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INSECT DIVERSITY AND ABUNDANCE DURING THE CREPUSCULAR AND NOCTURNAL TEMPORAL PERIODS IN THE KOTA GELANGGI LIMESTONE COMPLEX, PAHANG, MALAYSIA

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ABSTRACT

The diversity and abundance patterns of nocturnal insect orders during the crepuscular and nocturnal periods, 6pm-9pm, 10pm-1am and 4am-7am at Kota Gelanggi limestone complexes were investigated. The insects were collected by using light traps over a period of six months from May to October 2014. A total of 35 732 individuals from 19 orders were captured. Coleoptera (n=14 103, 39.5%), Hymenoptera (n=10 030, 28.1%) and Diptera (n=4 821, 13.5%) were the most abundant orders. The results showed a bimodal pattern in the abundance of insects where more were caught during dusk followed by dawn and the lowest during the nocturnal period. However there was no significant difference ($F= 0.71$, $df= 2$, $P> 0.05$) in insect abundance between the three sessions. Studies on nocturnal insect activity patterns give us an understanding of the behaviour of the insects especially agricultural pest insects, and this information is necessary to develop effective pest control management.

Keywords: bimodal activity, nocturnal insects, crepuscular insects, karst landscape, activity patterns

ABSTRAK

Kepelbagaian dan kelimpahan order serangga pada waktu malam semasa tempoh crepuscular dan pada waktu malam, 18:00-21:00, 22:00-01:00 dan 04:00-07:00 di kompleks batu kapur Kota Gelanggi telah dikaji. Serangga telah dikumpulkan dengan menggunakan perangkap cahaya dalam tempoh enam bulan dari Mei hingga Oktober 2014. Sebanyak 35, 732 individu dari 19 order telah dikumpulkan. Coleoptera (n = 14 103, 39.5%), Hymenoptera (n = 10 030, 28.1%) dan Diptera (n = 4 821, 13.5%) adalah order yang paling banyak. Hasil kajian menunjukkan corak bimodal dalam kelimpahan serangga di mana lebih banyak ditangkap semasa senja diikuti oleh subuh dan yang paling rendah dalam tempoh waktu malam. Walau bagaimanapun tidak terdapat perbezaan yang signifikan ($F = 0.71$, $df = 2$, $P > 0.05$) dalam kelimpahan serangga antara ketiga-tiga sesi. Kajian ke atas corak aktiviti serangga pada waktu malam memberi kita pemahaman tentang kelakuan serangga serangga perosak terutamanya di bidang pertanian, dan maklumat ini adalah perlu untuk merancang pengurusan kawalan perosak yang berkesan.

Kata kunci: aktiviti bimodal, serangga malam, serangga crepuscular, landskap kars, corak aktiviti

INTRODUCTION

Activity patterns or rhythms of insects are influenced by extrinsic and intrinsic factors. Extrinsic factors consist of abiotic (e.g., temperature, illumination, wind) and biotic variables (competition, predation). Intrinsic factors are physiological traits and systematic affiliation (Gottlieb et al. 2005). According to Kjernsmo (2014), insects have evolved different kinds of anti-predator adaptations such as mimicry, camouflage, chemical defence, variation in activity patterns and acoustics to ward off predators. They have developed polymodal emergence patterns which enhance survivorship in facing annual changes in environmental conditions (Fournet et al. 2004). Most insects will continue to fly at night, but change their seasonal activity so that their activity will not coincide with predator activity (Barbosa & Castellanos 2005).

Nocturnal insects have a general pattern of activity just prior to sunset, reaching a peak close to midnight and having another bout of activity before sunrise (Kunz 1973, Rautenbach et al. 1988, Pavey et al. 2001). Crepuscular animals evolved these patterns of activity as anti-predator adaptations. Nocturnal insects might change their flight strategy by becoming diurnal or flying only in twilight before predators emerge to reduce their exposure to danger. Thus, insectivore predators tend to show crepuscular activity in relation to the bimodal activity of insects. Predators such as bats started to forage during dusk and sometimes in the morning of the twilight (Pavey et al. 2001).

In agricultural ecosystems, pest monitoring is important as pests affect global food production (Petrovskii et al. 2014). Coleopterans, homopterans, lepidopterans and dipterans contain members that are known to cause severe damage to crops (Fournet et al. 2004, Fauziah & Kamarulnizam 2008). Thus, an understanding of the patterns of activity of these insects is important when developing effective pest control strategies (Petrovskii et al. 2014).

Studies on insect abundance and diversity in Malaysia have focused on diurnal or nocturnal insects without a temporal division of the time (Fauziah Abdullah 2006, Fauziah & Kamarulnizam 2008, Khadijah et al. 2013). The objective of this study was to determine if there is a difference in insect diversity and abundance between the crepuscular and nocturnal periods at the Kota Gelanggi limestone complexes.

MATERIALS AND METHODS

Study site

This study was carried out in Kota Gelanggi, Pahang located about 25 km from Jerantut at coordinates N03°53.594’ and E 102°28.421’ (Figure 1). The Kota Gelanggi limestone complex is about 350 acres and is surrounded by oil palm plantations, rubber plantations, disturbed forest, riparian forest and scattered local settlements. The average mean temperature is 27.0°C and the average mean relative humidity is 83.6% throughout the year (Malaysian Meteorological Department 2015).

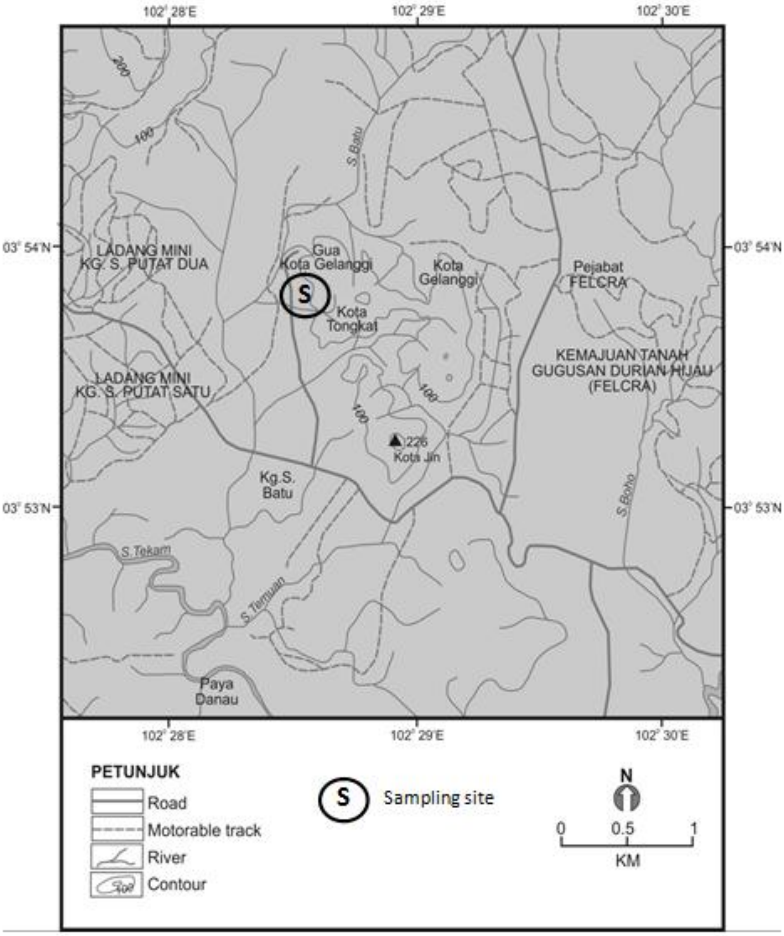

Figure 1 Map of Kota Gelanggi, Jerantut, Pahang

Sampling design

Insects were sampled for three nights in each month using light traps from May to October 2014. Nine sites were randomly selected around the Kota Gelanggi limestone complex. Each light trap was a combination of a white florescent and UV light designed to maximise the catch (Figure 2). The light traps were hung 5-8 m off the ground from a suitable tree branch. The collection was done over three time periods, namely, 6pm-9pm (S1), 10pm-1am (S2) and 4am-7am (S3), representing the nocturnal and crepuscular periods of activity of the insects. No sampling was done during the 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 was made by referring to Triplehorn and Johnson (2005), McGavin (2004) and comparison with insect collections deposited at the Centre for Insect Systematics (CIS) in UKM. Identification was made to the family level where possible.

Figure 2 Light trap with florescent and UV light for insect sampling

Data Analysis

One-way ANOVA was used to test the hypotheses that there would be differences in the abundance and diversity of insects between the three sampling sessions. The analysis was done with a significance level of 5% using Minitab 17.

RESULTS

The numbers of insects captured do not indicate the actual numbers within the entire community, but just represent an index of temporal distribution. A total of 35 732 individuals from 19 insect orders were collected, namely, Coleoptera, Hymenoptera, Diptera, Isoptera, Hemiptera, Orthoptera, Lepidoptera, Dermaptera, Odonata, Thysanoptera, Ephemeroptera, Trichoptera, Embioptera, Blattodae, Psocoptera, Megaloptera, Mantodae, Phasmatodae and Plecoptera (Table 1). The most abundant order was Coleoptera (14 103 individuals, 39.5%), followed by Hymenoptera (10 030, 28.1%) and Diptera (4 821, 13.5%).

Identification of the three most abundant orders was made to the family level. Twenty-one coleopteran families were identified, namely, Anobiidae, Attelabidae, Bostrichiidae, Brenthidae, Cantharidae, Carabidae, Chrysomelidae, Curculionidae, Dermestidae, Dycticidae, Elateridae, Entiminae, Hydrophilidae, Lycidae, Lymexlidae, Passalidae, Platypodidae, Scarabaeidae, Scotytidae, Cerambycidae and Staphylinidae followed by 6 hymenopteran families (Apidae, Braconidae, Chalcidoidae, Formicidae, Ichneumonidae and Vespidae) and five dipteran families (Muscidae, Chironomidae, Calliphoridae, Tipulidae and Culicidae).

Table 1 Insect diversity and abundance at Kota Gelanggi

Order	Abundance	
	Number	%
Blattodae	2	0.01
Coleoptera	14 103	39.47
Dermaptera	37	0.10
Diptera	4 821	13.49
Embioptera	7	0.02
Ephemeroptera	606	1.70
Hemiptera	2 193	6.14
Hymenoptera	10 030	28.07
Isoptera	673	1.88
Lepidoptera	1 888	5.28
Mantodae	10	0.03
Neuroptera	16	0.04
Odonata	10	0.03
Orthoptera	184	0.51
Phasmatodae	3	0.01
Plecoptera	1	0.0
Psocoptera	149	0.42
Thysanoptera	961	2.69
Trichoptera	38	0.11
TOTAL	**35 732**	**100**

The abundance of insects between the three different sessions, namely, 6pm-9pm (S1), 10pm-1am (S2) and 4am-7am (S3) was compared. The mean number of individuals showed a bimodal pattern (Figure 3). Coleoptera, Hemiptera, Orthoptera, Diptera, Lepidoptera, Dermaptera, Ephemeroptera, Trichoptera, Psocoptera and Neuroptera were found to be most abundant during S1 (Figure 4). Thysanoptera, Embioptera and

Phasmatodae were found in highest abundance during S2, while Hymenoptera, Isoptera, Odonata and Mantodae were found most abundant during S3. Blattaria was only found during S1 whereas, Plecoptera was only found during S2. Embioptera and Phasmatodae were found during S1 and S2 but not during S3. One-way ANOVA showed that there was no significant difference ($F= 0.71$, $df= 2$, $P> 0.05$) in insect orders between these three sessions.

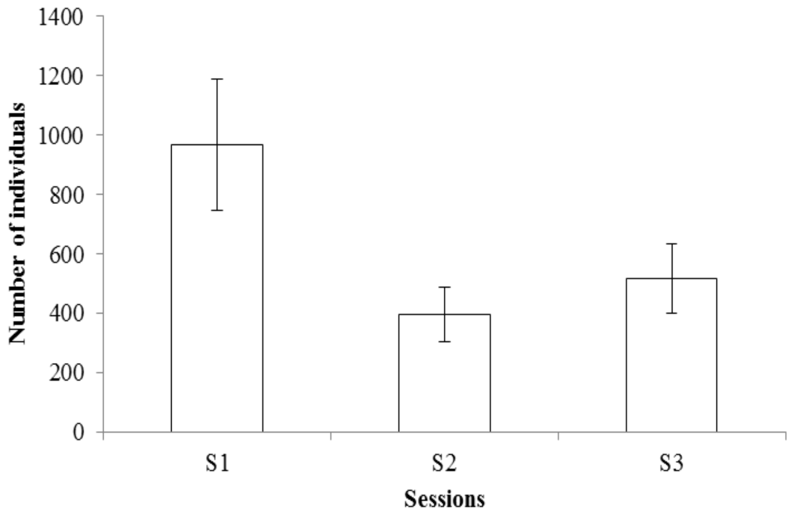

Figure 3 Mean number of individuals (±SE) in the three sampling sessions

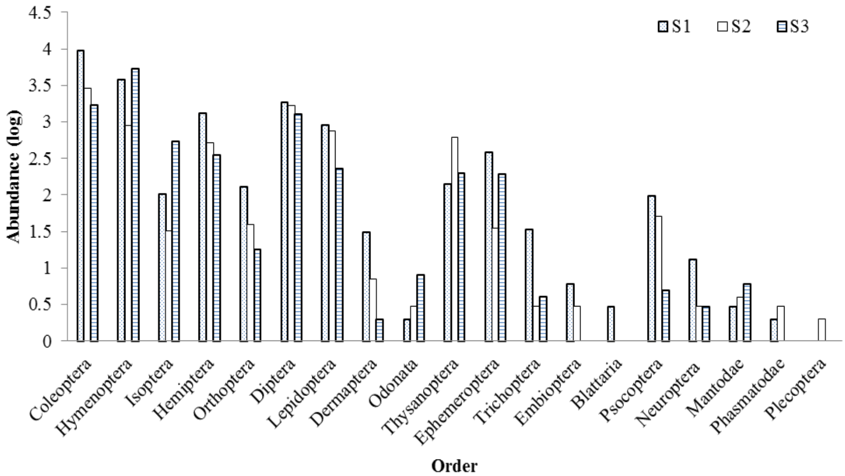

Figure 4 Insect order abundance (log+1) in the three trapping sessions

DISCUSSION

The insects in Kota Gelanggi showed a bimodal activity pattern. In a review of nocturnal insects, Kunz (1973) stated that nocturnal insects exhibit the general bimodal pattern of flight, where they are active before dusk until near midnight and than show a decline in activity which is then followed by a second period active activity before dawn. Nocturnal insects generally follow a bimodal pattern of activity in order to to avoid predation. An additional benefit of the bimodal pattern is to reduce competition between foragers (Gottlieb et al. 2005). Studies also showed that insect activities can also be influenced by environmental factors such as temperature, humidity, rainfall, wind and moonlight (Lewis & Taylor 1965, Nutting 1969, Chen & Seybold 2014).

Coleoptera was the most abundant nocturnal insect order (39.45%) collected in Kota Gelanggi. Chen & Seybold (2014) noted that the twig beetle exhibited diurnal flight followed by low activity in mid-morning but showed a high increase at dusk, where 76.4% were caught between 1800 and 2200 hrs. Besides, Kunz (1973) found that the flight activity of a number of beetles (Coleoptera) reach the highest level early after sunset. Our result also showed that Coleoptera were found to be more abundant during dusk.

Hymenoptera was the second most abundant order collected (28.1%) and were noted to be more abundant during dusk and dawn. Hymenoptera has broad temporal categories of foraging activity: matinal, diurnal, afternoon, crepuscular and nocturnal (Pittendrigh 1974). Some tropical bees and wasps have independently evolved a nocturnal lifestyle in response to the pressures of predation, parasitism and competition for limited resources (Hunt et al. 1995, Warrant 2008). According to Gottlieb et al. (2005), bees show bimodal daily activity pattern during foraging as it was correlated with nectar production during dawn and dusk. Nectar produced peak before dawn and thus showed highest foraging pattern (Gottlieb et al. 2005).

Dipterans were the third most abundant order and showed high abundance from dusk and decreased gradually towards dawn. Dipterans consist of flies, mosquitoes, midges and gnats but in this study mainly mosquitoes with a small number of flies were found. Mosquitoes are most active in twilight periods. Gary et al. (2011) found a distinct peak in flight activity in Culicidae two hours before and two hours after sunrise. Steven & Randy (2002) found that they rose quickly to a peak around 10 pm and decreased gradually towards sunrise. Flies (Muscidae) tend to be diurnal (Masmeatathip et al. 2006) although some were found in our collection.

Isoptera (winged termites) also a swarming insect showed a nocturnal bimodal pattern of abundance, where they were found more abundance during dusk and dawn and highest during dusk. Pavey et al. (2001) also mentioned that most bat feeding termite as they emerged in large number at dusk. Lepidoptera showed increasing abundance after sunset until midnight and declined towards dawn. Moths have been found to be most active around midnight (Pavey et al. 2001). Odonata (Libellulidae) and Mantodae were caught in low numbers around dawn. This is because odonates and mantids are considered predominantly diurnal insects whereby only few species are active during morning and evening twilight (Corbet 1999).

Sabu et al. (2011) investigated that different sampling methods will show the effectiveness of quantitative and qualitative data collection towards different insects. Light traps have been used widely to study insects abundance and diversity, and best represent collection of aerial insects that attracted to light but not for Blattodae (cockcroaches) as they avoiding light and less caught in light trap. Uses of ultraviolet (UV) light can catch significantly more spesies richness and abundance than cool white light traps (Heidinger 1971, García-López et al. 2011). Thus, light trap with a combination of UV and white florescent light was used to enhance the efficiency of catches. Light wavelengths and hours of sampling will influenced insect catches. Scarab beetles and moths are more attracted to UV light (García-López et al. 2011, Epsky et al. 2008) whereas incandescent lights attract flies and mosquitoes (Epsky et al. 2008).

CONCLUSION

In our study, most insects showed a bimodal activity pattern with peaks during the crepuscular periods (dawn or dusk) and minimal activity around midnight. They may develop polymodal emergence patterns as anti-predator adaptations and due to differences in environmental conditions. Crepuscular habit helps to reduce predation pressure as many predators forage at night. However, some insect predators exhibit crespuscular behaviour in order to get highest benefit when foraging for insects as most insects are active during this period. In addition, an understanding of insect pest activity patterns will facilitate more effective pest control measures.

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