
Review Article

Studies on Congregating Fireflies (Coleoptera; Lampyridae; *Pteroptyx* sp.) in Sabah, Malaysia: A Review

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Abstract

Five species of congregating firefly (Lampyridae; *Pteroptyx* sp.) in mainly mangrove forests of Sabah, Malaysia have been recorded. The recorded species are *P. tener*, *P. bearni* (formerly known as *P. similis* in Sabah), *P. gelasina*, *P. valida*, and *P. malacciae*. In certain parts of Sabah, these congregating fireflies are used in firefly-watching activities. This activity has no negative impact on the mangrove ecosystem, and it helps generate a profitable 13for local tourism operators. In light of this, congregating fireflies could be designated as umbrella species for the conservation of the mangrove ecosystem. However, in spite of the number of studies on congregating firefly in Sabah, only a few scientific findings have been reported and published locally. In this paper, the authors compiled and reviewed Sabah's congregating firefly studies. The compilation reveals that firefly studies were concentrated at the Klias peninsula, and were mainly focused on species diversity, population density, description of their habitats and display trees; while bionomics and life-cycle of these congregating fireflies are scantily known. Apart from Klias peninsula, the other areas studied and findings published are for the Kinabatangan floodplain, Paitan, Tuaran, Sepilok, Pulau Sakar off the coast of Lahad Datu and Kawang River, while another four unpublished studies were also included. More scientific studies are needed since the only habitat for congregating fireflies, the mangrove area, is fast depleting due to infrastructural development and mangrove deforestation pressures.

Keywords: *Pteroptyx*, fireflies, mangrove, Sabah, Malaysia

Introduction

Large congregations and synchronous flashing of fireflies in wetland areas were reported as early as 1680 by Dutch physician Engelbert Kaempfer in 1680 after his voyage downriver from Bangkok to the sea (Buck & Buck, 1968). These fireflies are actually from the genus *Pteroptyx* which have the unique characteristics of large congregations and synchronous flashing (Ohba & Sim

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1994; Ohba, 1999). So far, this phenomenon is only recorded in Southern Asia and the western Pacific, from East India through Thailand, Malaysia and Indonesia to the Philippines and Papua New Guinea (Hogarth 1999). All synchronous displays occur in trees or shrubs along tidal rivers in mangrove-nypha swamps (Ballantyne & McLean, 1970).

Fireflies are not actually "flies." They are beetles in the family Lampyridae. True "flies" have one pair of wings (like houseflies) while all other winged insects have two pairs of wings, or, four wings altogether. Fireflies have the ability to emit light through chemical reactions from the light organ which is located at the tip of their abdomen. The synchronous flashing of large congregations of fireflies gives a spectacular view along river banks, attracting nature lovers and tourists. It has been hypothesized that synchrony facilitates the female's ability to recognize her conspecific male's flash pattern (Buck & Buck 1968). A recent finding suggests that synchronous flashing is a behavioral strategy to minimize visual clutter (Moiseff & Copeland, 2010).

In Peninsular Malaysia, firefly tourism has become a popular attraction ever since it was introduced in the 1980s (Syed et al., 2001). Kampung Kuantan (upstream) and Kampung Bukit Belimbing (downstream) in Kuala Selangor are two important sites for this activity. Here, firefly tourism was commercialized since 1985 and 1997 respectively. The species of firefly which dominate at Kampung Kuantan has been identified as *Pteroptyx tener* along with two other species, *P. valida* dan *P. malaccaae*. In 1999, it was estimated that about RM50,000 was earned in a month from firefly tourism in both sites (Menayah, 2001). Fireflies in Kuala Selangor are being studied quite extensively by the Malaysian Nature Society. However in Sabah, very few studies on fireflies have been carried out so far.

Firefly (*Pteropteryx* spp.) Studies in Sabah

Firefly study has currently been a subject of interest because this particular insect has the potential of becoming a product for nature tourism in Sabah. Their ability to produce rhythmic, synchronous flashing lights in large population densities has made them an attraction. In addition, the loss of their natural habitat, the mangrove forests, has caused their extinction in several places, making them a subject for serious study. The firefly that has the potential as a nature tourism product is the one from the genus *Pteroptyx*. This genus has the unique characteristics of large congregations and synchronous flashing (Ohba & Sim, 1994; Ohba, 1999). To date, this phenomenon is only recorded in southern Asia and western Pacific, from East

India through Thailand, Malaysia and Indonesia to the Philippines and Papua New Guinea (Hogarth, 1999). In the Oriental region, congregations of these magnificent insects can be only found principally from mangrove trees along brackish rivers (Buck & Buck, 1968).

Ballantyne (2001) reported 11 species of this genus in South East Asia and added another four new species later in 2015 (Ballantyne et al., 2015). In the past, studies in Sabah were only focused on the taxonomic revisions of specimens collected by Ivan Polunin from a wide selection of localities, and supported by field data. From this collection, four species of *Pteroptyx* have been recorded in Sabah (Ballantyne, 2001). The first one, *P. gelasina* from Sipitang River was collected in 1970 and this specimen has been made as the holotype specimen of this species. Four other specimens were collected in Likas and kept as paratypes. Apparently, this species no longer exists in Likas at present time. The second species is *P. similis*, collected from Kudat Bay in 1970 and has been made as the holotype specimen of this species. Five other specimens were collected in Likas, and kept as paratype specimens. This species has also been wiped out from Likas. The third species, *P. malaccae*, was collected from Sipitang River in 1970 and the fourth species, *P. tener* was collected in Abai, Lower Kinabatangan in 1970. In a recent development of firefly study, *P. similis* which was thought to be endemic to Sabah (Ballantyne 2001) is actually a synonym to *P. bearni*, which is commonly recorded in many places in Peninsula Malaysia (Ballantyne & Lambkin, 2013). In 2007, Mahadimenakbar et al. discovered a fifth species, *P. valida* from Garama River at Klias peninsula, Sabah. The differences between the five species are shown in figure 1.

Presently in Sabah, there are a few places where we can see large population density of congregations of fireflies flashing and some even show mass synchrony among them (especially *P. tener*, and some said *P. malaccae*, but not other species in the genus). Almost all other natural habitats have been wiped out following infrastructural development, such as in the Likas area. Mangroves in Likas are now not suitable for sustaining firefly populations due to human disturbances. These disturbances do not only bring pollutants to mangrove areas but also artificial light, which disturbs light communication among fireflies, eventually eliminating their populations.

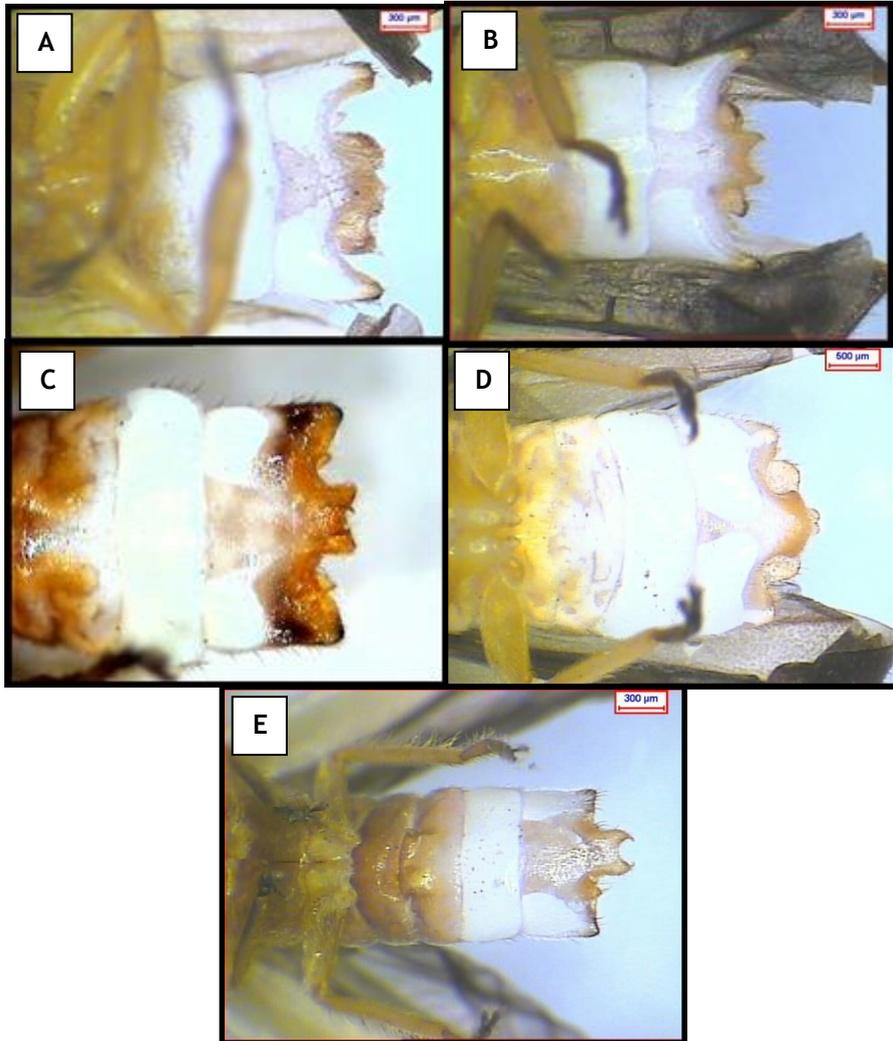


Figure 1. The morphological features of apex of abdomen of males of the five different species of *Pteroptyx* found in Sabah. **A** *P. malaccae*, **B** *P. gelasina*, **C** *P. bearni*, **D** *P. valida*, and **E** *P. tener*

In the west coast of Sabah, congregations of fireflies can be seen in many rivers in Klias Peninsular. Fireflies can be found along Garama River, Binsuluk River, Klias River, Teratak River and many other rivers towards Weston. Here, *P. bearni*, *P. tener*, *P. malaccae* and *P. valida* can be found living together in

the same rivers but in different colonies (Chey, 2004; Mahadimenakbar et al., 2007; Chey, 2010). *P. bearni* and *P. tener* were the two most common species spotted in the area while *P. malacca* and *P. valida* were quite rare (Mahadimenakbar et al., 2007). From all of these species, only *P. tener* is known to flash synchronously in large numbers (Chey, 2010). *Rhizophora apiculata*, *Ficus microcarpa*, *Clerodendrum inerme*, *Glochidion littorale*, *Bruguiera parviflora*, *Nypa fruticans*, *Excoecaria indica*, *Ficus benjamina* and *Hibiscus tiliaceus* were listed as the display trees for the fireflies (Mahadimenakbar et al., 2007; Chey, 2010). In Kampung Garama, firefly tourism has been commercialised as a part of tourism packages, and this is a similar case in Kampung Padang Teratak and in Weston. There are a few tour operators operating in these areas. In Teratak River however, the species compositions were a bit different. *P. bearni* dominated the area while *P. valida*, *P. malacca* and *P. tener* were found in smaller proportions (Foo & Mahadimenakbar, 2015).

Apart from Klias Peninsular, another place in the west coast of Sabah where fireflies are abundant is in Trayong, Tuaran. Here, *P. bearni* was reported as the most common firefly species while *P. gelasina* was the less common one, found on two dominant mangrove trees, *Scyphiphora hydrophyllacea* and *Lumnitzera littorea* (Chey, 2009). In the east coast, congregations of synchronous flashing fireflies are mainly found in Kinabatangan Floodplain. The best place to see these fireflies is at Kampung Abai. We can see congregations of fireflies flashing in unison on mangrove trees, *Sonneratia caseolaris* along brackish rivers. Danau Pitas, an ox-bow lake, located about 10 minutes from Kampung Abai is a good spot to see these fireflies. Here we can see thousands of *P. tener* flashing synchronously, mostly on *Excoecaria indica* (Mahadimenakbar et al., 2003).

In the northern part of Sabah in Paitan River, *P. bearni* and *P. gelasina* were reported to be found on *Avicennia alba*, *Rhizophora apiculata*, *Scyphiphora hydrophyllacea* and *Xylocarpus granatum* (Chey, 2006). The same species of fireflies can also be found in the north eastern part of Sabah, in the mangrove forests of Sepilok Forest Reserve (Chey, 2008). Although there are many rivers and tributaries that are believed to be potential habitats of fireflies in the northern region of Sabah, not many studies have been conducted in these areas. Table 1 summarizes the published / in press studies so far conducted in Sabah.

Table 1. Summarized of published / in press studies on congregating fireflies found in Sabah

River/area	Firefly species	Display tree	Source of info	Remarks
Kawang River	<i>P. bearni</i> & <i>P. malacca</i>	<i>Rhizophora mucronata</i> , <i>Aegiceras floridum</i> & <i>Lumnitzera littorea</i>	Foo & Mahadimenakbar (in press)	Random samplings 3 sampling occasions
Teratak River	<i>P. bearni</i> , <i>P. valida</i> , <i>P. malacca</i> & <i>P. tener</i>	<i>Avicennia alba</i>	Foo & Mahadimenakbar, 2015	10 display trees (stations) 6 sampling occasions
Sakar Island off coast of Lahad Datu Sabah	<i>P. bearni</i> & <i>P. gelasina</i>	<i>Scyphiphora hydrophyllacea</i> , <i>Rhizophora apiculata</i> , <i>Rhizophora mucronata</i> , <i>Rhizophora stylosa</i>	Chey, 2011	6 display trees (stations) 1 sampling occasion Threats from oil palm plantation
Garama River, Beaufort	<i>P. bearni</i> , <i>P. malacca</i> & <i>P. tener</i>	<i>Rhizophora apiculata</i> , <i>Ficus microcarpa</i> , <i>Clerodendrum inerme</i>	Chey, 2010	7 display trees (stations) 1 sampling occasion Threats from oil palm plantation
Klias River, Beaufort	<i>P. bearni</i> , <i>P. malacca</i> & <i>P. tener</i>	<i>Rhizophora apiculata</i> , <i>Glochidion littorale</i>	Chey, 2010	4 display trees (stations) 1 sampling occasion Threats from oil palm plantation
Trayong, Tuaran	<i>P. gelasina</i> & <i>P. bearni</i>	<i>Scyphiphora hydrophyllacea</i> , <i>Lumnitzera littorea</i>	Chey, 2009	Random samplings 09/07, 01/08, 05/08 6 sampling occasions
Mangrove of Sepilok Forest Reserve, Sandakan	<i>P. gelasina</i> & <i>P. bearni</i>	<i>Lumnitzera littorea</i> , <i>Rhizophora apiculata</i> , <i>Scyphiphora hydrophyllacea</i> , <i>Rhizophora mucronata</i>	Chey, 2008	10 display trees (stations) 1 sampling occasion

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Table 1. (continued)

River/area	Firefly species	Display tree	Source of info	Remarks
Garama River, Klias	<i>P. bearni</i> , <i>P. tener</i> , <i>P. malaccas</i> , <i>P. valida</i>	<i>Rhizophora apiculata</i> , <i>Bruguiera parviflora</i> , <i>Nypa fruticans</i> , <i>Excoecaria indica</i> , <i>Ficus benjamina</i> , <i>Hibiscus tiliaceus</i>	Mahadimenakbar et al., 2007	14 display trees (stations) April-June 2004 6 sampling occasions Light pollution from nearby villages
Paitan River	<i>P. bearni</i> & <i>P. getasina</i>	<i>Avicennia alba</i> , <i>Rhizophora apiculata</i> , <i>Scyphiphora hydrophyllacea</i> & <i>Xylocarpus granatum</i>	Chey, 2006	4 display trees (stations) 1 sampling occasion
Klias River	<i>P. tener</i>	<i>Heritiera littoralis</i> , <i>Rhizophora apiculata</i> , <i>Excoecaria indica</i> , <i>Ficus sp.</i> & <i>Sonneratia alba</i>	Chey, 2004	1 sampling occasion
Kinabatangan River	<i>P. tener</i>	<i>Sonneratia caseolaris</i> & <i>Excoecaria indica</i>	Mahadimenakbar et al. 2003	Random samplings

Wong 2010 has produced a poster showing the congregating firefly zones (CFZ) throughout Malaysia. The distribution of these zones in Sabah is shown in figure 2.

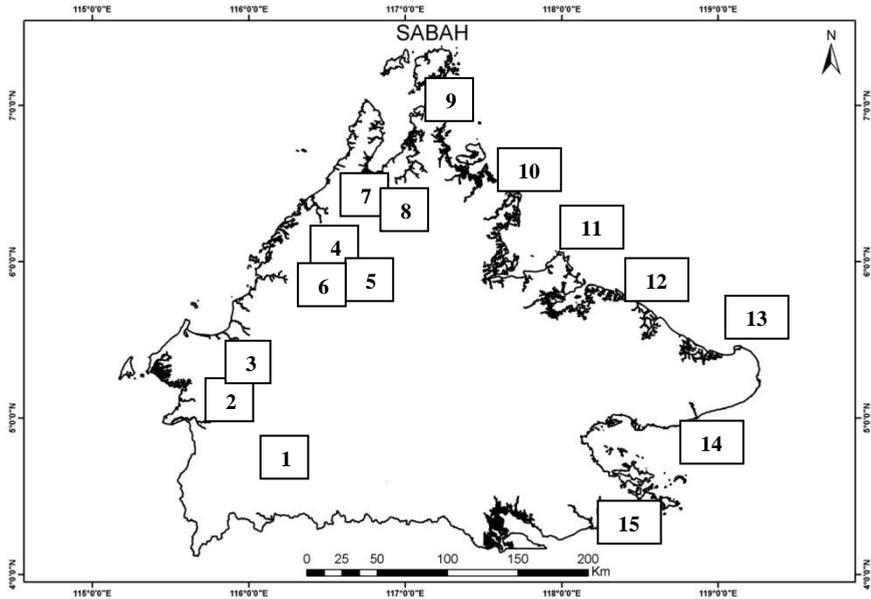


Figure 2. Congregating firefly zones (CFZ) in Sabah. 1- Sipitang River (s), (n); 2- Padas River-Weston Nature Park; 3- Klias-Binsulok-Garama Rivers (s), (n); 4- Likas River (s); 5- Likas Wetland (s); 6- Kinarut-Kawang Rivers, (s); 7- Mengkabong River, Tuaran (s),(n); 8- Kampung Sabandar, Tuaran (s), (n); 9- Kudat Bay (s); 10- Paitan River (s), (n); 11- Sugut River, Sabang Estate; 12- Sepilok Kecil River (s),(n); 13- Kinabatangan River, Danau Pitas (s); 14- Pulau Sakar, Lahad Datu (s), (n); 15- Semporna River-Pegagau-Tawau area (s), (n); (S) = synchronous fireflies; (n) = non-synchronous fireflies. Adapted from Wong 2010.

At the moment, studies are being conducted to study the ecology and habitat of these fireflies and to see the potential of these insects as a product of nature tourism in Sabah. Apart from that, the natural requirements of this insect are being investigated based on existing physical conditions and observations to obtain more accurate data and understanding. This includes the relationship between fireflies and their display trees, food chain and life circle. References on firefly ecology are limited, making the effort to study this organism difficult and challenging. At present time, our knowledge on this organism is based much on reports from the Malaysian Nature Society and also from a Japanese researcher, Dr. Ohba who has carried out a similar study in Singapore on *P. valida* (Ohba & Sim, 1994). The development of firefly tourism

as a tourist attraction obviously requires knowledge on the biology and ecology of firefly populations. It also needs careful planning and implementation to avoid environmental pollution which will eventually lead to population extinction.

There are also a few unpublished and ongoing studies on fireflies conducted by bachelor and postgraduate students. These studies, although unpublished, have a lot of information that need to be shared in the scientific world (Table 2).

Table 2. Summarized of unpublished studies on congregating fireflies found in Sabah

River/area	Firefly species	Display tree	Source of info	Remarks
Si Jam Jam River, extension Bukau-Maraba River and Bukau River, Weston	<i>P. tener</i> , <i>P. malacca</i> & <i>P. bearni</i> .	<i>Sonneratia caseolaris</i>	Lim, 2016. MSc theses, unpublished	Only 1 sampling occasion, 30 stations
Beringis River	<i>P. bearni</i> & <i>P. gelasina</i>	<i>Rhizophora apiculata</i>	Azizul Shararudin 2011. BSc theses, unpublished	20 sampling stations, 6 sampling occasions
Likas Wetland, Kota Kinabalu	<i>P. bearni</i>	<i>Avicennia alba</i>	Walters 2010. BSc theses, unpublished	4 sampling stations
Klias River	<i>P. tener</i> , <i>P. malacca</i> & <i>P. valida</i>	<i>Excoecaria indica</i> , <i>Heritiera littoralis</i> , <i>Cerbera odollam</i> , <i>Hibiscus tiliaceus</i> , <i>Ficus benjamina</i> , <i>Sonneratia alba</i> , <i>Rhizophora apiculata</i> , <i>Nypa fruticans</i> , <i>Hernandia nymphaeifolia</i> , <i>Barringtonia racemose</i> , <i>Acrostichum sp.</i> & <i>Acacia magnum</i>	Poukin 2007. MSc theses, unpublished	12 sampling occasions

Discussion

In Malaysia, most of the detailed published firefly studies were in West Malaysia (Wan Jusoh, 2010a; Wan Jusoh, 2010b; Wong & Yeap, 2012; Wan Juliana et al., 2012). In East Malaysia, the published studies mainly mention the presence of fireflies and their display trees (Chey, 2004; Chey, 2006; Chey 2008; Chey, 2009; Chey, 2010; Chey, 2011). Furthermore, most of the studies whether published or unpublished, were concentrated in the west coast of Sabah. This could be due to easy access to these locations coast as compared to other areas. More work needs to be done at other places such as in north and east Sabah. Most of the published studies were short term ones, mainly looking at the diversity of fireflies and their display trees, and all were published locally. Long term and detailed studies are very scarce. The detailed ecological studies, i.e. studies made for gaining Masters and Bachelor degrees were not published by the researchers, as shown in Table 2 above. More studies on life cycles, habitat requirements and preferences as well as disturbances and threats to the firefly populations should be done and published in international journals.

Pteroptyx sp. can be used as an umbrella species to protect mangrove ecosystems through the firefly watching activity, which can be done all year-round. It has the potential to attract a lot of tourists. Thus, another scope of study that relates to firefly watching that could be done is on the survival of this tourism activity, similar to what has been done in Kuala Selangor (Moktar et al., 2010). Another type of study could be to look at conservation consciousness among tourists involved in firefly watching activities. Apart from that, involvement of the local community in firefly watching activities appears to be increasing and may play a role in preserving the habitat of fireflies because of the perceived economic benefits. Studies on this aspect should also be carried out.

There is an urgent need to protect and conserve the unique congregating fireflies as well as the inter-tidal mangrove estuaries, freshwater swamp and riparian forests that forms their habitat. These forests are in imminent danger of being lost as a result of rapid and indiscriminate clearing for quick socio-economic benefits such as mangrove clearing for oil palm plantations (Chey, 2010; Chey, 2011). Oil palm plantations could reduce firefly habitats and hence adversely affect the firefly population (Chey, 2010). Erosion and application of chemical fertilizers in plantations cause pollution and subsequently decimation of wildlife including fireflies (Chey, 2011). Climate change may also threaten the survival of fireflies, as decreasing rain or rising

sea levels will increase salt water intrusion and wave action (Wong & Yeap, 2012).

Conclusion

The occurrence of congregating firefly populations can be wisely manipulated for tourism. This will directly provide benefits to local communities. Due to their importance in tourism, fireflies can be considered as an umbrella species that can be used to protect the whole mangrove ecosystem. Despite their popularity as a tourist attraction, comprehensive studies on them were very limited. More studies on firefly bionomics should be carried out in Sabah. Upon completing the studies, these should be published at least in local journals.

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