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Fauna of chrysomelid beetles (Coleoptera: Chrysomelidae) along an elevational gradient at Mount Fraser, Pahang, Malaysia

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Abstract

A study was conducted on the diversity and abundance of leaf beetles (Coleoptera: Chrysomelidae) along an elevational range from 400 m to 1,200 m in Mount Fraser, Pahang, Malaysia. Sampling was done during December 2014 until March 2015. In total, 714 individuals were successfully collected representing nine subfamilies and 85 species (25 identifiable + 60 morphospecies). Collections took place over three elevational ranges: low (400–500 m), middle (750–850 m) and peak (1,000–1,250 m). The highest abundance of Chrysomelidae was recorded in the low range, with 257 individuals from eight subfamilies collected; the middle range had the lowest abundance with only 217 individuals from seven subfamilies. An accumulation curve showed that the altitude range 400−500 m had probably reached its asymptote. The Galerucinae comprised the highest abundance of individuals sampled (354) whereas the Criocerinae has the lowest abundance with only seven individuals recorded. The Shannon Weiner diversity index and Simpson's diversity index were highest in the low altitude range (3.504 and 0.9527, respectively) and lowest at the peak (2.762 and 0.8552, respectively). Diversity of chrysomelids was significantly different ($p < 0.05$) for each elevational range. Species overlap was highest (98%) between the middle and peak ranges. The Galerucinae was the most abundant subfamily with 37 species (20 identifiable + 17 morphospecies) within 13 genera. The genus *Monolepta* had the highest abundance with 81 individuals comprising 17 species (10 identifiable + 7 morphospecies).

Introduction

The Chrysomelidae is among the largest beetle families in the world (Jolivet et al., 1988), and understandably, within Malaysia (Mohamedsaid, 2004). Chrysomelid beetles, also known as leaf beetles, have approximately 37,000 identified species and the number is likely to reach up to 50,000 species. There are 19 subfamilies recognized within the family (Jolivet et al., 1988). The study conducted by Mohamedsaid (2004) stated that only 13 out of 19 subfamilies were recorded in Malaysia of which the Galerucinae was the largest subfamily of Chrysomelidae. Many chrysomelid beetles are very colorful (Seeno and Wilcox 1982; Jolivet et al., 1988), and can be distinguished from other beetles by, among other things, the structure of tarsi (pseudotetramerous, with five true tarsomeres, but appearing to have four) and 11 segmented antennae. Leaf beetles are phytophagous and have a size range of approximately 1–27 mm (Jolivet et al, 1988).

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Many chrysomelid beetles are serious pests of agricultural crops and forests, mainly in the subfamilies of the Galerucinae, Criocerinae, Alticinae, Eumolpinae and Chrysomelinae; these pest species, such as the Colorado potato beetle *Leptinotarsa decemlineata* Say 1824, the cereal beetle *Oulema melanopus* Linnaeus 1758, and the corn rootworm *Diabrotica virgifera* Conte 1868 are highly adaptable and cause severe damage to crops (Annecke and Moran, 1982; Silfverberg, 1989). As Maulik (1945) pointed out, few cultivated or useful plants are not fed on by chrysomelids. On the other hand, due to the high degree of host specificity, some chrysomelid beetles have been advantageously used for biological control of imported toxic weeds and shrubs such as *Diorhabda elongata* Brullé (Galerucinae) which was used to control *Tamarix* spp. (Caryophyllales: Tamaricaceae) (Milbrath and Deloach, 2006).

There is no previous specific study recorded of chrysomelid beetles at Mount Fraser, Pahang, Malaysia. The latest study recorded only focused on the taxonomy with description of two new species of *Medythia* (Mohamedsaid 1999). The present study was conducted to compare the diversity of chrysomelid beetles at different altitudes and to prepare an inventory of chrysomelid beetles at Mount Fraser, Pahang.

Materials and Methods

Chrysomelidae were collected at Mount Fraser, Pahang (N3.71222 E101.72793) during December 2014 through March 2015. Sampling was done once every month at all elevations. The exact dates were 19–22 December 2014, 16–19 January 2015, 15–18 February 2015 and 12–15 March 2015. Collections took place over three elevational ranges: low (400–500 m), middle (750–850 m) and peak (1,000–1,250 m). Active and passive sampling methods were used. Active sampling was conducted using sweep nets during the daylight from 0900 hours until 1500 hours over three consecutive days. Specimens collected within each range were kept separate. Passive sampling was conducted using a light trap which was set up at night at locations within the three elevational ranges. Ultraviolet light was used because it is more attractive to insects. A white sheet was used as a backdrop for the light so that the insects could easily spotted as they were attracted to the light and were collected by hand. Specimens were preserved in 70% ethanol in the field, pinned and labelled, and dried in the oven at 40°C for a few days. All specimens were identified using a stereo microscope and compared to identified specimens within the collection at the Centre for Insect Systematics (CIS), Universiti Kebangsaan Malaysia (UKM). However, not all species could be assigned a species name; these unidentifiable species were assigned a morphospecies designation, for example Genus sp1. All specimens were deposited at the CIS, UKM.

Analyses were performed using PCORD 6 (2001; MjM Software; Gleneden Beach OR, USA) and the PAST software for analysis of the Shannon diversity index (H'), evenness index (E') and Simpson's diversity index (D'). All identified species were recorded. A species inventory of chrysomelid beetles at Mount Fraser, Pahang is presented here.

Results and Discussion

In total, 714 individuals of the Chrysomelidae were collected, consisting of 25 identifiable species and 60 morphospecies within nine subfamilies (Table 3). The nine subfamilies were the Galerucinae, Chrysomelinae, Eumolpinae, Hispinae, Alticinae, Crytocephalinae, Donaciinae, Cassidinae and Criocerinae (Table 1). In this study, the subfamily Galerucinae was represented by the largest number of individuals (354), and the Criocerinae was represented by the least (7).

Absolute abundance was the highest in the low altitude range (257 specimens), followed by the peak (240 specimens) and middle ranges (217 specimens). Difference in abundance was mainly driven by the large numbers of specimens belonging to two species: *Chiridopsis punctata* Weber 1801 (Cassidinae) with 35 specimens in the low range, and *Mimastra sumatrensis* Jacoby 1884 (Galerucinae) with 81 specimens in the peak range. *Chiridopsis punctata* was observed to be abundant in the low range due to the presence of *Ipomoea* sp. (Convolvulaceae), locally called "Pokok Seri Pagi". Although these plants were likely to be their host plant, further study on the host-plant interaction is crucial for verification. *Mimastra sumatrensis* Jacoby 1884 (Galerucinae) appeared to have the highest number of individuals (156) and was also found with increasing elevation. The relatively high number of specimens collected in the low range was mainly due to the abundance of the subfamilies Galerucinae and Chrysomelinae which contain many polyphagous species (Jolivet et al, 1988).

Table 1 Number of individuals and morphospecies of Chrysomelidae subfamilies collected at different elevations: L1 (400–500 m), L2 (750–850 m), L3 (1,000–1,250 m)

Subfamily	Morpho species	Number of individuals per altitude (morphospecies)						
		L1		L2		L3		Total
Galerucinae	47	114	(27)	113	(27)	127	(25)	354
Chrysomelinae	11	50	(9)	30	(6)	18	(4)	98
Eumolpinae	7	27	(6)	13	(3)	15	(4)	55
Hispinae	5	6	(4)	26	(2)	19	(2)	51
Alticinae	6	0	(0)	4	(2)	46	(6)	50
Crytocephaline	3	2	(2)	13	(2)	3	(1)	18
Donaciinae	2	10	(1)	18	(2)	10	(1)	38
Cassidinae	3	43	(3)	0	(0)	0	(0)	43
Criocerinae	1	5	(1)	0	(0)	2	(1)	7
Total individuals	-	257		217		240		714
Total subfamilies	9	8		7		8		-
Total morphospecies	85	53		44		44		-

The species accumulation curve (Fig. 1) shows that the middle and peak ranges had a similar number of species, but fewer than the low range. All curves were beginning to level off, indicating that if the sampling effort had continued, few new species would be collected. However, weather disturbances may have affected the catch. Additionally, other collecting techniques (flight intercept trap, litter sifting, canopy fogging, etc.) may have yielded new species that are rarely collected by sweeping or light traps. All three altitudinal ranges showed high diversity (H > 2.0; Table 2), with the highest in the low range (3.504), followed by the middle (3.096) and peak ranges (2.762). The low altitudinal range had the highest Shannon-Wiener diversity (H' = 3.504), richness index (R' = 9.731) and the greatest number of morphospecies (Table 1). These results were consistent with previous studies in Gunung Ledang by Khairiyah et al. (2013) which stated that vegetation such as young trees, shrubs and fir trees at lower altitudes showed higher abundance of insects than at higher altitudes. In addition, the results of previous studies in Mount Fraser indicated that the diversity and abundance of plants decreased with increasing altitude (Adam et al., 2011). The diversity of chrysomelid beetles is associated with the presence of host plants (Muhaimin et al., 2017) and the high diversity of vegetation at lower altitudes may be favorable to more species of chrysomelids.

The Shannon diversity index was significantly higher (F = 16.18, p = 0.027) at L1 than L2 or L3 (Table 2). This may have been influenced by the different vegetation structures between altitudes. From observations during field sampling, there were a lot of ferns (Pteridopyhta: Gleicheniaceae) at elevations higher than 750 m. The Gleicheniaceae are normally distributed in the top and middle highlands (Beaman and Edwards, 2007). This situation affects the distribution of chrysomelid beetles that have high host specificity (DeLoach et al., 2003).

Study on chrysomelids in Malaysia was initiated by European taxonomists in 1962 and the first galerucine beetle identified was *Chrysomela orientalis* (Mohamedsaid, 2004).

In this paper, a list of chrysomelid beetles collected from Mount Fraser, Pahang is presented. This is the first and preliminary species inventory of the Chrysomelidae at this site based on elevation (Table 3). Further study of chrysomelids at this site, particularly on the biology and ecology, will help maintain biodiversity into the future.

Conflict of Interest

The authors declare no conflict of interest.

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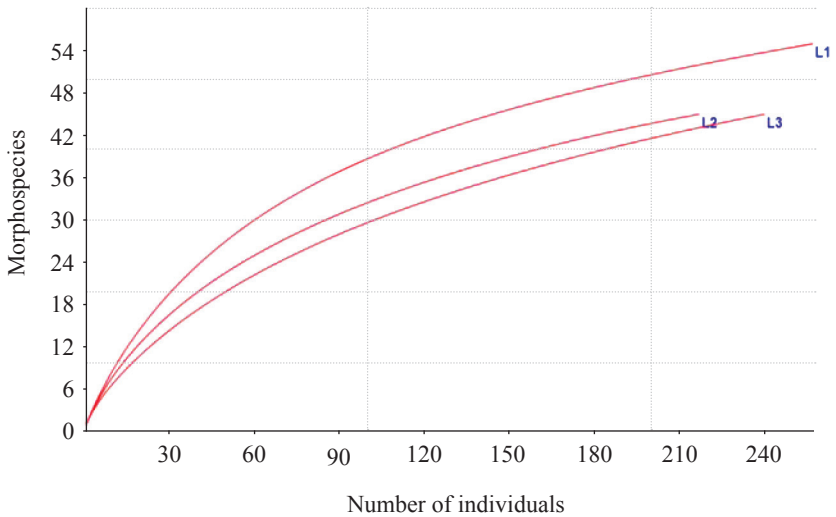

Fig. 1 Species accumulation curves based on elevation, where L1 = 400–500 m, L2 = 750–850 m and L3 = 1,000–1,250 m

Table 2 Shannon diversity index (H'), evenness index (E') and Simpson's diversity index (D') for total number of chrysomelid beetles by elevation: L1 (400–500 m); L2 (750–850 m); L3 (1,000–1,250 m)

Altitude	H'	E'	D'
L1	3.504[a]	0.874	0.9527
L2	3.096[b]	0.813	0.9163
L3	2.762[b]	0.725	0.8552
Total	3.542	0.392	0.9327

* Values of H ' with the same letter are not significantly different (t test, $p < 0.05$).

Table 3 List of species and morphospecies collected from Mount Fraser, Pahang, Malaysia based on different elevations

Subfamily/Genus Galerucinae	Species/Morphospecies	Number of individuals			%
		400–500 m	750–850 m	1,000–1,200 m	
Monolepta	*bifasciata* (Hornstedt, 1788)	4	0	2	0.8
	mentawiensis Jacoby, 1896	8	5	0	1.8
	ruffipennis Jacoby, 1899	0	0	1	0.1
	signata (Olivier, 1808)	4	1	2	0.9
	mohamedsaidi Hazmi & Wagner, 2013	4	0	2	0.8
	hageni Weise, 1916	0	2	0	0.2
	marginicollis Jacoby, 1897	1	2	1	0.5
	mustaphai Mohamedsaid, 1997	0	2	0	0.2
	basimarginata Jacoby 1884	6	0	0	0.8
	sulawensis Hazmi & Wagner, 2013	2	2	1	0.7
	sp 1.	0	0	4	0.5
	sp 2.	2	7	3	1.6
	sp 3.	1	0	0	0.1
	sp 4.	6	2	0	1.1
	sp 5.	1	1	0	0.2
	sp 6.	0	0	1	0.1
	sp 7.	1	0	0	0.1
Oides	*maculatus* (Olivier, 1807)	0	1	2	0.4
	sp 1.	0	1	2	0.4
Paleosepharia	*malayana* Mohamedsaid 1996	0	1	0	0.1
	sp 1.	1	4	6	1.5
	sp 2.	1	0	0	0.1
	sp 3.	1	0	2	0.4
	sp 4.	0	0	1	0.1
Mimastra	*sumatrensis* Jacoby, 1884	26	49	81	21.8
Aplosonyx	sp 1.	12	8	7	3.7
Arcastes	*suturalis* Jacoby, 1884	0	0	1	0.1
Aulocophora	*indica* (Gmelin, 1790)	4	3	0	0.9
	sp 1.	0	1	0	0.1
	sp 2.	3	0	1	0.8
	sp 3.	0	6	0	0.5
	sp 4.	0	0	1	0.1
Diabrotica	*capitata* Fabricius, 1801	0	1	0	0.1
	sp 1.	0	1	0	0.1
	sp 2.	3	0	0	0.4
Gallerucida	*balyi* (Duvivier 1885)	0	1	1	0.2

Table 3 Continued

Subfamily/Genus	Species/Morphospecies	Number of individuals			%
		400–500 m	750–850 m	1,000–1,200 m	
Medythia	*quadrimaculata* Jacoby 1887	0	0	1	0.1
	sp 1.	4	0	0	0.5
Pyrrhalta	sp 1.	0	4	1	0.7
Rubrarcastes	*sanguinea* (Hazmi & Wagner, 2010)	1	0	0	0.1
Theopea	*elegantula* Baly, 1864	3	1	0	0.5
	sp 1.	6	0	0	0.8
	sp 2.	1	0	0	0.1
Gen. 1	sp 1.	5	2	1	1.1
	sp 2.	3	3	1	0.9
	sp 3.	0	1	0	0.1
	sp 4..	0	1	1	0.2
Alticinae					
Gen. 1	sp 1.	0	0	31	4.3
	sp2.	0	0	3	0.4
	sp3.	0	2	4	0.8
	sp4.	0	2	2	0.5
	sp5.	0	0	1	0.1
	sp6.	0	0	5	0.7
Chrysochus	*auratus* (Fabricius, 1775)	5	0	0	0.7
	sp 1.	2	0	4	0.8
Gen. 1	sp1.	0	0	2	0.2
	sp2.	7	2	1	1.4
	sp3.	5	8	8	2.9
	sp4.	7	3	0	1.4
	sp5.	1	0	0	0.1
Chrysomelinae					
Gen. 1	sp1.	13	0	0	1.8
	sp2.	1	0	0	0.1
	sp3.	9	10	6	3.5
	sp4.	11	9	6	3.6
	sp5.	1	1	4	0.8
	sp6.	0	0	2	0.2
	sp7.	0	1	0	0.1
	sp8.	5	5	0	1.4
	sp9.	1	0	0	0.1
	sp10.	1	0	0	0.1
	sp11.	8	4	0	1.6
Criocerinae					
Lema	sp 1.	5	0	2	0.9

Table 3 Continued

Subfamily/Genus Cassidinae	Species/Morphospecies	Number of individuals			%
		400–500 m	750–850 m	1,000–1,200 m	
Aspidimorpha	*assimilis* Boheman, 1854	3	0	0	0.4
	sanctaecrucis (Fabricius, 1792)	5	0	0	0.7
Chiridopsis	*punctata* (Weber, 1801)	35	0	0	4.9
Crytocephalinae					
Crptocephalus	sp1.	0	1	0	0.1
Gen. 1	sp1.	1	12	3	2.2
	sp2.	1	0	0	0.1
Hispinae					
Dactylispa	*higoniae* (Lewis, 1896)	0	0	1	0.1
Sceloenopla	sp 1.	1	0	0	0.1
Gen. 1	sp1.	2	0	0	0.2
	sp2.	2	25	18	6.3
	sp3.	1	1	0	0.2
Donaciinae					
Gen. 1	sp1.	0	4	0	0.5
	sp2.	10	14	10	4.7

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