Assemblage Patterns of Hymenoptera at Different Elevations of Gunung Datuk, Rembau

Noor Nasuha Abd Aziz[1], Siti Khairiyah Mohd Hatta[2], Idris Abd Ghani[1] and Saiyid Jalaluddin Saiyid Shaifuddin[2]

[1]Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia.
[2]Faculty of Applied Science, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia.
E-mail: sitikhairiyah@salam.uitm.edu.my

Received: 7 February 2017
Accepted: 9 October 2017

ABSTRACT

A study on abundance and diversity of Hymenoptera was conducted in Gunung Datuk, Rembau. Samplings were conducted from November 2014 to February 2015 using six Malaise traps. Three traps were placed at Site 1 at 700m height for high elevation and the remaining traps were placed at Site 2 at 200m height for low elevation. A total number of 221 Hymenopteran were collected which consist of nine families namely Ichneumonidae, Formicidae, Braconidae, Bethylidae, Evaniidae, Tiphiidae, Vespidae, Pompilidae and Apidae. In this study, 93 individuals were obtained from Site 1, comprising nine families and 43 morphospecies while 127 individuals were obtained from Site 2 with nine families and 45 morphospecies. Formicidae was the most dominant family collected from both sites with a total of 104 individuals while the least family recorded was Apidae with only one individual. Shannon's Weiner Diversity Index (H') showed Site 1 had the higher diversity value with H' = 3.17 compared to Site 2 with value H' = 3.12. For Evenness Index, Site 1 had higher value compared to Site 2 with E' = 0.84 and E' = 0.82 respectively. Moreover, for Margalef Richness Index, Site 1 recorded R' = 9.24 while site two recorded R' = 9.08 which concluded that Site 1 had higher species richness compared to Site 2. Paired t-test showed that both sites had no significant difference with $p>0.05$. Overall study showed that the diversity and abundance of Hymenoptera in Gunung Datuk were low since the value of H' is less than 3.50.

Keywords: *diversity, abundance, hymenoptera, elevations, Gunung Datuk*

INTRODUCTION

Insects are the most abundant animals in earth. Insects can be found in almost anywhere, on plants, around buildings and under objects like rocks and logs. Aquatic insects can be found in ponds, lakes, streams, rivers, and bogs [1]. Among 1,250,000 species of animals, insects dominated about 1000000 of them [2]. Insects that are belong to the *Phylum Arthropoda*, *Subphylum Hexapoda* and *Class Insecta* are the most highly developed class of invertebrate animals. Insects can be determined by having three main body parts of which are head, thorax and abdomen, three pairs of jointed legs and one pair of antennae. Based on Wheeler *et al.* [3] class Insecta are commonly divided into 31 orders.

Insects that are categorised under the Order of *Hymenoptera* are ants, bees, wasps and sawflies. There are around 115,000 described species of *Hymenoptera* [4]. Based on the total described species *Hymenoptera* was placed behind Coleoptera and Lepidoptera which include in the five megadiverse insect order, however some hymenopterist argued that *Hymenoptera* would be morerich in species compared to other orders if the undescribed species were included [5]. *Hymenoptera* is divided into two main suborders known as *Symphyta* or sawflies, and also *Apocrita* or wasp-waisted *Hymenoptera* [6]. *Hymenoptera* is considered as an interesting group because of their biology as they can exhibit a great diversity of habits and complexity of behaviour culminating in the social organisation of the wasps, bees and ants [7].

The identifying characters of *Hymenoptera* are if there are presence of wings, the wings are membranous, chewing mouthpart and except for sawflies, base of abdomen constricted, may be distinctly threadlike. Mouthpart is the most useful features of *Hymenoptera*. The mouthparts are basically mandibulate, but in many species there is a tongue for lapping nectar from flowers [8]. According to Myers [9], the deforestation seem to be increased annually and could double in another decade. Thus this study is important to create awareness regarding the distribution of *Hymenoptera* and also as a preservation of diversity which provides insurance for future generations of human being.

METHOD

The research has been carried out at Gunung Datuk in Rembau, Negeri Sembilan from November 2014 to February 2015. In this study, six Malaise traps have been used to be set up at different elevations as shown in Figure 1. Three of the traps were placed at high elevation (700 m) while the other three were placed at low elevation (200 m). The traps have been left unattended for three months but the collecting bottles were replaced by the new one each month. Alcohol 70 % has been used to preserve the specimens. After that, the insects were sorted, pinned, labelled and identified according to their order.

Pins were required in handling insects to prevent defects. These pins are different from an average pins in which they are longer, stronger and thinner. They come in several sizes as different insects required different size of pins because sometimes inappropriate mounting can destroy the features required for the identification of insects. Furthermore, different insects also required different pin placement. In *Hymenoptera*, the pin should be passed the bases of the forewing, just to right of the middle. Next, the *Hymenoptera* were preserved for one week. Then, the specimens were left under sunlight several days for drying purpose.

After sorting the insects according to their order, the *Hymenoptera* were identified up to the family level. For further identification process, stereo microscope was used to recognise the important features of the *Hymenoptera*. Lastly after the recognition, these specimens were identified until their family level at the Centre of Insects Systematic, Faculty of Science and Technology, Universiti Kebangsaan Malaysia (UKM), Bangi Malaysia. The data obtained were analysed by using Shannon-Weiner Species Diversity Index and Margalef Richness Index. The Shannon-Weiner Species Diversity Index was calculated by taking the number of each species. In this study, the Shannon's Weiner diversity index formula was used to determine the diversity index (H), and from the diversity index obtained, Shannon's equitability was calculated for determination of evenness (E) among families. While Margalef Richness Index was used to measure the species richness (R). All of the analysis was done by using Bio-Dap software.

Figure 1: Malaise Trap (source by author)

RESULTS AND DISCUSSION

From this study, a total of 221 specimens of *Hymenoptera* have been collected at Gunung Datuk, Rembau at two different elevations. Based on the result, nine out of 90 families under order *Hymenoptera* have been identified. The recognised families are *Ichneumonidae, Formicidae, Evaniidae, Bethylidae, Braconidae, Tiphiidae, Apidae Pompiliidae* and *Vespidae* (Table 1).

Table 1: Number of *Hymenoptera* sampled from Gunung Datuk

Families	Morphospecies	Sites		Total	Percentage (%)
		1 (high)	2 (low)		
Ichneumonidae	24	22 (15)	18 (14)	40	18
Braconidae	10	7 (5)	20 (10)	27	12
Tiphiidae	4	7 (3)	3 (1)	10	5
Evaniidae	1	2 (1)	1 (1)	3	1
Formicidae	15	45 (11)	59 (12)	104	47
Vespidae	2	3 (1)	2 (2)	5	2
Apidae	1	1 (1)	0	1	1
Pompilidae	3	5 (3)	9 (3)	14	6
Bethylidae	4	2 (2)	15 (4)	17	8
Total individual		94	127	221	
Total family	9	9	9		
Total *morphospecies*	63	43	45		

Note: The numbers in the brackets represent the number of *morphospecies* identified

From the results obtained, the dominant families recorded were family *Formicidae* with 47% from the total of specimens collected at Gunung Datuk. Among the members of this family, 15 morphospecies have been found with 104 number of individuals. These results are supported by the statement of Werner and Wiezik [10] which claimed that, 10% or more total animal biomass in rainforest, grassland and other habitat is equal to this family member found in tropics. Nearly all ants are enthusiastically social insects or eusocial in which they normally live in structures nest communities that may be found in ground-level, underground or in trees. According to Delsinne *et al.* [11], in order to facilitate coexistence among species, there are three most important niche axes which includes space, food type as well as time may need to be partitioned.These factors also influenced the abundance and richness of ant species at Gunung Datuk.

Family *Ichneumonidae* recorded 18% from the total individual obtained. There are 24 morphospecies found with 40 individuals. This result indicates that family *Ichneumonidae* had high distribution on both elevations. This result is supported by Riedel and Hansen [12] which stated that the family *Ichneumonidae* is considered as a very species-rich family among parasitoid *Hymenoptera*. Based on previous study done by Fraser *et al.* [13], the best indicators of a high parasitoid abundance, richness and diversity for three or shrub species richness and broadleaf content are coming from *Ichneumonidae* family members. This is because this family depends on flowering vegetative. However, this result is slightly different from study done by Idris and Hainidah [14] which claimed that the role and population abundance of *Ichneumonid* could be influenced by environment, habitat character, the size of fragmented forest and the distance between fragmented forests with original forest.

Meanwhile, family *Braconidae* recorded 12% from overall specimens collected with ten morphospecies and 27 number of individuals. This result is supported by the previous study done by Pérez-Rodríguez *et al.* [15] which claimed that Family *Braconidae* is the second largest family within the parasitic *Hymenoptera* which can be found in several different habitats all over the world. Furthermore, according to Hanson and Gauld [16], *Braconidae* includes more than 15 000 species, but species richness is estimated in 100 000. The abundance and distribution of *Braconidae* can be influenced by the weather. Since the sampling was conducted during raining season, the number of individuals collected were low as raining can cause direct death of the eggs and larvae of insects. *Braconidae* wasps attack a wide range of host species included *Coleoptera, Diptera* and *Lepidoptera* [17].

Family *Bethylidae* recorded 8% from the total specimens, four morphospecies and 17 numbers of individuals. According to Daniele *et al.* [18], *Bethylidae* comprises about 100 genera with 2400 described species that are distributed widely throughout the world, however the majority of species occur in tropical regions. The distribution of this family is influenced by the food sources available at Gunung Datuk. Larvae of *Lepidoptera* and *Coleoptera* were often been parasitised by these wasp, however, there are several species of them attack moths or beetles that infest grain or flour and a few species that sting people [7].

On the other hand, family *Pompilidae* recorded 6% from the total specimens obtained. There were only three morphospecies recorded in both sites, while the total numbers of individuals obtained were 14 individuals. *Pompilidae* inhabit a variety of habitats and they live in relatively open situations such as forest clearings and trails [19]. The low numbers of individuals recorded for this family because of the traps were set up at dense forest instead of open area to avoid human interference. This family members are also known as spider wasps as their prey almost exclusively on spiders. *Nectivorous* females from this family selectively hunt food sources for their carnivorous larvae such as spiders [20].

Moreover, family *Tiphiidae* recorded 5% from the total specimens with two morphospecies and seven individuals. *Tiphiinae* is the largest subfamily and its members are fairly common and widely distributed [7]. Tiphiidae are parasitoids of wood-boring beetle larvae in which the females stings the larvae and laying an egg on it. The result obtained is influenced by the lower number of Coleoptera at the sampling site. So far as known, all *Tiphiidae* members parasitise Coleopterous [21].

Family *Vespidae* recorded 2% from the total specimens collected with two morphospecies and five individuals. This result is not parallel to the statement from the previous study done by Richter [22] which stated that they are surprisingly abundant in both temperate and tropical forest in order to find their food resources. *Vespidae* or also known as social wasps use masticated arthropod prey and other animal protein to progressively provision their developing brood [22]. Prey items most commonly include a variety of arthropods.

The least percentage family that has been recorded were family *Evaniidae* and *Apidae* with only 1% recorded from the total specimens collected (Table 1). Both of them had only one morphospecies with two and one number of individuals respectively. According to Madl and Ganeshan [23], the small family *Evaniidae* contains about 440 described species worldwide. This shows that this family represents only a small number of species compare to other families. Food sources also play an important role in determining habitat selection. The lower number of individuals of this family is because of the low number of cockroaches present in both sites. On the other hand, the world fauna of *Apiformes* has at least 20,000 species

[24]. This statement is contradictory to the result obtained from this study which recorded only one individual. One of the factors that contribute to this result is low flowering intensity that act as food sources. The changes of resource availability because of human disturbance of tropical rainforest may change the pollinator communities [25]. According to McGavin [2], *Hymenopteran* must be closed to the sources and nesting sites because they unable to fly farther distance to reach for food. Other factors also may affect the abundance of this family member such as temperature and season.

The Abundance of *Hymenoptera* at Different Elevations

Both sites showed the different number of distribution frequency of specimens. The total specimens collected from Site 1 were 94 individuals while 124 individuals collected from Site 2. However, both sites recorded nine families with 43 morphospecies collected from Site 1 and 45 morphospecies collected from Site 2.

The patterns of distribution of individual *Hymenoptera* collected from Site 1 and Site 2 showed no significant difference ($p>0.05$). This result is supported by previous study done by Siti Khairiyah *et al.* [26] which claimed that elevation and latitudinal gradient does not affect the patterns of abundant of insects.

Despite the fact that there is no significant different between Site 1 and Site 2, still the total number of specimens collected from Site 1 was lower compared to specimens collected from Site 2. The number of individuals from family *Ichneumonidae, Tiphiidae, Evaniidae, Apidae* and *Vespidae* were higher at Site 1 and the number of individuals for the remaining families which are *Formicidae, Bethylidae, Braconidae* and *Pompilidae* were higher at site two. Environmental and biological variability might influence the vertical distribution of insects in the forest and, as improved methods for accessing the canopy are mad available, it is becoming increasingly clear that arthropods are sensitive to these vertical gradients [27].

There are several factors that led to the slight difference between both sites. For example at high elevation, oxygen is insufficient for some insects as insects have an active lifestyle. Other than that, food sources available at high elevation are limited compared to at low elevation which is more vegetative as most of *Hymenopteran* are herbivorous. Furthermore, among the most important environmental stress factors of insects are extreme high and low temperature [28] so that, the low level of temperature and high in humidity at low elevation are more favourable for insects.

Diversity, Evenness and Richness of *Hymenoptera*

Understanding the relationship between species diversity and ecosystem function such as productivity of a system or the stability of production is important to maintain essential ecological processes if the impacts of biodiversity loss are to be predicted and management of ecosystems to be altered [29]. If the species diversity is higher, then the study area has a complex environment [30]. Measuring species richness is an essential for many community ecologists and conservation biologists. The intuitive and natural index of community structure are determined by the number of species in a local assemblage and both small and large spatial scales are measured to find out the patterns of species richness [31]. The higher species richness indicates the higher number of species types.

Based on Table 2, the species evenness for Site 1 is higher than site two in which E' value for site one is 0.84 while Site 2 is 0.82. This result indicates that the species in a given habitat was not completely uniform because the E' value is not approach 1.00. Margalef Richness value shows that Site 1 has higher number of species compared to Site 2 in which site one recorded R'= 9.24 and site 2 recorded R'=9.08. These two parameters, which are evenness index and species richness influenced the diversity index or the H' value.

Table 2: Diversity Indexes Analysis in Gunung Datuk

Elevations	H'	E'	R'
Site 1	3.17	0.84	9.24
Site 2	3.12	0.82	9.08

Thus, Site 1 has recorded higher value of H' with 3.17 compared to Site 2 which recorded only 3.12. This result indicates that Site 1 has more diverse communities against Site 2. However, according to Manuel [30], the value of H' value that fall below 3.5 can be considered as low species diversity. The lower diversity in the study site was influenced by the condition during the study was conducted. This study was conducted during raining season which is from November to February. This condition causes the direct death to the larvae and eggs. Other than that, it also affected by several factors such as environment, food resources and food preference and human activities as well as animals. The malaise traps were set up for three months at Gunung Datuk and the collecting bottles were replaced for each month. During this period of time, some of the traps were damaged because of animals and human interference. Furthermore, this sampling process was conducted during raining season so that some of the traps were damaged and during this season *Hymenopteran* were seeking for shelters which cause their activities were reduced during raining season. Other than that, Gunung Datuk is famous among hikers and this activity would disrupt *Hymenopteran's* habitats and limited their activities.

This data also has been analysed by using paired *t*-test in order to compare the significant differences of individuals between Site 1 and Site 2. The calculated result shows that there was no significant difference between Site 1 and Site 2 as the value of $p = 0.285$ which is higher than 0.05. This result indicated that there was no significant value in the species diversity and distribution for both sites.

CONCLUSION

As a conclusion, the study conducted at Gunung Datuk recorded 221 specimens of insects under order Hymenoptera in which 94 specimens were found from Site 1 and the remaining 127 specimens were found from Site 2. There were nine families and 63 morphospecies have been identified. Among these families, family *Formicidae* was the most dominant as the number of individuals were highest for both sites. The overall results showed that the values of Shannon- Weiner Diversity Index Gunung Datuk were low. This result can be used as a preliminary reference for future study because there is no research regarding family *Hymenoptera* at Gunung Datuk yet. Moreover, the result also can be used to manage and conserve the species *Hymenoptera* since *Hymenoptera* plays many important role in nature and has high economic value.

ACKNOWLEDGEMENT

The authors would like to take this opportunity to express their profound and regards to all research members in Universiti Teknologi MARA (UiTM) and staff of Centre for INsect Systematic Universiti Kebangsaan Malaysia (UKM) for their assistance and guidance. This work was financially supported by Research Acculturations Collaborative Effort RACE Universiti Teknologi MARA 16/6/2(19/2013).

REFERENCES

[1] M. Walid Fathy, and H.S. El Sayed, 2010. A checklist of some recorded Insects in Misurata, Libya. *Journal of King Saud University - Science, 22*(2), 61-65. DOI: http://doi.org/10.106/j.jksus.2010.02.001.

[2] G.C. McGavin, 2007. *Expedition Field Techniques Insects and Other Terrestrial Arthropods*. Royal Geography Society, London. pp. 1-94.

[3] W.C.Wheeler, M. Whitting, Q.D. Wheeler, and J.M. Carpenter, 2001. The Phylogeny of the Extant Hexapod Orders. *Cladistics*, *17*(2), pp.

113-169. DOI: 10.1111./j.1096-0031.2001.tb00115.x.

[4] M.J. Sharkey, 2007. Phylogeny and Classification of Hymenoptera. *Zootaxa*, *Special Issue* 42, pp. 521-548.

[5] E.E. Grissell, 1999. Hymenopteran diversity: Some Alien Notions. *American Entomologist*, *45*(4), pp. 235–244. DOI: 10.1093/ae/45.4.235.

[6] W.R.M. Mason, and J.T. Huber, 1993. Order Hymenoptera. In Henri Goulet & John Theodore Huber: Hymenotera of the World: An Identification Guide to Families, Ottawa: Agriculture Canada Publication, pp. 4-12.

[7] C.A. Triplehorn, and N.F. Johnson, 2005. Borror and Delong's *Introduction to the Study of Insects*. (7th Ed). Peter Marshall, United States. pp. 1-468.

[8] Jr. Arnett, and H. Ross, 2000. *American Insects*. (2nd Ed). CRC Press LLC, United States. pp. 531-548.

[9] Myers, N. (1992). *The Primary Source: Tropical Forests and Our Future*. Norton, New York, pp. 91.

[10] P. Werner, and M. Wiezik, 2007. Vespoidea: Formicidae (mravencovití). *Acta Entomologica Musei Nationalis Pragae*, *11*, 133-164.

[11] T. Delsinne, Y. Roisin, and M. Leponce, 2007. Spatial and Temporal Foraging Overlaps in a Chacoan Ground-Foraging Ant Assemblage. *Journal of Arid Environments, 71*(1), 29-44.

[12] M. Riedel, and L.O. Hansen, 2012. Ichneumonidae (Hymenoptera) New for the Fauna of Norway, Part 5. *Norwegian Journal of Entomology, 59*, 219–228.

[13] S.E.M. Fraser, C. Dytham, and P.J. Mayhew, 2007. Determinants of Parasitoid Abundance and Diversity in Woodland Habitats. *Journal*

of Applied Ecology, 44(2), pp. 352-361. DOI: 10.1111/j.1365-2664.2006.01266.x.

[14] A.B. Idris, and J Hainidah, 2003. Diversity of ichneumonids wasps in the logged over forest of Langat Basin in Selangor, Malaysia. O*nline Journal of Biological Sciences, 3*(2), pp. 259-270.

[15] J. Pérez-Rodríguez, T. Oltra-Moscardó, F. Peris-Felipo, and R. Jiménez-Peydró, 2013. Microgastrinae (Hymenoptera: Braconidae) in the Forest State of Artikutza (Navarra: Spain): Diversity and Community Structure. *Insects, 4*(3), pp. 493-505. DOI: 10.3390/insects4030493.

[16] P.E. Hanson, and I.D. Gauld, 2006. Hymenoptera De La Región Neotropical. M*emoirs of the American Entomological Institute, 77*, pp. 468-472.

[17] B. Ahmet, and A. Mitat, 2013. Additions to the Rare Species of Braconidae Fauna (hymenoptera: braconidae) from Turkey. *Mun. Ent. Zool, 8*(1), pp. 369-374.

[18] F. Daniele, Mugrabi, and C.O. Azevedo, 2010. Insecta, Hymenoptera, Bethylidae: Range Extension and Filling Gaps in Madagascar. *Journal of Species Lists and Distribution, 6*(1), pp. 62-63. DOI: 10.15560/6.1.062.

[19] M.S. Wasbauer, and L.S. Kimsey, 1985. *California Spider Wasps of the Subfamily Pompilinae (Hymenoptera: Pompilidae)*. University Of California Press: London, England, 26, pp. 1-135.

[20] J.O. Schmidt, 2004. Venom and the Good Life in Tarantula Hawks (Hymenoptera: Pompilidae): How to Eat, Not be Eaten, and Live Long. *Journal of Kansas Entomol. Society, 77*(4), pp. 402–413. DOI: 10.2317/E-39.1.

[21] K.V. Krombien, 1982. Biosystematic Studies of Ceylonese Wasps, IX: *A Monograph of the Tiphiidae Hymenoptera: Vespoidea*. Washington: Smithsonian Institution Press, pp 2-8.

[22] M.R. Richter, 2000. Socialwasp (Hymenoptera:Vespidae) Foraging Behavior. *Annu. Rev. Entomol., 45*, 121–150. DOI: 10.1146/annurev.ento.45.1.121.

[23] M. Madl, and S. Ganeshan, 2008. Notes on the Evaniida (Hymenoptera) of the Mascarenes. *Linzer Biol. Beitr., 40*(1), pp. 827-831.

[24] C.D. Michener, 1993. Siries Apiformes. Hymenotera of the World: In *An Identification Guide to Families.* Goulet, H., and Huber, J.T. (Eds.). Canada Communication Group, Canada. pp. 279-307.

[25] H. Samejima, M. Marzuki, T. Nagamitsu, and T. Nakasizuka, 2004. The Effects of Human Disturbance on a Stingless Bee Community in a Tropical Rainforest. *Biological Conservation, 120*(4), pp. 577-587. DOI:10.1016/j.biocon.2004.03.030.

[26] M.H. Siti Khairiyah, S. Usman, Y. Suzita, L. Florinsiah, and N. Shahirah, 2013. The Effect of Elevations on Diversity and Abundance of Class Insecta at Taman Negara Gunung Ledang, Johor. *IEE Business Engineering and Industrial Application Colloquium* (BEIAC), pp. 248-252.

[27] Y. Basset, P.M. Hammond, H. Barrios, J.D. Holloway, and S.D. Miller, 2003. Vertical Stratification of Arthropod Assemblages. In Y. Basset, V. Novotny, S. E. Miller, R. I. Kitch (eds.). Arthropods of Tropical Forests Cambridge University Press, Cambridge, MA. pp. 17-27.

[28] O.A. Bubliy, T.N. Kristensen, V. Kellermann, and V. Loeschcke, 2012. Humidity Affects Genetic Architecture of Heat Resistance in *Drosophila Melanogaster. J Evol Biol, 25*(6), pp. 1180-1188. DOI: 10.1111/j.1420-9101.2012.02506.x.

[29] K.S.H. Peh, 2009. The Relationship between Species Diversity and Ecosystem Function in Low and High-diversity Tropical African Forests. PhD's Thesis, The University of Leeds School of Geography.

[30] C.M. Jr. Manuel, 2008. Species abundance and Diversity. In Ecology Concepts and Applications (4th ed.). McGraw-Hill, New York. pp. 371-375.

[31] N.J. Gotelli, and R.K. Colwell, 2001. Estimating Species Richness. *Ecology Letters, 4*(4), pp. 379–391. DOI: 10.1046/j.1461-0248.2001.00230.x.