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Diversity and Abundance of Insects in the Recreational Forest of Bukit Keluang, Besut, Terengganu

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ABSTRACT

Bukit Keluang is one of the famous natural recreational sites in Besut, Terengganu due to their beautiful sandy beaches and beautiful landscapes. Bukit Keluang recreational forest consist coastal and lowland dipterocarp forest. The studies on the biodiversity are never been reported at this area and thus, we aimed to investigate the diversity and abundance of insects in the coastal and inland forest of Bukit Keluang recreational forest. We built two plots which are Plot A in the coastal area and Plot B in the inland forest at Bukit Keluang. For each plot, three types of insect traps were used; yellow pan traps, pitfall traps, and Malaise traps. The traps were left for seven days and all insect samples collected were brought to the laboratory for sorting, enumerating and identifying up to order level. A total of 455 individuals of insects consisted of 10 orders (i.e. Hymenoptera, Diptera, Lepidoptera, Coleoptera, Collembola, Homoptera, Orthoptera, Dermaptera, Blattodea and Isoptera) were successfully collected from the forest of Bukit Keluang. Among them, Hymenoptera order dominated the number of individuals collected at 67.25% followed by Diptera (11.21%) whilst Collembola and Dermaptera were the least abundance order collected at 0.22%, respectively. The coastal forest recorded a total of 271 individuals (nine orders) while inland forest recorded 184 individuals (eight orders). No significant difference ($p>0.05$) of insect abundance was recorded between both plots. However, the Shannon-Weiner Diversity Index (H') showed that the diversity of insects in the inland forest was slightly higher (H'=1.52) than the coastal forest (H'=0.86). We conclude that the insects' diversity in Bukit Keluang is relatively higher in inland forest but lower in coastal forest. As no other insect survey has been conducted in this study area in the past, this study delivers a basic evidence and dataset of diversity and abundance for insect which may beneficial for further conservation research at Bukit Keluang in the future.

Keywords: Insects, diversity index, Bukit Keluang, recreational forest

INTRODUCTION

Malaysia is one of the Southeast Asia countries that comprised about 20.62 million hectares of natural forests, which covering 62.5% of the country's land area (Faridah Hanum, 2015). It estimates that more than half of the species of plants and animals in the world live in the tropical rainforests (Myers et al., 2000). Nonetheless, the insects are the largest abundant of animals on earth with two-thirds populations in the tropical rainforests (Idris et al., 2001). According to Foottit and Adler (2017), insects are the world's most diverse group of animals and covered more than 58% of global biodiversity. About 5.5 million species of insects already recorded as an estimation of global species richness (Stork, 2018). This shows that insects are one of the main components in the ecosystem, including in the terrestrial ecosystem. Insects are functionally relevant to forest ecosystems, including pollinators, herbivores, decomposers, predators or parasitoids (Idris & Hasmawati, 2002).

Terengganu is a famous state in Peninsular Malaysia for its coastal tourism activities due to its long and beautiful coastline (Idris, 2017). Many of its beaches were developed as tourist areas and one of them is known as Bukit Keluang. This place is located about 19 km from Jerteh town in Besut district and popular as recreational and eco-tourism destination (Nurul Fatihah Sulaini, 2021). However, recreational activities particularly the hiking in Bukit Keluang would negatively affect the environment (Steven et al., 2011). Although the impact on insects is unknown but large-scale hiking may lead to habitat degradation, the introduction of alien species and the killing of insects occurring in places visited by people (Ciach et al., 2016). In addition, the garbage disposal issue also occurred in Bukit Keluang due to high visitors and recreational activities in the area (Raduan, 2018).

Due to the sensitivity to changes in the terrestrial environment, insect diversity is gradually being applied as an indicator for monitoring and evaluation of terrestrial quality and is important for studies of conservation and restoration of terrestrial. However, as no other insect survey has been conducted in this study area in the past, therefore, this research provides basic information and a dataset of insects' diversity and abundance which may useful for further ecological research at Bukit Keluang in the future. Hence, this study is to determine the diversity and abundance of insects in the coastal and inland forest of Bukit Keluang.

MATERIALS AND METHODS

Sampling site

This study was done at Bukit Keluang, Besut, Terengganu (5°47'56.0"N 102°36'28.6"E) with the highest summit is 346 m above sea level (asl) (Fig. 1). Sampling was carried out in two plots, namely the coastal forest (Plot A) and the inland forest (Plot B). Each plot consists of three sampling points and the selection of each sampling point is done randomly and covers different distances and not far from the hiking trail in collecting data. The coordinate and elevation of each sampling points were recorded using the Global Positioning System (GPS) (Garmin®, USA) as follows:

Plot	Sampling Point	GPS Coordinate	Elevation (asl)
A (Coastal)	1	5^0 48' 02.8"N 102^0 36' 22.3"E	4 m
	2	5^0 48' 01.8"N 102^0 36' 21.9"E	12 m
	3	5^0 48' 02.1"N 102^0 36' 19.7"E	41 m
B (Inland)	1	5^0 47' 40.8"N 102^0 36' 37.1"E	54 m
	2	5^0 47' 44.1"N 102^0 36' 37.3"E	90 m
	3	5^0 47' 46.0"N 102^0 36' 37.6"E	107 m

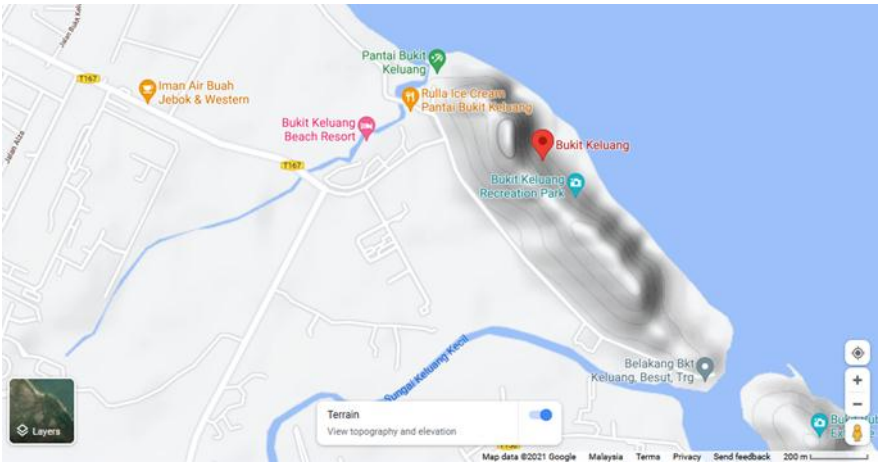

Fig. 1: Map of study area in Bukit Keluang.

Sampling method

The sampling of insects was done using three types of insect trapping techniques; yellow pan trap, pitfall trap and Malaise trap. For each plot, one Malaise trap, three yellow pan traps and three pitfall traps were placed in each of the sampling points. Traps were left in the forest for seven days (10 April 2019 – 16 April 2019). After seven days, the insects were collected and placed in specimen bottles containing 70% ethanol before being transferred to the laboratory for processing and classification process.

Insect identification

The insect samples were brought to the Entomology Laboratory, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, Terengganu for the identification process. All insects collected were sorted by forceps up to the order level. The insects were pinned and dried in the oven at 40°C for three days to maintain the sample structure and ease for identification process. The classification of the order was constructed on the physical morphological characteristic and examined under stereoscopy microscope (Olympus SZ51, Japan). All specimens were identified based on Triplehorn and Johnson (2005).

Data analysis

The T-test analysis was done to compare the abundance of insects between coastal and inland forests using Minitab software version 2019. The diversity, richness and evenness of the insect were analyzed by the Shannon-Weiner Diversity Index and the Margalef Richness Index using the Paleontological Statistics (PAST) Version 3.15. According to Izsák and Papp (2000), the diversity index of species diversity is commonly used to ascertain the species diversity.

RESULTS AND DISCUSSION

The abundance of insects in the coastal and inland forest of Bukit Keluang

In total, there were 455 individuals consist of 10 orders of insects have been successfully collected from both forests (Table 1). Among them, Hymenoptera was the most abundant order that representing 67.25% of total collection then followed by Diptera (11.21%), and Coleoptera, Homoptera and Orthoptera order with similar

abundance at 5.05%, respectively. Other orders were Lepidoptera (3.96%), Blattodea (1.32%), and Isoptera (0.66%). Whilst Collembola and Dermaptera was the least abundant orders at 0.22%, respectively (Table 1).

Table 1. Total number of insects and the percentage of insect order in Bukit Keluang.

	Insect Order	No. of Insect	Percentage (%)
1	Hymenoptera	306	67.25
2	Diptera	51	11.21
3	Coleoptera	23	5.05
4	Hemiptera	23	5.05
5	Orthoptera	23	5.05
6	Lepidoptera	18	3.96
7	Blattodea	6	1.32
8	Isoptera	3	0.66
9	Collembola	1	0.22
10	Dermaptera	1	0.22
	Total	**455**	**100**

Based on the findings, Hymenoptera order dominated the number of individuals in Bukit Keluang forest. This might be due to the lowland dipterocarp tropical forest surrounded Bukit Keluang is identified as the key factors for high number of Hymenoptera recorded. Hymenopteran insects usually live on land and settlements, for example the ants that usually live-in soils (both lowlands and highlands/mountains) that have moderate temperatures (Taib, 2012). Most of the hymenopterans are also beneficial to the ecosystem, either as natural enemies (parasitoids) or as flowering plant pollinators (bees and wasps) (Khairunnadia, 2019). In addition, Diptera was the second highest order recorded in the forest. Diptera is also important as a pollinator, scavenger, and predator (Khairul Husna et al., 2018). Similarly, both Hymenoptera and Diptera were also dominated the tropical rainforests of Perhentian Islands, Terengganu (Salmah et al., 2019), and Gunung Datuk, Negeri Sembilan (Siti Aishah et al., 2017).

Meanwhile, the results for each plots showed that a total of 271 individuals were collected from the coastal forest with nine insect orders (Table 2) whilst 184 individuals from the inland forest with eight insect orders (Table 3). Obviously, Hymenoptera order recorded the highest individuals recorded in coastal (79.34%) and inland (49.46%) forest whilst Isoptera order recorded the lowest individuals in both plots at 0.37% and 1.09%, respectively. However, there was no significant difference ($P>0.05$) of insect abundance between the inland and coastal forest of Bukit Keluang (Fig. 2).

Table 2. The composition of insect abundance of different orders in the coastal forest of Bukit Keluang.

	Insect Order	No. of Insect	Percentage (%)
1	Hymenoptera	215	79.34
2	Hemiptera	17	6.27
3	Diptera	15	5.54
4	Lepidoptera	10	3.69
5	Coleoptera	7	2.58
6	Orthoptera	4	1.48
7	Collembola	1	0.37
8	Dermaptera	1	0.37
9	Isoptera	1	0.37
	Total	**271**	**100**

Table 3. The composition of insect abundance of different orders in the inland forest of Bukit Keluang.

	Insect Order	No. of Insect	Percentage (%)
1	Hymenoptera	91	49.46
2	Diptera	36	19.57
3	Orthoptera	19	10.33
4	Coleoptera	16	8.70
5	Lepidoptera	8	4.35
6	Hemiptera	6	3.26
7	Blattodea	6	3.26
8	Isoptera	2	1.09
	Total	**184**	**100**

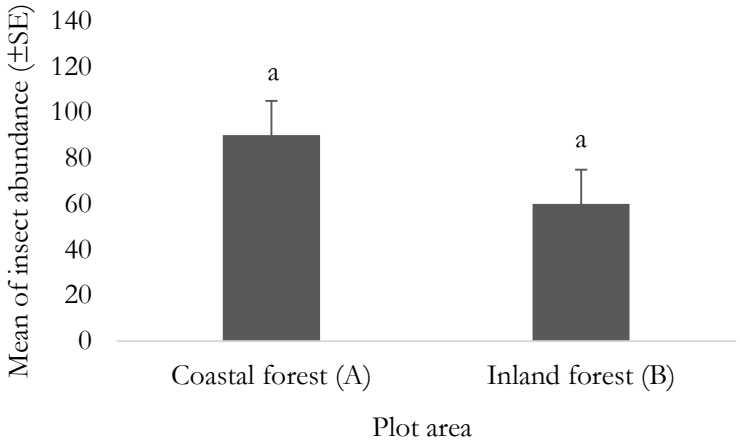

Fig. 2. Insect abundance between the coastal and inland forest of Bukit Keluang. Means with the same letters in different bars are not significantly different ($p>0.05$).

Although the abundance of insects in coastal forest showed slightly higher numbers than in inland forest but the insect population abundance was not significantly difference between the both plots (Fig. 2). This may be due to the low sampling altitude level which below 107 m asl. According to Abdelmutalab et al. (2018), the distribution of insects varies with every 100 m increase in elevation. Similarly, Salmah et al. (2019) found that no significant difference of insect abundance in coastal and inland forest of Perhentian Island.

Insect diversity, richness, and evenness

A summary of Shannon-Weiner Diversity Index, Margalef's Richness Index and Evenness Index in the coastal and inland forest of Bukit Keluang is shown in Table 4. Results showed that the diversity of insects was higher in the inland forest (H'=1.52) compared to the coastal forest (H'=0.86) indicated that the diversity of insects was relatively high in the inland forest but low in the coastal forest. Also, the insect species evenness was higher in inland forest (E'=0.73) but lower in coastal forest (E'=0.39). But the insect species richness (R') showed a higher value at 1.43 in coastal forest compared to inland forest with a lower value at 1.34.

Table 4. Shannon-Weiner Diversity Index, Margalef's Richness and Evenness Index Index in the inland and coastal forest of Bukit Keluang.

Index	Coastal Forest	Inland forest
Shannon-Wiener Index of Diversity (H')	0.86	1.52
Species Evenness (E')	0.39	0.73
Margalef's Richness (R')	1.43	1.34

Generally, the diversity index value is in the range of 1.5 – 3.50 where the values is increasing as it is positively related to the richness and evenness index of the community and the index is rarely greater than 4 (Chung et al., 2016). However, Magurran (2004) stated that low species diversity has H' value within 1.0 to 2.4. Hence, the diversity of insects in both plots of Bukit Keluang forest obtained in this study is considered low. It might be due to the high human activities in Bukit Keluang especially visitors who hike the hill. Report showed that the number of visitors hiking Bukit Keluang will increase up to 300 people during weekends and public holidays (Nurul Fatihah Sulaini, 2021). According to Ciach et al. (2016), hiking, especially on a large scale, may be having a negative influence on insect populations and moreover the habitat degradation will occur due to the expansion of trail networks and larger numbers of hikers. Kamel (2020) found that the hiking trail in Wadi Telah, Egypt had a negative impact on insect flower visitors and their associated floral resources. Therefore, more effective management of recreational areas needs to be carried out by the authorities to preserve the area.

Overall, the insect diversity recorded in Bukit Keluang was slightly lower than other studies areas such as in Perhentian Islands forest which the island is located about 20 km from Bukit Keluang (Salmah et al., 2019). The difference is thought to be due in addition to being influenced by season, human activities in clearance land, and structures vegetation as a habitat for insects (Putri & Allo, 2009). Purba (2002) suggests that activities in the regions settlement and recreation resulted in it changes in the physical and chemical properties of waters as well affect the composition and number of species organism. The consequences of this situation are the degradation of biodiversity in areas adjacent to settlements. Matilda (2012) stated that the diversity and abundance of insects are also affected by abiotic and biotic factors and their connections.

CONCLUSION

As the conclusion, this study successfully documented a total of 10 orders of insects found in recreational forest of Bukit Keluang with 455 insects' inventory. The insect orders recorded were Hymenoptera, Diptera, Coleoptera, Homoptera, Orthoptera, Lepidoptera, Blattodea, Isoptera, Collembola and Dermaptera. Among them, Hymenoptera was the most abundant insect order recorded in both plots. Although there was no significant difference of insect abundance was recorded between coastal and inland forest of Bukit Keluang but the diversity of insects in the inland forest was relatively higher than coastal forest in this area. This conclude that there was a variation in terms of the insect's diversity among both forest types. These findings will provide the baseline data for the preservation and protection of the ecosystem in the future.

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