A REVIEW OF DISTRIBUTION AND DIVERSITY OF BUTTERFLY (LEPIDOPTERA: RHOPALOCERA) FAUNA IN JOHOR, MALAYSIA

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ABSTRACT

The objectives of this paper are to (i) review the diversity and distribution of butterflies in different forested areas of Johor and (ii) compare the species composition in each study site. Data is based on field sampling and published records. This paper was able to review study sites from records dating as early as 1987. Study sites include Taman Negara Johor Endau Rompin (TNJER) Peta, TNJER Selai, Gunung Ledang, Bukit Reban Kambing, Bukit Soga and Hutan Lipur Sg Bantang. To evaluate the variation in butterfly diversity in the different forest, the study sites were characterized by describing and comparing overlapping species using hierarchical cluster analysis. To date, a total of 396 species of butterflies are recorded so far in Johor. This accounts for 37.57% of the overall butterfly fauna in Peninsular Malaysia. The highest species richness was recorded in TNJER with a total of 349 species discovered to date. Based on the cluster analysis, species composition in TNJER Peta and Selai showed the highest similarity at 37%. Locality with the most different species composition was Bukit Tukau, Bukit Belading and Bukit Reban Kambing with only 7% similarity. Remarkably, many of the protected species under Wildlife Conservation Act 2010 can be found in Johor. These species include *Zeuxidia aurelius aurelius* (Cramer), *Polyura eudamippus peninsularis* (Pendlebury), and *Troides helena cerberus* (C. & R. Felder). Data obtained from this paper is important for future planning and management of conservation areas in Johor.

Keywords: Lepidoptera, Diversity, Conservation, Johor

ABSTRAK

Objektif kajian ini adalah untuk (i) menyemak semula kepelbagaian dan taburan kupu-kupu di beberapa kawasan hutan di Johor dan (ii) membandingkan komposisi spesies di setiap kawasan kajian. Data dikumpulkan berdasarkan kerja lapangan dan rekod penerbitan terdahulu. Kajian ini menyemak rekod dari kawasan kajian seawal 1987. Kawasan kajian merangkumi Taman Negara Johor Endau Rompin (TNJER) Peta, TNJER Selai, Gunung Ledang, Bukit Reban Kambing, Bukit Soga and Hutan Lipur Sg Bantang. Untuk menilai variasi kupu-kupu dari kepelbagaian hutan berbeza, kawasan kajian dicirikan dengan memperihalkan spesies yang bertindih menggunakan analisis pengkelasan hirarki. Sehingga kini, sejumlah 396 spesies

kupu-kupu direkodkan dari |Johor. Jumlah ini menwakili 37.57% dari keseluruhan kupu-kupu dari Semenanjung Malaysia. Kekayaan spesies yang tertinggi direkodkan dari TNJER dengan sejumlah 349 spesies sehingga kini. Berdasarkan analisis pengkelasan, komposisi spesies di TNJER Peta dan Selai menunjukkan peratusan persamaan pada 37%. Lokasi yang menunjukkan perbezaan komposisi adalah Bukit Tukau, Bukit Belading dan Bukit Reban Kambing dengan 7% persamaan. Kebanyakan spesies terlindung di bawah Akta Pemulihaaran Hidupan Liar 2010 didapati di Johor. Spesies ini melibatkan spesies *Zeuxidia aurelius aurelius* (Cramer), *Polyura eudamippus peninsularis* (Pendlebury), dan *Troides helena cerberus* (C. & R. Felder). Data yang diperoleh dari kajian ini sangat penting untuk perancangan masa depan dalam pengurusan pemuliharaan di kawasan Johor.

Kata kunci: Lepidoptera, Kepelbagaian, Pemuliharaan, Johor

INTRODUCTION

Planning conservation areas and achieving conservation goals need a strategic framework to allow for better use of limited resources. In systematic conservation planning (Margules & Pressey 2000), reserves play a huge role in representing the biodiversity of the region and act as a barrier protecting this biodiversity from processes that would threaten their existence. To do this, one needs a clear idea on the choice of surrogates that will be used to represent the overall diversity of the area. Butterflies have long been used as a surrogate taxon in assessing biodiversity of an area at a community level with varying level of success (Blair 1999; Ricketts et al. 2002; Rakosy & Schmitt 2011; Syaripuddin et al. 2015). They are also considered as an excellent indicator of health for terrestrial ecosystems (Thomas 2005).

Regrettably, many of these researches are of butterflies from the temperate region such as the North America, Europe and Australia. Most of the studies done in the tropics focuses on habitat level conservation approach (Bonebrake et al. 2010). Conservation efforts in the tropics seldom focus on one specific species. Due to limited resources in terms of time, money and manpower, using surrogates to monitor overall biodiversity of an area makes economic sense. Tropical forests in South America such as Brazil follow this trend of research closely (Cambui et al. 2017; Shuey et al. 2017). On the other hand, knowledge on tropical butterfly of Southeast Asia, especially in Peninsular Malaysia is still deficient compared to those previously mentioned.

Relatively speaking, Lepidoptera is the most researched insect order in Malaysia, with Coleoptera following in second place (Cheng & Kirton 2007). A simple SCOPUS search for the term “Lepidoptera” and “United States” yielded 1762 papers. That same search with the term “Lepidoptera” and “Malaysia” yielded 175 papers. Out of that, the term “Sabah” matched to 52 papers while the term “Johor” only yielded 4 papers. This rather rough but significant exercise shows that knowledge on butterflies in Malaysia is still deficient, especially in the Southern region of Peninsular Malaysia. Most of the data in Johor is restricted to TNJER. We need more research on the specific biogeographic pattern of different species, and interspecies interactions, only then can we evaluate impacts due to habitat loss on butterfly diversity and the importance of proper conservation planning. To that end, this paper aims to review the butterfly diversity in the state of Johor, Malaysia in the hope to gather enough baseline data to facilitate future conservation planning.

MATERIALS AND METHODS

Sampling

A simple manual mapping of collated butterfly data pointed out forested areas in Johor that lack of data. These areas were chosen for samplings of butterflies to provide for complementary data. Two sampling methods were employed; baited traps and opportunistic sampling using aerial nets. Ten sampling stations were established at each site. Radius of each sampling station was approximately 50 meters. Each station was fitted with one bait trap adapted and modified from Daily & Ehrlich (1995). A mixture of rotten banana and pineapple was used as bait. Sampling was carried from 9 am to 5 pm when butterflies are most active; and in triplicates spanning from June 2016 to November 2017. Specimens were identified in the field whenever possible. All specimens collected were brought to the laboratory, prepared, mounted, dried and stored as a reference collection at Repository of the Centre of Research for Sustainable Uses of Natural Resources, Faculty of Applied Science and Technology, Universiti Tun Hussein Onn Malaysia.

Data Collection

Data were mainly collected from published records of checklists within the state. The study was limited to the state of Johor. Several authors of papers/reports were contacted to obtain complete data sets. Full citation of each paper is available. Sampling techniques, plot size and sampling frequency of each study are different with a minimum threshold set at three sampling days. Study sites included both primary and secondary forests, state parks and forest reserves.

Species Composition and Diversity Analysis

Hierarchical cluster analysis was performed to identify clusters of sites with varying consensus clustering solution. Data of presence/absence was applied and the average linkage aggregation method using Jaccard similarity distance was used in this analysis. This hierarchical cluster analysis was performed using PRIMER-E (Plymouth Routines In Multivariate Ecological Research) v.6 software package (Clarke & Gorley2006). Localities were mapped onto a projection of Johor to give a rough indication of the distribution of the group using QGIS version 2.81 (QGIS Development Team 2017).

RESULT AND DISCUSSION

History of Butterfly Collection in Johor

Knowledge on the diversity of butterflies in Johor could be traced back up to 162 years ago. Sir Alfred Russel Wallace (1823 – 1913), a British biologist, naturalist and explorer, travelled to the Malay Archipelago with a grant from the Royal Geographical Society in 1854. During his travels, he collected many biological specimens including insects, with special interest in Lepidopteran specimens. Wallace studied only Papilionidae (1865) and Pieridae (1867) in detail while Hewitson (1862 – 1878) later described most of the Lycaenidae he collected. Most of his specimens are now at the Natural History Museum, London. During his ventures to Mount Ophir, now referred to as Gunung Ledang in Johor, he described a few species of butterflies such as *Ornithoptera (Troides) amphrysus* (Cramer), *Graphium agamemnon* (Linnaeus), *G. antiphates* (Cramer), *Papilio memnon* Linnaeus, *P. iswara* White and *Pathysa delessertii* (Guerin-Meneville) (Wallace 1869).

The next recorded butterfly diversity study was during an expedition carried out in 1987 by the Malayan Nature Society through the Endau Rompin Heritage Expeditions. During this expedition, Kirton & Kirton (1987) recorded 179 species of butterflies in the Kuala Jasin area

of the Ulu Endau watershed. Some of the rarer species discovered there were *Hypochrysops coelisparsus kerri* Riley, *Hypolycaena merguia skapane* H.H. Druce and *Potanthus pamela* (Evans). *H. coelisparsus kerri* is considered very rare in Peninsular Malaysia, and was first taken on Penang Hill around 100 years ago (Corbet et al. 1992). *Hypolycaena merguia skapane* was officially recorded again from Sg Sedim Forest Reserve, Kulim in 2007 (Sulaiman et al. 2009). The later species, *P. pamela* also occurred in Gunung Kinabalu, Sabah (Hauser *et al*.,1997).

Since then, Endau – Rompin was gazzetted as a National Park on 2nd of September 1993 (DWNP, 1996). Managed under Johor National Parks Corporation, Taman Negara Johor Endau Rompin (TNJER) can be accessed through Kampung Peta, Kahang and Selai, Bekok. Since Kirton's expedition in 1987, several butterfly diversity studies have been done in TNJER. Sofian-Azirun et al. (2005) then recorded 206 species of butterflies in the southwestern part of TNJER with 84 new records. Some of the rare species include *Arhopala wildeyana wildeyana* Corbet, *Nacabuda solta* Eliot and *Papilio palinurus palinurus* Fabricius. In other forested areas of mainland Johor, published research on butterfly diversity is still lacking.

Documented Butterfly Diversity in Johor

The checklist in Appendix A is presented in systematic order, with the species arranged by family, subfamily and genus. To ease reference, individual species within the genera are arranged in alphabetical order. Taxonomy and nomenclature of the butterflies followed standard reference work by Corbet & Pendlebury (1992) including updates by Eliot & Kirton (2000) and Eliot (2006). Butterfly distribution was mapped using QGIS v.2.18 (Figure 1). Locality names and respective work referenced are abbreviated as per below:

UE = Ulu Endau. Sampling done in Kuala Jasin, Gunung Janing Barat and Buaya Sangkut waterfall. (Kirton & Kirton 1987).

SE = TNJER Selai, Labis. 2.4666 °N; 103.83916667 °E. Specimens gathered along the trail of Lubuk Tapah, Kampung Selai, Sungai Selai, Sungai Kemidak, Takah Tinggi and Gunug Tiong. (Sofian-Azirun et al. 2005).

LT = TNJER Selai. 2.466667 °N, 103.2167 °E. Sampling done within the Lubuk Tapah sector of the park, covering the entrance border near Kg. Selai towards basecamp and further upstream towards Lata Kasih. (Zaidi et al. 2009).

KJ = TNJER Peta. 2.53333 °N, 103.4000 °E. Sampling area is considered secondary lowland forest with sampling done close to undisturbed trail, old logging track and camping site in Kuala Jasin and NERC. (Ismail 2017; Maryati et al. 2013).

GL = Gunung Ledang, Sagil, 2.373855°N; 102.60818°E. Elevation: 400 m, 800 m and 1200 m a.s.l. Vegetation types consist of lowland dipterocarp forest, hill dipterocarp forest, lower montane and montane ericaceous. Specimens mostly obtained from the hiking trail heading to the peak and roadside trail heading to the telecommunications tower (Ismail 2017).

RB = Bukit Reban Kambing (BRK), Bukit Belading (BB) and Bukit Tukau (BT). 2.3361°N; 102.5416°E. Elevation: 118 m to 515 m a.s.l. These fragmented hill forests are adjacent to oil palm plantations, orchard and quarry activities. The locality is habitat for hyper endemic and critically endangered cycad species, *Cycas acantifolia* (Ismail & Maryati in press).

US = Ulu Sedili Forest Reserve, Kota Tinggi. 2.0394°N; 103.8451°E. Sampling location is originally a peat swamp forest. Now surrounded by secondary forest vegetation consisting almost exclusively of *Acacia mangium*.

BS = Bukit Soga Forest Reserve, Batu Pahat, 1.8494°N; 102.9597°E. Elevation: 85 m to 360 m a.s.l. Degraded lowland dipterocarp forest. Most records are from the recreational forest located at the edge of the forest reserve.

SB = Sungai Bantang Forest Reserve, Bekok, 2.347824°N; 103.157019°E. Locality surrounded by secondary forest that have been selectively logged. Sungai Bekok flows through this area from Gunung Bekok.

In the present survey, a total of 396 butterfly species has been recorded in Johor. This accounts for 37.57 % of butterfly fauna in Peninsular Malaysia with 1054 total species recorded (Corbet & Pendlebury 1992; Eliot & Kirton 2000; Eliot 2006) (Table 1). TNJER (SE, UE, KJ and LT) recorded the highest species richness followed second by Gunung Ledang (Figure 2). This may be due to several reasons. The area in TNJER is larger (48,905 ha) (Chew 2007) than the other study area. Its status as one of the oldest tropical rainforest in the world have attracted plenty of research interest and funding, therefore greater sampling effort were achieved. It also contributed to majority of new locality records in Johor since 1987 to 2013 (Figure 3).

Cluster Analysis of Species Composition at Different Sites

The cluster analysis using Jaccard coefficient indicated the most distinct species was found at RB where it separated at 7% from other 8 sampling locations (Figure 4). This shows that species collected at RB was different from other eight places. Meanwhile UE and SE trails presented the lowest average linkage similarity distance of 37%, which represented the highest degree of similarity between trails studied. These two trails were also related to LT followed by GL, KJ and SB with average linkage similarity distances of 27, 22, 21 and 18% respectively. Another group that was separated at 18% of similarity was between BS and US.

From this analysis, three distinct locality groups are identified. Group A included localities from TNJER, Gunung Ledang and Sungai Bantang. TNJER (UE, SE, LT & KJ) and Gunung Ledang (GL) are primary forests in Johor while Sungai Bantang is located within Bekok Forest Reserve, which is near TNJER. Therefore, it is expected that the species composition in these localities showed the highest similarity. Group B included Bukit Soga (BS) and Ulu Sedili (US). Both localities are secondary forests with Bukit Soga being a degraded dipterocarp hill forest and Ulu Sedili being a secondary forest and peat swap area. The outgroup for this cluster is Group C which is Bukit Tukau, Bukit Belading and Bukit Reban Kambing (RB). It is interesting to note that RB is the habitat to *Cycas acantifolia* which is Critically Endangered and considered as hyper endemic (Jutta *et al*. 2010). The butterfly species *Chilades pandava pandava* (Horsfield) or the Cycad Blue, is associated with the *Cycas* spp. as its host plant. In Johor, this plant species was only recorded in Gunung Ledang, Bukit Tukau and Bukit Belading proximity where *C. acantifolia* is considered endemic to this locality. In other countries such as Taiwan, the butterfly *C. pandava* is considered as pests as it feeds on ornamental cycad species (Raju 2009).

Updates in Nomenclature

This paper reviewed work back to 1987. Since then, several revisions have been done to the species checklist mainly by Corbet & Pendlebury (1992), Eliot & Kirton (2000), and Eliot (2006). Some of the species recorded in Johor are updated as per below.

In Kirton & Kirton (1987), *Trogonoptera brookiana mollumar* (D'Abrera, Doggett & Parker) is synonym to *Trogonoptera brookiana trogon* (Vollenhoeven). *Atrophaneura nox erebus* (Wallace) is now *Parides nox erebus* (Wallace). *Paranticopsis delessertii delessertii* (Guerin-Meneville) is now *Pathysa delessertii delessertii* (Guerin-Meneville). *Papilio fuscus prexaspes* C. & R. Felder is now *Papilio prexaspes prexaspes* C. & R. Felder. *Euploea diocletianus diocletianus* (Fabricius) is now *Euploea radamanthus radamanthus* (Fabricius). *Arhopala pseudocentaurus nakula* (C. & R. Felder) is now known as *Arhopala centaurus nakula* (C.& R. Felder). In Ismail (2017), *Athyma abiasa clerica* Butler is now *Athyma clerica clerica* Butler.

CONCLUSION

This study was able to review the overall diversity of butterflies in Johor. Taman Negara Johor Endau Rompin showed the highest species richness recorded compared to other localities. However, based on the distribution map generated, there are other forested areas in Johor that have not been explored. Future work should include documenting the diversity of butterflies in these areas.

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APPENDICES

Table 1 Breakdown of number of species in each butterfly family recorded in Johor and their percentage of the total butterfly fauna in Peninsular Malaysia.

Family	No of species recorded in Peninsular Malaysia	No of species recorded in Johor	Percentage of species recorded in Johor
Papilionidae	45	30	66.67
Pieridae	45	29	64.44
Nymphalidae	281	166	59.07
Lycaenidae + Riodinidae	418	121	28.95
Hesperiidae	265	50	18.87
Total	1054	396	37.57

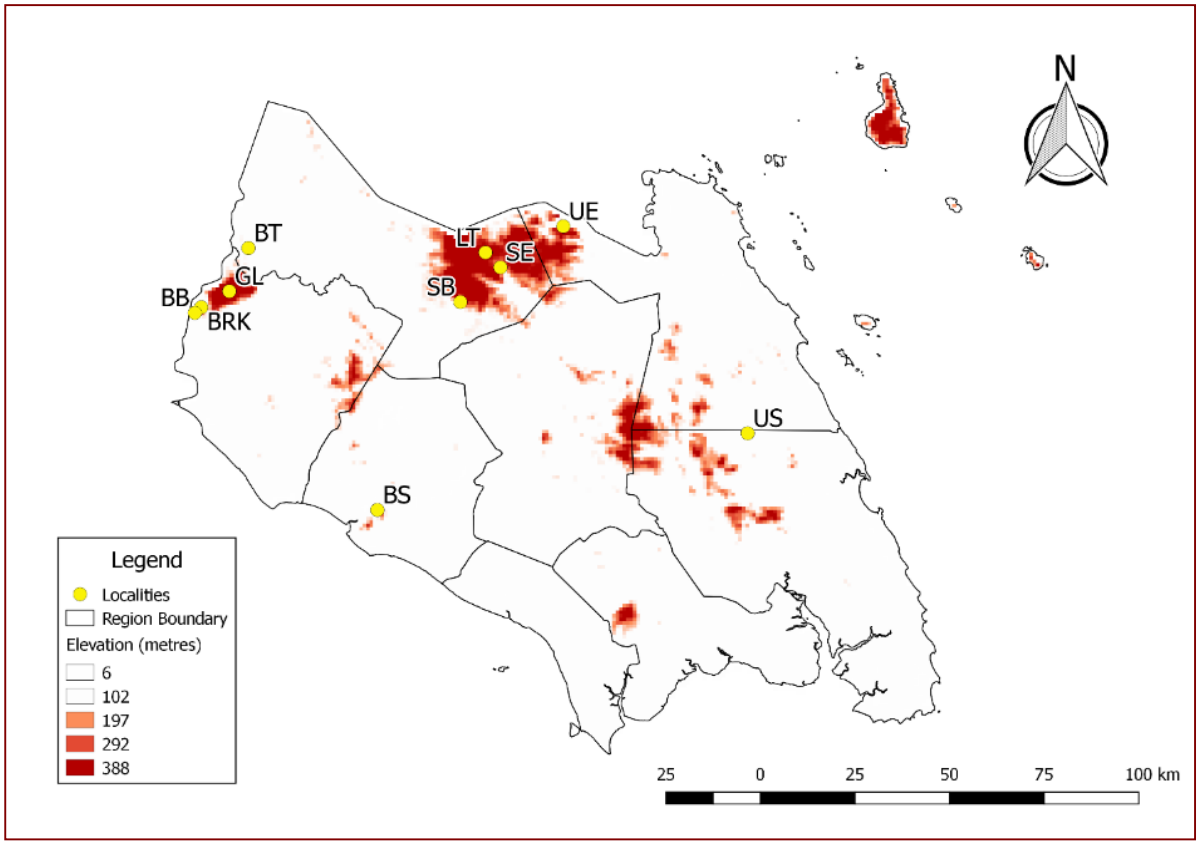

Figure 1 Locality map in the state of Johor.

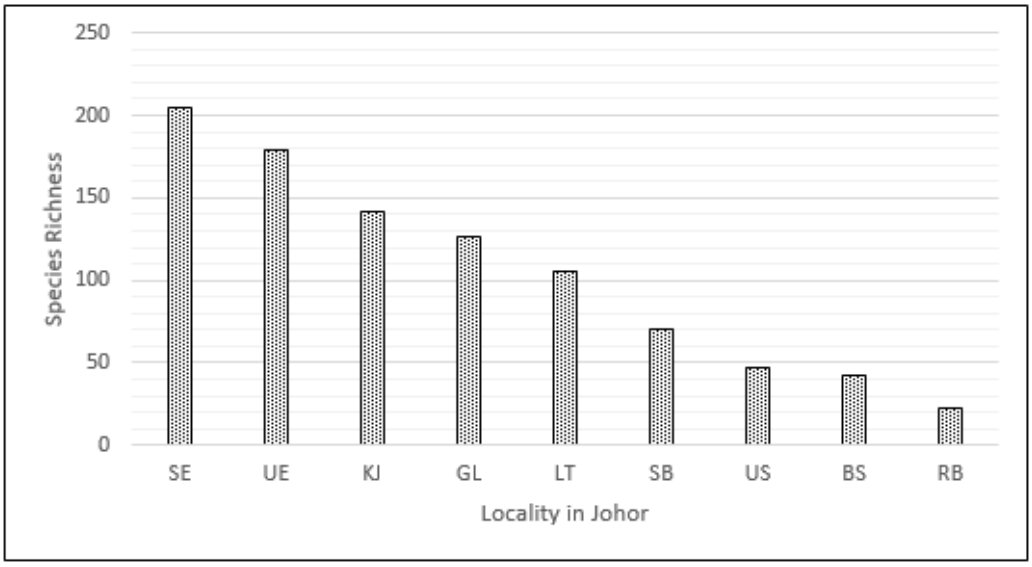

Figure 2 Graph of species richness in different localities in Johor. Locality reference as follows: UE = TNJER (Peta), Kirton & Kirton (1987); SE = TNJER (Selai) Sofian-Azirun *et al*. (2005); LT = TNJER (Selai), Zaidi *et al*. (2009); KJ = TNJER (Peta), Maryati *et al*., (2013); Ismail (2017); GL = Gunung Ledang, Ismail (2017); RB = Bukit Tukau, Bukit Belading & Bukit Reban Kambing, Ismail & Maryati (in press); US = Ulu Sedili Forest Reserve, BS = Bukit Soga Forest Reserve, SB = Sungai Bantang Forest Reserve

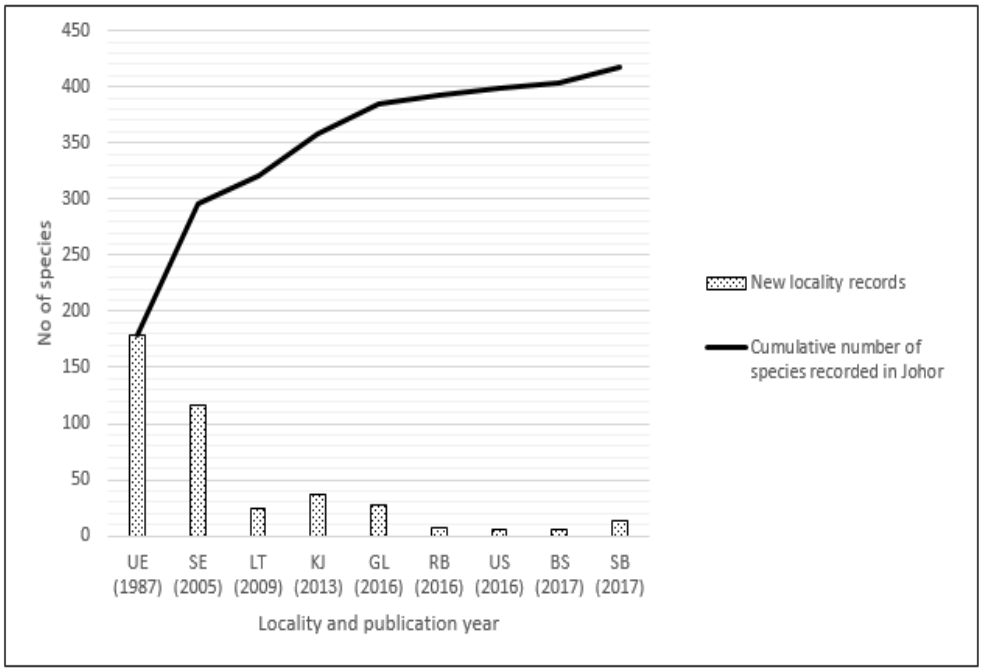

Figure 3 Graph of new locality records in Johor with the cumulative number of species recorded in Johor since 1987 to 2017. Trend shows low new locality records since 2009. Most of the species recorded in Johor is found in TNJER. This figure also shows that the number of butterfly species collected in Johor has more than doubled for the past 30 years.

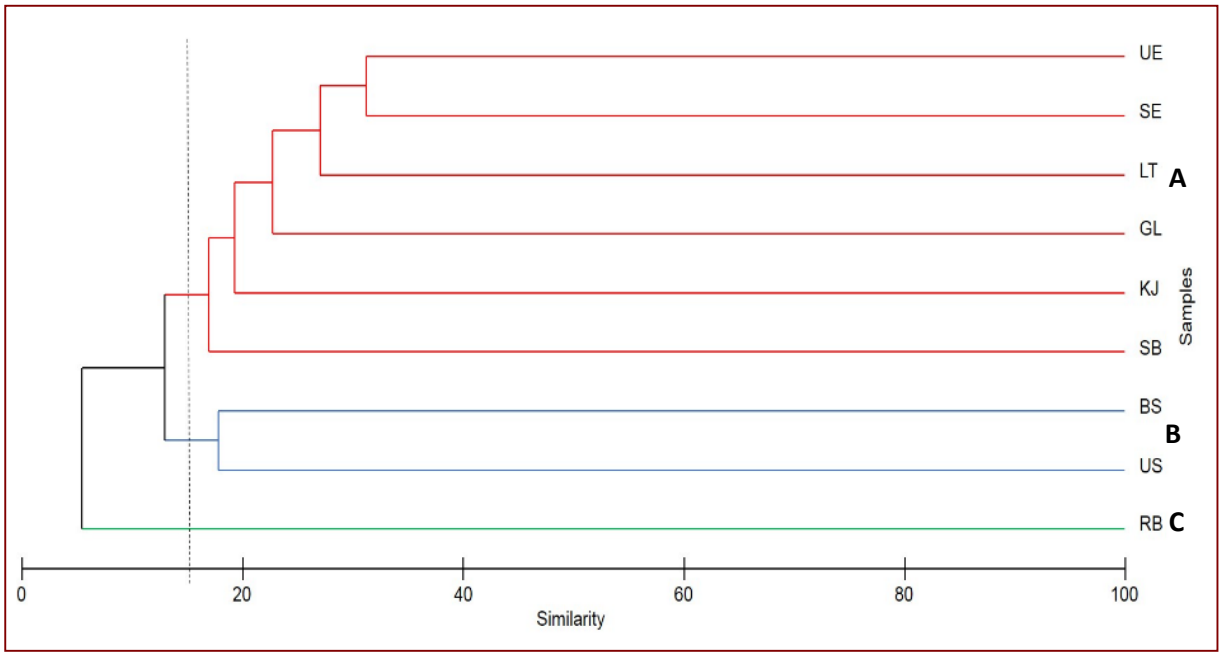

Figure 4 Hierarchical cluster analysis between sites using Jaccard distance similarity as aggregation method. The dotted line at 15% of similarity shows 3 groups were separated and highlighted using different colours; red (A), blue (B) and green (C).