, 2). Finally the caudal pyramid is more prominent in *afra*; the epipoct is longer and about equal to seg. 9 + 10, the paraprocts are slightly longer than the epiproct, and the cerci are about 0.6 of length of epiproct.

DISCUSSION

There is at present no classification of the Libellulidae which reflects modern concepts of phylogeny. Traditional classifications are mainly based upon wing

venation and these are unreliable and likely to lead to false phylogenies (DIJKSTRA & VICK, 2006). The Tetrathemistinae is poorly defined as it is based solely upon adult characters which may be plesiomorphic, and it is probably polyphyletic (VICK, 2000). They have generally been considered to be a 'primitive' group of libellulids, all are small forms with long narrow wings, short abdomen, coloured black and yellow and displaying a number of possibly plesiomorphic wing venational features. It is possible, however, that some of these characters are in fact secondary developments which are correlated with a narrowing of the wings. They display a number of specialised characteristics: superior appendages are frequently complex in shape (and hence are useful diagnostically at the species level), unlike those possessed by most of the more 'modern' libellulids and they possess a range of interesting oviposition strategies. Most species inhabit closed--canopy habitats in rainforests, some genera are predominantly stream dwellers, whilst others breed in shady pools.

DIJKSTRA & VICK (2006) discussed the status of a group of apparently monophyletic taxa, previously considered to be members of the Tetrathemistinae, which they have for convenience, pending a revision of the family, called the 'neodythemistinae'. All species possess two well-defined characters: similar hamular structures and additional bridge cross-veins; also there is a tendency to develop double-rowed forewing discoidal cells and additional cross-veins in the cubital and discoidal cells. They arranged the species in two genera *Neodythemis* (including *Allorrhizucha* Karsch, 1890 and *Mesumbethemis* Vick, 2000) and *Micromacromia*



Figs 3-7. *N hildebrandti* (Figs 3, 5-7) and *N. afra* (Fig. 4): (3-4) labium, dorsal view, showing setal arrangement on palps and mental setae; – (5) prementum in close up, showing detail of mental setae; – (6) right antenna, dorsal view; – (7) right hind leg, dorsal view.

(including *Eothemis* Ris, 1909, and *Monardithemis* Longfield, 1947). Other genera placed in the Tetrathemistinae were considered to be only distantly related to the 'neodythemistines' and are not necessarily monophyletic themselves.

Little appears to be known of the larvae of many of the species of the Tetrathemistinae, but descriptions are available of the larvae of certain African genera which are all 'non-neodythemistine'. The larvae of *Tetrathemis longfieldae* Legrand, 1977 is known (LEGRAND, 1977) and material of *T. bifida* Fraser, 1941 is available (CHELMICK, 2000). The two species of *Notiothemis* have been described: *jonesi* Ris, 1919 (SAMWAYS et al.,1997) and *robertsi* Fraser, 1944 (CLAUSNITZER, 1999). Also the larvae of the Asian *Tetrathemis irregularis* Brauer, 1868 (NEEDHAM & GYGER, 1937), *T. platyptera* Selys, 1878 (VAN TOL, 1992) and *Nannophlebia risi* Tillyard, 1913 (HAWKING & THEISCHINGER, 1999) have been described. All of the genera above appear to have larvae which share a number of characters: they have dorsal spines, or definite dorsal ridges relating to dorsal spines, long legs and a somewhat *Sympetrum*-like appearance (particularly regarding the shape of the head). In all these genera the labium possesses large crenulations on the distal margin of the labial palpus. Another African genus *Malgassophlebia*, has larvae similar to the above, except that these are not long-legged and both *M. aequatoris* Legrand, 1979 and *M. westfalli* Legrand, 1986 have lateral spines on segments 7-9 and 6-9 respectively, whereas the others have either none or they are small and confined to segs 8 & 9 (LEGRAND, 1986).

We possess larval material of three of the species of *Neodythemis*: *N. afra* (Figs 2, 4) and *N. klingi* (Karsch, 1890) from South-West Cameroon (unpublished) and *N. hildebrandti* (this paper). The first taxon is the correct name for *N. africana* Fraser, 1954 and the second taxon was originally placed in *Allorrhizucha*, which is now synonymised with *Neodythemis* (DIJKSTRA & VICK, 2006). There appear to be significant differences between these three *Neodythemis* species on the one hand and the other described members of the 'Tetrathemistinae' (as listed above) on the other. Firstly, the *Neodythemis* head (Figs 1, 2) bears a close similarity to that of *Orthetrum* spp., having small eyes and a subparallel lateral margin behind the eye, in contrast to the angled and convergent *Sympetrum*-type head with larger eyes of the above mentioned genera. Secondly the labium has the very characteristic 'reverse-curve' of setae on the prementum (Figs 3, 4) and the labial palps with very shallow crenulations on the distal margins of the labial palps and as few as 2 + 1 spines. Thirdly, the abdomen is particularly hairy, so much so that all exuviae of *N. hildebrandti* had to be cleaned of clinging mud thoroughly before they could be properly examined; whereas the other genera appear to have smooth larvae. Fourthly, the legs are slightly stouter and are certainly shorter than those in the other genera described; if extended the hind legs would only just clear the distal margin of the abdomen.

It is interesting that the larvae of the three species are so similar as they are very

widely separated on the African continent, *N. afra* and *N. klingi* from the tropical African mainland and *N. hildebrandti* endemic to Madagascar. These larval characters therefore support their common generic status and suggest strongly that *Neodythemis* is a well defined genus. We have not seen the larva of *Micromacromia*, but we have been informed that the larva of *M. camerunica* Karsch, 1890 is similar and though 'rather close' to that of *Neodythemis* with regard to head shape and anticlinal (inverted) pattern of mental setae, nevertheless bears distinct differences, not least in the presence of dorsal spines of the abdomen and lack of long setae on the posterior margin of the abdominal tergites (Dr G. Fleck, pers. comm.).

The two genera *Neodythemis* and *Micromacromia* are clearly closely related to each other and probably form a natural group; they are only distantly related to other genera presently classified within the subfamily. This supports the view that the Tetrathemistinae, like several other libellulid subfamilies are not a phylogenetically homogenous group.

ACKNOWLEDGEMENTS

We should like to thank GÜNTHER FLECK for valuable information concerning related species of larvae, K.-D.B. DIJKSTRA, R.G. KEMP and F. SUHLING for helpful discussions on taxonomy; and the late D.A.L. DAVIES, the late E.V. PRENDERGAST and M.J. PARR for assistance in the field in Madagascar.

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