研究資料（Research record）

List of dung beetles (Coleoptera : Coprophagous group of Scarabaeoidea) collected in lowland near Balikpapan, East Kalimantan, Indonesia

Akira UEDA[1)*], Dhian DWIBADRA[2)], Woro A. NOERDJITO[2)], SUGIARTO[3)], Masahiro KON[4)], Teruo OCHI[5)], Masayoshi TAKAHASHI[6)] and Kenji FUKUYAMA[7)]

Abstract

Dung beetles (coprophagus group of Scarabaeoidea) are useful indicators of habitat quality in tropical regions. In December of 2006 through 2008, we carried out surveys of the beetles using pitfall traps baited with human excrement and fish meat at 30 sites, 10–40 km north of Balikpapan, lowland of East Kalimantan, Indonesia. From these surveys we collected a total of 65 species and 8,073 individual dung beetles, and listed in the table. To provide a useful reference for future studies evaluating forest environments using assemblages of dung beetles, we estimated diet and habitat preferences of 44 species with collections of more than 5 individuals. Forty-one of the 44 species were collected with traps baited with both human excrement and fish meat. For 8 species the total of catch did not exceed 70% in either of the two bait types, and 5 of the 8 species were endemic to Borneo. Regarding habitat, 36 species abundant in natural forests were rarely collected in anthropogenic-destroyed forests, plantation forests, and open-lands, except for 7 species that were also abundant in such habitats. *Catharsius renaudpauliani* was only one species that was expected to reside mainly in destroyed forests and plantation forests. Seven species abundant in open-lands were rarely collected in natural forests. Species abundant in natural forests tend to have narrow distribution ranges, while species abundant in open-lands tend to have wide distribution ranges.

Key words: bait, Borneo Island, forest, grassland, habitat, Scarabaeidae

Introduction

Dung beetles (coprophagous group of Scarabaeoidea: Bolboceratidae, Hybosoridae, and parts of Scarabaeidae (Scarabaeinae and Aphodiinae) in the present study) are known to be an indicator of habitat quality and environmental change in tropical regions (McGeoch et al. 2002, Aguilar-Amuchastegui and Henebry 2007, Gardner et al. 2008a, Nichols and Gardner 2011). This beetle group is also known to be relatively easy to sample and identify compared with the vast majority of other insect groups (Spector 2006). For example, in a study carried out in an area of primary rainforest in Brazilian Amazonia, the sampling cost for these beetles was cheapest compared to the costs for 14 other taxa sampled and was second only to birds in terms of indicator performance (Gardner et al. 2008b, Nichols and Gardner 2011). As a result, at least 19 studies concerning the response of these beetles to tropical forest modification and fragmentation have been performed throughout the world (Nichols et al. 2007). These beetles also serve important ecological functions, such as promoting the rapid decomposition of dung and carcasses, as well as influencing nutrient cycling, bioturbation, plant growth enhancement, secondary seed dispersal, pollination of carrion-scented plants, and parasite control (Davis 1996, Andressen 2002, 2003, Larsen et al. 2005, Slade et al. 2007, 2011, Nichols et al. 2008, Kryger 2009, Ridsdill-Smith and Edwards 2011, Enari and Enari-Sakamaki 2014, Enari et al. 2016).

Because of their value as indicators of habitat quality, the low cost for sampling, and the variety of ecosystem functions they provide, we chose the dung beetles as the material to study the influences of afforestation on grasslands and how both natural and anthropogenic disturbances on forests influence insect diversities in lowland of East Kalimantan,

Received 4 July 2016, Accepted 22 March 2017
1) Kyushu Research Center, Forestry and Forest Products Research Institute (FFPRI)
2) Research Center for Biology, Indonesian Institute of Sciences
3) Kutai Timur Agricultural College
4) Sakyo-ku, Kyoto
5) Toyono-cho, Toyono-gun, Osaka
6) Center for Forest Damage and Risk management, FFPRI
7) Principal Research Coordinator, FFPRI
* Kyushu Research Center, FFPRI, 4-11-16 Kurokami, Chuo-ku, Kumamoto, 860-0862, Japan; e-mail: akira@ffpri.affrc.go.jp

Indonesia (Ueda et al. 2015b, c, d). Through these studies we accumulated the large collection of dung beetles that indicated both diet and habitat preferences for a range of species. Except for these studies we also collected the beetles with using the same method as preliminary or verificative studies. Our large collection may provide a useful reference for future studies aiming to better understand habitat quality of forests using dung beetles as indicators, particularly in lowland of East Kalimantan where our studies were carried out. Thus, here we have listed the dung beetles collected in our studies, and showed the numbers of beetles collected by the traps with different baits and the numbers in each vegetation type.

Methods

Study sites

We collected dung beetles at 30 sites (Table 1 and Fig. 1), located 10–40 km north of Balikpapan, lowland of East Kalimantan, Indonesia. The study area included two large intact natural forests: one was the Sungai Wain Protection Forest (SWPF) and the other was the Bukit Bangkirai Forest (BBF) (Fig. 1). These areas have not been logged in the last 50 years but SWPF was burned in 1993 and 1998 but left some adjacent remnants on the north-eastern area (Taylor et al. 1999, Yamaguchi and Tsuyuki 2001) (Fig. 1). We selected three sites inside the intact forests (vegetation type: CNF) and two sites near the edges (ENF) in the two forest reserves (Table 1 and Fig. 1). We also selected two sites at the lightly burned area including remnants (BNF) in SWPF (Table 1 and Fig. 1).

Outside of the two forest reserves, we selected four anthropogenic-destroyed forests (secondary forests) near villages (SCF) as study sites (Table 1 and Fig. 1). We also selected ten *Acacia mangium* plantations (PLF) as study sites to examine the habitat preference of the beetle (Table 1 and Fig. 1) because *A. mangium* is one of the most popular fast-growing tree species used for plantations in anthropogenic areas of tropical Asia and has been planted widely in the study area. Each plantation except for P12 and P38 was paired with another study site in the *Imperata cylindrica* (local name 'rumput alang-alang') grassland next to the plantation, and each grassland site (GRS) was 100–300 m away from the edge of the plantation. *Imperata cylindrica* grassland is widespread in post slash-burn agriculture areas (post-deforested, burned areas) of tropical Asia. Surveys were also conducted in one cattle pasture (CPS) beside the *A. mangium* plantation of site P12 to compare with the grassland sites (GRS) (Table 1 and Fig. 1).

Collection of dung beetles

Baited and flight intercepting pitfall traps that catch a larger number of species of dung beetles than normal baited pitfall traps (Ueda et al. 2015a) were used to collect the beetles.

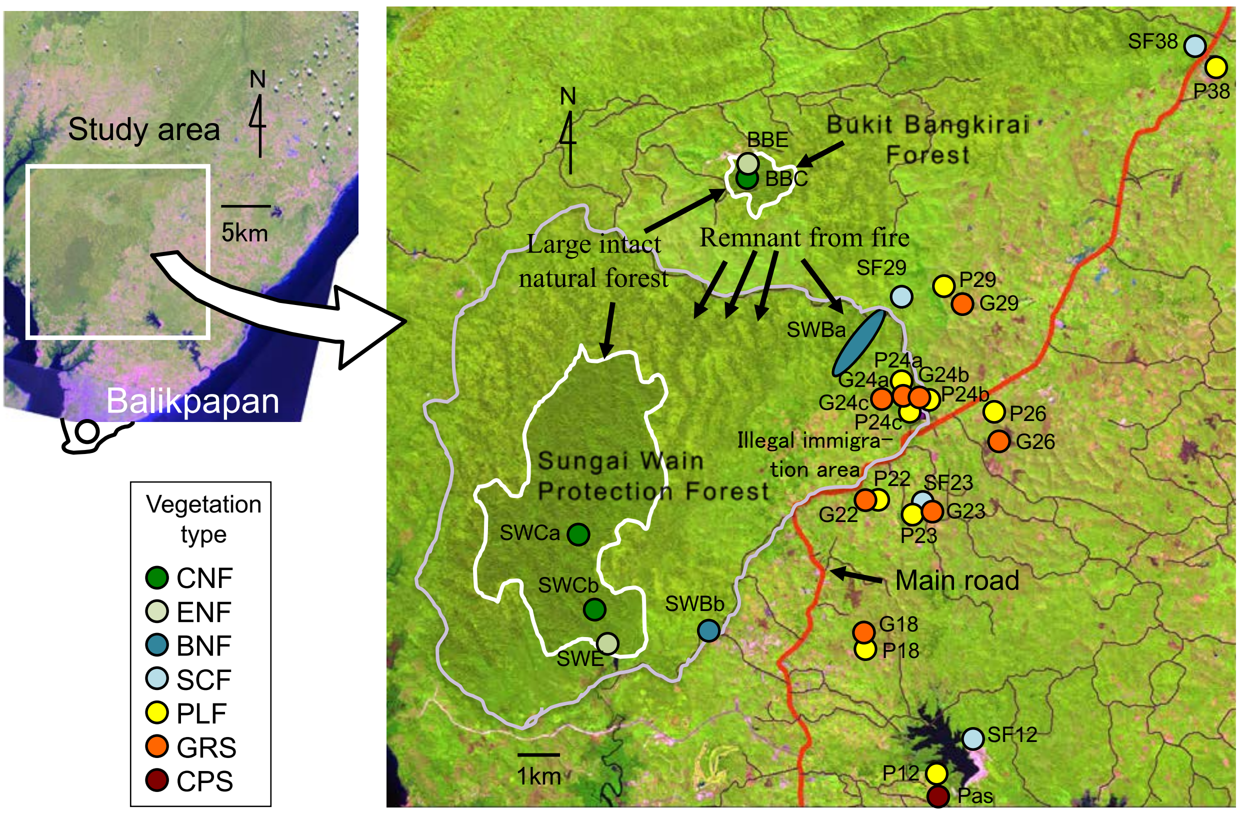

Fig. 1 Location of study sites.
Refer Table 1 for site names and categories of vegetation. The 'SPOTS5' satellite took this picture at 2:27:04 (GMT) on 19 June, 2005.

Table 1. Vegetation type, location, collection period, and number of installed trap-transensects in each site in each year

Site[a]	Vegetation type[b]	Latitude	Longitude	Asl. (m)	Collection period	No. trap-transects[c]	Note
SWCa	CNF	S 1° 06' 50	E 116° 49' 40	32	15-20 Dec. 2007	1	Near Camp 2 of SWPF. Data from Ueda et al. (2015b)
SWCb	CNF	S 1° 07' 52	E 116° 49' 53	50	16-21 Dec, 2006	1	Near Camp 1 of SWPF. Data in 2006 and 2007 from Ueda et al. (2015b)
					20-25 Dec. 2007	1	
					9-14 Dec. 2008	1	
BBC	CNF	S 1° 01' 47	E 116° 51' 58	88	13-18 Dec. 2007	1	Center of BBF. Data from Ueda et al. (2015b)
SWE	ENF	S 1° 08' 21	E 116° 50' 06	40	16-21 Dec. 2006	1	Near entrance of a trail of SWPF. Data in 2006 and on 20-25 Dec. 2007 from Ueda et al. (2015b)
					14-19 and 20-25 Dec. 2007	2	
					5-10 and 10-15 Dec. 2008	2	
BBE	ENF	S 1° 01' 35	E 116° 51' 59	55	13-18 Dec. 2007	1	Near entrance of a trail of BBF. Data from Ueda et al. (2015b)
SWBa	BNF	S 1° 03' 43	E 116° 53' 19	30	17 -22 and 22-27 Dec. 2006	5	Near POS 2 of SWPF. Data on 22-27 Dec. 2006 from Ueda et al. (2015b) and in 2007 from Ueda et al. (2015d) in part.
		~	~	~	19-24 Dec. 2007	6	
		S 1° 04' 32	E 116° 53' 56	80	5 -10 and 6-11 Dec, 2008	7	
SWBb	BNF	S 1° 08' 09	E 116° 51' 29	40	4-9 Dec. 2008	1	In the Sungai Wain Botanical Garden
SF12	SCF	S 1° 09' 44	E 116° 55' 09	29	15-20 Dec. 2007	1	Forest with heavy anthropogenic disturbance near villages
SF23	SCF	S 1° 06' 29	E 116° 54' 20	37	17-22 Dec. 2007	1	Forest along a stream in a village. Data from Ueda et al. (2015c)
SF29	SCF	S 1° 03' 34	E 116° 54' 10	42	18-23 Dec, 2006	1	Heavily burned forest near a village. Data from Ueda et al. (2015d)
SF38	SCF	S 1° 00' 03	E 116° 58' 20	21	16-21 Dec. 2007	1	Forest along a stream in a village
P12	PLF	S 1° 10' 10	E 116° 54' 41	26	23-28 Dec, 2006	1	Beside SF12. Data from Ueda et al. (2015b)
					15-20 Dec. 2007	1	
P18	PLF	S 1° 08' 21	E 116° 53' 39	36	19-24 Dec. 2006	1	Data from Ueda et al. (2015b)
P22	PLF	S 1° 06' 21	E 116° 53' 47	56	19-24 Dec. 2006	1	Data from Ueda et al. (2015b)
P23	PLF	S 1° 06' 30	E 116° 54' 20	35	19-24 Dec. 2006	1	Beside SF23. Data in 2006 and 2007 from Ueda et al. (2015b, c)
					17-22 Dec. 2007	1	
					6-11 Dec. 2008	1	
P24a	PLF	S 1° 04' 46	E 116° 54' 11	48	17-22 Dec. 2006	1	Data from Ueda et al. (2015b)
P24b	PLF	S 1° 05' 09	E 116° 54' 27	73	17-22 Dec. 2006	1	
P24c	PLF	S 1° 05' 04	E 116° 54' 30	77	7-12 Dec. 2008	1	
P26	PLF	S 1° 05' 05	E 116° 55' 28	46	23-28 Dec, 2006	1	Data from Ueda et al. (2015b)
P29	PLF	S 1° 03' 20	E 116° 54' 45	60	18-23 Dec. 2006	1	Beside SF29. Data from Ueda et al. (2015b)
P38	PLF	S 1° 00' 11	E 116° 58' 30	20	16-21 Dec. 2007	1	Beside SF38
G18	GRS	S 1° 08' 13	E 116° 53' 39	36	19-24 Dec. 2006	1	Beside P18. Data from Ueda et al. (2015b)
G22	GRS	S 1° 06' 23	E 116° 53' 37	67	19-24 Dec. 2006	1	Beside P22. Data from Ueda et al. (2015b)
G23	GRS	S 1° 06' 28	E 116° 54' 28	53	19-24 Dec. 2006	1	Beside SF23 and P23. Data in 2006 and 2007 from Ueda et al. (2015b, c)
					17-22 Dec. 2007	3	
					6-11 Dec. 2008	1	
G24a	GRS	S 1° 04' 56	E 116° 54' 14	40	17-22 Dec, 2006	1	Beside P24a. Data from Ueda et al. (2015b)
G24b	GRS	S 1° 05' 01	E 116° 54' 28	69	17-22 Dec. 2006	1	Beside P24b
G24c	GRS	S 1° 04' 52	E 116° 53' 50	59	7-12 Dec. 2008	1	Beside P24c
G26	GRS	S 1° 05' 34	E 116° 55' 33	46	23-28 Dec, 2006	1	Beside P26. Data from Ueda et al. (2015b)
G29	GRS	S 1° 03' 34	E 116° 55' 01	60	18-23 Dec, 2006	1	Beside P29. Data from Ueda et al. (2015b)
Pas	CPS	S 1° 10' 29	E 116° 54' 39	26	23-28 Dec, 2006	1	Beside P12. Data in 2006 and 2007 from Ueda et al. (2015b)
					21-26 Dec, 2007	1	
					7-12 Dec. 2008	1	

[a]SW: Site in the Sungai Wain Forest Reserve (SWPF). C: More than 0.5 km inside from edge of unburnt area of the forest reserves. BB: Site in the Bukit Bangkilai Forest (BBF). E: Near edge of unburnt area of the forest reserves.. B: Burned area of the forest reserve. SF: Anthropogenic-destroyed forest (secondary forest) near a village. P: *Acasia mangium* forest plantation estimated 5-11 years old. G: *Imperata cylindrica* grassland. Pas: Cattle pasture. The number of each site indicates the approximate km point of the junction on the main road used to access the site from Balikpapan to Samarinda.

[b]CNF: Center of natural forest, ENF: Edge of natural forest, BNF: Burned natural forest, SCF: Secondary forest, PLF: Plantation forest, GRS: Grassland, CPS: Cattle pasture.

[c]One trap-transect contained 5 human excrement baited traps and 5 fish meat baited traps set alternately with 10 m intervals on the 90 m line.

A plastic cup (8.4 cm in open diameter, 5.6 cm in minimum diameter, and 12.2-cm high) was driven into the ground with its opening level with the ground surface. Two B5-size transparent plastic sheets that crossed each other were then placed over the cup, upon which a plastic bowl (ceiling: 20 cm in diameter and 5-cm high) was placed upside down. Each trap contained a 50-ml glass bottle (4.3 cm in diameter and 8.0-cm high) with a perforated lid (having six holes, each 5 mm in diameter), and was baited to attract beetles. Fresh human excrement (10 g) and raw jack fish (30 g) were used as bait because these baits attract large numbers of species and individuals of dung beetles (Ueda et al. 2015a). A cut nylon net (with a 0.5-mm mesh) was placed between the lid and bottle to prevent small beetles from entering. The traps also contained a 30% solution of propylene glycol to kill and preserve the beetles collected. At all sites ten traps distributed along a 90-m transect at intervals of 10 m, alternating human excrement and raw fish as the attractant were set in the morning during the month of December 2006, 2007 and/or 2008 (Table 1). The captured insects were collected five days after trap installation (Table 1).

Identification and storage of specimen

All beetles captured in the present study were dried on absorbent cotton and identified with using a binocular microscope (Nikon Nature Scope). Some beetles were pinned and sent to Japan for identification. All beetles are stored in the insect specimen room of the Research Center for Biology, the Indonesian Institute of Science (LIPI), Cibinong, Indonesia.

Data analysis

Since females of two *Catharsius* species, *C. dayacus* and *C. renaudpauliani*, were difficult to distinguish each other, data of *Catharsius* female was treated as *Catharsius* spp.

To indicate the relationships between diet or habitat preference and the distribution ranges of the beetles, we categorized their distributions into 5 ranges; Bornean endemic, Sundaland (Borneo + Malay Peninsula, Sumatra, Java, and/or Palawan), Sundaland and Indochina ('Sundaland' + Thailand, Laos, Cambodia, and/or Vietnam), Southeast Asia ('Sundaland and Indochina' + Myanmar, Philippines and/or Sulawesi), and large area ('Southeast Asia' + India, Taiwan, China, Japan, New Guinea, and/or Australia). For the distribution ranges, we referred Balthasar (1963a, b), Zunino (1976), Krikken (1977), Ochi and Kon (1995, 1996, 2006a, b, 2014), Ochi (2006), Ochi et al. (2006, 2008, 2009), Masumoto et al. (2008a, b), Zidek and Pokorny (2010), Hosaka et al. (2013), and Li et al. (2013).

Results and discussion

A total of 65 species and 8,073 individuals of dung beetles were collected (Table 2 and 3). In 44 species that were collected more than 5 individuals, all species were collected by the traps baited with both human excrement and fish meat at least one individual, with the exception of three species (*Catharsius renaudpauliani, Caccobius binodulus,* and *Onthophagus (Pseudophanaeomophus) chandrai*) (Table 3). In 8 of the 44 species, total catches did not exceed 70% in either of the two bait types (Table 3). This result suggests that most of dung beetles in lowland of East Kalimantan are lured by odor from both dung and carrion. This sort of wide diet preference is also seen on the dung beetles on Sulawesi Island and Madagascar Island (Hanski and Krikken, 1991, Roslin and Viljanen 2011).

The number of beetles collected by human excrement baited traps was three times larger than that by fish baited traps (Table 4). This difference largely depended on the data from grassland (GRS) and cattle pasture (CPS) where rates of beetles collected by fish baited traps were very low (Table 4). This result suggests that dung beetles in open environments mainly feed on dung but those in forests utilize both dung and carrion. Regarding the relationships between the distribution ranges and the diet preferences, five of 8 species that did not exceed 70% in either of the two bait types in their total catches were Bornean endemic species, while species that exceeded 70 % did not tend to skew towards any particular distribution range (Table 5). This suggests that some Bornean endemic species have a wide host ranges whereas most species with wider distributions have narrow host ranges.

With respect to vegetation type, in the 44 species, 36 species were abundant in the forest reserves (CNF, ENF, and/or BNF). Two of the 36 species, *Microcopris fujiokai* and *Caccobius binodulus*, were collected only at CNF sites (Table 3) and it is expected that their main habitats are deep inside of intact natural forests. The species abundant in the unburned natural forests (CNF and/or ENF) were mostly seen in the lightly burned natural forests (BNF) but were rarely collected outside of the forest reserves (SCF, PLF, GRS, and CPS), with the exception of 7 species (*Bolbochromus catenatus, Panelus kalimantanicus, Parascatonomus semiaureus, Parascatonomus semicupreus, Proagoderus schwaneri, Onthophagus (Gibbonthophagus) obscurior,* and *Onthophagus (Onthophagus) waterstradti*). Five of the 7 species (*B. catenatus, P. semiaureus, P. semicupreus, P. schwaneri,* and *O. (O.) waterstradti*) were abundant in both destroyed forests (SCF) and/or plantation forests (PLF) (Table 3). These five species are likely to have wide habitat preferences in variety of forest types. *P. kalimantanicus*, one of the another 2 species that were seen in both forest and open environments, was relatively abundant in disturbed areas (i.e., SCF, PLF, GRS, and CPS), whereas *O. (G.) obscurior* was mainly abundant in forest environments (Table 3). Whatever happens, these two species may have only a weak habitat preference.

Table 2. Number of beetles collected in each yaer at each site

Vegetation type in Table 1	CNF					ENF				BNF				SCF				PL													GRS										CPS		
Site in Table 1	SWCa	SWCb			BBC	SWE			BBE	SWBa			SWBb	SF12	SF23	SF29	SF38	P12		P18	P22	P23			P24a	P24b	P24c	P26	P29	P38	G18	G22	G23			G24a	G24b	G24c	G26	G29	Pas		
Year (in December)	'07	'06	'07	'08	'07	'06	'07	'08	'07	'06	'07	'08	'08	'07	'07	'06	'07	'06	'07	'06	'06	'06	'07	'08	'06	'06	'08	'06	'06	'07	'06	'06	'06	'07	'08	'06	'06	'08	'06	'06	'06	'07	'08
Number of trap-transect set	1	1	1	1	1	1	2	2	1	5	6	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	3	1	1	1	1	1	1	1	1	1
Bolbochromus catenatus (Lansberge, 1886)	0	0	0	0	0	1	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phaeocrous emarginatus Castelnau, 1840	2	0	0	0	0	0	0	0	8	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phaeocroops sp.	6	0	2	22	0	3	1	1	0	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ochicanton simboroni Ochi et Kon, 2006	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ochicanton uedai Ochi, Kon et Hartini, 2007	0	1	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ochicanton woroae Ochi, Ueda et Kon, 2006	0	1	0	0	0	0	1	10	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Panelus kalimantanicus Ochi, Kon et Barclay, 2009	2	0	0	0	0	0	0	0	2	0	0	2	0	1	1	3	1	0	0	0	0	0	0	0	2	1	0	0	8	0	2	2	5	5	1	2	1	0	1	0	0	2	0
Panelus sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haroldius sumatranus Paulian et Scheuern, 1994	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paragymnopleurus maurus (Sharp, 1875)	41	5	87	16	29	1	14	26	19	36	327	13	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paragymnopleurus striatus (Sharp, 1875)	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sisyphus thoracicus Sharp, 1875	29	35	13	3	14	15	13	7	6	167	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synapsis ritsemae Lansberge, 1874	2	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Catharsius dayacus Lansberge, 1886 (male)	2	2	5	1	3	4	6	1	6	16	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Catharsius renaudpauliani Ochi et Kon, 1996 (male)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7	6	1	0	0	0	8	1	13	1	0	8	3	4	0	0	0	0	1	0	0	0	1	1	1	0	1	1	0
Catharsius spp. (female)	4	1	5	2	3	2	2	1	8	7	8	3	0	0	9	6	0	5	0	2	6	0	6	4	2	11	3	5	3	1	0	0	0	0	0	2	1	1	3	1	2	1	0
Copris agnus Sharp, 1875	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copris gibbulus Lansberge, 1886	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microcopris fujiokai Ochi et Kon, 1996	1	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oniticellus cinctus (Fabricius, 1775)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Oniticellus tesselatus (Harold, 1879)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Caccobius binodulus Harold, 1877	1	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caccobius unicornis (Fabricius, 1798)	0	0	0	0	0	0	0	0	0	4	0	0	0	0	9	9	0	6	0	11	0	20	1	0	12	119	0	16	10	0	28	42	15	19	0	45	109	30	36	3	93	32	0
Parascatonomus aurifex (Harold, 1877)	0	0	0	1	3	1	1	4	6	3	7	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Parascatonomus dux (Sharp, 1875)	16	6	18	3	21	6	15	1	21	26	56	7	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parascatonomus rudis (Sharp, 1875)	0	0	0	0	0	2	0	0	1	7	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parascatonomus semiaureus (Lansberge, 1883)	0	0	1	0	6	9	4	6	8	5	19	2	0	1	0	0	2	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Parascatonomus semicupreus (Harold, 1877)	4	4	3	14	2	33	21	27	4	17	17	85	16	2	0	4	2	12	18	0	5	3	1	1	1	3	3	1	16	2	0	0	0	0	0	0	0	2	0	1	0	1	0
Parascatonomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Proagoderus schwaneri (Lansberge, 1864)	6	17	28	9	17	8	33	2	37	178	149	21	0	7	3	65	2	9	0	6	7	1	2	0	12	26	3	0	150	2	0	0	0	0	0	10	13	5	0	1	1	1	0
Onthophagus (Gibbonthophagus) cervicapra Boucomont, 1914	4	13	22	3	0	0	3	7	0	19	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Gibbonthophagus) fujiii Ochi et Kon, 1995	1	1	0	1	0	6	3	4	0	12	9	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Gibbonthophagus) limbatus (Herbst, 1789)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	26	2	0	0	88	0	7	0	0	10	13	13	29	1	15	7	53	19	2	447	618	1
Onthophagus (Gibbonthophagus) obscurior Boucomont, 1914	0	3	0	0	0	3	7	3	2	20	5	0	0	3	0	4	0	0	0	0	2	0	2	0	0	3	0	2	4	1	0	0	0	0	0	0	0	0	0	0	0	7	0
Onthophagus (Serrophorus) laevis Harold, 1880	3	3	3	1	3	0	2	0	3	5	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Serrophorus) mulleri Lansberge, 1883	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Serrophorus) sagittarius (Fabricius, 1775)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Onthophagus (Indachorius) uedai Ochi et Kon, 2006	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	0	1	0	0	9	8	4	28	3	2	13	3	12	0	0	3	0
Onthophagus (Indachorius) woroae Ochi et Kon, 2006	0	0	3	1	1	1	0	1	0	2	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Indachorius) sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Pseudophanaeomophus) chandrai Ochi, 2006	2	0	1	4	0	0	0	6	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Pseudophanaeomophus) sugihartoi Ochi, 2006	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Furconthophagus) lilliputanus Lansberge, 1883	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	2	10	0	0	0	0	27	38	39	127	10	16	48	19	131	2	1	12	0
Onthophagus (Furconthophagus) papulatus Boucomont, 1914	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	13	54	0	458	38	9
Onthophagus (Onthophagiellus) crassicollis Boucomont, 1913	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagiellus) hidakai Ochi et Kon, 1995	0	1	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Colobonthophagus) armatus Blanchard. 1853	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Onthophagus (Paraphanaeomorphus) trituber (Widemann, 1823)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	3	0	5	0	4	2	1	1	44	2	10	0	0	11	119	14	42	7	9	15	79	39	13	349	153	50
Onthophagus (Hikidaeus) pastillatus Boucomont, 1914	12	8	2	7	0	1	1	13	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Hikidaeus) simboroni Ochi et Kon, 2006	3	0	1	0	1	0	4	1	1	4	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) aphodioides Lansberge, 1883	1	0	2	0	5	0	3	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) batillifer Harold, 1875	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) bonorae Zunino, 1976	1	0	1	1	3	2	1	47	1	8	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) borneensis Harold, 1877	3	2	2	2	0	1	4	10	0	1	0	0	0	1	0	0	0	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) incisus Harold, 1877	1	2	1	0	0	6	14	1	3	3	22	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) infucatus Harold, 1877	0	0	0	0	5	0	0	0	4	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) keikoae Ochi et Kon, 2014	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) ochromerus Harold, 1877	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) pacificus Lansberge, 1885	0	1	1	2	0	1	0	0	1	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) pavidus Harold, 1877	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) rutilans Sharp, 1875	0	0	0	0	14	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) semipacificus Ochi et Kon, 2006	0	0	0	2	10	0	0	1	8	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) vulpes Harold, 1877	10	9	7	6	9	5	23	6	12	9	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onthophagus (Onthophagus) waterstradti Boucomont, 1914	0	7	12	5	6	4	16	14	0	41	9	16	0	18	0	0	14	7	1	5	11	0	0	0	2	8	18	0	4	1	0	0	0	0	0	0	0	3	6	0	0	0	0
Aphodius marginellus (Fabricius, 1781)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	8	41
Aphodius sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

Table 3. Distribution range, number of beetles collected at each bait in 3 years, and number of beetles collected per trap transect at each vegetation type

Species name	Distri -bution range[a]	Number of beetles collected at each bait in 3 years				Number of beetles collected per trap transect at each vegetation type in 3 years						
		Human excre.	Fish meat	Total	% fish	CNF	ENF	BNF	SCF	PLF	GRS	CPS
Bolbochromus catenatus	Sunda.	5	1	6	16.7	-	0.2	0.2	0.3	-	-	-
Phaeocrous emarginatus	Large A.	4	10	14	71.4	0.4	1.3	0.1	0.5	-	-	-
Phaeocroops sp.	-	2	40	42	95.2	6.0	0.8	0.4	-	-	-	-
Ochicanton simboroni	Borneo	0	1	1	100	-	-	0.1	-	-	-	-
Ochicanton uedai	Borneo	6	1	7	14.3	0.2	-	0.3	-	-	-	-
Ochicanton woroae	Borneo	13	2	15	13.3	0.2	1.8	0.2	-	-	-	-
Panelus kalimantanicus	Borneo	29	15	44	34.1	0.4	0.3	0.1	1.5	0.7	1.6	0.7
Panelus sp.	-	1	0	1	0	0.2	-	-	-	-	-	-
Haroldius sumatranus	Sunda.	0	1	1	100	0.2	-	-	-	-	-	-
Paragymnopleurus maurus	Sunda.	595	23	618	3.7	35.6	10.0	19.8	-	0.3	-	-
Paragymnopleurus striatus	Sunda.	2	0	2	0	0.4	-	-	-	-	-	-
Sisyphus thoracicus	Indoch.	310	26	336	7.7	18.8	6.8	10.6	-	-	-	-
Synapsis ritsemae	Sunda.	4	0	4	0	0.6	0.2	-	-	-	-	-
Catharsius dayacus (male)	Borneo	53	6	59	10.2	2.6	2.8	1.5	-	-	-	-
Catharsius renaudpauliani (male)	Sunda.	59	0	59	0	-	-	0.1	3.5	2.5	0.3	0.7
Catharsius spp. (female)	-	108	12	120	10.0	3.0	2.2	0.9	3.8	3.2	0.7	1.0
Copris agnus	Indoch.	1	0	1	0	-	0.2	-	-	-	-	-
Copris gibbulus	Sunda.	0	1	1	100	0.2	-	-	-	-	-	-
Microcopris fujiokai	Borneo	8	3	11	27.3	2.2	-	-	-	-	-	-
Oniticellus cinctus	Large A.	0	1	1	100	-	-	-	-	-	-	0.3
Oniticellus tesselatus	Sunda.	1	1	2	50.0	-	-	-	-	-	-	0.7
Caccobius binodulus	Borneo	6	0	6	0	1.2	-	-	-	-	-	-
Caccobius unicornis	Large A.	599	70	669	10.5	-	-	0.2	4.5	13.0	27.3	41.7
Parascatonomus aurifex	Borneo	10	18	28	64.3	0.8	2.0	0.5	-	0.1	0.1	-
Parascatonomus dux	Borneo	22	177	199	88.9	12.8	7.2	4.7	0.5	0.1	-	-
Parascatonomus rudis	Large A.	2	23	25	92.0	-	0.5	1.1	0.3	-	-	-
Parascatonomus semiaureus	Sunda.	15	61	76	80.3	1.4	4.5	1.4	0.8	0.7	0.3	-
Parascatonomus semicupreus	Sunda.	62	263	325	80.9	5.4	14.2	7.1	2.0	4.4	0.3	0.3
Parascatonomus sp.	-	1	0	1	100	-	-	-	-	-	0.1	-
Proagoderus schwaneri	Sunda.	542	289	831	34.8	15.4	13.3	18.3	19.3	14.5	2.4	0.7
Onthophagus (Gibbonthophagus) cervicapra	Sunda.	77	18	95	18.9	8.4	1.7	1.8	-	0.6	-	-
Onthophagus (Gibbonthophagus) fujiii	Borneo	24	20	44	45.5	0.6	2.2	1.1	0.5	0.3	-	-
Onthophagus (Gibbonthophagus) limbatus	Large A.	1199	157	1356	11.6	-	-	-	0.5	8.4	13.5	355.3
Onthophagus (Gibbonthophagus) obscurior	Indoch.	40	31	71	43.7	0.6	2.5	1.3	1.8	0.9	-	2.3
Onthophagus (Serrophorus) laevis	Large A.	40	5	45	11.1	2.6	0.8	1.4	-	-	-	-
Onthophagus (Serrophorus) mulleri	Sunda.	3	1	4	25.0	-	0.5	-	0.3	-	-	-
Onthophagus (Serrophorus) sagittarius	Large A.	1	1	2	50.0	-	-	0.1	-	-	-	0.3
Onthophagus (Indachorius) uedai	Borneo	62	37	99	37.4	-	-	0.3	-	0.6	6.8	1.0
Onthophagus (Indachorius) woroae	Borneo	6	10	16	62.5	1.0	0.3	0.5	-	-	-	-
Onthophagus (Indachorius) sp.	-	0	1	1	100	-	-	0.1	-	-	-	-
Onthophagus (Pseudophanaeomophus) chandrai	Borneo	0	16	16	100	1.4	1.0	0.2	-	-	-	-
Onthophagus (Pseudophanaeomophus) sugihartoi	Borneo	1	0	1	0	-	0.2	-	-	-	-	-
Onthophagus (Furconthophagus) lilliputanus	SE. A.	440	58	498	11.6	-	-	-	4.0	0.8	38.1	4.3
Onthophagus (Furconthophagus) papulatus	Indoch.	526	50	576	8.7	-	-	-	0.3	-	5.8	168.3
Onthophagus (Onthophagiellus) crassicollis	Large A.	2	1	3	33.3	-	-	0.2	-	-	-	-
Onthophagus (Onthophagiellus) hidakai	Indoch.	4	1	5	20.0	0.2	0.2	0.2	-	-	-	-
Onthophagus (Colobonthophagus) armatus	SE. A.	1	0	1	0	-	-	-	-	-	0.1	-
Onthophagus (Paraphanaeomorphus) trituber	Large A.	853	133	986	13.5	-	-	-	3.5	4.8	29.0	184.0
Onthophagus (Hikidaeus) pastillatus	SE. A.	28	21	49	42.9	5.8	2.5	0.3	-	-	-	-
Onthophagus (Hikidaeus) simboroni	Borneo	18	2	20	10.0	1.0	1.0	0.4	-	0.1	0.1	-
Onthophagus (Onthophagus) aphodioides	SE. A.	15	2	17	11.8	1.6	0.5	0.3	-	-	-	-
Onthophagus (Onthophagus) batillifer	Indoch.	1	1	2	50.0	0.2	-	0.1	-	-	-	-
Onthophagus (Onthophagus) bonorae	Indoch.	3	68	71	95.8	1.2	8.5	0.7	-	-	-	-
Onthophagus (Onthophagus) borneensis	Sunda.	31	1	32	3.1	1.8	2.5	0.1	0.3	0.4	-	-
Onthophagus (Onthophagus) incisus	Sunda.	51	4	55	7.3	0.8	4.0	1.3	0.3	0.1	-	-
Onthophagus (Onthophagus) infucatus	Indoch.	11	1	12	8.3	1.0	0.7	0.2	-	-	-	-
Onthophagus (Onthophagus) keikoae	Borneo	0	1	1	100	0.2	-	-	-	-	-	-
Onthophagus (Onthophagus) ochromerus	Borneo	0	1	1	100	-	0.2	-	-	-	-	-
Onthophagus (Onthophagus) pacificus	SE. A.	15	2	17	11.8	0.8	0.3	0.6	-	-	-	-
Onthophagus (Onthophagus) pavidus	Sunda.	1	0	1	0	-	0.2	-	-	-	-	-
Onthophagus (Onthophagus) rutilans	Large A.	16	2	18	11.1	2.8	0.5	-	-	0.1	-	-
Onthophagus (Onthophagus) semipacificus	Borneo	23	1	24	4.2	2.4	1.5	0.2	-	-	-	-
Onthophagus (Onthophagus) vulpes	SE. A.	126	4	130	3.1	8.2	7.7	2.3	-	-	-	-
Onthophagus (Onthophagus) waterstradti	Borneo	167	61	228	26.8	6.0	5.7	3.5	8.0	3.8	0.8	-
Aphodius marginellus	Large A.	1	68	69	98.6	-	-	-	-	-	-	23.0
Aphodius sp.	-	0	2	2	100	-	-	-	-	-	-	0.7

[a]Boeneo: Bornean endemic, Sunda.: Sundaland (Borneo + Malay Peninsula, Sumatra, Java, Borneo, and/or Palawan), Indoch.: Sundaland and Indochina (Sunda. + Thailand, Laos, Cambodia, and/or Vietnam), SE. A.: Southeast Asia (Indoch. + Myanmar, Philippines and/or Sulawesi), Large A.: Large area (SE. A. + India, Taiwan, China, Japan, New Guinea, and/or Australia)

Table 4. Total number of beetles collected by each bait at each vegetation type

Vegetation type	Number of trap-transects in 3 years	Bait		% collected by fish bait
		Human excrement	Fish meat	
CNF	5	587	196	25.0
ENF	6	395	285	41.9
BNF	19	1,124	476	29.8
SCF	4	133	91	40.6
PLF	15	664	241	26.6
GRS	12	1,272	253	16.6
CPS	3	2,071	285	12.1
Total	64	6,246	1,827	22.6

Table 5. Number of species that was collected more than 5 individuals in each range of collection rates by fish meat baited traps in their total catches

Distribution range	% of beetles collected by fish meat baited traps			Total
	< 30	30 - 70	> 70	
Bornean endemic	8	5	2	15
Sundaland	6	1	2	9
Sundaland and Indochina	4	1	1	6
Southeast Asia	4	1		5
Large area	5		3	8

Catharsius renaudpauliani was only one species that was expected to reside mainly in destroyed forests and plantation forests because the males of the species was largely collected in both SCF and PLF but rare in the forest reserves and open environments (Table 3). Males of another species of the genus *Catharsius*, that is *C. dayacus*, had only ever been seen in the forest reserves (CNF, ENF, and BNF) (Table 3). This result suggests that these two species segregate their habitats with level of disturbance although their females are difficult to distinguish each other with their morphologies.

Seven of the 44 species were abundant in open environments (GRS and/or CPS), and rarely collected in forests (Table 3). Two of the 7 species, *Onthophagus (Furconthophagus) lilliputanus* and *Onthophagus (Indachorius) uedai*, were abundant in the grassland (GRS) but few were found in the cattle pasture (CPS) (Table 3). Conversely, 3 species, *Onthophagus (Furconthophagus) papulatus, Onthophagus (Gibbonthophagus) limbatus*, and *Aphodius marginellus* were quite abundant in the cattle pasture (CPS) (Table 3).

Regarding the relationships between the distribution range and habitat preferences, many Bornean endemic species inhabit only natural forests, while many of Sundaland species inhabit a variety of forests including destroyed forests (SCF) and plantation forests (PLF) (Table 3). This suggests that the Sundaland species might have obtained their relatively wide distributions due to having plasticity in their habitat preferences. Many of open-land species (species abundant in GRS and/or CPS) are distributed outside Sundaland (Table 3). Some of these open-land species may enlarge their distributions artificially through introductions of livestock.

Abundance on each vegetation type and collection rates from fish meat baited traps of each species are summarized in Appendix table.

Acknowledgements

We wish to thank Kazuma Matsumoto (Tokyo), Hiroshi Makihara (FFPRI), Kaoru Maeto (Kobe University), Kenichi Ozaki (FFPRI) and Masato Ito (Sapporo) who advised us to conduct this study, Rob Johns (Atlantic Forestry Centre, Canadian Forest Service) who edited the manuscript, the late Herwint Simbolon (LIPI), Chandradewana Boer (Mulawarman University), Agusdin (SWPF), Agus (SWPF), and the people of Sungai Wain Village, who helped us to conduct the field work, and anonymous referees, who made comments that led to considerable improvement of the text. This study was supported by a grant from Japan's Ministry of the Environment (Environmental Research by National Research Institutes of Government Ministries and Agencies, 2004–2008), and from JSPS KAKENHI (Grant Number JP26304028).

References

Aguilar-Amuchastegui, N. and Henebry, G. M. (2007) Assessing sustainability indicators for tropical forests: Spatio-temporal heterogeneity, logging intensity, and dung beetle communities. For. Ecol. Manage., 253, 56–67.

Andresen, E. (2002) Dung beetles in a Central Amazonian rainforest and their ecological role as secondary seed dispersers. Ecol. Entomol., 27, 257–270.

Andresen, E. (2003) Effect of forest fragmentation on dung beetle communities and functional consequences for plant regeneration. Ecography, 26, 87–97.

Balthasar, V. (1963a) Monographie der Scarabaeidae und Aphodidae der palaearktischen und Orientalischen Region. Tschechoslowakische Akademie der Wissenschaften Prag, 1, 1-391.

Balthasar, V. (1963b) Monographie der Scarabaeidae und Aphodidae der palaearktischen und Orientalischen Region (Coprinae Onitini Oniticellini Onthophagini). Tschechoslowakische Akademie der Wissenschaften Prag, 2, 1-627.

Davis, A. L. V. (1996) Seasonal dung beetle activity and dung dispersal in selected South African habitats: implications for pasture improvement in Australia. Agri. Eco. Environ. 58, 157-169.

Enari, H. and Enari-Sakamaki, H. (2014) Synergistic effects of primates and dung beetles on soil seed accumulation in snow regions. Ecol. Res., 29, 653-660.

Enari, H., Koike, S. and Enari-Sakamaki, H. (2016) Ecological implications of mammal feces buried in snow through dung beetle activities. J. For. Res., 21, 92-98.

Gardner, T. A., Hernández, M. I. M., Barlow, J. and Peres, C. A. (2008a) Understanding the biodiversity consequences of habitat change: the value of secondary and plantation forests for neotropical dung beetles. J. Appl. Ecol., 45, 883–893.

Gardner T. A., Barlow J. and the other 22 authors (2008b) The cost-effectiveness of biodiversity surveys in tropical forests. Ecol. Lett., 11, 139-150.

Hanski, I. and Krikken, J. (1991) Dung beetles in tropical forests in South-East Asia. In Hanski, I. and Cambefort, Y. (eds.): Dung beetle ecology. Princeton Univ. Press, Princeton, p. 179-197.

Hosaka, T., Kon, M., Ochi, T., Okuda, T., Yamada, T., Butod, E. and Kirton, L. G. (2013) Responses of dung beetles to logging under selective management system in Peninsular Malaysia. Malay. Nat. J., 65, 54-60.

Krikken, J. (1977) Some new and otherwise noteworthy species of *Onthophagus* Latreille from the Indo-Australian archipelago (Coleoptera: Scarabaeidae). Zoologische Mededelingen, 52, 169-184.

Kryger, U. (2009) Importance of dung beetles in ecosystems. In Scholtz, C. H., Davis, A. L. V. and Kryger, U. (eds): Evolutionary biology and conservation of dung beetles. Pensoft, Sofia, p. 389-412.

Larsen, T. H., Williams, N. M. and Kremen, C. (2005) Extinction order and altered community structure rapidly disrupt ecosystem functioning. Ecol. Lett., 8, 538-547.

Li, C.-L., Yang, P.-S., Krikken, J. and Wang, C.-C. (2013) Three new species of *Bolbochromus* Boucomont (Coleoptera, Geotrupidae, Bolboceratinae) from Southeast Asia. Zookeys, 290, 39-54.

Masumoto K., Ochi, T. and Hanboonsong, Y. (2008a) New species of the genus *Onthophagus* from Thailand. Part 3. Entomol. Rev. Jap., 63, 43-55.

Masumoto K., Ochi, T. and Hanboonsong, Y. (2008b) New species of the genus *Onthophagus* from Thailand. Part 4. Entomol. Rev. Jap., 63, 155-169.

McGeoch, M. A. , Rensburg, B. J. V., and Botes, A. (2002) The verification and application of bioindicators: a case study of dung beetles in a savanna ecosystem. J. Appl. Ecol., 39, 661–672.

Nichols, E. S. and Gardner, T. A. (2011) Dung beetles as a candidate study taxon in applied biodiversity conservation research. In Simmons, L. W. and Ridsdill-Smith, T. J. (eds): Ecology and evolution of dung beetles. Wiley-Blackwell, West Sussex, p. 267-291.

Nichols, E., Larsen, T., Spector, S., Davis, A. L., Escobar, F., Favila, M., Vulinec, K. and The Scarabaeinae Research Network (2007) Global dung beetle response to tropical forest modification and fragmentation: A quantitative literature review and meta-analysis. Biol. Conserv., 137, 1–19.

Nichols, E., Spector, S., Louzada, J., Larsen, T., Amezquita, S., Favila, M. E. and The Scarabaeinae Research Network (2008) Ecological functions and ecosystem services provided by Scarabaeinae dung beetles. Biol. Conserv., 141, 1461–1474.

Ochi, T. (2006) Notes on the coprophagous scarab-beetles (Coleoptera, Scarabaeidae) from Southeast Asia (XIV). A new subgenus and four new species of *Onthophagus* from Borneo. Entomol. Rev. Jap., 62, 91-102.

Ochi, T. and Kon, M. (1995) Dung beetles (Coleoptera, Scarabaeoidae) collected from Sabah, Borneo (II). Elytra, Tokyo, 23, 43-60.

Ochi, T. and Kon, M. (1996) Studies on the coprophagous scarab beetles from East Asia. IV (Coleoptera, Scarabaeidae). Giornale italiano di Entomologia, 8, 17-28.

Ochi, T. and Kon, M. (2006a) Notes on the coprophagous scarab-beetles (Coleoptera, Scarabaeidae) from Southeast Asia (XII). Six new species of *Onthophagus (Indachorius)* from Borneo. Entomol. Rev. Jap., 61, 169-180.

Ochi, T. and Kon, M. (2006b) Notes on the coprophagous scarab-beetles (Coleoptera, Scarabaeidae) from Southeast Asia (XIII). Seven new species of *Onthophagus (Onthophagus)* from Borneo. Entomol. Rev. Jap., 61, 181-194.

Ochi, T. and Kon, M. (2014) Notes on the coprophagous scarab-beetles (Coleoptera, Scarabaeidae) from Southeast Asia (XXIV). Four new species of *Onthophagus* from Malaysia. Jap. J. System. Entomol., 20, 341-346.

Ochi, T., Ueda, A. and Kon, M. (2006) *Ochicanthon* (Coleoptera, Scarabaeidae) from Borneo, with descriptions of four new species and a key to the Bornean species. Elytra, Tokyo, 34, 309-325.

Ochi, T., Kon, M. and Hartini, S. (2008) Three new species of the genus *Ochicanthon* (Coleoptera: Scarabaeidae) from Java and Borneo. Entomol. Rev. Jap., 62, 243-253.

Ochi, T., Kon, M. and Barclay, M. V. L. (2009) Notes on the coprophagous scarab-beetles (Coleoptera, Scarabaeidae) from Southeast Asia (XXII). A new species of *Haroldius* and four new species of *Panelus* from Borneo. Entomol. Rev. Jap., 64, 237-246.

Ridsdill-Smith, T. J. and Edwards, P. B. (2011) Biological control: ecosystem functions provided by dung beetles. In Simmons, L. W. and Ridsdill-Smith, T. J. (eds): Ecology and evolution of dung beetles. Wiley-Blackwell, West Sussex, p. 245-266.

Roslin, T. and Viljanen, H. (2011) Dung beetle populations: structure and consequences. In Simmons, L. W. and Ridsdill-Smith, T. J. (eds): Ecology and evolution of dung beetles. Wiley-Blackwell, West Sussex, p. 220-244.

Slade, E. M., Mann, D. J., Villanueva, J. F. and Lewis, O. T. (2007) Experimental evidence for the effects of dung beetle functional group richness and composition on ecosystem function in a tropical forest. J. Animal Ecol., 76, 1094-1104.

Slade, E. M., Mann, D. J. and Lewis, O. T. (2011) Biodiversity and ecosystem function of tropical forest dung beetles under constractiong logging regimes. Biol. Conserv., 144, 166-174.

Spector, S. (2006) Scarabaeine dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae): An invertebrate focal taxon for biodiversity research and conservation. Coleo. Bull., 60, 71-83.

Taylor, D., Saksena, P., Sanderson, P. G. and Kucera, K. (1999) Environmental change and rain forests on the Sunda shelf of Southeast Asia: drought, fire and the biological cooling of biodiversity hotspots. Biodiv. Conserv., 8, 1159-1177.

Ueda, A., Dwibadra, D., Noerdjito, W. A., Kon, M. and Fukuyama, K. (2015a) Comparison of baits and types of pitfall traps for capturing dung and carrion scarabaeid beetles in East Kalimantan. Bull. For. Forest Prod. Res. Inst., 14, 15-28.

Ueda, A., Dwibadra, D., Noerdjito, W. A., Sugiarto, Kon, M., Ochi, T., Takahashi, M. and Fukuyama, K. (2015b) Effect of habitat transformation from grassland to *Acacia mangium* plantation on dung beetle assemblage in East Kalimantan, Indonesia. J. Insect Conserv., 19, 765-780.

Ueda, A., Dwibadra, D., Noerdjito, W. A., Sugiarto, Kon, M., Ochi, T., Takahashi, M., Igarashi, T. and Fukuyama, K. (2015c) Buffer zones for placing baited traps in grasslands bordering forests and availability of riparian reserves of trees in grasslands: A preliminary study for dung beetle assemblages in East Kalimantan, Indonesia. Bull. For. Forest Prod. Res. Inst., 14, 125-134.

Ueda, A., Dwibadra, D., Noerdjito, W. A., Sugiarto, Kon, M., Ochi, T., Takahashi, M., Igarashi, T. and Fukuyama, K. (2015d) Effects of distance from devastated forests and topography on dung beetle assemblages in burned forests of East Kalimantan, Indonesia. Bull. For. Forest Prod. Res. Inst., 14, 135-144.

Yamaguchi, T. and Tsuyuki, S. (2001) Assessment of forest fire in East Kalimantan. Indonesia, based on remote sensing and GIS. Bull. Tokyo Univ. For., 106, 17-48 (in Japanese with English summary).

Zidek, J. and Pokorny, S. (2010) Review of *Synapsis* Bates, with description of a new species. Insecta Mundi, 142, 1-21.

Zunino, M. (1976) Revisione delle species paleartiche del sottogenere *Onthophagus* (sensu stricto) Latr. In Btes, H. W., Fairmaire, L., Harold, E. V., Lansberge, G. V., Marseul, S. A. D., Reiche, L. and Sharp, D. (eds.): Muséum National d'Histoire Naturelle di Parigi. Boll. Mus. Zool. Univ. Torino, Torino, p 71-110.

Appendix Abundant vegetation type and range of collection rates by fish meat baited traps in total catches for each beetle that was collected more than 5 individuals

Abundant vegetation type in the main	% of beetles collected by fish meat baited traps < 30	30 - 70	> 70
Deep inside of natural forest (CNF)	*Microcopris fujiokai* *Caccobius binodulus*		
Natural forest (CNF - BNF)	*Ochicanton uedai* *Ochicanton woroae* *Paragymnopleurus maurus* *Sisyphus thoracicus* *Catharsius dayacus* (male) *Onthophagus (Gibbonthophagus) cervicapra* *Onthophagus (Serrophorus) laevis* *Onthophagus (Onthophagiellus) hidakai* *Onthophagus (Hikidaeus) simboroni* *Onthophagus (Onthophagus) aphodioides* *Onthophagus (Onthophagus) borneensis* *Onthophagus (Onthophagus) incisus* *Onthophagus (Onthophagus) infucatus* *Onthophagus (Onthophagus) pacificus* *Onthophagus (Onthophagus) rutilans* *Onthophagus (Onthophagus) semipacificus* *Onthophagus (Onthophagus) vulpes*	*Parascatonomus aurifex* *Onthophagus (Gibbonthophagus) fujiii* *Onthophagus (Indachorius) woroae* *Onthophagus (Hikidaeus) pastillatus*	*Phaeocrous emarginatus* *Phaeocroops sp.* *Parascatonomus dux* *Parascatonomus rudis* *Onthophagus (Pseudophanaeomophus) chandrai* *Onthophagus (Onthophagus) bonorae*
Varaiety of forest types (CNF - PLF)	*Bolbochromus catenatus* *Onthophagus (Onthophagus) waterstradti*	*Proagoderus schwaneri*	*Parascatonomus semiaureus* *Parascatonomus semicupreus*
Secondary forest and plantation forest (SCF -PLF)	*Catharsius renaudpauliani* (male)		
Grassland (GRS)	*Onthophagus (Furconthophagus) lilliputanus*	*Onthophagus (Indachorius) uedai*	
Grassland and pasture (GRS - CPS)	*Caccobius unicornis* *Onthophagus (Paraphanaeomorphus) trituber*		
Pasture (CPS)	*Onthophagus (Furconthophagus) papulatus* *Onthophagus (Gibbonthophagus) limbatus*		*Aphodius marginellus*
All vegetation types?		*Panelus kalimantanicus* *Onthophagus (Gibbonthophagus) obscurior*	

インドネシア共和国東カリマンタン州バリクパパン近郊の低地で採集された糞虫（鞘翅目：コガネムシ上科食糞群）のリスト

上田 明良[1)*]、ディアン・ドウィバドラ[2)]、ウォロ・ノエルジト[2)]、
スギアルト[3)]、近 雅博[4)]、越智 輝雄[5)]、
高橋 正義[6)]、福山 研二[7)]

要旨

糞虫（コガネムシ上科食糞群）は熱帯において生息地の質の有用な指標者である。インドネシア共和国東カリマンタン州の低地、バリクパパンの北 10 〜 40km の地域において、2006 年から 2008 年の 12 月に、人糞と魚肉を誘引餌としたピットフォールトラップによる糞虫採集を 30 カ所で行った。65 種 8,073 個体の糞虫が捕獲され、そのリストを表に示した。糞虫群集を用いて森林環境を評価する今後の研究への有用な資料を提供するために、5 個体以上捕獲された 44 種の食性と生息地選好性を評価した。44 種のうち、41 種は人糞と魚肉の両方で採集された。8 種はどちらかの誘引餌へ偏りが 70％を超えず、そのうちの 5 種はボルネオ島固有種であった。生息地については、36 種が天然林に多く、人為的荒廃林、植林地と開放地でほとんど捕獲されなかったが、例外の 7 種はそういった生息地にも多かった。*Catharsius renaudpauliani* は荒廃林と植林地を主な生息地とする唯一の種と考えられた。開放地に多い 7 種は、天然林でほとんど捕獲されなかった。天然林に多い種は分布域が狭い傾向があったのに対し、開放地に多い種は分布域が広い傾向があった。

キーワード：誘引餌、ボルネオ島、森林、草地、生息地、コガネムシ科

原稿受付：平成 28 年 7 月 4 日　原稿受理：平成 29 年 3 月 22 日
1) 森林総合研究所九州支所
2) インドネシア科学院生物学研究所
3) 東クタイ農科大学
4) 京都市左京区
5) 大阪府豊能町
6) 森林総合研究所森林災害・被害研究拠点
7) 元森林総合研究所研究コーディネーター
* 森林総合研究所九州支所　〒 860-0862 熊本県熊本市中央区黒髪 4-11-16