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Original Article

Species composition and seasonal abundance of carabid beetles by three sampling methods on the campus of the faculty of agriculture, Shinshu University

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Abstract

Field surveys were conducted in an experimental forest area on the campus of the Faculty of Agriculture, Shinshu University, in Nagano Prefecture from April to October 2005 to investigate the species composition of carabid beetles by using three sampling methods (pitfall trapping, light trapping and leaf litter-sieving) and to compare the data of the three sampling methods. A total of 1627 individuals comprising 39 species of carabid beetles were collected in the present study. The number of individuals caught by pitfall trapping (1454) was much greater than that by light trapping (51) or leaf litter-sieving (122). The species richness of the sample caught by leaf litter-sieving (21) was similar to that of the sample caught by pitfall trapping (26), but the species richness in the case of light trapping (13) was lower than that found with the other two methods. The dominant species caught by pitfall trapping were *Carabus insulicola, Synuchus cycloderus* and *Leptocarabus procerulus*, which together represented 84.7% (1231 individuals) of the total. The three most numerous species caught by light trapping and leaf litter-sieving were *Harpalus griseus, Dromius prolixus* and *Asaphidion semilucidum*, representing 70.6% (36 individuals) of the total, and *Amara congrua, H. griseus* and *Harpalus tridens*, representing 63.1% (77 individuals) of the total, respectively. Subfamilies of Carabinae, Pterostichinae and Callistinae were mainly found in the pitfall trapping sample, whereas Lebiinae were captured mostly by light trapping. In the leaf litter-sieving sample, the frequently caught subfamilies were Zabrinae and Harpalinae. Pianka's similarity index showed that the species composition of pitfall trapping was not similar to those of light trapping and leaf litter sieving. We discuss here the use of these three sampling methods.

Key words : Carabid beetle, Species composition, Pitfall trapping, Light trapping, Leaf litter-sieving, Shinshu University

Introduction

Carabid beetles (Coleoptera: Carabidae) have been used and studied as indicator organisms for environmental assessment and biodiversity indicators (Lövei and Sunderland, 1996; Rainio and Niemelä, 2003). In addition, they have been studied as indicators of environmental pollution, soil nutrient status in forestry (Lövei and Sunderland, 1996; Ward and Ward, 2001) and bioindicator of sustainable forest management (Pearce and Venier, 2006). Carabids have also been the subjects of numerous studies both basic and applied because of their diversity, abundant in a wide range of habitats and ease of capture (Melnychuk *et al.*, 2003).

Most of these studies have employed pitfall trapping to sample carabid assemblages, the preference for which was mainly related to its convenience and labor efficiency for collections large enough to support rigorous statistical analyses (Thiele, 1977; Spence and Niemelä, 1994; Ward and Ward, 2001). Species activities and population density may be influenced by many factors, including temperature and moisture, surrounding vegetation, materials used for trap construction, and the size, shape and arrangement of traps. (Spence and Niemelä, 1994; Ward and Ward, 2001). Such factors require serious attention if pitfall data are to be used reliably. In spite of the limitations

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of pitfall trapping, scientists have continued to use this technique because there are no reasonable alternatives, and studies of the pitfall trap method have continued to suggest better way to apply the method and interpret data thus collected (Halsall and Wratten, 1988; Spence and Niemelä, 1994; Ward and Ward, 2001) . Spence and Niemelä (1994) mentioned that it is important, if using the pitfall method, to link data from pitfall catches to those from other sampling methods and to consider information about the life history and habits of species composing particular carabid assemblages.

The objectives of this study were to investigate the species composition of carabid beetles by using three sampling methods (pitfall trapping, light trapping and leaf litter-sieving) in the same survey area and to compare data of pitfall trap catches to data obtained by light trapping and leaf litter-sieving.

Materials and Methods

1. Study site

Field surveys were conducted in an experimental forest area on the campus of the Faculty of Agriculture, Shinshu University in Nagano Prefecture, by three collecting methods from April to October 2005. This survey site was dominated by Japanese larch, *Larix leptolepis*, Japanese cypress, *Chamaecyparis obtuse*, and some broadleaf trees, and in addition the area was covered with weeds. A sports play field was located immediately to the north of the experimental area and to the south of our experimental area was another experimental forest of Japanese larch and red pine, *Pinus densiflora*.

2. Study methods

In this study we employed three sampling methods. In the first method, pitfall trapping, we used ten transparent plastic cups (7.5 cm diameter, 9.5 cm deep) with lactic acid beverage (Calpis™, Calpis Co., Ltd., Tokyo) as bait. Each trap was covered with a plastic tray placed about 10 cm above the trap to prevent rainfall and falling leaves from entering the trap. The traps were collected twice a month.

The second method was light trapping using a mercury lamp (National HID LAMP BHRF100-110V160W) and a white sheet (2.5 m height × 3.0 m length) as a screen, with a blue plastic sheet spread on the ground. The light trap was conducted from 18:00 to 22:00. The trap was set once a month.

The last method was leaf litter-sieving conducted by randomly gathering 10 samples of the leaf litter layer (1 m × 1 m) down to the level of the humus layer. Leaf litter layer samples were taken to the laboratory and sieved using an 8 m/m sieve. Sieving was done three times per samples to separate carabid beetles from the litter, and then the small beetles were picked up by sight separation. Litter sieving was conducted once a month.

Results and discussion

1. Species composition

A total of 1627 individuals comprising 39 species of carabid beetles were collected in the present study. **Table 1** shows the species and numbers of carabid beetles collected using the sampling methods described above. A total of 1454 individuals belonging to 26 species were caught by pitfall trapping. Fewer carabid beetles were collected by light trapping (51 individuals, 13 species) and leaf litter-sieving (122 individuals, 21 species) than by pitfall trapping. The dominant species caught by pitfall trapping were *Carabus insulicola* (481 individuals), *Synuchus cycloderus* (377 individuals) and *Leptocarabus procerulus* (373 individuals), which together represented 84.7% (1231 individuals) of the total. The remaining 23 species were represented by fewer than 77 individuals.

The three most numerous species caught by light trapping were *Harpalus griseus*, *Dromius prolixus* and *Asaphidion semilucidum*, representing 70.6% (36 individuals) of the total. The three dominant species caught by leaf litter-sieving were *Amara congrua*, *H. griseus* and *Harpalus tridens*, representing 63.1% (77 individuals) of the total.

In this study we calculated the mean body size of carabid species collected using the sampling methods. Body size of each species was referred to Ueno *et al.* (1985). **Table 2** shows that the mean body size of 26 species collected by pitfall trapping was significantly larger than that of species collected by the other two methods.

2. Seasonal abundance

The seasonal abundance of all species caught by the three different methods is shown in **Fig. 1.** Carabid beetles were caught by pitfall trapping from April to October, and large peaks occurred between July and

Table 1 Species and number of individuals of carabid beetles collected by different sampling methods

Species	Sampling method			Total
	Pitfall trapping	Light trapping	Leaf litter-sieving	
Carabus insulicola Chaudoir	481			481
Leptocarabus procerulus (Chaudoir)	373			373
Hemicarabus tuberculosus (Dejean et Boisduval)	1			1
Notiopbilus inpressifrons Morawitz			3	3
Asaphidion semilucidum (Motschulsky)		6	4	10
Trigonognatha cuprescens Motschulsky	10			10
Pterostichus samurai (Lutshnik)	7			7
Pterostichus subovatus (Motschulsky)	44		1	45
Pterostichus microcephalus (Motschulsky)	8		5	13
Colpodes japonicus (Motschulsky)		1		1
Dolichus halensis (Schaller)	7			7
Synuchus nitidus (Motschulsky)	77			77
Synuchus cycloderus (Bates)	377	1		378
Synuchus dulcigradus (Bates)	10		1	11
Synuchus arcuaticollis (Motschulsky)	2			2
Amara congrua Morawitz	3		51	54
Amara chalcites Dejean	3		1	4
Amara simplicidens Morawitz			1	1
Anisodactylus signatus (Panzer)		2	3	5
Anisodactylus punctatipennis Morawitz	1		2	3
Anisodactylus sadoensis Schauberger	1	1	1	3
Harpalus vicarius Harold			1	1
Harpalus griseus (Panzer)	1	20	16	37
Harpalus tridens Morawitz	3	2	10	15
Harpalus corporosus (Motschulsky)	6	1		7
Harpalus discrepans Morawitz	15		3	18
Trichotichnus lucidus (Morawitz)			1	1
Bradycellus fimbriatus Bates			2	2
Stenolophus agonoides Bates			5	5
Stenolophus fulvicornis Bates		1	8	9
Chlaenius pallipes Gebler	13			13
Chlaenius abstersus Bates	2			2
Chlaenius micans (Fabricius)	2	1		3
Chlaenius naeviger Morawitz	1			1
Chlaenius posticalis Motschulsky	5			5
Cymindis daimio Bates			1	1
Lebidia octoguttata Morawitz		1		1
Lebidia bifenestrata Morawitz		4	2	6
Dromius prolixus Bates	1	10		11
Total	1454	51	122	1627
species richness	26	13	21	39

October, with a break in August. Carabids collected by light trapping showed peaks in June and August, with a break in July. The number of individuals collected by leaf litter-sieving increased beginning in April, with a peak in July, and then decreased gradually.

The seasonal abundances of the three dominant species collected by the three sampling methods are shown in **Fig. 2.** *C. insulicola* by pitfall trapping was caught from late April until late autumn and was mostly caught between early June and July. *S. cycloderus* was not found from spring season to late summer and then was mainly collected in early

October. *L. procerulus* was collected from late May and was mostly found in traps in September and October (**Fig. 2A**).

In light trapping, *H. griseus* appeared mostly in summer, with a high peak in August. *D. prolixus* was caught mainly from June to August, and *A. semilucidum* was caught mainly in June (**Fig. 2B**). In leaf litter-sieving, *A. congrua* was captured beginning early in the sampling period and was mostly found in July, the same as *H. griseus*, whereas *H. tridens* appeared mainly in May (**Fig. 2C**).

3. Comparison of three sampling methods

Many more individuals were caught by pitfall trapping than by light trapping and leaf litter-sieving. The species richness of the sample collected by leaf litter-sieving was similar to that of the sample collected by pitfall trapping, but the species richness of the sample collected by light trapping was lower than those of the other two samples (**Table 1**).

Twelve species (*C. insulicola, L. procerulus, Synuchus nitidus*, etc.) were captured only by pitfall trapping. Two species (*Colpodes japonicus* and *Lebidia octoguttata*) were captured only by light trapping. Seven species (*Stenolophus agonoides, Notiophilus impressifrons, Bradycellus fimbriatus*, etc.) were caught only by leaf litter-sieving. Only three species were common to all three sampling methods, *Anisodactylus sadoensis, H.*

Table 2 Mean body size of carabid beetle species caught by three sampling methods

	Pitfall trapping	Light trapping	Leaf-litter sieving
No. of species	26	13	21
Mean body size	13.88[ab]	9.82[a]	9.19[b]
S. D.	5.41	3.78	3.02
F value by ANOVA		7.743 P=0.001	

a, b: There was significant difference between sampling methods at $P<0.05$ and $P<0.01$, respectively (Scheffe's multiple range test).

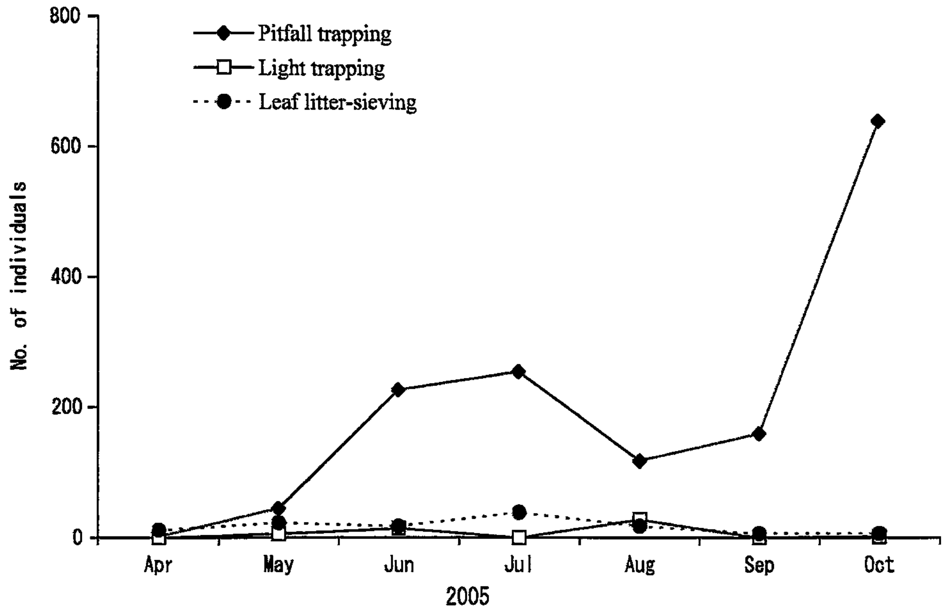

Fig. 1 Seasonal abundance of all the species caught by different sampling methods

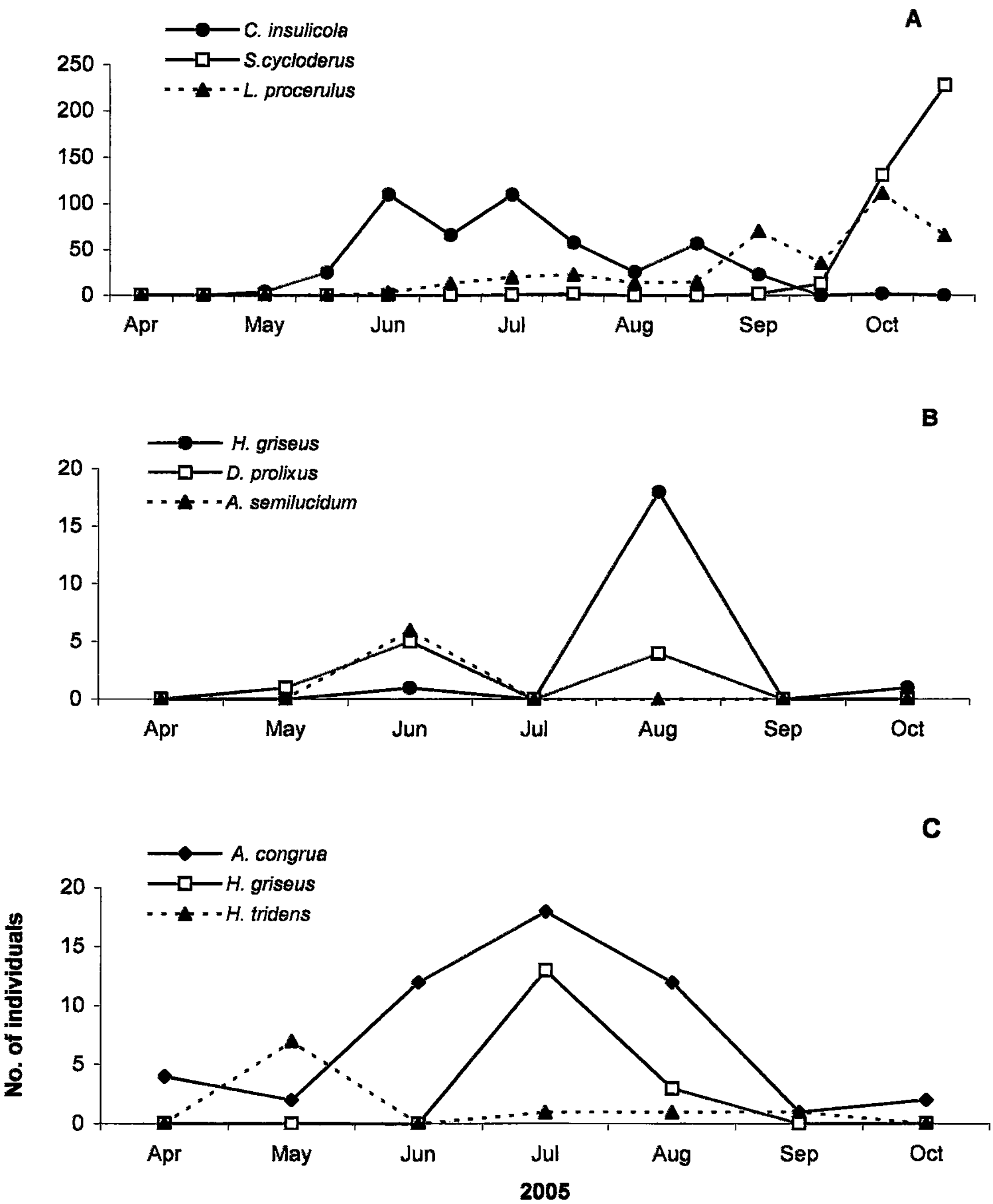

Fig. 2 Seasonal abundance of three dominant carabid beetles caught by pitfall trapping (A), light trapping (B), and leaf litter-sieving (C)

griseus and *H. tridens*.

The number of species in each subfamily of Carabidae trapped by the three sampling methods is given in **Table 3.** Subfamilies of Carabinae, Pterostichinae and Callistinae were mainly found in the pitfall trapping sample, whereas Lebiinae was captured mostly by light trapping. In the leaf-litter sieving method the most frequently caught subfamilies were Zabrinae and Harpalinae. The subfamily of Bembidiinae was caught equally by light trapping and leaf-litter sieving.

Similarity among the carabid beetles collected by three sampling methods is given in Table 4 Pianka's similarity index (α) (Pianka, 1973) showed that the species composition of beetles caught by pitfall trapping was not similar to those of beetles caught by light trapping and leaf litter sieving.

Relative abundance of species in the samples from the three methods was rather different. Samples from pitfall trapping were large-sized beetles, while individuals from light trapping and leaf litter-sieving were dominated by small-sized beetles (**Table 2**). This result agreed with reports by Franke *et al.* (1988) and Spence and Niemelä (1994). Moreover, this result also agreed with a report by Yahiro and Yano (1997) that the most common species caught by a light trap during their ten years study were dominated by small-sized species.

Three mechanisms may explain the finding that larger species were collected by pitfall trapping than by light trapping or leaf litter-sieving. First, large-sized species may be missed in the light trapping and leaf litter-sieving samples, because many of the larger species such as *C. insulicola* are flightless and may rest under fallen trees, branches or stones (Evans, 1986, 1990), where it may be difficult to take samples for sieving. Moreover, Spence and Niemelä (1994) reported that larger species might be more sensitive to the approach of humans taking leaf litter samples and might effectively escape before being captured.

Second, the high proportion of large-sized species collected by pitfall trapping might reflect a general positive correlation between body size and mobility in carabids (Luff, 1975; Theie, 1977; Spence and Niemelä, 1994). Consequently, if larger individuals range over greater areas, their probability of capture in pitfalls would be greater. On the other hand, Hassall and Wratten (1988) concluded that differences in capture rates in pitfalls among species were unrelated to body size or speed of movement.

Third, smaller-bodied species may escape more readily from pitfall traps. This is especially likely for traps constructed from plastic, which can become soiled and scratched, providing claw holds sufficient to support the mass of smaller carabids, especially when no preservatives are used (Luff, 1975). In this study we used plastic cups with a slippery surface so smaller beetles could not escape from the traps.

Similarity indexes indicated that samples caught by light trapping and leaf litter-sieving were partially similar, while those caught by pitfall trapping and leaf litter-sieving method were very different (**Table 4**). There were four species that were not found in pitfall traps but that were caught by both light traps and leaf

Table 3 Number of carabid beetles species in each subfamily caught by three sampling methods

Subfamily	Pitfall trapping	Light trapping	Leaf-litter sieving
Carabinae	3 (11.5%)	0 (0.0%)	0 (0.0%)
Nebriinae	0 (0.0%)	0 (0.0%)	1 (4.8%)
Bembidiinae	0 (0.0%)	1 (7.7%)	1 (4.8%)
Pterostichinae	9 (34.6%)	2 (15.4%)	3 (14.3%)
Zabrinae	2 (7.7%)	0 (0.0%)	3 (14.3%)
Harpalinae	6 (23.1%)	6 (46.2%)	11 (52.4%)
Callistinae	5 (19.2%)	1 (7.7%)	0 (0.0%)
Lebiinae	1 (3.8%)	3 (23.1%)	2 (9.5%)
Total number of species	26 (100%)	13 (100%)	21 (100%)

Table 4 Pianka's similarity index (α) of carabid beetles caught by three sampling methods

Sampling methods	Pitfall trapping	Light trapping
Light trapping	0.025	—
Leaf litter-sieving	0.009	0.290

litter-sieving, that is, *A. semilucidum*, *Anisodactylus signatus*, *S. fulvicornis* and *L. bifenestrata*. Many studies using the pitfall trapping method have reported that *A. signatus* was not found or was rarely found in forested areas (e.g., Ishitani and Yano, 1994; Suttiprapan *et al.*, 2003; Siddiquee and Nakamura, 2004). Ishitani and Yano (1994) reported that *A. signatus* was found as the second-most dominant species in a fig orchard. The habitat and activity of this beetle must be further researched.

The choice of an appropriate sampling method depends on the questions one wishes to study. For instance, in the survey of a large area, where the objective is to make a qualitative inventory of Carabidae, several kinds of sampling methods should be employed. Lebiinae such as *L. bifenestrata* were captured mostly by light trapping, and Zabrinae such as *A. congrua* and Harpalinae such as *H. griseus* were most frequently found in the leaf-litter sieving samplings (**Table 1, 3**). Spence and Niemelä, (1994) reported that pitfall trapping might be presently the only realistic available method for assessing and monitoring environments by using carabids as an indicator group or for making a statistical comparison of carabid communities. However, Hébert *et al.* (2000) recently reported a new highly efficient pit-light trap combined of a light trap and pitfall trap as a new standard tool to use for the study, inventory and monitoring of arthropods including carabid beetles. The number of carabid species caught by the pit-light traps was two times higher than the passive pitfall trap.

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3種類の採集方法による信州大学農学部構内のオサムシ科甲虫の種構成と季節変動

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信州大学農学部構内の演習林において，2005 年 4 月から 10 月にかけて，3 種類の採集方法（ピットフォールトラップ，ライトトラップ，ザルふるい法）によってオサムシ科甲虫の種構成と季節変動を調査し，これらの方法によって得られた結果を比較した．3 つの採集方法で合計 39 種 1627 個体のオサムシ科甲虫が採集された．ピットフォールトラップによる採集個体数（1454）が，ライトトラップ（51）やザルふるい法（122）よりはるかに多かった．ザルふるい法による種数（21）はピットフォールトラップ（26）とあまり変わらなかったが，ライトトラップの種数（13）は少なかった．ピットフォールトラップの優占種は，アオオサムシ *Carabus insulicola*, クロツヤヒラタゴミムシ *Synuchus cycloderus*, クロナガオサムシ *Leptocarabus procerulus* で，捕獲個体の 84.7%（1231個体）を占めた．ライトトラップでは，ケウスゴモクムシ *Harpalus griseus*, ホソアトキリゴミムシ *Dromius prolixus*, メダカチビカワゴミムシ *Asaphidion semilucidum* で，捕獲個体の 70.6%（36個体）を占めた．ザルふるい法では，ニセマルガタゴミムシ *Amara congrua*, ケウスゴモクムシ，コゴモクムシ *Harpalus tridens* で，捕獲個体の 63.1%（77個体）を占めた．オサムシ亜科，ナガゴミムシ亜科，アオゴミムシ亜科の種はピットフォールトラップで多く捕獲され，アトキリゴミムシ亜科はライトトラップ，マルガタゴミムシ亜科とゴモクムシ亜科はザルふるい法で多かった．ピットフォールトラップによって採集されたサンプルと他の 2 つの採集方法のサンプルとの類似度（α）は極めて低かった．これらの結果をもとに 3 つの採集方法の用い方について検討した．