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AN ASSESSMENT OF THE NOCTURNAL INSECT DIVERSITY AND ABUNDANCE BETWEEN AN AGRICULTURAL AND SUBURBAN LANDSCAPE IN PENINSULAR MALAYSIA

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ABSTRACT

A total of 46, 912 insects comprising 112 families from 14 orders were collected with light traps. The agricultural landscape had higher insect abundance compared to the suburban landscape where there were 27, 833 insect individuals belonging to 96 families and 19, 079 insect individuals belonging to 75 families respectively. The four most abundant orders collected at the agricultural landscape were Coleoptera followed by Hymenoptera, Hemiptera and Isoptera while at the suburban landscape were Hymenoptera followed by Coleoptera, Isoptera and Hemiptera. Eventhough the similarity index was 67.8% there was no significant difference in insect abundance between both sampling sites (P= 0.622, $p > 0.05$). The Shannon-Weiner diversity index at the agricultural landscape (H’ =

2.581) was higher compared to the suburban landscape (H’ = 2.422). However, the evenness at the suburban landscape (E_H = 0.1502) was higher compared to the agricultural landscape (E_H = 0.1376). The data obtained provides baseline information on nocturnal insect availability and activity in anthropogenically altered habitats which will be of use when studying foraging habits of nocturnal aerial insectivores and in insect pest control.

Keywords: insect diversity, nocturnal insects, agricultural habitat, suburban habitat

ABSTRAK

Sejumlah 46, 912 individu serangga yang terdiri dalam 112 famili daripada 14 order berjaya diperangkap menggunakan perangkap cahaya. Lanskap pertanian mempunyai kelimpahan serangga yang lebih tinggi daripada lanskap separa bandar iaitu terdiri daripada 27, 833 individu serangga daripada 96 famili dan 19, 079 individu daripada 75 famili masing – masing. Empat order serangga yang mempunyai kelimpahan tertinggi di lanskap pertanian ialah Coleoptera diikuti oleh Hymenoptera, Hemiptera dan Isoptera manakala di lanskap separa bandar pula ialah order Hymenoptera diikuti oleh Coleoptera, Isoptera dan Hemiptera. Walaupun indeks persamaan serangga di kedua – dua lanskap ialah 67. 8%, tetapi tidak terdapat perbezaan yang signifikan bagi kelimpahan serangga di kedua – dua lanskap (P= 0.622, $p > 0.05$). Indeks kepelbagaian Shannon – Weiner di lanskap pertanian (H’ = 2.581) adalah lebih tinggi daripada lanskap separa bandar (H’ = 2.422). Walaubagaimanapun, bagi kesamarataan serangga, lanskap separa bandar (EH = 0.1502) mempunyai nilai kesamarataan yang lebih tinggi daripada lanskap pertanian (EH = 0.1376). Data yang diperoleh memberikan maklumat asas kepada kehadiran serangga nokturnal dan aktiviti di habitat yang berubah secara antropogenik dimana hasil kajian akan digunakan apabila mengkaji tabiat mencari makan penmakan serangga nokturnal dan pengawal serangga perosak.

Kata kunci: kepelbagaian serangga, serangga malam, habitat pertanian, habitat subbandar

INTRODUCTION

Conversion of natural habitats due to agricultural activity and urbanization is accelerating worldwide causing significant habitat loss (Wu et al. 2013, Wu, 2014; Liu et al. 2014). In Malaysia, agricultural expansion and deforestation are spatial processes of land transformation that impact landscape patterns (Abdullah & Hezri, 2008). Oil palm and rubber plantations were reported as major contributors to forest fragmentation in Malaysia (Saiful Arif & Nakagoshi, 2007). In addition, Masron et al. (2012) reported that the urban population ratio in Malaysia grew from 26.8% to 61.8% from 1970 until 2000 and was estimated to be 74.7% in 2015.

Increasing agricultural intensification, urbanization and other types of land uses has caused large continuous forests to fragment into smaller and isolated patches (Sodhi et al., 2011). Insect diversity across the globe has been reported to show declines associated with anthropogenic impact on the environment (Diekötter et al. 2008; Fahrig & Jonsen, 1998; Turner et al. 2007). Insects comprise about half of the world's known animal species and play important roles in pollination, biological control, diease transmission, decomposition and as pests (Losey & Vaughan, 2006).

There has been a lot of research conducted related to the impact of habitat degradation on insect diversity worldwide

(Collinge, 2000; Hunter, 2007; Grez et al. 2004; Grez et al. 2008; Valladares, 2005). However very little research has been conducted on comparing insect diversity and abundance between agricultural and suburban habitats in Malaysia. Research that has been conducted tended to focus on specific orders of insects for example beetles (Abdullah Muhaimin, 2015; Aruchunnan, 2015), lepidoptera (Azhar 2015), and hymenoptera (Idris et al. 2009). Different groups of insects have their preferred activity periods where they can be diurnal, crepuscular, nocturnal, matutinal or vespertine. The focus in this study were nocturnal insects which are the prey of nocturnal aerial insectivores such as bats (Adri et al. 2016). There is very little published information available on nocturnal insect diversity in agricultural and suburban landscapes in Malaysia. The objective of this study was to compare the relative nocturnal insect abundance and diversity at selected agricultural and suburban landscapes in Peninsular Malaysia.

METHODOLOGY

Study Area

This study was conducted at Felda Chini, Pahang (3°15'40" N and 102°45'40 "E) and Universiti Kebangsaan Malaysia (UKM), Bangi, Selangor (2°55'016" N and 101°45'969 "E) from May to October 2014. Felda Chini is an intensively managed oil palm production habitat characterized by homogeneous oil palm plantations interspersed with scattered patches of remnant natural forest (Mushrifah and Ahmad Abbas, 2005). UKM is embedded in a suburban habitat with multiple land use such as oil palm and rubber plantations, village orchards, a fragmented forest reserve, and, residential and light industrial areas (Fatma et al. 2012).

Insect Trapping

Insects were sampled for three nights each month using light traps from May to October 2014. At Felda Chini insect light traps were setup at Sekolah Kebangsaan Chini 3 & 5 (102º57‟05.6”E, 03º22‟17.7”N), Sekolah Kebangsaan Chini 2 (102º56‟51.4”E, 03º22‟57.3”N), and the dental clinic at Felda Chini (102º55‟39.02”E, 03º22‟20.59”N). In UKM traps were setup at the Centre for Gene Analysis and Technology (CGAT; 101º47‟23.2”E, 02º54‟44.6”N), Danau Golf Club (101º47‟23.3”E, 02 º 54‟49.9”N) and Bukit Puteri housing complex (101º47‟43.2”E, 02 o 55‟29.1”N). Traps were located based on a preliminary home range study conducted on *Scotophilus kuhlii* (Nur Atiqah et al. 2015) and were separated by a 1 km distance from other light traps in each landscape.

Each light trap was a combination of a fluorescent and UV light designed to maximize the catch. The light traps were hung 5-8 m off the ground from a suitable tree branch between 1800 hrs and 0700 hrs. Insects were sampled using only one light trap at different points for three consecutive nights each month. No sampling was done during full moon as it is known to alter insect behavior (Threlfall et al. 2012). Captured insects were stored in bottles with 70% ethyl alcohol and brought back to the laboratory for sorting and identification.

Insect Identification and Analysis

Identification was done by referring to Triplehorn and Johnson (2005) and comparison with insect collections deposited at the Centre for Insect Systematics (CIS) in UKM. Identification was done to the familial level where possible. The PAST software was used to measure diversity indices and similarity index was measured using Biodiversity Pro. 2.0. Comparison of insect diversity between both landscapes and sampling months was done using the Mann-Whitney and Kruskal–Wallis tests respectively using Minitab version 16.0

RESULTS

A total of 46, 912 insects were collected from both landscapes consisting of 14 orders from 117 families namely Coleoptera, Hemiptera, Hymenoptera, Diptera, Orthoptera, Trichoptera, Isoptera, Lepidoptera, Blattodea, Dermaptera, Phasmotodea, Odonata, Neuroptera and Mantodea (Table 1). In the agricultural landscape 27, 833 insects consisting of 96 families from 13 orders were collected (Table 2). The most abundant order was Coleoptera followed by Hymenoptera, Hemiptera, Isoptera, Diptera, Lepidoptera, Orthoptera, Dermaptera, Trichoptera, Blattodea, Phasmatodea, Neuroptera and Odonata. In the suburban landscape 19, 079 insects belonging to 75 families from 13 orders were collected. The most abundant order was Hymenoptera followed by Coleoptera, Isoptera, Hemiptera, Diptera, Lepidoptera, Trichoptera, Orthoptera, Dermaptera, Blattodea, Mantodea, Neuroptera and Odonata.

The Shannon-Weiner diversity index for the agricultural landscape (H’ = 2.581) was higher compared to suburban landscape (H’ = 2.422) (Table 1). However, the evenness in the suburban landscape (E_H = 0.1502) was higher compared to agricultural landscape (E_H = 0.1376). Table 2 shows that the dominant families were similar in all 13 orders for both landscapes except for orders Trichoptera, Mantidae, Phasmotodea.

The Bray-Curtis Cluster Analysis (Figure 1) method was used to determine the extent of the overlap and it showed that there was a 67.8% similarity of insect orders betweeen both sites. There were some differences in the proportions of rare insect orders such as Phasmatodea which was only found in the agricultural landscape while Mantodea which only found in the suburban landscape. Coleoptera and Hymneoptera were twice as abundant in the agricultural landscape compared to the suburban landscape. Eventhough the similarity index was 67.8%, there was no significant differenence in insect abundance between both sampling sites (P= 0.622, $p > 0.05$).

Monthly sampling in the agricultural landscape (Figure 2) showed that Hymenoptera was most abundant in May (51.27%), June (51.83%) and September while the most abundant order in July (65.07%), August (47.71%) and October (63.96%) was the Coleoptera. In the suburban landscape (Figure 2), Hymenoptera (49.75%) was most abundant in May whereas Coleoptera was most abundant in June (44.45%), July (45.98%), September (60.24%) and October (41.71%) and Isoptera in August (44.21%). The number of insects trapped by Order in both landscapes showed some variation but no significant difference was detected between sampling months in the agricultural ($p=0.399$, $p> 0.05$) and suburban landscapes ($p=0.846$, $p> 0.05$)

DISCUSSION

The results of this study showed that the agricultural landscape had higher insect abundance and diversity compared to the suburban landscape. Hunter (2002) summarized that features of landscapes that influenced the abundance and richness of insects were ratio of habitat edge to interior, the isolation of habitat fragments, patch area, patch quality, patch diversity and microclimate. In addition, factors such as food resources and disturbance in the landscape may also influence the abundance and diversity of insects (Mohd Hanysyam et al. 2013) in anthropogenic habitats.

The results of the present study are supported by research conducted on dispersion of diving beetles in agricultural and urban landscapes where it was suggested that the agricultural landscape with a complex vegetation mosaic attracts far more species compared to an urban landscape with low vegetation complexity (Lundkvist et al. 2002). Abdullah Muhaimin et al. (2015) also stated that palm oil ecosystems can sustain insect species such as dung beetles because of ability of the area to provide food which comes from local domestic cows, shade from sunlight provide by the palm oil trees, and ground cover from small plants and shrubs. However, in this study we noted that the suburban landscape had an assemblage dominated by species that are infrequent in agricultural landscapes (Lundkvist et al. 2002).

Insect abundance and distribution between months are controlled by several biotic factors and their interactions. Among abiotic factors, temperature and rainfall patterns stand out as the most important key factors that influence abundance and distribution of insects. Moreover, it is well acknowledged that abiotic factors regulate the ecology of insect communities (Savopoulou-Soultani et al. 2012). Temperature is one of the climate variables that influence most activity of many insect species, determining their rates of development and reproduction (Brakefield 1987). Studies by Reisen et al. (2008) agreed that the temporal variation in the abundance of insects was linked significantly with temperature. In a study by Hafizal & Idris (2014) in Kuala Selangor and Sabak Bernam it was noted that the population abundance of Homoptera could be influenced by temperature.

Many studies have also reported that tropical insects undergo seasonal changes in abundance and that this is thought to be related to the alternation between the dry and rainy seasons (Pereira da Silva et al. 2011). However, it cannot be expected that ecologically and taxonomically different groups respond in the same manner to shifts in climate variables (Wolda & Fisk 1981).

Vegetation structure of modified landscapes were found to affect the insect abundance and diversity by many previous studies. The vegetation's diversity indirectly affects insect species diversity and abundance (Abdullah & Sina 2009). Higher abundance in agricultural landscape was suggested due to the persistence of insects within agricultural landscape (oil palm plantations) was much greater, with little adverse effect on a range of taxa and higher species abundance of ants, bees and moths (Danielsen et al. 2009) as compared to the suburban landscape.

CONCLUSION

The results of this preliminary study showed that the agricultural area contains higher insect diversity compared to suburban landscape. In future studies, factors such as vegetation structure, microclimate and landscape characteristics should to be measured in order to get a clear understanding of factors contributing to insect abundance and diversity in different landscapes.

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APPENDICES

Table 1 Comparison of insect orders between the agricultural and suburban landscape

Landscape/ Order	Agriculture			Suburban		
	Total Families	**Total Individuals**	**(%)**	**Total Families**	**Total Individuals**	**(%)**
Coleoptera	35	12300	44.19	24	6089	31.91
Hemiptera	21	2062	7.41	16	1608	8.43
Hymenoptera	2	12110	43.51	5	7010	36.74
Diptera	9	248	0.89	8	244	1.28
Orthoptera	4	121	0.43	3	25	0.13
Trichoptera	2	40	0.14	2	147	0.77
Isoptera	1	631	2.27	1	3702	19.40
Lepidoptera	13	248	0.89	9	239	1.25
Blattodea	1	12	0.04	2	3	0.02
Dermaptera	3	51	0.18	2	8	0.04
Phasmotodea	2	3	0.01	0	0	0.00
Odonata	1	1	0.00	1	1	0.01
Neuroptera	2	6	0.02	1	1	0.01
Mantodea	0	0	0.00	1	2	0.01
Total	**96**	**27833**	**100**	**75**	**19079**	**100**
Shannon		2.581			2.422	
Evenness		0.1376			0.1502	
Dominance		0.1627			0.1677	

Table 2 Comparison of insect families between the agricultural (AG) and suburban (SU) landscape

Order	**Family**	**AG**	**SU**	**Order**	**Family**	**AG**	**SU**
Blattodea	Ectobiidae	2	1	Hemiptera	Pyrrhocoridae	89	28
	Blatellidae	2	2		Ceccopidae	730	89
Coleoptera	Scydmaenidae	860	323		Cicadellidae	2	1171
	Coccinellidae	476	114		Coreidae	0	14
	Hydrophilidae	325	50		Mesoveliidae	398	6
	Chrysomelidae	355	424		Pentatomidae	44	51
	Elateridae	427	115		Hebridae	16	44
	Erotylidae	84	75		Reduviidae	71	17
	Nitidulidae	640	705		Cicadidae	324	6
	Silvanidae	70	298		Lygaeidae	26	53
	Staphylinidae	2322	1213		Alydidae	47	1
	Scarabaiedae	302	85		Belostomaiidae	2	0
	Platypodidae	183	184		Membracidae	0	0
	Tenebrionidae	2995	1278		Anthocoridae	0	0
	Cerambycidae	79	13		Corixidae	3	0
	Brentidae	46	28		Hydrometridae	1	0
	Pyrochroidae	1	2		Gerridae	194	1

	Curculionidae	73	72		Cydnidae	1	90
	Carabidae	1877	919		Aphrophoridae	78	1
	Endomychidae	89	26		Miridae	26	12
	Dycticidae	588	84		Nabidae	2	24
	Scolytidae	238	53		Tingidae	1	0
	Lycidae	26	8		Dictyopharidae	1	0
	Cicindelidae	6	0		Aradidae	10003	0
Coleoptera	Gyrinidae	22	0	Hymenoptera	Formicidae	0	6367
	Passalidae	7	0		Vespidae	0	15
	Historidae	6	0		Tenthredinidae	2107	1
	Languriidae	3	0		Ichneumonidae	0	612
	Cleridae	3	0		Apidae	120	15
	Meloidae	132	0	Isoptera	Termitidae	6	3762
	Heliplidae	4	0	Odonata	Corduliidae	1	1
	Bostrichidae	23	7	Orthoptera	Gryllidae	5	21
	Cantharidae	2	0		Acrididae	6	2
	Noteridae	21	0		Tetrigidae	32	0
	Cucujidae	7	0		Tettigoniidae	8	2
	Silvanidae	5	12	Phasmatodea	Phasmatidae	1	0
	Lucanidae	3	0		Heteronemiidae	0	0

Coeloptera	Rhipiceridae	6	1	Trichoptera	Limnephilidae	631	61
Mantodea	Mantidae	0	2		Hydropsychidae	120	86
Neuroptera	Chrysopidae	0	1	Lepidoptera	Noctuidae	74	158
	Mantispidae	0	0		Crambidae	8	6
Diptera	Culicidae	25	113		Erebidae	8	26
	Calliphoridae	0	57		Tortridae	3	3
	Emplididae	0	1		Arctiidae	1	36
	Simuliidae	18	7		Hepialidae	12	0
	Tipulidae	10	48		Sphingidae	1	0
	Milichidae	8	2		Hesperidae	12	6
	Lauxaniidae	1	7		Alucitidae	1	0
	Chironomiidae	27	0		Pyralidae	1	0
	Tephritidae	29	0		Acanthopteroctetidae	0	0
	Drosophilidae	10	0		Uraniidae	1	2
	Brosophilidae	98	0		Hyblaeidae	0	0
	Muscidae	12	9		Limacodidae	12	1
Dermaptera	Spongiphoridae	1	1		Geomtridae	20	1
	Forficulidae	1	7				
	Labiidae	5	0				

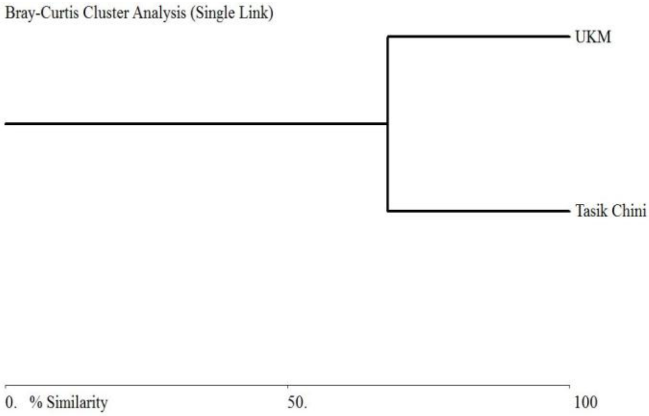

Figure 1 Overlap of insect Orders between agricultural and suburban landscapes

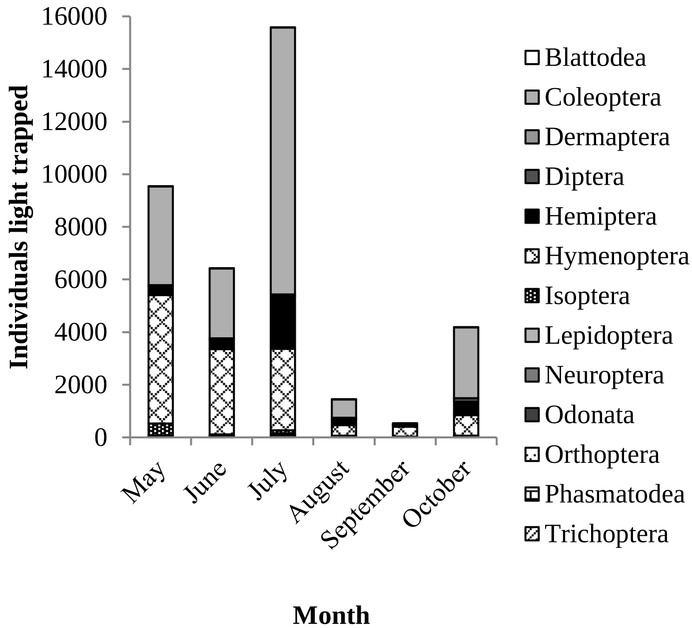

Figure 2 Abundance of insects trapped between May to October 2014 at the agricultural landscape.

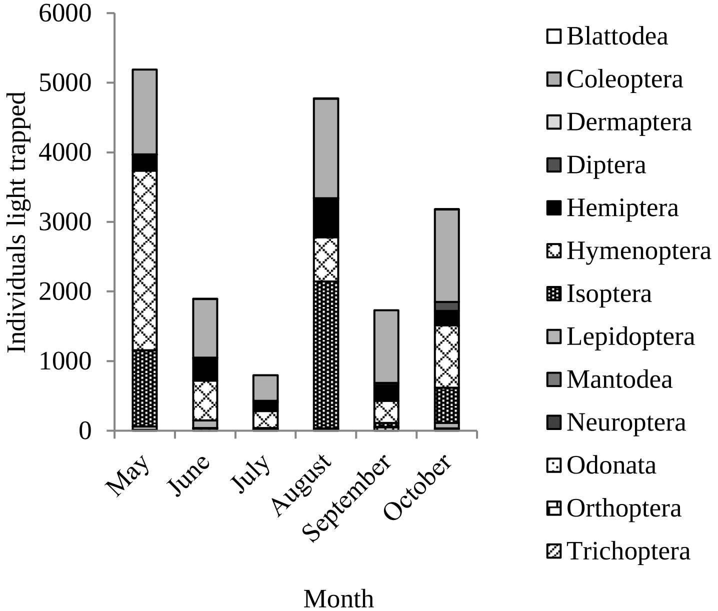

Figure 3 Abundance of insects trapped between May to October 2014 at the suburban landscape.