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MACROMOTHS

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ABSTRACT

The macromoth diversity in the Ban Limestone Area was investigated from 9 October 2001 to 1 November 2002. Modified Pennsylvanian light traps were employed throughout a total of 57 trapping nights. Altogether, 670 species and 2,317 individuals from 15 families were recorded. The Williams' Alpha diversity value for the macromoths was 316.02±20.79 (95% confidence range), which falls within the typical range for macromoths of other undisturbed Bornean forest. The most diverse family was Noctuidae, followed by Geometridae and Arctiidae with 207, 166 and 114 species, respectively. *Cyana maiae* (Arctiidae: Lithosiinae) with 109 individuals, represents the most abundant species. This is followed by *Condica illecta* (Noctuidae: Amphipyrinae) and *Hypomecis costaria* (Geometridae: Ennominae), which are represented by 46 and 46 individuals, respectively. The study also reveals a first record of *Creatonotos gangis* (Arctiidae: Arctiinae) in Borneo.

Keywords: limestone, light trap, moths, alpha diversity, Bau

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Abstract. The macromoth diversity in the Bau Limestone Area was investigated from 9 October 2001 to 1 November 2002. Modified Pennsylvanian light traps were employed throughout a total of 57 trapping nights. Altogether, 670 species and 2,317 individuals from 15 families were recorded. The Williams' Alpha diversity value for the macromoths was 316.02±20.79 (95% confidence range), which falls within the typical range for macromoths of other undisturbed Bornean forest. The most diverse family was Noctuidae, followed by Geometridae and Arctiidae with 207, 166 and 114 species, respectively. *Cyana maiae* (Arctiidae: Lithosiinae) with 109 individuals, represents the most abundant species. This is followed by *Condica illecta* (Noctuidae: Amphipyrinae) and *Hypomecis costaria* (Geometridae: Ennominae), which are represented by 46 and 46 individuals, respectively. The study also reveals a first record of *Creatonotos gangis* (Arctiidae: Arctiinae) in Borneo.

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INTRODUCTION

The Bau Limestone Area is one of the eight limestone habitats in Sarawak (Anderson, 1965). It is located at the southwest of Sarawak, about 22 km from Kuching, the State Capital of Sarawak. Unlike the limestone in Gunung Mulu National Park, scientific documentation on the Bau Limestone biodiversity is very scarce.

Macromoths (Lepidoptera: Heterocera) are one of the highly plant-dependent groups of insects and form a rich component of the Bornean rainforest fauna. Compared to the other megadiverse insect groups, the macromoths of Borneo, in particular, are taxonomically well known and

relatively easy to identify (Holloway, 1985a). They are also sensitive to environmental changes due to their habitat preference, thus making them a suitable biological indicator group in biodiversity assessment and documentation. Furthermore, the vast majority of both the macro- and micromoths are nocturnal and their response to light provides a very convenient method of sampling by using the ultra-violet or mercury vapour light trap (Holloway, 1985a).

Holloway (1984) studied the macromoths of limestone areas in Sarawak in Gunung Mulu National Park. However, his study was not only focused on limestone areas but included various other vegetation types viz. mixed dipterocarp, kerangas and alluvial forest at various altitudes. Results from the survey show that different types of vegetation and altitude gave different values of macromoth species diversity, and the highest diversity of macromoths was from the lower montane forest at an altitude of about 1,000 m (Holloway, 1984). A relatively high diversity of macromoths in limestone areas was also recorded during the assessment, though the area consisted of very low floristic (canopy trees) diversity compared with other forest types (Holloway, 1984). Other than Holloway (1984) no other work has been done on moth diversity of limestone areas in Sarawak.

The aim of this study was to determine the species diversity and composition of the macromoth fauna in the Bau Limestone Area.

MATERIALS AND METHODS

Two phases of moth assessments, which included preliminary survey and comprehensive study, were conducted at the Bau Limestone Area. The preliminary survey was carried out from 9 October 2001 until 12 April 2002 to obtain baseline data on the biodiversity of the area. Eighteen hills of the Bau Limestone Area were surveyed for this purpose, namely Gunung Kawa, Gunung Meraja, Gunung Aup, Gunung Poing, Gunung Stulang, Gunung Podam, Gunung Batu Payong, Gunung Apin, Gunung Tai Ton, Gunung Krian, Gunung Pambor, Gunung Tongga, Gunung Ropih, Gunung Batu, Gunung Doya, Gunung Jebong, Gunung Tabai and Gunung Lanyang.

Comprehensive study was conducted at four selected areas – Site A (Gunung Kawa, Gunung Meraja and Gunung Ropih); Site B (Gunung Aup, Gunung Poing and Gunung Stulang), located further southwest from the other Bau Limestone Area; Site C (Gunung Doya); and Site D (Gunung Tabai, Gunung Apin and Gunung Umbut). The four sites were selected based on preliminary findings of high flora and fauna diversity, easy to access, and representative of the scattered Bau Limestone Area. The comprehensive study was conducted from 6 May 2002 until 1 November

2002. Each site was sampled twice: 6-9 May 2002 and 25-28 June 2002 at Site A, 13-16 May 2002 and 9-12 July 2002 at Site B, 11-14 June and 29 Oct to 1 Nov 2002 at Site C, and 20-23 May 2002 and 1-4 Oct 2002 at Site D.

Macromoths were collected for three continuous nights using one modified Pennsylvanian light trap illuminated by 120W mercury vapour lamp at each hill during the preliminary survey or during every trip at each site for comprehensive study. Trappings were done from 1900 hr to 2300 hr. Specimens collected were kept in dry insect boxes and brought back to Sarawak Biodiversity Centre zoological collection for specimen preparations and identification. Moth specimens were classified to family level and were identified to species according to Barlow (1982) and Holloway (1983, 1985b, 1986, 1987a, 1988, 1989, 1993, 1996, 1997, 1998, 1999, 2001). Some of the specimens were identified using Sarawak Museum Collection and UNIMAS Museum Collection and some identified by Dr V.K. Chey (Sepilok Forest Research Centre). A new record for Borneo was referred to the taxonomic expert, Dr J.D. Holloway (Natural History Museum).

Williams' Alpha Diversity index (α), derived from the log-series distribution (Fisher *et al.*, 1943) was used to measure moth diversity. The index was chosen as it is independent of sample size and is the most widely used index for comparing light-trapped moth samples (Chey, 2000).

RESULTS AND DISCUSSION

Overall Species Diversity

A total of 2,317 individuals comprising of 670 species of macromoths was collected from the Bau Limestone Area during this survey. An almost similar number of species (697) and individuals (2,494) was also recorded from the lowland limestone forest canopy sample in Gunung Mulu National Park (Holloway, 1984). In Borneo a total of 3,429 macromoth species has been described so far (Holloway, 1993) and the Bau Limestone Area moths represent 19.5% of the Bornean species total.

The macromoth Williams' Alpha Diversity value (316.02±20.79, 95% confidence range) for the Bau Limestone Area was high in the range of 300-400, the typical values for the macromoth diversity in undisturbed Bornean forest (Holloway, 1987b). This is also in accordance with diversity value recorded for the lowland limestone forest canopy sample in Mulu National Park and support an indication that limestone area sustains a reasonably high moths diversity although compared with other primary rain forest, such as

mixed dipterocarp forest, limestone area is generally lower in floristic (canopy trees) diversity (Holloway, 1984).

A relatively high percentage (45.2%) of macromoth species represented by single individual (singleton) was recorded from the Bau Limestone Area. This is also true for the species represented by two and three individuals (29.1%). Barlow and Woiwod (1989) indicated that the large number of singletons might be an indication of a continuous stream of casual visitors from outside the trapping area. This could be further explained by the same situation for insect samples in tropical foliage, where the high proportion of rare insects collected is partly due to the diversity of surrounding habitats and increasing sampling effort with a particular method may only increase the proportion of rare species collected, unless the number of habitats sampled is increased then only this proportion may decrease as this procedure increases the probability of finding the 'true' habitat of some insect species (Basset, 1997). Thus, the high occurrence of the singletons in the Bau Limestone Area indicates that most of its species may be derived from the surrounding areas, including disturbed and undisturbed lowland forests.

Table 1 shows the number of species and individuals among different macromoth taxonomic groups collected from the Bau Limestone area. Generally, they resemble those in other forest types in Borneo, Noctuidae and Geometridae are predominant (Abang and Karim, 1999, 2000; Chey, 1994, 2000, 2002; Holloway, 1984).

Interestingly, the Arctiid subfamily Lithosiinae has the highest number of species (90) and individuals (500) (Table 1). This is in contrast to moth samples in other Bornean forests where Ennominae is usually predominant (Abang and Karim, 2000; Chey, 1994, 2000, 2002; Holloway, 1984; Karim, unpubl.). The high occurrence of the subfamily might be correlated with the abundance of mosses, lichens and algae in the Bau Limestone Area as the subfamily is commonly known to consist of a high proportion of browsers on mosses, lichens and algae (Barlow, 1982; Common, 1990; Holloway, 1988, 2001; Holloway *et al.*, 1990). The correlation between the high Lithosiinae diversity with the high availability of mosses could be found elsewhere (Chey, 2000).

The second and the third highest number of species and individuals were represented by the Noctuid subfamily Ophiderinae and Geometrid subfamily Ennominae (Table 1). Both of these families are usually found in abundance in Bornean rain forest. Besides, they have a wide range of food preferences during the larval stage as well as adult. They are also highly nocturnal, and readily attracted to light sources, which would also contribute to the high number of species and individuals caught.

Table 1: Number of species and individuals among different groups of macromoth fauna in the Bau Limestone Area.

Family / Subfamily	Species	Individual
1. Noctuidae	189	671
Acontiinae	3	9
Acronictinae	1	3
Aganainae	5	16
Agaristinae	6	29
Amphipyrinae	27	150
Catocalinae	19	57
Euteliinae	7	10
Hadeninae	9	16
Herminiinae	9	36
Hypeninae	8	41
Ophiderinae	86	290
Plusiinae	3	4
Stictopterinae	6	10
2. Geometridae	166	527
Desmobathrinae	13	56
Ennominae	79	286
Geometrinae	51	131
Larentiinae	8	16
Sterrhinae	15	38
3. Lymantriidae	61	136
4. Arctiidae	115	611
Arctiinae	16	76
Lithosiinae	90	500
Syntominae	9	35
5. Notodontidae	28	94
6. Drepanidae	17	35
7. Limacodidae	17	22
8. Sphingidae	16	73
9. Lasiocampidae	11	23
10. Uraniidae	16	39
11. Bombycidae	5	22
12. Saturniidae	1	1
13. Eupterotidae	4	6
14. Cossidae	1	1
15. Nolidae	23	56
Total	670	2317

The Cossidae and Saturniidae had the least number of species and individuals for the Bau Limestone Area, where only single species and individuals were recorded for each of the two families. A higher number of individual were recorded for each of the two families. A higher number of species and individuals should be expected, as in Borneo these families are represented by a moderate number of species, 34 and 22 species, respectively. The possible reason for the low number of the Cossidae might