

A description of the larva of *Heliaeschna idae* Brauer from Borneo, with a supplementary note on the larva of *H. univervulata* Martin (Odonata: Aeshnidae)

Albert G. Orr^{a*}, Robin W.J. Ngiam^b and Rory A. Dow^c

^aGriffith, School of the Environment, Griffith University, Nathan, Q 4111, Australia; ^bNational Biodiversity Centre, National Parks Board, Singapore Botanic Gardens, 1 Cluny Road, S(259569), Singapore; ^cNaturalis Biodiversity Center, PO Box 9517, 2300 RA, Leiden, the Netherlands

(Received 28 February 2013; final version received 14 April 2013)

The final instar larva of *Heliaeschna idae* Brauer is described and figured for the first time based on the exuvia from an advanced female larva collected in Sarawak, Borneo (East Malaysia). It is compared with the known larvae of the genus and is concluded to be most closely allied to *Heliaeschna simplicia* Karsch, with which it shares a unique structure on the anterior margin of the prementum of the labium, along with several other distinctive characters. The dorsal structure of the head of *H. univervulata* is re-examined and illustrated. It is shown to bear a prominent convexity and tuft of long setae on the vertex which is similar to a structure previously recorded only in *H. simplicia*, and which is only weakly developed in *H. idae*. The taxonomic implications of these partly conflicting observations are discussed and it is concluded the Oriental members of the genus *Heliaeschna* might be separated into two or three separate genera, which are as yet unnamed.

Keywords: Aeshnidae; dragonfly; *Heliaeschna idae*; larva; Sarawak

Introduction

The genus *Heliaeschna* Selys currently includes 11 recognised species occurring in tropical Africa and south-east Asia (Schorr & Paulson, 2012). Present thinking holds that the five African species and six Asian species are not congeneric (Dijkstra, 2005), and it has been suggested on the basis of larval characters that the south-east Asian species may represent at least two, possibly three genera (Kawashima & Sasamoto, 2007; Orr & Ngiam, 2011; Butler & Orr, 2013). To date there is no available description of the larva of any African species but the larvae of three Oriental species are known and described. These are *H. filostyla* Martin, a species endemic to Sulawesi, described by Kawashima and Sasamoto (2007), *H. univervulata* Martin from Singapore (Orr & Ngiam, 2011) and *H. simplicia* Karsch from Borneo (Butler & Orr, 2013). The adults of these three species are all very distinct. Another distinctive grouping is formed by the two very closely allied species *H. idae* (Brauer) and *H. crassa* Krüger, the affinities of which might be clarified by larval characters. The position within the genus of the sixth Oriental species, *H. bartelsi* Lieftinck, is also uncertain.

*Corresponding author, at: 26 Currimundi Rd, Caloundra, Q4551, Australia. Email: agorr@bigpond.com

Recently, one of us (RWJN) collected an advanced female larva from Sarawak, Borneo. The adult emerged soon after and has been identified as *H. idae* on the basis of comparisons with voucher specimens of female *H. idae* and *H. crassa* taken *in copula*. The separation of females of these two species has long proved virtually impossible (Orr, 2003), and therefore the determination as *H. idae* should probably still be considered provisional. Here we describe the final stadium of female larva of *H. idae* based on the exuvia left after emergence.

We compare the larval characters of this species with those of the three *Heliaeschna* species for which larvae are already known and discuss their taxonomic implications. In addition we amend the description of *H. uninervulata* (Orr & Ngiam, 2011) following further examination of exuviae of both sexes of this species.

The larva of *Heliaeschna idae*

Material examined

One exuvia ex larva, collected 3 May 2012, Malaysia, Sarawak, Usun Apau National Park, 03.02666°N, 114.64799°E, alt. 969 m, muddy forest pool, leg. Robin Ngiam. One adult female, emerged from larva, same locality data.

Description

Diagnosis. Habitus typically aeshnid (Figure 1); head large with prominent eyes and strongly developed mouthparts elongating the face, outer margins of mandibles angulated and prominent in dorsal view, legs moderately long, abdomen fusiform with moderately long anal appendages and lateral spines on S5–S10. Coloration of exuvia pale greyish ochre with a fairly well-defined pattern and prominent dark speckles associated with small tubercles at the base of larger setae (Figure 1); in life reddish brown with heavy dark markings, eyes yellowish. Body surface generally finely pilose with patches of heavier setae in places.

Head. Large, robust, roughly rounded pentagonal, with very prominent eyes (Figure 2a). Postocular lobes well developed and evenly rounded. Glabrous suboval areas immediately behind bases of eyes reaching almost to hind margin, each ringed by a line of small tubercles surmounted by setae. Remainder of postocular area weakly pilose, with strong marginal and submarginal setae in the posterolateral regions, the bases of these setae mounted on small dark tubercles presenting a strong speckled appearance. Vertex very slightly swollen behind ocelli with a small compact tuft of dark setae. Anterior part of head well developed. Dorsally frons and clypeus broad. Labrum with row of coarse setae along its distal margin. In dorsal view labrum not completely covering labium, with movable hooks and part of palps clearly visible. Mandibles very prominent in dorsal view, their outer margins meeting at an angle of *c.* 90°; outer angle somewhat bulbous and bearing dense setae. Antennae 7 segmented, mainly dark with pale marking basally on S1 and distally on S2; overall moderately long. Length ratio of segments 1–7 as follows: 1.0 : 1.1 : 1.7 : 1.1 : 1.3 : 1.0 : 1.0. Head with rather low profile (Figure 3a); vertex scarcely rising above level of eyes; frons slightly convex anteriorly but with median transverse groove; ante- and postclypeus broad and well defined but almost in same plane, labrum slanted sharply downward. Labium (Figure 2b, c, d, e) with prementum long and robust, the distal third expanded laterally with a rounded margin bearing a row of 30+ strong, dark, recurved spines. This row continues basad onto the dorsal surface of the prementum with up to 10 more smaller spines, gradually diminishing in size. Most spines are associated with a single long pale seta, inserted anteroventrally at the base of the spine (Figure 2c). Lateral margins in basal two thirds of prementum taper evenly to a narrow base.

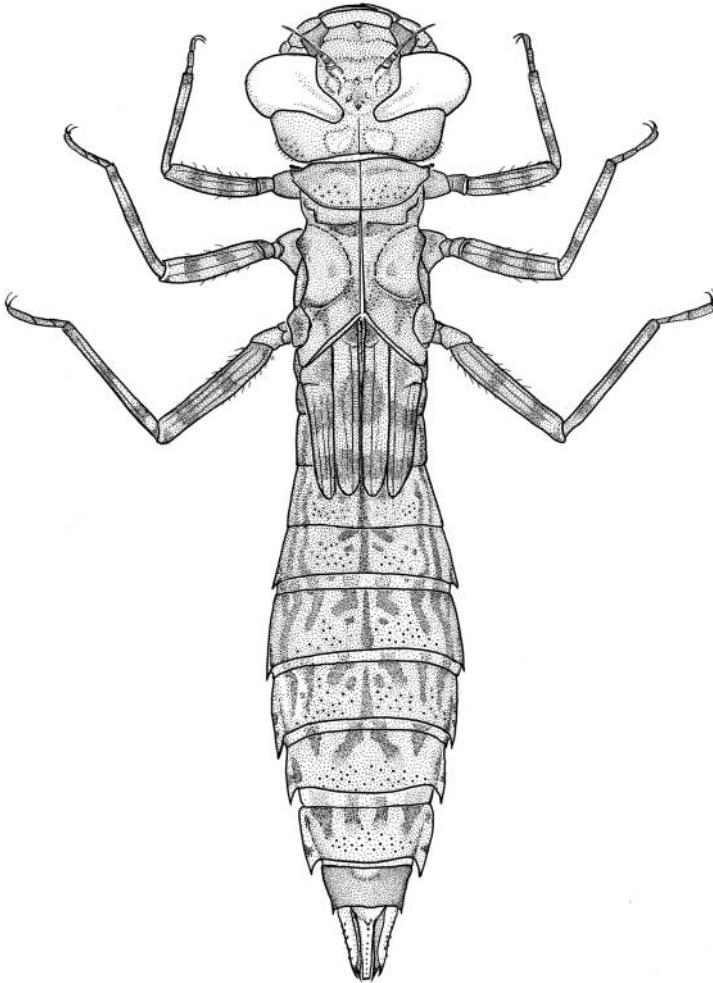


Figure 1. *Heliaeschna idae* ♀ exuvia, habitus.

Anterior margin of the prementum with two prominent lobes each occupying about one fifth of its total width, separated centrally by a deep V-shaped incision, and also defined laterally by two further incisions on each side, before the base of the labial palps which in dorsal view overlap a second, smaller, outer pair of fleshy lobes, clearly seen in ventral view (Figure 2d). The inner lobes have a thin, naked, blade-like rim centrally, extending slightly beyond the fleshy part of the lobe; this rim ends in a well-defined step at approximately one third of the lobe width measured from the central 'V', after which the margin continues smoothly bearing a row of 30+ short stout setae inserted ventrally and reaching the outer shoulder of the lobe (Figure 2d, e). The labial palps bear long, fairly robust hooks, strongly curved inward apically and forming a blunt point; inner margin with row of coarse serrations. Movable hooks long, slender and curved. Mandibles in ventral view (Figure 2f) with protruding, outer corners forming an angle of $c.90^\circ$ and moderately long, with complex well-defined dentition arising from both incisor and molar surfaces, the former bifid on the left, weakly trifid on the right, the latter strongly bifid on both sides.

Thorax. Relatively short; narrower than head. Pronotum shield-shaped, terminating in a blunt point on each side which overlaps the supracoxal processes, just visible in dorsal view (Figure 1).

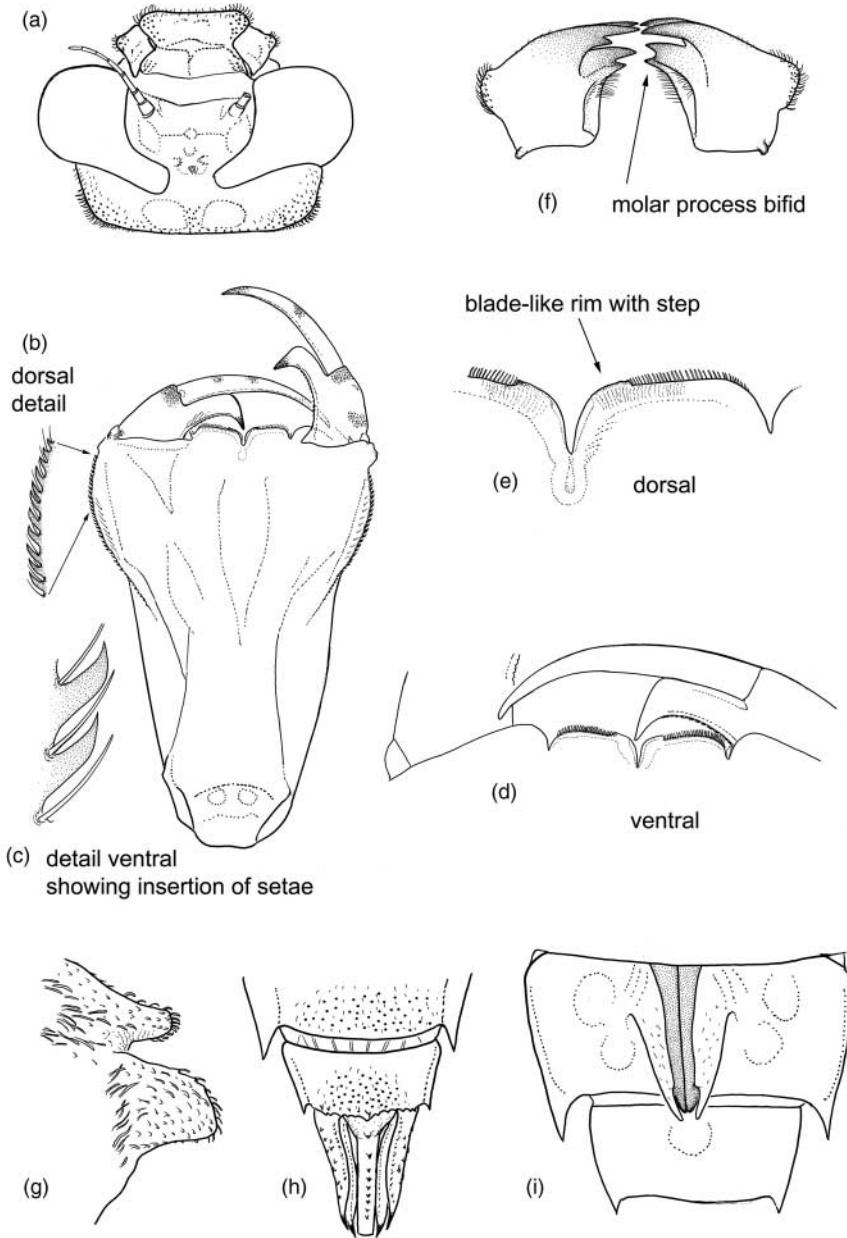


Figure 2. *Heliaeschna idae* ♀ exuvia: (a) dorsal view of head, labium removed; (b) dorsal view of anterior part of labium, with detail of lateral spines shown to left; (c) ventral detail of spines, showing associated setae; (d) ventral detail of anterior part of prementum showing insertion of rows of setae along anterior lobes; (e) dorsal detail of anterior margin of prementum; (f) ventral view of mandibles; (g) detail of prothoracic supracoxal processes; (h) dorsal view anal appendages; (i) ventral view S9–S10 with gonapophyses.

Supracoxal processes robust, the anterior one finger-like, the posterior one broad and subquadrate, the two lying close together and separated by a narrow ‘V’ shape. Both processes covered in small tubercles and bearing coarse, sparse setae basally and apically (Figure 2g). In the posterior part of the thorax are slight protuberances above meso- and metacoxae, the intervening area being saddle-shaped (Figure 1). Legs moderately long, distinctly banded. Wing sheaths reaching anterior margin of S4 or a little beyond; distinctly banded.

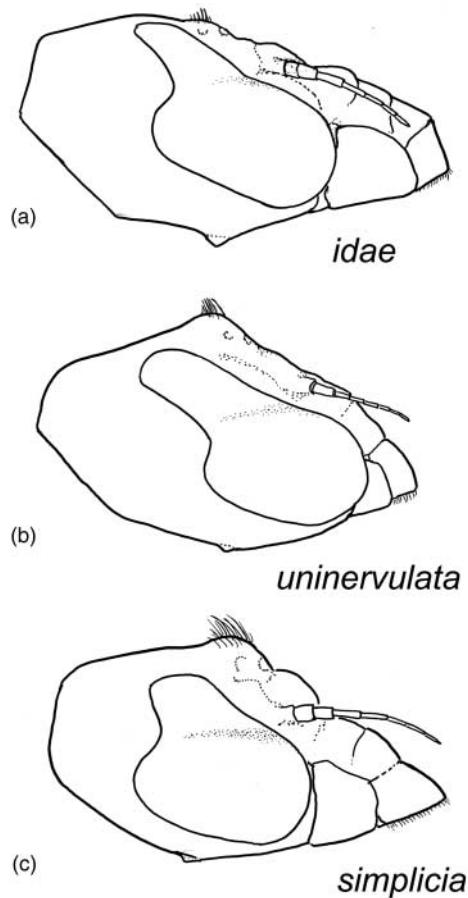


Figure 3. Profile of head, labium and maxillae removed, showing tuft on vertex: (a) *H. idae*; (b) *H. uninervulata*; (c) *H. simplicia* (redrawn from Butler & Orr, 2013).

Abdomen. Moderately high in profile, in section a somewhat flattened inverted catenary shape. Dorsal spines absent. In dorsal view fusiform. S5–10 with ventrolateral spines, longest on S7–8 (Figure 1).

Appendages (Figure 2g) long; epiproct 1.6 times length of S10, terminating bluntly; row of small spines along dorsum. Paraprocts slightly longer, turned slightly inwards apically and terminating in a sharp point; outer surface with scattering of small blunt spines especially along outer margin; overall with a few long fine setae and a sparse covering of fine short setae. Cerci relatively very long, almost reaching end of epiproct, slightly hooked inward toward the tip and terminating in a sharp point. Gonapophyses (Figure 2i) extend for full length of sternum 9 and overlap base of S10; outer gonapophyses extending beyond tips of inner gonapophyses, their inner margin with a subapical step.

Measurements (mm). Total length 39.0; head width 9.2; pronotum dorsal width 5.7; length of paraprocts 3.0.

Habitat

The larva was found in a pool formed by a fallen log in an upland forest stream. The pool was about 0.5 m deep, muddy and filled with leaf litter. The main stream from which the pool was

formed had a sandy, gravelly substrate. The surrounding vegetation was pristine, dense, tall and mossy dipterocarp forest.

Heliaeschna uninervulata

Following the description of the larva of this species (Orr & Ngiam, 2011) the larva of *H. simplicia* was discovered and described (Butler & Orr, 2013). *H. simplicia* presented an unusual character, a swelling on the top of the vertex incorporating the ocellar mound bearing a dense tuft of long, thick setae. The character is easily overlooked, and in one specimen the tuft was poorly developed or damaged, but this prompted us to re-examine material of *H. uninervulata*, specifically to check for this character.

Material examined

1 ♀ exuvia (reared), collected as F-4 larva, 14 July 2010, Singapore, forest pool at Chestnut streams within Central Catchment Nature Reserve, RWJN leg., emerged 12 September 2010. 1 ♂ exuvia (reared), collected as F-3 larva, 23 December 2010, Singapore, forest pool at Chestnut streams within Central Catchment Nature Reserve, RWJN leg., emerged 9 February 2011.

Head. Seen in profile upper side of head strongly raised, culminating in a slightly swollen summit immediately behind ocelli (Figure 3b). This area bears a tuft of long thick setae.

Discussion

In almost all characters the larva of *H. idae* bears a strong resemblance to that of *H. simplicia* and many of these characters are not shared with other *Heliaeschna* or *Gynacantha* species, with which they share a general similarity in habitus. Both species have lateral spines on abdominal S10 (lacking in *H. filostyla* and *H. uninervulata*); in both the anterior process of the supracoxal armature is distinctly smaller than the posterior process and separated by a V-shape (a condition approximately found also in *H. filostyla* but subequal and separated by a broad 'U' in *H. uninervulata*); in both the mandibles are exceptionally developed laterally forming an acute or nearly acute outer angle (the mandibles are much weaker and distally rounded in *H. uninervulata*). However the principal character which unites these two species is the form of the anterior margin of the prementum. The blade-like inner bilobate structure flanked on either side by a well-defined row of setae is of identical structure in both species, differing only in the relative widths of blade and row of setae with respect to the lobe which bears them. Such a structure is, to the best of our knowledge, unknown elsewhere in the Aeshnidae. It strongly suggests, along with other considerations, that *H. idae* and *H. simplicia*, and presumably *H. crassa*, are congeneric. Conversely these features suggest they are not congeneric with either *H. filostyla* described by Kawashima and Sasamoto (2007) or *H. uninervulata* described by Orr and Ngiam (2011).

The main differences between *H. idae* and *H. simplicia* are: the cerci are relatively much longer in *H. idae*; the shape of the supracoxal processes differs, especially the posterior process which is subquadrate in *H. idae* rather than triangular as in *H. simplicia*; seen dorsally the head is more robust in *H. idae* with the postocular lobes better developed; the mask is generally slightly more sturdy, with the fixed hooks on the labial palps blunter and heavier, with very much coarser serrations on their inner margin, suggestive of a different diet; the mandibles are quite similar in their outer profile, the outer angle being only a little more acute in *H. simplicia*, but the internal dentition is quite different, with *H. idae* having shorter incisor and molar processes, the latter being bifid rather than a single long spine as in *H. simplicia*. The most obvious difference between the two species is the presence in *H. simplicia* of a strongly elevated area of the vertex surmounted by

a tuft of long setae (Figure 3c). In *H. idae* this area is reduced to a low, slightly swollen convexity and bears only a modest tuft of short dark setae.

The presence of a tuft on the vertex of *H. uninervulata*, outwardly similar to that found in *H. simplicia*, raises a conundrum. With the possible exception of *H. filostyla*, all *Heliaeschna* larvae so far known have a general form similar to that commonly found in *Gynacantha*, which is consistent with the views of von Ellenrieder (2002), based on adult characters. In the case of *H. uninervulata* the form of the mask falls easily with the range of variation known in *Gynacantha* (Matsuki, 1986a, 1986b; Theischinger, 2002, 2007; C.Y. Choong, pers. comm.), as do other characters. On the other hand no *Gynacantha* has been recorded with a tuft of setae on the vertex. It might be argued that the character is easily overlooked, and indeed this is the case, but we are informed that a range of *Gynacantha* species in the collection of S.G. Butler bore no tuft (S.G. Butler, pers. comm.). On this evidence, we suggest that the tuft may represent a synapomorphy, confined to the Oriental *Heliaeschna* excepting *H. filostyla* (A. Sasamoto, pers. comm.), which is now believed to lie well outside the *Gynacantha*–*Heliaeschna* group (Kawashima & Sasamoto, 2007). Its very modest development in *H. idae* may indicate it is quite a labile character, and while it is strikingly similar in form in *H. simplicia* and *H. uninervulata*, the overall form of the head and mouthparts in these species is very different. In particular in *H. uninervulata* the labial palp bears five long, strong setae, a character shared, with variation in the number of setae, with all known *Gynacantha* and *Triacanthagyna* species as presented by Heckman (2006), as well as *Austrogynacantha heterogena* Tillyard (Theischinger, 2002). The securiform processes on the labial palps of *H. uninervulata* are also typical of *Gynacantha*.

Therefore on present knowledge we should consider two taxonomic scenarios. Conservatively, all African *Heliaeschna* plus *H. uninervulata* might be moved to *Gynacantha*. The remaining Oriental species would include two new genera (because the type species of *Heliaeschna* is the African *H. fuliginosa* Selys), one including *H. filostyla* and another with the remaining species, *H. bartelsi*, *H. crassa*, *H. idae* and *H. simplicia*. For this group the genus group name *Malayaeschna* Foerster is available (Foerster 1909) with generotype *H. simplicia*. A less conservative approach, and one which would reconcile the presence of a tuft of setae on its vertex, would be to erect a new genus for *H. uninervulata*, as suggested by Orr and Ngiam (2011). Obviously further light could be shed on this problem by DNA analysis, but as yet too little data is available to resolve the problem raised here by considerations of larval morphology.

Acknowledgements

We thank in particular Stephen Butler, who donated a specimen of *H. simplicia* larva for comparison and provided much helpful information and discussion, and Akihito Sasamoto and Gunther Theischinger for their critical comments and helpful suggestions on the manuscript. RJWN and RAD are grateful to the Sarawak Forest Department and Sarawak Forestry Corporation for granting permission to collect Odonata in Sarawak and to enter Usun Apau National Park. RJWN was funded by the National Parks Board, Singapore. Fieldwork in Usun Apau National Park was also supported by grants from The Mohamed bin Zayed Species Conservation Fund and the International Dragonfly Fund. RJWN and RAD owe special thanks to Luke Southwell and Yusof Tegong for their assistance with all aspects of the Usun Apau expedition, and to Graham Reels for his contribution.

References

- Butler, S.G., & Orr, A.G. (2013). The larva of *Heliaeschna simplicia* Karsch 1891 (Anisoptera: Aeshnidae). *Odonatologica*, 42, 151–156.
- Dijkstra, K.-D.B. (2005). Taxonomy and identification of the continental African *Gynacantha* and *Heliaeschna* species (Odonata: Aeshnidae). *International Journal of Odonatology*, 8, 1–32. doi: 10.1080/13887890.2005.9748240
- Foerster, F. (1909). Beiträge zu den Gattungen und Arten der Libellen. *Jahrbücher des Nassauischen Vereins für Naturkunde in Wiesbaden*, 62, 211–235.
- Heckman, C.W. (2006). *Encyclopedia of South American Aquatic Insects: Odonata – Anisopteras*. Dordrecht: Springer.

- Kawashima, I., & Sasamoto, A. (2007). Descriptions of the last two instar larvae of *Heliaeschna filostyla* Martin, 1906 (Anisoptera, Aeshnidae, Aeshninae) from Sulawesi Island, Indonesia. *Tombo, Matsumoto*, 49, 9–14.
- Matsuki, K. (1986a). Description of the possible larva of *Gynacantha hyalina* Selys from Taiwan (Odonata, Aeshnidae). *Gekkan-Mushi*, 182, 26–27. [In Japanese; English subtitle].
- Matsuki, K. (1986b). The larva of *Gynacantha hyalina* Selys from Taiwan (Odonata, Aeshnidae). *Gekkan-Mushi*, 189, 31. [In Japanese; English subtitle].
- Orr, A.G. (2003). *A guide to the dragonflies of Borneo – their identification and biology*. Natural History Publications, Kota Kinabalu.
- Orr, A.G., & Ngiam, R.W.J. (2011). A description of the larva of *Heliaeschna uninervulata* Martin (Odonata: Aeshnidae) from Singapore, with notes on its relationships. *International Journal of Odonatology*, 14, 163–169. doi: 10.1080/13887890.2011.575729
- Schorr, M., & Paulson, D. (2012). *World Odonata List* [Internet]. University of Puget Sound, WA. Retrieved from <http://www.pugetsound.edu/academics/academic-resources/slater-museum/biodiversity-resources/dragonflies/world-odonata-list/>
- Theischinger, G. (2002). *Preliminary keys for the identification of larvae of the Australian Petaluridae, Archipetaliidae, Austropetaliidae, Telephlebiidae and Aeshnidae (Odonata)*. Thurgoona, NSW: Cooperative Research Centre for Freshwater Ecology.
- Theischinger, G. (2007). The final instar larvae of *Gynacantha rosenbergi* Kaup and *Antipodogomphus proselythus* (Martin) (Odonata, Aeshnidae & Gomphidae). *Linzer biologische Beiträge*, 39, 1233–1237. Available from: http://www.landesmuseum.at/biophp/de/arti_det.php?litnr=25388&artin=59805
- von Ellenrieder, N. (2002). A phylogenetic analysis of the extant Aeshnidae (Odonata: Anisoptera). *Systematic Entomology*, 27, 437–467. doi: 10.1046/j.1365-3113.2002.00190.x