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# The Diversity of Odonates in Five Islands within the West Coast of Peninsular Malaysia

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**Abstract:** The odonate fauna of five islands within the west coast of Peninsular Malaysia, namely Besar Island (Melaka), Carey Island (Selangor), Pangkor Island (Perak), Penang Island (Penang) and Langkawi Island (Kedah) were surveyed. A total of 54 species belonging to 12 family groups were identified. The highlights of the collection is an endemic species of Pulau Langkawi and one new record for Peninsular Malaysia. Although no other endemics were found in Besar Island, it was first record for the island.

**Key words:** Odonata · Species · Islands · Diversity · New Records

## INTRODUCTION

Malaysia is a country blessed with beautiful islands. Being a tropical country, most of the islands are rich with corals and marine life which become a major tourist attraction and successfully generated large sum of economic income to the country. The offshore archipelagos of Peninsular Malaysia have been the subject of increasing interest in recent years. Many of these islands insect's diversity have never been surveyed and recent explorations are only the beginning to uncover the hidden treasures of diversity and endemism that they shelter [1-3].

Studies about insect, particularly the odonates (dragonflies and damselflies) are now receiving worldwide attention as object of research. Even in Malaysia, continuous works on Odonata is done by various institutions are encouraging and has to be ongoing to compile a comprehensive odonate listing for the country [4, 5]. Nevertheless, most of the study sites were on the mainland of Malaysia and only a few studies were done on the islands of Malaysia. The Odonates are valuable as biological indicators of aquatic and terrestrial ecosystem [6] and also play a vital role as prey and predator to maintain the balance of tropic levels of food chain. They are also among the important component of freshwater ecosystems [7]. Odonata can be found in almost all kinds of habitats, ranging from permanent running waters, lakes to small temporary rain pools and which had been known to be as a potential for biological indicator [8]. Similarly, Noss [9] found that studies on larvae as well as adults are necessary to assess the role of Odonata within the nature communities of stream ecosystems. Findings from these studies would further increase the potential of odonates in biological monitoring lending support for the evaluation of conservation strategies. Being indicators of the environment, odonates are sensitive towards their surroundings and any changes in their habitat parameters may lead to the changes in their status [10]. Recent studies in the Western Ghat of India have showed that changes in land use pattern had affected odonates community structure [11].

In biodiversity conservation, dragonflies serve as umbrella species representing specific biotic wetland assemblages [9]. A number of literatures had reported on the role of odonates as indicators species for environmental health [12, 13]. Fincke *et al*. [14] found that

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odonates are keystone species in tree holes on Barro Colorado Island where they are the most common large predators. The aim of this study was to document the Odonata diversity for these fast exploited islands and to assess their distribution and abundance. It is hoped that the findings will contribute to be a baseline data depicting current situation which can be utilized for future comparison in order to analyse human or environmental impacts on the island habitats.

## MATERIALS AND METHODS

**Study Area:** Five major islands in the west coast of Peninsular Malaysia were selected as study sites. The islands were Besar Island, Melaka; Carey Island, Selangor; Pangkor Island, Perak; Penang Island and Langkawi Island, Kedah (Figure 1 and Table 1).

- Besar island is located in the Melaka Straits, approximately 5 km off the coast of Umbai, 10 km south of the town of Melaka. It is the largest (1.33 km$^2$) of eight islands that form the Water Islands Archipelago, off the west coast of Peninsular Malaysia. Much of the island's natural vegetation has been destroyed and converted into a golf course and several large resorts. A small pocket of natural habitat remains on the northwestern coast of the island, consisting of a small mangrove swamp and rocky granite outcrops which are disjointed in their distribution across the island.
- Carey Island is situated on the south of Port Klang, separated from the mainland by Klang River, connected by a bridge from Chodoi near Banting. It is a very huge island, with total area of 16 000 ha and 11 700 ha of the area are belongs to the Sime


Fig. 1: Islands in Peninsular Malaysia. Insert picture is Carey Island

Table 1: Description and locations reading of sampling sites in the islands

| Island | GPS Reading | Habitat Structure |
|---|---|---|
| Besar Island | N 2°6'36" / E 102°19'37" | -Stagnant pond in golf course area, 5 m diameter and maximum depth about 2 m. Vegetation primarly *Nelumbo sp.* and *Typha sp.* |
| Carey Island | N 2°51'27"/ E 101°24'32" | -Area with palm oil trees, a slow flowing, almost stagnant stream with grassy banks. Width was about 3 m and 1.5 m depth |
| Pangkor Island | N 4°13'55" / E 100°33'6" | -Forest reserve, small, slow flowing stream of 1 m wide and less than 0.5 m depth. Vegetation of primary swampy forest. -Man made pond near Kem Raudhah and a small fast flowing stream of 1 m wide with grassy banks. |
| Langkawi Island | N 6°22'3" / E 99°47'50" | - A recreational forest with fast to slow flowing main river (5 meter wide) and two small river, width was about 2 meter). - A freshwater lake. Vegetation of dipterocarp forest around the lake. - An open pond with 5m diameter an depth about 4m. Vegetation primarily grass and shrubs. |
| Penang Island | N 5°26'47" / E 100°12'54" | - A recreational forest with slow to fast flowing river. Vegetation of dipterocarp forest. - A small, slow flowing stream with 0.5 m wide with grassy banks. - A waterfalls with fast to slow flowing. Width was about 4 meter. Vegetation of dipterocarp forest. |

Darby Plantation. It is an initial settlement area for the Mah Meri who is one of the aborigine tribes of Malaysia and the island is now largely planted with oil palm [15].

- Pangkor Island, approximately 18km$^2$ and situated 3.5km from the west coast of Peninsular Malaysia. The island's interior remain heavily forested and maintains a river system, Sungai Pinang, which supplies a significant source of permanent fresh water in the form of multiple stream.
- Penang Island is the fourth-largest in the country with an area of 293 km$^2$. It is also the most populated island in the country with an estimated population of 678,000.The island is connected with the mainland by the Penang Bridge. The bridge begins at Gelugor on the island and ends in Perai on the mainland.
- Langkawi Island is an archipelago encompasses 104 islands lying 35 km off the northwest coast of the state of Kedah, West Malaysia and is the largest conglomerate of islands associated with peninsular Malaysia. Its islands range in size from 0.01-328 km$^2$ and for the most part, are covered entirely by primary forest. The largest of these islands, Pulau Langkawi (328 km$^2$), is also the most environmentally diverse. Its interior is mountainous and covered with mixed dipterocarp forest [16, 17]. Broad, flat, low-lying expanses fringe the interior mountains providing suitable relief for agriculture areas as well as lowland dipterocarp forest, coastal vegetation and mangrove communities.

**Sampling Methodology:** Methods of sampling and preservation of odonates were based on Orr [18] and Borror and White [19]. Adult Odonata were collected using handheld nets. The long handle net with 25cm diameter and an open-mesh net with little air resistance to make it easier to catch flying odonates. Larval odonates were sampled using a long handle D-shaped aquatic net (15cm diameter, 40cm long, 200µm mesh net). The net was dragged over a meter of river substrates or margin. For each location, a transect of 50 meters by 50 meters were covered and sampling time started from 9.00am till 5.00pm. The adult specimens were killed by pressing the thorax, folding the wings and kept in the triangle acid free paper envelopes. Larvae are preserved in alcohol with 95% concentration in the universal bottles. All adult odonates and larvae were identified up to species level by using pertinent literatures by Orr [18, 20] and Catherine and Yong [21].

## RESULTS AND DISCUSSION

Odonata diversity on islands in Malaysia (except Penang Island) have yet to gain the attention of researchers. Only a few records have been published, such as by Kitagawa [22] recorded 54 species of Odonata in Penang Island, Norma-Rashid et al [4] made an inventory of Odonata in several islands in the Straits of Malacca and recorded 15 species belonging to the families of Libellulidae and Coenagrionidae. Kalkman [23] on his trip to Tioman Island in 2002, listed 11 species of odonates.

Fairly rich communities of dragonflies were recorded from the five islands (Table 2). Overall, 408 individual (adult and larva) were collected and a total of 54 species belonging to 12 family group were identified. Among these five islands, the highest number of species

Table 2: Diversity List of the dragonflies (Anisoptera) and damselflies (Zygoptera) in five islands on the west coast of Peninsular Malaysia

| Species List | Besar Island | Carey Island | Langkawi Island | Pangkor Island | Penang Island |
|---|---|---|---|---|---|
| FAMILI: LIBELLULIDAE | | | | | |
| 1. *Orthetrum sabina* (Drury, 1770) | X | X | X | X | X |
| 2. *Orthetrum glaucum* (Brauer, 1868) | | | X | X | X |
| 3. *Orthetrum testaceum* (Burmeister, 1839) | | X | | X | X |
| 4. *Orthetrum chrysis* (Selys, 1891) | X | X | | X | X |
| 5. *Neurothemis fluctuans* (Fabricius, 1793) | | X | X | X | X |
| 6. *Pseudothemis jorina* Forster, 1904 | | | | | X |
| 7. *Acisoma panorpoides* Rambur, 1842 | | X | X | | X |
| 8. *Pantala flavescens* (Fabricius, 1798) | | X | X | | X |
| 9. *Trithemis festiva* (Rambur, 1842) | | | | | X |
| 10. *Trithemis aurora* (Burmeister, 1839) | | | | X | X |
| 11. *Rhyothemis phyllis* (Sulzer, 1776) | | X | | | |
| 12. *Brachydiplax chalybea* Brauer, 1868 | | X | X | | |
| 13. *Diplacodes trivialis* (Rambur, 1842) | | | X | X | |
| 14. *Aethriamanta gracilis* (Brauer, 1878) | | | X | | |
| 15. *Aethriamanta aethra* Ris, 1912 | | | X | | |
| 16. *Crocothemis servilia* (Drury, 1770) | | | X | X | |
| 17. *Potamarcha congener* (Rambur, 1842) | | | X | | |
| 18. *Zygonyx iris malayana* (Laidlaw,1902) | | | X | | |
| 19. *Tramea transmarine euryale* Selys 1878 | | | | X | |
| 20. *Nannophya pygmaea* Rambur 1842 | | | | X | X |
| 21. *Agrionoptera insignis* (Rambur, 1842) | | | | X | |
| 22. *Orthetrum pruinosum* | X | | | | |
| 23. *Tholymis tillarga* | | X | | X | |
| 24. *Brachythemis contaminata* | | | | | X |
| FAMILI: GOMPHIDAE | | | | | |
| 25. *Ictinogomphus decorates* (Selys, 1858) | | | X | | X |
| 26. *Megalogomphus icterops* (Martin, 1902) | | | X | | |
| 27. *Microgomphus chelifer* Selys, 1858 | X | | X | X | X |
| 28. *Acrogomphus malayanus* Laidlaw, 1925 | X | | X | X | |
| 29. *Macrogomphus sp.* (larvae) | X | | X | | |
| FAMILI: AESHNIDAE | | | | | |
| 30. *Anax sp*. (larvae) | X | | | | |
| FAMILI: CORDULIIDAE | | | | | |
| 31. *Epophthalmia vittigera* (Rambur, 1842) | | | X | | X |
| 32. *Idionyx yolanda* | X | | X | X | |
| 33. *Macromia cincta* | | | | | X |
| FAMILI: EUPHAEIDAE | | | | | |
| 34. *Euphaea impar* Selys, 1859 | | | | | X |
| 35. *Euphaea ochracea* Selys 1859 | | | | | X |
| FAMILI: PROTONEURIDAE | | | | | |
| 36. *Prodasineura collaris* (Selys, 1860) | | | | X | X |
| 37. *Prodasineura laidlawii* (Forster, 1907) | | | X | | X |
| 38. *Prodasineura humeralis* (Selys, 1860) | | | X | | |
| FAMILI: COENAGRIONIDAE | | | | | |
| 39. *Agriocnemis femina* (Brauer, 1868) | | X | | X | X |
| 40. *Argiocnemis rubescens* Selys 1877 | | | | X | |
| 41. *Pseudagrion pruinosum* (Brumeister, 1839) | | | | | X |
| 42. *Ischnura senegalensis* (Rambur, 1842) | X | X | | X | |
| 43. *Pseudagrion rubriceps* Selys, 1876 | X | | | | |
| 44. *Pseudagrion microcephalum* (Rambur, 1842) | X | X | X | X | |
| 45. *Amphicnemis gracilis* Kruger, 1898 | | X | | | |
| 46. *Ceriagrion cerinorubellum* (Brauer, 1865) | | | | X | |

Table 2: Continued

| | | | | | |
|---|---|---|---|---|---|
| FAMILI: CALOPTERYGIDAE | | | | | |
| 47. *Vestalis gracilis* (Rambur, 1842) | | | X | | X |
| 48. *Neurobasis chinensis* (Linnaeus, 1758) | | | | | X |
| FAMILI: CHLOROCYPHIDAE | | | | | |
| 49. *Libellago lineata* (Burmeister, 1839) | | | | | X |
| 50. *Heliocypha biforata* (Selys, 1859) | | | X | | |
| FAMILI: PLATYSTICTIDAE | | | | | |
| 51. *Drepanosticta fontinalis* Lieftinck, 1937 | | | | | X |
| FAMILI: PLATYCNEMIDIDAE | | | | | |
| 52. *Coeliccia octogesima* (Selys, 1863) | | | | X | |
| 53. *Copera vittata* (Selys, 1863) | | | | X | |
| FAMILI: AMPHIPTERYGIDAE | | | | | |
| 54. *Devadatta argyoides* (Selys, 1859) | | | | X | |
| Number of Species | 11 | 13 | 24 | 24 | 26 |

ecorded was 26 species in Penang. Previous record by Kitagawa [22] recorded a total of 54 species Odonata in Penang Island, with 17 new records in the northern region. Pangkor Island and Langkawi Island recorded 24 species of odonates in each island. Only 11 species of Odonata was found in Besar Island because the environment of this island is dry with no river drainage. Most of the adults and larvae were collected from two stagnant pools in the golf course. A main water resource in Besar Island is from underground water wells. A lot of wells can be seen around this island. Some are still being used for water supply while some are abandons old wells and covered with steel net.

The Suborder Anisoptera was represented by 4 families and Zygoptera represented by 8 families. Libellulidae was the most common anisopteran family, represented by 24 species. A very rich assemblage of Libellulidae was recorded in these five islands, which is not unusual for this diverse family group [24]. Libellulidae are adaptable to various environments with wide variety of habitats and very tolerant to low dissolve oxygen (DO) levels or highly eutropic environments [25]. Gomphidae had 5 representatives, among this, the key highlight is the endemic species of Langkawi Island, *Megalogomphus icterops*, only an adult male was successfully captured. Worldwide, the genus *Megalogomphus* is represented by 11 species while in Malaysia there are only two species; namely *Megalogomphus sumatranus* and *Megalogomphus icterops* [18]). *Megalogomphus icterops* is a little larger than *M. sumatranus* (hindwing, 43-45 mm) and inhabit clear forest streams open to sunlight. This species is widespread in Sundaland but in Peninsular Malaysia is recorded only from Langkawi Island [20]. The other two anisopteran subfamilies were Cordullidae and Aeshnidae, with three and one representatives subsequently.

The sub order Zygoptera had smaller representatives, with 21 species from four families. The family Coenagrionidae is well presented with 8 species. Pangkor Island recorded the highest number of Zygopteran species with 10 species and the least is Besar Island, only with three species. Nevertheless, a new record of a Coenagrionidae was found in Langkawi Island, *Ceriagrion praetermissum*, Lieftinck 1929. Four individuals, three male and a female was captured. Orr [18, 20] listed six species of *Ceriagrion* in Peninsular Malaysia and two species in Borneo. Only *Ceriagrion cerinorubellum* was found in Peninsular Malaysia and Borneo. An article about this new record will be published later.

Another interesting species is *Neurobasis chinensis*, belonged to the Calopterygidae family, recorded from Penang Island. Individuals of adult and larvae were successfully captured at the site. This species, like other members of the Calopterygidae, occur in pristine habitats such as clear forest streams and swamp forest where there is good water quality [18]. *Neurobasis chinensis* has the potential to act as bioindicators of rivers with diverse substrates and fast flowing undisturbed water [26].

The Shannon, Simpson and Evenness indices were calculated as a measure of diversity in different habitats of the five islands. The Shannon's diversity index indicated that Penang Island is relatively diverse (H' = 2.945), followed by Langkawi Island (H'=2.916), Pangkor Island (H'= 2.346), Besar Island (H'=2.12) and the lowest diversity index was Pulau Carey (H' = 1.949). For the Simpson's diversity index, also revealed almost the same order except, the third most diverse island was Carey Island (S'=0.8193) and Besar Island was the least diverse (S'=0.8163) (Table 3). Penang Island and Langkawi island are big islands with an area more than 200 $km^2$ and these two island showed higher diversity indices compared to the other three islands.

Table 3: The Shannon's Diversity Index (H'), Evenness Index (E') and Simpson's Diversity Index (D')

| | E' | H' | D` |
|---|---|---|---|
| Besar Island | 0.853 | 2.120b | 0.8163 |
| Carey Island | 0.784 | 1.949c | 0.8193 |
| Langkawi Island | 0.918 | 2.916a | 0.9319 |
| Pangkor Island | 0.738 | 2.346ab | 0.8175 |
| Penang Island | 0.893 | 2.945a | 0.9348 |

Studies by researchers showed a positive correlation between island area and species diversity and it has been so widely documented that it comes close to be a universal ecological 'law' [27, 28, 29, 30]. Area might influence species diversity directly in two ways; (1) larger island present larger target for individual dispersal and (2) they generally able to support larger population of flora and fauna [31]. There was a significant different in H' values among the islands (Table 3). Penang Island had significantly higher H' value than the Carey Island but not with Langkawi Island, Pangkor Island and Besar Island. Although Penang Island and Langkawi Island have been known to be highly disturbed habitat for ordonates, the size is contributing factors to its high H' value as compared to the other Islands. As expected and according to MacArthur and Wilson [31] habitat size, beside distances from the other islands for proof to be among the determine factors for insect population, abundance and species diversity.

In conclusion, Orr [18] listed a total of 230 species of Odonata in Peninsular Malaysia (including Singapore). Mean while, this study had listed 54 species from five islands within the Straits of Malacca and, it's approximately 25% of the odonates fauna documented in Orr [20]. Therefore, more sampling efforts are needed to be done in these islands in the future. Furthermore, most of the species found in these islands were adapted to clean environment. The presence of Gomphidae, Protoneuridae, Calopterygidae, Corduliidae, Chlorocyphidae reflected such condition. Most of the species preferred overhanging vegetation with various microsites for perching, as well as wide range of provision and concealment from their predators.

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