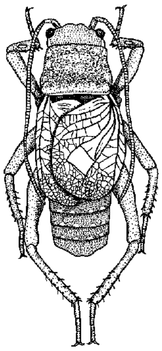

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ABUNDANCE, DIVERSITY AND DISTRIBUTION OF ABOVE-GROUND ARTHROPODS COLLECTED BY WINDOW TRAPS FROM SATOYAMA IN KANAZAWA, JAPAN: AN ORDER LEVEL ANALYSIS

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Satoyama, the traditional rural landscape of Japan, has been paid much attention because, beside its many important roles, it is a key to biodiversity conservation in Japan. The effects of habitat heterogeneity and restoration activities on the abundance and diversity of above-ground arthropod assemblages were studied using window traps in a "satoyama area" within Kanazawa University's Campus, Kanazawa, Japan in 2005 and 2006. Monthly samples were taken at upper and ground levels from nine sites, including forested areas and valley areas with paddies under restoration. A total of 93,134 individuals from 24 orders, including 18 Insecta orders, 3 Arachnida, 2 Crustacea and 1 Chilopoda, were collected during the study, and an order level analysis was carried out. At the upper level, Diptera was the dominant order (about 70%), followed by Homoptera and Coleoptera (5-10 %), and at ground level, Diptera (about 40%), Collembola (10%), and ants (8%) were dominant. DCA ordination revealed a clear separation of arthropod order compositions among different habitat types and between upper and ground levels, but the separation was less apparent between years. DCA ordination of 18 orders revealed the variation of spatial distribution of these orders in accordance with habit ("flying" or "non-flying") and habitat preference ("forests" or "cultivated valley" sites).

KEY WORDS: satoyama management, rural landscape, biodiversity, above-ground arthropod assemblage, higher taxon approach, window trap, DCA analysis.

И. Триснавати, К. Накамура. Плотность, разнообразие и распределение надпочвенныъх членистоногих, собранных оконными ловушками в Канадзаве, Япония: анализ на уровне отрядов // Дальневосточный энтомолог. 2008. N 181. С. 1-23.

Традиционный сельский ландшафт в Японии (сатояма) привлекает пристальное внимание исследователей, помимо всего прочего, как ключевой для сохранения биоразнообразия этой страны. В 2005-2006 гг. эффект влияния разнородности местообитаний и рекультивации традиционных агроладшафтов на численность и разнообразие комплексов надпочвенных членистоногих был изучен с использованием оконных ловушек в окрестностях кампуса университета Канадзавы (Япония: Хонсю). Пробы отбирались ежемесячно на уровне почвы и выше в 9 точках, включая лесные биотопы и долины с рисовыми чеками после их восстановления. Всего было собрано 93134 экз. членистоногих из 24 отрядов, в том числе насекомых (Insecta) – 18 отрядов, Arachnida – 3, Crustacea – 2, Chilopoda – 1 отряд; полученные данные проанализированы на уровне отрядов. В надпочвенном ярусе доминировали двукрылые (около 70%), равнокрылые хоботные и жескокрылые насекомые (5-10%); на почве доминировали двукрылые (около 40%), коллемболы (10%) и муравьи (8%). DCA ординация показала ясные отличия сообществ членистоногих на уровне отрядов как в различных местообитаниях, так и в надпочвенном ярусе и на уровне почвы, тогда как различия между 2005 и 2006 гг. менее выражены. DCA ординация 18 отрядов показала, что варьирование стациального распределения этих отрядов зависит от поведения ("летающие" и "нелетающие" насекомые) и предпочтительных местообитаний ("лесные" и "возделываемые долинные" участки).

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INTRODUCTION

The traditional rural landscape of Japan, "satoyama", making up about 40% of the land area of Japan, is characterized by mosaic habitats with diverse habitat types such as secondary forests, grasslands, rice paddy fields, and ponds within a narrow area (Tabata, 1997; Kato, 2001). Satoyama provides a variety of habitat types for wildlife with a high structural diversity of landscape elements facilitating the migration and dispersal of fauna and flora between different habitats. This landscape is a key element to biodiversity conservation in Japan (Washitani, 2001; Ministry of the Environment..., 2002). However, rapid economic growth since the 1960s has brought urban development and expansion of abandoned areas caused by the decreasing and aging population in satoyama areas. Under these conditions, habitat diversity is likely to decline, and undoubtedly this decline is a serious threat to biodiversity in Japan’s countryside (Kato, 2001; Washitani, 2001).

For conservation planning of satoyama areas we need greater understanding of the rural habitat capacity and impacts of habitat changes on biodiversity (Hutcheson et al., 1999; Kremen et al., 1993). Biodiversity monitoring should be conducted to evaluate changes in habitat composition, structure, and functioning related to the effects of natural trends and/or anthropogenic activities over time (Noss, 1990). Besides the ubiquity and taxonomical richness, the sensitivity of many arthropods to ecological factors such as climate, vegetation changes, and intensities of managements makes arthropods effective indicators of habitat changes at both the local and regional scales.

In the present study, we collected above-ground arthropods using standardized IBOY flight traps (window traps) at upper and ground levels from different habitat types in a "satoyama area" within Kanazawa University's Kakuma Campus, Kanazawa, Japan in 2005 and 2006. Recently, in this satoyama area we monitored seasonal/annual biodiversity and ecological relationships between organisms such as pollination and seed dispersal (Nakamura et al., 2006). The previous studies (summarized in Nakamura et al., 2006) included : (1) flying insects collected by chemical attractant traps in 1996-2000 (Kanagami, et al., 1996; Nakamura et al., 2006), (2) insects collected by four IBOY-specified traps (pitfall, window, light, and malaise traps) in 2001, (3) flying beetles collected by water pan trap from different vertical strata in 1999-2000 (Leksono et al., 2005), and (4) ground beetles collected by pitfall traps among restored and non-restored habitats in 2004-2005 (Nakamura et al., 2006).

In this study, we analyzed the arthropod samples at the order level as a surrogate for arthropod biodiversity at the species level (Báldi, 2003). We adopted order level assessment as a rapid procedure to evaluate habitat heterogeneity in this satoyama area. The reliability of such a higher taxon approach has been reported recently (Basset et al., 2004; Tanabe et al, 2006; Biaggini, et al., 2007; Moreno et al., 2008) and will also be discussed in this study.

STUDY SITES

Climate and topography: The study was carried out in a satoyama area (74 ha, 60-150 m altitude, 5 km southeast of central Kanazawa city, Ishikawa prefecture) within Kanazawa University's Kakuma Campus (N36°32' E136°42') (Fig. 1). In Kanazawa, the average annual temperature value was 14.8°C with a monthly range from 3.5 °C (January) to 26.8 °C (August) and annual rainfall of 2545 mm (for 30 years : 1977-2006, Japan Meteorological Agency, http://www.data.jma.go.jp).

Sampling site: Kakuma forests consist mainly of deciduous broad leaved trees predominated by two oak species, *Quercus serrata* and *Q. variabilis*, patches of plantations of Japanese cedar, *Cryptomeria japonica*, and moso bamboo, *Phyllostachys* sp. When local people owned the forests in Kakuma, they managed them as satoyama forests. The forests have been abandoned since the land was sold to Kanazawa University 30 years ago. The forests in the campus have become taller and denser with shrubs and undergrowth, and the cedar plantations and bamboo have been

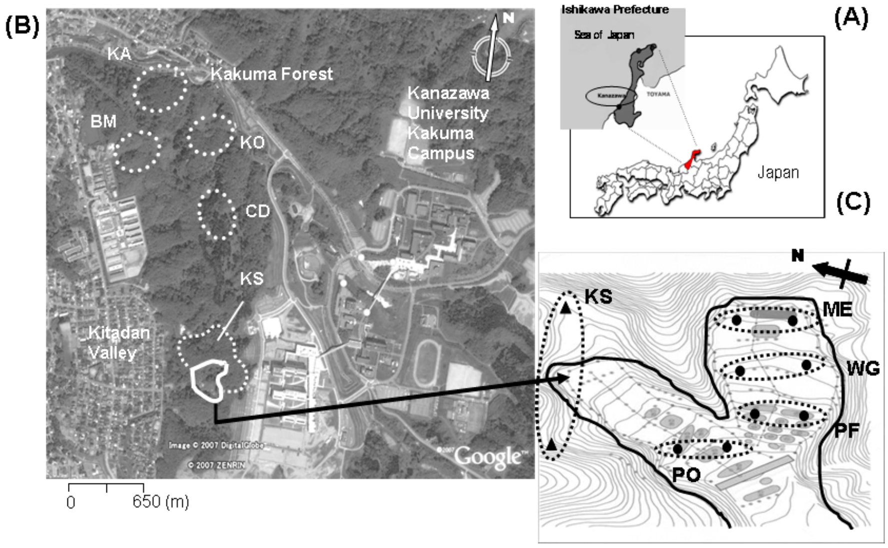

Fig. 1. Maps showing the locations of (A) Ishikawa Prefecture and Kanazawa City, Japan; (B) the five sampling sites (dotted circle) in the forests of the satoyama area within Kanazawa University's Kakuma Campus and the border of Kitadan Valley (bold line); and (C) an enlarged map of Kitadan Valley, showing the four sampling sites each of which included two sampling plots (closed triangle). See the text for the explanations of sampling site codes

left unmanaged. The bamboo patches have expanded quickly, killing trees and other plants that were overgrown by the bamboo. Terraced rice paddies cultivated in almost all the valleys in Kakuma were also abandoned at the same time. Since 2002, terraced paddies in Kitadan, a small valley (0.5 ha, Fig. 1), have been restored gradually by local volunteers for nature education and for monitoring the recovery of biodiversity.

In this study, a total of nine sampling sites were established in the largest forest patch (62 ha) running along the western border of the campus. Five of the sites were established in areas of the forest with different vegetation profiles: (1) site KO in deciduous broad-leaved forest dominated by oak, *Quercus serrata*; (2) site KA in deciduous broad-leaved forest dominated by oaks, *Q. serrata* and *Q. variabilis*; (3) site KS in *Q. serrata* forest with dense dwarf bamboo undergrowth, *Sasa* sp; (4) site CD in an unmanaged plantation of Japanese cedar, *Cryptomeria japonica*; and (5) site BM in an unmanaged moso bamboo grove, *Phyllostachys* sp. All five sites except KS, which is located near Kitadan, were located in the upper half of the forest patch (Table 1, Fig. 1). Inside Kitadan valley four sampling site were established: (1) site PO on the bank of an area of artificial ponds and ditches for irrigation, where in 2005 and 2006 management practices, e.g. mowing weeds and construction of water ditches, were conducted frequently; (2) site PF on a path between rice paddies, where

Table 1

Environmental characteristics of the nine sampling sites in the study area (for locations, see Fig. 1)

Code	Vegetation and Land uses	Dominant species	Management types	No. of traps
KO	Secondary broad-leaved forest	Oak, *Quercus serrata*	none	4 each *
KA	Secondary broad-leaved forest	Oaks, *Q. serrata and Q. variabilis*	none	4 each *
KS	Secondary broad-leaved forest	Oak, *Q.serrata* ; dwarf bamboo, *Sasa* sp.	none	4 each *
CD	Plantation	Japanese cedar, *Cryptomeria japonica*	none	4 each *
BM	Plantation	Moso bamboo, *Phyllostachys* sp.		4 each *
PO	Banks of artificial ponds	Herbaceous plants	Mowing (May, July, Sept, Nov : 2005; April, Nov : 2006), ditches construction (April, Oct : 2005; June, Sept : 2006)	4 each *
PF	Paddy field, under restoration	Rice plant, *Oryza sativa* ssp. *japonica*	Ploughing (April, 2005; May, 2006), mowing (May, July, Sept, Nov : 2005; April, June, Aug, Nov : 2006), rice paddy cultivation (April-Sept : 2005 and 2006)	4 each *
WG	Wet grassland	Perennial tall grass, *Miscanthus sp.*	Grass-cutting : only once in spring	4 each *
ME	Cereal plantation	Japanese millet	Cereal cultivation : May-Sept	4 each *
			Total no. of traps	36

* (1 each at upper and ground levels) x 2 replications

ploughing and mowing were conducted from June to September; (3) site WG in a wet grassland of *Miscanthus* sp. reaching 1.5-2.5 m high, where grass-cutting management activities were infrequent (only once in spring); and (4) site ME in a Japanese millet plantation, which was the driest site in Kitadan and plowed for cereal plantation from May to September (Table 1). In this article, the six sites in the forests and four sites in Kitadan valley are referred to as "forested" and "cultivated valley" sites, respectively.

SAMPLING METHODS

To collect above-ground (flying) invertebrates, IBOY standard window traps consisting of a yellow collecting bucket (diameter 35 cm and 15 cm high) and transparent intersect panels (50 cm high x 45 cm wide) were used (Nakashizuka & Stork, 2002). The buckets were filled with 1.5 L of 50% ethylene glycol as a preservative and a small amount of detergent was added.

At each sampling site, two replications, each containing two traps at ground and upper levels, were placed 5-10 m from each other. At ground level, the trap was set at the height of 1.5 from the ground using ropes. At the upper level, the trap was suspended by a rope using a canopy pulley at heights, ranging from 10-15 m in the forest sites, which represents the lower canopy stratum (Humphrey et al., 1999), and at height of 5-10 m at the sites in Kitadan Valley. Monthly sampling was carried out by opening the traps between June and November in 2005 and 2006. The samples were taken back to the laboratory and were identified at class or order levels using Borror et al. (1989) and Nauman et al. (1991). Arthropods belong to the order Hymenoptera were then separated into Formicidae (ants) and other Hymenoptera (non Formicidae) groups (henceforth referred to as "Hymenoptera-ant" and "Hymenoptera non-ant", respectively). Diptera were further determined to suborder and family levels, and some of them to species levels, the results of which will be published subsequently.

Out of 24 orders that were recorded in this study, the 14 orders (Diptera, Homoptera, Hymenoptera-non ant, Coleoptera, Lepidoptera, Thysanoptera, Psocoptera, Hemiptera, Neuroptera, Trichoptera, Mecoptera, Plecoptera, Odonata, and Ephemeroptera) are categorized as "flying" orders and the other 10 orders (Collembola, Araneae, Hymenoptera-ant, Amphipoda, Orthoptera, Opiliones, Isopoda, Acarina, Blattaria, and Lithobiomorpha) as "non-flying" orders in this article.

DATA ANALYSIS

Mann-Whitney U test and/or Kruskall-Wallis test (H) were used to examine the differences in the abundance and diversity of arthropod orders among the sites, between the strata, and between the years. Detrended Correspondence Analysis (DCA) was carried out to visualize the variation in the composition of arthropod orders among the sampling sites (Fig. 7) and the spatial distribution of arthropod orders, which is represented by the number of individuals in each order collected from each

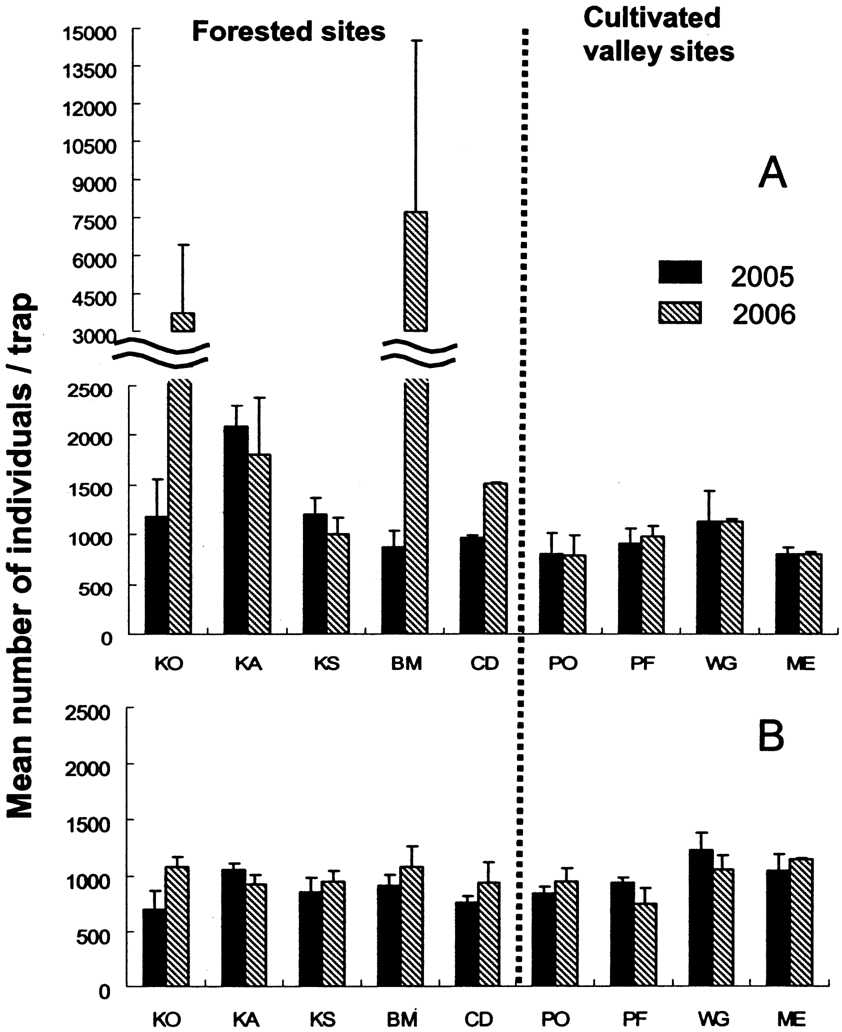

Fig. 2. Comparison of the average number of the individuals collected per trap (± 1 SE) among the sampling sites. A : upper level, B : ground level

sampling site (Fig. 8). After the number for each taxon was square root-transformed, CANOCO version 4.5 (ter Braak and Smilauer, 2002) was used for the calculations. DCA site scores and taxon scores from the first and second axes (Jongman et al., 1995) were further examined using t-test. All statistical tests of analysis of variance were performed using STATISTICA 6.0 software.

RESULTS

ABUNDANCE

Whole study sites

In 2005, a total of 36,548 individuals were collected from the whole study site (19,877 and 16,671 individuals at upper and ground levels, respectively); while in 2006, a total of 56,586 individuals were collected (38,874 and 17,712, respectively) (Tables 2, 3). The difference between the two levels was significant (Mann-Whitney U test, P<0.05 and P<0.001 in 2005 and 2006, respectively). The abundance in 2006 was increased sharply from that in 2005 at the upper level but only slightly at ground level.

Habitat groups and each study site

At the upper level, the abundance per site in “forested” sites was larger than in “cultivated valley” sites in both years (Fig. 2). At ground level, there was no significant difference between the “forested" and "cultivated valley" sites in both years (Mann-Whitney U test, $P<0.05$ at upper level and $P>0.05$ at ground level) (Fig. 2, bottom). The abundance per site was more variable at the upper level, especially among forested sites in 2006, than at ground level in both years (Fig. 2, Tables 2, 3).

In 2005, the abundance per site ranged from 797 individuals/trap (ME) to 2087.5 (KA) at the upper level (Fig. 2, top) and from 700.5 (KO) to 1231.5 (WG) at ground level Fig. 2, bottom). At the upper level, sites KA, KS, and KO (oak sites) showed higher abundance (2087.5, 1198, and 1176, respectively) than other sites (Fig. 2, top). In 2006, at the upper level site BM showed the highest abundance (7699.5), which increased sharply from that of 2005 (867.5). Sites PO (792) and ME (796) had the lowest abundance levels (Fig. 2, top). At ground level, arthropod abundance ranged from 741 (PF) to 1151 (ME) (Fig. 2, bottom). Abundance was significantly different among the sites at the upper level in 2005 (Kruskal-Wallis test, $P<0.05$) and more significant in 2006 ($P<0.001$). Abundance at ground level in 2006 ($P<0.01$) was significantly different, but significance was not observed in 2005 ($P>0.05$). At each site, differences in abundance between the upper and ground levels were larger in 2006 than that in 2005 (Fig. 2, Tables 2, 3).

ORDER RICHNESS

Whole study sites

A total of 24 orders were collected during the entire study with 23 orders recorded in each year. Order richness at the upper level in 2006 (23) was slightly higher than in 2005 (21); however, at ground level, it was the same in both years (23) (Fig. 3, Tables 2, 3).

Habitat groups and among study sites

In both years, order richness per site in the "cultivated valley" sites ranged between 18 and 22 orders and in "forested" sites between 18 and 21 orders (Fig. 3). However, there was no significant difference between the habitat groups and strata (Kruskal-Wallis test, $P>0.05$). At the upper level, order richness per site increased slightly from 2005 (range 13 to 19) to 2006 (16 to 20) in all sites, except sites KS, PO, and WG. However, at ground level the differences in order richness were less apparent between the years (Fig. 3).

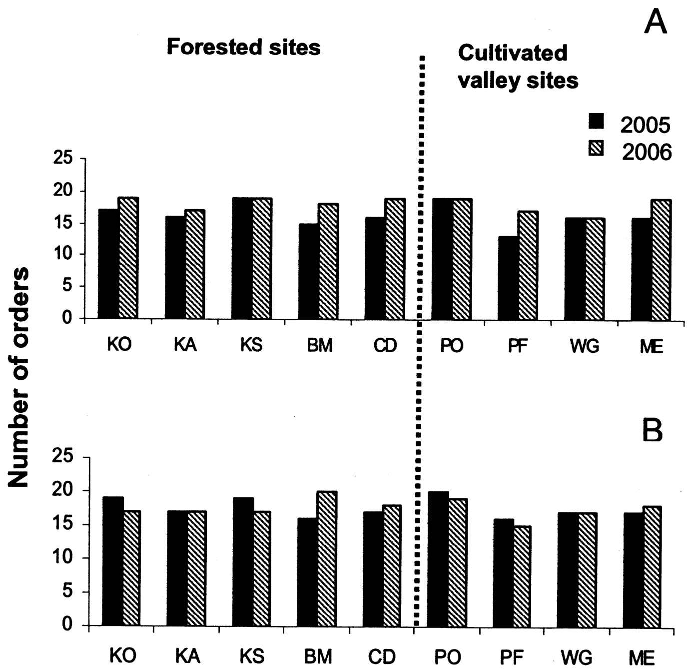

Fig. 3. Comparison of the number of orders collected per site among the sampling sites. A : upper level, B : ground level

ORDER RANKING

At the upper level in 2005 and 2006, Diptera was the dominant order, making up 65.7% and 78.5%, respectively, of the total number of individuals collected from all study sites (Fig. 4, left). The 10 orders are ranked in order of abundance; Homoptera (10.9% and 5.0%), Coleoptera (5.3% and 4.0%), Hymenoptera-non ant (4.6% and 4.0%), Araneae (3.7% and 2.0%), Lepidoptera (2.9% and 1.4%), Hymenoptera-ant (2.3% and 2.2%), Collembola (1.3% and 0.5%), Thysanoptera (1.0% and 1.1%), Psocoptera (0.7% and 0.5%), Hemiptera (0.5 and 0.2 %), Acarina (0.4% and 0.1%)

and Orthoptera (0.4% and 0.1%). The top 13 orders at the upper level accounted for 99.5% (2005) and 99.6% (2006) of all arthropods (Fig. 4, left). At ground level in 2005 and 2006, Diptera was also the ranked first (41.9% and 42.9%), followed by Collembola (10.3% and 10.5%), Hymenoptera-non ant (8.6% and 7.4%), Araneae (6.8% and 5.5%), Coleoptera (6.3% and 5.9%), Homoptera (6.1% and 7.8%), Hymenoptera-ant (5.5% and 8.7%), Amphipoda (3.9% and 1.6%), Orthoptera (2.6% and 2.0%) Lepidoptera (2.6% and 1.0%), Opiliones (1.9% and 1.8%), Isopoda (1.3% and 2.4%) and Acarina (0.9% and 0.8%). Diptera and these 12 orders accounted for 98.7% (2005) and 98.3% (2006) of all arthropods (Fig. 4, right).

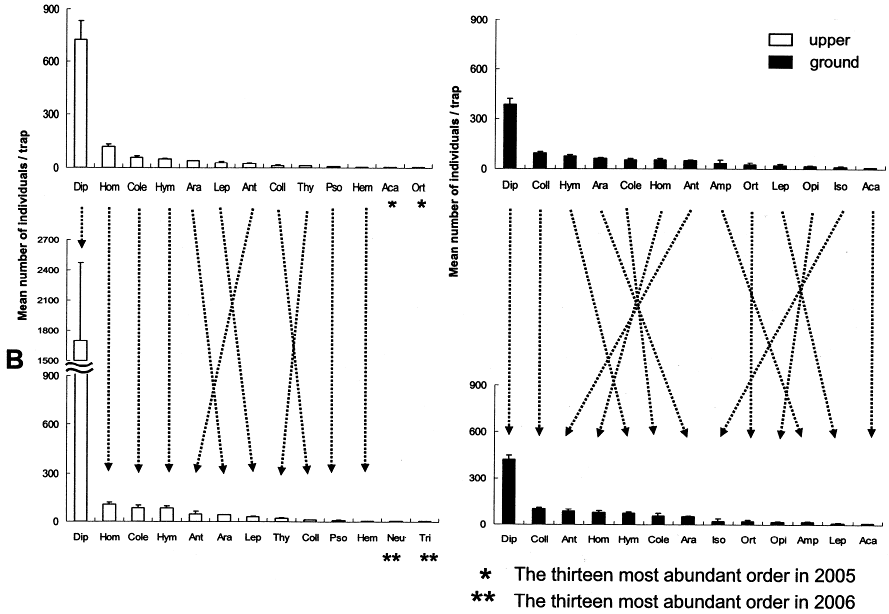

Fig. 4. Abundance ranking at order level for the whole study area. The results are presented separately as the average number of individuals per trap, per year, and for the upper and ground levels

By comparing the two levels, it was found that (1) “flying" orders were naturally more dominant at the upper level than at ground level, i.e. 7 vs 5 (2005) and 9 vs 5 (2006) out of the top 13 orders; (2) the ranking of the top 13 orders between the two years was more stable at the upper level than at ground level (Fig. 4), i.e. of the 13 major orders at upper level, the four top orders (Diptera, Homoptera, Coleoptera, and Hymenoptera-non ant) were ranked in the same sequence, the following seven orders (5th to 11th in the ranking) were the same with a few changes in ranking, and the last two orders (12th and 13th) were replaced with others (Fig. 4, left). However, at ground level the top two orders (Diptera and Collembola) were the same, but the subsequent eleven orders (3rd to 13th) changed their ranks (Fig.4, right). "Non-flying" orders were naturally more abundant at ground level, e.g. Collembola, Araneae, Hymenoptera-ant, Amphipoda, Opiliones, Isopoda, and Acarina (Fig. 4, right). However, some "non-flying" orders were included in the top 13 orders at the upper level, e.g. Araneae, Hymenoptera-ant, Collembola, and Acarina.

ORDER COMPOSITION AT EACH SITE

Figures 5, 6 and Tables 2, 3 shows the composition of the orders at each site, at the two levels, and in both years separately. In this section, the order composition of the samples was compared in terms of the proportion (%) of the sample collected at each site. In both years, the following abundant orders were more prevalent in the "forested" sites than in the "cultivated valley" sites: Diptera, Coleoptera, Collembola, Hymenoptera-ant, and Opiliones. Conversely, Homoptera, Hymenoptera-non ant, Araneae, Amphipoda, and Isopoda were collected more frequently in the "cultivated valley" sites than in the "forested" sites.

SPATIAL DISTRIBUTION OF ABUNDANT ORDERS

"Flying" orders

(1) Diptera was the most abundant order across all the study sites (Fig. 4) and was widespread over all sites (Figs. 5, 6). Its proportion was higher in "forested" than "cultivated valley" sites (Mann-Whitney U test, $P<0.001$ at the upper level, $P>0.05$ at ground level) and higher at the upper level than at ground level (Mann-Whitney U test, $P<0.001$ in both years) (Tables 2, 3, Figs. 5, 6). The highest proportion occurred at the upper level in 2005 at sites KA (85%) and KS (64%) (Fig. 5) due to swarming behavior of particular families, and in 2006 at sites BM (95%) and KO (86%) (Fig. 6); at ground level in 2005 at site KA (62%), and in 2006 at sites PF (52%) and CD (48%) (Tables 2, 3).

(2) Homoptera was second ranked at the upper level for the whole sample in both years but sixth (2005) and fourth (2006) ranked at ground level (Fig. 4). Its proportion was higher in "cultivated valley" than "forested" sites (Mann-Whitney U test, $P<0.001$ at the two levels), and higher at the upper level than at ground level (Mann-Whitney U test, $P<0.001$ in both years) (Tables 2, 3, Figs. 5, 6). The highest proportion was in 2005 at sites PO (20%) and ME (18%) at the upper level and at site PF (14%) at ground level; in 2006 at sites PF (18% and 24% at upper and ground levels, respectively) and WG (17% and 10%) (Figs. 5, 6).

(3) Coleoptera was third ranked at the upper level for the whole sample in both years and fifth (2005) and sixth (2006) ranked at ground level (Fig. 4). Its proportion was higher at the upper level than at ground level (Mann-Whitney U test, $P>0.05$ in 2005 and $P<0.001$ in 2006) and higher in "forested" sites (except BM at the upper level) than "cultivated valley" sites (Mann-Whitney U test, $P<0.001$ at the two levels) (Figs. 5, 6).

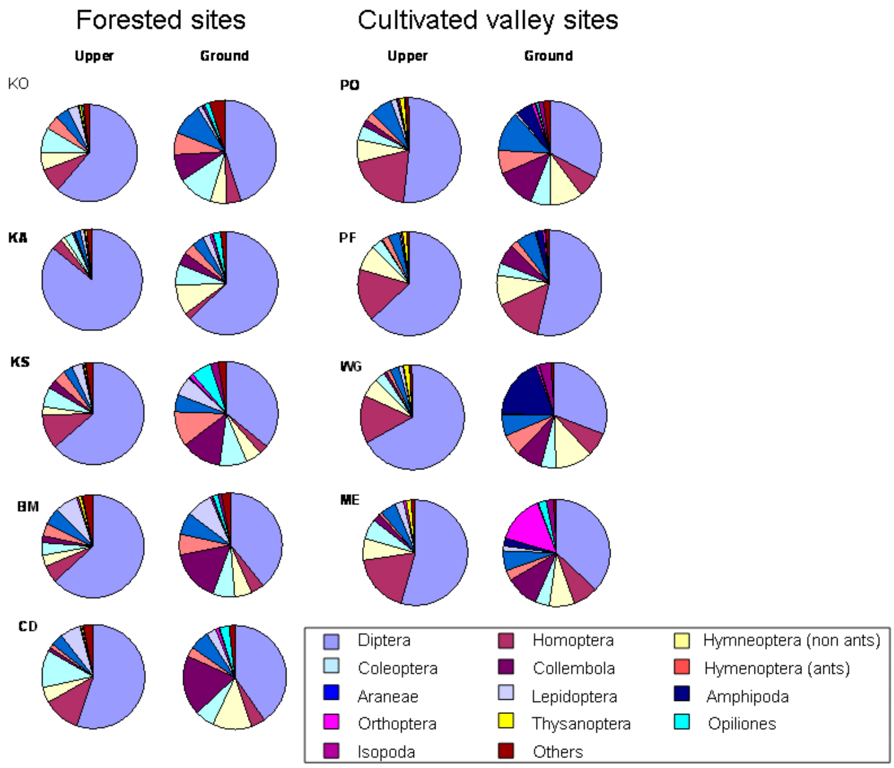

Fig. 5. Comparison of arthropod faunal composition among the sampling sites in 2005. See the text for an explanation of the sampling site codes and site groups, i.e. "Forest" and "Cultivated valley"

(4) Hymenoptera non-ant was ranked fourth in both years at the upper level and third (2005) and fifth (2006) at ground level with a higher proportion in all "cultivated valley" sites at both levels (Figs. 5, 6). In some "forested" sites (e.g. KA and CD) its proportion was higher at ground level than at the upper level.

(5) Orthoptera's highest proportion was at ground level at site ME, a "cultivated valley" site (16% in 2005 and 8% in 2006) (Figs. 5, 6) where many ground crickets were collected.

"Non-flying" orders

(1) Collembola was second ranked at ground level in both years and collected more in "forested" than "cultivated valley" sites in both years (Tables 2, 3) with its highest proportion at sites CD and BM (19% and 16%, respectively) in 2005, and at sites CD and KS (16% and 14%, respectively) in 2006 (Figs. 5, 6).

(2) Hymenoptera-ant was collected more frequently in "forested" sites at ground level. The highest proportion was observed at site KS (11%) in 2005 and at site BM in 2006 (18%).

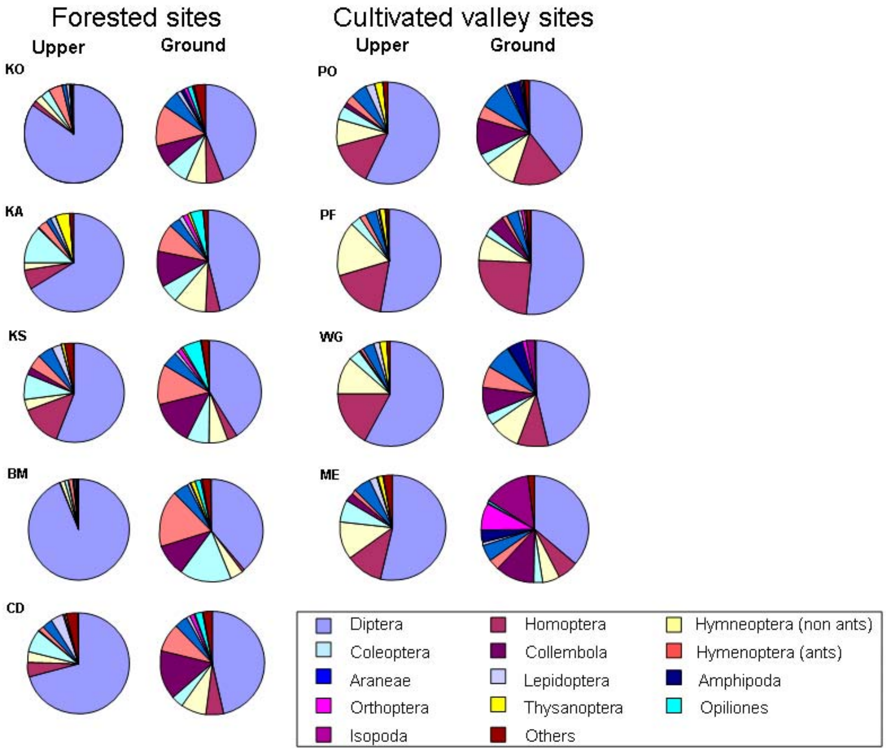

Fig. 6. Comparison of arthropod faunal composition among the sampling sites in 2006. See the text for an explanation of the sampling site codes and site groups, i.e. "Forest" and "Cultivated valley"

(3) Araneae was collected more frequently in "cultivated valley" than "forested" sites at ground level (Tables 2, 3) and with its highest proportion in site PO in both years (13% and 9%).

(4) Amphipoda preferred moist habitats in "cultivated valley" sites (site WG) in both years (18% and 5%) and at ground level rather than at the upper level (Tables 2, 3, Figs. 5, 6).

(5) Isopoda was also found more frequently at ground level rather than at the upper level in particular "cultivated valley" sites (ME and WG) (Tables 2, 3, Figs. 5, 6).

(6) Opiliones was collected in "forested" sites with its highest proportion at site KS in both years (6% in 2005 and 2006).

MULTIVARIATE ANALYSES

Variation in faunal composition among sites

DCA ordination revealed a clear separation of arthropod order compositions, reflecting different habitat types and at upper and ground levels, but it was less apparent between years (Fig. 7). Upper and ground levels were separated from each

Table 2

The number of individuals in different arthropod orders collected using window traps in Kakuma forest

Order	KO		KA		KS		BM		CD	
Year	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Acarina										
Upper	8	6	27	4	16	7	15	3	9	2
Ground	51	54	18	13	17	21	38	31	10	10
Araneae										
Upper	104	107	70	62	75	101	99	81	76	95
Ground	142	127	81	69	89	84	125	106	90	77
Opiliones										
Upper	11	4	2	3	10	2	3	3	1	1
Ground	24	38	43	73	106	115	31	34	43	44
Amphipoda										
Upper	0	1	0	0	0	0	0	0	0	0
Ground	7	26	0	0	9	0	0	1	1	0
Isopoda										
Upper	1	0	0	0	1	0	0	1	0	1
Ground	0	10	0	0	42	7	19	16	0	5
Lithobiomorpha										
Upper	0	0	0	0	0	0	0	0	0	0
Ground	0	0	0	0	5	0	0	0	0	0
Blattaria										
Upper	0	1	1	0	0	1	0	0	0	2
Ground	0	0	0	2	0	0	0	1	2	0
Coleoptera										
Upper	191	231	112	451	147	171	71	172	222	218
Ground	155	155	145	108	149	128	129	348	92	64
Collembola										
Upper	5	11	22	24	66	44	37	25	22	13
Ground	116	158	83	214	211	260	295	216	284	286
Diptera										
Upper	1441	6308	3578	2390	1523	1118	1096	14467	1070	2141
Ground	629	950	1327	854	616	774	714	834	607	867
Ephemeroptera										
Upper	0	1	0	1	0	0	0	0	0	0
Ground	0	0	0	0	0	0	0	0	0	1
Hemiptera										
Upper	13	13	8	8	12	9	1	2	22	12
Ground	5	6	6	2	10	6	1	7	4	18
Homoptera										
Upper	189	119	151	225	260	265	90	46	229	146
Ground	62	121	39	81	45	58	76	24	68	97

Table 2 (continued)

Order	KO		KA		KS		BM		CD	
Year	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Hymenoptera-ant										
Upper	115	317	18	105	95	86	68	191	25	51
Ground	98	286	71	163	190	242	116	384	47	172
Hymenoptera-non ant										
Upper	138	184	63	80	64	70	63	218	91	94
Ground	73	143	202	191	87	120	94	89	184	150
Lepidoptera										
Upper	81	67	55	64	77	60	123	92	121	127
Ground	19	29	53	27	105	25	152	18	45	22
Mecoptera										
Upper	0	4	0	0	2	2	0	0	0	0
Ground	2	17	2	2	7	9	0	1	3	6
Neuroptera										
Upper	4	10	0	10	5	8	0	7	4	15
Ground	2	0	1	1	1	0	2	1	0	1
Odonata										
Upper	0	0	0	0	0	0	0	0	0	0
Ground	1	0	0	0	0	1	0	0	0	0
Orthoptera										
Upper	9	5	14	4	6	4	10	11	4	10
Ground	6	25	20	23	17	25	10	9	17	23
Plecoptera										
Upper	0	0	0	1	1	1	0	1	0	5
Ground	0	0	0	0	0	0	0	0	0	0
Psocoptera										
Upper	17	19	27	22	20	21	35	33	23	61
Ground	4	3	16	10	5	3	12	13	11	13
Thysanoptera										
Upper	21	29	24	148	15	23	16	37	16	23
Ground	2	2	5	21	4	11	5	26	3	7
Trichoptera										
Upper	4	9	3	6	1	6	8	9	3	13
Ground	3	0	1	0	0	0	0	2	0	1
Total: specimens										
Upper	2352	7446	4175	3608	2396	1999	1735	15399	1938	3030
Ground	1401	2150	2113	1854	1715	1889	1819	2161	1511	1864
Total: orders										
Upper	17	20	16	18	19	19	15	18	16	19
Ground	19	17	17	17	19	17	16	20	17	19

Table 3

The number of individuals in different arthropod orders collected using window traps in Kitadan valley

Order	PO		PF		WG		ME	
Year	2005	2006	2005	2006	2005	2006	2005	2006
Acarina								
Upper	4	2	0	1	3	0	4	2
Ground	9	6	4	1	2	1	5	10
Araneae								
Upper	112	82	63	66	68	83	74	84
Ground	211	168	115	59	164	161	124	114
Opiliones								
Upper	1	0	0	0	0	0	0	0
Ground	14	2	0	0	3	2	52	23
Amphipoda								
Upper	5	1	0	0	4	0	2	1
Ground	87	70	38	0	454	102	51	80
Isopoda								
Upper	2	1	0	2	1	1	0	3
Ground	25	13	0	0	92	42	43	325
Lithobiomorpha								
Upper	0	0	0	0	0	0	0	0
Ground	2	0	0	0	0	0	0	0
Blattaria								
Upper	0	0	0	0	0	0	0	0
Ground	0	0	0	0	0	0	0	0
Coleoptera								
Upper	70	68	61	63	75	81	97	105
Ground	102	71	72	37	116	75	93	57
Collembola								
Upper	34	25	5	1	24	16	33	43
Ground	211	206	114	75	199	175	209	275
Diptera								
Upper	833	902	1150	1029	1507	1302	868	855
Ground	551	749	1007	762	762	979	770	829
Ephemeroptera								
Upper	1	0	0	0	0	0	0	0
Ground	0	0	0	0	0	0	0	0
Hemiptera								
Upper	4	4	7	11	13	18	9	9
Ground	17	4	7	10	13	3	10	18
Homoptera								
Upper	314	220	298	350	333	386	292	182
Ground	120	292	270	360	173	194	156	147

Table 3 (continued)

Order	PO		PF		WG		ME	
Year	2005	2006	2005	2006	2005	2006	2005	2006
Hymenoptera-ant								
Upper	48	40	42	36	21	15	21	21
Ground	122	80	43	14	156	135	66	70
Hymenoptera-non ant								
Upper	112	135	147	333	135	258	108	185
Ground	175	186	175	117	285	203	154	117
Lepidoptera								
Upper	30	44	11	20	30	37	42	42
Ground	10	17	7	12	7	9	31	24
Mecoptera								
Upper	2	5	0	0	0	0	2	3
Ground	2	0	0	0	0	1	2	5
Neuroptera								
Upper	5	2	4	2	1	2	5	7
Ground	0	1	0	0	4	0	1	0
Odonata								
Upper	0	0	0	1	0	0	0	0
Ground	1	4	0	2	0	0	0	0
Orthoptera								
Upper	7	2	5	6	0	2	14	5
Ground	19	14	14	18	26	23	308	194
Plecoptera								
Upper	2	1	0	0	1	1	0	5
Ground	0	5	6	1	6	6	0	4
Psocoptera								
Upper	3	10	3	7	2	5	2	14
Ground	3	2	5	2	3	0	6	0
Thysanoptera								
Upper	23	38	26	31	36	47	21	22
Ground	5	3	4	9	1	0	7	4
Trichoptera								
Upper	0	1	0	2	0	1	0	4
Ground	3	2	1	0	0	0	0	0
Total: specimens								
Upper	1612	1583	1822	1961	2254	2255	1594	1592
Ground	1689	1895	1882	1479	2466	2111	2088	2296
Total: orders								
Upper	19	20	13	17	16	16	16	19
Ground	20	20	16	15	17	17	17	18

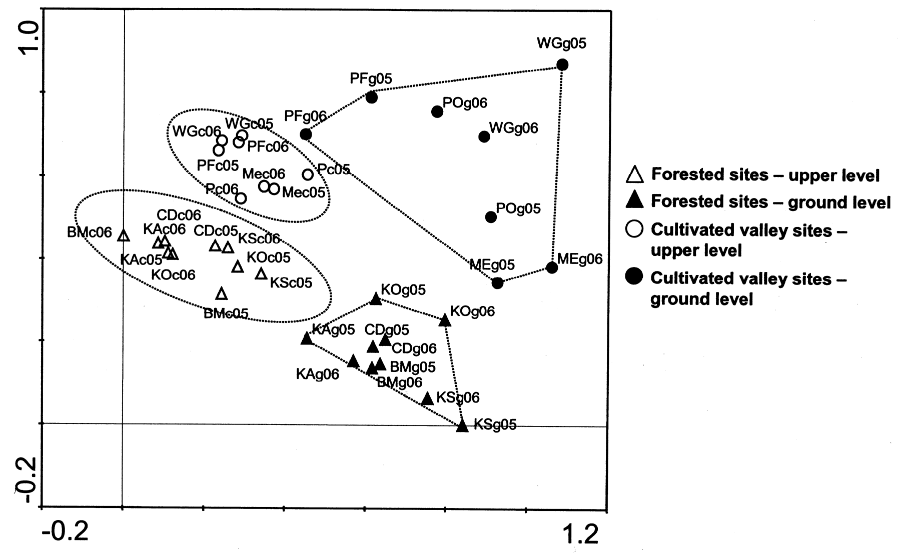

Fig. 7. DCA ordination showing the distribution of arthropod orders collected from different sampling sites, strata, and years. Triangles and circles indicate the "forested" and "cultivated valley" sites, respectively. Open and closed symbols indicate the upper and ground levels, respectively. See the text for an explanation of the sampling site codes

other along the first axis, while the site groups, i.e. "cultivated valley" sites (PO, PF, WG, and ME) and "forested" sites (KO, KA, KS, BM, and CD), were separated along the second axis. At the upper level, between-site-groups heterogeneity was nearly the same in the two habitat groups. Site BM was obviously more different between the two years than other sites. However, at ground level, among-sites heterogeneity was larger (lower similarity among-sites) in "cultivated valley" sites than those in "forested" sites. Sites in the "cultivated valley", except site ME, were relatively different between the years. Both axes explained 50.2% of the variability in the order composition of the samples. Site score analysis by DCA discriminated effectively among the site groups and strata (t-test, $P<0.0001$ for the first and second axes).

Variation in spatial distribution of orders

Figure 8 shows DCA ordination of 18 orders consisting of 11 "flying" and seven "non-flying" orders. The former consisted of seven "forested" and four "cultivated valley" orders, which were more frequently collected from "forested" and "cultivated valley" sites, respectively, and the latter four "forested" and three "cultivated valley" orders (Fig. 8, Tables 2, 3). Figure 8 shows a clear separation of the 18 orders into four

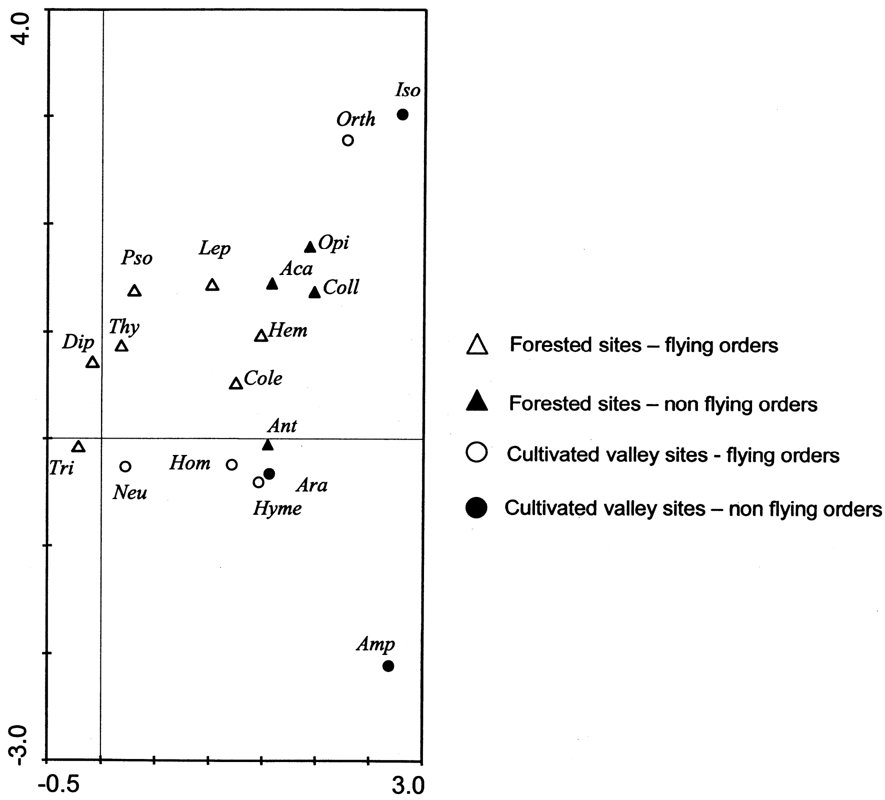

Fig. 8. DCA ordination showing the spatial distribution of each arthropod order among the study sites. Abbreviations for taxa : Dip, Diptera; Lep, Lepidoptera; Cole, Coleoptera; Thy, Thysanoptera; Pso, Psocoptera; Hom, Homoptera; Neu, Neuroptera; Tri, Trichoptera; Hym, Hymenoptera-non ant; Hem, Hemiptera; Ple, Plecoptera; Mec, Mecoptera; Ara, Araneae; Amp, Amphipoda; Ort, Orthoptera; Iso, Isopoda; Aca, Acarina; Coll, Collembola; Opi, Opiliones; Ant, Hymenoptera-ant

groups; (1) separation of "forest" orders and "cultivated valley" orders along the second axis; (2) the "forest" orders aggregated closely and they were separated clearly into "flying" and "non-flying" orders along the first axis; (3) "cultivated valley" orders located below "forested" orders, except for Orthoptera (categorized as "flying" order, but samples of this order were composed mainly of ground crickets) and Isopoda, were again separated into "flying" and "non-flying" orders along the first axis; and (4) three "non-flying" orders, Isopoda (together with Orthoptera), Amphipoda, and Araneae, were separated from one another reflecting their localized distribution at particular sites in the "cultivated valley" (sites WG and ME, see explanation of spatial distribution of each order). The first and second axes explained 50.2% of the variability in order distribution among the sites. Analysis of the taxon scores confirmed the significant difference in the distribution of the orders among sampling sites (t-test; $P<0.0001$ and $P= 0.034$ for the first and second axes, respectively).

DISCUSSION

For the present study, few comparable data sets have been collected from satoyama areas using similar sampling and analyzing methods, so below we discuss the present results using our own data. First, we collected arthropods in the present study area using four types of IBOY-specified traps (light, window, malaise, and pitfall traps) at two levels (upper and ground levels) in three places within the *Quercus* forest, where site KO was located in the present study (forest inside, edge and upper slope, located within a radius of 100 m) in June, August, and October of 2001 (three days duration each time; henceforth referred to as the IBOY study; Nakamura et al., 2006). Second, we studied the arthropod diversity in a satoyama area with mixed deciduous forest predominated by red pines, *Pinus densiflora*, and a sporadic mixture of oaks, *Quercus*, where a matsutake mushroom, *Tricholoma matsutake*, revival project was taking place, in Suzu city on the Noto Peninsula (230 km north of Kanazawa). In this project, trees other than pine trees were cut and the forest floor was raked. The effects of the management on invertebrate communities were examined using four sampling methods: window and pitfall traps and sampling of litter and soil. Samples were collected only once in September 2005 from the "managed site" and from the surrounding "control site" without management (Linawati et al., 2006; referred to as Suzu study). In the IBOY study, window traps collected 1115 individuals comprising five top ranked orders (Diptera 48%, Coleoptera 24%, Hymenoptera-non ant 11%, Hemiptera 7%, and Hymenoptera-ant 5%; Nakamura et al., 2006). In the Suzu study, window traps collected 1253 invertebrates; Diptera (31%), Hymenoptera non-ant (18%), Homoptera (13%) and Araneae (13%) were abundant at the control site and comprised 75% of the total catch. In the managed site, Hymenoptera non-ant (49%), Diptera (23%), Homoptera (13%), and Lepidoptera (4%) accounted for 89% of the total catch (Linawati et al., 2006). In the present study, Diptera (ca. 70% for the whole study area and also in KO) was ranked first in abundance, followed by Homoptera, Coleoptera, and Hymenoptera non-ant (Tables 2, 3). Compared to the present study, the abundance rankings of orders in the IBOY and Suzu studies were similar, but the proportion of Diptera was lower in both studies possibly due to the fact that samples were not collected in November when Diptera abundance increased rapidly. In addition, the satoyama forest in Suzu was more open and dominated by pines, which provided different conditions from the present study area. In the IBOY and Suzu studies, DCA ordinations using higher taxa, which were similar to the present study, revealed that the taxonomic composition and numbers of individuals collected varied greatly depending on the type of traps used, indicating that it is not possible to accurately understand biodiversity using only certain trapping methods. In the IBOY study, DCA ordination using only window trap samples also separated the taxonomic compositions among the three sites within one forest but differences between the strata was not detected (Nakamura et al., 2006). In the Suzu study, DCA ordination of window trap samples as well as those of other samples clearly separated the control site from the managed site. In Suzu, some groups of flying insects belonging to Diptera, Homoptera, and Hymenoptera tended to show higher abundance (although a lower percentage) at the managed site compared to the control site. This pattern may be attributed to the preference of these orders for open habitats and their photophilous nature (Linawati et al., 2006). In the present study, the "cultivated valley" was under restoration and the habitat conditions of the sites within the valley were diverse, e.g. ME, PO, PF, and WG, reflecting their unique compositions of arthropod orders (Tables 2, 3, Figs. 5, 6). As shown in the Suzu study, managing activity can affect arthropod assemblages in the present study area, as DCA ordination indicated in the separation of the "cultivated valley" sites from "forested" sites (Fig. 7) although the difference in the topography and related vegetation are also included.

In the present study site, monthly pitfall sampling of ground arthropods was carried out in 2004 and 2005. DCA ordination using higher taxonomic composition (order and class) clearly separated the major habitat types as well as the effects of management activities (Nakamura et al. 2006), which is generally in accordance with the present results obtained by window trap data (Fig. 7). Moreover, species level analysis with Carabidae (ground beetles) also showed similar results (Fig. 4 in Nakamura et al. 2006). In the next stage; first, the difference in the grouping of the habitats and the resolutions of the separation between the data using window traps in the present study and those obtained by pitfall traps should be examined at the higher taxonomic levels; and second, more detailed examination of habitat heterogeneity and effects of managements should be done on lower taxonomic levels, which we have started with Diptera and will be published subsequently.

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