「森林総合研究所研究報告」(Bulletin of FFPRI) Vol.14 No.1 (No.434) 15 - 28 March 2015

論　文（Original article）

Comparison of baits and types of pitfall traps for capturing dung and carrion scarabaeoid beetles in East Kalimantan

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Abstract

To contribute to develop a standardized, quantitative protocol for sampling coprophagous scarabaeoid beetle communities, we carried out a study in lowland of East Kalimantan, Indonesia to examine different bait and pitfall equipment. First, we checked pitfall trap captures with cow dung, human feces, raw fish meat, and dried fishes as baits on the fourth and eighth day after trap installation. Next, we set pitfall traps with different sizes of holes perforated through the container of human feces and raw fish meat as baits, and we also set pitfall traps upon which the sheets were laid to intercept the flying beetles. We checked trap captures every day up to the fifth day after trap installation. As the results, the numbers of species and individuals captured were larger on human feces and raw fish meat, and those in the first four days on cow dung, human feces, and raw fish meat were smaller than those in the successive four days. Hole size did not affect trap captures, but the flight interceptive sheets increased the numbers of species captured. The numbers of species and individuals captured on human feces were decreased on the third day after trap installation, but those on raw fish meat were abundant up to the fifth day except for the first day. Our results recommended using the flight intercept pitfall trap baited with human feces and raw fish meat and the trap periods of at least three and five days after trap installation for human feces and raw fish meat, respectively.

Key words : bait, Borneo, coprophagous, flight interceptive trap, pitfall trap

1. Introduction

Coprophagous scarabaeoid beetles are known to be a superior indicator of habitat quality and environmental change in forests and the surrounding environments of tropical regions (Davis et al. 2001, McGeoch et al. 2002, Aguilar-Amuchastegui and Henebry 2007, Nichols and Gardner 2011). This beetle group is also known to be relatively easier 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 in terms of indicator performance only to birds (Gardner et al. 2008a, 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, and parasite control (Nichols et al. 2008).

To sample these beetles baited pitfall trap have been largely used in the world. About kinds of baits used in tropical region, cattle dung was used as bait in some studies (Doube 1983, Horgan 2002, 2007, Horgan and Fuentes 2005, Shahabuddin et al. 2005, Andresen 2005, 2008), but human feces is more commonly used than cattle dung (Hanski 1983, Klein 1989, Nummelin and Hanski 1989, Hanski and Krikken 1991, Holloway et al. 1992, Kikuta et al. 1997, Davis 2000a, Davis et al. 2000, 2001, Halffter and Arellano 2002, Vulinec 2002, Feer and Hingrat 2005, Scheffler 2005, Aguilar-Amuchastegui and Henebry 2007, Navarrete and Halffter 2008, Gardner et al. 2008b, Vulinec et al. 2008, Vieira et al. 2008, Edwards et al. 2011). Alternative baits to cattle dung and human feces used in other studies include the dung of monkey, pig, horse, dog, elephant, wallaby, and coati (Estrada et al. 1993, 1998, Hill 1996, McGeoch et al. 2002, Estrada and Coetes-Estrada 2002, Andresen 2003, Boonrotpong et al. 2004, Horgan 2005, Vieira et al. 2008). Many coprophagous scarabaeoid beetles are also known to be attracted by decaying organisms (carrion), and some species specialize on decaying organisms. Therefore, many studies have also used traps baited with decaying organisms in addition to the traps baited with excrement. The most

Received 28 March 2014, Accepted 1 December 2014
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common carrion used as bait is fish meat (Hanski 1983, Hanski and Krikken 1991, Holloway et al. 1992, Kikuta et al. 1997, Davis and Sutton 1998, Navarrete and Halffter 2008), although some studies have also used decaying squid, beef, deer meat, birds, rats, liver, fruits, fruiting bodies of fungi, frogs, insects, and even millipedes (Hanski 1983, Klein 1989, Hill 1996, Halffter and Arellano 2002, Andresen 2005, 2008, Larsen et al. 2006).

Human feces and fish meat are more popular now than other baits as mentioned above but there are few studies that compare the beetles lured and captured by different baits. In the past study, traps baited with human feces captured 5 times more individuals and over two times more species of dung beetles than traps with cow dung in tropical forests in Peru (Larsen et al. 2006). Human feces also captured over twice as many individuals per trap as cow dung in a tropical forest in El Salvador, although cow dung captured nearly 4 times more beetles than human feces in pastures (Horgan 2007). Other than cattle dung, human feces captured more individuals than both monkey and horse dung (Howden and Nealis 1975, Vieira et al. 2008) and there was no difference in numbers of species and individuals caught using pig dung in neotropical forests (Horgan 2005). About decaying organisms fish meat (in the literature wrote as "large fish meat") captured more individuals than bird meat, rat meat, and rotting fruit in a forest of Sulawesi, Indonesia (Hanski and Krikken 1991). Vertebrate carrion (total data using lizards, chicken, fish, rodents, frogs, snakes, and an opossum) captured more individuals than invertebrate carrion (total data using grasshoppers, beetles, millipedes, caterpillars, and cockroaches), fruiting bodies of fungus, rotting fruits, and live millipede in various environments including forests and grasslands in Peru (Larsen et al. 2006).

The size of the bait used in traps also affects the capture of the beetles. Peck and Howden (1984) captured about 20 times more individuals by a trap using 200 ml of human feces compared with a trap baited with only 2 ml of human feces. This result suggests that the quantity of odor emitted from bait may further affect the capture of the beetles.

To develop a standardized, quantitative protocol for sampling coprophagous scarabaeoid beetle communities, we studied different baits and pitfall trap setups in Borneo, Indonesia. First, we compared the attractiveness of cow dung and human feces for beetles using baited pitfall traps in grasslands, plantations, and a natural forest. Additionally, we evaluated the use of dried fish as bait, as it is easier to store and treat than raw fish meat and compared its efficiency with raw fish meat. In our study, we also compared the beetle captures in traps that had different size of holes perforated to evaporate odor through a container of bait because the different size of holes might cause the different quantity of odor from the traps, because hole size perforated through a container of insect attractant affects the volume of attractant evaporated (Zang and Schlyter 2003). Additionally, we used a baited flight-intercept pitfall trap that we developed so that the trap could function as both a baited pitfall trap and a flight intercept trap (FIT), and determined if the captures were superior to that of the ordinary baited pitfall traps, because FIT has been used singly or additionally with baited pitfall traps to survey coprophagous scarabaeoid beetle communities (Hanski and Krikken 1991, Davis 2000a, 2000b, Davis et al. 2000, 2001).

2. Methods

2.1 Study sites

In 2005, we selected three *Acacia mangium* plantations with different ages located 10 to 30 km north of Balikpapan in the lowlands of East Kalimantan, Indonesia. *A. mangium* is one of the most common fast-growing tree species used for plantations in the anthropogenic areas of tropical Asia. Ages of the three plantations were 4-years old ("Plantation 4 yrs": S1˚03'34, E116˚55'01, 60 m asl.), 7-years old ("Plantation 7 yrs": S1˚04'46, E116˚54'11, 48 m asl.), and 10-years old ("Plantation 10 yrs": S1˚10'10, E116˚54'41, 26 m asl.). Four and 7-year old plantations were paired with adjacent study sites in the *Imperata cylindrical* (local name 'Alang-alang') grasslands ("Grassland A" and "Grassland B") and each grassland site was at least 100 m away from the edge of a plantation. *Imperata cylindrical* distributes widely in post-deforested, burned areas of tropical Asia. An intact natural forest site ("Intact forest": S1˚08'21, E116˚50'06, 40 m asl.) was also selected at the place 200 m inside from the edge of the large forest of the Sungai Wain Forest Reserve. This area had not been disturbed over the past 50 years by selective logging, forest fires or other cases.

In 2006, surveys were again conducted at the 5-years old plantation ("Plantation 5 yrs") that grew a year older from 2005, 'Grassland A', and "Intact forest".

2.2 Comparison among baits in 2005

Baited pitfall traps were used to capture the beetles. For pitfall traps, 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. A white plastic bowl (ceiling: 14 cm in diameter and 4-cm high with 3 windows on the lateral side) was placed upside down and laid over the cup, and a small stone or a twig was laid on the bowl as a weight (Fig. 1). Each trap contained a 50-ml glass bottle (4.3 cm in diameter and 8.0-cm high) with a perforated lid (having five holes, each

3 mm in diameter) that was baited to attract beetles (Fig. 1). As baits we used cow dung (30g) dropped in between the past 12 and 30 hours, human feces (5 g) dropped in between the past 24 and 30 hours, fresh raw jack fish meat (20 g), and eight dried fish with about 5 cm in length (about 10 g). 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 50 ml of a 0.1 % solution of both sodium benzoate and neutral detergent to kill and preserve the beetles collected.

At each site, we made 5 plots with 10 m square. The plots were separated at least 70 m each other because intervals of at least 50 m between plots were needed to minimize interference between traps having same baits (Larsen and Forsyth 2005). We set up a pit fall trap on the corner of each study plot (4 traps with different baits per plot). All traps were set up on 27 December 2005 and beetles were collected on the fourth day (31 December 2005) and the solution changed without replacing the baits. All trappings were finished on the eighth day (4 January 2006).

2.3 Comparison among trap types in 2006

Three types of pitfall traps were used to capture the beetles. Two types of baited pitfall traps used the same cup, bottle, and bowl with 2005. One of the two types had the same lid with 2005 (having five holes, each 3 mm in diameter): a baited pitfall trap with small holes (PS). Another type had a lid with six holes, each 5 mm in diameter: a baited pitfall trap with large holes (PL). Additionally, flight-intercept pitfall (FP) traps were used to collect the beetles. For FP traps, two B5-size transparent plastic sheets that crossed each other were then laid over the cup, upon which a plastic bowl (ceiling: 20 cm in diameter and 5-cm high) was placed upside down (Fig. 2). The same lid of the bottle with PL was used for FP. Fresh human feces (10 g) dropped within 6 hours and fresh raw jack fish meat (30 g) were used as bait. 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 did not contain any solution so as to collect mites on the body surface of the living beetles for another study before killing. For each trap type at each site (PS, PL, and FP), 6 traps were baited with human feces and 6 with fish meat. Overall, there were 36 traps (3 types of trap * 2 types of bait * 6 traps) set up with 10 m distance between traps randomly along the transect through each site. Captured beetles were removed daily without replacement of bait. Collection was done for 5 days in 4 - 9 August 2006 in the intact natural forest and in 5 - 10 August 2006 in both the plantation and the grassland.

2.4 Identification and storage of specimen

All beetles captured in the present study were dried on absorbent cotton and identified with using a binocular (Nikon Nature Scope). Some beetles were pined and sent to Dr. Teruo Ochi of Toyono-cho, Toyono-gun, Osaka Prefecture, Japan who helped identification. All beetles are stored in the insect specimen room of Research Center for Biology, Indonesian Institute of Science (LIPI), Cibinong, Indonesia.

2.5 Data analysis

For data in 2005 the numbers of both species and individuals were compared among four kinds of baits. Generalized linear mixed model (GLMM) analyses with a negative binomial error structure incorporating differences

Fig. 1. A pitfall trap containing a baited glass bottle with a perforated lid having five holes, each 3 mm in diameter. The right photograph shows the trap without its ceiling.

Fig. 2. A flight intercept pitfall trap containing a baited glass bottle with a perforated lid having six holes, each 5 mm in diameter.

of site and plot as random effects were done to compare the numbers of species and individuals. Tukey's test was used to examine the differences in the numbers of species and individuals captured among baits.

For data in 2006 the numbers of both species and individuals were compared between two kinds of baits and among three types of pitfall traps. Generalized linear model (GLM) analyses with a negative binomial error structure incorporating difference of site as a random effect were done to compare the numbers of species and individuals. Tukey's test was used to examine the differences in the numbers of species and individuals captured among trap types.

For GLMM, GLM and Tukey's test, the glmmadmb function of glmmADMB package, the glm.nb function of MASS package, and the glht function of multcomp package were used, respectively, in R 3.1.1 (R Core Team 2014).

3. Results

3.1 Comparison among baits in 2005

Because a trap baited with raw fish meat in both the 'Plantation 4 yrs' and 'Grassland A' sites was disturbed in a plot by an unidentified vertebrate, all data from this plot were deleted from analyses. Since females of two *Catharsius* species (*C. dayacus* and *C. renaudpauliani*) were difficult to distinguish from each other, the data on these two species were combined as *Catharsius* spp.

A total of 26 species and 1,297 individuals of dung and carrion scarabaeoid beetles was captured (Table 1). The numbers of both species and individuals captured by cow dung were significantly smaller than those by the other three baits (Fig. 3). The number of individuals captured by dried fishes was also significantly smaller than that by raw fish meat (Fig. 3). In the respective vegetation types, the numbers of both species and individuals captured by cow dung and dried fish were not smaller than those by human feces and raw fish meat in the two grasslands (Figs. 4 and 5). However, in three plantations and an intact forest the numbers of both species and individuals captured by cow dung and dried fish were relatively smaller than those by human feces and raw fish meat except for the number of species captured by dried fish in "Plantation 4 yrs" (Figs. 4 and 5).

The total number of species did not diminish largely from the first 4 days to the next 4 days after trap installation (reduction rates from the first 4 days: 18-36%), except in treatments using cow dung (reduction rate: 63%) (Table 2). On the contrary, the total number of individuals declined largely from the first 4 day to the next 4 days after trap installation (reduction rates: 59-82%) with the exception of dried fish treatment (reduction rate: 32%) (Table 2).

3.2 Comparison among trap types in 2006

A total of 34 species and 2,338 individuals of dung and carrion scarabaeoid beetles was captured (Table 3). The numbers of both species and individuals were not significantly different between baits (Fig. 6). The number of species captured by FP traps was significantly larger than those by PS and PL traps but the number of individuals was not significantly different among trap types (Fig. 6).

In the respective sites, the number of species captured by FP traps was relatively larger than those by PS and PL traps in the plantation and the intact forest except for bait with raw fish meat in the intact forest, but it did not differ among trap types in the grassland (Fig. 7). The number of individuals captured by FP traps was relatively larger than those by PS and PL traps in the bait of human feces in the intact forest (Fig. 7). This difference was occurred by the species that were apparently abundant on FP traps such as *Catharsius* spp., *Onthophagus incisus*, and *O. waterstradti* (Table 3).

The total numbers of species and individuals captured with human feces declined on the third and fourth days after trap installation (Fig. 8). The numbers of species and individuals captured with raw fish meat were relatively stable, except for on the first day after installation (Fig. 8).

Table 1. Total number of scarabaeoid dung and carrion beetles captured by pitfall traps with different baits in 2005

Species	Bait[a]			
	CD	HF	RF	DF
Phaeocroops sp.	0	0	2	0
Ochicanton woroae	2	4	6	6
Panelus bakeri?	50	44	17	88
Catharsius sp.	0	0	1	0
Onthophagus aurifex	0	2	24	3
Onthophagus batillifer	0	2	0	0
Onthophagus bonorae	2	51	188	9
Onthophagus bornensis	0	3	0	1
Onthophagus discedens	0	0	1	1
Onthophagus dux	0	10	37	7
Onthophagus incisus	0	8	0	2
Onthophagus lilliputanus	51	111	64	99
Onthophagus limbatus	0	1	4	0
Onthophagus obscurior	0	0	1	0
Onthophagus ochromerus	0	1	0	0
Onthophagus pacificus	1	0	0	0
Onthophagus pastillatus	1	1	0	2
Onthophagus rudis	0	0	5	0
Onthophagus schwaneri	0	0	1	0
Onthophagus semiaureus	0	2	23	1
Onthophagus semicupreus	2	48	187	10
Onthophagus trituber	0	4	25	6
Onthophagus uedai	7	12	14	14
Onthophagus vulpes	0	0	1	0
Onthophagus waterstradti	0	5	16	2
Onthophagus sp. 1	0	8	13	6

[a]CD: cow dung, HF: human feces, RF: raw fish meat, DF: dried fish

Table 2. Total numbers of species and individuals captured with each bait in 4 days and from 5 to 8 days after trap installation in 2005

	First 4 days (a)	Successive 4 days (b)	Reduction rate (%) (a-b)/a
Number of species			
Cow dung	8	3 (0)	62.5
Human feces	16	11 (2)	31.3
Raw fish meat	17	14 (3)	17.6
Dried fish	14	9 (2)	35.7
Number of individuals			
Cow dung	82	34	58.5
Human feces	240	77	67.9
Raw fish meat	533	97	81.8
Dried fish	153	104	32.0

Parenthesized number indicates the number of species absent in the first 4 days.

Table 3. Total number of scarabaeoid dung and carrion beetles captured by different types of pitfall traps baited with human feces and raw fish meat in 2006

Species name	Human feces			Raw fish meat		
	PS[a]	PL[b]	FP[c]	PS	PL	FP
Phaeochrous emarginatus	0	0	0	0	1	0
Phaeocroops sp.	0	1	0	1	0	1
Ochicanton woroae	1	0	0	1	1	0
Panelus bakeri?	16	19	10	1	3	6
Paragymnopleurus maurus	26	23	12	0	0	0
Sisyphus thoracicus	0	4	5	0	0	0
Catharsius spp.	16	16	34	0	4	3
Onthophagus aphodioides	0	0	5	0	0	0
Onthophagus aurifex	0	0	1	3	1	6
Onthophagus bonorae	2	1	2	13	10	8
Onthophagus borneensis	9	2	6	0	0	0
Onthophagus cervicapra	2	2	9	0	0	0
Onthophagus dux	1	3	2	8	7	6
Onthophagus fujiii	0	0	1	1	0	5
Onthophagus incisus	17	15	62	0	0	17
Onthophagus johkii	0	1	0	0	0	0
Onthophagus lilliputanus	7	10	6	1	2	1
Onthophagus limbatus	0	2	2	0	0	1
Onthophagus obscurior	0	0	3	1	0	2
Onthophagus pacificus	0	1	1	0	0	0
Onthophagus pastillatus	2	1	7	0	0	0
Onthophagus rudis	0	0	3	6	2	14
Onthophagus schwaneri	0	7	31	0	7	21
Onthophagus semiaureus	0	2	5	11	9	5
Onthophagus semicupreus	42	63	71	570	371	381
Onthophagus trituber	4	12	8	0	1	1
Onthophagus uedai	3	5	2	0	0	0
Onthophagus vulpes	14	6	8	0	0	0
Onthophagus waterstradti	42	21	90	2	1	2
Onthophagus sp. 1	0	0	0	0	1	0
Onthophagus sp. 2	2	1	4	1	0	0
Onthophagus sp. 3	1	0	0	0	0	0
Onthophagus sp. 4	1	0	0	0	0	0
Aphodius sp.	1	0	0	0	0	0

[a]Pitfall trap containing a baited glass bottle with a perforated lid having five holes, each 3 mm in diameter.

[b]Pitfall trap containing a baited glass bottle with a perforated lid having six holes, each 5 mm in diameter.

[c]Fright intercept pitfall trap containing a baited glass bottle with a perforated lid having six holes, each 5 mm in diameter.

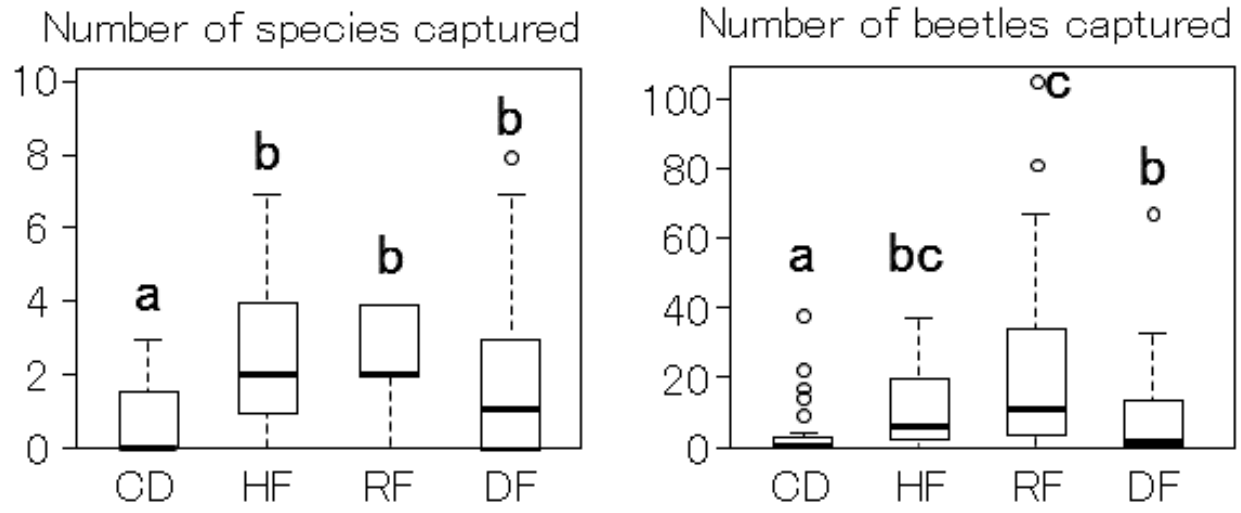

Fig. 3. The number of beetle species (left figure) and individuals (right figure) captured by pitfall traps with different baits surveyed in 2005. CD: cow dung, HF: human feces, RF: raw fish meat, DF: dried fish. Boxes and thick horizontal lines illustrate the interquartile range (lower limit: 25th percentile; upper limit: 75th percentile) and the median value (50th percentile), respectively. Bottom and top whiskers depict the lowest and highest values. Circles in the figures indicate the value of an outlier (lying over 2 times of the box length above the 75th percentile). Different letters indicate significant differences ($P < 0.05$).

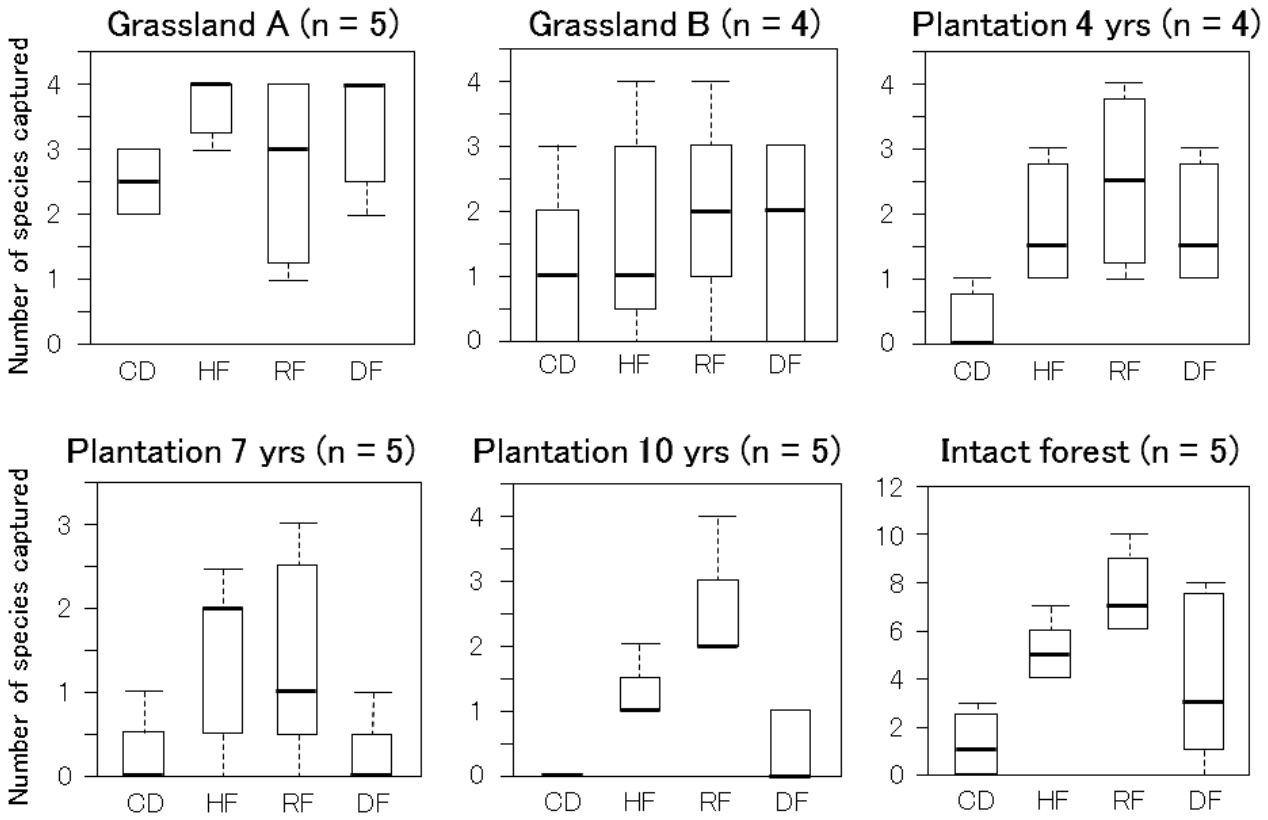

Fig. 4. The number of beetle species captured by pitfall traps with different baits at each site surveyed in 2005. Abbreviations, an asterisk, boxes, thick horizontal lines, and whiskers are the same with Fig. 3.

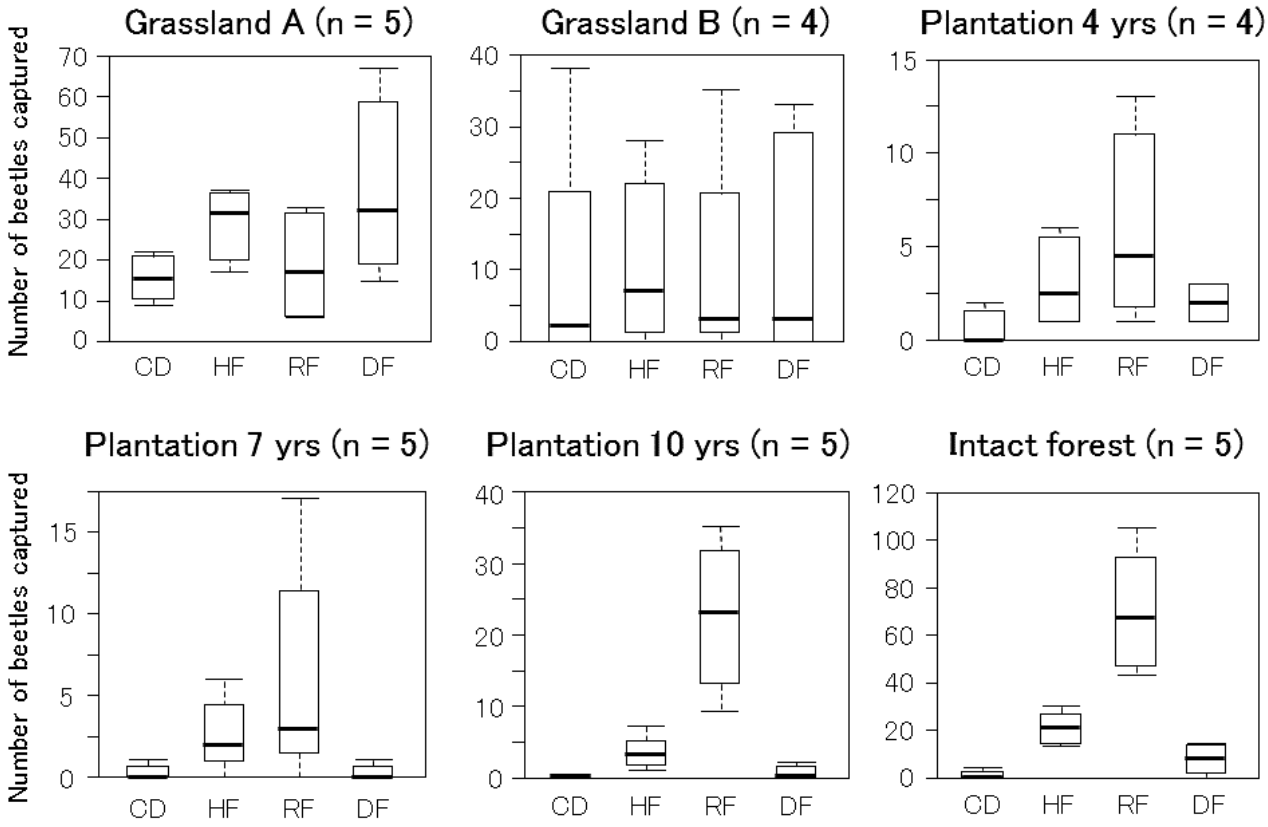

Fig. 5. The number of individual beetles captured by pitfall traps with different baits surveyed in 2005. Abbreviations, an asterisk, boxes, thick horizontal lines, and whiskers are the same with Fig. 3.

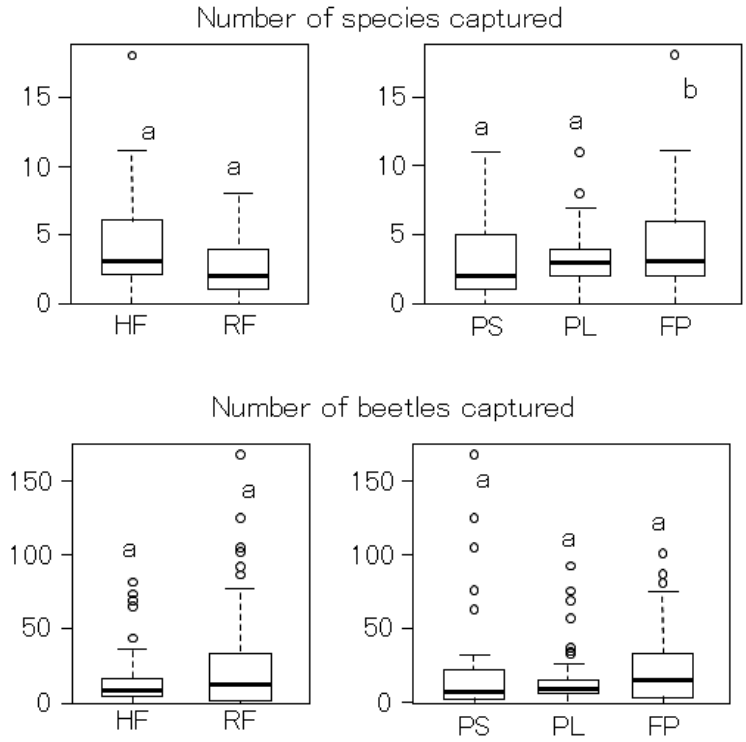

Fig. 6. The numbers of beetle species (upper figures) and individuals (lower figures) captured by different types of pitfall traps baited with human feces and raw fish meat surveyed in 2006. Abbreviations for baits and different types of pitfall traps are the same with Fig. 3 and Table 3, respectively. Boxes, thick horizontal lines, whiskers, circles, and letters are the same with Fig. 3.

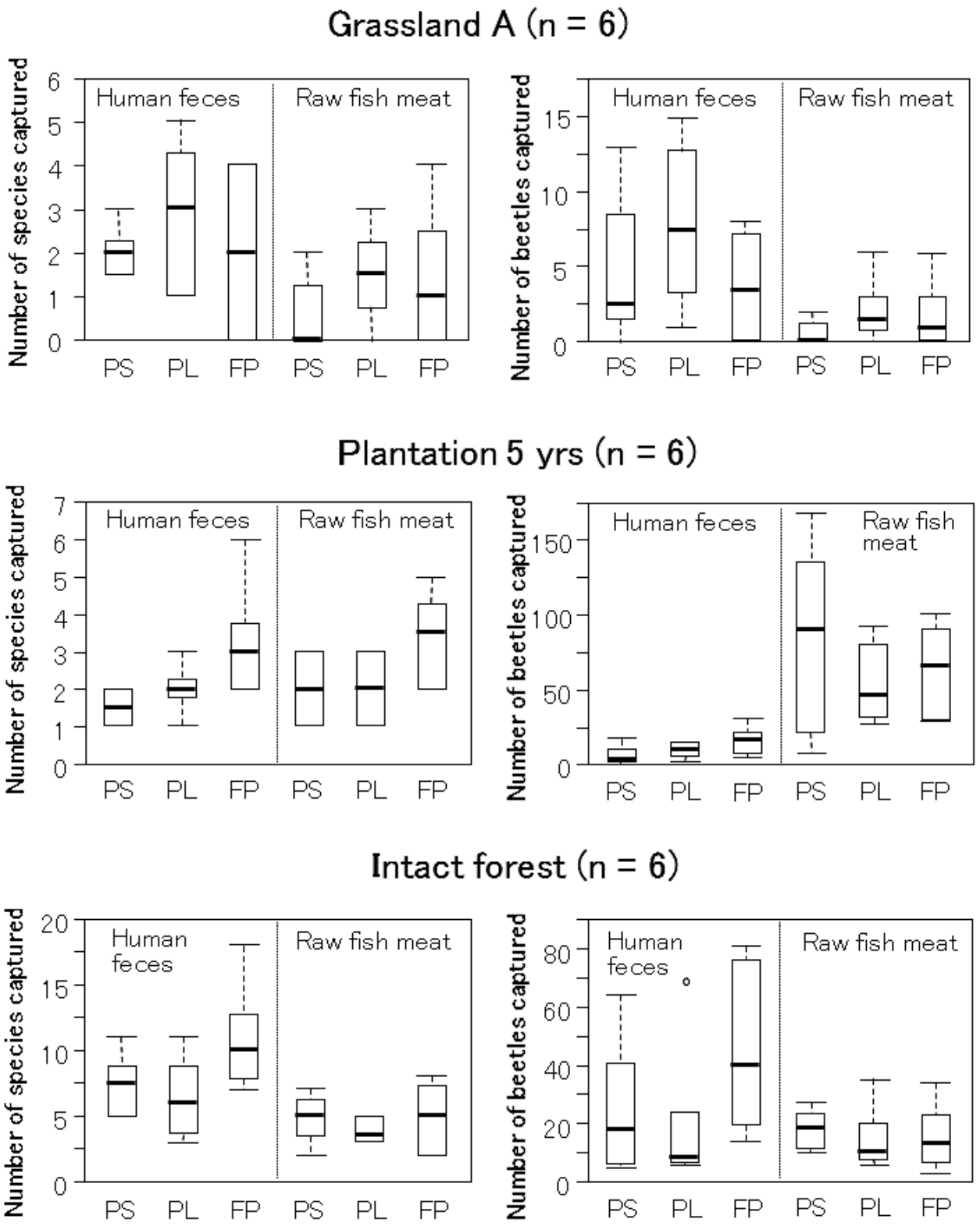

Fig. 7. The numbers of beetle species (left figures) and individuals (right figures) captured by different types of pitfall traps baited with human feces and raw fish meat at each site surveyed in 2006. Abbreviations for different types of pitfall traps are the same with Table 3. Boxes, thick horizontal lines, whiskers, and a circle are the same with Fig. 3.

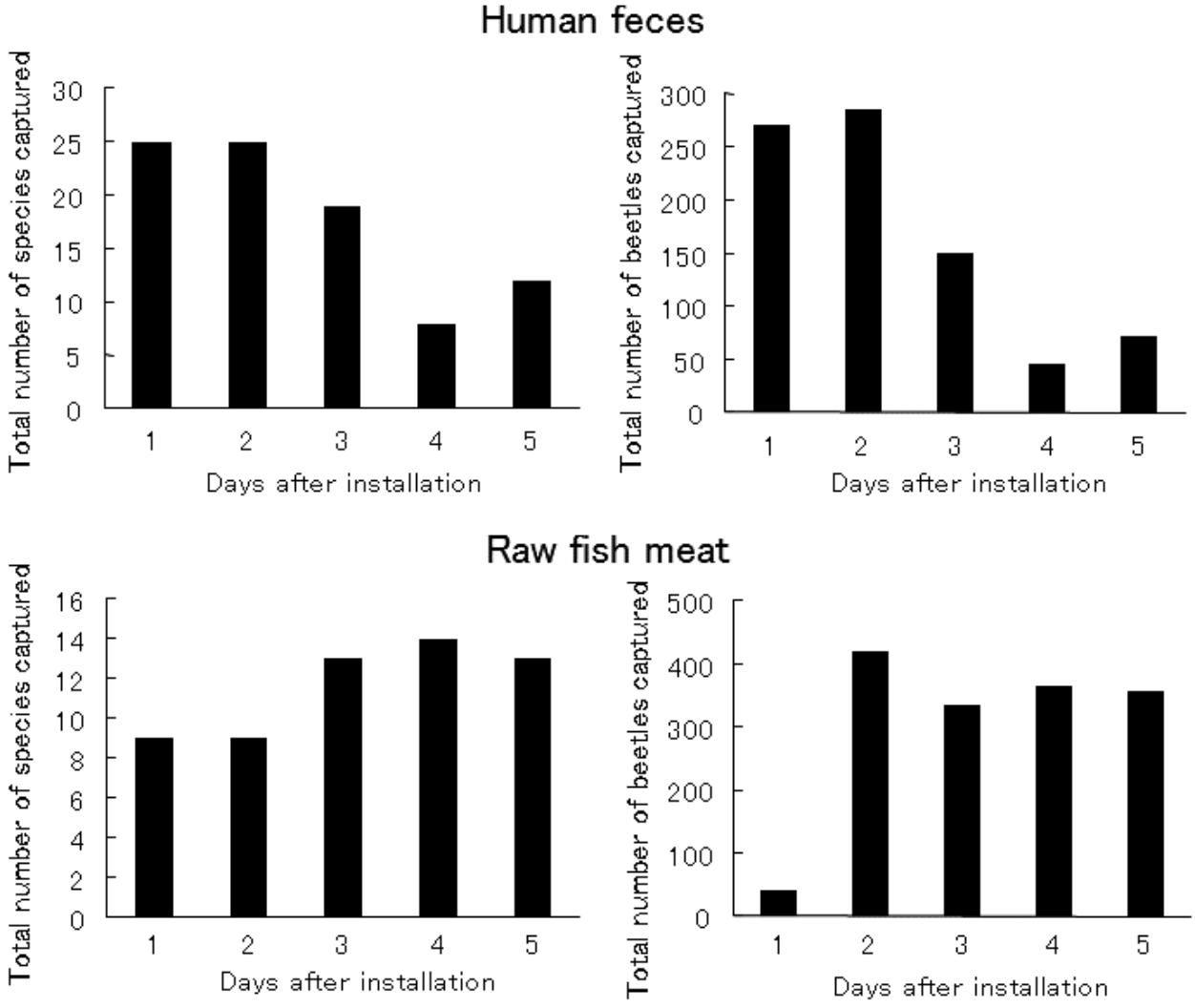

Fig. 8. Daily total numbers of beetle species (left figures) and individuals (right figures) captured by pitfall traps baited with human feces (upper figures) and raw fish meat (lower figures) in 2006.

4. Discussion

4.1 Comparison among baits in 2005

In comparison between cow dung and human feces in the present study, the numbers of both species and individuals of beetles captured were significantly higher for traps baited with human feces than with cow dung (Fig. 3); however those captured with cow dung did not differ from those captured with human feces in the grasslands (Figs. 4 and 5). This result is almost the same as has been found in neotropical regions (Larsen et al. 2006, Horgan 2007). Fourteen species were captured more individuals with human feces than with cow dung, whereas just two species were captured more individuals with cow dung than human feces (Table 1). These results suggest that it may be beneficial to use human feces as bait to collect dung beetles in the lowland of Borneo rather than cow dung. Although pig dung also lured an abundance of beetles, as did human feces in neotropical region (Horgan 2005), further study in South-East Asia is needed to clarify the attractiveness of pig dung relative to human feces.

In comparison between raw fish meat and dried fish, the number of individuals captured was higher in traps baited with raw fish meat compared with those with dried fish (Fig. 3). In the three plantations and the intact forest, the number of individuals captured by raw fish meat was relatively higher than those by dried fish (Figs. 4 and 5). Fifteen species were captured more individuals with raw fish meat than with dried fish, whereas just 5 species were captured more individuals with dried fish than with raw fish meat (Table 1). These results supported the idea of using raw fish meat as bait to collect carrion beetles in the lowland of Borneo.

It has been shown that many coprophagous scarabaeoid beetles are lured by both dung and carrion (Hanski 1983, 1989, Hanski and Krikken 1991, Hill 1996, Kikuta et al. 1997, Andresen 2005, 2008, Navarrete and Halffter 2008). In the present study, we also found that there were many species captured with both dung (cow dung and/or human feces) and carrion (raw fish meat and/or dried fish) (Table 1). This was also observed in 2006 (Table 3, Fig. 6). However, there were some species that clearly preferred dung (ex. *Onthophagus incisus*) as well as those preferred carrion (ex. *Onthophagus aurifex*) (Table 1). These results indicate that using both human feces and raw fish meat as bait for sampling coprophagous scarabaeoid beetle communities may be effective in the lowland of Borneo.

4.2 Comparison among trap types in 2006

It has been shown that the large bait in size captured larger number of beetles than the small bait (Peck and Howden 1984), which suggests that the quantity of odor from bait affects the capture of beetles. In our study, we compared the beetle captures in traps that had different size of holes perforated through the lid to see if this influenced the attractiveness of the traps because the different size of holes might cause the different quantity of odor from the traps. We found, however, that there were no differences between PS and PL on the numbers of both species and individuals (Fig 6), indicating that the size of hole did not affect trap catches. This result suggests that there is no need to be concerned about hole size perforated to evaporate odor through a container of bait in traps.

In our newly developed FP traps we captured significantly higher number of species than we did in the PS and PL traps (Fig. 6). Similar trends were also observed on the number of individuals in the traps baited with human feces in the intact forest (Fig. 7). These were occurred by some species apparently abundant on FP traps (Table 3). From these results, we can conclude that the baited flight intercept pitfall trap is a useful tool to survey the coprophagous scarabaeoid beetle communities in the lowland of Borneo.

4.3 Trapping period

In 2005, we used human feces dropped 24 to 30 hours before, and the total number of individuals captured with human feces declined largely from the first 4 day to the next 4 days after trap installation (Table 2). In 2006, we used fresh human feces within 6 hours after dropping, the total numbers of both species and individuals captured with human feces decreased on the third and fourth days after installation (Fig. 8). These results indicate that human feces must be used as bait as soon as possible after dropping and the trapping should last at least 3 days after installation. On the contrary, our results in 2006 showed that raw fish meat decayed for one day was the best for bait and the attractiveness continues at least up to the fifth day (Fig. 8). However, the attractiveness of decaying fish did not continue for long. Our result in 2005 showed that number of beetles captured by raw fish meat in the fast 4 days was much higher than the number in the successive 4 days, with captures that were similar in number to traps using human feces (Table 2). This result suggests that the attractiveness of decaying fish might decrease after the sixth day from installation. Moreover, few species preferred the aged fish meat because 11 of 14 species captured in the successive 4 days with raw fish meat were captured also in the first 4 days (Table 2). Therefore, we can use fresh raw fish meat as bait without decaying if the trapping period is more than 5 days.

Three *Onthophagus* species (*O. trituber, O. uedai*, and *O. waterstradti*) were more abundant on raw fish meat than on human feces in 2005 but they were abundant on human feces and relatively rare on raw fish meat in 2006 (Table 1 and 3). Our results from 2007 to 2008 (unpubl. data) showed the same trend as in 2006. In 2006, 81% of these three species were captured in 2 days after trap installation. These three species might have preferred the odor from decaying fish meat to the odor of aged human feces in 2005, although they generally preferred the odor of fresh human feces to the odor of decaying fish meat.

Acknowledgement

We wish to thank Teruo Ochi (of Toyono-cho) who helped identifying the specimens, Kazuma Matsumoto (of FFPRI's Tohoku Res. Ctr.), Hiroshi Makihara (of FFPRI), Masahiko Tokoro (of FFPRI), and Kaoru Maeto (of Kobe University), who advised us to conduct this study, Hiroki Ito of FFPRI for his help in the statistical analyses, Rob Johns of Atlantic Forestry Centre, Canadian Forest Service for his review of the manuscript, the late Herwint Simbolon of the Indonesian Institute of Science (LIPI), Sugiarto and Chandra Boer of Tropical Forest Research Center, Mulawarman University (PPHT, UNMUL), Agustin and Agus of the Sungai Wain Forest Reserve, and the people of Sungai Wain Village, who helped us to conduct the field work. This study was supported by grants from Japan's Ministry of the Environment (Global Environmental Research Account by National Institute, 2004–2008), and from JSPS KAKENHI (Grant Number 26304028).

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東カリマンタン州での糞・腐肉食性コガネムシ類捕獲における ベイト間およびピットフォールトラップのタイプ間の比較

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要 旨

糞食性コガネムシ類群集のサンプリングにおける標準的な定量的捕獲法の開発に寄与することを目的に、インドネシア共和国東カリマンタン州の低地においてベイトとトラップタイプを検討する研究を行った。まず、牛糞、人糞、魚肉、煮干しをベイトにしたピットフォールトラップを用い、４日目と８日目に捕獲虫を回収した。次に、人糞と魚肉をベイトとして、臭いを出すためにベイト容器に開けた穴のサイズが異なるピットフォールトラップと、上に衝突板を立てたピットフォールトラップを５日間設置し､毎日捕獲虫を回収した｡その結果､人糞と魚肉で種数と捕獲数が多かった。また、牛糞、人糞、魚肉では最初の４日間に比べて残りの４日間は捕獲数が大きく減少した。穴サイズは捕獲に影響しなかったが、衝突板は種数を増加させた。人糞では３日目以降種数と捕獲数が低下したが、魚肉は、初日を除き５日目まで多かった。以上の結果から、人糞と魚肉をベイトに用いた衝突板付きピットフォールトラップを人糞は最低３日間、魚肉は５日間設置することが推奨された。

キーワード：ベイト、ボルネオ、糞食性、衝突板トラップ、ピットフォールトラップ

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