

GIS Mapping for Distribution of Firefly along Sungai Sepetang, Perak

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Abstract: Kuala Sepetang is well-known for its firefly-watching activities at night as ecotourism benefits mangrove ecosystems and has no negative effects. This study is to generate a GIS mapping for firefly hotspot distribution and the objectives of this study are to map the firefly hotspots and identify the number of fireflies in Kuala Sepetang. The GIS hotspot analysis of the firefly population in Kuala Sepetang has not yet been studied. Ten (10) sampling stations were chosen based on surrounding indicators to emphasize the number of fireflies. The fieldwork has been operating from November 2021 until April 2022 for 5 nights monthly along Sepetang Estuary. During the daytime, the boat will stop by the riverbanks for 10-15 minutes at all stations to collect and identify the vegetations and measure the parameters for the water quality inspections while the counting for fireflies occurs during the night-time survey. The result showed the number of fireflies in Station 6 has the largest population of fireflies, with 55,719 total fireflies discovered over the duration of six months. Moreover, Station 6 was chosen as the best display tree due to its density of flashing lights. However, this study only covered the GIS mapping for distribution of firefly along Sungai Sepetang. Hotspot analysis in GIS were used to identify the distribution of fireflies and investigate the environmental parameters affecting the number of fireflies. More studies are required since the only habitats for congregating fireflies which is the mangrove area are depleting due to developments and deforestation.

Keywords: GIS, hotspot analysis, firefly, mangroves and firefly habitat.

1.0 Introduction

Many agencies are now preferring GIS and the analysis at the current moment. Maps are being used by the required agencies to highlight the important area for the intelligence, investigations and operations. GIS is a technological tool that employs hardware, software, an operator, and geographic data to help obtain, store, manipulate, and analyse the necessary information (Chang, 2018). The analysis for the distribution of firefly is made possible with the aid of GIS, which can help determine where the highest and lowest distributions of fireflies are found and which parameters depend on the population of fireflies.

As the sector of ecotourism grows, fireflies are becoming a very valuable resource for this nation. Firefly emits light through its abdomen giving the spectacular flashing pattern nights (Khairunnisa et al., 2016) The flashing light of firefly is captivating for the tourists to visit the riparian zone as its natural habitats at night as one of the ecotourism activities in Kuala Sepetang. The largest order of insects, the Coleoptera, includes the firefly or Lampyridae (*Pteroptyx tener*) (Mckenna & Farrell, 2015). It is a remarkable Southeast Asian bent-winged firefly that may be easily found in warm and humid climates. Even though they can quickly access their food supplies, this species prefers to inhabit around mangrove swamps or riverbanks. A little insect like the Lampyridae has a significant impact on local residents' quality of life and, in turn, indirectly on the economy.

Utusan Malaysia and Sinar Harian (2013) cited the Perak State government designated Sungai Sepetang on November 6th 2013 as a 152.98 ha protected area known as the Firefly Forest Reserve. Sungai Sepetang is well known for its fishing activities and charcoal produce which then slowly gaining publicity for ecotourism activities such as firefly night watching, eagle and dolphin watching tours. *Ficus* sp., *Acrostichum aureum* (Piai Raya), *Rhizophora apiculata* (Bakau Minyak), *Rhizophora mucronata* (Bakau Kurap), *Nypa fruticans* (Nipah), and *Sonneratia caseolaris* (Berembang) are mostly found in Sungai Sepetang. Jusoh et al., 2010 also stated along Sungai Sepetang, *Sonneratia caseolaris* is the most abundant mangrove species where the synchronous fireflies, *Pteroptyx tener* love to inhabit. Khoo (2014) stated the synchronous fireflies, *Pteroptyx tener* congregate mainly on the *Sonneratia caseolaris* along Sungai Sepetang.

Ballantyne et al. (2019) and Jusoh et al. (2018) agreed that Malaysia is a country that consists a wide range of *Pteroptyx* fireflies such as *Pteroptyx tener*, *Pteroptyx malaccasae* and *Lucilla pupilla*. Hence, Jusoh et al. (2018) stated the most common species of firefly found in Malaysia are *Pteroptyx tener* and *Pteroptyx bearni*. Foo & Mahadimenakbar (2017) studied the *Pteroptyx* genus of fireflies are mostly connected by the riverbank of mangrove forests. The *Pteroptyx tener* gathers in large congregations each night in specific mangrove trees near tidal rivers and offering a spectacular view. Jusoh et al. (2010) ranked them among the attractive insects because of their bioluminescent flashing. Adult firefly; males and females have different light flashes to assist them in finding partners (Buck & Buck, 1978).

The aim of this study is to provide the GIS mapping of firefly hotspot distribution in Kuala Sepetang. The objectives of this study are to identify the population of firefly in Kuala Sepetang and mapping the hotspot distribution of firefly. There is none research regarding the hotspot analysis using GIS on the population of firefly in Kuala Sepetang. Therefore, this study will be a great start as a new finding to firefly research in Kuala Sepetang.

2.0 Study Area

Kuala Sepetang is a village that opened a few tourists spot such as charcoal factory, Matang Mangrove Forest Ecological Park, shrimp ponds and fish breeding ponds. Moreover, Kuala Sepetang is well-known for its ecotourism activities such as fireflies watching, tours to eagle feeding and dolphins watching its signature food as prawn noodles "Mee Udang". However, the Sungai Sepetang (4°52'13.5305"N, 100°38'08.6204"E) is located at Kuala Sepetang (refer Figure 1) in the Larut and Matang District, Northern Perak.

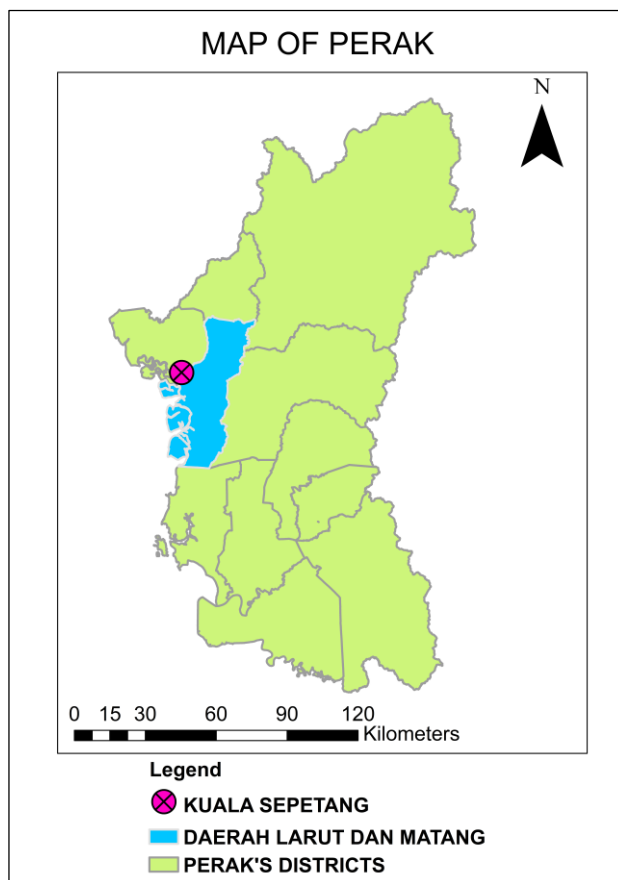


Figure 1: Study Area Map in Kuala Sepetang.

3.0 Materials and Methodology

3.1 Materials on Location of Study Area

Kuala Sepetang is a small village that open many opportunities to the locals for their livelihood due to its ecotourism activities. There are ten (10) sampling stations for the identification of abundance firefly as in Figure 2 along Sungai Sepetang. The coordinates of each station were listed in Table 1 with their respective type of vegetation that fireflies inhabit. The stations are located along the eight (8) km of the Sungai Sepetang. The stations have been chosen as the most preferable display trees due to its populations and easy to access by the riverbanks. However, the studies have been carried out only on the right-side of the riverbanks from the Port Weld Jetty. The coordinates were taken from handheld Altimeter GPS+ version 4.7.3 at 10 sampling station respectively. The coordinates were pinned for two (2) minutes at the stations until no redundancy points were obtained.

Table 1: Coordinates of sampling stations with the name of vegetation.

| Number of Station | Name of Vegetation | Latitude | Longitude |
|-------------------|------------------------------|----------|-----------|
| 1 | <i>Sonneratia Caseolaris</i> | 4.888062 | 100.63437 |
| 2 | <i>Sonneratia Caseolaris</i> | 4.886972 | 100.6314 |
| 3 | <i>Sonneratia Caseolaris</i> | 4.882146 | 100.63026 |
| 4 | <i>Sonneratia Caseolaris</i> | 4.879974 | 100.63216 |
| 5 | <i>Sonneratia Caseolaris</i> | 4.879918 | 100.63304 |
| 6 | <i>Sonneratia Caseolaris</i> | 4.877828 | 100.63743 |
| 7 | <i>Sonneratia Caseolaris</i> | 4.875141 | 100.63537 |
| 8 | <i>Rhizophora Mucronata</i> | 4.859359 | 100.62481 |
| 9 | <i>Rhizophora Mucronata</i> | 4.858397 | 100.62517 |
| 10 | <i>Rhizophora apiculata</i> | 4.856724 | 100.62716 |

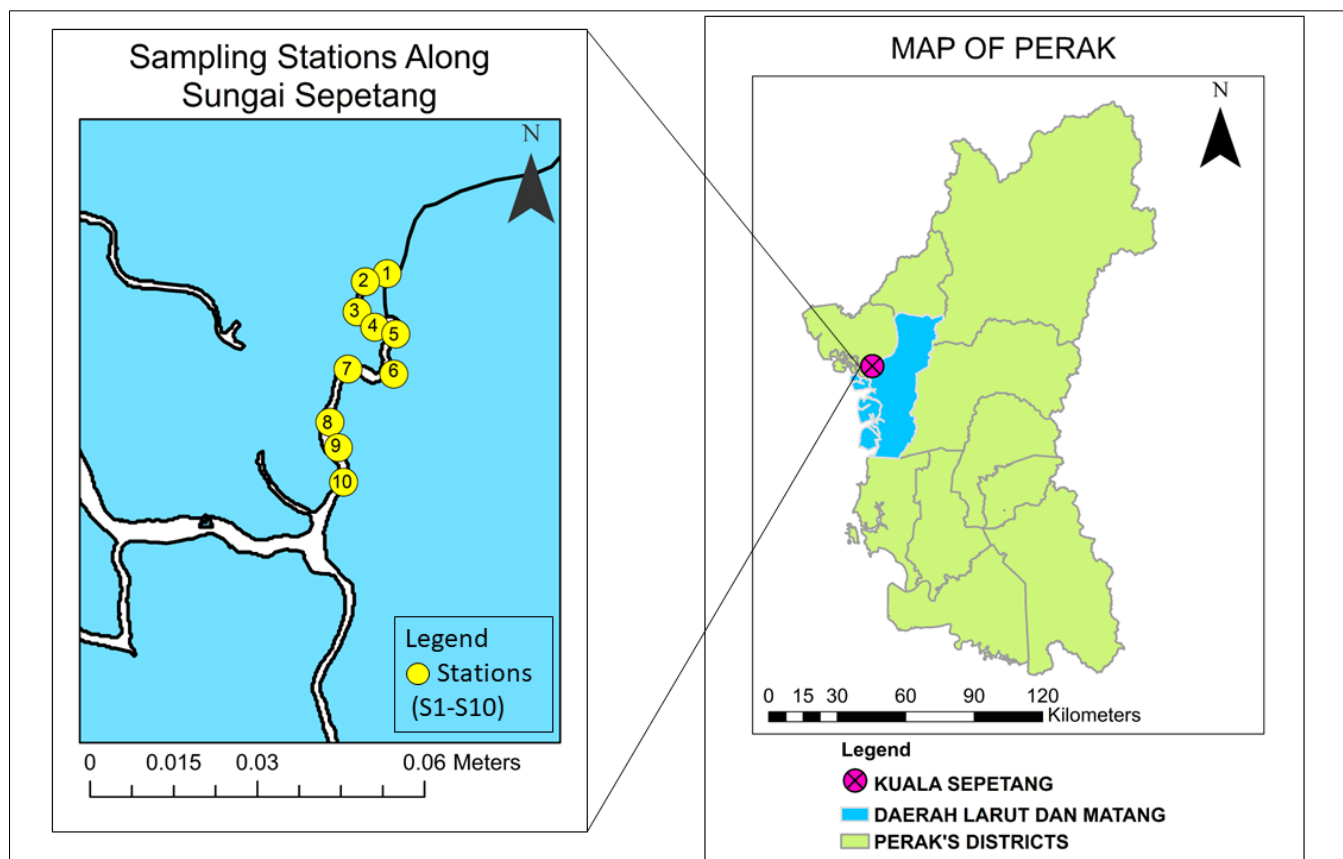


Figure 2: The location of study area with its sampling stations along Sungai Sepetang

3.2 Methodology / framework / theory

The study was conducted along Sungai Sepetang for five (5) nights consecutively in every month starting from November 2021 until April 2022. The boat trips usually started at 5.30pm and finished at 8.30pm. By 5.30pm, the boat trips usually went for testing water inspections for environmental parameters at the ten (10) stations, to investigate the parameters surrounding mangroves which affecting the number of fireflies. A few samples of adults' firefly were then collected by using sweep-netting technique for 2 minutes, then carefully preserved it with 95% ethanol in a sample glass bottle for the identification of insects.

The environmental parameters used in this study are Total Dissolved Solid (TDS), Water Conductivity, Water Salinity, Wind Speed, Air Temperature, Air Humidity, and pH water. The boatman will ride the boat along Sungai Sepetang from the upstream to the downstream for the firefly counting. The firefly counting was recorded using counters, the counting usually started at 7.30pm until 8.20pm. 7.30pm was the most suitable time to count as the sun set, firefly started to appear with its flashing light. Each station was allocated 5 minutes to count from the top of display trees until the bottom as the flashing lights emitted. Two persons counted and covered by dividing the section of the display trees into two, which is top-sectional and bottom-sectional.

The previous studies related to firefly distribution and firefly conservation was analysed for the usage of GIS analysis using Hotspot technique. Therefore, the distribution of firefly was calculated by using total numbers of firefly for 5 nights monthly for six (6) months total. The coordinates of stations transferred into attribute tables together with the number of fireflies. Later, ArcGIS was used to analyse the attribute table into 10 stations (points) on the Sungai Sepetang layer. Firstly, for hotspot analysis, the creation or the identification of data set must be created, then identify the suitable base map. The base map of Kuala Sepetang shapefile downloaded from the DIVA GIS, then the Sungai Sepetang has been digitized accordingly to the spatial data. However, the clustering data has been tested to fit into the base map. Next, the hotspot map has been created through the selection of Arc Toolbox. Last but not least, the hotspot map legend threshold needs to be defined.

4.0 Results

4.1 Distribution of fireflies in Kuala Sepetang

The sampling has been carried out for 5 nights per months started from November 2021 until April 2022 to study the patterns of the number of fireflies. Table 2 consists all the number of fireflies in Sungai Sepetang according to each station and monthly sampling schedule. From the numbers, the deductions can be made due to rising of tide level, changes of weather and the visibility of the moon. By referring to the Table 2, Figure 3 below shows a lower number of fireflies in Sungai Sepetang at Station 1, 2, 8, 9, and 10. The population of fireflies at station 1, 2, 8, 9 and 10 recorded to be below 10000. Station 1 and 2 is located nearby the shrimp ponds, were exposed to several artificial lights by the shrimp ponds but Station 2 was less exposed than Station 1.

Station 8,9 and 10, the vegetations for the fireflies are actually *Rhizophora apiculata* (Bakau Minyak) and *Rhizophora mucronata* (Bakau Kurap) made the number of fireflies seem to be lower than other stations with *Sonneratia caseolaris* (Berembang). Number of fireflies in November 2021 appeared to be the lowest because for the straight 5 nights of firefly counting, the weather was raining heavily.

Table 2: Distribution of Firefly in Sungai Sepetang

| | STN1 | STN2 | STN3 | STN4 | STN5 | STN6 | STN7 | STN8 | STN9 | STN10 |
|--------------------------------|------|------|------|------|-------|-------|-------|------|------|-------|
| NOV-21 | 72 | 114 | 799 | 831 | 2233 | 7250 | 1292 | 418 | 116 | 68 |
| DEC-21 | 87 | 88 | 1101 | 1099 | 4952 | 6238 | 1510 | 319 | 182 | 55 |
| JAN-22 | 118 | 327 | 1095 | 1642 | 6120 | 14238 | 3175 | 100 | 73 | 31 |
| FEB-22 | 65 | 425 | 1244 | 1829 | 6207 | 9845 | 1666 | 200 | 121 | 99 |
| MAR-22 | 70 | 336 | 901 | 1303 | 2573 | 9023 | 2260 | 109 | 105 | 113 |
| APR-22 | 190 | 458 | 1239 | 1574 | 3038 | 9125 | 1351 | 121 | 126 | 151 |
| TOTAL NUMBER OF FIREFLY | 602 | 1748 | 6379 | 8278 | 25123 | 55719 | 11254 | 1267 | 723 | 517 |

The number of fireflies in Station 6 (Figure 3) shows the highest number of fireflies in Sungai Sepetang with 55,719 fireflies were found altogether for the six months. Station 6 was categorized as the hotspot of the firefly by the local, tourists and the boatmen because of the density of the fireflies with the area itself. Station 6 was surrounded by *Sonneratia caseolaris* (Berembang) and located at the mouth bar. The flashing lights emitted from Station 6 was the most preferable display tree for the mapping of hotspot of firefly in Sungai Sepetang thus make it the highlight of the firefly watching-trip for the eco-tourism activities.

Stations 10 were like to have a minimal number of fireflies because there are closed floating restaurant which has been guarded by the dog and surrounded by the lamps. Therefore, the area at station 10 are likely exposed to artificial lights which means lowest number of fireflies in Sungai Sepetang. The total number of fireflies in Station 7 is different to Station 5 by 13,869 number of fireflies.

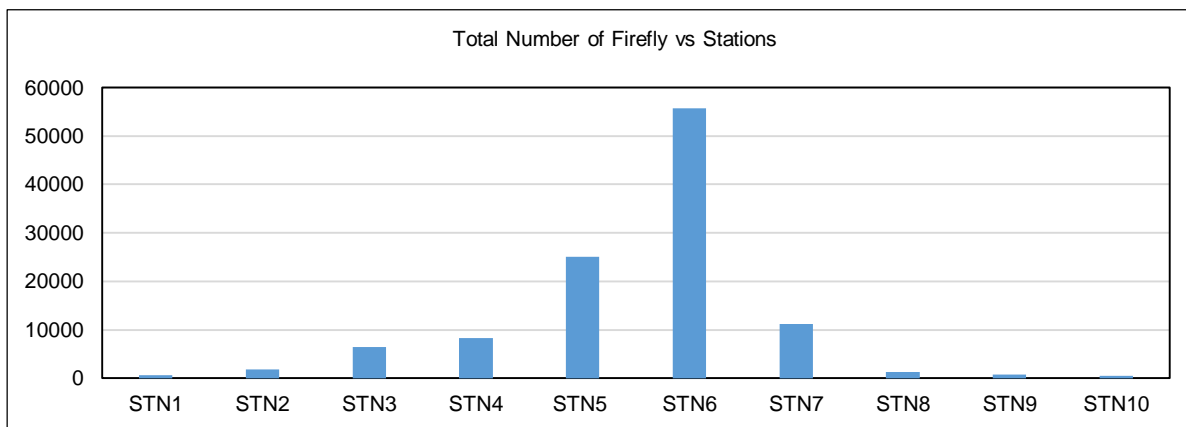


Figure 3: Total Number of Firefly vs Stations

Figure 4 portrays the scatter plot of distribution of fireflies with the total number of fireflies. Station 5 has been proven to show a significant number of fireflies before Station 6 with 25,123. The minimal number shown by Station 5 during March 2022 (Table 2) was 2,573 shows that the number of fireflies was varying with the surrounding abiotic factors and biotic factors. Station 5 shows the increasing line in Figure 4 as well as Station 6. However, the population seems to be increasing due to parameters of abiotic and biotic factors surrounding the mangrove habitats.

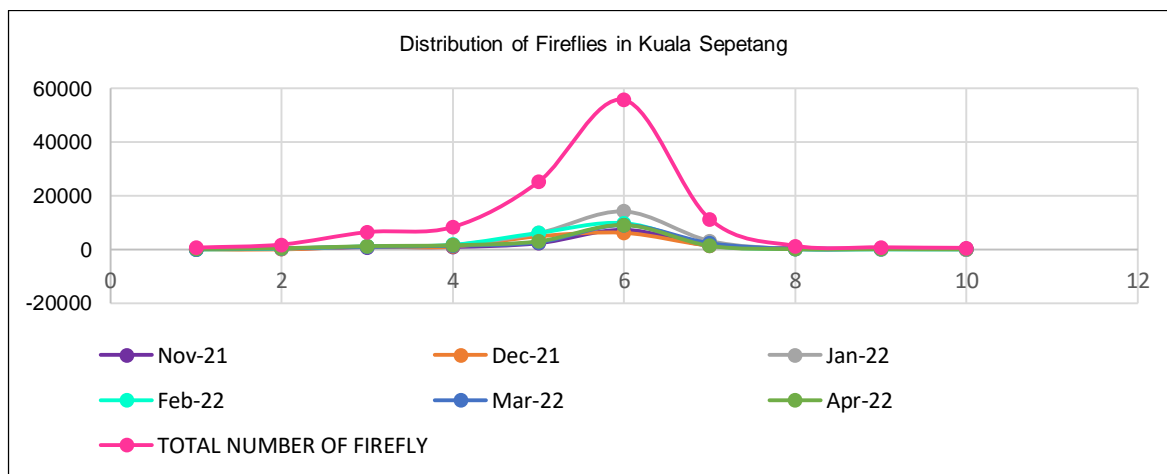


Figure 4: Scatter Plot of Distribution of Fireflies in Sungai Sepetang

4.2 Hotspot Map of Fireflies Along Sungai Sepetang

Figure 5 depicts the hotspot map of fireflies in Sungai Sepetang to portray the geographical location of each station has been mapped using ArcGIS 10.3. Since the Station 1 and 2 are located at upstream, there are most likely having a smaller number of fireflies than Station 6. Station 6 consists 55,719 number of fireflies made it the greatest number of fireflies in Sungai Sepetang. The location of the Station 6 is the most strategically with the biggest area of *Sonneratia caseolaris* (Berembang) on the map. The fireflies were found along Sungai Sepetang were 100% identical to *Pteroptyx tener* along *Sonneratia caseolaris* (Berembang). To support the previous statement, the sample of *Pteroptyx tener* was collected from all the ten (10) display trees along the Sungai Sepetang. The variant of insect communities found in Sungai Sepetang is strongly depending to the vegetation composition. Therefore, Sungai Sepetang is highly dominated by *Sonneratia caseolaris* (Berembang) as the habitats to the firefly.

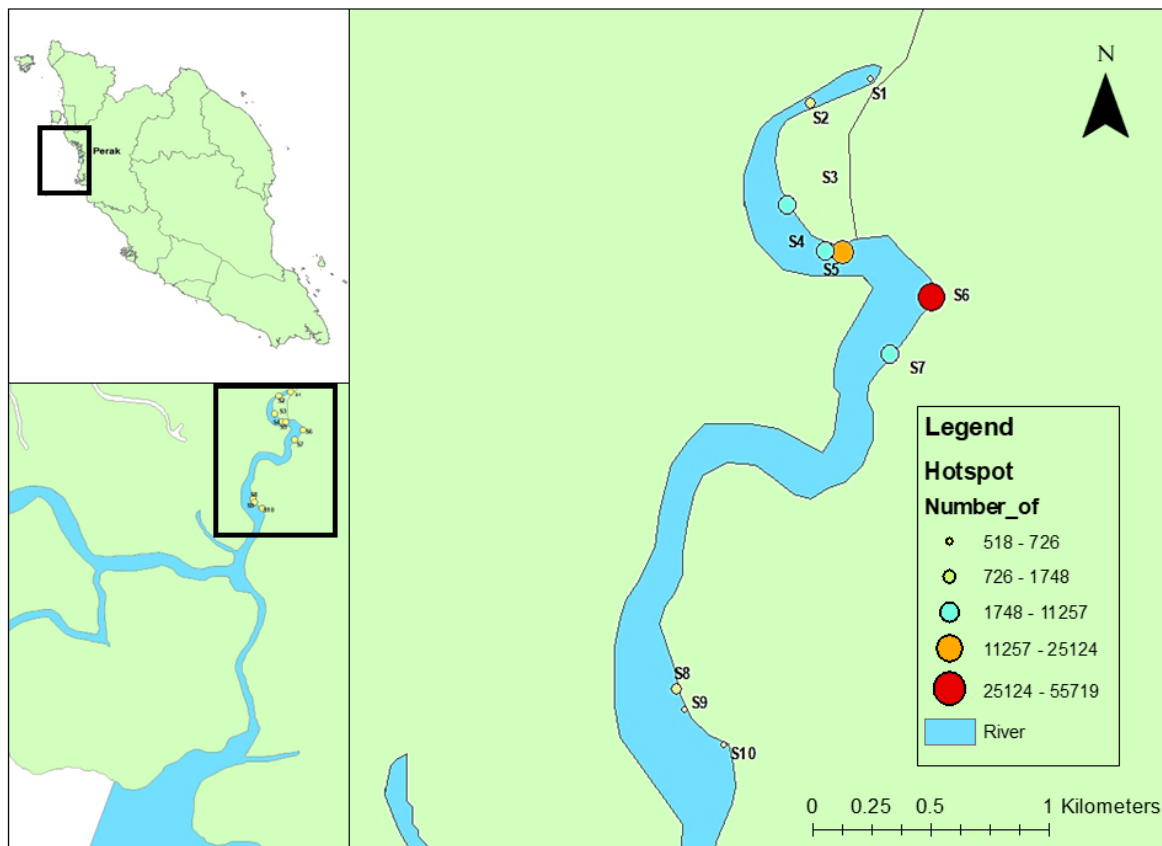


Figure 5: Hotspot Map of Fireflies in Sungai Sepetang.

5.0 Discussion

The distribution of *Pteroptyx tener* along Sungai Sepetang was concentrated along the part of the river with a dominant mangrove vegetation species of *Sonneratia caseolaris* (Berembang). The finding for the study has been identified Station 6 as the greatest number of fireflies. Station 6 was located in the mouth bar of the river and the trees were planted in compact position among themselves which made the flashing patterns brighter than other stations. Shahara et. al (2017) discovered the display trees of the firefly in Miri, Sarawak were distinct from those in Peninsular Malaysia. The *Sonneratia caseolaris* tree is the one that *P. tener* prefers to congregate in Peninsular Malaysia. There are several rivers in Peninsular Malaysia including Sungai Selangor, Sungai Sepetang, and Sungai Johor are dominated by *Sonneratia caseolaris*, also known as Berembang (Norela et al., 2016). Previous studies of firefly with GIS approach only shows about zonation and the review on location in Malaysia. Jusoh et al., (2011) discovered the distribution of *P. tener* along Kerteh River concentrated along the river where the dominant vegetation is *S. caseolaris* into Zonation Map to show their geographic positions. Nada B. et al., (2012) monitored the fireflies along Selangor River on the need to conserve the abundance fireflies and the vegetations by using several standard parameters to achieve the predicted regression for few months.

This study is simply to map the hotspot of the distribution of firefly in Kuala Sepetang supported by the number of fireflies and the vegetations found as the habitats of fireflies. In contrast, there has not yet been studies regarding the hotspot analysis using GIS on the population of firefly in Kuala Sepetang specifically. Therefore, this study will be a great start as a new finding to firefly research in Kuala Sepetang. The limitation of this study only focused on the population of firefly in Kuala Sepetang with the sole primary data of fireflies and its vegetation. The recommendation of this study is to prepare a buffer map with 50m land use to ensure the ecological activities and the relationship between the distribution of firefly with its environmental parameters to conserve the habitats of firefly.

6.0 Conclusions

As a conclusion, the hotspot map of firefly distribution in Kuala Sepetang has been successfully mapped and it is the most suitable approach to identify the distribution of fireflies in Sungai Sepetang. The objectives of this study have been achieved to identify the population of firefly in Kuala Sepetang and mapping the hotspot distribution of firefly. It is possible to establish Sungai Sepetang and other mangrove swamps in Peninsular Malaysia into synchronizing firefly ecotourism destinations. However, in order for the places to be sustainable ecotourism attractions, adequate facilities and organization structure need to be implemented. The results in this study can be used as a future guide to determine the variables or parameters either dependent or independent for other research study area. For upcoming preservation and conservation programmes, all knowledge regarding display trees along Sungai Sepetang may be helpful. As a step towards the conservation and preservation, it is recommended to conduct more research on the analysis using GIS to investigate the land use land cover around the display trees sections.

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Conflicts of Interest The authors declare no conflict of interest.

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