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FIREFLIES POPULATION AND THE AQUACULTURE INDUSTRY (COLEOPTERA: LAMPYRIDAE) OF THE SUNGAI SEPETANG, KAMPUNG DEW, PERAK, MALAYSIA

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ABSTRACT

A study on the population of fireflies along the Sungai Sepetang, Kampung Dew, Perak was conducted on March, May and June 2014. This study aim to investigate the abundance of fireflies from the upstream to downstream of the Sungai Sepetang in regards to the shrimp pond located at the side of Sungai Sepetang as well as investigating the correlation of water and soil quality to the abundance of fireflies there. The 2 minutes sweep-netting for fireflies, water and soil sampling was adopted. The 20 sampling stations indicated by stations before the shrimp pond (station 1-10) and after the shrimp pond (station 11-20). A total of 3044 individuals of fireflies were recorded. The stations before the shrimp pond recorded higher abundance (2421) of fireflies compared to the later (623). There was a significant different ($p<0.05$) on the abundance of fireflies within the sampling station. The Water Quality Index (WQI) obtained was 59% indicated the status polluted. Sungai Sepetang is categorized in class III based on Interim National Water Quality Standards (INWQS) for Malaysia. The WQI have a positive correlation in regards to the abundance of fireflies indicated the abundance increases as the quality of water increase. ANOVA test on the abundance of fireflies and heavy metal showed that there is a significant different ($p<0.05$) but fireflies have a negative correlation with heavy metal. The abundance of fireflies decreases with the increasing concentration of heavy metal in the river. Fireflies are more abundance at the area where the percentage of silt in soils is high indicates that the eggs and larva of fireflies are suitable to live in soils with high percentage of silts. It can be concluded that fireflies are sensitive to the environmental changes, and the abundance of fireflies are highly dependent on the environmental factor such as water quality.

Keywords: fireflies, aquaculture, Kampung Dew, Perak, Malaysia.

ABSTRAK

Kajian ke atas populasi kelip-kelip di Sungai Sepetang, Kampung Dew, Taiping, Perak telah di jalankan pada bulan Mac, Mei dan Jun 2014. Kajian ini di jalankan untuk mengkaji kelimpahan populasi kelip-kelip di Sungai Sepetang berikutan kolam udang yang terdapat di tepi Sungai Sepetang, dan juga untuk mengkaji hubungan antara kualiti air dan tanah dengan kelimpahan kelip-kelip. Persampelan dengan kaedah saukan selama 2 minit menggunakan jaring sauk, dan persampelan kualiati air dan tanah telah di jalankan. Sebanyak 20 stesen persampelan telah ditentukan iaitu 10 stesen sebelum kolam udang (stesen 1-10), dan 10 stesen lain selepas kolam udang (stesen 11-20) dengan aliran dari hulu ke hilir sungai. Sebanyak

3044 individu kelip-kelip telah direkodkan. Stesen sebelum kolam udang merekodkan taburan yang lebih tinggi dengan 2421 kelip-kelip telah direkodkan berbanding dengan hanya 623 individu kelip-kelip selepas kolam udang. Terdapat perbezaan yang signifikan ($p<0.05$) pada kelimpahan kelip-kelip antara stesen persampelan. Indeks Kualiti Air (IKA) yang diperolehi adalah 59% dengan status tercemar. Sungai Sepetang termasuk dalam kategori kelas III berdasarkan Piawai Interim Kualiti Air Kebangsaan (INWQS) untuk Malaysia. Hasil menunjukkan terdapat korelasi positif antara Indeks Kualiti Air (IKA) dengan kelimpahan kelip-kelip, menunjukkan bahawa populasi kelip-kelip meningkat dengan peningkatan kualiti air. Ujian ANOVA menunjukkan terdapat perbezaan yang signifikan ($p<0.05$) antara logam berat dengan kelimpahan kelip-kelip, tetapi korelasi negatif di tunjukkan antara kelimpahan kelip-kelip dengan logam berat. Populasi kelip-kelip berkurang dengan peningkatan kepekatan logam berat di dalam air sungai. Kelip-kelip lebih banyak terdapat di kawasan peratus lodak yang tinggi dan ini menunjukkan bahawa telur dan larva kelip-kelip sesuai untuk hidup di kawasan tanah yang mempunyai peratus lodak yang tinggi. Dapat disimpulkan bahawa kelip-kelip sangat sensitif kepada perubahan persekitaran, dan kelimpahan kelip-kelip adalah sangat bergantung kepada faktor persekitaran seperti kualiti air.

Kata kunci: kelip-kelip, akuakultur, Kampung Dew, Perak, Malaysia.

INTRODUCTION

Sungai Sepetang is the major river running through the Kampung Dew and a habitat for many mangrove species and organisms. The rarely seen insect, fireflies can be found along the Sungai Sepetang, Kampung Dew. Kampung Dew was nominated as one of the top three successful firefly conservation sanctuary of the world as a result of tremendous effort and collaboration from the local people with NGO's namely, Malaysian Nature Society (MNS), Kelip-kelip Cahaya Alam Perak (KECAP) and Universiti Kebangsaan Malaysia (UKM). Sungai Sepetang is a host to a lot of mangrove species such as *Ficus* sp, *Acrostichum aureum* (Piai Raya), *Rhizophora apiculata* (Bakau), *Nypa fruticans* (Nipah) and *Sonneratia caseolaris* (Berembang). One of the most abundant mangrove species along the Sungai Sepetang is *S. caseolaris*, where fireflies love to perch on this plant species (Anon 2013a).

Fireflies are categorized in the family Lampyridae. They live near the water, especially in mangroves. Fireflies lay their eggs in the riverbanks, near the Nypa tree and their larvae survive by consuming small river snails and insects. Fireflies prefer living in Berembang trees, which are found in the muddy intertidal zones along the riverbank, a few kilometers from the estuaries. The habitat of fireflies is threatened by human activities (Kirton et al. 2006b). Environmental degradation such as land conversion and loss of natural vegetation along the intertidal zone of the river, erosion of riverbank and increased salt water intrusion as a result of the dam built may give negative impact on the abundance of fireflies (MNS 2011). During and after the process of habitat destruction and degradation, mangrove trees are felled to be used in industrial, aquaculture and plantation activities. The abundance of fireflies are declining and caused by the changes of river water quality resulting from river pollution, the use of diesel by-products and development within the habitat of fireflies (Wan Faridah Akmal et al. 2010). This situation needs quick rectification as the fireflies and their mangrove habitats are becoming endangered by anthropogenic activities (Nallakumar 2002; Nada & Kirton 2004; Ohba & Wong 2004; Wong 2008).

In Malaysia, information on the distribution and abundance of fireflies largely remains undocumented and lack of detailed information. Most reports are based on opportunistic observations (Nallakumar 2002; Zaidi et al. 2006; Wan Faridah Akmal 2007; Nada et al. 2008). Fireflies and their mangrove habitats are fast becoming endangered by anthropogenic activities (Nallakumar 2002; Nada & Kirton 2004; Ohba & Wong 2004; Wong 2008). Accurate understanding of the distribution, abundance & habitat requirements of fireflies is essential towards the effective conservation of firefly population (Takeda et al. 2006). Not much is known about the distribution, abundance and habitat requirements of fireflies in Kampung Dew, Perak. Meanwhile, from the observation and the conversation with the local people, the abundance of fireflies along the Sungai Sepetang in Kampung Dew is facing declination as the shrimp pond has been established in the area. Therefore, this study was carried out to investigate the abundance of fireflies from the upstream to the downstream of the Sungai Sepetang in regards to the shrimp pond located at the side of Sungai Sepetang, and to study the effect of the aquaculture industry to the abundance of fireflies along Sungai Sepetang, Kampung Dew, Perak.

Taking into account what has happened in Kuala Gula, Perak, about 29.5 km from Kampung Dew, the population of fireflies has extinct due to the habitat destruction and aquaculture industry that was established. In order to prevent such situation to happen in Kampung Dew, this study provided data on the current status of fireflies' population of Kampung Dew.

MATERIALS AND METHODS

A field sampling was carried out along 8 km of Sungai Sepetang on the *Sonneratia caseolaris,* berembang trees which the fireflies were distributed. A total of 20 firefly-flashing riparian berembang trees were accessed by boat at night and tagged. The 20 trees were chosen as sampling stations, in such a way that the first 10 stations (namely station 1 – 10) being at the most-upstream end before passing by the shrimp ponds which situated at the side of the river. The last 10 stations (namely station 11 – 20) situated at the most-downstream end of the stretch of 8 km of Sungai Sepetang after the shrimp ponds. The stations were chosen as they appeared to be relatively good firefly-flashing trees along the stretch.

A 2-minute sweep-netting sampling of the fireflies in each station at night-time was then conducted in March, May and June respectively. Approximately 2 minute of sweeping was done in each station using sweep net. The samples collected in the net were calculated and recorded before released back to its habitat. Sampling as such, was repeated for another two occasions.

The water quality assessment was also carried out in Sungai Sepetang. Ten sampling locations (namely DW 1 – DW 10) were chosen based on accessibility and environmental factor such as near the shrimp pond, charcoal factory, jetty and located further away from shrimp pond and several water quality parameters were analyzed. The parameters are pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonia-Nitrogen (NH3-N), Total Suspended Solid (TSS), Dissolved Oxygen (DO), Conductivity (EC), Total Dissolved Solid (TDS), Salinity and Nitrate (NO3). Water samples were taken at three different places in each station (at the side and middle sector of the river), sum up a total of 30 bottles of water samples. The depth of the river was determined using depth meter at the middle sector of the river.

At each sampling location for water quality analysis, samples of soils were taken on the edge of the river. The samples kept in a plastic bag and brought to the laboratory for further analysis.

RESULTS

The distributed firefly species was identified as *Pteroptyx tener*, similar to the previous record by Zaidi et al. (2006). A total of 3044 fireflies have been observed from the sampling locality. The upstream of Sungai Sepetang, namely station 1 to station 10 shows greater number of fireflies (2421) compared to the downstream (623) (station 11 until station 20) (Table 1).

The one-way ANOVA test showed that there is a significant difference ($p<0.05$) on the abundance of fireflies between each station. Station 1, the nearest to the jetty is the most upstream station within this study. It is located far from the shrimp pond. The result shows that station 1 has the most abundant number of fireflies with total of 393 individuals. The number followed by 254 individuals from station 6, which is located before the shrimp pond. Station 6 has abundance number of fireflies probably because there are fewer disturbances around that area. The less number of fireflies collected are from the station 20 with only 41 individuals observed. Station 20 situated far at the most downstream sector of the sampling location. The station collected the least number of fireflies probably because station 20 is the accumulation area that collects all the wastes and effluents flowing from the upstream of the river. The domestic wastes come from the nearby residential area and jetty, effluents from charcoal and rubber factory and effluents from shrimp ponds all flowing from upstream to downstream sector of the river.

Table 1. Total number of fireflies at each station

Station \ Month	March	May	June	Total number of fireflies
1	130	122	141	393
2	60	66	69	195
3	50	78	121	249
4	35	53	100	188
5	50	97	99	246
6	105	41	108	254
7	34	36	171	241
8	63	60	116	239
9	60	27	147	234
10	30	34	118	182
Total	**617**	**614**	**1190**	**2421**
11	23	29	20	72
12	15	18	24	57
13	19	32	31	82
14	18	23	19	60
15	28	17	22	67
16	27	23	24	74
17	28	11	26	65
18	16	14	23	53
19	19	10	23	52
20	10	11	20	41
Total	**203**	**188**	**232**	**623**
Grand Total	**820**	**802**	**1422**	**3044**

The mean values of WQI at each sampling stations of Sungai Sepetang were in the range of 56-63% with the upstream stations (DW1-DW5) showed better water quality compared to the downstream stations (DW6-DW10). The mean value of WQI for Sungai Sepetang was 59% indicated the status polluted, categorized in class III. Table 2 showed the parameters studied during water quality assessment.

Table 2. Water Quality Assessment for each station

Parameters	**Mean values**	**ANOVA**	**Trend (DW1→DW10)**
pH	5.73 to 6.73 mg/L	$p<0.05$	
Biochemical Oxygen Demand (BOD)	0.33 to 3.79 mg/L	$p>0.05$	
Chemical Oxygen Demand (COD)	37.6 to 159.2 mg/L	$p<0.05$	Increasing
Total Suspended Solid (TSS)	8.83 to 52.33 mg/L	$p<0.05$	Increasing
Dissolved Oxygen (DO)	1.53 to 5.54 mg/L	$p<0.05$	Increasing
Ammonia-Nitrogen (AN)		$p<0.05$	Increasing
Conductivity (EC)		$p<0.05$	Increasing
Total Dissolved Solid (TDS)		$p<0.05$	
Salinity		$p<0.05$	Increasing
Nitrate (NO3)		$p<0.05$	Decreasing

The range of pH falls in the range preferred by most estuarine organisms is 6.5 to 8.5 (Ronald & Kathleen 2006). Meanwhile, for DO, station DW3 was expected to record the lowest concentration due to the location that situated near the area of the shrimp pond and the charcoal factory near the station. Effluent from the shrimp pond and factory are drained directly into the river. The effluent usually contains high level of organic material which requires microorganisms to decompose it. The decomposition processes will use up DO available in the water and cause the DO content to be low (Lim et al. 2001; Mazlin et al. 2001). Concentration of DO at the last station, DW10 record the highest among the sampling stations. High DO contents indicate that the area is less disturbed by human activities that contribute to the reduction of DO concentration.

BOD is the rate at which microorganisms in water take up oxygen to degrade the organic components present in water. One-way ANOVA test showed that there is no significant different ($p>0.05$) for BOD in each station. COD is the total measurement of all chemicals (organic and inorganic) in the water that can be oxidized. Station DW9 records the highest COD value (159.2 mg/L) indicates the presence of high organic material. Generally, the trend showed by COD is low at the upstream and high at downstream. This is due to the accumulation of waste from upstream to downstream sector of the river. The organic material may come from the shrimp pond and domestic effluent which is carried from the upstream to the downstream sector of the river.

Total Suspended Solid (TSS) reflects organic and inorganic particulates in the wastewater (Nyanti et al. 2011). Station DW8 records the highest concentration of TSS. The downstream station (DW6 to DW10) act as an accumulation point of TSS which is produced at the upstream of the river basin as a result of activities such as shrimp farming, charcoal factory and oil palm plantations. Ammonia-nitrogen (AN) indicates nutrients status, organic enrichment and health of the water body (Radojevic et al. 2007). One of the factors that lead to high concentrations of ammonia is the domestic effluent contained in the river (Lim et al. 2001; Mazlin et al. 2001). Other than that, AN was also associated with the use of fertilizer for land and agricultural development (Mansor et al. 1989; Norhayati et al. 2004). From the studies of loading of pollutants from shrimp farms, Ling et al. (2010) and Nyanti et al. (2011) reported that high loads of ammonia-nitrogen were releases from the ponds during harvesting. High level of AN at station DW6 to DW10 are due to the effluents from the shrimp ponds.

Station DW10 records the highest salinity since it was located at the downstream sector of the river, which is nearer to the sea. Salinity was the lowest at DW1 as it is the most upstream station among all stations and it receives input of fresh water from the watershed upstream. High level of nitrate at station DW1 are due to the human activities such as use of fertilizer that contribute to nutrient input into the river. Nitrogen is essential for the growth of algae and other plants. Excessive concentration of nutrients however, can over stimulate aquatic plant and algae growth and enhance the process of eutrophication which can lead to an abundant supply of vegetation and causes low DO (Addy & Green 1997; Kramer 1987).

As reported by Alloway (1995), the cations Na, Mg, K and Ca constitute more than 30% of total element content of the Earth's crust. Due to the rapid development in aquaculture and fishing activities, heavy metals are released or leached into the environment, which has contributed to the degradation and destruction of the ecosystem. The accumulation of metals in the environment is due to the fact that they cannot be broken down, unlike the organic pollutants that can be degraded to carbon dioxide and water (Gupta et al. 2001; Khan et al. 2004). The trend for EC is increasing from station DW1 to DW10. Aris et al. (2012) found that high value of EC could be related to seawater intrusion. Station DW10 is at downstream which is near to the sea compared to other station

Table 3. Soil composition for each station

Component of soil	Content	Trend (DW1→DW10)
Clay	Highest	Increasing
Silt	Intermediate	Decreasing
Sand	Lowest	

The percentage of clay is high at the downstream station compared to the upstream station but percentage of silt is high at the upstream station compared to the downstream station (Table 3). Sand constitutes the lowest percentage of soils. Clay is the finest particles and able to retain greater amounts of water because of their very small size and large surface area. Sand is a small rock fragments and have little or no ability to supply plants with nutrients or to retain them against leaching. Silt is intermediate in size and chemical and physical properties between clay and sand. The silt particles have limited ability to retain plant nutrients and it retains a large amount of water but releases the water readily to plants. The fireflies egg need moist soil and shaded area so that the eggs are not easily damaged when exposed to heat and dryness (Wan Faridah et al. 2010). The most suitable size of soils for the egg of fireflies is silt because it has the intermediate amount of water and other chemical and physical properties. Too much water content in the soil could harm the egg and larva of fireflies.

Table 4. Correlation test

Factors	Relationship	Correlation and coefficient value
Fireflies and water quality	Positive	r= 0.443
Fireflies and soils	Positive	r= 0.862

The correlation test showed a moderate uphill (positive) relationship on the abundance of fireflies and the water quality index. Table 4 indicates the abundance of fireflies will increase as the value of WQI increases. High value of WQI indicates the water body is in a good condition and low value of WQI indicates that the water is polluted. Fireflies prefer a clean environment to sustain life. Degraded water quality will cause the abundance of fireflies to decline and lead to extinction.

Fireflies are relatively sensitive to environmental changes in the habitat (Yuma 2000). Water quality is known to have a marked impact on the abundance of many aquatic insects (Ward 1992; Courtney & Clements 1998; Suh & Samways 2001). Water quality is thought to affect fireflies' abundance and act as the direct determinant of larval habitat quality (Takeda et al. 2006). Low water quality will affect the larval habitat at the bank side of the river. Disturbed habitat affects the larval life and may affect the whole lifecycle of fireflies. Previous studies on the water quality of rivers indicated that nutrients were higher near the shrimp farming areas (Ling et al. 2010b). Shrimp pond effluent was reported to be high in TSS, BOD, COD, AN and nitrogen (Ling et al. 2010; Nyanti et al. 2011). From this study, we concluded that the abundance of fireflies is highly associated with the water quality, whereas the water quality is affected by the effluent from the shrimp pond, charcoal and rubber factory and domestic wastes thrown in the river.

There is a positive linear relationship on the abundance of fireflies and the percentage of silt in the soils. Table 4 that indicates that the abundance of fireflies increases as the increased in percentage of silt in the soils. This can be claim that the egg and larva of fireflies are suitable with the soils condition. Fireflies reported to prefer moist soils to lay their eggs. Excessive water is good for the larvae of fireflies and it encourages the population growth (Ohba & Sim 1994; Nallakumar 2002). However, too much water, from the increasing river flows resulting from heavy rainfalls may restrict the foraging activities of small larvae and may also adversely affect populations of the larvae's prey (Nallakumar 2002; Yuma 2007). Silt has less ability to retain water compared to clay, which is more suitable for the larva of fireflies.

DISCUSSIONS

The results on the abundance of fireflies within the 20 stations proved that the shrimp pond do have an effect on the population of fireflies. Shrimp ponds are located in the estuaries where it supplies the brackish water needed and it also receives the discharge of the pond effluent during harvesting (Ling et al. 2012). World-wide, there have been reports of environmental degradation due to loadings of pollutants from shrimp ponds. These include eutrophication due to the discharge of high nutrient pond water during pond harvesting which has an impact on the aquatic organisms, fisheries and indirectly on the life cycle of fireflies residing within the vicinity. Shrimp farming is also associated with the destruction of natural habitat through direct conversion of the mangrove into shrimp ponds. Mangrove have a wide variety of functions includes producing a range of wood and other forest products such as firewood, poles, wood chips, charcoal, bark for tanning and dyes and honey. Mangrove protects shoreline against flooding and inundation in storms. In addition, mangrove also increases the sedimentation and accretion and also reduces erosion. Mangrove forests are important to the overall biodiversity of its wider estuarine systems, as a source of nutrients and detritus and as a shelter for a variety of species (Boyd & Clay 1998). This includes the population of fireflies, in which its life cycle depends on the mangrove ecosystem.

Other than that, shrimp farming is the causes of the organic matter and nutrient pollution. The water in shrimp ponds is high in nutrients and organic matter. These nutrients are derived mainly from waste food and metabolic products, as well as from the small quantities of fertilizer added to stimulate plankton blooms (Institute of Aquaculture 1996). When pond water contains high concentrations of nutrients and organic matter, it will be discharged into coastal waters. The effect depends on the ecosystem's capacity to receive the discharge.

Some of the negative effects are the unusual rates of sedimentation, eutrophication with increased risk of harmful algal blooms, oxygen depletion, toxicity from sulfide compounds and ammonia following degradation of organic matter, and increased incidence of disease, stemming from poor water quality and stress on marine life (Clay 1996; Dierberg & Kiattisimkul 1996; Lin 1995). These impacts may be detrimental to the farm itself and to the wider environment, include the population of fireflies.

CONCLUSIONS

The abundance of fireflies within the sampling stations (upstream and downstream) is differed significantly. The release of pollutants such as heavy metals, effluent from shrimp ponds, agricultural activities and domestic wastes leads to the deterioration of river quality, depletion of river sources, loss of biodiversity and causes the abundance of fireflies to decline. It is recommended that the shrimp pond water must be treated before discharge. Good management practices can reduce the export of harmful substances to the river and environment. Water quality is highly variable over time due to both natural and human factors. Continuous monitoring of the river and fireflies habitat need to be done to ensure the area is not polluted and prevents continuous declining of fireflies.

Conservation of fireflies is crucial as it plays many important roles such as a biological indicator to ascertain the health of the environment and it have generated worldwide interest due to its fascinating light and directly develops tourism industry.

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