DIVERSITY AND DISTRIBUTION OF CLASS INSECTA FROM DIFFERENT LANDSCAPES AT KUALA KENIAM RESERVE FOREST, PAHANG

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ABSTRACT

A study on the diversity and abundance of Class Insecta was conducted at Kuala Keniam National Park, Pahang, Malaysia from 30th October 2021 to 1st November 2021 using malaise traps. Three environmental gradients namely forest fringe, middle forest, and inner forest were chosen and set up with Trap 1, Trap 2, and Trap 3, respectively. One trap was placed for each landscape. A total of 2732 insect specimens belonging to 12 orders and 264 morphospecies of insects were collected. The orders identified were Collembola, Homoptera, Orthoptera, Hemiptera, Trichoptera, Blattodea, Mantodea, Siphonaptera, Coleoptera, Diptera, Hymenoptera, and Lepidoptera. Dipteran were the most abundant order found where 297 individuals (72 morphospecies) were collected in the forest fringe followed by 588 individuals (61 morphospecies) in the middle forest and 1032 individuals (41 morphospecies) in the inner forest. Mantodea recorded the lowest number of individuals collected where it can be only found in the forest fringe with only one individual. Shannon–Wiener Diversity Index (H′) showed that the forest fringe had the highest diversity value with H′ = 1.42, followed by the middle forest with H′ = 1.09 and the inner forest with H′ = 0.74. The Evenness Index (E′) and Margalef Richness Index (R′) also showed the highest value from the forest fringe with E′ = 0.34 and R′ = 1.71 respectively, compared to the middle forest and the inner forest. Kruskal–Wallis test showed that there was a significant difference in insect distribution across the environmental gradients where a value of $P<0.05$. Overall, this study suggests that the diversity of Class Insecta at the three different locations in Kuala Keniam National Park is low. The short duration of sampling together with the rainy season might be the factors contributed to the low number of insects diversity. This study is important as it provides the baseline data for further study of insect in Kuala Keniam National Park, Pahang as well as to increase the awareness of conservation of insects.

Keywords: Abundance, diversity, environmental gradient, Class Insecta

ABSTRAK

Satu kajian mengenai kepelbagaian dan taburan kelas Insecta telah dijalankan di Taman Negara Kuala Keniam, Pahang, Malaysia pada 30 Oktober 2022 sehingga 1 November 2022 menggunakan perangkap malaise. Tiga kecerunan persekitaran iaitu pinggir hutan, hutan tengah dan hutan dalam telah dipilih yang mewakili Perangkap 1, Perangkap 2, dan Perangkap 3. Sebanyak 2732 spesimen yang terdiri daripada 12 order dan 264 morfospesies serangga telah dikumpul. Order yang dikenal pasti adalah Collembola, Homoptera, Orthoptera, Hemiptera, Trichoptera, Blattodea, Mantodea, Siphonaptera, Coleoptera, Diptera, Hymenoptera dan Lepidoptera. Diptera merupakan order yang paling melimpah di mana 297 individu (72 morfospesies) dikumpulkan dari pinggir hutan, diikuti oleh 588 individu (61 morfospesies) di hutan tengah dan 1032 individu (41 morfospesies) di hutan dalam. Mantodea mencatatkan bilangan individu yang paling rendah dikumpul di mana ia hanya boleh ditemui di pinggir hutan dengan hanya satu individu. Indeks Kepelbagaian Shannon-Wiener (H') menunjukkan bahawa pinggir hutan mempunyai nilai kepelbagaian tertinggi dengan H'=1.42, diikuti oleh hutan tengah dengan H'=1.09, dan hutan dalam dengan H'= 0.74. Indeks Keseragaman (E’) dan Indeks Kekayaan Margalef (R’) juga menunjukkan nilai tertinggi dari pinggir hutan dengan E’=0.34 dan R’=1.71 berbanding dengan hutan tengah dan hutan dalam. Ujian Kruskal-Wallis menunjukkan terdapat perbezaan yang signifikan dalam taburan serangga merentasi kecerunan persekitaran di mana nilai $P<0.05$. Secara keseluruhannya, kajian ini menunjukkan bahawa kepelbagaian kelas serangga di tiga lokasi berbeza di Taman Negara Kuala Keniam adalah rendah. Tempoh pensampelan yang singkat dan musim hujan mungkin menjadi faktor penyumbang kepada bilangan kepelbagaian serangga yang rendah. Kajian ini amat penting kerana ia menyediakan data asas untuk kajian lanjut serangga di Taman Negara Kuala Keniam, Pahang serta meningkatkan kesedaran pemuliharaan serangga.

Kata kunci: Kebanyakan, diversiti, kecerunanan persekitaran, Kelas Insekta

INTRODUCTION

Insects can be found in every terrestrial and freshwater ecosystem, including deserts, freshwater ponds, and tropical forests where their diversity is incredible (Myers 2001). An insect is an arthropod with six legs and two pairs of wings that has been classified under the class Insecta (Hexapod). This class is well known for being the largest group of organisms as it consists of 30 orders with eight dominant orders, where only two of the major orders are the wingless insects which are Archaeognatha (jumping bristletails) and Zygentoma (silverfish) (Urryet et al. 2020). The rest are the winged orders namely Coleoptera (beetles), Diptera (mosquitoes and flies), Hymenoptera (wasps, bees, and ants), Hemiptera (true bugs), Lepidoptera (butterflies and moths), and Orthoptera (grasshoppers and crickets). Insects play an important role as predators, pollinators, parasites, decomposers, and source of protein for other animals such as lizards, rats, and birds (Urryet et al. 2020).

Insects are one of the largest classes of the phylum Arthropoda, having segmented bodies, jointed legs, and external skeletons. They have an exoskeleton that will protect them from shocks and dryness (James 2009). Living insects have a wide range of body sizes, ranging from 0.015 cm, such as feather-winged beetles and parasitic wasps which are almost microscopic, to the Hercules moth, which has a wingspan of about 30 cm (Clapham & Karr 2012). Insects are differentiated by their body, the segmented thorax, and abdomen, which contain the digestive, excretory, and reproductive systems (Wigglesworth 2020). The head of an adult insect has two large compound eyes which function to detect small movements. A pair of articulated antennae are also present on the head, which varies in size and shape, depending on the species of the insects. The antennae give insects the ability to detect odours and vibrations (Triplehorn & Johnson 2005). The thorax of an insect is the midsection of the body. The thorax functions to hold the wings, head, and abdomen. The third component of an insect is the abdomen. The digestive tract, the heart, respiratory system, and reproductive organs are all located in the abdomen.

Metamorphosis is a process where insects undergo physical changes from larva to adult (Urryet et al. 2020). The metamorphosis that occurs in different insect groups varies, and these variations may be loosely divided into three types: ametabolous (no metamorphosis), hemimetabolous (incomplete metamorphosis), and holometabolous (complete metamorphosis). In ametabolous metamorphosis, wingless insects undergo direct development: the hatchling is a smaller form of the adult, and their form stays constant throughout their development to adulthood. The adult continues to moult, usually alternating moults with periods of reproduction (Truman 2019). Meanwhile, for hemimetabolous metamorphosis, the insects change from a nymph to an adult by passing through a series of moults and shedding its exoskeleton at each moult. In the end, the nymph becomes a full-sized adult, acquires wings, and becomes more sexually mature (Hall & Martín-Vega 2019). In holometabolous metamorphosis, the insects undergo more drastic changes, which are from egg to larva to pupa to adult (Hall & Martín-Vega 2019). The pupa is a transitional stage between the larva and the adult that occurs through non-feeding (Truman 2019). Adults and their young have distinct characteristics that help them to avoid intraspecific competition for food and habitat, and the internalisation of wing development allows larval forms to better burrow into food sources and soil (Klowden 2013). A pupal stage occurs between the larval and adult stages of metamorphosis (Urryet et al. 2020).

Many insects are incredibly essential to humans and society, and it is impossible to be without them (Triplehorn & Johnson 2005). Insects have given beneficial impacts economically and ecologically. They provide a wide range of ecosystem services, including seed dispersal, pollination, organic matter digestion, nutrient cycling, and water filtration (Crespo-Pérez et al. 2020). Insects also have tremendous economic importance as they produce useful substances such as honey, wax, lac, dyes, and silk that are commercially beneficial (Scudder 2017). However, they may also cause much damage to the environment, especially in agricultural and forest crops, where many of them are disease vectors (Chowański et al. 2016). In general, moths, cutworms, armyworms, earworms, borers, and grain moths are the most harmful to crops around the world, followed by beetles such as rootworms, wireworms, grubs, grain borers, and weevils (García-Lara & Saldivar 2016).

Previously, no complete documentation on the distribution and diversity of insects has been done in Kuala Keniam National Park, Pahang, leading to difficulties in obtaining specific data such as the types of insects present, where their economic and ecological roles are still unknown. Nowadays, anthropogenic effects due to deforestation, agriculture, tourism, mining, and the release of industrial waste through the clearing of the forest have caused a huge decline in the diversity of flora and fauna, including insects. For example, rapid deforestation due to the development of infrastructures near the livelihoods of Batek Negrito, an indigenous people tribe living next to the national park, has threatened the diversity and abundance of the insect species as well destroyed aborigines' villages (Yng et al. 2015).

From this study, we sought to understand the diversity and abundance of class Insecta at selected sampling sites in Kuala Keniam National Park and the relationship between insect distribution and the environmental gradient from the forest fringe to the inner forest. The questions asked from this study were (1) What kind of insect's orders present in Kuala Keniam Reserve Forest and (2) Is the distribution of Class Insecta differ from different landscapes from the forest fringe to the inner forest as to how much anthropogenic impact affects the insect's distribution. This research will provide a list of insect's orders present in Kuala Keniam Reserve Forest at different landscapes to see how human activities affected their distributions. In addition, this study provides beneficial information, knowledge, and documented references about the diversity of insect species present in the national park useful for the community, researchers, or even the Department of Wildlife and National Parks, Peninsular Malaysia (DWNP) for conservation planning.

MATERIALS AND METHODs

Study Site

The study site chosen was Kuala Keniam National Park, located about 25 km from Kuala Tahan (Figure 1). A boat voyage from the jetty of Kampung Pagi to Kuala Keniam via Sungai Tahan was needed to get there and it took around 40 min of boat riding. Universiti Teknologi Mara (UiTM) has established a research station in Kuala Keniam to conduct studies in the fields of biodiversity, ecology, sustainability, and climate change (Suratman 2012).

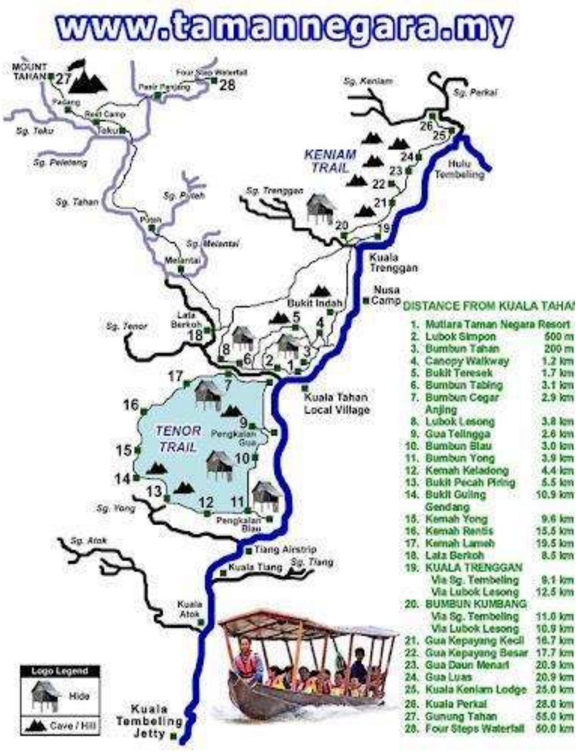

Figure 1. Map of Kuala Keniam National Park, Pahang

(Source: Halim 2014)

Sampling Methods
The insects were collected using malaise traps and then sorted into their correct orders based on their morphology and physical appearance. The malaise trap is a passive tent-like intercept trap (Figure 2) that is used to collect flying insects such as flies, bees, and wasps, as well as low-flying and ground insects (Evans 2016). The trap's collecting or killing bottle was affixed to the top, and the killing bottle was filled with one-third of a 70% ethanol solution (Upton & Mantle 2010). Insects that fly upwards have landed in the 70% alcohol-filled death container.

Figure 2. Malaise trap at Kuala Keniam National Park, Pahang

Three malaise traps were placed in 3 areas separated 250 m from each other starting from the forest fringe, the middle of the forest, and the inner forest (Figure 3). The traps were left unattended for three days. The samples were collected on the third day from the killing bottle attached to the trap. The collected insects were pinned and identified using a microscope based on their morphology and physical appearance before being sorted into their respective orders. Only the external morphological characters such as body shape, colour patters and types of antennae were used in identifying the orders.

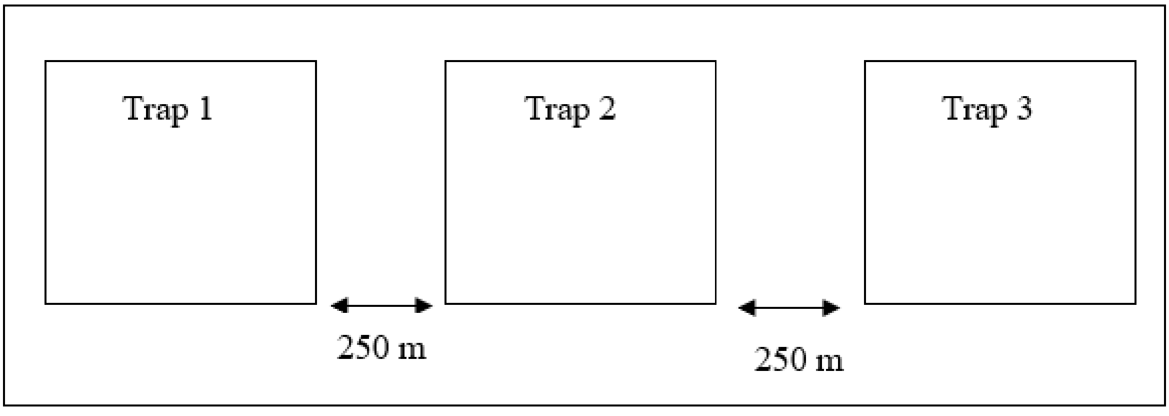

Figure 3. Arrangement of malaise traps

Data Analysis
All data were analysed using Paleontological Statistics (PAST) software. The indices that were measured are Shannon–Wiener Diversity Index, Evenness Index, and Margalef Richness Index. Normality test and Kruskal–Wallis test were performed by using Statistical Product and Service Solutions (SPSS) to see the differences in insect's distribution across three different landscapes.

RESULTS AND DISCUSSION

Abundance of Class Insecta at Kuala Keniam National Park
Throughout the study, a total of 12 orders of insects comprising 2732 individuals were successfully collected and sorted from Kuala Keniam National Park, Pahang (Figure 4).

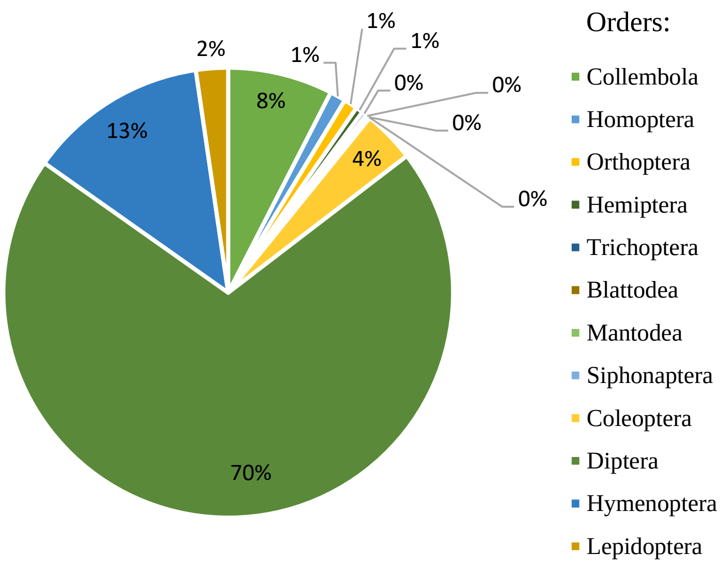

Figure 4. Percentage of insects collected based on orders

The 12 orders of insects in descending order were Diptera with 70% of individuals followed by Hymenoptera with 13%, Collembola (8%), Coleoptera (4%), Lepidoptera (2%), Homoptera, Hemiptera, and Orthoptera with 1% each, while Trichoptera, Blattodea, Mantodea, and Siphonaptera recorded less than 10 individuals. A total of 264 morphospecies were identified based on their morphology difference.

Abundance of Insect Orders at Different Traps
Table 1 shows the abundance of insects in Kuala Keniam National Park caught from different traps. The total insect specimens that were collected at the study sites was 2732 individuals. Trap 1 represents the forest fringe, Trap 2 represents the middle of the forest, and Trap 3 represents the inner forest.

Table 1. Abundance of insects in different traps at Kuala Keniam National Park

Order	Morphospecies	Trap			Total no of Individuals
		1	2	3	
Collembola	7	13(4)	113(5)	80(7)	206
Homoptera	5	2(2)	5(2)	24(4)	31
Orthoptera	5	13(3)	7(3)	7(2)	27

Hemiptera	8	8(6)	6(5)	0	14
Trichoptera	5	3(3)	3(1)	3(2)	9
Blattodea	4	4(4)	2(1)	0	6
Mantodea	1	1(1)	0	0	1
Siphonaptera	2	2(2)	0	0	2
Coleoptera	49	61(32)	23(18)	19(14)	103
Diptera	110	297(72)	588(61)	1032(41)	1917
Hymenoptera	46	177(31)	105(27)	71(17)	353
Lepidoptera	22	32(11)	15(9)	16(9)	63
Total Individual		613 22%	867 32%	1252 46%	2732
Total Order	12	12	10	8	
Total Morphospecies	264	171	132	96	

*The value in the bracket is the total number of morphospecies.

The distribution of the percentage of insects collected at Kuala Keniam National Park from the malaise traps that were placed separately 250 m from each other starting from the forest fringe (Trap 1), the middle of the forest (Trap 2), and the inner forest (Trap 3) is presented in Figure 5.

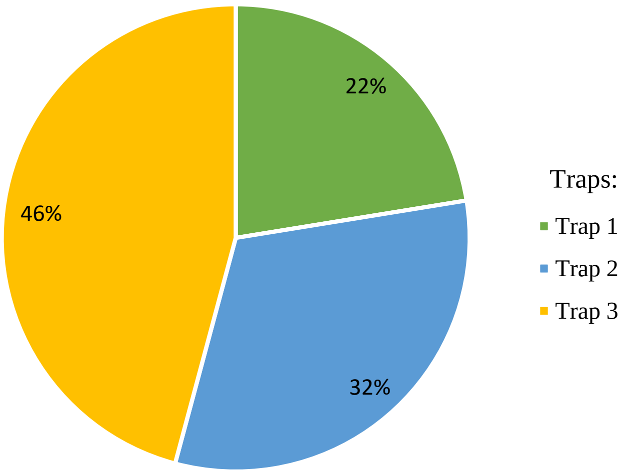

Figure 5. Percentage of total individual insects in each trap

Trap 3, which was in the inner forest, had the most abundant insects that represent 46% of total individuals collected in Kuala Keniam National Park with 1252 individuals, compared to Trap 1 with 22% and Trap 2 with 32% of total individuals. The morphospecies distribution of Class Insecta from the three different malaise traps is shown in Figure 6.

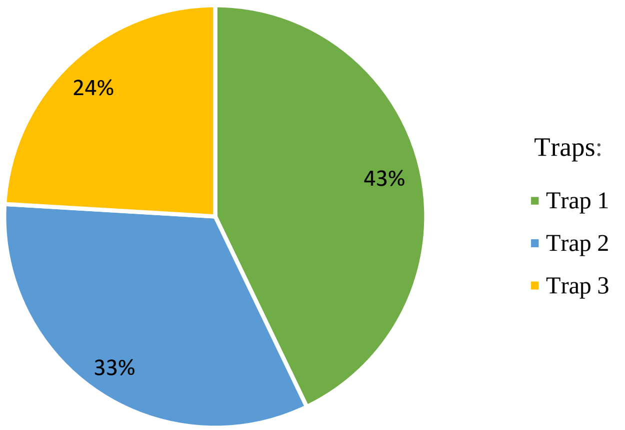

Figure 6. Percentage of insect morphospecies in each trap

A total of 264 insect morphospecies were identified based on their morphology and physical appearance. Trap 1 was the most diverse with 171 morphospecies (43%), followed by Trap 2 with 132 morphospecies (33%) and Trap 3 with 96 morphospecies that contributed to 24% of total morphospecies in Kuala Keniam National Park.

Based on Table 1, Diptera were the most abundant order at Kuala Keniam National Park with 1917 individuals and 110 morphospecies collected. This is due to their incredibly diverse larval habitats (Nizam et al. 2022). Diptera were collected the most at Trap 3, which was in the inner forest, with 1032 individuals. The densely forested area with a high number of shrubs contributed to the high total number of Diptera individuals. This result is supported by the outcome that Trap 3 was set up in the inner forest near the riverbank, where woody shrubs typically thrive (Goeltenboth et al. 2006). Herb coverage, according to Scherber et al. (2014), is positively related to Dipteran richness and abundance due to increased food resource availability and a larger accessible vegetation area. This finding, however, contradicts a previous study by Mohd Hatta et al. (2011), who found a lower number of Diptera in the inner forest compared to the forest fringe. Diptera play important roles in the earth's ecological relations, such as controlling pests, flower pollinators, decomposers, and disease vectors (Skevington & Dang 2002).

Hymenoptera recorded the second-highest total individuals found with 353 specimens identified and 46 morphospecies. The total individual of Hymenoptera was greater in Trap 1, which was in the forest fringe, compared to Trap 2 and Trap 3. This result, however, contradicts the findings of Mohd Hatta et al. (2015), who concluded that the inner forest has the highest number of individuals collected when compared to the forest fringe. In their study, the inner forest had a higher population density due to the low temperature and high humidity, whereas the forest fringe area was more open and exposed (Mohd Hatta et al. 2015). Hymenopterans are beneficial to the ecosystem, either as natural enemies (parasitoids) or as pollinators of flowering plants (bees and wasps) (Mohamed et al. 2019).

Collembola recorded the third-highest total individuals found with 206 specimens and 7 morphospecies. Most species of Collembola feed on plant litter, fungi, bacteria, algae, live plant tissues, and plant pathogens (Feng et al. 2019). A study by Widrializa et al. (2015) stated that Collembola total and diversity are related to each individual’s ability to adapt to the changing environmental conditions and food availability. In their study, infrequently, it was found that the lack of litter and canopy are an unfavourable condition for Collembola. This is due to the incoming sunlight to the soil surface, and it causes high temperature and low humidity of the environment. Therefore, this supports the finding that the total number of Collembola individuals is higher in Trap 2 (middle of the forest) compared to Trap 1 and Trap 3, as it has high humidity and low exposure of sunlight. This is due to the condition of the middle of the forest that has more canopy with the presence of vegetation. This situation indicates the importance of food availability and cover crop as soil cover and shelter for Collembola. Collembola also play an important role towards the ecosystem in maintaining the environment as a biocontrol agent and stimulator of microbial activity (Widrializa et al. 2015).

Based on this study, Coleoptera were in the category of least abundant individual collected with 103 individuals and 49 morphospecies. This could be due to climate change, which contributes to the low diversity and abundance of Coleoptera. It is supported by the study from Musthafa and Abdullah (2019), which stated that multiple factors influence beetle distribution and diversity, including anthropogenic disturbances, historical factors, and numerous environmental factors. Based on the result, Trap 1 (forest fringe) has a high number of Coleoptera individuals compared to Trap 2 and Trap 3. This is because Trap 1 was located at the forest fringe, which receives high exposure of light. The high total of Coleoptera individuals in Trap 1 is supported by a study done by de Medeiros et al. (2017), where they proposed that light draws a high number of Coleoptera from a broad range of families and larger diversity, even if a few species prefer light that are less appealing to most species. However, Coleoptera had the highest number of morphospecies recorded with 49 morphospecies compared to Hymenoptera with 46 morphospecies, although Hymenoptera had the second-highest number of individuals.

Lepidoptera is one of the most important insect orders, both in terms of size and diversity, with some 160,000 described species in more than 120 families (Cranston & Gullan 2010). However, this study area only recorded 63 total individuals with 22 morphospecies for Lepidoptera. In this study, a malaise trap was used for sampling, which contributed to the low number of total Lepidoptera individuals. Ranius et al. (2014) proposed using a light trap to collect Lepidoptera, as it draws their attraction to the light. In their study, temperature and light source had an effect on observed species richness and abundance of Lepidoptera. Norberg and Leimar (2002) proposed that widely distributed butterfly species have a greater proclivity for habitat exploration than localised and rare species and presented empirical evidence to support this hypothesis. However, in this study, the highest number of Lepidoptera individuals was recorded in Trap 1 (forest fringe) compared to Trap 2 and Trap 3. This might be due to the presence of shrubs and flowering plants that provide nectars as their food (Wäckers et al. 2007). The rest of the orders were the least individuals found in Kuala Keniam National Park, as the percentage of individuals was less than 2%. The reasons for these findings were unclear, but they could be related to their habitat preferences and abiotic factors.

The overall findings concluded that the abundance of insects in Kuala Keniam National Park, Pahang, was different between the traps at different environmental gradients. However, in this study, the low number of individuals gathered was significantly influenced by the three-day duration of sampling activities. In contrast, for the research conducted by Mohd Hatta et al. (2015) at a selected forest in Langkawi, the malaise trap was set up from October to March 2013, approximately six months, with collecting bottles replaced every two months, guaranteeing a higher number of specimens collected. Sample collection was also influenced by the rainy season (Brown 2006), which causes the wings of flying insects to become wet, making it difficult for them to fly back to their habitat. This study was conducted during the rainy season, thus contributing to the smaller number of specimens collected.

The malaise traps were set at three different environmental gradients, which are Trap 1 (forest fringe), Trap 2 (middle forest) and Trap 3 (inner forest). Malaise trap that was set at the inner forest are less likely to be disturbed by any disturbances because the location was densely forested with low human activities and disturbances. Inner forest is rich with timber species in the family of Dipterocarpaceae with Meranti (*Shorea* spp.) and Keruing (*Dipterocarpus* spp.) (Suratman et al. 2010). The inner site of the forest also has lower temperature compared to the forest fringe. The humidity was also quite high due to the placement of a malaise trap near to the river. This statement is supported by the claim made by Siti Khairiyah et al. (2015) that most insects were found in the inner forest. Insects need shelter to protect from predators or human activities. Thus, on the forest fringe where there are fewer trees, shrubs and grass, insects do not prefer to build their nest. Moreover, a malaise trap set at the forest fringe was near to the research station. Thus, it might have an indirect impact on the number of insects collected compared to inner forest as it is more open and exposed.

Availability of food sources such as nectar also influences the differences in total individuals of insects (Nepi et al. 2018). However, Trap 1 had low abundant individuals even though it was located at the forest edge with open space, which was strongly associated with human disturbances and activities (Beche et al. 2022). Anthropogenic activities (for example, logging, farming, mining, and tourism) cause fragmentation and degradation, affecting the growth and distribution of plant communities (Hussein et al. 2021). The location of Trap 1 near the research station might have an indirect impact on the number of insects collected in it. Meanwhile, Trap 3 recorded the highest number of individuals because the location was densely forested with low human activities and disturbances.

Species Diversity, Evenness, and Richness of Insects

PAST software version 4 was used to analyse the diversity of Class Insecta at Kuala Keniam National Park, Pahang. The statistical software consists of three indices that were used namely, Shannon–Wiener Diversity Index (H′), Shannon–Wiener Evenness Index (E′), and Margalef Richness Index (R′). Table 2 shows the diversity indices analysis of insects, which quantified the insect diversity representing the Kuala Keniam National Park, Pahang.

Table 2. Diversity indices analysis of Kuala Keniam National Park

Trap	**H′**	**E′**	**R′**
Trap 1	1.42	0.34	1.71
Trap 2	1.09	0.30	1.33
Trap 3	0.74	0.26	0.98

The Shannon–Wiener Diversity Index (H′) was used to compute the ecosystem's diversity index and test for a significant difference in insect species diversity between the traps (Okrikata & Yusuf 2016). Based on Table 2, the overall Shannon–Wiener Diversity Index computes that the diversity was higher in Trap 1 compared to Trap 2 and Trap 3. The H′ value for Trap 1 (H′ = 1.42) was the highest, followed by H′ value from Trap 2 (H′ = 1.09) and Trap 3 (H′ = 0.74). This indicates that Trap 1 had the highest diversity compared to Trap 2 and Trap 3, despite the least number of individuals collected here. In most ecological studies, the range of H’ is between 1.5 and 3.5 where this number is rarely exceeded 4 (Mohamed et al. 2019).

All three traps from the forest fringe towards the inner forest recorded a value of H' less than 2.0. Low diversity at all three traps may be due to sample collection being done during the rainy season. The study done by Mohd Hatta et al. (2015) states that during this wet period, insects will seek safety by limiting foraging and seeking shelter as rainfall causes immediate mortality of larvae and eggs and shifts insect development.

The value for Shannon–Wiener Evenness Index for Trap 1 (E′ = 0.34) was higher compared to the E′ value for Trap 2 (E′ = 0.30) and Trap 3 (E′ = 0.26). The Evenness Index ranges from 0 to 1 in which 1 is complete evenness (Smith & Wilson 1996). The huge variation between the most abundant and the least abundant numbers of order collected in each trap led to the low range of Shannon–Wiener Evenness Index. No dominating families in each trap could lead to the high E' value where 1.00 is max E' value (Manuel 2009) which in this study, all traps showed less than 0.5 indicating some orders dominated the traps.

Trap 1 recorded the highest Margalef Richness Index (R′ = 1.71) compared to Trap 2 (R′ = 1.33) and Trap 3 (R′ = 0.98). This shows that Trap 1 had the highest species richness compared to the other traps even though the number of individuals in Trap 1 was the least. The Margalef index has no limit and varies according to the number of species. Because of its sensitivity to sample size, it only considers one aspect of diversity (species richness) when comparing the sites (Kocataş 1992).

A normality test was performed and a non-parametric Kruskal-Wallis test was used due to non-normal distribution ($P<0.05$). The hypothesis for this study was the distribution of insects was similar across the environmental gradient from the forest fringe to the inner forest. The null hypothesis was rejected because $P<0.05$, which indicates that there was a significant difference between the distribution of orders across the environmental gradients (Kruskal-Wallis, $\chi^2 = 84.65$, df = 2, $P<0.05$). The post hoc test through pairwise comparison shows the significance from all traps. The differences in the *p* values between traps are shown in Table 3.

Table 3. Pairwise comparisons across the trap

Traps	**Pairwise Comparisons of Trap (*P* value)**
Trap 1 – Trap 2	<0.001
Trap 2 – Trap 3	<0.001
Trap 1 – Trap 3	0.019

Table 3 shows that there was a significant distribution of morphospecies of Class Insecta across all traps. The distributions of morphospecies of Class Insecta were statistically significant among Trap 1–Trap 2, Trap 2–Trap 3, and Trap 1–Trap 3 as their *P* values were less than 0.05. The Kruskal–Wallis test results show that there was a significant difference in insect distribution across the environmental gradients where Trap 1–Trap 3 had a significantly higher distribution compared to Trap 1–Trap 2 and Trap 2–Trap 3. It means that the distribution of insects is higher in Trap 1–Trap 3 compared to others.

CONCLUSION

In conclusion, a total of 2732 individuals of insects were successfully collected at Kuala Keniam National Park, Pahang where the inner forest is highly abundant compared to the forest fringe and the middle forest. The diversity in Kuala Keniam Reserve Forest is considered low where the H’ do not even reach the normal range for the H’ which are between 1.5- 3.5. The short sampling period of only 3 days, low number of traps used, and the rainy seasons contributed to the low diversity of insects here. The forest fringe recorded the highest insect diversity even though it had the least number of individuals collected due to its location near food sources, exposure to sunlight, and high temperature; these factors allow some insects to live comfortably there, as opposed to the inner forest, which has low temperature and high humidity. The study of diversity and abundance Class Insecta at Kuala Keniam National Park, Pahang hopefully can provide the baseline data for the use of upcoming research to be compared with for better research and understanding.

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AUTHORS DECLARATIONS

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Conflict of Interest
None declared.

Ethics Declarations
No ethical issue required for this research.

Data Availability Statement
This manuscript has no associated data.

Authors' Contributions
SKMH conceived this research and designed experiments; NNMY, SHK and AA participated in the design and interpretation of the data; NHH, NBMN and NAN performed experiments and analysis; SKMH, NHH and INSY wrote the paper and participated in the revisions of it. All authors read and approved the final manuscript.

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