International Dragonfly Fund - Report
Journal of the International Dragonfly Fund

1- 25

Rory A. Dow & F.R. Stokvis

Odonata from Gunung Melatai and two other locations in Kapit Division, Sarawak, with a review of the genus Heliogomphus in Borneo, Peninsular Malaysia and Singapore

Published: 13.08.2018

122
The International Dragonfly Fund (IDF) is a scientific society founded in 1996 for the improvement of odonatological knowledge and the protection of species. Internet: http://www.dragonflyfund.org/

This series intends to publish studies promoted by IDF and to facilitate cost-efficient and rapid dissemination of odonatological data.

Editorial Work: Rory A. Dow, Milen Marinov and Martin Schorr
Layout: Martin Schorr
IDF-home page: Holger Hunger
Printing: Colour Connection GmbH, Frankfurt
Impressum: Publisher: International Dragonfly Fund e.V., Schulstr. 7B, 54314 Zerf, Germany. E-mail: oestlap@online.de
Responsible editor: Martin Schorr

Cover picture: Idionyx species cf yolanda
Photographer: Rory A. Dow
Odonata from Gunung Melatai and two other locations in Kapit Division, Sarawak, with a review of the genus Heliogomphus in Borneo, Peninsular Malaysia and Singapore

Rory A. Dow¹,² & Frank R. Stokvis¹

¹Naturalis Biodiversity Center, P.O. Box 9517, 2300 RA Leiden, The Netherlands
E-mail: rory.dow230@yahoo.co.uk
²Sarawak Museum Campus Project, Jabatan Muzium Sarawak, Jalan Barrack, 9300 Kuching, Sarawak, Malaysia

Abstract
Records of Odonata from Gunung Melatai, Nanga Gaat and the Kastima Logging area, all in Sarawak’s Kapit Division, are presented. The most notable records are of Matronoides cyaneipennis Förster, 1897 and Heliogomphus blandulus Lietinck, 1929. A distribution map for Matronoides cyaneipennis and updated distribution maps for three species from the Coeliccia borneensis-group are given. Tentative identifications to species of previously published records of Idionyx females are given. The genus Heliogomphus in Borneo, Peninsular Malaysia and Singapore is reviewed and a simple one marker molecular analysis is presented for the genus in this region. Based on re-examination of specimens from the genus and the molecular results, an additional member of the genus is reported from Borneo: H. sp. cf olivaceus Lietinck, 1961. Although both morphological and molecular results remain incomplete, it does appear likely that there is at least one more species of Heliogomphus present in Borneo than has been recognised until now, and that H. borneensis Lietinck, 1964 may be a junior synonym of H. kelantanensis (Laidlaw, 1902).

Key words: Odonata, Coeliccia borneensis-group, Heliogomphus, Idionyx, Matronoides, gene trees, COI.

Introduction
In September 2015 the first author made an IDF funded trip to Gunung Melatai (peak approximately 1880m a.s.l.), a mountain at the border between Sarawak and Indonesia, in Sarawak’s Kapit Division. Unfortunately the trip coincided with the 2015 El Niño event, and large fires burning in West Kalimantan created a severe haze in many parts of Sarawak. In the Gunung Melatai area the haze was so severe that visibility was down to 500m on most days and there was effectively no sunshine. Other factors contributed to this trip being probably the least successful that the first author has made in Sarawak with IDF funding. The vehicle broke down almost immediately on departure from Kapit Town, and the resulting delay led to a missed appointment at a gate in the Nanga Gaat area on the logging road leading to Gunung Melatai. This gate is normally locked and only opened by arrangement
with the timber company (WTK Holdings Berhad) which has the timber licences in the Gunung Melatai area, since this was during a public holiday, once the appointment was missed there was no one to open it for several days, leaving the party stranded in the Nanga Gaat area. The first author made the most of this delay by sampling in the Nanga Gaat area, and these results are also included here. Once the Melatai area was reached, it was discovered that the terrain was so steep and landslide prone that working there was extremely hazardous. Areas of as-yet unlogged forest were accessible via a narrow logging road driven across an extremely steep slope of the mountain, and at the end of another logging road almost at the border, but even in the uncut forest there were signs of landslides everywhere and it was evident that most of the streams we sampled had been seriously affected by landslides in the not-too-distant past. The furthest and highest parts of the logging road on Melatai had to be judged too dangerous to use after the vehicle was almost hit by a landslide, which would have pushed it into the ravine below. Attempts to reach higher altitudes in the uncut areas by walking up ridges (the normal method) were thwarted on every occasion because parts of the ridge were encountered that had collapsed during landslides and were still too unstable to traverse. These factors limited the sampling that could be conducted and the altitude that that could be reached, and the lack of sunlight undoubtedly reduced the number and variety of odonates flying. There were also many frustrating sightings of interesting looking Anisoptera, including *Chlorogomphus*, which stubbornly refused to be caught.

We have also included records from another part of Kapit Division, the Kastima logging area in Belaga district, made during a short survey as part of a High Conservation Value Forest (HCVF) assessment in 2016. Fig. 1 shows the positions in Sarawak of all of the areas reported on here.

---

**Figure 1.** Positions of the sampled areas in Sarawak. Base image from Google Earth.
This paper is divided into two parts. The first part deals with the results of the surveys outlined above. One of the most significant finds during the Gunung Melatai trip was a mature male of the poorly known *Heliogomphus blandulus* Lieftinck, 1929. This find, re-examination of specimens in the collection of the first author and some in the Naturalis Biodiversity Center, and interesting but as-yet inadequate molecular results for the genus suggested to us that a brief review of the genus might be useful. In the second part of the paper we give such review, summarising available knowledge of *Heliogomphus* in Borneo, Peninsular Malaysia and Singapore and present COI gene trees for the genus in this region.

**Part I: Species collected at Gunung Melatai, Nanga Gaat and the Kastima Logging area**

**Locations**

Nanga Gaat locations:

1. Streams in disturbed forest: (a) ca 113-150m 1.7352N, 113.3384E; (b) ca 243m, 1.7472N, 113.3487E; (c) ca 310m, 1.7412N, 113.3846E.

2. A pond by a logging road, ca 148m, 1.7398N, 113.3402E.

3. By logging roads etc.

![Map of Gunung Melatai area](image)

**Figure 2. Sampling sites in the Gunung Melatai area. Base image from Google Earth.**

Gunung Melatai Locations (Fig. 2 shows the Gunung Melatai locations in more detail):

4. Stream at camp site, logged forest, ca 630-680m, 1.3211N, 113.6733E.

5. Stream down road from camp, logged forest, ca 396-418m, 1.3328N, 113.6909E.

6. Small streams near camp, logged forest, ca 600m, 1.3181N, 113.6716E.
7. Stream system crossing road at ca 900m, sampled to ca 1050m, unlogged forest but heavily disturbed by past landslides around the stream, 1.3095N, 113.6316E.
8. Stream system crossing road at ca 1000m, sampled to ca 1350m, unlogged forest, disturbed by landslides, 1.3058N, 113.6182E.
9. Other stream systems crossing the road above 1000m, unlogged forest, but only sampled near road due to extreme steepness.
10. Streams in unlogged forest very near border with Kalimantan, ca 1200m, 1.2643N, 113.6034E.
11. Pools on and beside old logging tracks, by logging road etc.

Fig. 3. Sampling sites in the Kastima logging area. Base image from Google Earth.

Kastima Logging area locations (Fig. 3 shows the Kastima locations in more detail):
12. Sungai Kayan and tributaries, disturbed forest, ca 180-270m, 2.838N, 113.8327E.
13. Sungai Pesun and tributaries, disturbed forest, ca 160-200m, 2.8712N, 113.7856E.
14. Stream on steep hill, disturbed forest, ca 450-550m, 2.8541N, 113.8184E.
15. Ponds etc., at the logging camp and besides logging roads, coordinates at camp, 2.8347N, 113.7464E.

List of species
Frequently occurring collectors names are abbreviated as follows (anak abbreviated as ak): MB - Manau ak Budi, RD - R.A. Dow, LS - Luke Southwell.
**Odonata from Gunung Melatai with a review of the genus Heliogomphus in Borneo**

**Zygoptera**

**Platystictidae**

*Drepanosticta acteaon* Laidlaw, 1934  
Material listed in Dow (2017), locations 7, 8, 14.

*Drepanosticta attala* Lieftinck, 1934  
12 – ♂, 21.vi.2016, RD.

*Drepanosticta species cf crenitis* Lieftinck, 1933  

*Drepanosticta dulitensis* Kimmins, 1936  

*Drepanosticta rufostigma* (Selys, 1886)  
Material listed in Dow (2017); locations 1a, 1b, 1c, 5, 8, 12, 13, 14.

*Drepanosticta versicolor* Laidlaw, 1913  

*Telosticta longigaster* Dow & Orr, 2012  

---

**Fig. 4.** Known distribution of *Matronoides cyaneipennis*. Red square: Gunung Melatai record; yellow circles: other records. Map made using DIVA-GIS.
**Calopterygidae**

*Matronoides cyaneipennis* Förster, 1897

A population found on Gunung Melatai is the most southern yet found of this species. Fig. 4 shows the known distribution of *M. cyaneipennis*, note that some of the data used to create this map has not yet been published.


*Neurobasis longipes* Hagen, 1887


*Vestalis amaryllis* Lieftinck, 1965

6 – ♀, 13.ix.2015, RD.

*Vestalis amnicola* Lieftinck, 1965


*Vestalis amoena* Hagen in Selys, 1853


*Vestalis atropha* Lieftinck, 1965


*Vestalis beryllae* Laidlaw, 1915


**Chlorocyphidae**

*Helicypha biseriata* (Selys, 1859)


*Rhinocypha aurofulgens* Laidlaw, 1931


*Rhinocypha spinifer* Laidlaw, 1931

8 – ♀♂, 12.ix.2015, MB.

*Rhinocypha species* cf *spinifer* Laidlaw, 1931

1c – ♀♂, 6.ix.2015, RD.

**Devadattidae**

*Devadatta aran* Dow, Hämäläinen & Stokvis, 2015

Devadatta clavicauda Dow, Hämäläinen & Stokvis, 2015

6 – ♂, 13.ix.2015, RD.

Devadatta somoh Dow, Hämäläinen & Stokvis, 2015


**Euphaeidae**

*Euphaea impar* Selys, 1859


*Euphaea subcostalis* Selys, 1873


*Euphaea subnodalis* (Laidlaw, 1915)

4 – 5 ♂♂♂, 10.ix.2015, RD. 5 – 2 ♂♂♂, 13.ix.2015, MB.

**Philosinidae**

*Rhinagrion borneense* (Selys, 1886)

12 – ♂, 21.vi.2016, RD.

**Platycnemididae**

Dow (2010) includes distribution maps of *Coeliccia borneensis*-group species; these have become out-dated. Up-to-date distribution maps for the *C. borneensis*-group species listed in this paper are given here; note that some of the data used to create these maps have not yet been published.

*Coeliccia borneensis* (Selys, 1866)

The currently known distribution of this species or complex of species is shown in Fig. 5.


*Coeliccia campioni* Laidlaw, 1918

The currently known distribution of this species is shown in Fig. 6.


*Coeliccia cyaneothorax* Kimmins, 1936


*Coeliccia kenyah* Dow, 2010

The currently known distribution of this species is shown in Fig. 6.

14 – 6 ♂♂♂, 23.vi.2016, RD.
Fig. 5. Known distribution of *Coeliccia borneensis*. Map made using DIVA-GIS.

Fig. 6. Known distributions of *Coeliccia campioni* (yellow square) and *C. kenyah* (red circle). Map made using DIVA-GIS.
Coeliccia nigrohamata Laidlaw, 1918
Coeliccia species cf nemoricola Laidlaw, 1912
7 – ♀, 8.ix.2015, RD. 8 – ♂, 11.ix.2015, RD; ♂, 12.ix.2015, RD.

Prodasineura dorsalis (Selys, 1860)
13 – ♂, 22.vi.2016, RD.

Prodasineura herytra (Selys, 1886)
13 – ♂, 22.vi.2016, RD.

Prodasineura verticalis (Selys, 1860)

Coenagrionidae

Agriocnemis femina (Brauer, 1868)
15 – ♂, 21.vi.2016, RD.

Argiocnemis species
2 – ♂, 5.ix.2015, RD.

Ceriagrion bellona Laidlaw, 1915

Ceriagrion cerinorubellum (Brauer, 1865)
15 – ♂, 23.vi.2016, RD.

Pseudagrion microcephalum (Rambur, 1842)
15 – 2 ♂♂, 23.vi.2016, RD.

Pseudagrion perfuscatum Lieftinck, 1937

Stenagrion dubium (Laidlaw, 1912)

Xiphiagrion cyanomelas (Selys, 1876)
15 – ♂+♀, 21.vi.2016, RD.

Anisoptera
Aeshnidae

Gynacantha species
12 – ♀, 21.vi.2016, RD.
Indaeschna grubaueri (Förster, 1904)
11 – ♀, 13.ix.2015, RD.
Tetracanthagyna species
1b – ♀, 5.ix.2015, MB.

Gomphidae
Heliogomphus blandulus Liefstink, 1929
There are few records of this species, see part II of this paper.
5 – ♀, 10.ix.2015, MB & LS.
Ictinogomphus decoratus melaenops (Selys, 1858)
2 – ♀, 5.ix.2015, RD.
Leptogomphus williamsoni Laidlaw, 1912
Material listed in Dow, Stokvis & Ngiam (2017). Location 1b.

Macromiidae
Macromia westwoodii Selys, 1874
9 – 3 ♀♂, 12.ix.2015, LS.

Synthemistidae
Identification of the females of the three Idionyx species known from Borneo is problematic. The only significant differences apart from size and extent and degree of tinting of the wings (both of which will be variable within species) between female specimens appear to be in the markings of the metepimeron. Until now the first author has been hesitant to identify the females of this genus based on the markings of the metepimeron. However after examining long series of both sexes, differences in the markings of this part of the synthora appear consistent in males. No intermediate forms have been found in the females examined and, assuming that the markings are consistent between the sexes, it does seem that this is likely to be a simple and reliable method to distinguish at least one of the species from the others (see below) and tentatively to distinguish the others as well. Revised identifications of previously published female Idionyx records are given in Table 1.
Idionyx ♀montana Karsch, 1891
A female Idionyx from location 1c is tentatively assigned to I. montana on the basis of similarity of the marking of the metepimeron to males of that species.
1c – ♀, 6.ix.2015, RD.
Idionyx species cf yolanda Selys, 1871
Another female Idionyx from location 1c can be associated with the unnamed species referred to as Idionyx species cf selysi in various publications (Dow & Reels 2009, Dow & Reels 2010, Dow 2012b, Dow, Reels & Butler 2013a, 2013b, Dow, Reels & Ngiam 2015a) by the yellow marking on the metepimeron divided into two (in agreement with the male) instead of one continuous mark in males of the
<table>
<thead>
<tr>
<th>New ID</th>
<th>Previous ID</th>
<th>Location</th>
<th>Date of collection</th>
<th>Publication</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Idionyx species</em></td>
<td></td>
<td>Ulu Balui</td>
<td>17.vi.2013</td>
<td>Dow &amp; Ngiam 2014</td>
</tr>
<tr>
<td><em>Idionyx species</em></td>
<td></td>
<td>Sg Kohei area, Ulu Balui</td>
<td>6.ix.2013</td>
<td>Dow &amp; Ngiam 2014</td>
</tr>
<tr>
<td><em>Idionyx species</em></td>
<td></td>
<td>Borneo Highlands</td>
<td>17.vii.2015</td>
<td>Dow, Butler &amp; Reels 2016</td>
</tr>
<tr>
<td><em>Idionyx sp</em></td>
<td></td>
<td>Ulu Mujak</td>
<td>21.viii.2016 (one of two females from this location and date)</td>
<td>Dow et al. 2018</td>
</tr>
<tr>
<td><em>Idionyx sp</em></td>
<td></td>
<td>LEWS: Nanga Bloh</td>
<td>1.xi.2011, 6.xi.2017</td>
<td>Dow et al. 2018</td>
</tr>
<tr>
<td><em>Idionyx ? yolanda</em></td>
<td><em>Idionyx species</em></td>
<td>Usun Apau</td>
<td>2.v.2012</td>
<td>Dow, Reels &amp; Ngiam 2015b</td>
</tr>
<tr>
<td><em>Idionyx sp.</em></td>
<td></td>
<td>Ulu Mujak</td>
<td>2.viii.2015, 3.vii.2015, 21.viii.2016 (one of two females from this location and date)</td>
<td>Dow et al. 2018</td>
</tr>
<tr>
<td><em>Idionyx species of yolanda</em></td>
<td><em>Idionyx species</em></td>
<td>Gn Mulu NP</td>
<td>2005-2006</td>
<td>Dow &amp; Reels 2008</td>
</tr>
<tr>
<td><em>Idionyx new species</em></td>
<td><em>Idionyx species</em></td>
<td>Hose Mountains</td>
<td>15.iv.2011</td>
<td>Dow &amp; Ngiam 2012</td>
</tr>
<tr>
<td><em>Idionyx species</em></td>
<td></td>
<td>Sg Kohei area, Ulu Balui</td>
<td>16.vi.2013</td>
<td>Dow &amp; Ngiam 2014 (one of two listed from this date, other currently unavailable)</td>
</tr>
</tbody>
</table>

Other species known to occur in Borneo (at least in examples available to the first author for examination). Fig. 7 shows a female specimen. Males of this species have been compared with the type of *I. selysi* (in the Natural History Museum, London) and are clearly distinct from it. In fact they are more closely related to
I. yolanda, but differ from it in details of the anal appendages, accessory genitalia, synthorax markings and some other features, as well as in the possession of a large spine on the dorsum of $10. Given the closer relationship with I. yo-

Fig. 7: Supposed female of Idionyx species cf yolanda (photo of a specimen from Kubah National Park).

I. yolanda we have dropped the label cf selysi for this species and list it as Idionyx species cf yolanda until it is described. Note that I. selysi is incorrectly listed as a synonym of I. yolanda, a species from which it differs in many respects, in the Catalogue of Life (http://www.catalogueoflife.org/col/search/scientific/; accessed 17.vi.2018). 1c – ♀, 6.ix.2015, RD.

Libellulidae

Brachydiplax chalybea Brauer, 1868

15 – ♂, 21.vi.2016, RD.

Cratilla metallica (Brauer, 1878)

8 – ♂, 14.ix.2015, RD. 11 – 2 ♀, 13.ix.2015, RD.
Lyriothemis biappendiculata (Selys, 1878)

Lyriothemis cleis Brauer, 1868
   1c – ♂, 6.ix.2015, RD. 11 – ♂, 13.ix.2015, RD.

Nannophya pygmaea Rambur, 1842
   6 – 2 ♂♀, 13.ix.2015, MB.

Neurothemis fluctuans (Fabricius, 1793)

Orchithemis pulcherrima Brauer, 1878
   15 – ♀, 21.vi.2016, RD.

Orthetrum chrysis (Selys, 1891)

Orthetrum glaucum (Brauer, 1865)

Orthetrum pruinosem schneideri Förster, 1903

Orthetrum testaceum (Burmeister, 1839)

Pantala flavescens (Fabricius, 1798)
   15 – ♂, 22.vi.2016, RD.

Rhyothemis triangularis Kirby, 1889
   2 – ♂, 5.ix.2015, RD.

Tholymis tillarga (Fabricius, 1798)
   15 – ♂, 21.vi.2016, RD.

Trithemis aurora (Burmeister, 1839)

Trithemis festiva (Rambur, 1842)

Tyriobapta forrda Kirby, 1889

Urothemis signata insignata (Selys, 1872)
   15 – ♂, 23.vi.2016, RD.

Zygonyx ida errans Lieftinck, 1953
Part II: *Heliogomphus* in Borneo, Peninsular Malaysia and Singapore

Introduction

Adults of *Heliogomphus* are amongst the most elusive of the Gomphidae in Borneo and Peninsular Malaysia. Most records of the genus are of larvae or teneral individuals and most of the fully mature examples that have been collected are female; mature male specimens are very rarely collected. Small, but intriguing differences between some of the few available specimens and the named species from the genus, and the limited molecular data available suggests that there might be at least one more species. Here we review the genus in Borneo, Singapore and Peninsular Malaysia, and present COI gene trees for the genus in the region.

Review of records

Three named species of *Heliogomphus* have been recorded from Borneo, Singapore and Peninsular Malaysia: *Heliogomphus blandulus* Lieftinck, 1929, *H. borneensis* Lieftinck, 1964 and *H. kelantanensis* (Laidlaw, 1902). *Heliogomphus kelantanensis* was the first of these to be described (Laidlaw 1902a), as *Gomphus consobrinus*, a preoccupied name changed to *G. kelantanensis* in Laidlaw (1902b: foot note on page 382). It was then treated as a *Leptogomphus* (Williamson 1907, Laidlaw 1914, 1922). Later Laidlaw (1925) transferred the species to *Heliogomphus*, a genus erected in Laidlaw (1922). The species was described from a mature male from Kuala Aring in Kelantan; a teneral female from the same location is also listed in Laidlaw (1902a) but this was “too much withered to describe.” Later records of the species are few and far between, and in some cases possibly suspect. Lieftinck (1933) described the supposed larva from an exuvia collected with a freshly emerged female; however given that the female of the species had not been described the identification might be considered insecure in this case. Furtado (1969) recorded the species based on exuviae from Sungai Gombak in Selangor; again it cannot be considered certain that this record really refers to *H. kelantanensis*. Norma-Rashid (2009) lists the species from Kenaboi Forest Reserve in Negeri Sembilan without details or further comment. All other records of the genus from Peninsular Malaysia that we are aware of are of females (Vick 1993) or larvae (Che Salmah et al. 2005) not assigned to a species. *Heliogomphus kelantanensis* has also been recorded from Singapore, firstly by Murphy (1997) at Nee Soon Swamp Forest. More recently a female was collected on Pulau Ubin (Ngiam & Cheong 2016). The anal appendages of male *H. kelantanensis* are not typical of the genus; the superior appendages are not lyrate in form, unlike those of most species.

The first species of the genus recorded from Borneo was *H. blandulus*, described from Sungai Bika in the basin of the Kapuas River in West Kalimantan (Lieftinck 1929, Laidlaw 1931). *Heliogomphus blandulus* has typical male anal appendages for the genus. Later Dow & Ngiam (2012) recorded a teneral male from the Hose Mountains in Sarawak and then (Dow & Ngiam 2014) a male and the supposed female from Ulu Balui, also in Sarawak. The only other definite published record is that in this publication, Luke et al. 2017 recorded *Heliogomphus cf* blandulus from the south-east of Sabah; it has not yet been possible to re-examine this specimen.
The second species described from Borneo was *H. borneensis*, from both sexes from locations in East Kalimantan (Lief tinck 1964). This species was noted to be very similar to *H. kelantanensis* but differed in small details of the male anal appendages: “Very near *H. kelantanensis* (Laidlaw), but differ ing slightly in the shape of the anal appendages and in details of coloration” (Lief tinck: 1964: 90). The differences apparent between males of the two species in Lief tinck (1964: Figs 1–4) are indeed very slight and could easily be merely intraspecific variation. Later the species was recorded from Gunung Mulu National Park in Sarawak (Dow & Reels 2008), the Maliau Basin in Sabah (Ng et al. 2008), the Hose Mountains (Dow & Ngiam 2012) and the Samunsam Wildlife Sanctuary in Sarawak (Dow 2016); it has also been recorded from a location in Bintulu Division, Sarawak (Dow et al. in preparation). Dow (2012a) recorded *Heliogomphus borneensis* from Gunung Penrissen in Sarawak based on teneral males and females and Dow et al. (2018) recorded possible teneral specimens from the Lanjak Entimau Wildlife Sanctuary in Sarawak. The first author has a specimen from Mount Matang in Kuching Division. Additionally a teneral female from the Tunoh area of Kapit Division, listed as *H.* species in Dow & Ngiam (2015a: 27, collected 18.vi.2013), is a good match in its markings to *H. borneensis* and is listed as *H. borneensis* cf in the molecular analyses below.

A male of a species similar to, but different from *H. blandulus* was collected at Gunung Mulu National Park in 2007. Re-examination of this specimen has revealed that it is close but possibly not identical to *H. olivaceus* Lief tinck, 1961, described from Busuanga Island in the Palawan region of the Philippines (Lief tinck 1961) and later also reported from Palawan itself (Asahina 1980). This brings the number of *Heliogomphus* species known from Borneo to three. The teneral male from the Ulu Mujok area of the Lanjak Entimau Wildlife Sanctuary, listed as *Heliogomphus* cf *blandulus* in Dow et al. (2018), is re-identified here as *H.* cf *olivaceus*. Additionally two females (and a larva) have been matched to this species using DNA (see the next section), and another two females have been matched to these in turn, based on morphological similarity. One of these females (from Kubah National Park) was reported in Dow, Reels & Butler 2013b as *Heliogomphus* species. The other female is also from Gunung Mulu National Park, while the larva is from the Nanga Bloh area of the Lanjak Entimau Wildlife Sanctuary. These locations are spread across Sarawak, so the species is clearly widely distributed in the state. The female of this species has no significant horns, tubercles or ridges on the vertex behind or between the ocelli or on the occiput, and has a very constant ratio of width of occiput (measured at the narrowest point) to the total width of the head at the same point: 0.23. The lack of ornamentation on the dorsum of the head is unique among females from Borneo examined and the occiput is narrower than in any other females examined whose condition allowed this measurement to be made. The female of *H. olivaceus* from the Philippines has not been described and there are some differences between males from Sarawak and, judging from the published descriptions and illustrations, those from the Palawan region. For these reasons it is not certain that the species from Sarawak is the same as that in the Philippines.

A number of female specimens from south-western Sarawak in the first author’s collection (from the Matang Range, Gunung Gading and Gunung Penrissen), provisionally
associated with *H. borneensis*, possess a pair of widely spaced horns on the vertex behind the ocelli, while the occiput is particularly wide. The ratio of width of occiput (measured at the narrowest point) to the total width of the head at the same point is 0.26-0.29. Horns have not been found on the occiput of any females from other parts of Sarawak examined by the first author and are not mentioned in the description of the female of *H. borneensis* in Lieftinck (1964). However the only mature male with non-lyrate superior anal appendages available from south-western Sarawak (that from Mount Matang mentioned above) is in good agreement with male *H. borneensis*.


A number of other *Heliogomphus* species are known from adjacent regions: *H. drescheri* Lieftinck, 1929 from Java and Sumatra, *H. gracilis* (Krüger, 1899) from Sumatra, *H. bakeri* Laidlaw, 1925 and, as already mentioned, *H. olivaceus* Lieftinck, 1961 from the Philippines. The widespread *H. selysi* (Fraser, 1925) has been recorded from Thailand; another species known from Thailand that has been placed in *Heliogomphus* has very recently been shown (Makbun & Fleck 2018) to belong in *Microgomphus*: *M. svihleri* (Asahina, 1970). All of these *Heliogomphus* species have the typical lyrate male superior anal appendages.

**Molecular analyses**

The dataset used here includes 29 *Heliogomphus* specimens (adult and larval) from Peninsular Malaysia, Sarawak and Brunei (see Table 2) as well as from other areas (Table 3). The mitochondrial marker COI was amplified from these samples and the gene trees resulting from the neighbour joining, Maximum Likelihood (ML) and Bayesian Inference (BI) of these sequences, plus others from outside of Borneo, are shown in Figs. 8-9.

**Methods**

**DNA extraction and amplification.** Genomic DNA was extracted from legs, using a NucleoMag 96 Tissue kit (Macherey-Nagel GmbH & Co.) on a KingFisher Flex magnetic particle processor (Thermo Scientific). A volume of 150 μl was used for elution. A 658 bp fragment of the mtDNA cytochrome c oxidase I (COI) gene was amplified using primer combinations provided in Table 4. 25 μl of PCR reaction mix contained 5 μl of 5x Phire II Reaction Buffer (ThermoFisher), 1 μl of each primer (10 μM), 0.5 μl of Phire Hot Start II DNA Polymerase (ThermoFisher), 0.5 μl of dNTPs and 1 μl of DNA template. The amplification protocol consisted of 30 sec at 98°C followed by 40 cycles of 5 s at 98°C, 5 s at 50°C and 15 s at 72°C, and a final 5 min at 72°C.
# Odonata from Gunung Melatai with a review of the genus *Heliogomphus* in Borneo

Table 2: Collection codes and BOLD Process IDs for *Heliogomphus* specimens used for molecular analysis, and including the *Microgomphus* outgroup. Specimens listed are from Brunei and Malaysia, the state, and approximate location are listed for each specimen. Male is indicated by m, female by f and larva by l. The collection codes can be used to locate the COI sequences on the BOLD website, and also appear as BOLD Sample IDs there.

<table>
<thead>
<tr>
<th>Species</th>
<th>RMNH number</th>
<th>Sex/stage</th>
<th>Country/Province</th>
<th>Location &amp; date</th>
<th>BOLD process ID</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Heliogomphus blandulus</em></td>
<td>RMNH:INS:500718</td>
<td>m</td>
<td>Brunei, Temburong</td>
<td>Kuala Belalong Field Studies Centre (KBFSC), 19.xi.2004</td>
<td>ODOBFP083-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:509658</td>
<td>m</td>
<td>Malaysia, Sarawak</td>
<td>Sungai Kahai, 16.vi.2013</td>
<td>ODOBFP112-16</td>
</tr>
<tr>
<td><em>Heliogomphus oli-vaceus cf</em></td>
<td>RMNH:INS:228970</td>
<td>m</td>
<td>Malaysia, Sarawak</td>
<td>Gunung Mulu National Park, 30.xi.2012</td>
<td>ODOBFP7463-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:500028</td>
<td>f</td>
<td>Malaysia, Sarawak</td>
<td>Gunung Mulu National Park, 11.Ix.2008</td>
<td>ODOBFP7703-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:506899</td>
<td>f</td>
<td>Malaysia, Sarawak</td>
<td>Kubah National Park, 3.Ix.2012</td>
<td>ODOBFP5240-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:557693</td>
<td>l</td>
<td>Malaysia, Sarawak</td>
<td>Lanjak Entimau Wildlife Sanctuary, Nanga Blih, 23.vi.2013</td>
<td>ODOBFP4721-16</td>
</tr>
<tr>
<td><em>Heliogomphus borneensis cf</em></td>
<td>RMNH:INS:509663</td>
<td>f</td>
<td>Malaysia, Sarawak</td>
<td>Between the Haze Mountains and Kapit town, 18.vi.2013</td>
<td>ODOBFP7117-16</td>
</tr>
<tr>
<td><em>Heliogomphus kianfanensis cf</em></td>
<td>RMNH:INS:505762</td>
<td>f</td>
<td>Malaysia, Johor</td>
<td>Pantai Forest Reserve, 25.iv.2009</td>
<td>ODOBFP3344-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:506333</td>
<td>f</td>
<td>Malaysia, Sarawak</td>
<td>Usun Apau National Park, 24.IV.2012</td>
<td>ODOBFP3750-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:506348</td>
<td>f</td>
<td>Malaysia, Sarawak</td>
<td>Usun Apau National Park, 3.v.2012</td>
<td>ODOBFP3764-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:506352</td>
<td>m</td>
<td>Malaysia, Sarawak</td>
<td>Usun Apau National Park, 1.v.2012</td>
<td>ODOBFP3768-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:506819</td>
<td>f</td>
<td>Malaysia, Sarawak</td>
<td>Gunung Pentissen, 24.vii.2012</td>
<td>ODOBFP5165-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:509693</td>
<td>l</td>
<td>Malaysia, Sarawak</td>
<td>Kubah National Park, 1.vi.2013</td>
<td>ODOBFP4201-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:557692</td>
<td>l</td>
<td>Malaysia, Sarawak</td>
<td>Lanjak Entimau Wildlife Sanctuary, Nanga Blih, 23.vili.2013</td>
<td>ODOBFP4720-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:557696</td>
<td>l</td>
<td>Malaysia, Sarawak</td>
<td>Lanjak Entimau Wildlife Sanctuary, Nanga Blih, 25.vili.2013</td>
<td>ODOBFP4724-16</td>
</tr>
<tr>
<td></td>
<td>RMNH:INS:557864</td>
<td>l</td>
<td>Brunei, Beaufort</td>
<td>Sungai Ingel, 24.II.2014</td>
<td>ODOBFP4888-16</td>
</tr>
</tbody>
</table>
Table 3: Collection codes and BOLD Process IDs for *Heliogomphus* specimens used for molecular analysis. Specimens listed are from outside of Borneo and Malaysia, the country and island or province are listed for each specimen. Male is indicated by m, female by f and larva by l. The collection codes can be used to locate the COI sequences on the BOLD website, and also appear as BOLD Sample IDs there.

<table>
<thead>
<tr>
<th>Species</th>
<th>RMNH number</th>
<th>Sex/ stage</th>
<th>Country/ Province/ Island</th>
<th>Location &amp; date</th>
<th>BOLD process ID</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Heliogomphus bakeri</em></td>
<td>RMNH.JS.509409</td>
<td>f</td>
<td>The Philippines, Dinagat</td>
<td>Paragguay, 23.III.2013</td>
<td>ODOBSP6869-16</td>
</tr>
<tr>
<td></td>
<td>RMNH.JS.509444</td>
<td>m</td>
<td>The Philippines, Mindanao</td>
<td>Between Trento and Bisib, 25.III.2013</td>
<td>ODOBSP6904-16</td>
</tr>
<tr>
<td></td>
<td>RMNH.JS.509474</td>
<td>m</td>
<td>The Philippines, Mindanao</td>
<td>Near Tinuy-An Falls, 26.III.2013</td>
<td>ODOBSP6933-16</td>
</tr>
<tr>
<td></td>
<td>RMNH.JS.509479</td>
<td>f</td>
<td>The Philippines, Mindanao</td>
<td>Near Tinuy-An Falls, 26.III.2013</td>
<td>ODOBSP6938-16</td>
</tr>
<tr>
<td></td>
<td>RMNH.JS.509485</td>
<td>m</td>
<td>The Philippines, Mindanao</td>
<td>Near Tinuy-An Falls, 26.III.2013</td>
<td>ODOBSP6944-16</td>
</tr>
<tr>
<td><em>Heliogomphus scorpio</em></td>
<td>RMNH.JS.506477</td>
<td>m</td>
<td>China, Hong Kong</td>
<td>Sha Lo Tung, 30.v.2012</td>
<td>ODOBSP3887-16</td>
</tr>
<tr>
<td></td>
<td>RMNH.JS.506482</td>
<td>m</td>
<td>China, Hong Kong</td>
<td>Sha Lo Tung, 30.v.2012</td>
<td>ODOBSP3892-16</td>
</tr>
<tr>
<td><em>Heliogomphus sp.</em></td>
<td>RMNH.JS.228375</td>
<td>I</td>
<td>Vietnam, Dak Lak</td>
<td>Chu Yang Sin National Park, 3.vi.2007</td>
<td>ODOBSP7304-16</td>
</tr>
<tr>
<td></td>
<td>RMNH.JS.228575</td>
<td>I</td>
<td>Vietnam, Dak Lak</td>
<td>Chu Yang Sin National Park, 10.vi.2007</td>
<td>ODOBSP7326-16</td>
</tr>
<tr>
<td></td>
<td>RMNH.JS.228582</td>
<td>I</td>
<td>Vietnam, Dak Lak</td>
<td>Chu Yang Sin National Park, 10.vi.2007</td>
<td>ODOBSP7333-16</td>
</tr>
</tbody>
</table>

Bi-directional Sanger sequencing was performed at Macrogen Europe and at BaseClear, Leiden, The Netherlands. Sequences were edited with Sequencher 4.10.1 (Gene Codes Corporation) and checked for stop-codons in Geneious 8.1.8 (Kearse et al. 2012). All sequence data and additional geographic and ecological data as well as photographs of the specimens were uploaded to the Barcode of Life Data System (BOLD: Ratnasingham & Hebert 2007).

**Phylogenetic and neighbour joining analyses.** Multiple sequence alignments were performed using MAFFT 7 (Katoh et al. 2009) under default parameters. The neighbour joining analysis was performed in Geneious 8.1.8 (Kearse et al. 2012) using the uncorrected p-distance model. Partitioning, Maximum likelihood (ML) and Bayesian inference (BI) were performed on the Naturalis OpenStack computing cloud, using the PhyloStack.
Fig. 8. Neighbour joining COI gene tree for *Heliogomphus* taxa. RMNH collection codes are shown for each specimen, as well as the sex of the specimen (Male is indicated by m, female by f and larva by l) and an indication of where it was collected; the reader is also referred to Tables 2 and 3.

pipeline (Doorenweerd 2016). Alignments of different markers were concatenated using VoSeq 1.7.4. (Peña & Malm 2012). Optimal partitioning of the three codon positions of COI was performed with PartitionFinder 2 (Lanfear et al. 2012), using RAxML 8 (Stamatakis 2014) with the GTR substitution model, BIC model selection, rcluster scheme and a minimum subset size of 300 bp. ML analyses were run with RAxML using the GTRCAT model. The best Maximum Likelihood tree was calculated using the –D parameter. A multiparametric bootstrap search was performed, which automatically stopped based on the extended majority rule criterion. The Bayesian inference was performed with ExaBayes 1.5 (Aberer et al. 2014) using the GTR substitution model. Four independent runs with four Monte Carlo Markov Chains each, were run for 1,000,000 generations during which convergence, with a standard deviation of split frequencies < 2 %, had been reached. The effective sample size was
Fig. 9. COI gene tree for *Heliogomphus* taxa from Maximum Likelihood (ML) and Bayesian Inference (BI). The best ML tree is shown, with posterior probabilities from the BI analysis also depicted on the branches. Bootstrap values and posterior probabilities are shown if less than 100 or 1.0 respectively. RMNH collection codes are shown for each specimen, as well as the sex (Male is indicated by m, female by f and larva by l) of the specimen and an indication of where it was collected; the reader is also referred to Tables 2 and 3.
confirmed using Tracer 1.6.0 (Rambaut et al. 2014). Bootstrap supports and posterior probabilities were depicted on the branches of the best ML tree using P4 (Foster 2004). The trees resulting from the neighbour joining and phylogenetic analyses were all rooted with the same taxon as outgroup: a species of Microgosphus. The resulting trees were visualised in FigTree 1.4.3 (Rambaut 2014).

Results
The neighbour joining tree (Fig. 8) shows wide separations even between some samples considered to belong to the same species, for instance H. blandulus and H. bakeri. If one accepts (which we do not) the idea that a three percent (or some similar, arbitrarily chosen, value) difference between COI sequences indicates distinct species, then this gene tree suggests that at least six species of Heliogomphus are present in Sarawak and Brunei and that the Philippine H. bakeri is composed of two separate species. However we suspect that at least some of the differences seen in this gene tree are merely the combined result of large variability in COI within species in this group plus insufficient samples included, e.g. with more samples, especially from intermediate locations, some of the apparent differences would become blurred.

The gene tree produced using phylogenetic methods (Fig. 9) tells a somewhat different story, although the basic groupings are preserved. The two H. blandulus samples cluster together, albeit with low support. Heliogomphus species cf olivaceus from Gunung Mulu National Park is clearly separated from the two confirmed H. blandulus samples, and forms a well-supported clade with females and a larva from other locations across Sarawak. This clade is (with poor support) the sister of a clade consisting of species from outside of Borneo; however the taxon sampling from outside of Borneo is insufficient to draw any firm conclusion from this even if the support values were higher. In any case an analysis with additional markers is needed to deal with the broader relationships within the genus. The H. species cf kelantanensis sample from Johor falls into a clade consisting of samples from Brunei and Sarawak east of the Lupar River and including a H. cf borneensis female which might be the true H. borneensis. Large differences between samples from different populations are seen in this clade. Although the whole clade is divided into two clades (with moderate (ML) or complete (BI) support), this cannot be taken as strong evidence that two species are represented, given the high variability between populations. The whole clade has complete (BI) or moderate (ML) support. Two samples from south-western Sarawak form a clade that is the sister (with very poor support) of all the rest: a female from Gunung Penrissen and a larva from Kubah National Park in the Matang Range. Possibly this south-western clade will be found to be associated with the horned females mentioned above, but since it is not currently possible to re-examine the female from the molecular analysis, this cannot be confirmed. It is also at least possible that the south-western clade is due to a non-coding copy of COI present in the genome in some south-western populations of one of the other species. Although the south-western clade and horned females are intriguing, we do not consider the evidence of a fourth species in Borneo as completely overwhelming yet, although it does seem likely.
It would be premature to draw any definite conclusion from these analyses, especially given the poor support values from ML (see Fig. 9), but they do suggest that four or possibly more, rather than three, species might be present in the material from Borneo. They also suggest that *H. borneensis* and *H. kelantanensis* may be the same species, although since no confirmed male sample of either species is included in the analyses, synonymising *H. borneensis* with *H. kelantanensis* would certainly be premature at this stage. Two (at least) of the species from our region of interest show rather high variability in the COI marker, and we suspect that this is also true for the Philippine *H. bakeri*, rather than that it is composed of two cryptic species. The bottom line here is that a critical mass of material is needed to make complete sense of this group in Borneo, Singapore and Peninsular Malaysia, whether morphological or molecular methods are used (ideally both would be used), and this critical mass has not yet been obtained.

**Acknowledgements**

The first author would like to thank the Sarawak Forestry Corporation and Sarawak Forest Department for granting permission to collect Odonata in Sarawak. The Timber Division of WTK Holdings Berhad allowed the first author to work in their timber concessions in the Gunung Melatai area and provided assistance on the ground at Gunung Melatai; Tuan Haji Madhan of the SFC helped make arrangements with WTK for the trip. Joanes Unggang allowed the first author to join the trip to the Kastima logging area. Last but far from least, the trip to Gunung Melatai was made possible by a grant from the International Dragonfly Fund.

**References**


INSTRUCTION TO AUTHORS

Faunistic studies of South-East Asian and Pacific islands Odonata is a journal of the International Dragonfly Fund (IDF). It is referred to as the journal in the remainder of these instructions. Transfer of copyright to IDF is considered to have taken place implicitly once a paper has been published in the journal.

The journal publishes original papers only. By original is meant papers that: a) have not been published elsewhere before, and b) the scientific results of the paper have not been published in their entirety under a different title and/or with different wording elsewhere. The republishing of any part of a paper published in the journal must be negotiated with the Editorial Board and can only proceed after mutual agreement.

Papers reporting studies financially supported by the IDF will be reviewed with priority, however, authors working with Odonata from the focal area (as defined on the back page of the front cover) are encouraged to submit their manuscripts even if they have not received any funds from IDF.

Manuscripts submitted to the journal should preferably be in English; alternatively German or French will also be accepted. Every manuscript should be checked by a native speaker of the language in which it is written; if it is not possible for the authors to arrange this, they must inform the Editorial Board on submission of the paper. Authors are encouraged, if possible, to include a version of the abstract in the primary language of the country in which their study was made.

Authors can choose the best way for them to submit their manuscripts between these options: a) via e-mail to the publisher, or b) on a CD, DVD or any other IBM-compatible device. Manuscripts should be prepared in Microsoft Word for Windows.

While preparing the manuscript authors should consider that, although the journal gives some freedom in the style and arrangements of the sections, the editors would like to see the following clearly defined sections: Title (with authors names, physical and e-mail addresses), Abstract, Introduction, Material & Methods, Results, Discussion, Acknowledgments and Referencias. This is a widely used scheme by scientists that everyone should be familiar with. No further instructions are given here, but every author should check the style of the journal.

Authors are advised to avoid any formatting of the text. The manuscripts will be stylised according to the font type and size adopted by the journal. However, check for: a) all species names must be given in italic; b) the authority and year of publication are required on the first appearance of a species name in the text, but not thereafter, and c) citations and reference list must be arranged following the format below.

Reference cited in the text should read as follows: Tillyard (1924), (Tillyard 1924), Swezey & Williams (1942).

The reference list should be prepared according to the following standard:
Tillyard, R., 1924. The dragonflies [Order Odonata] of Fiji, with special reference to a collection made by Mr. H.W. Simmonds, F.E.S., on the island of Viti Levu, Transactions of the Entomological Society London 1923 Ill-IV: 305-346.

Citations of internet sources should include the date of access.

The manuscript should end with a list of captions to the figures and tables. The latter should be submitted separately from the text preferably as graphics made using one of the Microsoft Office products or as a high resolution picture saved as a .jpg .tif or .ps file. Pictures should be at least 11 cm wide and with a minimum 300 dpi resolution, better 360 dpi. Line drawings and graphics could have 1200 dpi for better details. If you compose many pictures to one figure, please submit the original files as well. Please leave some space in the upper left corner of each picture, to insert a letter (a, b, c,...) later. Hand-made drawings should be scanned and submitted electronically. Printed figures sent by the post could be damaged, in which case authors will be asked to resubmit them.

Manuscripts not arranged according to these instructions may also be accepted, but in that case their publication will be delayed until the journal’s standards are achieved.