DIVERSITY AND ABUNDANCE OF BEETLE AT KUALA KELAPOR, NATIONAL PARK, MALAYSIA

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ABSTRACT

National Park is one of the oldest rainforests found in South-east Asia andit hasa very complex ecosystem. The objective of this study was to preparean inventory on beetle abundance and diversity at Kuala Kelapor National Park, Malaysia. Beetles were sample during pitfall traps, Malaise traps and light traps at five different trails in April 2015. This study successfully recorded709 individuals of beetles from 93 different species belonging to 26 different families. The most abundant species was *Coccotrypes* sp. 1, followed by *Coccotrypes* sp. 2 and *Aetheomorpha* sp. 1. The abundant beetle families were Curculionidae, Chrysomelidae and Scarabaeidae. Light traps and pitfall traps showed almost identical number of beetles collected, while Malaise traps recorded of107 individuals. Higher number of beetles were collected from Trail 3, followed by Trail 1 and base camp. The Shannon diversity index, Simpson diversity index and Fisher alpha diversity showed higher diversity values, which suggests that National Park accommodates a high diversity of beetles. Abundance is measured using Margalef index and Menhinick indices, showed values of 13.88 and 3.47, respectively. This information could be used as an initial step to analyze the potential use of beetles as a bioindicator group in Malaysia and climate change studies.

Keywords: Biodiversity, forest, ecosystem, traps, beetles

ABSTRAK

Taman Negara ialah salah satu hutan hujan tertua di Asia Tenggara dan ekosistemnya sangat kompleks. Objektif kajian ini adalah untuk menyediakaninventori kelimpahan dan kepelbagaian kumbang di Taman Negara Kuala Kelapor,Malaysia. Persampelan kumang telah menggunakan perangkap lubang, perangkap malaise dan perangkap cahaya di lima denaiberlainan pada April 2015. Kajian ini telah berjaya merekodkan sejumlah709 kumbang daripada 93 spesies yang berlainan di dalam26 famili yang berbeza. Spesies yang paling melimpahdirekodkan adalah *Coccotrypes* sp. 1, diikuti dengan *Coccotrypes* sp. 2 dan *Aetheomorpha* sp. 1. Famili kumbang yang paling melimpah pulaadalah Curculionidae, Chrysomelidae dan Scarabaeidae. Perangkap cahaya dan perangkap lubangmerekodkanbilangan kumbang yang hampir sama, manakala perangkap malaise merekodkan107 individu. Bilangan kumbang tertinggi telah dikumpulkan dari Denai 3, diikuti dengan Denai 1 dan tapak perkhemahan. Indeks kepelbagaian Shannon, Indeks kepelbagaian Simpson dan kepelbagaian alfa Fisher menunjukkan nilaiyang tinggi, menggambarkan habitat yang baik untuk kelestarian kumbang di Taman Negara. Kelimpahan kumbang telahdiukur menggunakan Indeks Margalef dan Indeks Menhinick, masing-masing menunjukkan nilai sebanyak 13.88 dan 3.47. Maklumat daripada kajian ini boleh digunakan sebagai langkah awal untuk menganalisis potensi penggunaan kumbang sebagai kumpulan biopenunjuk di Malaysia dan kajian perubahan iklim.

Kata kunci: kepelbagaian, hutan, ekosistem, perangkap, kumbang

INTRODUCTION

The distribution of biodiversity is uneven on earth which has fascinated naturalists for more than 200 years in different parts of the world (Fischer et al. 2011; Ficetola et al. 2017). Tropical ecosystems are the focal point on harboring the most biodiversity, among the terrestrial ecosystems on earth (Myers et al. 2000; Körner et al. 2017). The tropics are always spectacular sites that are not meant for recreational purposes only, but also for studying many facets of biodiversity, in conjunction with rapid environmental change (Fischer et al. 2011; Nunes et al. 2016). These types of ecosystems are facing severe pressure, such as the anthropogenic disturbances, global warming, agriculture, biological invasions, poaching, infrastructure developments and tourism (Peh et al. 2011; Squires 2014).

A number of tropical ecosystems are found in Malaysia, which is a biodiversity hotspot. Kuala Kelapor National Park is among the oldest rainforests which has evolved over more than million years accommodating myriad of habitats, which was previously known as King George V National Park (DWNP 1987). This contributes massively to the wildlife richness of Peninsular Malaysia (DWNP 2000; Zanisah et al. 2009; Fatanah et al. 2012; Mohd-Salleh et al. 2012), which is relatively undisturbed due to its remoteness as well.This precious natural reserve covers Pahang (2,477 km^2), Kelantan (1,013 km^2) and Terengganu (853 km^2) states in Peninsular Malaysia with a total land area of 4343 km^2(DWNP 2000; Pakhriazad et al. 2009).The observed habitats include rivers, freshwater swamp, dipterocarp montane forests, lower montane forest, montane oak, montane ericaceous and upper montane forestand riparian forest (Tingga et al. 2012). Riverine ecosystem of Kuala Kelapor National Park covers three major rivers (Sungai Lebir, Sungai Terengganu and Sungai Tembeling) and many small rivers (Khan 1990). The highest peak ie. Gunung Tahan is found in Kuala Kelapor National Park. This complex ecosystem supports large mammals, small mammals, birds, amphibians, fishes, insects and plants (Siti-Hawa et al. 1985; Zulkiflee et al. 2012). The previous studies at Kuala Kelapor National Park were focused on Sumatran rhinos (Foose & Van Strien 1997), tigers (Kawanishi & Sunquist 2004), elephants (Saaban et al. 2011), large animals (Khan & Khan 1990), primates (Chivers 1990), mammals (Siti-Hawa et al. 1985), wild pigs (Othman 1990), small mammals (Lim et al. 1989; Liat & Anan 1990; Tingga et al. 2012), snakes (Liat et al. 1990), amphibians (Heang 1990), fishes (Zakaria-Ismail 1984; Mohd-Azham& Singh 2012; Farinordin et al. 2016) and birds (Siti-Hawa et al. 1985; Wells 1990; Saad et al. 2014). Moreover, different types of plants are also well studied too (Dransfield & Kiew 1990; Kiew 1990; Kochummen 1990; Ohba 1990).

The studies on insects from Kuala Kelapor National Park are relatively less compared to some of the other taxa. There are studies on butterflies (Kirton et al. 1990) and dragonflies (Choong et al. 2018) of Kuala Kelapor National Park, but unfortunately there is no study on beetle diversity and abundance. Studies on beetles in Peninsular Malaysia have been conducted from different parts and different ecosystems, such as in islands (Abdullah 2005; Abdullah 2008; Abdullah et al. 2012a; Abdullah et al. 2012b; Musthafa & Abdullah 2019), mountains (Idris et al. 2002; Abdullah et al. 2011a; Abdullah et al. 2012c; Abdullah & Sabri 2013; Abdullah &Sabri 2014; Musthafa & Abdullah 2015; Musthafa et al. 2018; Musthafa & Abdullah 2019a; Musthafa & Abdullah 2019b) and forests (Abdullah 2007; Abdullah et al.2011b). Even though, beetles play key roles on ecosystems, the diversity and distribution of them has not attracted the scientific community in Kuala Kelapor National Park. Therefore, the objective of this study is to assess the beetle diversity and abundance from Kuala Kelapor, Taman Negara National Park.

MATERIALS AND METHODS

Sample collection was conducted during the scientific expedition organized by Department of Wildlife and National Parks (DWNP/PERHILITAN) at National Park (Pahang).

Study Site

National Park (Pahang)is selected for sampling with the focal sampling area at Kuala Kelapoh (4°33’57.6” N, 102°34’54.8” E), where the sample collection was done between 11–20 April 2015 (Figure 1). Kuala Kelapohhas lowland dipterocarp forests, swamps, marshes and small streams such as Sungai Kelapoh and Sungai Sat. The maximum elevation from the sampling site was 150 m from the sea level. Sampling was conducted using five different forest trails within Kuala Kelapoh area.

Beetle Sampling

Three different trapping methods were used to collect beetles: light traps, Malaise traps and pitfall traps. The two light traps, two Malaise traps and 25 pitfall traps were fixed at each sampling trail throughout the sampling period. Malaise trap were made up of nylon net (black/white) with a collection jar half filled with 70% alcohol. Malaise traps were fixed at branches of trees around 1.0 m from the ground level. Malaise traps were set for 48 hours while pitfall traps were set in the site for 24 hours starting from 0800 hr. Pitfall traps were 200 ml plastic cups (65 mm diameter, 9.5 cm depth) sunk into the ground with the brim at the same level as the ground. Beetles were sampled using pitfall traps partially filled with 70% alcohol at each elevation gradient. Large leaves were positioned to protect the traps from rain. Light traps were made of mosquito net with a 160 watt mercury bulb connected to a portable Honda EU10i portable power generator. It was fixed just above ground level and the beetles attracted to the light were collected using collection bottles for further identification.

Taxonomic Identification and Data Analysis

All the collected samples were sorted and tallied to family level based on Borror and Delong’s ‘Introduction to the Study of Insects’ (Triplehorn & Johnson 2005). Even though some of the specimens could not be identified at the species level, they were compared with other unidentified materials and assigned to morphospecies with name codes. Therefore, in this study, “species” include both morphospecies and determined species.

Species diversity and abundance values were calculated for overall collection and each sampling methods at different sampled trails. For diversity analysis, Shannon diversity index, Simpson diversity index and Fisher’s Alpha diversity indexes were used, while Margalef index was used for abundance calculation. Margalef index has been widely used to estimate abundance, but at the same time it is irrespective of the sample size, species accumulation curve, which estimates the sampling quality was also calculated. Moreover, Chao 1 estimators was used to calculate the species richness using PAST 3.07(Hammer et al. 2001).

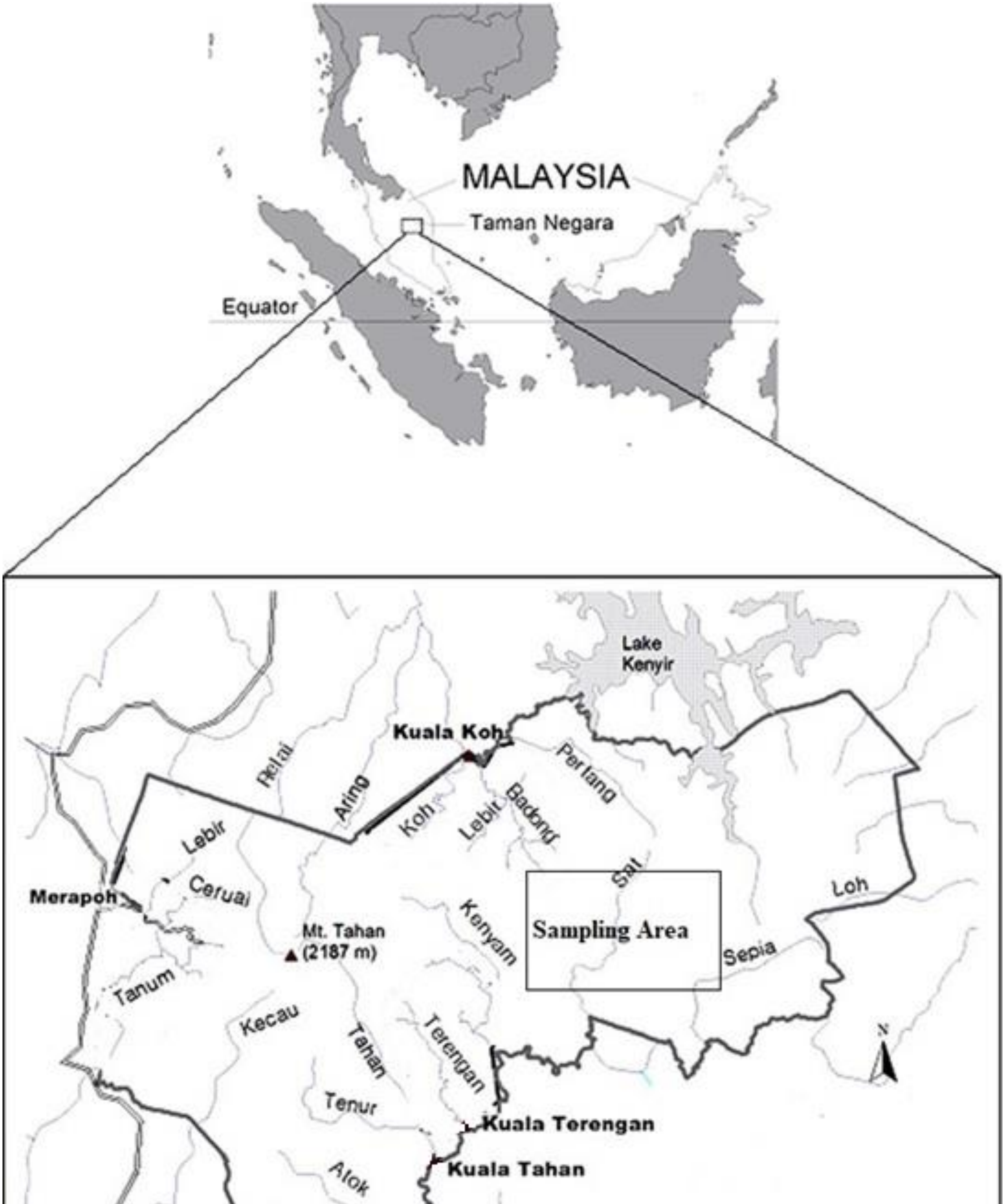

Figure 1. Beetle sampling area within the National Park

RESULTS AND DISCUSSION

The expedition at Kuala Kelapor National Park resulted in 709 specimens was successfully collected, representing 93 different species from 26 different families. The most abundant species was *Coccotrypes* sp. 1 (n=93; 13.12%), followed by *Coccotrypes* sp. 2 (n=68; 9.59%) and *Aetheomorpha* sp. 1 (n=43; 6.06%) (Table 1). Out of these species, 25 species were singletons (only one specimen was collected), whereas 13 were doubletons (only two specimens were collected). The abundant beetle families were Curculionidae (n=278), Chrysomelidae (n=100) and Scarabaeidae (n=63), where these families represent 70% of the total collection. Curculionidae is one of the most diverse group of insects found on earth and their ecological roles are immeasurable (Anderson 2002). They feed on different plants and the economic loss they bring about exceeds that of any other group of beetles (Campbell et al. 1989). There are more than 37,000 described species in Chrysomelidae (leaf beetles) (Gomez-Zurita et al. 2008) and their feeding behaviour make them as a good candidate for ecological researches (García-Robledo et al. 2013). Moreover, Scarabaeidae has been widely studied due to their fundamental role in ecosystems as recyclers of the organic material produced by vertebrates, contributing to nutrient turnover in the principal biochemical cycles (Nichols et al. 2008). Therefore, the roles of these beetles' families are highly important for the ecological functioning at the Kuala Kelapor National Park.

Table 1. The inventory of beetles sampledat Kuala Kelapor National Park, Malaysia

FAMILY	SPECIES NAME	NUMBER OF INDIVIDUALS	PERCENTAGE
ANTHRIBIDAE	*Araecerus* sp. 1	4	0.5642
	Araecerus sp. 2	2	0.2821
CARABIDAE	*Parena* sp. 1	27	3.8082
	Spinolypropslateralis Pic, 1917	5	0.7052
	Slenophori sp. 1	6	0.8463
	Luprobua sp. 1	2	0.2821
	Heteropausis sp. 1	1	0.1410
	Clivinine A	7	0.9873
	Therates sp. 1	4	0.5642
	Cylindera sp. 1	1	0.1410
CASSIDINAE	*Eumorphuspolitus*	11	1.5515
	Eumorphusalboguttatus	5	0.7052
CERAMBYCIDAE	*Noemia* sp. 1	3	0.4231
	Glenea sp. 1	1	0.1410
	Ceram C	2	0.2821
CHELONARIIDAE	*Chelonarium* sp. 1	1	0.1410
CHRYSOMELIDAE	Eumolpinae sp. 1	15	2.1157
	Eumolpinae sp. 2	3	0.4231
	Dactylispa sp. 1	2	0.2821
	Aulacophora sp. 1	1	0.1410
	Aetheomorpha sp. 1	43	6.0649
	Clytrasoma sp. 1	8	1.1283

	Chryso F	7	0.9873
	Chryso G	9	1.2694
	Borneola sp. 1	1	0.1410
	Chryso I	5	0.7052
CLERIDAE	*Omadiusindicus*Laporte de Castelnau, 1836	1	0.1410
COCCINELLIDAE	Coccinella sp. 1	5	0.7052
	Cheilomenes sp. 1	2	0.2821
	Menochilus sp. 1	4	0.5642
	Halmus sp. 1	1	0.1410
	Monocoryna sp. 1	1	0.1410
CURCULIONIDAE	*Aulacolepisdecorata* Balky, 1867	5	0.7052
	Xyleborus sp. 1	41	5.7828
	Xyleborus sp. 2	25	3.5261
	Anisandrusursa	10	1.4104
	Coccotrypes sp. 1	93	13.1171
	Coccotrypes sp. 2	68	9.5910
	Coccotrypes sp. 3	5	0.7052
	Anisandrus sp. 2	14	1.9746
	Crypturgus sp. 1	5	0.7052
	Conoderinae sp. 1	1	0.1410
	Conoderinae sp. 2	3	0.4231
	Lechriops sp. 1	1	0.1410
	Lechriops sp. 2	6	0.8463
	Curcu F	5	0.7052
	Curcu G	1	0.1410
	Platypodinae A	5	0.7052
DERMESTIDAE	*Orphinus* sp. 1	5	0.7052
ELATERIDAE	*Mulsanteus* sp. 1	3	0.4231
	Agonischius sp. 1	5	0.7052
	Anchastus sp. 1	4	0.5642
	Galbitesbounvouloiri (Fleutiaux)	1	0.1410
EROTYLIDAE	*Pharaxonotha* sp. 1	1	0.1410
EUCNEMIDAE	Euci A	7	0.9873
	Ceratus sp. 1	2	0.2821
	Ceratus sp. 2	3	0.4231
	Eumorphus sp. 1	1	0.1410
	Euryptychus sp. 1	2	0.2821
	Limonius sp. 1	8	1.1283
LAMPYRIDAE	*Luciolinaepallescens*	2	0.2821
	Casnonidea sp. 1	4	0.5642
LEIODIDAE	*Cholevinae* sp. 1	2	0.2821
LUCANIDAE	Luca A	1	0.1410
LYCIDAE	*Plateros* sp. 1	4	0.5642
	Xylobanus sp. 1	1	0.1410
	Haptonchus sp. 1	2	0.2821

MELANDRYIDAE	Melandryidae A	6	0.8463
PASSALIDAE	*Aulacocyclus* sp. 1	1	0.1410
SALPINGIDAE	*Rhinosimus* sp. 1	1	0.1410
	Priognathus sp. 1	1	0.1410
SCARABAEIDAE	*Anomala* sp. 1	25	3.5261
	Anomala sp. 2	2	0.2821
	Anomala sp. 3	16	2.2567
	Anomalaorientalis	2	0.2821
	Eriesthis sp. 1	1	0.1410
	Anomalorhinaosaensis	1	0.1410
	Anomalorhina sp. 1	6	0.8463
	Anomalorhina sp. 2	11	1.5515
SILVANIDAE	*Psammoecus* sp. 1	3	0.4231
	Silvanus sp. 1	13	1.8336
SPHINDIDAE	*Aspidiphorus* sp. 1	16	2.2567
STAPHYLINIDAE	Aleocharinae A	17	2.3977
	Homaeotarsus sp. 1	1	0.1410
	Eccoptolonthuslaevigatus	3	0.4231
	Hesperosoma sp. 1	1	0.1410
	Platydracus sp. 1	3	0.4231
	Platydracus sp. 2	1	0.1410
	Paedarus sp. 1	20	2.8209
	Paedarus sp. 2	11	1.5515
TENEBRIONIDAE	*Strongylium* sp. 1	2	0.2821
	Gonocnemis sp. 1	5	0.7052
THROSCIDAE	Throscidae A	4	0.5642
TOTAL		709	

The species accumulation curve showed a continuously increasing species curve at Kuala Kelapor National Park(Figure 2), which is widely observed in the tropics due to their specious nature as suggested by Escobar et al. (2005). Species accumulation curve is a good predictive model for assessing the sampling effort, to describe the rate of new species additions to the inventories and good tool for designing sampling protocols (Soberón et al. 2007).

Since three different trapping methods were used, a comparison of the beetle abundance was conducted (Figure 3). Light traps (n=305) and pitfall traps (n=297) recorded almost identical number of beetles, while Malaise traps only manage to record about 107 individuals. The sampling was conducted at five different trails and the results were displayed in Figure 4. Highest number of beetles were collected from Trail 3 (n=230), followed by Trail 1 (n=187) and base camp (n=108). More than 100 beetle individuals were collected from all the trails except Trail 2. The trail 3 was characterized by small water streams and mangrove vegetation. Trail 1 accommodates wide variety of older trees, whereas base camp was located beside the Sungai Sat. These complex and virgin ecosystems are vital to maintain the biodiversity of Kuala Kelapor National Park. Light trap at Trail 1 and Trail 3 sampled more than 100 beetle specimens. Pitfall trap collection was the highest at Trail 3 (n=95) and lowest at Trail 2 (n=29). All the Malaise traps collections were less than 50.

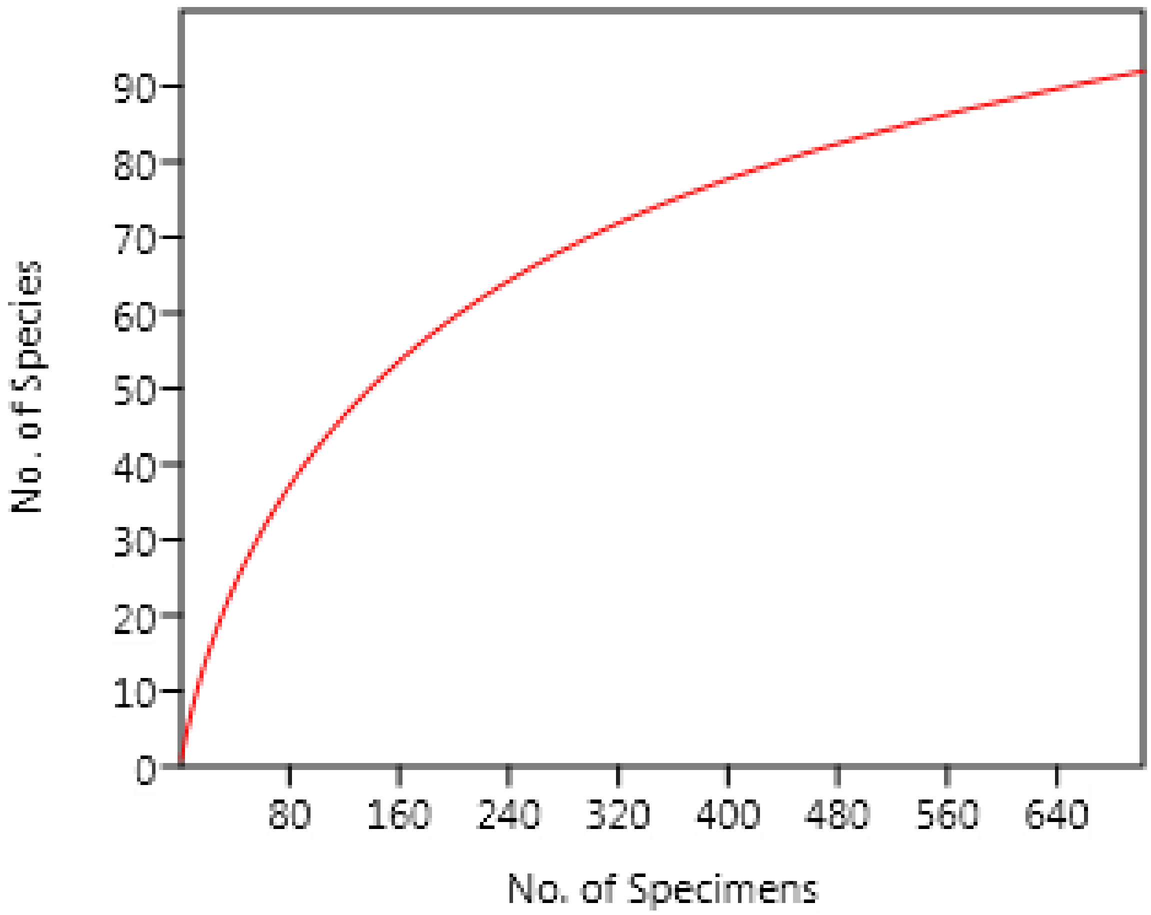

Figure 2. Species accumulation curve for the overall collection at Kuala Kelapor National Park

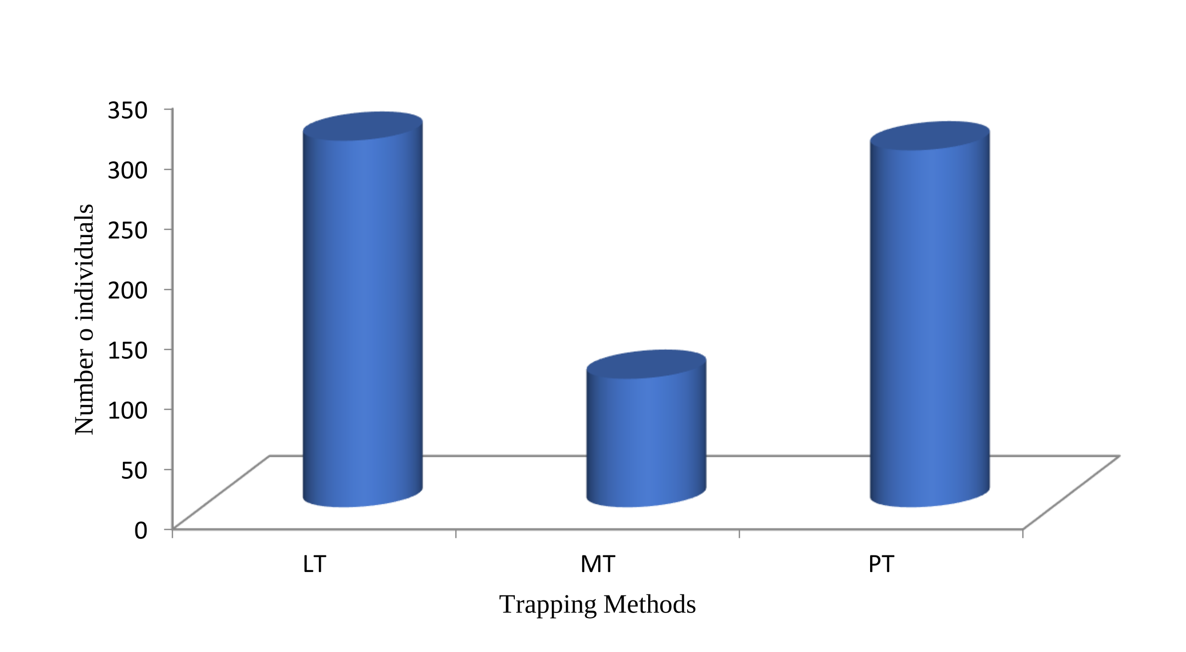

Figure 3. Number of specimens collected using three trapping methods (LT- light traps; MT- Malaise traps; PT- pitfall traps)

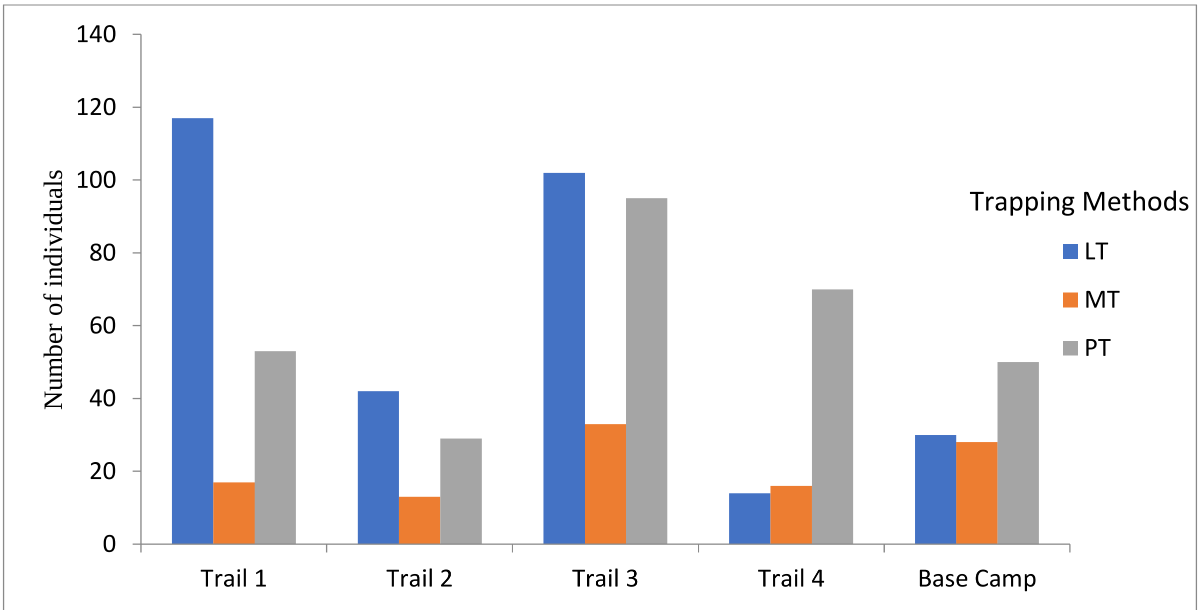

Figure 4. Number of specimens collected from different trails at Kuala Kelapor National Park (LT- light traps; MT- Malaise traps; PT- pitfall traps)

Table 2 represents the diversity and abundance values of the overall collection. The Shannon diversity index (3.727) and Simpson diversity index (0.955) and Fisher alpha diversity (28.29), where three of the index displayed a higher diversity value. The most popular index used to quantify biodiversity composition is Shannon (Nagendra 2002) and Margalef index (1972) which values is typically between 1.5 and 3.5, and rarely exceeds a value of 4. Simpson diversity index also showed higher values (>0.93) for all the altitudinal bands whereas, Fisher alpha diversity values were also high above 10. Fisher's alpha diversity measure is regarded as one of the more useful and often recommended indicators of community diversity due to its independence from sample size (Magurran 2004). The use of Shannon and Simpson diversity indices to assess the biodiversity are widely acceptable since they are highly associated with situations and sites, thus require greater importance during interpretation (Nagendra 2002; Morris et al. 2014). Therefore, there is no single diversity measure that can be applied for the all the situations as a universal parameter (Morris et al. 2014). Brillouin index is also used as a measure of diversity measure with a value of 3. 523.The species abundance was calculated using Margalef index and Menhinick indices showed values of 13.88 and 3.47, respectively. The Margalef and Menhinick indexes were widely used to estimate abundance but at the same time it is irrespective of the sample size. Estimated species richness value was calculated using Chao 1 showed a value of 113.4, which is around 82% of the number of species observed (93) (Table 2). Chao 1 used to produce relatively unbiased estimates for species richness but still produce inflated error rates in designs assessing on short-term and long term (Gwinn et al. 2016).

Table 2. Diversity and abundance indices for overall collection

DIVERSITY AND ABUNDANCE INDICES	**VALUES**
NUMBER OF SPECIES COLLECTED	93
NUMBER OF INDIVIDUALS	709
SIMPSON DIVERSITY INDEX	0.9554
SHANNON DIVERSITY INDEX	3.727
BRILLOUIN	3.523
MENHINICK	3.47
MARGALEF INDEX	13.88
FISHER ALPHA DIVERSITY INDEX	28.29
CHAO 1	113.4

The highly abundant families are good candidates for bioindicators, as suggested by Rainio& Niemela (2009) and Adamski et al. (2019). Curculionidae (weevils) consists of more than 60,000 described species so far and not only the largest family of beetles, but also the largest of any taxonomic group on earth (Oberprieler et al. 2007). Weevils can be good indicators of forest conservation efforts (Anderson & Ashe 2000; Cano & Schuster 2009). Košťálová and Szénási (2015) discussed about the ability of weevil species as bioindicators at sandy habitats. The family Chrysomelidae (leaf beetles) is also highly diverse beetle fauna with variety of roles in ecosystem. Chrysomelidae traditionally shows good response to environmental disturbance (Pimenta & De Marco Jr. 2015). Family Scarabaeidae (dung beetles) has the ability to react to the perturbations in the environment, where they occupy different trophic levels as well. Moreover, they are handy organisms for monitoring the impacts of forest alterations and for evaluating the changes in the ecosystems (McGeoch et al. 2002; Gardner et al. 2008).

The three different trap types resulted indifferent beetle taxa sampled in relation to abundance and richness. These traps are widely used for passive sampling of beetles; however, all these trapping methods are complementary to each other. Further, the light trap and pitfall traps were effective, when compared to the other method but it has been widely suggested to use multiple trapping methods by several other studies for complete beetle diversity researches especially in tropics (Skvarla & Dowling 2017).

The biggest logging effect in Asia is reported in the Malay Archipelago where 1.8 million ha of forest land were logged annually (Doll et al. 2014). Furthermore, due to the limited access, biodiversity of Kuala Kelapor National Parkis relatively less disturbed compared to some of the other forests in Malaysia, but the pressure is mounting on this pristine ecosystem. It has been widely discussed about the rise of anthropogenic disturbances in Peninsular Malaysia, where the conservation efforts are lagging (Sodhi et al. 2010; Laurance 2016). Therefore, it is very vital to increase the number of studies on biodiversity assessments in Malaysia in relation to anthropogenic activities and climate change imprints. Malaysia possesses some of the oldest tropical forests which could also serve as a good base study to formulate number of ecological hypotheses on species diversity patterns in tropics.

Kuala Kelapor National Park habituates appreciable amounts of beetles and their ecological roles are very vital for the smooth management of this highly complex ecosystem. This information could be used as an initial step to analyze the potential use of beetles as a bioindicator group in Malaysia. Future studies on different beetle communities in Malaysia need to be oriented at the specific species patterns and their links with environmental variation, as well as at interplays between ecosystem components and beetle species to gain further understanding. Environmental influences on species diversity are very vital to implement effective conservation management, particularly under rapidly inflicting climate change effects.

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