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## Ground Beetle (Coleoptera: Carabidae) at Lanjak Entimau, Sarawak, Malaysia

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**Abstract:** A study was conducted on the abundance and diversity of ground beetles (Coleoptera: Carabidae) in Lanjak Entimau to determine whether the forests has been disturbed. The study was conducted from 16th to 29th June 2008 at five sites namely Kawi river, Transeks Menyaring 2, Satap river, Bergua and Joh river. All Carabid beetles were sampled using 20 light traps, 20 Malaise traps and 250 pitfall traps. From this study, 44 specimens comprising of 8 species were assembled. Carabids at Transeks Menyaring 2 was most abundant (Margalef index: 2.164) and most specious (Shannon Weaver index: 1.386) compared to other sites. New records of ground beetles for Lanjak Entimau, Sarawak, Malaysia are *Abacetus chalcopterus* Reiche, *Abacetus* sp., *Dioryche torta* Mcleay and *Orthogonius* sp. Four species were unidentified even to genus level and coded as Cara E, Cara F, Cara G and Cara H are possibly new species which will be described later in another report. This study shows that there is low abundance (Margalef index, 1.85) and low diversity (Shannon weaver index, 1.38) of ground beetles at Lanjak Entimau, Sarawak indicating that the area has been disturbed by activities of local ethnic people that depended on the forest for their subsistence. This study also shows that light traps assembled the most abundant and specious Carabid beetles (Margalef index: 2.056; Shannon Weaver index, 1.475).

**Key words:** Ground beetle, Carabidae, disturbance, abundance, diversity, specious, Lanjak Entimau

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### INTRODUCTION

Lanjak Entimau Wildlife Sanctuary (LEWS), with an area of 168,758 ha and its proposed extension of 18,414 ha was initially established as a Lanjak Entimau Protected Forest in 1940. Because of its importance as natural habitat for wildlife the area was gazetted as a Wildlife Sanctuary in 1983. With a size of almost 200,000 ha, the area is now the largest Totally Protected Area in Sarawak. The Sanctuary comprises of two watersheds. The Northern part of the Sanctuary is drained by the Rajang tributaries such as Katibas river, Ngemah river and Kanowit river, while in the South by the tributaries of Batang Lupar namely Batang Ai, Engkari river and Batang Skrang.

Ribera *et al.* (2001) and Martinez *et al.* (2009) reported that the family Carabidae commonly known as ground beetle are considered good indicators of environmental health in agricultural regions, forests, open lands and urbanizing areas.

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Sampling on carabids has been carried out at prairies of Washington (Maynard, 2007), in forest fragments of Northwestern, Ohio (Oates *et al.*, 2005) and in agricultural landscape of Northeast Germany (Brose, 2003a). In Malaysia, carabids has been studied in the forest of Langkawi Island (Abdullah, 2005) at the man-made lake, Tasik Kenyir (Abdullah *et al.*, 2008) and in mango farm (Abdullah and Shamsulaman, 2008).

Chey Vun Khen (1988) reported that the insect fauna of Lanjak Entimau was rich with a total of 6176 specimens, from 8 orders and 58 families, with 1053 sorted species sampled. Rajah Brooke's Birdwing *Troides brookiana brookiana* Wallace, which was getting scarce in other parts of Borneo, was most abundant in the alluvial forest of Nanga Joh. Several endemic butterfly species were found in the lowland forest of Ulu Engkari, underlining the conservation importance of the site. Bees were found to be unexpectedly low in abundance in the deep forest under storey. Termites were found to be rather diverse. Forty species out of 100 odd known in Borneo, but pest termites, common in plantation monocultures, were rare in Lanjak-Entimau Wildlife Sanctuary (Chey Vun Khen, 1988).

This study would not only give the check list of Carabid found at Lanjak Entimau and the best collection method in sampling the Carabids but most importantly the main objective of this study was to determine whether Lanjak Entimau Wildlife Sanctuary remains undisturbed as reported 21 years ago, or otherwise, by studying the abundance and diversity of Carabid beetles as an indicator of environmental health and disturbance.

## MATERIALS AND METHODS

### Study Area

The study was done at Lanjak Entimau Wildlife Sanctuary, Sarawak located at 1° 34' 60.00 N 112° 16' 60.00 E. This area is out of bound except for research groups with permission from Sarawak Forest Department. From Sibu, a 2 h speedboat journey to a small town Song, then 8 h by a small longboat manned by ethnic people called Iban. The river is very shallow with many rapids and stones. Occasionally the boat needed to be pushed or carried by passengers on their shoulder when the river water level was very low. Five sites namely Kawi river, Transeks Menyaring 2, Satap river, Joh river and Bergua river were studied from 16th to 29th June 2008.

### Samplings

Sampling methods in the study followed the methodology used by recent researches in diversity study in tropical rainforests in Malaysia (Abdullah, 2005; Abdullah and Shamsulaman, 2008; Abdullah *et al.*, 2008; Abdullah and Sina, 2009). In this study ground beetle specimens were collected using 20 flight interception trap (Malaise traps) and 250 pitfall traps for 24 h. Night samplings were conducted using twenty light traps set for 4 h from 19:00 to 23:00 h at each study site. The traps were set up on hill slopes, at river bank and in the middle of the forests.

### Flight Interception Trap

Each Malaise trap (Fig. 1) was tied in between the trees about 1 m above the ground. Flying insects encountering the net entered from all sides of the net then flew upwards into a hole adjoining a 500 mL plastic collection bottle filled with 200 mL of 70% alcohol. Insects in the collection bottle remained preserved in the alcohol until collected 24 h later. Carabid beetles were sorted from other insects collected in the bottle.





Fig. 1: Beetles that flew into the Malaise trap flew upward into a hole which opened into the collection bottle containing 70% alcohol and preserved until collected 24 h later



Fig. 2: A pitfall trap consisted of a plastic cup containing 70% alcohol in the ground at Lanjak Entimau. A dried leaf placed over two wooden pegs sheltered the pitfall trap from rain

#### **Pitfall Trap**

Each pitfall trap (Fig. 2) consisted of a 250 mL plastic cup placed in a hole dug in the ground. One hundred milliliter of 70% alcohol was poured into the plastic cup. Two wooden pegs were placed opposite each other in the ground on the right and left side of the plastic cup. A big dry leaf collected from the forest floor was placed on top of the two pegs about 5 cm above the hole thus sheltering the hole from rainwater. Walking insects on the ground and forest floor encountering the pit fell into the alcohol and remained preserved until the alcohol was collected 24 h later. Five pitfall traps were set up in a quadrat 1 m from each other with the fifth pitfall in the middle. Carabid beetles collected from the pitfall were sorted from other insects.

#### **Light Trapping**

A white mosquito net of size 1.8 X 2.0 X 2.0 m was tied up between trees (Fig. 3). A mercury bulb of 200-Watt was hung on to a wooden pole placed standing in the middle of





Fig. 3: A white mosquito net tied between trees lighted by a mercury bulb powered by a generator served as a light trap for nocturnal trapping of carabid beetles at Lanjak Entimau

the net. The bulb was powered by a generator model Honda EU10i (AC 220 V; Frequency 50 Hz, rated output 900 V Ampere max output 1000 VA; DC 12 v, current 8 Amp). One side of the net was open to allow insects attracted to the light to enter the net and to settle on the ceiling and inside the walls of the net. Insect also settled on top of the net and on all sides of the net. Carabid beetles which were collected by hand or by using an aspirator were placed in the killing jar containing ethyl acetate before being sorted from other insects.

Carabid beetles collected from all traps were pinned, brought back to University Malaya, dried in the oven and kept in insect boxes for identification purposes.

#### **Sorting, Preservation and Identification**

Carabid specimens preserved in 70% alcohol were sorted to family according to Borror and DeLong (1971). Recently, Johnson and Triplehorn (2004) included tiger beetles (Family: Cicindelidae) in the same family as ground beetle (Family: Carabidae). The ground beetles were identified at Department of Agriculture of Peninsular Malaysia.

#### **Ecological Indices Calculation**

The abundance and species richness of the carabids were calculated using Margalef index. It considers a simple and constant relationship between S the number of species recorded in a sample with that of sample size N.

$$\text{Margalef index, } H = S-1/\ln(N)$$

Abundance increased proportionately with the value of Margalef index.

Shannon-Weaver Index (Krebs, 1985) was used to calculate the diversity of the beetle.

$$\text{Shannon-Weaver index } H = - \sum p_i \log p_i$$

This index assumes that each species was represented in each sample and that there was random sampling of individuals from an infinitely large population. Shannon weaver index has a maximum value of 5, diversity increases with increase in the value of Shannon index.

**RESULTS**

In this study, forty four specimens of ground beetles comprising of 8 species were sampled at Lanjak Entimau. Table 1 gives the checklist of ground beetle species found during the expedition. The species were *Abacetus* sp. (Fig. 4), *Abacetus chalcopterus* Reiche (Fig. 5), *Orthogonius* sp. (Fig. 6), *Dioryche torta* Mcleay (Fig. 7) and four unidentified species coded as Cara E, Cara F, Cara G and Cara H. Since this is the first study on ground beetles at Lanjak Entimau all species are new records for Lanjak Entimau.

Table 1: Checklist of ground beetle species sampled at Lanjak Entimau

Species of ground beetle	No. of individuals at sampling sites				
	Kawi river	Transeks menyaring 2	Satap river	Bergua	Joh river
<i>Abacetus</i> sp.	2	0	0	3	0
<i>Dioryche torta</i>	0	1	0	21	0
<i>Abacetus chalcopterus</i>	0	1	2	6	3
<i>Orthogonius</i> sp.	0	1	0	0	0
Cara E*	0	1	0	0	0
Cara F*	0	0	0	0	1
Cara G*	0	0	0	0	1
Cara H*	0	0	0	0	1
Total	2	4	2	30	6

\*Unidentified species



Fig. 4: *Abacetus* sp. (3.75 mm)



Fig. 5: *Abacetus chalcopterus* Reiche (3.97 mm)





Fig. 6: *Orthogonius* sp. (4.64 mm)



Fig. 7: *Dioryche torta* Mcleay (3.67 mm)

All five individuals of *Abacetus* sp. was collected by light trap (Table 3) two individuals from Kawi river and three individuals collected at Begua (Table 1). The *Abacetus* sp. was 3.75 mm in length. *Abecetus chalcopertus* 3.97 mm in length were found at all sampling sites except Kawi river. *Orthogonius* sp. of measurement 4.64 mm was only sampled at Transek Menyaring 2 also by light trap. Twenty one individuals of *Dioryche torta* of 3.67 in length were collected at Begua and one individual was sampled at Transek Menyaring 2 (Table 1).

#### **Abundance and Diversity at Sampling Sites**

Most ground beetle specimens (N = 30, 68.2%) were collected at Bergua (Table 1). The ground beetles at Transeks Menyaring 2 was most abundant (Margalef index: 2.16) and most specious (Shannon Weaver index: 1.39) compared to other sites as shown in Table 2.

#### **Efficiency of Traps**

Eighty four percent of ground beetle specimens (N = 37) were sampled using light traps followed by 13.6% (N = 6) by pitfall traps and the least only 2.3% (N = 1) by Malaise traps (Table 2). At Lanjak Entimau, the pitfall traps collected four species of ground beetle comprising of three individuals of *Abecetus chalcopertus* and three other unknown species given code name Cara F, Cara G and Cara H. All ground beetles collected were from Joh river (Table 2). No ground beetle was collected using pitfall trap at all other sites.

Table 2: Abundance and diversity of ground beetle at different sites

Site	Specimen			No. of specimen	No. of species	Margalef index	Shannon weaver index
	LT	MT	PF				
Kawi river	2	0	0	2	1	0.00	0.00
Transeks menyaring 2	4	0	0	4	4	2.16	1.39
Satap river	1	1	0	2	1	-	-
Joh river	0	0	6	6	4	1.67	1.24
Bergua	30	0	0	30	3	0.56	0.80
Total	37	1	6	44	8		
Overall Margalef index for Lanjak Entimau						1.85	
Overall Shannon weaver index for Lanjak Entimau						1.38	

LT: Light trap; MT: Malaise trap; PF: Pitfall

Table 3: Ground beetle species sampled using different traps

Species of ground beetle	No. of specimen caught		
	Light trap	Malaise trap	Pitfall trap
<i>Abacetus</i> sp.	5	0	0
<i>Dioryche torta</i>	22	0	0
<i>Abacetus chalcopterus</i>	8	1	3
<i>Orthogonius</i> sp.	1	0	0
Cara E*	1	0	0
Cara F*	0	0	1
Cara G*	0	0	1
Cara H*	0	0	1
Total	37	1	6

Light traps assembled five species (62.5%) of ground beetles with 59.5% (N = 22) were *Dioryche torta* followed by 21.6% *Abecetus chalcopterus* and one unidentified species Cara E. Malaise trap was the least efficient method of collection for ground beetle with only one catch of *Abecetus chalcopterus* at Satap river (Table 3). This study shows that there is low abundance (Margalef index: 1.85) and low diversity of ground beetle at Lanjak Entimau (Shannon Weaver index: 1.38) (Table 2).

## DISCUSSION

The low value of Margalef (1964) index and low value of Shannon weaver index of Carabids found in this study indicates the environmental status of Lanjak Entimau. In contrast to the findings of Chey Vun Khen (1988) results of this study shows that Lanjak Entimau is presently disturbed. Chey Vun Khen (1988) reported that there was a rich insect fauna at Lanjak Entimau with a total of 6176 specimens, from 8 orders and 58 families, with 1053 sorted species sampled. Even though Lanjak Entimau is not accessible to visitors except to invited scientist via a research permit, the ethnic people of Sarawak, Iban is given special permission to enter because their long house are situated along the river from the small town Song along the river leading to Lanjak Entimau. The ethnic Iban people often enters the forests at Lanjak Entimau to hunt for wild boars and small mammals for their food consumption. This would definitely have an effect on ground beetle fauna. The ground of the forests at Lanjak Entimau is fairly disturbed thus explaining the low assemblage of ground beetle in this study. The low diversity and low abundance of carabid beetles contrast the findings of Abdullah and Sina (2009) who found moderate diversity and high abundance of Staphylinid beetles at Lanjak Entimau. This was due to clean rivers and tributaries at Lanjak Entimau since Staphylinids prefer moist habitats along margins of streams since Staphylinids also live under stones along the shores of river margins (Abdullah and Sina,



2009). McCrav and Willand (2005) and Synder and Ives (2001) suggested that higher humidity and soil humidity decreased the abundance and diversity of ground beetle. Small rivers along tracks at every study sites of Lanjak Entimau increase the humidity of air and soil which is preferred by Staphylinid beetles but not Carabid beetles.

The number of species of ground beetle sampled at Lanjak Entimau on Borneo Island during this expedition was lesser than that sampled from Langkawi Island, North East Langkawi islands, Endau Rompin reserved forest and the man made lake Tasek Kenyir all situated on peninsular Malaysia. In earlier studies, 25 species of Carabid were sampled from Langkawi island (Abdullah, 2005) and 29 species of Carabid were sampled from Tasik Kenyir (Abdullah *et al.*, 2008). *Abacetus* sp. and *Orthogonius* sp. that was collected at Lanjak Entimau were also collected at Langkawi Island and Tasik Kenyir. This study shows that ground beetles in Lanjak Entimau is less abundant (Margalef index: 1.85) and less diversified (Shannon-Weaver index: 1.38) compared to beetle collected at Tasik Kenyir (Margalef index: 5.45; Shannon weaver index: 2.40). The ground beetles sampled at North East Langkawi islands was also more abundant than Lanjak Entimau (Margalef index, 2.394).

However the ground beetles at Lanjak Entimau is more abundant and specious compared to ground beetle that was sampled in the mango *Mangifera indica* plantation at Chuping, Perlis, Malaysia (Margalef index: 0.48; Shannon Weaver index: 1.17). Abdullah and Shamsulaman (2008) reported that Chuping mango farm in Perlis Malaysia is a well managed farm with constant sweeping and burning of leaf debris. The lower abundance and lower diversity of ground beetles at Chuping mango farm was due to scheduled pesticide spraying according to fruiting season and non fruiting season. Veistola (1996) reported that insecticide reduced the abundance of ground beetles in cereal fields.

Carabids are polyphagous (Ellsbury *et al.*, 1998; Suenaga and Hamamura, 1998). Predators of pest insects (Synder and Wise, 1999) and consumers of plant material (Carmona and Landis, 1999) particularly weed seeds (White *et al.*, 2007). Oates *et al.* (2005) reported that large forest has lower diversity of carabids than smaller fragmented forests. He also reported that Carabids diversity increase as fragmented forest increased. Lanjak Entimau has lower abundance and diversity of Carabids compared to Tasik Kenyir. Tasik Kenyir represented a high fragmented area with many small islands which has been developed for resort and ecotourism. Sarawak is situated on Borneo Island which is separated from Peninsular Malaysia by South China Sea. According to Brose (2003b) there was no significant relationship between Carabid species richness and the isolation parameters. Therefore low abundance and diversity of ground beetles at Lanjak Entimau are not influenced by the separation by South China Sea.

Study on ground beetles conducted using pitfall trap by Maynard (2007) has collected 12,464 specimens representing 24 species whereas Oates *et al.* (2005) collected 412 carabids constituting of 41 species. However, at Lanjak Entimau, 37 specimens from 5 species were collected using light trapping whereas pitfall traps collected only four species from 6 individuals. Abdullah *et al.* (2008) collected 98% (N = 80) of ground beetles at Tasek Kenyir using light traps. This study showed that light trap was the most efficient method in sampling for ground beetles. Results from this study shows that ground beetles were nocturnal and certain species were attracted to mercury light.

Twenty one years ago (Chey Vun Khen, 1988) Lanjak Entimau wildlife Sanctuary and Batang Ai National Park was reported to be a relatively undisturbed primary forest with among the richest sites for flora and fauna in Borneo with eight distinct forest types including the rare montane mossy forest. However, the findings of this study shows otherwise. Lanjak Entimau is at present disturbed shown by the results of this study which



use Carabid beetle as indicator of environmental health. In 1988 the 30 to over 100 years old secondary forests that were also found in Lanjak Entimau were offering ecologists and botanists unique opportunities to study species succession and forest dynamics. Thus it is important that the ethnic people Iban living along the rivers at Song and going towards Lanjak entimau should be offered other means of living and occupations so that they will be able to be given a livelihood that does not depend on hunting small mammals in the forests of Lanjak Entimau. This way Lanjak Entimau will be prevented from further disturbance otherwise further disturbance would definitely impose many ecological implications to National heritage of Malaysia.

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