Notes on Congregating Fireflies (Coleoptera, Lampyridae) of Binsulok River, Sabah

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ABSTRACT

A brief survey on congregating fireflies of Binsulok River was conducted on September 9th and 16th, 2017. Altogether 9, sampling stations were selected among the displaytrees,of Rhizophora apiculata. Water quality parameters were also recorded close to each sampling station. This is the first record where all 5 Pteroptyx species recorded in Sabah were found in a single area on 1 species of display tree. P. bearni was the predominant species with 33 male individuals, followed by P. tener (5 males), P. valida (5 males), P. gelasina (2 males) and P. malaccae (1 male) were sampled. In terms of water quality, only water pH (which was mostly acidic, mean pH 4.51 ± 0.03), and low dissolved oxygen (D.O., mean 3.36 ± 0.64 mg/L), can be considered not suitable for aquatic life, which could contribute to the decreasing population of fireflies, as larvae of fireflies feed on river snails. An aerial survey of the area by a drone showed that there were some encroachment and land use changes from its original mangrove forest. However, these results could not be quantifiable but this survey suggested that the land usage could contribute to the firefly population decline.

Keywords: fireflies, *Pteroptyx*, mangrove forest, conservation.

Introduction

Fireflies are beetles (Order Coleoptera) under the family Lampyridae. Beetles in this family have the ability to emit light from luminous organs located at the tip of their abdomen. Fireflies use their flashing signals to attract the opposite sex of the same species (Ohba & Sim, 1994, Ohba, 1999). Their ability to produce rhythmic synchronous flashing light in large

population densities has made them to become an attraction (Buck 1988). Furthermore, the loss of their natural habitat, the mangrove forests, has caused their extinction in several places, making them a subject for serious study (Ballantyne *et al*. 2011). The firefly that has the potential as ecotourism product is the one from the genus *Pteroptyx* (Mahadimenakbar *et al.* 2009). There are currently five *Pteroptyx* species, namely *P. bearni*, *P. tener, P. malaccae, P gelasina*, and *P. valida,* that can be found in Sabah (Mahadimenakbar & Fiffy, 2016). *P. similis* Ballantyne, which thought to be endemic to Sabah (Ballantyne 2001), is now synonymised with *P. bearni* (Ballantyne & Lambkin 2013).

Each species has a unique flashing frequency and their courtship involves an exchange of flashing signals at dusk or after dark. In general, they can be divided into three different groups, which are 1) the congregating synchronous flashing type; 2) the congregating non-synchronous flashing type; and 3) the solitary fireflies. The congregating firefly is commonly found in the mangrove regions of South-east Asia (Hogarth, 1999). In the Oriental region, the congregations of these magnificent insects can only be found principally from mangrove trees along brackish rivers (Buck & Buck, 1968). All synchronous displays occur in trees or shrubs along tidal rivers in mangrove-nypa swamps (Ballantyne & McLean 1970).

Malaysia is blessed with an abundance of these congregating species in most of the mangrove inter-tidal rivers where the numbers depend wholly on the health of the riparian forest and the water quality. In order to ensure the fireflies can survive in their natural habitats, it is crucial to conserve the habitat that the insects reside in (Foo & Mahadimenakbar 2015). Assessments of the area and baseline scientific studies are needed to determine the population status of the fireflies for the conservation planning and development (Foo & Mahadimenakbar 2017).

Methodology

Binsulok River is located in Klias Peninsula. It is a potentially good destination for nature tourism and environmental education (Mohamed *et. al*., 2000). Initial population survey was conducted on 9th September 2017, followed by a sampling occasion on 16th September 2017 in

Binsulok River. Prior to sampling activity, aerial photos were taken by using a drone at selected points of the surveyed area to study potential threats to the populations of fireflies.

In the evening, fireflies were surveyed from the boat berth (N 05°31’27.0” E 115°43’03.2’’) where tourists start their journey for river cruising up to the end point (N 05°31’50.3” E 115°42’05.0’’).

For the sampling occasion, the surveyed area was divided into 3 sections, where 3 display trees (sampling stations) with most firefly congregation were sampled at each section. Fireflies were sampled by using an aerial net for approximately 2 minutes. Specimens collected from each display tree were placed in separate plastic bags (Foo & Mahadimenakbar, 2016).

The plastic bags were later brought to the lab and kept in a freezer overnight to kill all the specimens. Specimens were later transferred to vials containing ethanol solution 75%. Specimens were then identified based on reference collections in Universiti Malaysia Sabah.

In addition, there were 6 aquatic i.e, pH, water temperature, dissolved oxygen (DO), conductivity, salinity and total dissolved solid (TDS) and 4 terrestrial parameters i.e. wind speed, relative humidity (RH), ambient temperature and light intensity (LI) from 3 sections (1) Boat berth – Starting point (N 05°31’27.0” E 115°43’03.2’’), (2) Mid-point (N 05°31’34.9” E 115°42’34.2’’) and (3) End-point (N 05°31’50.3” E 115°42’05.0’’) were recorded with 3 replicates (A-I) for each section. Aquatic variables were recorded by using Eutech Instruments PCD650 Multiparameter Meter while other terrestrial variables were recorded by using Kestrel 5500 Portable Weather Meter.

Results and Discussion

1. Species Diversity

In terms of firefly species, all five (5) *Pteroptyx* fireflies that are recorded in Sabah were found from the area, namely *P. bearni*, *P. tener*, *P. malaccae*, *P gelasina*, and *P. valida*. This was the first record in Sabah where all five *Pteroptyx* species were recorded in a same area (Table 1). Binsulok can be considered a good place for congregating fireflies since in a short study

conducted (one sampling occasion on nine display trees) can generate all five *Pteroptyx* species found in Sabah. The display trees were all from the same species, *Rhizophora apiculata* (Nilus *et. al.* 2010).

This result suggested that Binsulok River has the highest number of species in one area in Sabah compared to other firefly sites reported earlier such as Klias, Paitan, Sepilok, Tuaran, Beaufort, and Pulau Sakar (Chey 2004; Chey 2006; Chey 2008; Chey 2009; Chey 2010; Chey 2011).

Table 1. The number of samples collected on each display Tree.

Station		*P. bearni*	*P. tener*	*P. valida*	*P. gelasina*	*P. malaccae*
1	A	5	0	3	0	0
	B	5	0	0	0	0
	C	2	0	0	1	0
2	D	3	0	0	1	0
	E	2	0	2	0	0
	F	0	1	0	0	1
3	G	3	1	0	0	0
	H	10	0	0	0	0
	I	3	3	0	0	0
Total		33	5	5	2	1

Throughout Malaysia, there are only seven species of *Pteroptyx* recorded, and in Sabah, only five have been confirmed. All five *Pteroptyx* species in Sabah can be found in Binsulok River. This result also suggests that Binsulok River has the richest species of congregating fireflies in Sabah, hence the need to conserve the area.

2. Land Use

The drone survey has shown that there is a small patch of palm oil plantation, a poultry farm, few small watermelon farms and disused villager's garden patches. The drone survey also revealed that there is a significant construction of roadwork in the pristine area of the mangrove across the Binsulok Nature Resort. These results could not be quantifiable but this survey suggested that these land use changes could contribute to the firefly populationdecline.

However, from the researcher's point of view, this only has a small effect, as the visibility of fireflies sighted during research was still high compared to other fireflies' research sites in Sabah.

3. Aquatic and Terrestrial Parameters

The survey for aquatic and terrestrial parameters suggest that most organisms living in estuaries prefer a pH between 6.5 and 8.5. If the pH drops below 5.0 or goes above 9.0, many marine organisms will have trouble surviving (Robertson-Bryan 2004). In Binsulok, water pH recorded from all stations were below 5.

Water temperature recorded was between 28.2-28.4 °C and this is considered normal in tropical area (Table 2).

Table 2. The results of the aquatic and terrestrial parameters. Standard error of the means (SE$\bar{x}$) were calculated:

Station		Parameters									
		pH	Water Temp (°C)	DO (mg/L)	EC (µS/cm)	Salinity (mg/L)	TDS (mg/L)	Wind Speed (m/s)	RH (%)	Ambient Temp (°C)	LI (lux)
1	A	4.77	28.3	4.14	92.76	130	59.22	0.0	82.9	28.3	0.0
	B	4.54	28.2	4.82	92.54	150	60.15	0.0	82.0	28.2	0.0
	C	4.53	28.3	7.75	91.49	180	58.55	0.0	82.9	28.3	0.0
2	D	4.48	28.4	2.29	104.6	170	66.94	0.0	85.8	27.9	0.0
	E	4.47	28.4	1.44	115.1	110	73.66	0.0	85.8	27.8	0.0
	F	4.47	28.4	2.14	109.4	170	70.01	0.0	85.8	27.9	0.0
3	G	4.46	28.4	2.69	116.4	140	74.49	0.0	88.7	27.3	0.0
	H	4.46	28.4	2.69	118.5	130	75.84	0.0	87.2	27.6	0.0
	I	4.45	28.4	2.31	115.8	150	74.11	0.6	86.7	27.7	0.0
Mean ± SE		4.51 ± 0.03	28.36 ± 0.02	3.36 ± 0.64	106.29 ± 3.77	147.78 ± 7.60	68.11 ± 2.37	0.07 ± 0.07	85.31 ± 0.75	27.89 ± 0.11	0.00

Data on dissolved oxygen DO (mg/L) showed that dissolved oxygen in Sungai Binsulok was quite low. Most stations gave readings lower than 5 mg/L. Only station 1 C gave reading above 5 mg/L. This indicated that Binsulok River has low dissolved oxygen which is crucial for aquatic organisms to survive. Dissolved oxygen above 5 mg/l is needed for most marine plants and animals to survive because they can get plenty of oxygen to breath. When the dissolved oxygen is low, below 3 mg/l, the water is called hypoxic. If all the dissolved oxygen is used up, below

0.5 mg/l, the water is called anoxic. Under hypoxic conditions, many marine plants and animals may not survive. No marine plants and animals that require oxygen can survive in anoxic conditions. However, further water quality analysis has to be done in order to ensure the status of water quality of the river as the data obtained from this study were too minimal to determine the status.

Electric Conductivity (µS/cm) readings showed Binsulok River is not very salty since readings from all stations were between 118.5 (max) – 91.49 (min) µS/cm. The more ions that are present, the higher the conductivity of water. Most fresh drinking water will have less than 100 µS/cm conductivity. Very brackish water could be around 27,000 µS/cm. Seawater has conductivity of around 54,000 µS/cm.

The average ocean salinity is 35ppt (35,000 mg/L) and the average river water salinity is 0.5ppt (500 mg/L) or less. Because the water in estuaries is a mix of fresh water and ocean water, the salinity in most estuaries is less than the open ocean. Salinity of Binsulok River was between 110 to 180 mg/L.

Total dissolved solids (TDS) is defined as all inorganic and organic substances contained in water that can pass through a 2 micron filter. TDS is anything—other than the pure water—in water that cannot be seen. This could include any salt, metal or mineral, and the lower the TDS level is, the purer the water. The range of TDS of Sungai Binsulok was between 58.88 - 75.84 mg/L and this level is considered excellent.

All other terrestrial parameters (Wind speed, relative humidity, air temperature and light intensity) did not show any peculiar patterns. Light intensity readings were all showed no reading because measurements were made at night time, indicating that there were no light pollution at the display trees.

Only two tests out of 10 came back with two negative results. The low pH (acidic) and the low dissolved oxygen (hypoxic) of the river water also could contribute to the decreasing population of the fireflies. Since the eight other tests have shown positive results, it shows the river is still healthy hence the high visibility of firefly sightings.

Conclusions

Binsulok river has the highest species richness of congregating fireflies compared to other studied areas in Sabah. All five species are available and were able to be recorded in a short study period.

From the water quality study, two variables, pH and dissolved oxygen (DO) showed range of values that is of concern as these variables are important for the survival of many species.

Photos taken from the drone showed that there were some anthropological disturbances of the natural habitat. This, if not controlled, can give a considerable impact to the firefly populations as fireflies are very dependent on their natural habitat for their survival since they need swampy areas as breeding grounds, good and healthy mangrove trees as their display trees and a high abundance of snailsas source of food for the firefly larvae.

References

Ballantyne, L.A. and McLean, M.R. 1970. Revisional studies on the firefly genus Pteroptyx Oliver (Coleoptera; Lampyridae; Luciolinae; Luciolini). *Transactions of the American Entomological Society*, **96:** 223-305.

Ballantyne, L. A. 2001. The bent winged Fireflies of Cambodia, Indonesia, Malaysia, Philippines and Thailand (Coleoptera: Lampiridae: Luciolinae: Luciolini). Pteroptyx spp. Of the Polunin Collection. *Serangga* **6(1):** 51-95.

Ballantyne, L. A. and Lambkin, C. L. 2013. Systematics and Phylogenetics of Indo-Pacific Luciolinae Fireflies (Coleoptera: Lampyridae) and the Description of new Genera. *Zootaxa* **3653 (1):** 1 - 162

Ballantyne, L. A., Fu, X. H., Shih, C. H., Cheng, C. Y. and Yui, V. 2011. *Pteroptyx maipo* Ballantyne, a new species of bent-winged firefly (Coleoptera: Lampyridae) from Hong Kong, and its relevance to firefly biology and conservation. *Zootaxa* **2931:** 8 - 34

Buck, J. and Buck, E. 1968. Mechanism of rhythmic synchronous flashing of fireflies. *Science*, **159:** 1319-1327

Buck, J. 1988. Synchronous Rhythmic Flashing of Fireflies. *The Quarterly Review of Biology* **63 (3):** 265-289

Chey V. K. 2004. Fireflies of Sungai Klias and their display trees. *Sepilok Bulletin* **1:**65–66

Chey V. K. 2006. Fireflies of Sungai Paitan. *Sepilok Bulletin* **5:**1–6

Chey V. K. 2008. Fireflies of Sepilok. *Sepilok Bulletin* **9:**3–11

Chey V. K. 2009. Fireflies of Tuaran. *Sepilok Bulletin* **10:**25–33

Chey V. K. 2010. Fireflies of Beaufort with special reference to Sungai Garama and Sungai Klias. *Sepilok Bulletin* **12:**13–19

Chey V. K. 2011. Fireflies of Pulau Sakar. *Sepilok Bulletin* **13&14:**27–32

Foo, K. and Mahadimenakbar M. D. 2015. Diversity of fireflies (Coleoptera: Lampyridae) of Sungai Teratak, Sabah, Malaysia. *Journal of Tropical Biology and Conservation*. **12:** 1-11.

Foo, K. and Mahadimenakbar M. D. 2016. Short Notes on Fireflies of Sungai Kawang, Sabah. *Journal of Tropical Biology and Conservation*.**13:** 125-128.

Foo, K. and Mahadimenakbar M. D. 2017. Diversity of Pteroptyx Fireflies (Coleoptera: Lampyridae) and Their Display Trees at Klias Peninsula, Sabah, Malaysia. *Journal of Tropical Biology and Conservation* **14**: 95–103

Hogarth, 1999. The Biology of Mangroves. Oxford University Press, Oxford.

Nilus, R, Chung, A. Y. C., Pereira, J. T., Sugau, J. B., Tangah, J., Suzana S., Chong, R. F. Y. 2010. *Mangrove of Sabah: An Introduction to the Flora and Fauna*. Sabah Forestry Department, Sandakan.

Mahadimenakbar M. D. and Fiffy Hanisdah Saikim. 2016. Studies on congregating fireflies (Coleoptera; Lampyridae; Pteroptyx sp.) in Sabah, Malaysia: A review. *Journal of Tropical Biology and Conservation*. **13:** 13-25

Mahadimenakbar M. D., Fiffy H. S. and Elia G. 2009. Studies on the potential of firefly watching tourism for firefly (Coleoptera; Lampyridae; Pteroptyx spp.) conservation. 2009. *Proceedings of JSPS-VCC Core University Program*. International Seminar on Wetland and Sustainability. pp. 351-358.

Mohamed, M., Yusoff, M. and Unchi, S. 2000. *Klias-Binsulok Scientific Expedition*. Universiti Malaysia Sabah.

Ohba N., Sim S. H., 1994. The morphology, behavior and life cycle of *Pteroptyx valida* (Coleoptera; Lampyridae)in Singapore. *Science Report of Yokosuka City Museum* **(42):** 1- 11

Ohba N., 1999. Synchronous flashing of the firefly, *Pteroptyx effulgens* in Papua New Guinea. *Science Report of Yokosuka City Museum* **(46):** 33-40

Robertson-Bryan 2004. Technical Memorandum pH Requirements of Freshwater Aquatic Life. RobertsonBryan,Inc.https://www.waterboards.ca.gov/rwqcb5/water_issues/basin_plans/ph_turbidity/ph_turbidity_04phreq.pdf