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BEETLE ABUNDANCE, DIVERSITY AND SPECIES RICHNESS OF PULAU PANGKOR, PERAK, MALAYSIA

FAUZIAH ABDULLAH* AND MUNEEB M. MUSTHAFA

Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603, Kuala Lumpur.
Centre of Biotechnology in Agriculture, University Malaya, Kuala Lumpur, Malaysia
Centre of Tropical Biodiversity, University Malaya, Kuala Lumpur, Malaysia

*Corresponding author
Email: fauziah@um.edu.my

Abstract: Islands have attracted great enthusiasm for biogeographers, evolutionary biologists and ecologists as they are good testing grounds for various biological hypotheses. The objective of this study was to assess the beetle diversity and abundance of Pulau Pangkor forest reserves. Beetles were collected using 12 light traps for 4 hours at night, 24 hours collection daily using 100 pitfall traps and 12 Malaise traps for a duration of six days from 15th to 21st July 2017. A total of 277 beetle specimens comprising of 116 species from 26 families were collected, where 75.21% of the collections were singletones. Shannon-Weaver Index showed a value of 3.847 whereas, Fisher alpha diversity index and Simpson Diversity index showed 72.45 and 0.948, respectively. Margalef index for abundance showed a value of 20.09, while the estimated species richness based on Chao 1 showed 347.80. The most abundant family is Bostrichidae accounting for 86 specimens from 20 different species followed by Carabidae with 57 specimens from 10 species. The *Cyclosomus* sp. (Family Carabidae) collected is reported to be a new species to be described later. Species accumulation curve doesn't reach the asymptote which is generally observed in the tropics due to the high specious nature. This study shows the beetle diversity at Pulau Pangkor is unique and it requires conservation of habitats. This study can be extended to annual beetle diversity pattern to assess the hypothesis related to biomass reduction, anthropogenic disturbances and island biogeography.

Key words: Beetle, diversity, island, Pulau Pangkor.

INTRODUCTION

Islands have attracted great enthusiasm for biogeographers, evolutionary biologists and ecologists as they are very good testing grounds for various biological hypotheses in the modern day contexts (Case & Cody 1987). Malaysian islands are amazing to be considered for ecological studies due to the fact that Malaysia is a tropical biodiversity hotspot where biodiversity is facing huge pressure from various factors in different magnitude highlighted by anthropogenic activities, encroachments, fragmentation and habitat loss on a humongous structured scales (Laurance et al. 2014). Responses to changes by biological organisms have been studied across variety of taxonomic groups and geographical regions where insects are reported to be strongest sentinels (Walther et al. 2002; Forister & Shapiro 2003; Parmesan & Yohe 2003; Andrew et al. 2013).

Coleoptera, commonly called as beetles is one of the many orders of insects which comprise of more species than any other Orders on earth with almost 25% of known living organisms (Powell 2009; Bouchard et al. 2009; Slipinski et al. 2011) while, 40% of all described insects species are beetles (Hammond 1992). The beetles are extremely diverse and observed in almost all habitats, where they are acclimatized to survive successfully (Whittaker et al. 2014). Owing to the very poor knowledge on exact number of beetles, their distribution and diversity is highly threatened by climate change effects. Therefore, only a very small number of species has been displayed on regional and global red list. Dunn (2005) reported extinction of 44,000 insect species over the past 600 years but actually only 70 have been documented. In North America alone 29,000 insect species are threatened or endangered but just 37 were reported in the regional red list (Dunn 2005; Redak 2000). All in all, diversity of beetles has received very poor attention by the scientific community, due not least to hurdles in funds, energy and time to explicitly study the megadiverse beetles. Apart from that, body size, highly diverse colour patterns and tiny little structures make the identification of beetles highly challenging when compared to the other components of biodiversity (Schuldt et al. 2012). So the beetle diversity studies generally are confronted with more challenges than any other fauna and flora (Rabosky 2013).

Malaysian islands are very good models in many aspects owing to the recent rapid research interests on offshore archipelagos of Peninsular Malaysia; since islands possess very good models for biodiversity studies and as well beetles have been documented from various research groups for their notable role in ecosystem (Miller 1996). Parts of Borneo have been subjected to beetles diversity studies by various research groups (Tung 1983; Mohamedsaid 2004), Kalimantan (Reid 1997), East Kalimantan (Makihara 1999), Sarawak (Abang 2000), Sabah (Mohamedsaid 1997; Chey 1996) and Pulau Pangkor (Abdullah et al. 2012) but in Peninsular Malaysia islands are not attracted to that level. Beetles can be very good candidate for climate change studies since they possess some good biological characteritics described by various researchers all around the globe (Carignan & Villard 2002). This is a befitting scenario where beetle diversity among these islands have been poorly addressed while recent awareness is just the beginning of unearthening the hidden treasures of biodiversity and endemism (Belair et al. 2010; Chan et al. 2009; Grismer 2008; Grismer & Norhayati 2008; Grismer & Pan 2008; Grismer et al. 2008). Therefore, our objective is to study and document the beetle diversity, species richness and abundance at Pangkor Island by the expedition called Pangkor Island Scientific Expedtions 2017 organised by ECOMY.

MATERIALS AND METHODS

Study Site

The study was conducted in 2017 at Pulau Pangkor (Figure 1), one of the famous islands situated between N 04° 13.0’ latitude and E 100° 33.0′ longitude on the western coast of Peninsular Malaysia. This island is 8 km^2 in area with a population is 25,000 people and it has been classified as a tropical and coastal hill forest with a high conservation priorities. The climate pattern has been typical humid tropical and seasonal heavy rainfall with the average annual rainfall of 1820.23mm. The highest mean temperature in dry seasons is 27.65°C during February- May, whereas the lowest mean temperature is 26.8°C prevailing around September-December. The elevation ranges between sea level to 350m. The island is divided into three parts for sampling during this expedition such as Pangkor North, Sungai Pinang and Pangkor South.

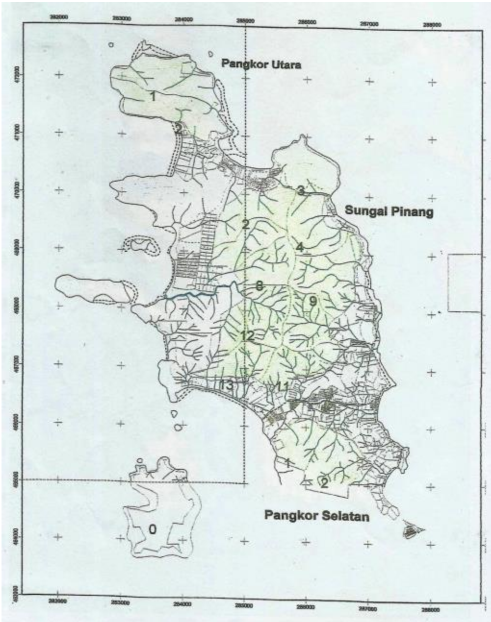

Figure 1: Sampling localities at Pangkor Island during the expedition.

Sampling Methods

Three types of sampling method were employed including, Malaise traps (MT), pitfall traps (PT) and light traps (LT). At each site two light traps and four malaise traps were fixed while four sets of pitfall traps (five each) were used. Malaise trap are usually made up of black/white nylon net with a collection jar; half-filled with 75% alcohol were fixed at the top most end of a tree which is not more than 1.5m from the ground level. The beetles will be attracted to the smell of alcohol. Malaise traps were fixed for 48 hrs while pitfall traps were fixed in the site for 24 hrs starting from 0800 hr. Pitfall traps are small containers (plastic cups) that are buried into the ground with the brim at the same level as the ground. Beetles were sampled using pitfall traps partially filled with 97% alcohol at each elevational gradient. Large leaves were positioned to protect the traps from rain. Light traps were made up of mosquito net with a 160 watt mercury bulb connected to a portable Honda EU10i power generator. It was fixed just above the ground level and the beetles are attracted to the light were collected using collection bottles. Collected specimens were sorted and tallied based on the morphospecies and cross-checked with the Forestry Department Peninsular Malaysia collection. The beetle specimens were photographed with Leica microscope model EZ4D attached with a digital camera.

Recording of Environamental Parameters

Environmental parameters at every site such as temperature, relative humidity and luminance were measured and recorded apart from the elevation. Elevation was measured using Garmin GPSMAP® 78s global positioning system (GPS). Temperature and relative humidity were recorded using Center 310 (RS-232) Humidity Temperature Meter, whereas, Milwaukee MW 700 portable lux meter was used to measure the luminance. Annual rainfall data has been derived from the Meteorological Department of Malaysia.

Specimens identification and biodiversity indices

Collected specimens were sorted and tallied to genus/species level based on various keys and further cross-cheked with Forestry Department of Malaysia collections. When all the samples are collected in sampling sites, the plot lines usually reaches a horizontal asymptote. The data collected from these samples were analyzed for Margalef index (abundance), Shannon Weiner, Simpson diversity, Berger-Parker, Fisher Alpha and Chao 1 index for the diversity and distribution using PAST 3.07 software (Hammer et al., 2001).

Margalef index (D_{Mg}) for abundance defined by Magurran (2004):

$$D_{Mg} = \frac{(S-1)}{\ln N}$$

; where S is the number of species recorded and N is the total number of individuals in the sample (ln is the natural log).

Shannon Weiner diversity index (H’),

$$H' = -\sum_{i=1}^{R} p_i \ln p_i$$

,

Simpson’s diversity index (D) has been defined as;

$$D = \frac{1}{\sum_{i=1}^{s} p_i^2}$$

, where p is the proportion of ith individuals of one particular species found (n) divided by the total number of individuals found (N) (Colwell 2009).

The Brillouin index is defined as;

$$HB = \frac{\ln(N!) - \sum_{i=1}^{S} \ln(n_i!)}{N}$$

where, N is the total number of individuals in the sample, ni is the number of individuals belonging to the ith species and s the species number.

The Menhinick's index is defined as;

$Dmn = \frac{S}{\sqrt{N}}$ where N is the total number of individuals in the sample and S the species number (Whittaker, 1977).

RESULTS

A total of 277 specimens of 116 species and 26 families of Coleoptera was obtained from Pulau Pangkor during the sampling period (Table 1). Shannon-Weaver diversity Index showed a value of 3.847 whereas, Fisher alpha diversity index, Brillouin Index and Simpson Diversity index showed 72.45, 3.39 and 0.948, respectively (Table 2). Menhinick index shows the species richness with a value of 6.85. Margalef index for abundance showed a value of 20.09 whereas, dominance index was calculated using Simpson Dominance index (0.052) and Berger-Parker index (0.148). Estimated species richness based on Chao-1 method showed 347.8 and the sampling completeness was displayed 33.64% based on the same estimator. So far there is no clear demarkation for the tropical islands sampling completeness for beetles.

Table 1a. List of beetles identified to genus/species level collected at Pulau Pangkor.

Family	Genus/Species names	Pangkor North	Sungai Pinang	Pangkor South	Total
Bostrichidae	*Crypturgus* sp1			1	1
	Xylopsocus sp1			1	1
	Xylopsocus sp2	1		1	2
	Xylopsocus sp3	1			1
	Xylopsocus sp4	1			1
	Xyleborus sp1			15	15
	Xylopsocus sp3			1	1
	Xylopsocus sp5			1	1
	Anisandrus ursa Eggers		2		2
	Anisandrus sp1		3		3
	Anisandrus sp2		1		1
	Xyleborus sp2		4		4
	Coccotrypes sp1		2		2
	Xyleborus sp3		41		41
	Xyleborus sp4		2		2
	Coccotrypes sp2		1		1
	Coccotrypes sp3		1		1

Table 1a. (Continued).

Family	Genus/Species names	Pangkor North	Sungai Pinang	Pangkor South	Total
Bothrideridae dry bark beetles	*Antibothrus* sp1	1			1
	Antibothrus sp2	1			1
	Anthiribus sp.	1			1
Carabidae Ground beetles	*Cyclosomus* sp			14	14
	Colpodes sp1			2	2
	Colpodes sp2			33	33
	Perigona sp1			1	1
	Parena sp1			1	1
	Macrocheilus sp	1			1
Cerambycidae Longhorn beetles	*Glenea suturalis* Jordan	1			1
Cicindelidae Tiger beetles	*Cosmodela aurulenta* Fabricius			1	1
Cleridae checkered beetles	*Anthicoclerus* sp1		2		2
	Anthicoclerus sp 2		1		1
Coccinellidae Lady Beetles	*Harmonia* sp			1	1
Hydrophilidae water scavenger beetles	*Hydrobiomorpha* sp.		1		1
	Sternolophus sp1			1	1
	Sternolophus sp2			1	1
	Sternolophus sp3			1	1
Endomychidae handsome fungus beetles	*Eumorphus quadriguttatus* Illiger		1		1
Lymexylidae ship-timber beetle	*Melittomma* sp1			1	1
	Melittomma sp2	1			1
Nitidulidae sap beetle	*Urophorus* sp1	1			1
	Urophorus sp2	1	4		5
	Urophorus sp3	1			1
	Epuraea ocularis Fairmaire		1		1
	Epuraea sp2		2		2
	Epuraea sp3		1		1
	Stilbus sp1		1		1
	Stilbus sp2		1		1
	Stilbus sp3		1		1
	Stilbus sp4		15		15

Table 1a. (Continued).

Family	Genus/Species names	Pangkor North	Sungai Pinang	Pangkor South	Total
Passalidae bessbugs	*Uloma* sp1		1		1
Scarabaeidae dung beetle	*Anomala* sp1			1	1
	Ericmodes sylvaticus Philippi & Philippi		2	2	4
	Ericmodes sp2			2	2
	Anomala sp2			2	2
	Anomala sp3			1	1
Scirtidae marsh beetles	*Scirtes* sp1		1		1
	Scirtes sp2		1		1
Silvanidae silvan flat bark beetles	*Silvanus lewisi* Reitter	1			2
	Silvanus sp1		1	1	2
	Silvanus sp2		1		1
Staphylinidae rove beetle	*Paedarus* sp1			1	1
Tenebrionidae Darkling beetle	*Ceropria* sp1	17			17

Table 1b. List of beetles identified to family level collected at Pulau Pangkor.

Family	Morphospecies	Pangkor North	Sungai Pinang	Pangkor South	Total
Anobiidae wood borer	Anobi A			1	1
	Anobi B			1	1
	Anobi C			1	1
Bostrichidae	Bostri O		5		5
Brentidae straight-snouted weevils	Brenti B		1		1
	Brenti C		1		1
	Bostri S		1		1
Carabidae	Cara F		1		1
	Cara G		1		1
	Cara H		1		1
	Cara J	1			1
	Cara K			1	1
Chrysomelidae leaf beetles	Subfamily Eumolpinae 1	1			1
	Subfamily Eumolpinae 2	1			1

Table 1b. (Continued).

Family	Morphospecies	Pangkor North	Sungai Pinang	Pangkor South	Total
	Chryso C			2	2
	Chryso D			1	1
	Chryso E			1	1
	Chryso F			1	1
	Chryso G		1		1
	Chryso H	1			1
	Chryso I	1			1
	Chryso J		1		1
Cleridae	Cleri A		1		1
	Cleri B	1			1
Coccinellidae	Cocci D		1		1
Curculionidae True beetle	Curcu A			1	1
	Curcu B	1			1
Elateridae click beetles	Ela A		1		1
Endomychidae	Endo B		1		1
	Endo C		1		1
	Endo D		1		1
	Endo F		1		1
Meloidae Blister beetles	Meloidi C		1		1
Mordellidae tumbling flower beetles	Mordeli A			1	1
	Mordeli B			1	1
	Mordeli C		1		1
Phalacridae shining flower beetles	Phlaca D		1		1
	Phlaca E		1		1
Scarabaeidae	Scara F		1		1
Silvanidae	Silva C			1	1
Staphylinidae	Staphy B			1	1
	Staphy C		1		1
	Staphy D		1		1
	Staphy D		2		2
	Staphy E		1		1
	Staphy F		1		1

Table 1b. (Continued).

Family	Morphospecies	Pangkor North	Sungai Pinang	Pangkor South	Total
	Staphy G		2		2
	Staphy H		1		1
	Staphy I		1		1
	Staphy J		1		1
	Staphy K		2		2
	Staphy L		3		3
	Staphy M		1		1
Ceratocanthidae	Xerocan A		1		1

Table 1c. List of beetles genus diagnostic characters used to identify beetles at Pulau Pangkor.

Genus	Characteristics
Crypturgus	Length 1.1–1.5 mm, mature colour brown to black. Surface of pronotum reticulate, subshining, with fine but distinct and densely set punctures. Striae of elytra deeply impressed, interstriae elevated, rugose, without reticulation or shagrination, shiny (Jordal & Knizek, 2007).
Xylopsocus	Antenna 9-segmented, first and second segments of antennal club transverse. Anterolateral part of pronotum and basal part of pronotal disk punctured. Elytral declivity without costae, strongly punctured throughout (Sittichaya et al., 2009).
Anisandrus	*Anisandrus* has pronotal mycangial tuft, antennal features (antenna type 1, flattened), shape of the tibia, conspicuous tibial denticles and overall body shape (Hulcr et al., 2007).
Xyleborus	Middle-sized, elongated, light-coloured. Antennal club type 2, with segment 1 dominant on posterior side but not covering it all. Protibia obliquely triangular. Eyes shallowly or deeply emarginate, upper part smaller than lower part. Antennal club approximately circular, club type two (Hulcr & Smith, 2010).
Coccotrypes	Species in this genus range from 1.2 to 2.5 mm in length. Their colour ranges from reddish brown to almost black. The frons is convergently aciculate with a sparse, hair-like vestiture. The club is obliquely truncate, with none to two recurved sutures on its posterior face. The procoxae are contiguous (Mercado, 2010).

Table 1c. (Continued).

Genus	**Characteristics**
Colpodes	Colour pattern typical for the genus: dorsum brown, without metallic luster; mouthparts, antennae, legs, lateral margins of both pronotum and elytra, as well as elytral suture, pale. Head and pronotum shiny, elytra alutaceous. Head without impressions. Elytral microsculpture is a mix of isodiametric and transverse meshes (Fedorenko, 2015).
Silvanus	Tarsi simple, i.e. neither lobed nor appearing lobed and segment 3 not incrassate. Thorax with sides finely denticulate, not margined; anterior angles usually produced antero-laterally (Halstead, 1973).
Cyclosomus	Colour of the pronotal disc ranges from reddish brown to dark brown or piceous. The colour of the basal one-eighth of the elytra from the midline to elytral stria 5, together with the full length of elytral interval 1, ranges from reddish brown to black among individuals, and teneral specimens may have these areas entirely pale. The elytral "middle dark band" may be represented by a relatively thick, dark, jagged, roughly V-shaped band extended laterally onto interval 7 on each side, by a thinner, paler yet narrowly continuous band, or by reduced and disconnected vestiges of that band (Wang et al., 2017).
Antibothrus	Length less than 3.0 mm; body flat–cylindrical, surface subglabrous; pronotum slightly hexagonal, without distinct longitudinal carina, with weak depression on base; antennae 11-segmented, with two-segmented club; procoxae narrowly separated; elytra parallel-sided; all tibiae expanded apically; tarsomere I distinctly longer than II (Lee et al., 2017).
Anomala	Body shape. Elongate ovoid; sides of elytra subparallel. Entirely orange brown with rather strong iridescent shine (color might be more red in living or fresh specimens); legs light brown; metasternum, metacoxae and abdominal sternites dark castaneous (Zorn, 2011).
Harmonia	Elytra with fine microsculpture between punctures; larger species. (Metasternal epimera entirely yellow; anterior margin of mesosternum slightly emarginate medially; oval; ground coloration testaceous or yellow with a number of black marks on pronotum and elytra, varying in size.

Table 1c. (Continued).

Genus	Characteristics
Urophorus	Loose antennal club between antennomeres 9 and 10, spiracles of tergite VI widely transverse, medially convex and moderately widened apex of prosternal process. Medium body size, subvertical pronotal and elytral sides, slightly curved along procoxae to subfl attened prosternal process with strongly widened apex and simple mesoventrite (Kirejtshuk, 2008).
Perigona	Characterized by the Trechus-like body shape, by lack of elongate frontal furrows, by elongate and acute terminal palpomeres, and by the wide depressed, usually pilose subapical marginal elytral channel (Baehr, 2014).
Macrocheilus	Medium sized (length from 8.0 to17.0 mm), elongate, whole body coarsely punctate and pubescent, except for labrum and middle region of ventral side of head. Elytra with deep striae and setiferous pores; intervals slightly or rather convex (Zhao & Tian, 2010).
Epuraea	Oblong, moderately convex; dorsum dark brown and with bronze lustre, underside reddish-brown with appendages slightly lighter, pronotal and elytral margins light reddish to yellow; dorsum with long, strongly conspicuous and sparse silver yellowish hairs, which are three times longer than distance between their insertions (Zhao et al., 2014).
Scirtes	Body oblong oval, moderately convex, covered with black (on black cuticle) and yellowish (on remaining parts of body) suberect hairs. Body testaceous, elytra yellow, slightly darkened along suture, with two black patches on each elytron. Legs testaceous, mouthparts testaceous with darkened (brownish) mandibles and maxillary palpi, antenna black with three basal antennomeres yellow, base of 4th antennomere and apex of terminal antennomere lightened (Ruta et al., 2014).
Ericmodes	Body size 4mm-7mm and flattened. Labrum Fairly broad, almost vertical. Distribution of setae on dorsal surface. Clypeus separated from frons by a narrow, fairly indistinct membranous area. Anterior tentorial grooves not recognizable (Beutel & Slipiñski, 2001).
Stilbus	Body length in mm 1.1-2.5. Body shape in lateral view moderately to strongly convex. Head capsule width at tempora equal to width at eyes. Number of segments in antennal club 3. Antennal scape simple, cylindrical. Maxillary palp short, much shorter than antenna. Antennomere 11 normal (*Gimmel, 2011*).

Table 1c. (Continued).

Genus	Characteristics
Melittomma	Adults usually lightly to moderately sclerotized, rarely heavily sclerotized male abdominal segment IX with paratergites appendiculate. mesosternum simple anteriorly, or elevated and "A"-shaped (Wheeler, 1986).
Sternolophus	Body length 7.5–14 mm. Labrum with a median row of systematic punctures. First segment of antennal club not lunulate or divided; without long setae. (Short, 2010)
Hydrobiomorpha	There is a great variability in body-shape, from hemispherical to rather flat, from oblong ovoid to short, and in the length and shape of antennal club-segments and maxillary palpi, in the shape of eyes, clypeus, pronotum and elytra. Prosternum anteromedially with short projection. Meso-metaventral keel anteriorly with a small notch and few long setae, posteriorly extending in a short spine (Komarek, 2003).
Parena	Head with a neck. Retinaculum absent, sometimes with an excision instead with simple claws (Hondô, 2012).

Highest number of specimens collected was *Xyleborus* sp3 (n=41) (Figure 2a) followed by *Colpodes* sp2 (n=33) (Figure 2b), *Ceropria* sp1 (n=17) (Figure 2c) and *Stilbus* sp4 (n=15) (Figure 2d). Highest number of specimens were collected by pitfall traps (n=143) whereas light traps and Malaise traps yielded 101 and 33 specimens, respectively. The areas sampled within Pulau Pangkor (Pangkor North, Sungai Pinang and Pangkor South) using the three trapping methods results were tabulated (Table 3), where pitfall traps was most efficient collection method (n=143) followed by light trap and Malaise traps respectively. From Pangkor North, 17 species were collected from 12 families whereas, at Sungai Pinang, 56 species were collected from 17 different families. Pangkor South resulted in 37 species from 13 families. Pangkor North is dominated by *Ceropria* sp1 whereas, Sungai Pinang and Pangkor South were dominated by *Xyleborus* sp1 (Figure 2e) and *Colpodes* sp2, respectively. The *Cyclosomus* sp. (Figure 2f) (Family Carabidae) collected from this expedition is reported to be a new species to be described later. Further the highest species catch at Pangkor North was *Ceropria* sp1 (Tenebrionidae) using light trap, at Sungai Pinang, *Xyleborus* sp3 (Bostrichidae) using pitfall trap and at Pangkor South, *Colpodes* sp2 (Carabidae) using light traps. Diversity indices were calculated for the sampled areas are listed on Table 4 and the highest Shannon diversity index was found at Sungai Pinang whereas lowest was observed at Pangkor North.

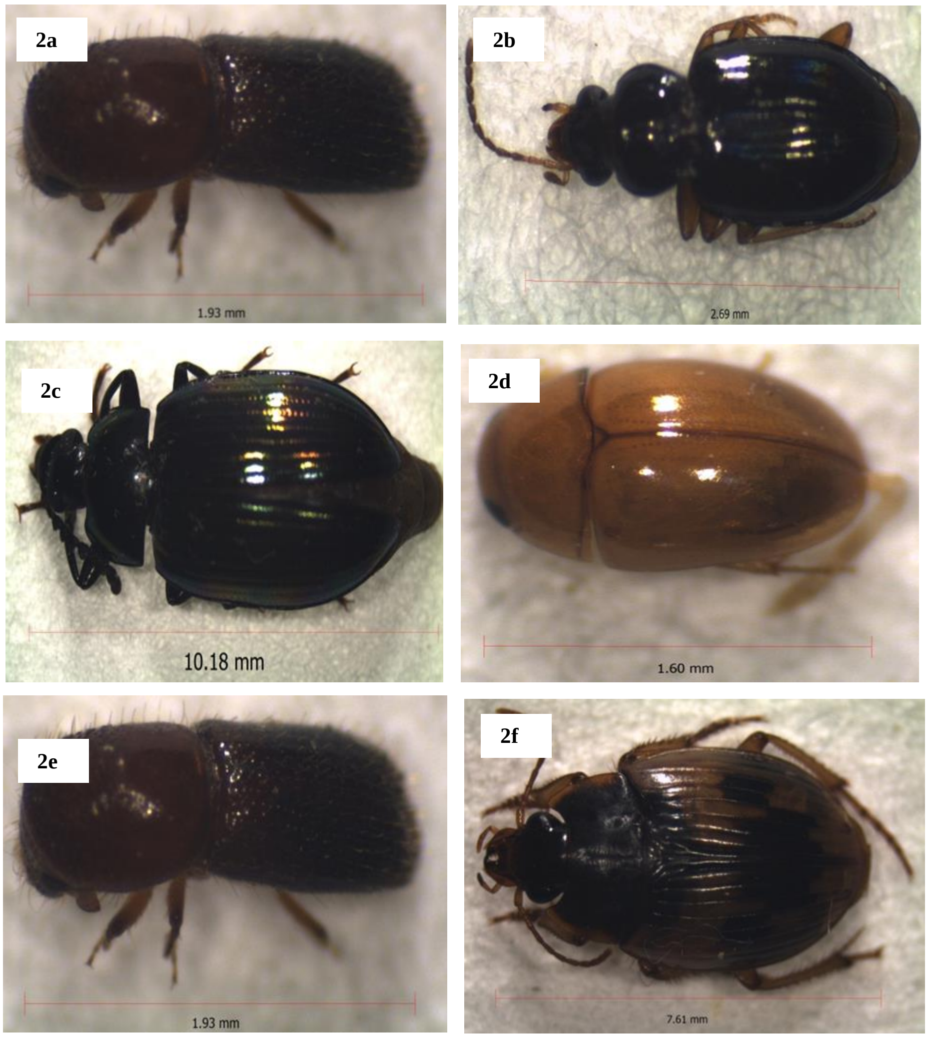

Figure 2: Some of the dominant species found at Pulau Pangkor: a) *Xyleborus* sp3 b) *Ceropria* sp1; *Xyleborus* sp3; 2c. *Colpodes* sp1; d) *Stilbus* sp4; e) *Xyleborus* sp1; f) *Cyclosomus* sp

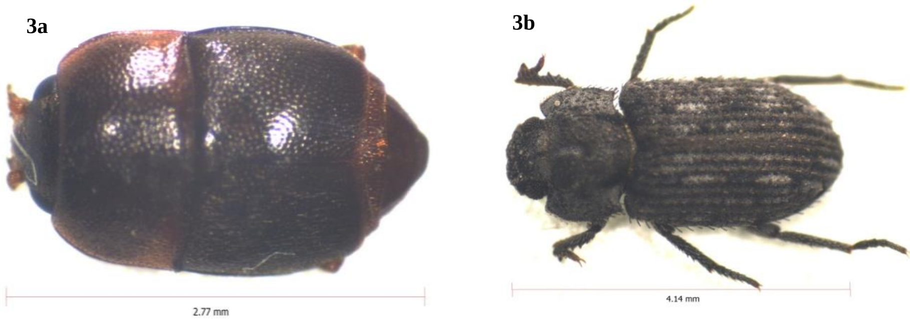

Figure 3: Common species that observed at least two different localities a) *Urophorus* sp; b) *Ericmodes sylvaticus*

Table 2: Overall biodiversity indices at Pulau Pangkor .

Indices	**2017**
Number of species	116
Number of specimens	277
Simpson Dominance Index	0.05188
Simpson diversity Index	0.9481
Shannon diversity Index	3.847
Brillouin Index	3.388
Menhinick index	6.85
Margalef index	20.09
Fisher alpha diversity Index	72.45
Berger-Parker	0.148
Chao-1 estimated species richness	347.8

Table 3: Number of specimens collected from three trapping methods.

	Light Trap	**Pitfall Trap**	**Malaise Trap**
Species	33	50	23
Individuals	101	143	33
Simpson Dominance Index	0.1618	0.1441	0.0503
Simpson diversity index	0.8382	0.8559	0.9497
Shannon diversity Index	2.511	2.951	3.078
Brillouin	2.156	2.497	2.261
Menhinick	3.284	4.603	4.511
Margalef	6.934	10.27	6.752
Fisher alpha	17.06	32.75	95.68
Berger-Parker	0.3267	0.3475	0.1154
Chao-1	72.43	137.9	128

DISCUSSION

This study displayed higher beetle diversity and abundance at Pulau Pangkor via Margarlef index, Shannon Weaver diversity index, Simpson diversity index and Fisher alpha indices. This could be due to many reasons such as ambient temperature, increased temperature at higher elevations, more primary producers and low requirements for flight activity for beetle communities. Moreover, beetle diversity have been depend upon many non-exclusive factors proposed to explain species richness, including, micro-sites, vegetation, and even historical factors (Fischer et al. 2011).

This study showed higher Shannon diversity index and highest catch at Sungai Pinang where sampling was carried out for three compared to the one day each at the other localities. Comparison of trapping methods resulted with more than 50% of the collection from pitfall traps to the other traps which are not commonly reported in Peninsular Malaysia. Previous study at Pulau Pangkor in 2009 showed lower values for Shannon-Weaver index (3.127), Margalef index (8.034) and Simpson diversity index (0.931) (Abdullah et al. 2012). Further, the number of species collected was also lower (38) and the number of specimens (100) too, even though, the days of sampling was five (5) in 2009 while four (4) days of sampling in 2017. Due to the increased amount of species diversity measures, it is really important to examine the beetle diversity at Pulau Pangkor continually to revisit the island biodiversity theories with the emergence of intermediate disturbance hypothesis (IDH). The Margalef index from this study is closely compared with the values with Northeast Langkawi (18.764). Shannon-Weaver index for Northeast Langkawi (2.442) is lower compared to Pangkor island (3.847) (Abdullah et al. 2012).

Generally, if the Shannon Weiner index is less than one is considered to be below average whereas 1-3 is considered moderate and above 3 to be a good diversity. At the same time, typically managed ecosystem shows 1.5-3.5 Shannon Weiner index (MacDonald, 2003), while the value rarely surpasses 4 (Margalef, 1972). The values for Shannon Weiner index and Brillouin index obtained rarely exceeds 4.5 and both Indices tend to give similar comparative measures (*Pielou 1975*). This study showed more than 3.5 for Shannon index at Pangkor island, indicating a higher beetle diversity. Brillouin index is better than Shannon for a small population (Maurer & McGill, 2011). Margalef's index is used to measure abundance, while, Simpson's index consider both richness and relative abundance which is equivalent to the probability of the next individual sampled being from a different species to the last individual (Hurlbert 1971). Simpson's index has low sensitiveness to species richness but high sensitiveness to the species abundance (Magurran, 1988). Simpson diversity index vary between 0 to 1, where, stable and mature populations display higher values between 0.6 to 0.9. According to Dash (2003), lower values (around 0) can be observed for populations under stress. In this study Simpson diversity index showed higher values reflects the maturity and stableness on this island.

Since the tropics serve as the cradle (high speciation rates) and museum (low extinction rates) of species diversity, more research focus should be addressed by the scientific community (Brown 2014). Biodiversity researches related to islands are particularly related since they can serve as bastations on climate change with increased human influences. According to the latest study by Hallmann et al. (2017), the flying insect biomass had been dramtically decreased in Germany. Thus, studying the biomass reduction in tropical island ecosystems will enlighten our understanding on biomass reduction. As a consequence of biomass reduction trophic level complications will disturb the ecosystems (Musthafa et al. 2018). Moreover, conservation of the local species within their habitat and its dynamism is a focal point in an environment, where anthropogenic imprints are showing some telling effects on ecosystems in the form of climate change (Musthafa et al. 2018). Therefore, this study can be extended to assess the annual beetle community change inrelation to climate change, biomass reduction and anthropogenic disturbances

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