



The Odonata of Binyo Penyilam, a unique tropical wetland area in Bintulu Division, Sarawak, Malaysia

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Author Details: see end of this article.

Author Contribution: RAD identification of, and information on, the Odonata collected, history of Odonata records from Bintulu division, photography. JU general information on BPCA and the SPFP area, information on the habitats and flora of the BPCA, maps, photography.

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Abstract: Binyo Penyilam is a unique wetland conservation area within the Sarawak Planted Forest Project zone in Sarawak's Bintulu Division. A variety of forest and open habitats are present in the area; these are characterised. An annotated list of 61 species of Odonata from 11 families collected in the area to-date is presented. At least seven of these species had not been found in Sarawak prior to their discovery at Binyo Penyilam, of these four – *Pseudagrion coomansi*, *Merogomphus femoralis*, *Brachygonia puella* and *Chalybeothemis fluviatilis* – have still not been found elsewhere in the state; no other location is known for the genus *Merogomphus* in Borneo. Although under-sampling makes assessments of the conservation status of south-east Asian Odonata difficult, at least 16 of the species found at Binyo Penyilam can be considered to be of potential conservation concern, at least within Sarawak.

Keywords: Bintulu, Binyo Penyilam, Borneo, conservation, Malaysia, Odonata, Planted Forest Project, Sarawak.

Bahasa Malaysia Abstract: Binyo Penyilam adalah kawasan konservasi tanah lembah yang unik di dalam zon Sarawak Planted Forest Project di Daerah Bintulu, Sarawak. Pelbagai jenis hutan dan habitat terbuka yang telah dikenalpasti terdapat di kawasan tersebut. Sehingga ke hari ini 61 spesies Odonata dari 11 famili yang telah dikumpul di kawasan ini telah disenaraikan di sini. Sekurang kurangnya tujuh daripada spesies ini tidak pernah direkodkan di Sarawak sebelum penemuannya di Binyo Penyilam, daripada senarai itu empat spesies – *Pseudagrion coomansi*, *Merogomphus femoralis*, *Brachygonia puella* dan *Chalybeothemis fluviatilis* – masih belum dijumpai di mana mana tempat di Sarawak; tidak ada lokasi lain pula yang diketahui untuk genus *Merogomphus* di Borneo. Walaupun kekurangan pengumpulan sampel spesimen menyukarkan penilaian untuk status konservasi Odonata di Asia Tenggara, sekurang kurangnya 16 spesies yang terdapat di Binyo Penyilam itu boleh dianggap sebagai berpotensi untuk diberi perhatian dari segi Konservasi sekurang kurangnya di dalam Sarawak.

INTRODUCTION

Historically there has been very little collecting of Odonata (dragonflies and damselflies) in Sarawak's Bintulu Division. A few records had been published prior to 2007 (Laidlaw 1915; Laidlaw 1920; Hincks 1930), with a total of just 14 species recorded from the entire division. A number of publications dealing with Odonata and including records from locations in Bintulu Division have appeared from 2007 onwards (Dow et al. 2007; Dow 2008; Dow & Hämäläinen 2008; Dow & Reels 2010). A large part of Bintulu Division is now included in the Sarawak Planted Forest Project (SPFP), formerly known as the Planted Forest Zone. Here we present records of Odonata from the Binyo Penyilam Conservation Area (BPCA), a wetland area within the SPFP.

The SPFP (Image 1) lies within a gently rolling landscape, situated northwest of a series of high, parallel ridges that separate it from the Rejang River basin. It covers 490,000ha, of which 150,000ha have been identified as being suitable for the establishment of forest plantations. 220,000ha are being retained as natural forest and managed as reserves of various types. The balance of 120,000ha is Native Customary Rights land. In the long term at least half of the entire area will remain as natural forest, with two thirds of this protected.



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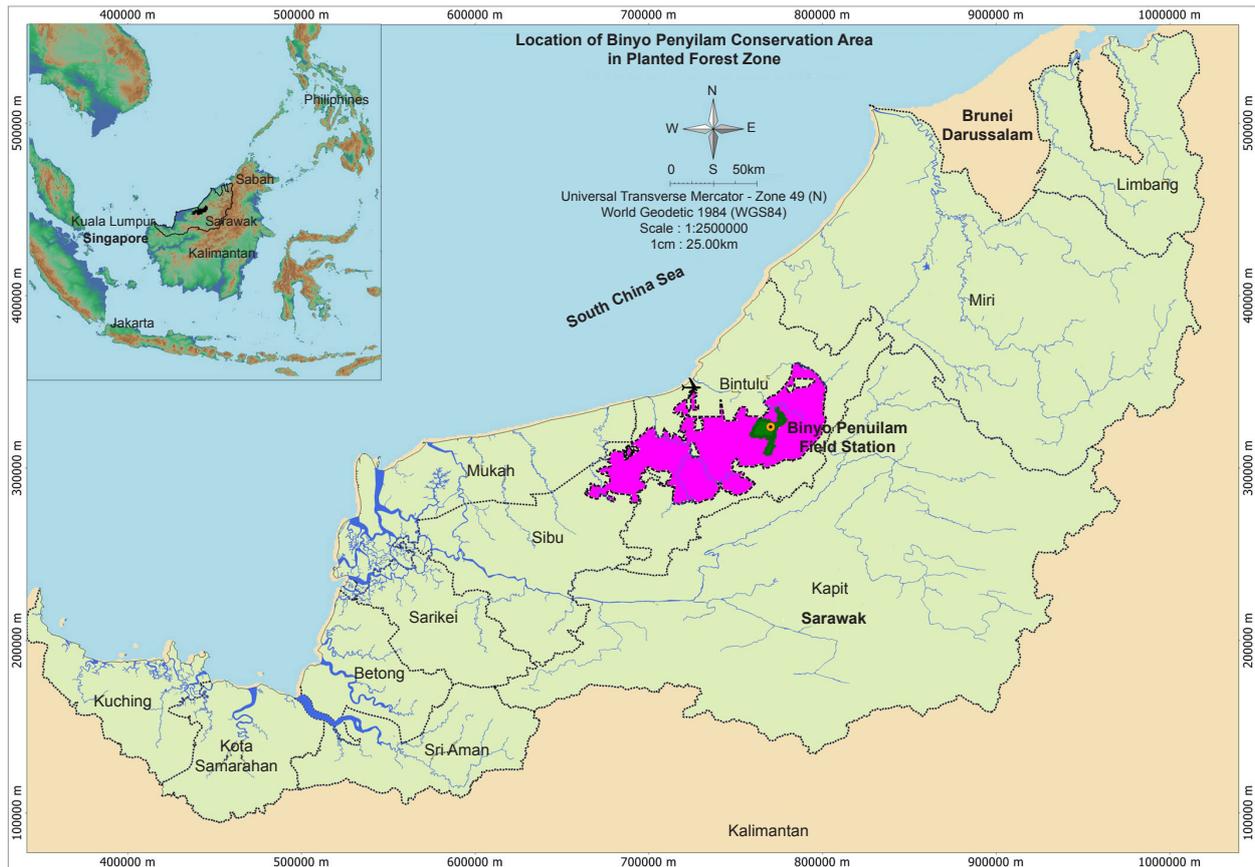


Image 1. Map of Sarawak showing the location of the Sarawak Planted Forest Project and the Binyo Penyilam Conservation Area.

A variety of vegetation types can be found within the area, including lowland mixed dipterocarp forest, peat swamps, limestone associations and kerangas forest, as well as *Acacia mangium* plantation. The SPFP Conservation Department has been conducting plant inventories together with international and local partners in Bintulu division, which had been poorly known floristically.

The BPCA (Image 1) is situated in the eastern central SPFP, and consists of kerangas forest, peat dome forest and peat swamp “lakes”, and has a total area of 15,300ha. It is a mosaic of partially disturbed and original swamp forest that has developed over a deep inland basin. Details of vertebrate groups found in the BPCA can be found in Stuebing et al. (2007). The vegetation of the BPCA is mainly influenced by the permanently and semi-permanently flooded nature of the area. The poor drainage of the area has led to the formation of an unusual type of peat dome forest, creating unique padang communities of stunted trees and grasses and black water lakes. Within the permanently flooded area there are peat dome forests of Alan (*Shorea albida*) and Ramin (*Gonystylus bancanus* and *G. maingayi*). Some small clumps of higher ground surrounded by the swamps and small lakes are mostly dominated by dipterocarps and gymnosperm species.

About 150 species of ferns and fern-allies and flowering plants have been collected and identified in the BPCA to-date (Demies et al. 2006). Trees and shrubs are well represented by 67 species, orchids with 25 species, ferns and fern-allies with 15 species. Four palm species and two species from the Cyperaceae, a grass family, have been found. The Araceae (aroids) is represented by five species, and at least five climber species have been found. Elements of the deep peat swamp flora (i.e. species that only grow on peat domes) are represented by two species of *Gonystylus*, one from the Bombaxaceae, one aroid and two *Pandanus* species. Padang communities are dominated by grasses such as Cyperaceae, and carnivorous plants such as *Nepenthes*. *Nepenthes* species are rich in the marsh areas and around the lakes, seven species have been recorded (Unggang 2007), of which *N. bicalcarata* and *N. albomarginata* are Bornean endemics. Another unusual plant of the BPCA is a fern, *Trichomanes singaporeanum*, that until recently had only been found growing on mountain ridges.

Sampling of Odonata has been conducted in most of the habitat types stated above except the lake areas, but only a small part of Binyo Penyilam has been sampled to-date. Sixty-one species of Odonata have been found in the area so far. This total is certain to rise with further

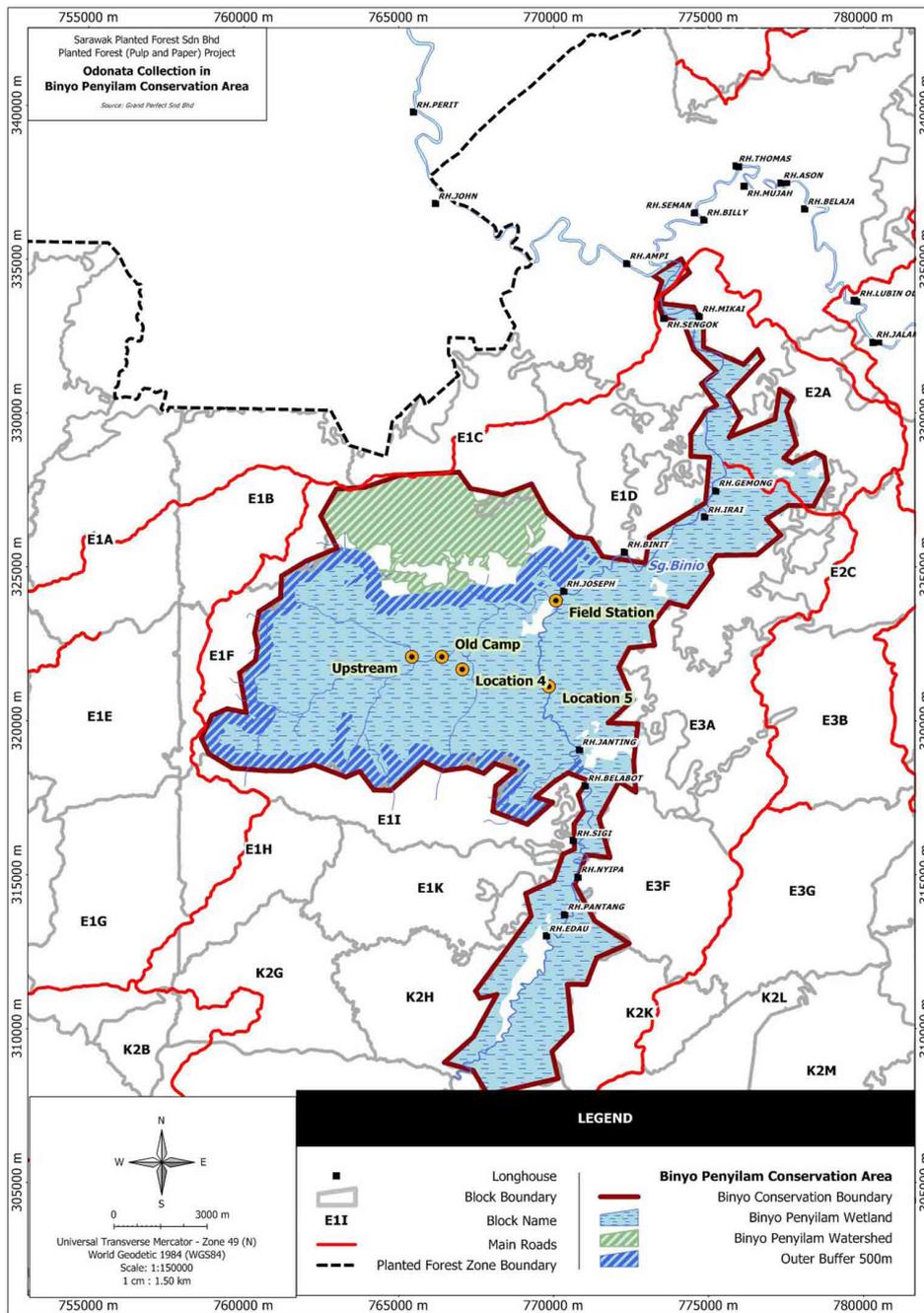


Image 2. Map of the sampling area.

sampling, but already includes a relatively high proportion of species that can be considered as rare and/or poorly known, and several first records for Sarawak and, in some cases, Borneo.

MATERIAL AND METHODS

To-date only sampling of adult Odonata has taken place within Binyo Penyilam. Collecting has been conducted using hand-held nets, and has taken place on foot, or when this was not possible, from boats. Collecting

was carried out on 8-11 March in 2006, and on 26-29 January and 5-10 October in 2008. At each location sampled the aim was to collect at least one specimen of each species present. In cases where species are difficult to distinguish in the field, or of particular interest, an effort was made to take longer series of specimens. However, many adult odonates are difficult to capture, hence not every species encountered was successfully collected. Conversely, little effort was made to capture more than a single voucher specimen for common and widely distributed species that are easily identified in the field. Most of the material collected is currently held in the



Image 3. The downstream Sg. Penyilam at a narrow section of the channel



Image 4. A wider, more open section of the channel at the mouth of the Sg. Penyilam



Image 5. Upstream Sg. Penyilam



Image 6. A section of flooded forest by the Sg. Penyilam



Image 7. An aerial view of one of the lake areas



Image 8. A black water pool in one of the open marshland areas

collection of the first author, with duplicates to be placed in the Sarawak Forest Research Centre.

Collecting was carried out at the locations listed below:

- (1) The Sg. Penyilam. This stream, a tributary of the

Sg. Binyo, naturally has the characteristic clear dark water of peat swamps, indicating very little sediment input. It ran clear when sampled in 2006, but was turbid during sampling in 2008. The downstream part of the stream flows through a generally wide and regularly flooded area with extensive stands of *Pandanus andersonii*, with some

much narrower areas (Image 3), with the more open areas often lined with *Donax* sp. (Image 4); the upstream part to the furthest point sampled flows through disturbed low pH swamp forest (Image 5). Sampling has been conducted between the locations marked as “Field Station” and “Upstream” in Image 2.

(2) Swamp forest (Image 6) around the Sg. Penyilam and small hillocks arising from the swamp. Sampling was carried out at a number of individual sites along the Sg. Penyilam.

(3) Open flooded areas at the landward margins of the large *Pandanus andersonii* areas in the lower part of the Sg. Penyilam.

(4) Open meadows, black water marshes and lagoons (Images 7-8), marked as “Location 4” in Image 2.

(5) A tributary to the Sg. Binyo, upstream and on the opposite shore to the Sg. Penyilam, in disturbed forest, marked as “Location 5” in Image 2.

(6) The Sg. Binyo, a turbid river.

(7) At the SPFP Conservation Department field station, “Field Station” in Image 2.

(8) Rumah Joseph, an Iban longhouse on the Sg. Binyo, close to the mouth of Sg. Penyilam.

Collecting was carried out by the first author and the following members of the SPFP Conservation staff: in March 2006 by Azizan Juhin and Stephen Stone, in January 2008 by Roslina Ragai, and in October 2008 by Jimmy Teo and Tony Chaong.

RESULTS

The following is a list of all species collected at Binyo Penyilam to-date. For each species a list of material, brief notes and a list of locations where they were collected are given. The family level taxonomy used here follows that in Orr (2003).

Zygoptera

Chlorocyphidae

(i) *Libellago aurantiaca* Selys, 1859 – Moderately common on the upstream Sg. Penyilam. Location 1: 2 males, 11.iii.2006; 1 male, 28.i.2008.

(ii) *Libellago hyalina* Selys, 1859 – A common species, especially on streams in swamp forest; it is often extremely abundant on the Sg. Penyilam. Locations 1, 2, 5: 3 males, 3 females, 8-10.iii.2006; 4 males, 26-29.i.2008; 4 males, 5-9.x.2008.

(iii) *Libellago orri* Dow & Hämäläinen, 2008 – A recently described species (Dow & Hämäläinen 2008), so far only known from Bintulu division, where all the known sites are within the PFZ. This species is allied to *L. hyalina*, and although the males are easily separable by colouration, the females of the two species are almost identical. Abundant on parts of the Sg. Penyilam. Only material not



Image 9. *Elattoneura aurantiaca* male

included in the type series is listed here. Location 1: 10 males, 26-29.i.2008; 2 males, 5-8.x.2008.

Euphaeidae

(i) *Dysphaea dimidiata* (Selys, 1853) – Usually a species of larger streams and rivers, not common at Binyo Penyilam. Location 1: 1 male, 9.iii.2006.

Calopterygidae

(i) *Vestalis amabilis* Lieftinck, 1965 – In March 2006 when the Sg. Penyilam still ran clear this species was common on the upstream part, but on subsequent visits it was much scarcer; it is unclear whether this is the result of the increased turbidity or of natural population fluctuations, or of some other factor not apparent to the authors. In Sarawak this species is most often encountered on streams in swamp forest or kerangas areas. Locations 1, 2: 11 males, 1 female, 8-11.iii.2006; 4 males, 27-28.i.2008; 1 male, 6.x.2008.

Megapodagrionidae

(i) *Podolestes orientalis* Selys, 1862 – A common species in swampy lowland forest. Location 2: 1 male, 8.iii.2006; 2 males, 29.i.2008; 1 male, 8.x.2008.

Protoneuridae

(i) *Elattoneura aurantiaca* (Selys, 1886) – In Sarawak this species appears to be confined to streams in swamp forest (usually peat swamp); it has been abundant on the Sg. Penyilam during all sampling periods to-date (Image 9). Locations 1, 2, 5: 20 males, 3 females, 8-11.iii.2006; 16 males, 5 females, 26-29.i.2008; 4 males, 2 females, 5-9.x.2008.

(ii) *Elattoneura longispina* Lieftinck, 1937 – This species, remarkable for the structure of its anal appendages, has not been recorded from Sarawak previously. It is otherwise known from north-west and south-east Kalimantan and Belitung (formerly Billiton) island (Lieftinck 1954). It occurs very locally in swamp forest at Binyo Penyilam, and has also been found at another location in Bintulu Division. It has yet to be found

elsewhere in East Malaysia. Locations 2, 10: 1 male, 8.iii.2006; 6 males, 2 females, 27-29.i.2008.

(iii) *Prodasineura verticalis* (Selys, 1860) – A common stream and river species, but only occurring at low densities at Binyo Penyilam. It favours streams with an open canopy. Locations 1, 6: 1 male, 26.i.2008; 3 males, 6-9.x.2008.

Coenagrionidae

(i) *Aciagrion borneense* Ris, 1911 – A moderately common, and easily overlooked species, typically found on shallow grassy pools in open habitats. Location 4: 1 male, 1 female, 10.iii.2006; 1 female, 7.x.2008.

(ii) *Agriocnemis femina* (Brauer, 1868) – A very common species in open lentic habitats, but to-date only one female has been collected at Binyo Penyilam. Location 1: 1 female, 29.i.2008.

(iii) *Amphicnemis annae* Lieftinck, 1940 – A moderately uncommon species of peat swamp and other low pH swamp forest. Location 2: 5 males, 1 female, 8-9.iii.2006; 1 male, 1 female, 8.x.2008.

(iv) *Amphicnemis* sp. cf. *dactylostyla* Lieftinck, 1953 – This problematic form is commoner at Binyo Penyilam than the last species, and appears to be distributed across Sarawak from the west to Loagan Bunut National Park in the north-east. It is clearly closely allied to *dactylostyla*, but determination of its true status will have to await a revision of the genus in Borneo. It is also closely related to *A. martini* Ris, 1911, but appears to be distinct from that species, which in Sarawak has only been found recently in Gunung Mulu National Park. All records of *A. martini* in Sarawak from west of Gunung Mulu National Park appear to actually refer to this form/species. It is usually, but not always, found in peat swamp forest; like the last species it is very local in its occurrence at Binyo Penyilam. Location 2: 5 males, 3 females, 9-10.iii.2006; 4 males, 11 females, 27-28.iii.2008.

(v) *Amphicnemis* sp. cf. *gracilis* Krüger, 1898 – An even more problematic form than the last; it has similarities with *A. gracilis*, *A. billitonis* Lieftinck, 1940 and *A. wallacii* Selys, 1863. Although in the structure of its terminal appendages the male is most similar to *A. gracilis*, it is possible that it and forms found further east in Sarawak are all merely local variants of *A. wallacii*. Abundant in swamp at Binyo Penyilam and known from other locations in Bintulu Division. Location 2: 3 males, 2 females, 8-10.iii.2006; 14 males, 13 females, 27-28.i.2008; 2 males, 3 females, 8.x.2008.

(vi) *Archibasis incisura* Lieftinck, 1949 – This is not generally a common species in Sarawak, but appears to be quite abundant on the Sg. Penyilam, and may favour low pH forest streams. Locations 1, 5: 2 males, 1 female, 9.iii.2006; 6 males, 2 females, 26-29.i.2008; 7 males, 5-9.x.2008.

(vii) *Archibasis melanocyana* (Selys, 1877) – In the authors experience this is not a common species in

Sarawak, although it is common in Brunei (Orr 2001), but it is sometimes abundant on the Sg. Penyilam. Locations 1, 3, 4 (two females were taken at a pool at this location): 20 males, 4 females, 9-11.iii.2006; 5 males, 26-29.i.2008.

(viii) *Archibasis tenella* Lieftinck, 1949 – This species is normally commoner than the preceding two in Sarawak, and occurs on a larger range of stream types; however at Binyo Penyilam only a single teneral (freshly emerged) specimen has been collected. Location 1: 1 male, 10.iii.2006.

(ix) *Archibasis viola* Lieftinck, 1948 – The commonest member of the genus in Sarawak. Locations 1, 2, 5: 3 males, 1 female, 8-11.iii.2006; 2 males, 27-28.i.2008; 3 males, 1 female, 6-9.x.2008.

(x) *Ceriagrion cerinorubellum* (Brauer, 1865) – A very common species, especially in open and disturbed habitats. Locations 1, 4: 2 males, 9-10.iii.2006; 1 male, 29.i.2008.

(xi) *Mortonagrion falcatum* Lieftinck, 1934 – A single female was collected at the edge of a blackwater pool in the open marshland area. *M. falcatum* has a wide distribution in Sundaland, but had not been recorded in Sarawak prior to 2006, when it was also collected in Gunung Mulu National Park (Dow & Reels 2008). However it has been recorded in Brunei (Orr 2001) and is easily overlooked on account of its small size, so is likely to be under-recorded in Sarawak. Location 4: 1 female, 10.iii.2006.

(xii) *Mortonagrion* new sp. – This small, dark species was first discovered in peat swamp forest on the UNIMAS campus at Kota Samarahan in 2005; it has subsequently been found at a number of low pH forest locations in Sarawak, and is locally common at Binyo Penyilam. A description is in preparation by the first author. Location 2: 1 male, 1 female, 8-10.iii.2006; 9 males, 7 females, 27-28.i.2008; 6 males, 1 female, 8.x.2008.

(xiii) *Pseudagrion coomansi* Lieftinck, 1937 – apart from one old and questionable record of a female (Lieftinck 1954) this is the first record of this species from East Malaysia. It is moderately common in the open marshland at Binyo Penyilam, where it is found flying over black water pools. Location 4: 4 males, 1 female, 10.iii.2006; 3 males, 7.x.2008.

Platycnemididae

(i) *Copera vittata* (Selys, 1863) – This is a widespread species in tropical and subtropical Asia, with a confusing variety of named subspecies, and still more unnamed forms. The typical form in Borneo has red legs, but a form with yellowish legs exists in western Sarawak, a form with black legs exists in Brunei (Orr 2001, 2003) and a form with yellow and black legs is found in Bintulu Division. The determination of the true status of these forms awaits a thorough revision of the genus. Locations 2, 5: 1 female, 11.iii.2006; 1 male, 9.x.2008.

Image 10. *Ictinogomphus acutus* maleImage 11. *Brachygonia puella* female

Anisoptera

Gomphidae

(i) *Ictinogomphus acutus* (Laidlaw, 1914) – This species appears to be a specialist found in low pH habitats. It is classified as Near Threatened in the IUCN Red List (IUCN 2010). It is usually common on the Sg. Penyilam, but the first author has found it at only one other location in Sarawak: Loagan Bunut (Dow & Reels 2006) (Image 10). Locations 1, 3, 6: 7 males, 9-11.iii.2006; 6 males, 3 females, 26-29.i.2008; 3 males, 2 females, 5-9.x.2008.

(ii) *Ictinogomphus decoratus melaenops* (Selys, 1858) – The commonest member of the Gomphidae in Sarawak, found on open lentic and slowly flowing waters. Location 1: 1 male, 29.i.2008.

(iii) *Macrogomphus parallelogramma albardae* (Selys, 1878) – This species has not previously been recorded from Sarawak, it appeared to be moderately common on the Sg. Penyilam in March 2006, but has not been found there subsequently. One male was captured while foraging at the streams edge at dusk; records of crepuscular (dusk and evening) flight in this family are scarce; but the first author has subsequently observed similar behaviour from this species at Bukit Sarang (also in Bintulu Division). Wilson (2008) recorded crepuscular activity in *Orientogomphus minor* (Laidlaw, 1931) in Thailand, so perhaps dusk and evening flight in the Gomphidae is more common than has been supposed. Location 1: 3 males, 1 female, 8-11.iii.2006.

(iv) *Macrogomphus quadratus* (Selys, 1878) – A distinctively marked species, the commonest of its genus in Sarawak, found on a variety of forest streams. Location 1: 3 males, 9-11.iii.2006; 4 males, 28-29.i.2008.

(v) *Merogomphus femoralis* Laidlaw, 1931 – This is the first record of a *Merogomphus* species from Borneo; the Sg. Penyilam remains the only site known on the island for the genus. *M. femoralis* was previously only known from the holotype, taken in west Malaysia, but a photographic record probably of this species was recently

made in Singapore (Cheong et al. 2009). Location 1: 3 males, 1 female, 9-11.iii.2006; 2 males, 6.x.2008.

(vi) *Microgomphus* sp. – A single teneral female was collected on the Sg. Penyilam. The only species of the genus so far recorded from Borneo is *M. chelifera* (Selys, 1858), but as the adults of *Microgomphus* species are very elusive, there could well be additional species present on the island. As the specimen is in poor condition, it is not possible to come to any firm conclusion regarding its status. Location 1: 1 female, 11.iii.2006.

Aeshnidae

(i) *Gynacantha basiguttata* Selys, 1882 – Likely to be quite common in Sarawak, but not many records have been made in the state to-date. The single specimen collected at Binyo Penyilam was foraging during rain in the late afternoon. Location 7: 1 male, 7.x.2008.

(ii) *Gynacantha dohrni* Krüger, 1899 – This is the most frequently collected *Gynacantha* species in Sarawak, often coming to lights at buildings near to lowland forest. Locations 2, 7, 8: 1 male, 1 female, 10-11.iii.2006; 5 males, 1 female, 5-8.x.2008.

(iii) *Gynacantha* species – A female collected at Rumah Joseph in 2008 is not *G. basiguttata* or *G. dohrni*, but it has not been possible to identify it to species. Location 8: 1 female, 26.i.2008.

Corduliidae

(i) *Hemicordulia tenera* Lieftinck, 1930 – A fast flying species, in Sarawak seemingly confined to swampy forest areas and very local in occurrence. Sometimes quite common on the Sg. Penyilam where males patrol sections of the stream. Location 1: 2 males, 9-10.iii.2006; 3 males, 5-8.x.2009.

(ii) *Macromia arachnomima* Lieftinck, 1953 – The exuviae of the distinctive long legged larvae of this species were found in large numbers on the Sg. Penyilam in January 2008. All records from Sarawak are of larvae or exuviae, with the first record of the species in the state

being made at Gunung Mulu National Park earlier in January 2008 (Dow & Reels 2009). Location 1.

(iii) *Macromia cincta* Rambur, 1842 – The commonest *Macromia* species in Sarawak, abundant on the Sg. Penyilam. Location 1: 6 males, 9-11.iii.2006; 2 males, 26-29.i.2008; 7 males, 1 female, 5-8.x.2008.

Libellulidae

(i) *Brachygonia oculata* (Brauer, 1878) – A common species of swamp habitats. Locations 1, 2: 2 males, 8.iii.2006; 2 males, 26-28.i.2008; 1 male, 2 females, 5-9.x.2008.

(ii) *Brachygonia puella* Lieftinck, 1937 – This is the first record of this small species from Sarawak; it is otherwise only known from Belitung and south Kalimantan (e.g. Lieftinck 1954). It is common in parts of the open marsh land at Binyo Penyilam. Image 11. Locations 1, 2, 4: 10 males, 7 females, 10.iii.2006; 3 males, 3 females, 27-29.i.2008; 4 males, 1 female, 7-8.x.2008.

(iii) *Chalybeothemis fluviatilis* Lieftinck, 1933 – Apparently an extremely local and specialised species, confined to low pH habitats. First recorded from Sarawak at Binyo Penyilam (Dow et al. 2007), and still not recorded elsewhere in the state. It is moderately common at ponds in the open marsh land at Binyo Penyilam and sometimes occurs on the open parts of the Sg. Penyilam. Locations 1, 4: 1 male, 26.i.2008; 6 males, 5-8.x.2008.

(iv) *Cratilla metallica* (Brauer, 1878) – A common species on pools in lowland forest, but at Binyo Penyilam just two females have been collected, perched high over the Sg. Penyilam, an unusual location for the species. Location 1: 2 females, 9-11.iii.2006.

(v) *Nannophya pygmaea* Rambur, 1842 – A common species of marshlands and shallow ponds, sometimes also found on streams. Locations 1, 4: 7 males, 2 females, 8-10.iii.2006; 1 male, 1 female, 28-29.i.2008; 3 males, 6-7.x.2008.

(vi) *Nannophyopsis chalcosoma* Lieftinck, 1935 – A very poorly known species, not recorded in Sarawak since 1953 (Lieftinck 1953), until it was rediscovered at Binyo Penyilam in January 2008, where it was found in one section of flooded forest bordering the Sg. Penyilam. Several males and one female were observed, although it was only possible to collect one male. Males appeared to prefer low perches, and were extremely inconspicuous. Location 2: 1 male, 29.i.2008.

(vii) *Nesoxenia lineata* (Selys, 1879) – A widespread species, but local in occurrence, found in swampy forest habitats and seldom common. Locations 1, 3: 2 males, 2 females, 29.i.2008; 1 male, 9.x.2008.

(viii) *Neurothemis fluctuans* (Fabricius, 1793) – An extremely common species in Sarawak, especially in open disturbed habitats. Locations 3, 4: 1 male, 10.iii.2006; 2 males, 29.i.2008; 1 male, 7.x.2008.

(ix) *Onychothemis culminicola* Förster, 1904 – A riverine species first recorded in Sarawak in 2006 (e.g.



Image 12. *Orchithemis xanthosoma* female

Dow & Reels 2008); an earlier record of *O. c. celebensis* Ris, 1912 (Laidlaw 1920) actually referred to *O. coccinea* Lieftinck, 1953 (Lieftinck 1954). Probably rather common in Sarawak, but wary and fast flying, hence under-recorded in the state. Location 1: 1 female, 6.x.2008.

(x) *Orchithemis pruinans* (Selys, 1878) – A very local species in Sarawak, but quite common at Binyo Penyilam. Locations 1, 2: 1 female, 8.iii.2006; 3 males, 3 females, 5.x.2008.

(xi) *Orchithemis pulcherrima* Brauer, 1878 – A very common species in swamps and marshes, abundant at Binyo Penyilam. Locations 1, 2, 4, 5, 7: 3 males, 8 females, 8-11.iii.2006; 3 males, 3 females, 26-28.i.2008; 4 males, 2 females, 5-9.x.2008.

(xii) *Orchithemis xanthosoma* Laidlaw, 1911 – A species that is regarded as rare, but appears to be moderately common at Binyo Penyilam. The first author has found this species at a number of locations across Sarawak since 2006, always in association with low pH swamp forest. Image 12. Locations 1, 2: 5 males, 1 female, 8-10.iii.2006; 2 males, 4 females, 27-28.i.2008; 1 male, 6.x.2008.

(xiii) *Orthetrum chrysis* (Selys, 1891) – A common species found in a variety of lotic and lentic habitats. Locations 1, 4, 8: 1 male, 1 female, 9-11.iii.2006; 1 male, 7.x.2008.

(xiv) *Orthetrum sabina* (Drury, 1773) – A very common species, usually found in disturbed habitats. Location 1, 3, 4: 2 males, 10.iii.2006; 1 male, 29.i.2008; 1 male, 6.x.2008.

(xv) *Orthetrum testaceum* (Burmeister, 1839) – Another very common species usually found in disturbed habitats. Location 1: 1 male, 11.iii.2006.

(xvi) *Pornothemis serrata* Krüger, 1902 – A specialist swamp forest species. Males are sometimes found guarding small pools, and at Binyo Penyilam also occasionally on the Sg. Penyilam. Locations 1, 2: 2 males, 28.i.2008; 1 male, 2 females, 5-6.x.2008.

(xvii) *Raphismia inermis* Ris, 1910 – Seemingly a very rare species. A single male was captured at camp lights at

Binyo Penyilam one evening in March 2006 and another in shade near one of the ponds in an open marsh area in October 2008. The author is aware of no other recent record from Sarawak, and only one historical record (Laidlaw 1920). Locations 2, 4: 1 male, 8.iii.2006; 1 male, 8.x.2008.

(xviii) *Rhodothermis rufa* (Rambur, 1842) – A common species in open habitats. Location 1: 1 female, 9.iii.2006.

(xix) *Rhyothemis aterrima* Selys, 1891 – A local species, but common at Binyo Penyilam. Locations 1, 4: 3 males, 26-27.i.2008; 3 males, 5-7.x.2008.

(xx) *Rhyothemis obsolescens* Kirby, 1889 – Common at Binyo Penyilam. Locations 1, 2, 3, 4, 5: 7 males, 3 females, 8-11.iii.2006; 4 males, 2 females, 25-29.i.2008; 7 males, 7-9.x.2008.

(xxi) *Rhyothemis pygmaea* (Brauer, 1867) – The least common and most local of the *Rhyothemis* species occurring in Sarawak. Locations 1, 2, 4: 1 male, 10.iii.2006; 1 female, 27.i.2008; 1 female, 8.x.2008.

(xxii) *Tramea phaeoneura* Lieftinck, 1953 – A local species of open standing water habitats; probably under-recorded due to its similarity with the widespread and common *Tramea transmarina euryale* Selys, 1878. Location 4: 2 males, 10.iii.2006; 2 males, 7.x.2008.

(xxiii) *Tyriobapta laidlawi* Ris, 1919 – A local species, most often found in low pH swamp forest. Location 2: 2 males, 8-11.iii.2006; 3 males, 3 females, 27.i.2008; 3 males, 8.x.2008.

(xxiv) *Tyriobapta torrida* Kirby, 1889 – Generally the commonest *Tyriobapta* species in lowland forest in

Sarawak, but less common in swamp forest. Locations 2, 5: 2 males, 6-8.iii.2006; 1 male, 9.x.2008.

(xxv) *Urothemis signata insignata* (Selys, 1872) – A common, widespread species, abundant on the more open parts of the Sg. Penyilam. Locations 1, 3, 4: 3 males, 1 female, 9-10.iii.2006; 4 males, 1 female, 26-29.i.2008; 1 male, 5.x.2008.

(xxvi) *Zygomma petiolatum* Rambur, 1842 – A common crepuscular species. Location 8: 1 male, 1 female, 26.i.2008.

DISCUSSION

As a large area consisting mainly of low pH swamp forest (albeit disturbed) mixed with naturally open habitats, Binyo Penyilam is an exceptionally interesting area for Odonata in Sarawak. A number of the habitats at Binyo Penyilam are unusual and may not be represented in totally protected areas in Sarawak. Low pH swamp forest is relatively poorly represented in Sarawak's currently gazetted protected areas (compared, for instance, to hill-side mixed dipterocarp forest), but provides a habitat for a number of specialist species. Natural open habitats are scarce in Sarawak, and the open marsh areas at Binyo Penyilam appear to offer suitable habitat for some species not found elsewhere in the state.

At least seven species (*Libellago orri*, *Elatoneura longispina*, *Pseudagrion coomansi*, *Macrogomphus parallelogramma albarda*, *Merogomphus femoralis*,

Table 1. Odonata species recorded from Binyo Penyilam and potentially of conservation concern.

Species	Justification
<i>Libellago orri</i>	Endemic to Sarawak, only known from the SPFP area.
<i>Elatoneura aurantiaca</i>	Currently only three sites are known in Sarawak for this species (BPCA, Bukit Sarang, also in Bintulu division, and a site near Kuching); none of these is totally protected at the time of writing.
<i>Elatoneura longispina</i>	The only other site known for this species in Sarawak is Bukit Sarang.
<i>Mortonagrion falcatum</i>	Currently known from only two sites in Sarawak (BPCA and Gunung Mulu National Park).
<i>Mortonagrion</i> new species	Although this species is widespread in Sarawak, it is not known outside the state and is only known from one totally protected area (Loagan Bunut National Park); several of the known sites in Kuching and Samarahan divisions are likely to be lost in the near future.
<i>Pseudagrion coomansi</i>	Binyo Penyilam is the only location known for this species in Sarawak.
<i>Ictinogomphus acutus</i>	Only two sites are currently known for this species in Sarawak (BPCA and Loagan Bunut National Park); it has been assessed as Near Threatened for the IUCN Red List (IUCN 2010).
<i>Macrogomphus parallelogramma</i>	Only three sites (BPCA, a site upstream in the sources of the Sungai Binyo, and Bukit Sarang), all in the SPFP, are currently known for this species in Sarawak.
<i>Merogomphus femoralis</i>	Binyo Penyilam is the only location known for this genus in Borneo.
<i>Hemicordulia tenera</i>	Only currently known from two areas (BPCA and around Bario in Miri division) in Sarawak.
<i>Brachygonia puella</i>	Binyo Penyilam is the only location known for this species in Sarawak.
<i>Chalybeothemis fluviatilis</i>	Binyo Penyilam is the only location known for this species in Sarawak.
<i>Nannophyopsis chalcosoma</i>	Binyo Penyilam is the only currently known location for this species in Sarawak.
<i>Raphismia inermis</i>	Binyo Penyilam is the only currently known location for this species in Sarawak.
<i>Rhyothemis pygmaea</i>	Only two sites (BPCA and Bukit Sarang) are currently known for this species in Sarawak, both in the SPFP.
<i>Tramea phaeoneura</i>	Only two sites (BPCA and around Bario in Miri division) are currently known for this species in Sarawak.

Brachygona puella and *Chalybeothemis fluviatilis*) not definitely recorded in Sarawak prior to 2006 have been found at Binyo Penyilam, a high number for a single area; four of these species have still not been found elsewhere in the state (*P. coomansi*, *M. femoralis*, *B. puella* and *C. fluviatilis*). The Sg. Penyilam remains the only known site for a *Merogomphus* species on Borneo. Two other species collected in this area have not been recorded anywhere else in Sarawak for decades, these are the apparently very rare *Nannophyopsis chalcosoma* and *Raphismia inermis*.

Because of under-sampling it is generally difficult to assess the conservation status of Odonata in south-east Asia. However 16 of the species found at Binyo Penyilam can be considered to be of potential conservation concern, at least within Sarawak. These species are listed in Table 1, together with a brief justification for their inclusion.

A number of the species listed in Table 1 (*Mortonagrion falcatum*, *Ictinogomphus acutus*, *Hemicordulia tenera*, *Chalybeothemis fluviatilis*, *Nannophyopsis chalcosoma*, *Rhyothemis pygmaea*, *Tramea phaeoneura*) have also been recorded in Brunei, but all are very localised there and in many cases their habitats are at risk (Orr 2001; pers. comm.).

Odonate diversity in lowland swamp and marshland habitats in Borneo is not as high as in mixed dipterocarp forest (Orr 2006). That said, diversity at Binyo Penyilam is relatively high, with 61 species from 11 families of Odonata recorded. Most of the collecting effort to-date has been concentrated on the Sg. Penyilam, or in the open marshland; relatively little time has been spent within the swamp forest areas, it is likely that more collecting here would result in a significant increase in the number of species recorded in the area. The lakes present in the area, not sampled for Odonata yet, are also likely to yield additional species.

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