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**Faunal studies of sap beetles (Coleoptera: Nitidulidae)  
in primary and secondary tropical rainforests in the middle reaches of  
the Baram River Basin, Borneo**

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**ABSTRACT** This study presents a species inventory of sap beetles (Coleoptera: Nitidulidae), together with descriptions of their habitat types, in lowland tropical rainforests in the middle reaches of the Baram River Basin, Borneo (Sarawak, Malaysia). Thirty-two nitidulid species belonging to 14 genera from six subfamilies were collected by banana-baited traps. There was no significant difference in species richness, abundance, diversity, or species composition between the primary and secondary forests, with 13 species being shared.

**KEY WORDS** banana-baited trap / biodiversity / nitidulid assemblage / Sarawak / Southeast Asian tropics

### **Introduction**

The compilation of biodiversity inventories, together with monitoring, form a critical part of characterizing biological communities and implementing conservation plans (Kremen et al. 1993; Longino & Colwell 1997). Since insects are an important constituent of the high biodiversity found in the tropics, various inventories have been gathered in many parts of the world (e.g., Lawton et al. 1998; Barlow et al. 2007). Borneo has vast tropical forests harboring very rich flora and fauna, and many insect surveys have been conducted in these forests. Most of these studies have focused on groups that are readily identifiable, such as butterflies (e.g., Otsuka 1988; Hill et al. 2001; Itioka et al. 2009), and very few have documented other smaller-bodied taxa. Tanabe et al. (2002) and Akutsu et al. (2007) described the diversity of small flying-insects in relation to environmental gradients in Sabah, although both groups of authors adopted a higher-taxon approach (at the order or family level). All of these approaches necessitate inventories covering a wider variety of taxa, with higher taxonomic resolution, or description and identification at a finer scale, ideally at the species level, for better understanding of tropical biodiversity and community structure.

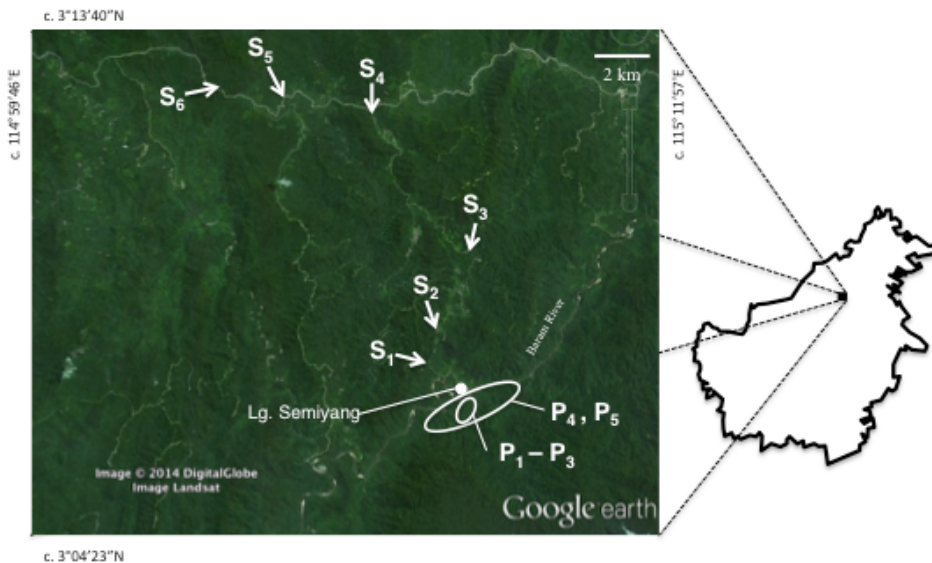
Nitidulidae is a diverse family, with nearly 4,500 species distributed worldwide (Jelínek et al. 2010). As very few documentations of Nitidulidae exist for Borneo, such inventorial studies would constitute a significant contribution to

furthering knowledge on nitidulid fauna in Southeast Asia.

This study presents a species inventory of sap beetles in lowland tropical rainforests in the middle reaches of the Baram River Basin, Borneo (Sarawak, Malaysia), and provides information on their habitat types using comparisons between primary and secondary forests.

### Study site and Methods

We selected six plots ( $S_1$ – $S_6$ ) in secondary forest along the road from Long Akah to Long Semiyang ( $3^{\circ}04'–3^{\circ}13'N$ ,  $115^{\circ}03'–115^{\circ}10'E$ ; ca. 200–650 m a.s.l.), and five plots in primary forest around Long Semiyang ( $3^{\circ}06'13''–3^{\circ}06'57''N$ ,  $115^{\circ}07'00''–115^{\circ}08'30''E$ ), in the middle reaches of the Baram River Basin (Fig. 1). The area comprises a mix of primary and secondary forests, and slash-and-burn cultivation fields. The primary forest contained well-stratified vegetation typical to Sunderland, dominated by high dipterocarp trees. The target secondary forest was dominated by *Macaranga hosei* (Euphorbiaceae), with lower canopy layers than in the primary forest. The six plots in the secondary forest were the same plots as P01–P06 in Kishimoto-Yamada et al. (2013), which were situated at gradients in distance to the primary forest and had remnant primary forest cover. The distances between any given pair of plots among the five plots in the primary forest were >100 m.



**Figure 1.** Locations of 11 study plots: 6 in secondary forests ( $S_1$ – $S_6$ ) and 5 in primary forests ( $P_1$ – $P_5$ ).

Nitidulids were sampled using banana-baited traps from July 30th to August 13th, 2009. Nine traps were set in each plot. Each trap comprised a 200-ml plastic cup containing fermented banana, which was hung from a tree branch at a height of 1 m and a distance of >50 m from the nearest neighboring trap. All adult beetles attracted to the traps were collected on the following day. One trap in plot S<sub>5</sub> was lost and thus failed to be collected. Nitidulid individuals were identified to species level. All voucher specimens are deposited at the Forest Department, Sarawak, at the Kyoto University Museum and at the Ehime University Museum, Japan.

After pooling the data across traps, the following parameters of nitidulid assemblages were calculated for each of the forest plots: species richness (total number of species), genus richness (total number of genera), total abundance (total number of individuals), Simpson's index of diversity ( $1/D$ ), and Pielou's index of evenness ( $J'$ ). The data for plot S<sub>5</sub> were included in these analyses without calibrating for the missing trap, on the assumption that the missing trap did not significantly decrease the species diversity, given the relatively high numbers of species and individuals sampled there (Table 1). In addition, rarefied species richness was calculated to minimize the differences in sampling efforts and in abundance effects among the forest plots. Each of these parameters was compared between the forest types using Student's  $t$ -test. One *Epuraea* (*Haptoncus*) sample collected in plot S<sub>2</sub> was excluded from the analyses because it was hard to judge whether this species was different from the other three species of *Haptoncus* (Table 1).

We examined the similarities in species composition between all pairs of forest plots using the Bray–Curtis index after the data had been square-root-transformed, and using the Sørensen index based on presence–absence data. Then, non-metric multidimensional scaling (NMDS) and analysis of similarities (ANOSIM) were performed based on each similarity matrix. ANOSIM is a multivariate analysis method based on nonparametric permutation using  $R$  values;  $R$  is 1 when all within-group similarities are greater than any between-group similarity, and  $R$  is close to 0 when similarities within and between groups are almost identical. (Clarke 1993). All analyses were performed using R 3.1.1 (R Development Core Team. 2014) with the package Vegan (Oksanen et al. 2013).

## Results

In total, 694 individuals of 32 species in 14 genera from six subfamilies were collected (Table 1). *Epuraea ocellaris* was the most abundant (282 individuals), followed by *Brachypeplus aequalis*, *Urophorus* sp.1, and *E. dubia* (123, 88 and 58

**Table 1.** Total number of individuals for nitidulid species collected at primary and secondary forest plots. Individuals whose abundance is shown in parenthesis were excluded from the analyses.

Subfamily Species	Primary forest plot					Secondary forest plot					
	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>4</sub>	P <sub>5</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>
Amphicrossinae Kirejtshuk, 1986											
<i>Amphicrossus oblongus</i> Grouvelle, 1897	4	3	0	8	8	8	8	1	5	0	0
Carpophilinae Erichson, 1842											
<i>Carpophilus acutangulus</i> Reitter, 1884	0	0	0	0	0	0	2	0	0	0	0
<i>Carpophilus cingulatooides</i> Nakane, 1959	0	0	0	0	0	0	3	0	0	0	0
<i>Carpophilus plagiatipennis</i> (Motschulsky, 1858)	0	0	0	0	0	0	0	0	3	1	0
<i>Carpophilus rubescens</i> Murray, 1864	0	0	0	0	0	0	0	2	0	0	0
<i>Carpophilus</i> sp.1	0	0	0	0	0	0	1	0	0	1	0
<i>Carpophilus</i> sp.2	0	0	0	0	0	1	0	0	0	0	0
<i>Carpophilus</i> sp.3	1	0	0	2	0	0	0	0	5	0	0
<i>Carpophilus</i> sp.4	0	0	0	0	0	0	0	0	3	0	0
<i>Urophorus foveicollis</i> (Murray, 1864)	0	0	0	1	0	0	0	0	0	0	0
<i>Urophorus</i> sp.1	13	23	8	34	0	3	4	0	3	0	0
Cillaeinae Kirejtshuk & Audisio, 1986											
<i>Brachypeplus aequalis</i> (Walker, 1858)	34	15	8	4	0	5	26	1	6	19	5
<i>Brachypeplus triangularis</i> Grouvelle, 1910	1	0	0	0	0	1	0	1	1	0	1
<i>Brachypeplus</i> sp.1	2	0	0	1	0	0	1	0	0	0	0
<i>Brachypeplus</i> sp.2	0	0	0	0	0	0	0	0	0	1	0
<i>Colopterus vieticus</i> Kirejtshuk, 1984	0	0	0	0	0	0	0	0	0	1	0
<i>Platynema puncticeps</i> (Murray, 1864)	0	0	1	0	0	0	0	0	0	0	0
Cryptarchinae C. G. Thomson, 1859											
<i>Cryptarcha</i> sp.1	0	0	0	0	0	0	0	1	0	0	0
<i>Fucalospaera parvula</i> Kirejtshuk, 1987	0	0	0	0	0	1	0	0	0	2	0
Eपुरaeinae Kirejtshuk, 1986											
<i>Eपुरaea (Eपुरaea)</i> sp.1	0	0	1	0	0	0	0	0	0	0	0
<i>Eपुरaea (Haptoncus) concolor</i> Murray, 1864	1	1	1	1	0	3	1	0	0	1	1
<i>Eपुरaea (Haptoncus) dubia</i> Grouvelle, 1897	4	3	1	0	0	2	5	0	0	20	23
<i>Eपुरaea (Haptoncus) ocularis</i> Fairmaire, 1849	55	25	26	5	11	28	69	9	5	13	36
<i>Eपुरaea (Haptoncus)</i> sp.1	1	0	0	0	0	1	(1)	0	0	1	0
<i>Eपुरaea (Micruria)</i> sp.1	0	0	0	0	1	0	1	0	0	0	0
<i>Trimenus hydroporoides</i> Murray, 1864	5	4	6	7	0	0	2	0	1	0	1
<i>Trimenus parallelipedus</i> (Motschulsky, 1863)	0	0	0	0	0	0	2	0	0	0	0
Nitidulinae Latreille, 1802											
<i>Aethina (Circopes) ruficollis</i> Grouvelle, 1897	0	0	1	1	0	0	2	0	0	1	1
<i>Aethina (Circopes) subquadrata</i> (Motschulsky, 1858)	0	0	0	0	0	0	1	0	0	0	0
<i>Phenolia (Lasiodites) picta</i> (MacLeay, 1825)	0	0	0	0	0	0	0	1	0	0	0
<i>Stelidota</i> sp.1	1	0	0	0	0	0	0	0	0	0	0
<i>Tetrisus cholevooides</i> Murray, 1864	0	0	2	0	0	0	0	0	0	0	0

individuals, respectively). The number of occurrences was also highest in *E. ocularis*, which appeared in all 11 forest plots, followed by *B. aequalis*, *Amphicrossus oblongus*, and *E. concolor* (which occurred in 10, 8, and 8 plots, respectively).

Eighteen and twenty-seven species were obtained from the primary and secondary forests, respectively, 13 of which were shared between the two forest types (Table 1). For the genus *Carpophilus*, eight species occurred in the secondary forest, whereas only one occurred in the primary forest. *Trimenus hydroporoides* and *Urophorus* sp.1, by contrast, were far more abundant in the primary forest than in the secondary forest.

No significant difference was detected in any of the assemblage parameters between the primary and secondary forests (Table 2). The ANOSIM test did not show any significant difference in species composition between the forest types (Bray-Curtis index,  $R = 0.029$ ,  $P = 0.358$ ; Sørensen index,  $R = -0.047$ ,  $P = 0.644$ ). Additionally, the NMDS ordination did not exhibit any distinctive difference between the forest types, although it showed a relative similarity in assemblage structure between the four primary forest plots (P<sub>1</sub>–P<sub>4</sub>) and the three secondary forest plots (S<sub>1</sub>, S<sub>2</sub>, and S<sub>6</sub>; Fig. 2).

**Table 2.** Differences in assemblage parameters (mean  $\pm$  SE) between the two forest types. The results of Student's *t*-test are also shown.

Assemblage parameter	Forest type		<i>t</i> -test	
	Primary	Secondary	<i>t</i>	<i>P</i>
Species richness	8.40 $\pm$ 1.57	9.83 $\pm$ 1.22	-0.732	0.483
Genus richness	5.60 $\pm$ 0.98	5.83 $\pm$ 0.40	-0.236	0.819
Total abundance	67.00 $\pm$ 16.49	59.67 $\pm$ 15.77	0.320	0.756
1/ <i>D</i>	3.21 $\pm$ 0.29	3.78 $\pm$ 0.73	-0.662	0.524
<i>J'</i>	0.72 $\pm$ 0.03	0.71 $\pm$ 0.05	0.162	0.875
Rarefied species richness	1.69 $\pm$ 0.03	1.72 $\pm$ 0.04	-0.541	0.601

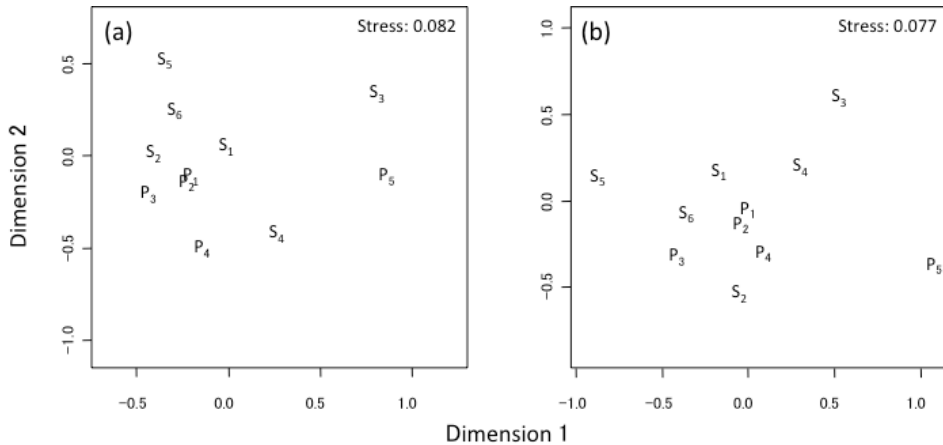
## Discussion

To our knowledge, nitidulid faunas have not previously been documented in the middle reaches of the Baram River Basin. Accordingly, such inventorial studies at higher taxonomic resolution are valuable for providing fundamental information on the taxonomy, ecology, and biogeography of sap beetles in the area.

No significant difference was detected in the richness, abundance, diversity, and species composition of sap beetles between the primary and secondary forests. At present, we are unable to draw any clear conclusions from our results because the number of study plots analyzed was insufficient to perform powerful statistical tests. More intensive sampling is required to examine the differences between the forest types.

The NMDS ordination showed that the species compositions in the three secondary forest plots (S<sub>1</sub>, S<sub>2</sub>, and S<sub>6</sub>) were more similar to those in the primary forest plots (P<sub>1</sub>–P<sub>4</sub>) than those in the other secondary forest plots (S<sub>3</sub>–S<sub>5</sub>) (Fig. 2). This may be related to the percentage of remnant primary forest areas in the neighboring areas surrounding the target secondary forest; the proportion of remnant primary forest area within a 100-m-radius circle around the plot was higher for each of S<sub>1</sub>, S<sub>2</sub> and S<sub>6</sub> than

for any of  $S_3$ – $S_5$  (Kishimoto-Yamada et al. 2013; see Table 1 in the literature for the data;  $S_1$ – $S_6$  correspond to P01–P06, respectively). This possible relationship should be examined in future using a sufficient number of plots and more appropriate experimental designs.



**Figure 2.** NMDS ordination diagrams of nitidulid assemblages based on the (a) Bray-Curtis index and (b) Sørensen index. Primary and secondary forest plots are represented as P<sub>1</sub>–P<sub>5</sub> and S<sub>1</sub>–S<sub>6</sub>, respectively.

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