THE STUDY OF FIREFLY (COLEOPTERA: LAMPYRIDAE) GENUS *PTEROPTYX* IN WESTON, BEAUFORT, SABAH

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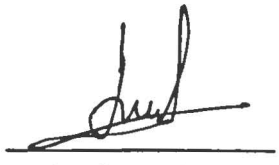
DECLARATION

I hereby declare that the material in this thesis is my own except for quatations, excepts, equations, sumarries and references, which has been duly acknowledge.



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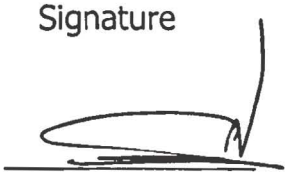

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ABSTRACT

Weston was visited by tourists for firefly watching activities by cruising along the river by boats since 1996. The aims of this study were to assess the health status of firefly congregating zones in Weston and to compare the patterns of firefly swarms against the firefly watching activities. Five sections of the river (Sg. Jam Jam and extension of Sg. Bukau-Sg. Maraba) were selected for river surveys for six moon cycles continuously from November 2011 till May 2012. On each moon cycle, a total of 8 nights of river surveys were done on eight phases of moon phase for every non-raining night. The density of each firefly colony was measured by using a percentage density chart. Parameters such as colony diameter size, wind force, height of the host plants, the abundance of leaves of host plants and relative humidity level were recorded. At the end of the river surveys, fireflies were caught using a sweep net for identification and preservation purpose. A total of 776 sights of fireflies colony were recorded during six cycles of moon. Three *Pteroptyx* species (*P. malaccae, P. tener* and *P. bearni*) were found in Weston. *Sonnerattia caseolaris* (Pidada / Berembang tree) trees were used by fireflies as their host plants. Pearson correlation analysis showed that tree height has a negative weak relationship against fireflies' colonies density (r= -0.188, p= 0.00); while, leaves abundance has a positive very weak relationship against fireflies colonies density (r= 0.101, p= 0.005).

ABSTRAK

KAJIAN EKOLOGI KELIP- KELIP DI WESTON, BEAUFORT, SABAH

Pekan Weston telah dikunjungi oleh pelancong untuk aktiviti pemerhatian kelip-kelip dengan bot dari sungai sejak tahun 1996. Kajian ini bertujuan untuk menilai status kesihatan zon kongregat kelip-kelip di Weston dan kesan aktiviti permerhatian kelip-kelip terhadap kelip-kelip. Pemerhatian telah dijalankan di lima bahagian sungai (Sg. Si Jam jam, Lanjutan Sg. Maraba- Sg Bukau) untuk enam kitaran dari November 2011 sehingga Mei 2012. Pada setiap kitaran bulan, sejumlah lapan malam tinjauan telah dijalankan ke atas 8 fasa bulan untuk malam yang tidak hujan. Kepadatan setiap koloni kelip-kelip telah diukur dengan menggunakan carta peratusan kepadatan dan parameter seperti saiz diameter koloni, kelajuan angin, ketinggian tumbuhan perumah, kepadatan daun tumbuhan dan tahap kelembapan relatif telah direkodkan. Pada akhir kaji selidik, kelip-kelip telah ditangkap menggunakan jaring sauk untuk dikenalpasti dan pengawetan. Sebanyak 776 pemerhatian koloni kelip-kelip telah direkodkan sepanjang enam kitaran bulan. Tiga spesies kelip-kelip Pteroptyx (P. malaccae, P. tener dan P. bearni) telah ditemui di Weston. Sonnerattia caseolaris (pokok Pidada / Berembang) merupakan tumbuhan perumah bagi ketiga-tiga kelip- kelip tersebut. Analisis korelasi Pearson menunjukkan bahawa ketinggian pokok mempunyai hubungan negatif yang lemah terhadap kepadatan koloni kelip-kelip (r= -0.188, p= 0.00) ; manakala, kepadatan daun mempunyai hubungan positif yang lemah terhadap kepadatan koloni kelip-kelip (r= 0.101, p= 0.005).

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LIST OF ABBREVATIONS

a.m. - ante meridiem (Latin) – before noon

e.g. - exemplum gratia (Latin) – or example

Sg. - Sungai (Malay) - River

mm. - millimetres

p.m. - post meridiem (Latin) – after noon

LIST OF SYMBOLS

®	-	Registered (Trademark)
&	-	and
%	-	percent

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Fireflies are fascinating insects that always get attention from public society mainly due to fireflies' charismatic flashing light at fireflies' abdomen (Chey, 2004). These lights are generated by the bioluminescence organs. Studies of fireflies basically comprise of taxonomy, diversity, ecology as well as social economics such as nature tourism. However, information of fireflies among the public is very limited.

In Malaysia, the studies of firefly are insufficient. Especially in Sabah, the diversity of fireflies is still yet to be confirmed. Most of the studies were only covered for the distribution of Fireflies species in Sabah. In east coast of Sabah, *Pteroptyx bearni* and *P. gelasina* found at Pulau Sakar, Sg. Paitan and Sepilok (Chey, 2006, Chey 2008 & Chey, 2011). While, in west coast of Sabah, *P. bearni* and *P. gelasina* were found at Tuaran (Chey, 2009); *P. malaccae*, P. bearni and P. tener found at Klias Peninsular and Sg. Garama (Beaufort) (Mahadimenakbar *et al*, 2007; Chey, 2004 & Chey, 2010).

In Malaysia, fireflies are commercialized as a product in nature tourism. For instance, in Kuala Selangor, Selangor, tourists are brought to the mangroves to watch fireflies flashing on the mangrove trees (Mahadimenakbar, 2006). In Sabah, the township of Weston is popular for such activity among local and foreign tourists.

The populations of firefly declines mainly due to anthropological activities such as, land conversions for agriculture purposes, water pollutions, light pollutions and poor managed tourism activities (Mak, 2013). These affect the fireflies mainly

due to the reason that fireflies, where in larval stage, the young larvae live at the edge of waterbed (river, creek and other mangrove water bodies (Mak, 2013).

However, the significance of the effects is yet to be determined. Fireflies' ecology is crucial for the conservation of the fireflies as well as to make sure the fireflies' tourism remains as a sustainable activity (Mahadimenakbar *et al.*, 2003).

1.2 Research Question and Justification

Fireflies of Weston have fascinated thousands of tourists since the establishment of the Borneo Eco Stay (BES) lodge (established since 1996), Weston Proboscis Monkey Sanctuary (WPMS) lodge (established since 2005) and Weston Wetland Park (WWP) (established since 2010). For WPMS lodge, the company served 1131 tourists during January 2012 and 936 tourists during February 2012. In Appendix 7 shows that, he two month record of tourist from WMPS lodge shows that the company served around 1,000 visitors monthly. Hence, WPMS lodge alone would generate about RM 200,000 to RM240,000 annually. For BES lodge and WWP, the numbers of visitors are not disclosed by operators. As for sure, the gross profit contributed by fireflies alone. Other than fireflies, Weston also well-known of its Proboscis monkey (*Nasalis larvatus*).

The tour operator claims that thousands of visitors come to Weston to experience the fireflies annually. However, there is no record of researches carried out regarding the ecology of fireflies in Weston. The consequences of the lack of such documentation will cause difficulties to related government departments as well as non government bodies in the effort to monitor and to practice sustainable firefly ecotourism. Hence, this study is a one of milestones that gathers the information of fireflies' ecology, including abiotic and biotic factors, in southwest coast of Sabah.

The aim of this study is to obtain a baseline data of the ecology fireflies in the area of Weston town for record and future study use. At the same time, it was also able to be used as baseline data for assessment of the health status of fireflies

in their natural habitat in term of food availability, environment quality and the status of display tree of fireflies.

There are a few species of fireflies that occurs in Weston. These species have some characteristics which differ between species, for instance, the flashing pattern. Each species of fireflies has their own flashing pattern. For an example, Photinus firefly produce different flash signal pattern for different species (Lewia & Cratsley, 2008). Certain types of fireflies flash synchronously (e.g. *Peroptyx tener*).

Fireflies are flashes on a tree as swarms of fireflies which called 'colony'. In some species, they can control their flashing frequencies into synchronous, some species don't. Hence, fireflies are observed as a colony instead of individuals group.

According to Chey (2004), *Pteroptyx* firefly is selecting few types of tree as their display tree; but, Pidada Tree (*Sonneratia caseolaris*) is much more preferred. However, Pidada tree is not the only type of tree that fireflies roosted on. This is because, if fireflies were choosing only S. caseolaris as their display tree, then, the conservation of S. caseolaris was a very important in the survival of *Pteroptyx* fireflies. According Wan Jusoh et al (2010 b), there is also a relationship between the fireflies and the vegetation assemblages. Thus, by assessing the species of tree that fireflies used as display tree, we will be able to know to what extent the fireflies choosing their display tree. Then, the conservation and restoration of fireflies population can be done.

Firefly can flash on their display tree whole night until day break (Mahadimenakbar *et al*, 2003: 33). However, some species don't. Hence, the assessment of the condition of the display tree is in need to discover the ideal tree for fireflies to display throughout the night.

1.3 Objectives

In order to achieve the aim of this research, there are two main objectives were stated; which are:

a. Identification of the species and density of fireflies in selected rivers of Weston.
b. Determination of the relationship of display tree structure (tree height, leaf condition and species of tree) against the fireflies population.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Fireflies have fascinate people by its charismatic flashing light of its abdomen. The flashing light of fireflies is generated by the bioluminescence organs located at their abdomen. The light colour, light intensity and flashing frequency of fireflies varies from one species to another. For an example, *Pteroptyx tener*, they can flash synchronously. Hence, it makes the people to feel fascinates and willing to travel far just to watch them.

Due to its bioluminescence ability, fireflies have caught the attention of scientists. The field of researches mostly been done comprise of the taxonomy, ethology (especially flashing behaviour), ecology and the biochemical response. However, the population of fireflies are decreased due to human activities such as land use, pollutions, deforestation and other anthropological effects.

2.2 Taxonomy of Fireflies

Firefly is a beetle (Coleoptera) categorized under the class of Insecta. Coleoptera is the largest Order among the Class of Insecta. So far, there are about 250,000 species of beetles that have been described and identified (Tung, 1983, & Arrow, 2005). In fact, fireflies are insects that are belong to the order Coleoptera under the super family Scarabaeidae (Tung, 1983).

Table 2.1: Classification Table of Firefly

Phylum	Arthropoda
Class	Insecta
Order	Coleoptera
Family	Scarabaeidae
Subfamily	Lampyridae

For all species of fireflies, they are categorized in the subfamily of Lampyridea. Worldwide, fireflies have 83 genera and there has about 2000 species of fireflies been described (Branham, 2010). Fireflies are widespread among the world, fireflies can be found at temperate region such as Europe and North America and also tropical region such as Asia and Central America.

According to Jeng (2008), firefly (*Lampris noctiluca*) was the first described firefly by Linnaeus in Systema Naturae at 1758. However, the family group classification was initiated and further developed by several naturalists and entomologists in 1800's. Among them are Laporte de Castelnau (1833), Melsheimer (1846), Motchulsky (1852), LeConte (1851), Lacordaire (1857), Olivier (1885), Gorham (1880) and several others.

Within the subfamily of Lampyridea, Fireflies has been further divided into several genera, for instances, *Pteroptyx, Luciola, Luciolini, Photinus, Photonini Pygoluciola* and many more. Each genus has their own distinctive characteristic that has separated them into those genera. For instance, *Pteroptyx* fireflies are called as bended wing fireflies. This is because; the male *Pteroptyx* fireflies possess bended elytra which are functioned as a clamp during their mating process (Wing *et al*, 1983).

Among all fireflies in Malaysia, *Pteroptyx* fireflies are the utmost well studied genera in Malaysia. This may be due to their ability to flash synchronously (or time-lag synchronously) in their swarm (Ohba & Sim, 1994). According to Ballantyne (2001), the species of *Pteroptyx* can be found in Malaysia are *P. tener*, *P. bearni*, *P. malaccae*, *P. valida*, *P. similis* (currently has merged as *P.bearni)*, *P.decolor*, *P. asymmetria* and *P. gelasina*.

Four species of *Pteroptyx* fireflies have been recorded in Sabah; namely as *P. tener*, *P. malaccae*, *P. bearni* (formerly known as *P. similis*) and *P. gelasina* (Chey, 2004, 2006, 2009, 2008, 2010 & 2011; Ballantyne, 2001).

Ballantyne & Lambkin (2001) also discovered a new genus of firefly at Sabah, namely *Luciola kinabalua* at Mt. Kinabalu. It was a new species of firefly discovered at Sabah. *L. kinabalua* was found at 5000ft. above sea level.

According to Nallakumar (2002), there are two species of fireflies from the genus *Luciola* found in Malaysia; namely, *Luciola ovalis* (also known as *L. circumdata*) and *Luciola sp.* Besides that, one species from the genus of *Colophotia* (*Colophotia brevis*) and two species of *Lynchnuris* (*Lynchnuris analis* and *L.antricola*) also discovered during his work. These were the only recorded species of fireflies other than *Pteroptyx* fireflies found in Peninsular Malaysia. This is because, *Pteroptyx* fireflies has a more direct impact to the tourism industries (Ballantyne et al, 2011). This may be due to their congregating flashing behavior at mangroves swamp (which was easier to locating the fireflies compared to other species of fireflies).

2.3 Morphology of Fireflies

In general, all members of subfamily Lampyridea, they shares a characteristics includes: a bio-luminous segments in their abdomen, possessed 3 pairs of appendages, 2 pairs of wings which is membrane wing, and hardened wing (elytra). According to Oxford English Dictionary (version 2011), the word Lampyridae is derived from the Latin Word "lampas" which mean "glow" or "illuminate". Hence, Lampyridae carries the meaning as a subfamily of beetles that has the ability to produce light.

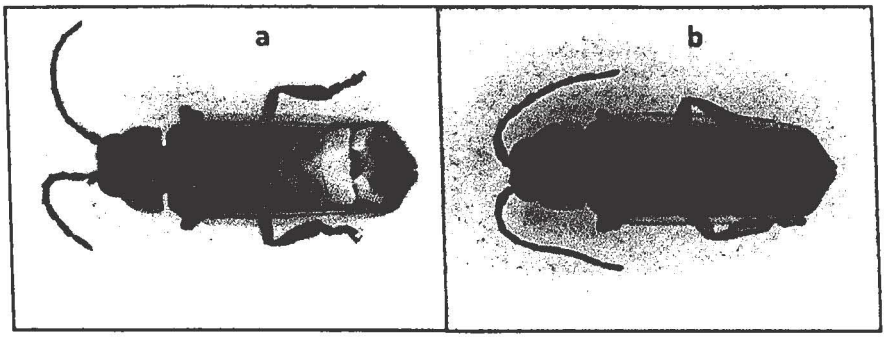

Figure 2.1: Morphology of *Pteroptyx* Firefly (a). Ventral view (b) dorsal view.

As a distinguishable feature of fireflies against other species of beetle, fireflies possess bioluminescence organs at their abdomen that be used to attract the mate for mating. However, only a portion of fireflies has the ability to produce bioluminescence light at their adult stage (Branham, 2010). For certain firefly species, they are using pheromones to locate their mating pair, especially, species from the genus of *Photinus* (Branham, 2010).

2.4 Lifecycle of Fireflies

Although the morphology of fireflies are varies from a species to another species, but they shares the common features of a beetle. All beetles (Coleoptera) are having a complete life cycle which is namely as holometabolous life cycle. Holometabolous life cycle has four stages; which are: egg, larvae, pupa and adult. There are very few of studies been done regarding on the lifecycle of *Pteroptyx* fireflies (Ohba & Sim, 1994).

Ohba & Sim (1994) has described the life cycle for *Pteroptyx valida* in detail. Rearing in laboratory, the total lifespan of *P. valida* is ranged 135-146 days after hatched from egg.

After mating with the male fireflies, a *Pteroptyx valida* female firefly can lay up to 70 eggs during oviposit (Ohba & Sim, 1994). During oviposit, the female will oviposit the eggs singularly on wet mangrove mud. According to them, the eggs of *P. valida* are hatched 12-days after the female adult oviposit them.

Similar to any other insects, the larval stage of fireflies is a rapid growth and development stage which requires a huge amount of food intake. Hence, the suffice food resource is an important key which leads to the survival of species of fireflies. To ensure the larvae have sufficient food, it is believed that the female fireflies would always lay their eggs closely to the young larvae's food source (the gastropods).

For certain fireflies species, the first and second larvae instars were aquatic. They were known as aquatic fireflies due to their amphibial behaviour. According to Fu & Ballantyne (2009); *Luciola substriata* possess a modified bristle which is functioned as gills during their first instar and second instar of their larval stage. This has enabled the larvae to submerge below the water surface by crawling at the substrate of the pond and hunt for their food – aquatic snails. This feature is vital for aquatic fireflies larvae as their food (aquatic snails) are in water.

At the same time, the larvae of *Pteroptyx malaccae* also have the ability to breath under water by absorbing the oxygen through the membranous cuticle or caudal grasping organ (Sommai & Angoon, 2007). This enables the larvae to go underwater to searching brackish water snail. But, apparently, this ability disappears after the larvae emerged as adult.

However, for *Luciola* larvae, during the third to sixth instars, the larvae is lacking their branched –tracheal gill but developed a glabrous body shape and two parallel pair of tubercle at the both side at the sixth instar (Fu *et al*, 2005). The larvae are using their leg to swim instead of dives into the pond to prey.

For *Pteroptyx* fireflies, the larvae are feeding on the mangrove snails. But, only certain kinds of snail are chosen by the larvae as their food. According to Ohba & Sim (1994), they discovered five species of snails found in the area, namely: *Subulina octona* Bruguiere, *Sphaerassiminea brevicula* Pfeiffer, *Lemodonta puncstriatostriata* Adamus 1855, *Fairbankia sp.* and an unidentified tree snail. However, only *Lemodonta puncstriatostriata* are not eaten by the *P. valida*'s larvae. Hence, it showed that fireflies larvae do choose the type of snail to attack. Besides that, the larvae are also more likely to attack the snail from behind and top of their shell (Ohba & Sim, 1994). It is believed that by such way, it would greatly increase the chance of successful attack.

For the pupae of *Pteroptyx valida*, they stayed at the subterranean chamber just below the ground surface that they bored during their pre-pupation period (Ohba & Sim, 1994). Reared in laboratory, the pupae took about six days to morph

into adult. Then, the adult would remain dormant for three days before they merge into surface to searching for mate. After pupation, the average life span of adult is 12 days after emergence from pupae. However, for *P. malaccae,* their pupation will took an average of 10 days during laboratory rearing condition (Sommai & Angoon, 2007).

2.5 Micro-habitat of Fireflies

According to Branham (2010), most of the fireflies can be found at mesic (moderate amount of moisture) environment. Only certain species of fireflies are also can be found at arid (very dry) environment. For an example, the fireflies from the genus of *Microphotus* LeConte and certain members of *Pleotomus* LeConte. This is because, the food of fireflies can only be found at mesic environment. It is believed that, *Microphotus* and *Pleotomus* fireflies are adapted to the arid environment by choosing other organism as food despite of gastropods.

In general, at each stage in their life, fireflies require different kind of environment to live. At larval stage, fireflies would live at ground level. But, for the aquatic fireflies, they would go into the water to hunt for prey. Fu & Ballantyne (2009) described that the larvae of *Luciola substriata* possess the ability to breath underwater. The first and second instars of *L. substriata* have bristle which is functioned as gills to enable the larvae to temporary submerge into the water to hunt for their prey. However, once they turn into adult, they would change to live nearby to the river side, but, they lost the ability to breath in water. In another words, the micro-habitat of *L. substriata* are limited to fresh water riverside.

During pre-pupation period, *Pteroptyx* fireflies would bore a chamber beneath the mud surface for pupation (Ohba & Sim, 1994). As we know, mud soils are water permeable soils. Hence, selection of the location for the larvae to undergo pupation is vital to fireflies. If, the chamber will submerge into the water during high tide, then, it will die. So, naturally, fireflies would choose to build the pupation chamber higher than the high tide water level.

The microclimate at sago palm (*Metroxylon* sagu) or Nipah palm (*Nypa fruticans*) which was more cool, humid and shaded was favours by the fireflies larvae. (Kirton *et al*, 2006). They found that the density of fireflies larvae at sago palm or Nipah Palm was high compared to oil palm plantation and orchards. Meanwhile, snails' density is also high in the area. Hence, it might be the snails that attracted the larvae to the area.

For *Pteroptyx* fireflies, the adult fireflies are displayed at the mangroves tree and flashing on it to attract the mates at the night. It is believed that this kind of sexual communication behaviour is evolved from the pheromones-attracted behaviour. This is because, some basally members in the Lampyridea family are used in conjunction with pheromones, but, subsequently it is replaced by Photic signals in Lampyridae lineages (Branham & Wenzel, 2003). Although, Photic signals seem to be more effective than the pheromone signals, this courtship behaviour is affecting by the brightness of the environment. However, the effects of light intensity towards the fireflies flashing behaviour are yet to be confirmed.

2.6 Fireflies and its Display Tree

After fireflies entering the stage of adult, fireflies are sexually matured and ready to mate. However their body size is comparably too small and insignificant, this would be hard for them locate their pairs to mate. Hence, congregating together on a tree would highly increase their chance to mate. During dusk, the adult *Pteroptyx* fireflies will gather to the selected tree species as their display tree (Ohba & Wong, 2004; Mahadimenakbar, 2006; Chey, 2004).

Chey (2004) proposed that fireflies would choose a variety suitable tree species as their display instead of a certain species of tree. The species tree that is suitable for fireflies to display on varied from *Avicennia sps.*, *Sonnerattia alba* Smith, *Sonnerattia caseolaris* (L.) Eng., *Nypa fruticans* Wurmb, *Rhizophora apiculata* Blumb and *Excoecaria indica* L.

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