Far Eastern Entomologist

Дальневосточный энтомолог

Journal published by Far East Branch of the Russian Entomological Society and Laboratory of Entomology, Institute of Biology and Soil Science, Vladivostok

Number 222: 1-23 ISSN 1026-051X March 2011

ABUNDANCE AND DIVERSITY OF FLYING BEETLES (COLEOPTERA) COLLECTED BY WINDOW TRAPS IN SATOYAMA PINE FORESTS IN NOTO PENINSULA, JAPAN, WITH SPECIAL REFERENCE TO THE MANAGEMENT CONDITIONS: A FAMILY LEVEL ANALYSIS

C. Y. Barsulo[1] and K. Nakamura[1,2]

1) Graduate School of Natural Science and Technology, Kanazawa University, Kakuma, Kanazawa, 920-1192, Japan. E-mail: chriswebyan@gmail.com

2) Division of Biodiversity, Institute of Nature and Environmental Technology, Kanazawa University, Kakuma, Kanazawa, 920-1192, Japan. E-mail: koji@kenroku.kanazawa-u.ac.jp

In Noto Peninsula, red-pine (*Pinus densiflora*) forests were managed strictly for mushroom cultivation by raking the forest bed to remove litter and other vegetation. However, most of the pine forests have changed into mixed forests with other trees being present because they have been abandoned for several decades. This article aims to clarify the abundance and diversity of flying beetle assemblages of pine forests at a family level. In the northern tip of Noto Peninsula, the beetles were collected monthly from May to October 2009 using flight-interception traps at canopy and ground strata from 3 red-pine forests, each containing 1 pair of managed and unmanaged sites. Samplings with the same methods were carried out in 2 evergreen forests, 2 deciduous forests and 1 sugi plantation. The results obtained in the pine forests are as follows: (1) a total of 2957 beetles belonging to 51 families were collected, (2) the number of individuals was not significantly different between the managed and unmanaged sites, (3) the number of individuals collected at the canopy was larger than that at ground strata in both managed and unmanaged sites, (4) CA ordination shows that the family composition of pine forests was separated from those of other forest types (evergreen, deciduous forests and sugi plantation), (5) family composition was different between the canopy and ground strata, but not between the managed and unmanaged sites, and (6) the 5 most dominant families were Cantharidae, Elateridae, Scolytidae, Rhipiphoridae and Mordellidae regardless of strata and management conditions.

KEY WORDS: Coleoptera, beetle assemblages, window trap, satoyama, pine forest, forest management, biodiversity.

Х.Я. Барсуло, К. Накамура. Численность и разнообразие жесткокрылых насекомых (Coleoptera), собранных оконными ловушками в сосновых лесах на полуострове Ното, Япония, с учетом воздействия на леса в традиционном сельском ландшафте: анализ на уровне семейств // Дальневосточный энтомолог. 2011. N 222. С. 1-23.

На полуострове Ното сложенные *Pinus densiflora* сосновые леса использовались для выращивания грибов, для чего подстилка разрыхлялась с целью удаления опада и травы. Однако, большинство сосняков, не используемых в течение последних десятилетий, постепенно превращается в смешанные леса за счет прироста деревьев широколиственных пород. Целью настоящей статьи является изучение численности и разнообразия хорошо летающих жесткокрылых насекомых сообществ сосновых лесов на уровне семейств. Жуки отлавливались ежемесячно с мая по октябрь на северной оконечности полуострова Ното с использование оконных ловушек как в кронах деревьев, так и на уровне почвы на 3 модельных участках, причем в каждом участке были обследованы как возделываемые, так и ненарушенные местообитания. Аналогичные сборы проведены в 2 вечнозеленых, 2 листопадных лесах и в посадках криптомерии. В сосновых лесах получены следующие результаты: (1) всего собрано 2957 жуков из 51 семейства; (2) в возделываемых и ненарушенных местообитаниях количество собранных экземпляров жуков существенно не различалось; (3) количество собранных в кроне жуков было больше, чем на уровне почвы как на возделываемых, так и в ненарушенных участках леса; (4) ординация методом CA показала, что состав семейств жескокрылых в сосняках отличается от такового в других типах леса (вечнозеленые и листопадные леса, посадки криптомерии); (5) состав семейств жесткокрылых в кронах и на уровне почвы различается, а между возделываемыми и естественным местообитаниями существенных различий не обнаружено; (6) вне зависимости от яруса растительности и степени антропогенного воздействия в сосняках преобладают представители семейств Cantharidae, Elateridae, Scolytidae, Rhipiphoridae и Mordellidae.

1) Высшая школа естественных наук и технологии Университет Канадзавы, Канадзава, Япония.

2) Отделение биоразнообразия, Институт природы и технологий охраны окружажщей среды, Университет Канадзавы, Канадзава, Япония.

INTRODUCTION

Satoyama is a secondary natural environment formed as a result of human activities in agriculture and forestry over many years. It is a mosaic ecosystem comprised of paddies, woodlands, plantations, grasslands and others. Satoyama, covering around 40% and 60% of Japanese national land and Ishikawa Prefecture, respectively, has many important ecosystem services such providing food and materials, regulating environmental conditions and providing cultural services for human wellbeing. Biodiversity is a key element for the resiliency and functioning of satoyama (Washitani, 2001; Kobori & Primack, 2003; Takeuchi, 2010). Satoyama has undergone significant decline over the last 50 years owing to socio-economic factors, such as a decreasing and aging population, resulting in negative consequences for human wellbeing and biodiversity (JASS, 2010).

Until 50 years ago, in lowland areas of satoyama of Noto Peninsula, which juts out into the Japan Sea in the central region of the Japanese Archipelago, pine forests (*Pinus densiflora* Sieb. et Zucc.) were widespread and were strictly managed for matsutake mushrooms (*Tricholoma matsutake* (Ito et Imai) Sing.) and highly exploited for fuel wood. Since this ectomycorrhizal symbiont of pine trees requires a clean forest floor and infertile soil conditions to thrive, management of young pine forests (about 20-30 years old) is essential (Kato, 2001; Ogawa, 1978). Deciduous *Quercus* forests were also widespread and regularly cut (20-30-year cycles) for fuel wood, charcoal making and cultivation of shiitake mushrooms (*Lentinus edodes*). As mentioned above, forests in Noto Peninsula, the same as in other satoyama areas, have been neglected without management for a long time, resulting in the succession of forest vegetation and change in biodiversity. There is a need for more research on the consequences of satoyama abandonment on change in ecosystems, especially in terms of biodiversity.

In our previous study (Linawati et al., 2006) we investigated the effects of red-pine forest management for matsutake mushroom production on invertebrate communities using four sampling methods: window and pitfall traps, and sampling of litter and soil. Samples were collected from the "managed site" and from the surrounding "control site" without management. The results were examined in terms of abundance and composition of higher taxa.

This study was aimed to compare the flying beetle assemblages in red-pine forests in Noto Peninsula. The samples collected using window traps were compared, first, between the managed and unmanaged forests, second, between the canopy and ground strata, and third, between pine forests and forests with different types of forest vegetation such as evergreen forests, deciduous forests and a sugi plantation in Noto Peninsula. This article deals with a family level analysis, followed by a species level analysis in succeeding articles. Flying beetles are selected as indicators of vegetation and intensity of management practices because of high abundance, species diversity, diversified ecological functions (guild status in ecological communities) and sensitivity toward environmental changes (Hyvarinen et al., 2006; Hyvarinen et al., 2009).

STUDY SITES

Geographical location and climate condition: The study sites were located in Suzu city and Noto town (Fig. 1). The average annual temperature and rainfall from the nearest weather station at Wajima city (WAJIMA Station, 37°23.5' N and 136°53.7' E) were 13.02°C and 2247.8 mm, respectively (data from 1930 to 2009). The elevation of sampling sites ranged from 20 to 277 m above sea level.

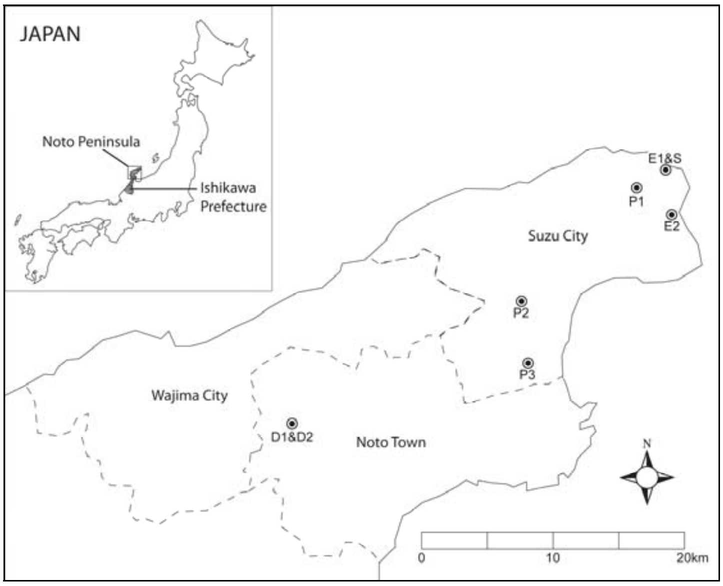

Fig. 1. Map showing the locations of sampling sites in the tip of Noto Peninsula. Vegetation codes (P, D, E and S) are the same as in Table 1.

Satoyama forests of Noto Peninsula in the past and present: In Noto Peninsula, with a predominantly warm temperate climate, the original vegetation was evergreen broadleaf forest. In the prehistoric age, when human impact on the vegetation was negligible, the lowland of the peninsula was covered with the original vegetation. As human populations expanded with increasing agriculture and forestry activities, the original evergreen forests were changed into deciduous broadleaf forests predominated by oaks (*Quercus* spp.), pine forests (*Pinus* spp.), paddies and other kinds of man-made habitats, and then the satoyama landscapes were established. From the 1950s to the 1970s, sugi cedar (*Cryptomeria japonica*) plantations were established in large areas. As a result, at present, mature evergreen forests are found in only a few locations, most of which are left as shrine forests. Pine forests, only a part of which are strictly managed for mushroom cultivation, are still widespread and mostly unmanaged. Table 1 shows a summary of the features of pine and other forest sites for sampling of beetles.

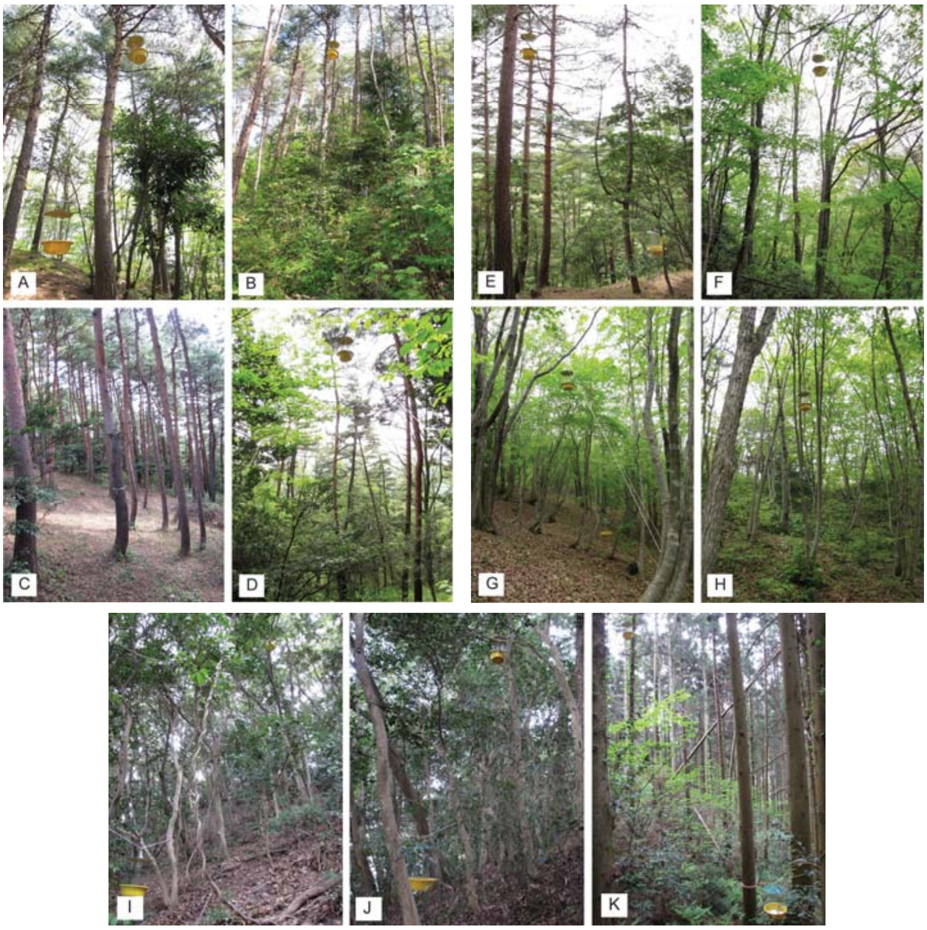

Fig. 2. Photos of the sampling sites (A-K). Sampling site codes are parenthesized. Managed pine forest: A (P1M), C (P2M) and E (P3M); unmanaged pine forest: B (P1U), D (P2U) and F (P3U); deciduous broadleaf forest: G (D1) and H (D2); evergreen broadleaf forest: I (E1) and J (E2); sugi plantation: K (S).

Pine forest sites (P): Three unmanaged pine forests were selected (P1, P2 and P3) (Fig. 1), each of which had a small strictly managed part, with these managed sites designated as P1M, P2M and P3M (Fig. 2 A, C, E). The areas of sites ranged from 0.5 to 0.6 ha. Corresponding to each managed site, an unmanaged site was selected in the surrounding unmanaged areas. These sites were named as P1U, P2U and P3U (Fig. 2 B, D, F). The distance between a pair of managed and unmanaged sites, for examples P1M and P1U, was 10 to 20m.

Deciduous oak forest (D): Two rectangular *Quercus* stands, D1 (0.25 ha) and D2 (0.125 ha), separated by a small road and strictly managed by forest bed raking for mushroom cultivation, were selected (Table 1, Figs. 1 and 2 G-H).

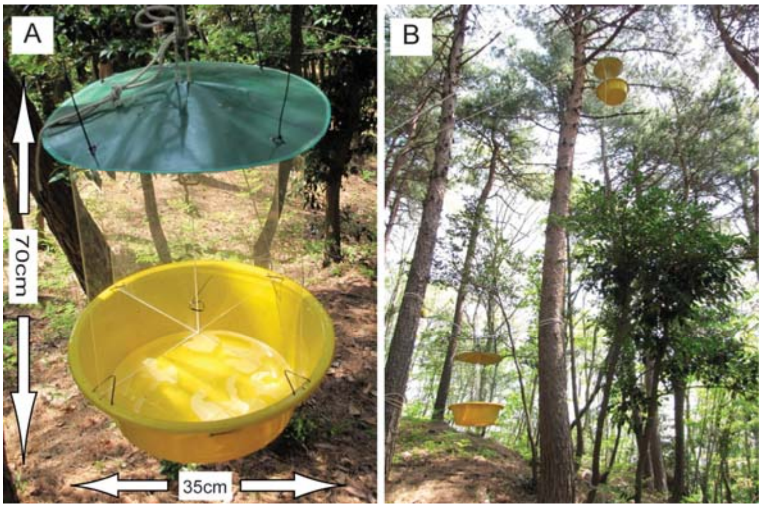

Fig. 3. A: IBOY-type window trap. B: Traps set at canopy and ground strata.

Evergreen forests (E): Sampling site E1 (Fig. 2 I) was established in a mature evergreen forest (>2 ha) of Yamabushi hill (184 m asl), which is one of the Ishikawa prefectural designated cultural assets. The hill is surrounded by large mixed deciduous forests, sugi plantations and vegetables fields. A second site, E2 (Fig. 2 J), was located in small a patch (< 1 ha) of mature evergreen forest at the rear side of Katahime shrine hill. This forest is surrounded by paddy fields and residential areas.

Sugi plantation (S): S is located at the foot of Yamabushi hill (Fig. 2 K).

SAMPLING METHODS

Beetles were sampled monthly from May to October 2009, using IBOY standard window trap (Nakashizuka & Stork, 2002). The trap consisted of 1 yellow bucket and 2 transparent intersect panels (Fig. 3A). In each sampling site, two replications, each containing two traps at ground and upper levels (Fig. 3 B), were placed 10-20 m apart. The traps were suspended using ropes and canopy pulley in the canopy, ranging from 10-15 m above ground strata, and at ground strata at 1.5 m from the ground. Two liters of 10% ethylene glycol and a few drops of detergent were added to the trap bucket as killing agent and insect preservative. The traps were exposed for 6 days before the samples were collected.

Identification of specimens: From all specimens collected, 73% were identified to species level, 5% to genus level and 22% to family level. Morphospecies identification methods (Oliver & Beattie, 1996) were applied to specimens at genus and family levels for further analysis. The books of «Coleoptera of Japan in Color» (Ueno et al., 1985; Kurosawa et al., 1985; Hayashi et al., 1989) were used for identification. All specimens were pinned and deposited at the Laboratory of Ecology Graduate School of Natural Science and Technology, Kanazawa University.

DATA ANALYSIS

Mann-Whitney U test and/or Kruskal-Wallis test (H) were used to examine the differences in mean number of individuals and that of families of beetles collected among the sites, between treatments (managed and unmanaged) and between strata (canopy and ground). All statistical tests were performed using PAST software version 1.95 (Hammer et al., 2001).

Correspondence analysis (CA) was used to visualize the variation in the composition of beetle family assemblages between pine forest sites and other forest types and also within pine forest sites (Hirst & Jackson, 2007). CANOCO software version 4.5 (ter Braak & Smilauer, 2002) was used for the calculation.

RESULTS

1. Abundance

1) ***All sampling sites***. In this study, a total of 2957 (123.2 per trap) individuals, 1743 (145.3) and 1214 (101.2) in unmanaged and managed sites, and 1931 (160.9) and 1026 (85.5) at canopy and ground strata, respectively, were collected from all sites. The difference between the strata was larger in the unmanaged sites (214.2 vs. 76.3) than in the managed sites (107.7 vs. 94.7). The difference between the treatments was larger in the canopy (214.2 vs. 107.7) than at ground strata (76.3 vs. 94.7) (Table 2 and Fig. 4).

2) ***Each site***. Among the 3 sites, the largest number of individuals per trap was collected in P1 (178.0), followed by P2 (119.0) and P3 (72.6) (Kruskal-Wallis test among sites, $P>0.05$) (Fig. 4). When the two strata were pooled for each of the three sites, the range of number of beetles collected in unmanaged sites (P1U, P2U and P3U) was larger than that of managed sites (P1M, P2M and P3M) (77.5-234.0 and 67.8-122.0, respectively, Mann-Whitney test, $P>0.05$) (Fig. 4). When the two treatments were pooled for each of the three sites, the range of number of beetles collected at the canopy was larger than that at ground strata (57.5-409.0 and 41.0-129.0, respectively) (Fig. 4, Mann-Whitney test, $P<0.05$).

2. Diversity

1) Number of families

(1) ***All sampling sites***. A total of 51 families were collected from all the study sites during the entire study period. The total numbers of families collected from managed and unmanaged sites were 42 and 45, and those collected at canopy and ground strata were 44 and 43, respectively (Fig. 5).

(2) ***Each sampling site***. The total numbers of families collected were 39 in P1 and P2 and 37 in P2. When the two strata were pooled for each of the three sites, the numbers of families ranged from 30-33 and 28-32 beetles collected in unmanaged and managed sites, respectively. When the two treatments were pooled for each of the three sites, the numbers of families collected ranged from 19-32 and

18-28 at canopy and ground strata, respectively (Fig. 5). No significant difference was found in number of families between treatments or between strata among the sampling sites (Kruskal-Wallis test, P>0.05).

Table 1. Characteristics of the sampling sites. Vegetation codes: P = pine forest; D = deciduous broadleaf forest; E = evergreen broadleaf forest; S = sugi plantation. Treatment codes: M = managed; U = unmanaged; N = natural.

Forest type code	Treatment	Repli-cation	Location	Altitude ca. (m)	Slope (degree)	Tree species found at the sampling site surrounding the traps
P	M	1	37°29'58.50"N, 137°18'22.60"E	129	0-30	*Pinus densiflora, Eurya japonica*
		2	37°25'26.30"N, 137°12'19.90"E	226	0-15	Ditto.
		3	37°22'52.20"N, 137°12'38.30"E	158	0-45	Ditto.
	U	1	Ditto.	129	0-30	*P. densiflora, Acer sieboldianum, Eleutherococcus sciadophylloides*
		2		226	0-30	*P. densiflora, Quercus serrata, E. japonica, Ilex macropoda*
		3		158	0-45	*Q. serrata, A. sieboldianum, E. japonica, Cryptomeria japonica, P. densiflora*
D	M	1	37°20'4.70"N, 137°0'48.10"E	277	0-10	*Q. serrata, Q. variabilis, A. sieboldianum, A. rufinerve, Carpinus japonica, Padus grayana*
		2	37°20'4.70"N, 137°0'48.10"E	277	0-30	Ditto.
E	N	1	37°30'38.40"N, 137°19'53.90"E	172	15-50	*Q. acuta, Machilus tunbergii, Camellia japonica, E. japonica, A. sieboldianum, Neolitsea sericea*
	N	2	37°28'47.80"N, 137°20'10.60"E	20	0-45	*Castanopsis sieboldii, C. japonica, M. tunbergii,* (*Sasa sp., Polystichum ohmurae*)
S	U	1	37°30'40.50"N, 137°19'56.90"E	167	0-30	*C. japonica*

2) Family ranking in abundance

(1) ***All sampling sites***. MU-CG in Figure 6 shows the family ranking in terms of the number of individuals collected in all sites, combining both treatments (managed,

M, and unmanaged, U) and two strata (canopy, C, and ground, G). It indicates that the top 5 families are as follows: Cantharidae (44.6%), Elateridae (14.2%), Scolytidae (6.2%), Rhipiphoridae (6%) and Mordellidae (4.6%) (the percentages in parentheses are the proportions of the total number of individuals in the sample).

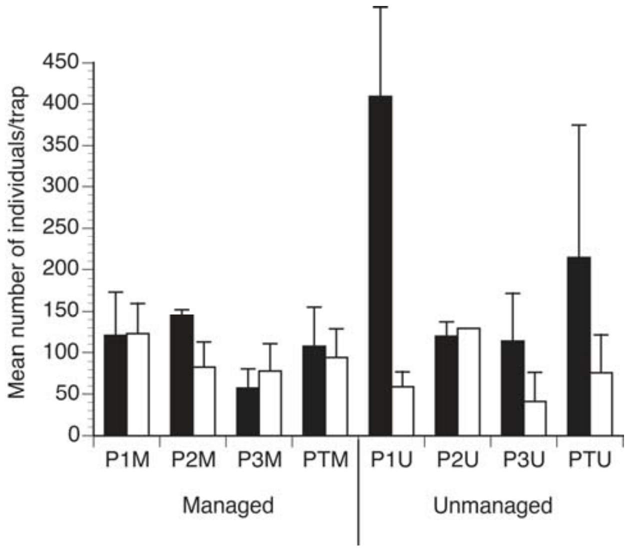

Fig. 4. Comparison of mean number of individuals collected per trap ($\overline{X}$ ± 1 SD) with different treatments and strata (■ = canopy, and □ = ground) among pine forest sampling sites. See Table 2 for detail.

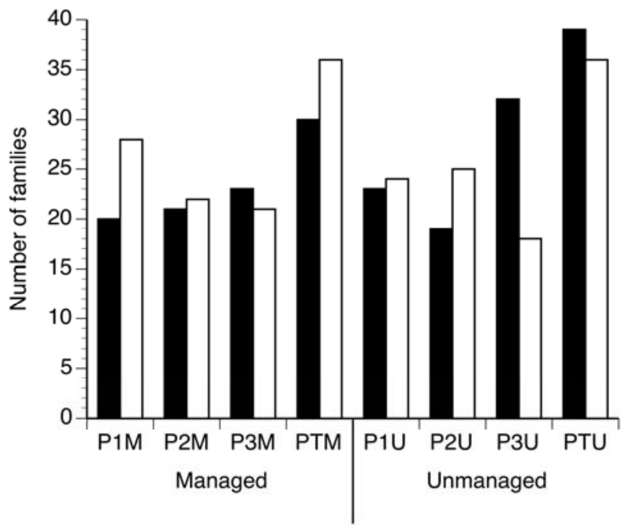

Fig. 5. Comparison of number of families with different treatments and strata (■ = canopy, and □ = ground) among pine forest sampling sites. See Table 3 for detail.

M-CG and U-CG in Fig. 6 show the abundance ranking of families in the managed (M) and unmanaged (U) sites, combining the two strata (C and G). These figures indicate that 4 families (Cantharidae, Elateridae, Rhipiphoridae, Scolytidae) out of the 5 top-ranked families in both treatments were the same and Mordellidae was third-ranked in managed sites and Staphylinidae 5th in unmanaged sites. In the top 10 ranking families, 8 were shared. Eucnemidae and Cucujidae were found only in managed sites and Staphylinidae and Cerambicidae only in unmanaged sites. In summary, the family composition and ranking were similar in both treatments. The number of Cantharidae, the first-ranked, was much higher in U (49%) than M (38.2%), while that of Elateridae, the second-ranked, was higher in M (20.3%) than in U (10%).

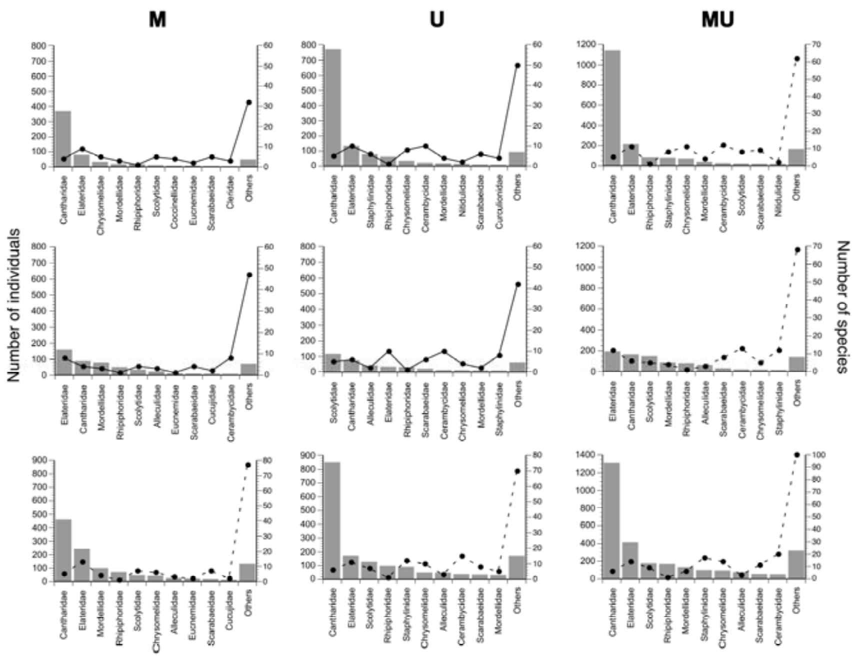

Fig. 6. Comparison of abundance ranking of top 10 beetle families from total pine forest sampling sites with different combinations of treatments (M = managed, U = unmanaged, MU = M+U) and strata (C = canopy, G = ground, CG = C+G). ■ = number of individuals, ● = number of species.

MU-C and MU-G in Fig. 6 show the abundance rankings of families collected at canopy (C) and ground (G), combining the two treatments (M and U). These figures indicate that (1) among the top 5 families 3 (Cantharidae, Elateridae, Rhipiphoridae) were shared by the 2 strata. Among the top 10 ranked families 9 were shared by C and G, while Nitidulidae and Alleculidae were recorded in the top 10 only in C and G, respectively. In summary, the ranking was variable between the two strata, and the number of Cantharidae was markedly higher in C (59.4%) than G (16.7%).

M-C, M-G, U-C and U-G in Fig. 6 show the abundance ranking of families with different combinations of treatments and strata. These figures indicate that (1) the beetle assemblages at canopy strata in managed sites (M-C) are characterized by Cantharidae (first ranked with a high number), Coccinellidae (7th) and Cleridae (10th), (2) at canopy strata in unmanaged sites (U-C) by Cantharidae (first with an extremely high number), Staphylinidae (3rd), Nitidulidae (7th) and Curculionidae (10th), (3) at ground strata in managed sites (M-G) by Elateridae (first) and Cucujidae (9th), and (4) at ground strata in unmanaged sites (U-G) by Scolytidae (first), Alleculidae (3rd) and Staphylinidae (10th). In summary, the ranking was variable among the treatments and strata, and differences were detected between the strata as follows: (1) the abundance of Cantharidae was markedly different between the strata, and (2) the order of families among top 5 ranked varied between strata in both treatments. While the family ranking (first to 5th) at canopy strata was the same in both treatments, that at ground level was different between the treatments.

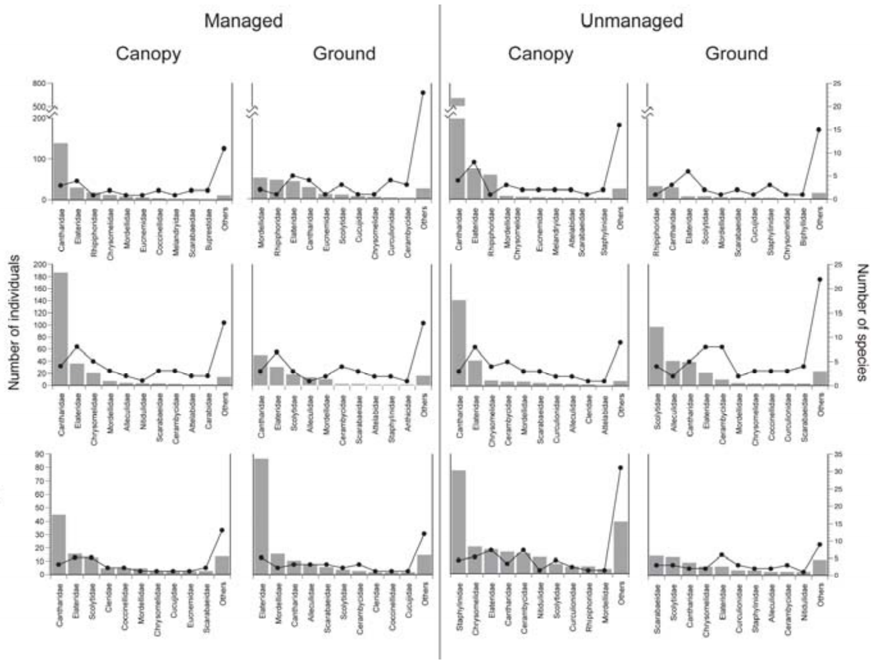

Fig. 7. Comparison of abundance ranking of top 10 beetle families in each pine forest sampling site with different treatments (M = managed and U = unmanaged) and strata (C = canopy and G = ground). ■ = number of individuals, ● = number of species.

(2) ***Each sampling site***. In 9 out of 12 sites, first ranked families were one of the top 5 families shown in MU-CG in Figure 6, namely, Cantharidae (first-ranked) for 6 sites, and Elateridae (second-ranked), Scolytidae (third-ranked), Rhipiphoridae (fourth-ranked); and Mordellidae (fifth-ranked) each for 1 site. In 11 out of 12 sampling

sites, the top 5 families were composed of 3 or more families belonging to the most abundant families mentioned above. Distinct family ranking was found in the following sites: Staphylinidae (6th-ranked) (MU-CG in Fig. 6) and Scarabaeidae (9th-ranked) were first-ranked in P3 unmanaged sites at canopy and ground strata, respectively.

3) Species richness within family for all sampling sites

MU-UG in Figure 6 and Table 2 show that Cerambycidae, represented by 20 species, was top-ranked by the number of species within a family, followed by Staphylinidae (17), Chrysomelidae (14), Elateridae (14) and Scarabaeidae (11). These 5 families except Elateridae were not among the top 5 families in the ranking by abundance. In summary, ranking by abundance and that by species richness did not correspond, which is also found for each sampling site as mentioned below (Fig. 7).

3. Multivariate analysis

1) ***Comparison of beetle family assemblages between red-pine forests and other forests***. CA ordination (Fig. 8 Top) reveals that the pine forest sites except P3U are clearly separated from those of deciduous forests and the sugi plantation by both axes 1 and 2, and from evergreen forests only by axis 1. Figure 8 also shows that, for the pine forests, the family compositions of the managed sites were more homogeneous than those of the unmanaged sites. It should be noted that Staphylinidae and Scarabeidae were top-ranked at canopy and ground strata, respectively, in the assemblages of P3U (Fig. 7). Figure 8 (bottom) shows that each forest was characterized with some top 10 families: pine forests with Cantharidae and Rhipiphoridae, deciduous forests with Scolytidae, evergreen forests with Chrysomelidae and Nitidulidae and the sugi plantation with Staphylinidae. Both axes explained 50.2% of the variability in the family composition of the samples.

2) ***Comparison of the beetle family assemblages of pine forests among sites, treatments and strata***. Figure 9 (Top) shows that (1) the family assemblages collected in the managed sites were not separated from those in the unmanaged ones, as shown in Fig. 8, and (2) those collected at the canopy except P3MC were clearly separated from those at ground strata, which is shown by the difference along the second axis. Figure 9 (Bottom) shows that two of the top five families, namely, Cantharidae and Rhipiphoridae, corresponded to the canopy while Elateridae (Elat.), Mordellidae (Mord.) and Scolytidae (Scol.) corresponded to the ground. Both axes explained 57.1% of the variability.

DISCUSSION

1. ***Pine forest and other forest types of flying beetle family assemblages related to forest successional stages***. CA ordination (Fig. 8) shows that the family composition of pine forests was separated from those of other forest types (evergreen, deciduous forests and sugi plantation). This separation can be explained by the stages

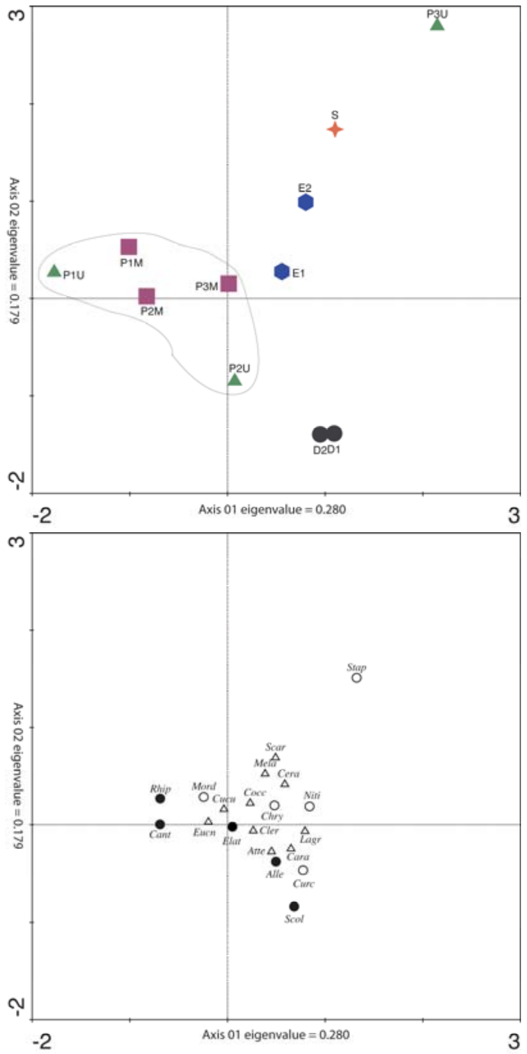

Fig. 8. Top: CA ordination showing the distribution of family assemblages of the beetles collected from the forests with different types of vegetation, namely, ■, managed and ▲, unmanaged pine forests; ●, deciduous forests; ⬢, evergreen forests and ✦, sugi plantation.

Bottom: CA ordination showing the distribution of each flying beetle families collected over different types of vegetation as mentioned above. Different symbols refer to the abundance ranking of beetle families from total catch in all forest types: ●, ranked 1-5 (Cantharidae, Elateridae, Scolytidae, Rhipiphoridae, Alleculidae, respectively); ○, 6-10 (Mordellidae, Chrysomelidae, Curculionidae, Staphylinidae; Nitidulidae, respectively) and △, 11-20 (Scarabeidae, Cerambycidae, Eucnemidae, Melandryidae, Attelabidae, Cucujidae, Coccinellidae, Cleridae, Carabidae, Lagriidae). See Appendix A for the list of families in other forest types.

Table 2. The number of individuals collected in the whole study site (PT) and at each site (P1 - 3). M = managed; U = unmanaged; C = canopy; G = ground; A = total number of individuals; B = average number of individuals per trap $\overline{X} \pm$ SD.

Site	A B	Treatment	A B	Strata	A	A B
PT	2957 123.2±99.1	M	1214 101.2±40.1	C		646 107.7±47.8
				G		568 94.7±33.8
		U	1743 145.3±133.6	C		1285 214.2±160.7
				G		458 76.3±45.2
P1	1424 178±152.9	M	488 122±36.9	C1	84	242 121±52.3
				C2	158	
				G1	97	246 123±36.8
				G2	149	
		U	936 234±211.7	C1	333	818 409±107.5
				C2	485	
				G1	72	118 59±18.4
				G2	46	
P2	952 119±27.64	M	455 113.8±39.7	C1	139	289 144.5±7.8
				C2	150	
				G1	104	166 83±29.7
				G2	62	
		U	497 124.3±11.6	C1	107	239 119.5±17.7
				C2	132	
				G1	129	258 129±0
				G2	129	
P3	581 72.6±41.7	M	271 67.8±26.0	C1	41	115 57.5±23.3
				C2	74	
				G1	101	156 78±32.5
				G2	55	
		U	310 77.5±57.6	C1	73	228 114±58.0
				C2	155	
				G1	16	82 41±35.4
				G2	66	

Table 3. The number of families collected in the whole study site (PT) and at each site (P1 - 3). M = managed; U = unmanaged; C = canopy; G = ground; A = number of families; B = average number of families per trap $\overline{X} \pm$ SD.

Site	A B	Treatment	A B	Strata	A	A B
PT	51 16.5±4.5	M	42 15.8±4.3	C		30 14.83±3.6
				G		36 16.7±4.9
		U	45 17.3±4.8	C		39 18.3±5.7
				G		36 16.3±3.9
P1	39 16.9±3.5	M	32 16.8±4.9	C1	11	20
				C2	17	14±4.2
				G1	16	28
				G2	23	19.5±4.9
		U	30 17.0±2.2	C1	19	23
				C2	17	18±1.4
				G1	14	24
				G2	18	16±2.8
P2	37 16.1±3.9	M	28 16.0±3.6	C1	11	21
				C2	19	15±5.7
				G1	18	22
				G2	16	17±1.4
		U	30 16.3±4.9	C1	10	19
				C2	15	12.5±3.5
				G1	21	25
				G2	19	20±1.4
P3	39 16.6±6.2	M	29 14.5±5.1	C1	13	23
				C2	18	15.5±3.5
				G1	19	21
				G2	8	13.5±7.8
		U	33 18.8±7.2	C1	26	32
				C2	23	24.5±2.1
				G1	10	18
				G2	16	13±4.2

Table 4. Number of individuals and species in different beetle families collected using window traps in pine forests. M = managed; U = unmanaged; C = canopy; G = ground; T = total sites. Family rank is separated on the basis of (1) total number of individuals and (2) total number of species in each family. Guild: X= xylophages; H = herbivores; S = saprophages; F = fungivores; P = predators; O = omnivores.

Family	No. of Individuals																		No.of Species		Guild	Habitat			
	M								U								Total	Rank	Total	Rank		M		U	
	1		2		3		T		1		2		3		T							C	G	C	G
	C	G	C	G	C	G	C	G	C	G	C	G	C	G	C	G									
Alleculidae	0	1	5	15	1	8	6	24	0	0	4	42	2	3	6	45	81	8	3	16	O	✓	✓	✓	✓
Anthicidae	0	0	0	3	0	0	0	3	0	0	0	0	1	2	1	2	6	24	1	32	S		✓	✓	✓
Attelabidae	1	1	2	3	1	1	4	5	4	1	1	2	2	2	7	5	21	16	6	10	H	✓	✓	✓	✓
Biphyllidae	0	3	1	1	0	0	1	4	1	2	0	1	1	1	2	4	11	19	3	17	F	✓	✓	✓	✓
Bruchidae	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	46	1	33	H	✓			
Buprestidae	2	0	0	1	1	0	3	1	0	0	1	1	0	0	1	1	6	25	2	23	H	✓	✓	✓	✓
Cantharidae	139	29	188	52	45	11	372	92	616	29	142	40	17	10	775	79	1318	1	6	11	P	✓	✓	✓	✓
Carabidae	0	3	2	0	0	0	2	3	0	0	1	0	1	0	2	0	7	22	7	9	P	✓	✓	✓	
Cephaloidae	1	1	0	0	1	0	2	1	3	1	1	0	0	0	4	1	8	20	1	34	H	✓	✓	✓	✓
Cerambycidae	2	3	3	4	0	3	5	10	1	1	8	11	16	3	25	15	55	10	20	1	X	✓	✓	✓	✓
Cerylonidae	1	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	2	39	2	24	F	✓			
Chrysomelidae	13	6	21	2	3	1	37	9	7	3	10	4	21	7	38	14	98	7	14	3	H	✓	✓	✓	✓
Ciidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	47	1	35	F			✓	
Cleridae	1	1	2	2	5	2	8	5	2	0	3	0	3	0	8	0	21	17	4	14	P	✓	✓	✓	
Coccinellidae	5	1	2	0	5	2	12	3	0	1	1	4	2	1	3	6	24	15	8	8	P/H	✓	✓	✓	✓
Corylophidae	0	0	1	0	1	0	2	0	2	0	0	1	3	0	5	1	8	21	3	18	F	✓		✓	✓
Cucujidae	2	8	0	1	3	2	5	11	2	4	1	2	1	0	4	6	26	14	3	19	F	✓	✓	✓	✓
Curculionidae	0	4	1	1	2	0	3	5	1	2	5	4	6	4	12	10	30	13	11	5	H	✓	✓	✓	✓
Dermestidae	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	48	1	36	O	✓			
Elateridae	30	44	37	32	16	87	83	163	76	8	43	22	19	7	138	37	421	2	14	4	O	✓	✓	✓	✓
Erotylidae	1	0	1	1	0	0	2	1	3	0	0	0	0	0	3	0	6	26	3	20	F	✓	✓	✓	
Eucnemidae	7	13	2	0	3	1	12	14	6	2	0	0	1	0	7	2	35	11	2	25	O	✓	✓	✓	✓
Hydrophilidae	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	49	1	37	O		✓		
Lagriidae	0	0	0	0	0	0	0	0	2	1	0	0	3	0	5	1	6	27	2	26	S			✓	✓
Lampyridae	0	1	0	2	0	2	0	5	0	0	0	0	0	1	0	1	6	28	2	27	P		✓	✓	✓
Languriidae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	50	1	38	O			✓	

Table 4 (continued).

Family	No. of Individuals																		No.of Species		Guild	Habitat			
	M								U								Total	Rank	Total	Rank		M		U	
	1		2		3		T		1		2		3		T										
	C	G	C	G	C	G	C	G	C	G	C	G	C	G	C	G						C	G	C	G
Lathridiidae	0	0	0	0	0	0	0	0	1	0	0	1	3	0	4	1	5	29	2	28	F			✓	✓
Leiodidae	0	0	0	0	0	1	0	1	0	1	1	0	0	0	1	1	3	32	2	29	F		✓	✓	✓
Lycidae	0	1	0	0	0	0	0	1	0	1	0	3	0	0	0	4	5	30	2	30	H		✓	✓	✓
Melandryidae	3	1	0	1	0	0	3	2	5	0	1	2	0	0	6	2	13	18	4	15	F	✓	✓	✓	✓
Melyridae	0	0	0	0	0	0	0	0	2	1	0	0	0	0	2	1	3	33	1	39	O			✓	✓
Mordellidae	9	53	8	12	5	16	22	81	9	6	8	5	4	2	21	13	137	5	6	12	H	✓	✓	✓	✓
Mycetophagidae	0	1	1	0	1	0	2	1	0	1	0	0	3	0	3	1	7	23	3	21	F	✓	✓	✓	✓
Niponiidae	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2	40	1	40	P			✓	✓
Nitidulidae	0	2	4	2	1	1	5	5	3	0	1	2	13	3	17	5	32	12	5	13	O	✓	✓	✓	✓
Platypodidae	0	0	0	0	0	2	0	2	0	0	0	0	1	0	1	0	3	34	1	41	X		✓	✓	
Ptiliidae	0	1	0	0	0	0	0	1	0	0	0	0	2	0	2	0	3	35	1	42	F		✓	✓	
Ptinidae	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	41	1	43	S		✓		
Rhipiceridae	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	3	36	1	44	H			✓	
Rhipiphoridae	19	48	2	3	1	1	22	52	61	32	0	0	6	2	67	34	175	4	1	45	P	✓	✓	✓	✓
Rhizophagidae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	51	1	46	F				✓
Scaphidiidae	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	2	42	2	31	F		✓	✓	✓
Scarabaeidae	3	2	4	4	3	6	10	12	4	5	6	4	3	15	13	24	59	9	11	6	H/S	✓	✓	✓	✓
Scolytidae	1	12	1	20	13	4	15	36	3	8	0	98	8	14	11	120	182	3	9	7	X	✓	✓	✓	✓
Scydmaenidae	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	2	43	1	47	P		✓		
Silphidae	0	0	0	0	0	1	0	1	0	0	0	0	1	1	1	1	3	37	1	48	S		✓	✓	✓
Silvanidae	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	2	44	1	49	O	✓		✓	
Sphindidae	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	2	45	1	50	F				✓
Staphylinidae	1	2	0	3	1	2	2	7	4	4	0	4	78	4	82	12	103	6	17	2	P	✓	✓	✓	✓
Tenebrionidae	0	0	0	0	1	0	1	0	0	2	0	1	0	0	0	3	4	31	3	22	O	✓			✓
Throscidae	0	1	0	0	0	0	0	1	0	1	0	0	1	0	1	1	3	38	1	51	O		✓	✓	✓
Total no.individuals	242	246	289	166	115	156	646	568	818	118	239	258	228	82	1285	458	2957								
Total no.families	20	28	21	22	23	21	30	36	23	24	19	25	32	18	39	36	51								
Total no.species	30	48	46	41	36	36	73	85	43	36	41	64	66	36	106	96	201								

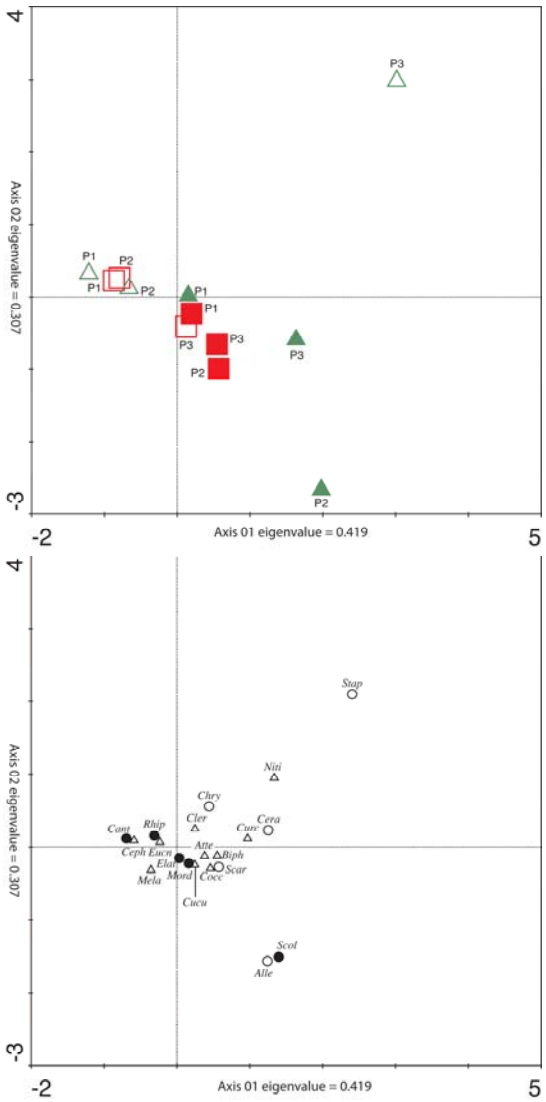

Fig. 9. Top: CA ordination showing the distribution of flying beetle assemblages at the family level collected from pine forest sampling sites with different types of management (square, managed and triangle, unmanaged) and strata (open, canopy and closed, ground).

Bottom: CA ordination showing the distribution of each flying beetle family collected from pine sampling sites with different treatments and at different strata. Different symbols refer to the abundance ranking of beetle families in Fig. 6-MUCG and Table 5: ●, ranked 1-5; ○, 6-10; and △, 11-20.

of forest succession, producing an increase in complexity of vegetation structure and food resources for insects. Vegetation complexity becomes higher as the succession proceeds from strictly managed pine forests (PM) (or those just after the colonization into the newly formed open habitats), to abandoned pine forests (PU), then to deciduous oak forests (D) and, finally, to reach matured evergreen forests (E). Sugi plantation (S) is another starting condition of succession. It has been documented that highly complex habitats support greater numbers of species and individuals in coleopteran assemblages, possibly through increasing the availability of resources (Lassau et al., 2005). The numbers of families and species are larger in unmanaged sites than in managed sites (Tables 3 and 4). CA ordination (Fig. 8) shows the larger heterogeneity of beetle assemblages in unmanaged sites than in the managed sites, reflecting the higher complexity of the vegetation. The complexity of forest habitat conditions, especially vegetation structure, must be studied in more detail in relation to the ecology and guild structure of beetles.

2. ***Effects of management and vertical strata on the flying beetle assemblages in pine forests***. Linawati et al. (2006) reported the effects of pine forest management for mushroom cultivation on the ground, below- and above-ground invertebrates in Suzu. Their study, carried out near the present pine forest sites, included the sampling using the same window traps but set only at 1.5 m above the ground. There were no differences in the numbers of higher taxa (at order or higher level) and individuals between the managed and unmanaged sites. The number of Coleoptera was significantly higher ($P< 0.05$) in the unmanaged site than in the managed site, but in other taxa such as Diptera and Hymenoptera, the results were opposite due to the different preference to the management-induced simplification of habitats. Trisnawati and Nakamura (2008) carried out a study of the effects of habitat heterogeneity and restoration activities on the abundance and diversity of above-ground arthropod assemblages in a “satoyama area” within Kanazawa University’s Campus, Kanazawa city, in 2005 and 2006. Monthly samples were taken at upper (10-15 m) and ground levels (1.5 m) from nine sites, including forested areas and valley areas with paddies under restoration. This study showed the separation of the assemblages among the different habitats. In addition, these two previous studies showed the separation of the assemblages between canopy and ground strata at order or higher levels, which is also shown by the present study.

The present results show that family composition was not different between the managed and unmanaged sites (Figs. 6, 7 and 9). This is explained by the spatial arrangement of the sampling sites and traps. Owing to the restriction of the number of managed pine forests, ownership and topography of the study forests, managed pine forests were usually located in small patches, surrounded with large unmanaged forests, and the boundaries of forests with different owners are highly irregular. These restrictions caused the sites and traps to be located close together. In addition, flying beetles may have the dispersal power to move between unmanaged and managed sites. Makihara in Maeto et al. (2002) showed that some beetles can fly from adjacent stands and be caught in a trap at a distance of 30-50 m from the stands of emergence.

We showed the clear separation of beetle assemblages between the canopy and ground strata. That is attributed to the following facts: (1) the abundance ranking of families (Fig. 6 and 7) was more evenly distributed at ground than at canopy strata. Cantharidae was by far the most abundant at canopy strata except in P3 unmanaged sites. Leksono et al. (2005) studied the vertical distribution of flying beetle assemblages using water pan traps in unmanaged deciduous oak, *Quercus*, forests in the campus of Kanazawa University, and indicated that the abundance and species richness of Cantharidae were high at canopy 11 to 20 m above ground; (2) in Suzu, management practice for matsutake cultivation is strict enough to remove all vegetation and litter on the ground except pine trees (see site pictures 2A, C, E), leading to extremely simplified conditions on the ground, while the canopy layer is not affected or pines have more canopy layers thanks to better growth due to less competition with other vegetation. As we pointed out previously (Linawati et al. 2006; Trisnawati & Nakamura, 2008), it should be noted that management practices to cultivate matsutake mushrooms are beneficial for some flying insects, but for other groups it negatively affects the structure of litter- and soil-dwelling beetle assemblages in red-pine forests and can reduce function in the decomposition processes for which they are responsible.

3. ***Flying beetle families as an indicator for biodiversity assessment***. The present results show the potential of a family level analysis of flying beetle assemblages as an indicator of biodiversity for rapid assessment among different forest types. For pine forests, the 5 most dominant families included Cantharidae, Elateridae, Scolytidae, Rhipiphoridae and Mordellidae, which were collected in almost all pine forests, so that family composition was not so different between the managed and unmanaged sites, although it was different between the canopy and ground strata. The numbers of species of the above dominant families except Elateridae were lower than those of some other families such as Cerambycidae and Staphylinidae (Figs. 6, 7 and Table 2). These facts suggest the necessity of more detailed analysis at the species level.

ACKNOWLEDGEMENTS

We wish to express our sincere thanks to the following persons and institutions for their support and encouragement in the course of this study: Dr. Akaishi Daisuke of Noto Peninsula Satoyama-Satoumi Nature School for the arrangements of this study; Mr. Noriyuki Takaichi for the permission to use the deciduous forest sites; Noto Forest Owner Cooperative and Mr. Hideo Kato for access to the pine forest sites; and Cultural Assets Division in Ishikawa Prefectural Board of Education, Headman of Awazu hamlet and Katahime Shrine for access to evergreen forests. Cordial thanks are given to all staff of Noto Satoyama Meister Program of Kanazawa University and all members of the Laboratory of Ecology, College of Natural Science and Engineering, Kanazawa University, for their support and encouragement in the fieldwork. This study is supported in part by a special grant for "Noto Satoyama Satoumi Reactivation Research Project" from the Ministry of Education, Culture, Sports, Science, and Technology (Monbukagakusho) to KN, and also partly by Monbukagakusho Scholarship to CY.

REFERENCES

Hammer, Ø., Harper, D.A.T., & Ryan, P.D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica* 4(1): 9pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Hayashi, M., Morimoto, K. & Kimoto, S. 1985. *The Coleoptera of Japan in Color*. Vol. IV. Hoikusha Publishing Co., Ltd, Japan.

Hirst, C.N. & Jackson, A. 2007. Reconstructing community relationships: the impact of sampling error, ordination approach, and gradient length. *Diversity and Distributions* 13: 361–371.

Hyvärinen, E., Kouki, J. & Martikainen, P. 2006. A comparison of three trapping methods used to survey forest-dwelling Coleoptera. *European Journal of Entomology* 103: 397–407.

Hyvärinen, E., Kouki, J. & Martikainen, P. 2009. Prescribed fires and retention trees help to conserve beetle diversity in managed boreal forests despite their transient negative effects in some beetle groups. *Insect Conservation and Diversity* 16: 1–13.

Japan Stoyama Satoumi Assessment. 2010. *Satoyama-Satoumi Ecosystems and Human Well-being: Socio-ecological Production Landscapes of Japan-Summary for Decision Makders*. United Nations University, Tokyo, Japan, 36 pp.

Kato, M. 2001. 'SATOYAMA' and biodiversity conservation: 'SATOYAMA' as important insect habitats. *Global Environment Researches* 5(2): 135–149.

Kobori, H. & Primack, R.B. 2003. Participatory conservation approaches for satoyama, the traditional forest and agricultural landscape of Japan. *Ambio* 32(4): 307–311.

Kurosawa, Y., Hisamatsu, S. & Sasaji, H. 1985. *The Coleoptera of Japan in Color*. Vol. III. Hoikusha Publishing Co., Ltd, Japan.

Lassau, S.A., Hochuli, D.F., Cassis, G., & Reid, C.A.M. 2005. Effects of habitat complexity on forest beetle diversity: do functional groups respond consistently? *Diversity and Distributions* 11: 73–82.

Leksono, A.S., Nakagoshi, N., Takada, K., & Nakamura, K. 2005. Vertical and seasonal of Attelabidae and Cantharidae (Coleoptera) in a suburban mixed forest. *Entomological Science* 8: 235–243.

Linawati, Tanabe, S., Ohwaki, A., Akaishi, D., Putra, R.E., Trisnawati, I., Kinasih, I., Kikuchi, C., Kasagi, T., Nagashima, S. & Nakamura, K. 2006. Effects of the red-pine forest management for mushroom cultivation on the ground, below- and above-ground invertebrates in Suzu, Central Japan. *Far Eastern Entomologist* 166: 1–15.

Maeto, K., Sato, S. & Miyata, H. 2002. Species diversity of longicorn beetles in humid warm- temperate forests: the impact of forest management practices on old-growth forest species in southwestern Japan. *Biodiversity and Conservation* 11: 1919–1937.

Nakashizuka, T. & Stork, N. 2002. *Biodiversity research methods: IBOY in Western Pacific and Asia*. Kyoto University Press. P. 52–53.

Ogawa, M. 1978. *Biologi of Matsutake mushroom*. Tsukiji Shokan, Tokyo. (In Japanese).

Oliver, I. & Beattie, A.J. 1996. Designing a cost-effective invertebrate survey : A test of methods for rapid assessment of biodiversity. *Ecological Applications* 6(2): 594–607.

ter Braak, C.J.F, & Smilauer, P. 2002. *Canoco for Windows version 4.5* Biometris-Plant Research International, Wageningen, The Netherlands.

Takeuchi, K. 2010. Rebuilding the relationship between people and nature: the Satoyama Iniative. *Ecology Restoration* 25: 891–897.

Trisnawati, I. & Nakamura, K. 2008. Abundance, diversity and distribution of above-ground arthropods collected by window traps from Satoyama in Kanazawa, Japan: an order level analysis. *Far Eastern Entomologist* 181: 1–23.

Ueno, S. I., Kurosawa, Y. & Sato, M. 1985. *The Coleoptera of Japan in Color*. Vol. II. Hoikusha Publishing Co., Ltd, Japan.

Washitani, I. 2001. Traditional sustainable ecosystem 'SATOYAMA' and biodiversity crisis in Japan: Conservation ecological perspective. *Global Environment Researches* 5(2): 119–133.

Appendix A. Number of individuals in different beetle families collected using window traps in other forest types. D = deciduous forest; E = evergreen forest; S = sugi plantation; M = managed; U = unmanaged; C = canopy; G = ground.

Forest type	D				E				S		Total
Site Number	1		2		1		2		1		
Family	C	G	C	G	C	G	C	G	C	G	
Aderidae	0	0	0	1	0	0	0	0	0	0	1
Alleculidae	13	39	4	7	14	43	8	4	1	0	133
Anobiidae	0	0	0	0	4	1	7	5	0	0	17
Anthicidae	0	3	0	1	0	3	0	1	0	0	8
Attelabidae	7	8	6	2	3	4	1	1	1	0	33
Biphyllidae	0	2	1	4	1	0	2	0	2	0	12
Bostrychidae	0	0	0	0	0	0	0	0	1	0	1
Bruchidae	0	0	0	0	1	0	0	0	0	0	1
Buprestidae	0	0	2	0	0	1	0	1	0	0	4
Cantharidae	52	32	70	43	63	32	26	12	9	2	341
Carabidae	3	3	2	7	1	0	2	4	1	1	24
Cephaloidae	0	0	3	0	0	0	0	0	0	0	3
Cerambycidae	0	4	1	5	3	3	2	0	0	0	18
Cerylonidae	0	0	1	0	1	1	0	1	0	0	4
Chrysomelidae	15	20	10	10	5	2	6	2	13	0	83
Ciidae	0	0	0	0	0	1	0	0	0	0	1
Clambidae	0	0	0	0	0	0	0	1	1	1	3
Cleridae	1	2	6	0	0	0	2	0	0	0	11
Coccinellidae	0	3	1	1	2	2	1	1	1	1	13
Corylophidae	0	1	1	0	2	1	4	0	4	0	13
Cryptophagidae	0	0	0	0	0	0	0	0	0	1	1
Cucujidae	2	2	0	4	3	3	2	0	3	1	20
Curculionidae	19	16	28	15	17	15	4	2	1	0	117
Discolomidae	1	0	0	0	0	0	0	0	0	0	1
Elateridae	28	52	43	31	12	48	22	35	11	6	288
Endomychidae	0	0	0	0	0	1	0	0	0	0	1
Erotylidae	0	2	2	3	1	1	4	2	2	0	17
Eucnemidae	6	1	4	4	4	3	1	0	2	0	25
Helodidae	0	0	2	0	0	1	2	0	1	0	6
Lagriidae	5	5	0	4	2	3	0	0	2	2	23
Lampyridae	0	2	0	2	1	3	0	0	3	4	15
Languriidae	0	0	0	0	0	0	0	0	1	0	1
Lathridiidae	0	3	3	4	0	1	1	0	1	0	13

Appendix A (continued).

Forest type	D				E				S		Total
Site Number	1		2		1		2		1		
Family	C	G	C	G	C	G	C	G	C	G	
Leiodidae	0	0	0	4	0	1	0	0	0	0	5
Lucanidae	0	0	0	0	0	0	1	0	0	0	1
Lycidae	0	0	0	0	0	0	0	0	1	0	1
Melandryidae	0	0	4	1	2	6	2	28	1	2	46
Melyridae	3	1	4	0	3	0	0	0	6	0	17
Mordellidae	5	4	7	2	3	6	10	7	8	0	52
Mycetophagidae	0	1	0	0	2	1	1	1	5	0	11
Nitidulidae	13	6	10	9	13	3	5	1	10	0	70
Oedemeridae	1	0	1	0	0	0	0	0	0	0	2
Omethidae	0	0	0	1	0	0	0	0	0	0	1
Phalacridae	1	0	0	1	0	0	0	0	0	0	2
Platypodidae	0	0	0	0	1	0	0	1	1	0	3
Ptiliidae	0	0	0	0	0	0	0	0	0	1	1
Ptilodactylidae	0	0	0	0	1	0	1	0	0	0	2
Ptinidae	0	0	0	0	0	3	0	0	0	0	3
Rhipiceridae	0	0	0	0	1	0	0	0	0	0	1
Rhipiphoridae	8	13	11	1	14	1	0	0	7	6	61
Rhizophagidae	0	0	0	1	0	0	0	0	0	1	2
Scaphidiidae	0	0	0	1	0	0	0	0	0	0	1
Scarabaeidae	0	512	1	516	3	0	10	3	8	4	39
Scolytidae	50	1	10	6	3	7	6	6	4	2	375
Silphidae	0	0	1	1	0	6	2	2	0	4	16
Sphindidae	0	1	0	4	0	0	0	0	0	0	5
Staphylinidae	5	4	5	5	8	6	2	4	2	2	43
Tenebrionidae	0	0	0	1	0	2	1	0	0	0	4
Throscidae	0	1	0	0	0	1	0	1	2	1	6
Grand Total	238	357	244	351	194	216	138	126	116	42	2022