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Faunal and Biological Studies of Ground Beetles (Coleoptera;Carabidae and Brachinidae)(1) Species Compositions on the Banks of the Same River System[1)]

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Abstract Species composition of ground beetles in three river banks of the same river system in Yamaguchi City, Japan was investigated by pitfall trappings in 1991–1995. A total of 41 species of the two families, Carabidae and Brachinidae, were collected. The faunas found are different between river banks situated within a distance of 1.3 km. The difference is discussed concerning the environmental factors of habitats. Species diversity and similarity of the ground beetles on the three banks are described. Seasonal patterns of adult activities of the dominant or abundant species are illustrated. The faunas found are compared with those of nearby different habitats to clarify characteristics of river bank ground beetle fauna. Attempts are also made to select indicator species of river banks.

Key words: ground beetles; species composition; species diversity; pitfall trapping; river banks; indicator species.

Introduction

Many studies have hitherto been made on the species composition and seasonal abundance of ground beetles in various habitats (THIELE, 1977; LUFF, 1987). Some similar studies have been carried out in Japan (ISHITANI, 1996). However, almost all the data have been obtained from agro-ecosystems and forest areas. River banks or riparian habitats have been less studied probably

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because of their non-economical value and few taxonomic or environmental interests. Some previous studies showed that the ground beetle fauna was rather variable according to habitats even in the same river system. This made it difficult to select indicator species (ANDERSEN, 1969; PLACHTER, 1986; ISHII *et al.*, 1996). The data obtained suggest that river banks are not uniform but variable in relation to topography, vegetation, surrounding environments, and so on, so far as concerned with ground beetles. Consequently, this study is intended to accumulate data in Japan, in which only a study was made at several sites of the same river (ISHII *et al.*, 1996) besides several fragmentary reports on riparian ground beetles (TERADA, 1983; TANAKA, 1988a, b, 1990; ISHITANI, 1996). In this study, three sites situated within a short distance of the same river system were selected for examining the difference of the ground beetle faunas. The result will be useful for understanding the whole ground beetle fauna of the river from the upper to the lower reaches, and also of the other rivers in the Yamaguchi area.

Meanwhile, it has recently been accelerated to make researches on environmental indicators by using some insect groups such as aquatic insects, butterflies and others (TANAKA, 1988; SUNOSE, 1992 a, b, c). Ground beetles have also been discussed as indicator insects (MÜLLER-MOTZFELD, 1989; DUFRENE *et al.*, 1990; SUNOSE, 1992a, b, c; ISHITANI, 1996). It is requested to select indicator species of ground beetles on river banks, since the habitat has been considered important in current environmental issues and since ground beetles are considered to be the best insect group for this purpose owing to its abundance and simple methods for samplings.

In the present study, we selected three banks within a short-distance of the same river including its branch in Yamaguchi City to know characteristics of riparian ground beetles and tried to select indicator species of river banks.

The first author made a series of field studies on ground beetles in Hiroshima City by using pitfall trappings in different habitats including a river bank (ISHITANI, 1996). Based on the results obtained, he proposed a new index of disturbance (ID-index) indicating the disturbance degree by human activities or natural disaster such as floodings of a given area. This index is applied to the present study for analizing the results obtained at the three sites.

It is also aimed to compare the present result on the species composition and seasonal abundance with those of such other habitats in the Yamaguchi area such as paddy fields (YAHIRO *et al.*, 1992), a vineyard (YANO *et al.*, 1989), a forage crop field (ISHITANI *et al.*, 1994) or forest (YAHIRO *et al.*, 1990). This comparative study would contribute to the knowledge of ground beetle fauna of river banks.

Study Sites and Methods

1. *Study sites*

Three sites were selected on the Fushino-gawa River banks including its branch river, Niho-gawa River (Fig. 1). These sites were situated within 1.3 km and on the right bank of the rivers. Field surveys by means of pitfall traps were made in 1991–1995, covering one year for each site, to know seasonal abundance. Vegetations of three sites were investigated by Penfound Method in early June, 1996. Five quadrats (5×5 m) were selected in each site. Brief accounts of each site are described below.

Site 1. Fushino-gawa River. Soudayu-cho, Yamaguchi City (Fig. 2A)

Study site (9×40 m) was narrow with a dike (3 m in height) on the west and the river on the east. The river at the site was about 70 m between dikes and with a flow of 15 m in width. Small hills were located at the eastern side of the river providing the most natural scenery to the three sites. Factories were situated on the western side of the dike which was used as a road.

The study site was 1.5 m above the water level, with a concrete wall at the flow side.

The vegetation of the site was rather diverse with 21 plant species. Four

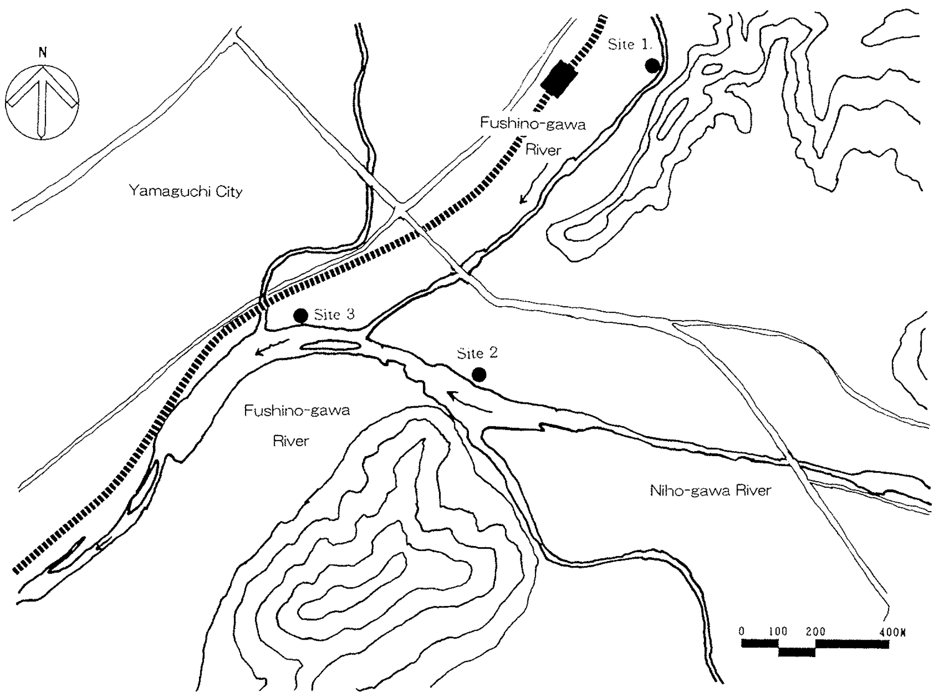

Fig. 1. Map of study area (Sites 1, 2 and 3) in Yamaguchi City (for explanation of sites, see text).

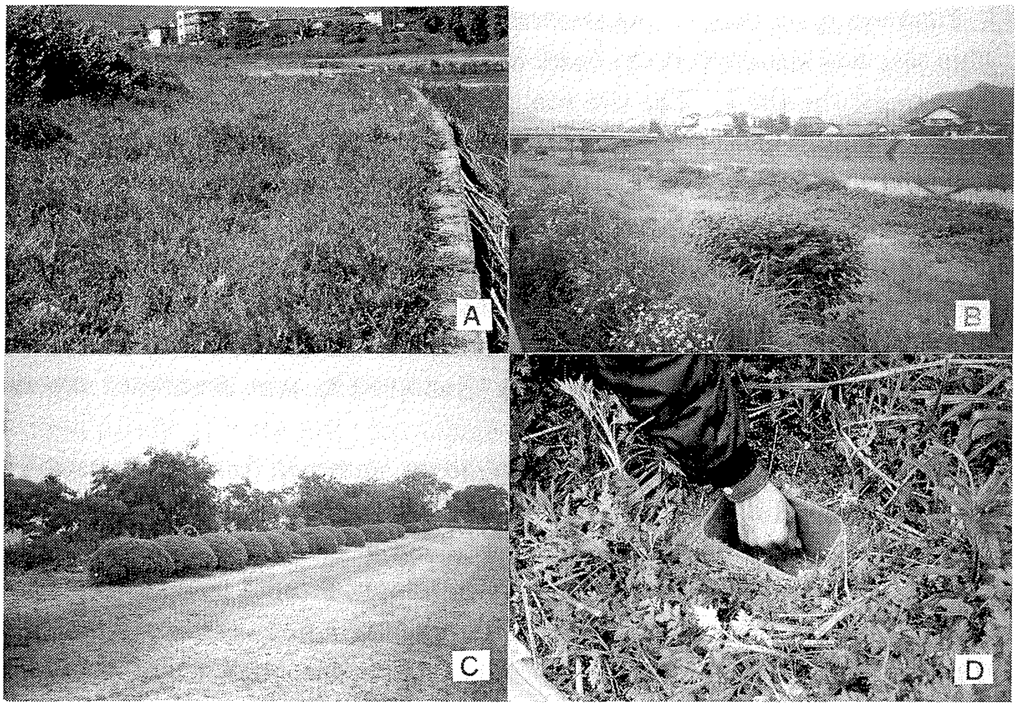

Fig. 2. Study sites of ground beetles on river banks (Yamaguchi City). A, Site 1, Fushino-gawa River, B, Site 2, Niho-gawa River, C, Site 3, Fushino-gawa River, D, Collecting from the trap at site 2.

dominant species were recognized: two species of Compositae, one species of Gramineae and *Polygonum cuspidatum* (SIEB. et ZUCC.). Values of total height (cm), total cover, summed dominance ratio (%) and index of species diversity were 2480, 26.96, 574.3 and 12.5162, respectively.

Site 2. Niho-gawa River. Miyajima-cho, Yamaguchi City (Fig. 2B)

This site was situated on the bank of the Niho-gawa River which empties into the Fushino-gawa River shortly downstream from the site as in Fig. 1. The river had a flow of 90 m in width. There was a submerging dam about 100 m down from the site. The site was 10 m in width, about 0.3 m above the water level and with a concrete wall at the flow side.

The river bank was rather open in prospect though hills were located on the opposite side. There was a high school campus at the northern side of the site. A paved road on the dike (2 m in height) was situated between the campus and the site.

The vegetation of the site was of the second richness in species diversity among three sites. Three dominant species, each one species of Gramineae and Compositae and *Miscanthus sinensis* ANDERSS., were found among 14 species in all. Values of total height (cm), total cover, summed dominance ratio (%) and index of species diversity were 1580, 27.4, 494.1 and 10.5679, respectively.

Site 3. Fushino-gawa River. Asahi-dori, Yamaguchi City (Fig. 2C)

This site was situated on the bank of the Fushino-gawa River about 1.2 km downstream of the site 1. The site was part of the Idegahara River Bank Park, and a row of small bush plants and 10 trees including *Prunus* and *Quercus* trees were planted at the flow side and at the dike side, respectively. The site (36× 70 m) was covered with grasses receiving occasional weeding, and with a concrete wall at the flow side. The river was about 120 m between dikes and a flow was about 80 m in width. The site was about 3 m above the water level.

The vegetation of the site was the poorest in species diversity of the three sites. Only one species, *Eleusine indica* GAERTNER, was dominant among 9 species in all.

The values of total height (cm), total cover, summed dominance ratio (%) and index of species diversity were 560, 24.2, 211.5 and 4.7637, respectively.

The duration time of the sun light received at each site is mentioned here to describe the environmental condition, though ground beetles are almost nocturnal. The site 1 receives sun light for 11 hours 20 minutes and the site 2 for 12 hours 50 minutes in middle July. The time at the site 3 is almost the same as at the site 2, though it is reduced by trees.

2. *Study methods*

Trappings were made from January to December 1991 at the site 1, from November 1992 to December 1993 at the site 2 and from February 1994 to January 1995 at the site 3. Pitfall traps used were plastic cups (diameter 8.5 cm ×13.5 cm deep) for the site 1, and transparent plastic cases (10×18×12 cm) for the sites 2 and 3. Small holes for drainage were made through the bottoms of these traps. Plastic plates were set 5 cm above traps to protect rainfall and falling leaves.

Ten traps were set at the site 1, 9 at the site 2 and 10 at the site 3. At the site 1, each 5 traps were set at both the northern and southern ends of the site, and at a distance of 4m between traps. At the site 2, each 3 traps in a row were set in parallel with flow and the farthest row was 5 m apart from the flow. Each trap in a row was set at a distance of 3 m.

At the site 3, 5 traps were set inside bush plants at the flow side, and 5 at the dike side under trees. Each trap in a row was set at a distance of 10 m. Traps were emptied once every 10 days in all sites through the year studied (Fig. 2D).

Results

1. *Species composition*

A total of 1,271 individuals of beetles belonging to 41 species of 2 families were collected from the 3 sites (Table 1). Seventeen species of Carabidae were recorded from the site 1, 29 of 2 families from the site 2, and 18 of 2 families from the site 3.

1) Site 1

Of the 486 individuals of 17 species caught, 7 species were most frequently caught amounting to 428 individuals or 88.1% of the total figure. These 7 abundant species were *Harpalus sinicus*, *Hr. eous*, *Amara gigantea*, *Dolichus halensis*, *Hr. tridens*, *Amara chalcites* and *Diplocheila zeelandica* in a decreasing order. *Hr. sinicus* was most frequently caught representing 41.4% of the total. A second group of 3 species, *Am. congrua*, *Chlaenius variicornis* and *Haplochlaenius costiger*, were caught fewer in individual number. Individuals of the remaining 7 species numbered fewer than 5. The mean individual number per day and per trap was 0.11.

A brachinid species, *Pheropsophus jessoensis*, was not collected from this site though it was collected at the other two sites.

2) Site 2

A total of 489 individuals belonging to 29 species of 2 families were collected. Individuals of the 6 most frequently caught species amounted to 357 or 73.0% of the total figure. These 6 abundant species were *Pterostichus microcephalus*, *Ch. pallipes*, *Ph. jessoensis*, *Dl. halensis*, *Am. chalcites and Hr. niigatanus* in decreasing order. *Pt. microcephalus* was most frequently caught representing 45.8% of the total.

In the second group of species, *Synuchus dulcigradus*, *Bembidion eurygonum*, *Pt. longinquus*, *Am. simplicidens*, *Nebria chinensis* and *Lachnolebia cribricollis*, the numbers collected were fewer. The mean individual number per day and per trap was 0.14.

3) Site 3

A total of 296 individuals belonging to 18 species of 2 families were collected. Individuals of the 5 most frequently caught species amounted to 237, 80.1% of the total figure. These 5 abundant species were *Am. chalcites*, *Hr. niigatanus*, *Hr. tridens*, *Ph. jessoensis*, and *Hr. jureceki* in decreasing order. *Am. chalcites* was most frequently caught, representing 37.8% of the total. Remaining species were fewer in the number of individuals collected. The mean individual number per day and per trap was 0.08 indicating the least number of the three sites.

Five species are common to all three sites. They are *Dl. halensis*, *Am. chalcites*, *Hr. jureceki*, *Hr. tridens* and *Ch. variicornis.* Thirteen species are

Table 1. Number of individual ground beetles caught on banks (Yamaguchi City, pitfall catches, 1991–1995).[1]

Species	Site 1	Site 2	Site 3	Total
Carabidae				
Nebria chinensis BATES	0	12	8	20
Scarites acutidens CHAUDOIR	0	2	0	2
Sc. terricola pacificus MORAWITZ	0	1	1	2
Bembidion eurygonum BATES	0	15	0	15
Archipatrobus flavipes (MOTSCHULSKY)	0	4	0	4
Lesticus magnus (MOTSCHULSKY)	0	3	0	3
Pterostichus longinquus BATES	0	15	0	15
Pt. microcephalus (MOTSCHULSKY)	0	224	1	225
Pt. prolongatus MORAWITZ	0	6	0	6
Dolichus halensis (SCHALLER)	35	23	10	68
Synuchus callitheres callitheres (BATES)	4	6	0	10
Sy. dulcigradus (BATES)	0	18	1	19
Amara chalcites DEJEAN	21	20	112	153
Am. chalcophaea BATES	0	3	0	3
Am. congrua MORAWITZ	12	0	0	12
Am. gigantea (MOTSCHULSKY)	60	1	0	61
Am. macronota ovalipennis JÉDLICKA	0	1	0	1
Am. simplicidens MORAWITZ	2	13	0	15
Anisodactylus punctatipennis MORAWITZ	0	0	4	4
An. sadoensis SCHAUBERGER	0	0	9	9
An. signatus (PANZER)	0	0	7	7
Harpalus capito MORAWITZ	0	1	0	1
Hr. discrepans MORAWITZ	4	0	0	4
Hr. eous TSCHITSCHERINE	65	0	2	67
Hr. jureceki (JÉDLICKA)	4	4	20	28
Hr. niigatanus SCHAUBERGER	0	20	53	73
Hr. sinicus HOPE	201	1	0	202
Hr. tinctulus BATES	0	0	8	8
Hr. tridens MORAWITZ	27	1	29	57
Trichotichnus congruus (MOTSCHULSKY)	3	0	0	3
Bradycellus subditus (LEWIS)	3	0	0	3
Diplocheila zeelandica (REDTENBACHER)	19	1	0	20
Chlaenius micans (FABRICIUS)	3	0	2	5
Ch. naeviger MORAWITZ	0	3	0	3
Ch. pallipes GEBLER	0	45	0	45
Ch. posticalis MOTSCHULSKY	0	0	3	3
Ch. variicornis MORAWITZ	12	6	3	21
Ch. vilgulifer CHAUDOIR	0	2	0	2
Haplochlaenius costiger (CHAUDOIR)	11	2	0	13
Lachnolebia cribricollis (MORAWITZ)	0	11	0	11
Brachinidae				
Pheropsophus jessoensis MORAWITZ	0	25	23	48
No. species	17	29	18	41
Total	486	489	296	1271

[1] For location of three sites and number of traps used, see text.

common to two sites, though 6 of them are represented by only one individual in one of the two sites concerned.

Numbers of individuals of the first 5 species in order of abundance in each of the three sites are listed in Table 2. As shown in the table, these 11 species were abundant only in one or two sites.

2. *Species diversity and similarity*

Species diversity and species similarity of ground beetles of the three sites are described (Table 3). Index of species diversity is the greatest at the site 3, and then at the site 1 and the site 2 in decreasing order. Index of similarity between two habitats in decreasing order is the sites 2 and 3, the sites 1 and 3 and the sites 1 and 2. The similarity index of the sites and other habitats are shown in Table 4. Judging from the data, the fauna in the forest is different

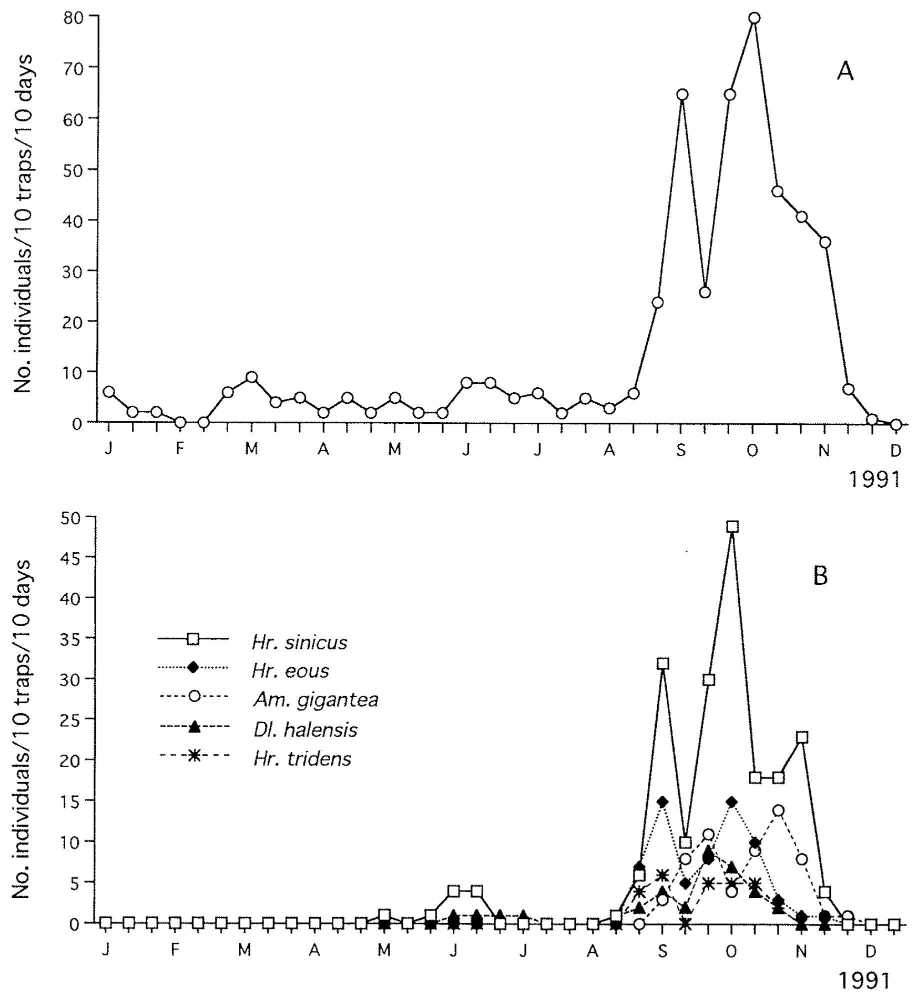

Fig. 3. Seasonal abundance of ground beetles collected at the site 1 on the river bank of Fushino-gawa River (Yamaguchi City, pitfall catches, 1991). A, All species; B, five species.

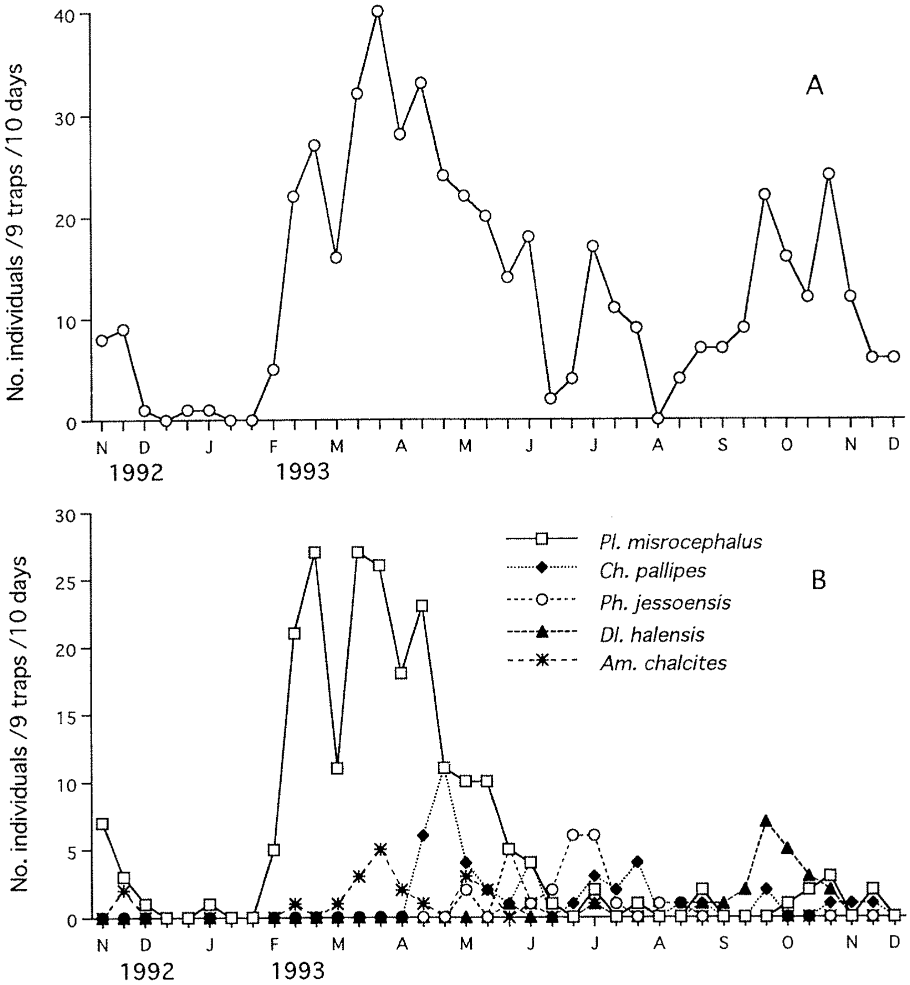

Fig. 4. Seasonal abundance of ground beetles collected at the site 2 on the river bank of Niho-gawa River (Yamaguchi City, pitfall catches, 1992–1993). A, All species; B, five species.

from those of other habitats studied.

3. *Seasonal abundance*

Seasonal abundances of the ground beetles caught are illustrated by overall number of individuals and by those of the first 5 species in order of abundance in each site (Figs. 3–5).

1) Site 1

Overall seasonal abundance of all species caught is shown in Fig. 3A, and those of 5 species in Fig. 3B. Ground beetles were collected through the year showing a high peak in the autumn with a break in late September. The peak was mainly formed by *Hr. sinicus* and two other *Harpalus* species.

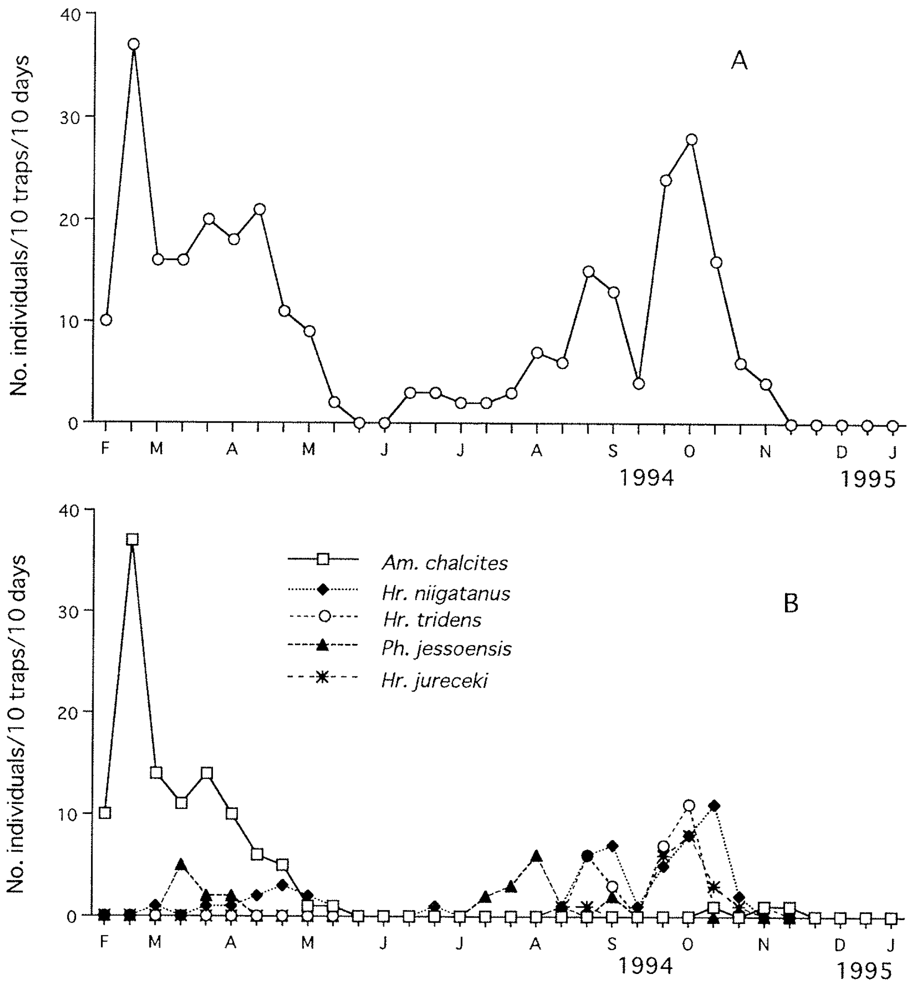

Fig. 5. Seasonal abundance of ground beetles collected at the site 3 on the river bank of Fushino-gawa River (Yamaguchi City, pitfall catches, 1994–1995). A, All species; B, five species.

2) Site 2

As shown in Fig. 4A, ground beetles showed their activity almost through the year. Two distinct peaks were recognized, one in the spring and the other in the late autumn. The former was substantially formed by *Pt. microcephalus*, a spring breeder, with wide distribution from open lands to forests (HABU & SADANAGA, 1961), and the latter was mainly formed by *Dl. halensis*, autumn breeder (Fig. 4B).

3) Site 3

Overall seasonal abundance of all species (Fig. 5A) showed a similar pattern to that of the site 2 having two peaks in the spring and autumn. These peaks, were, however, formed by species different from those at the site 2. The spring peak was mainly formed by *Am. chalcites*, spring breeder, and the one in

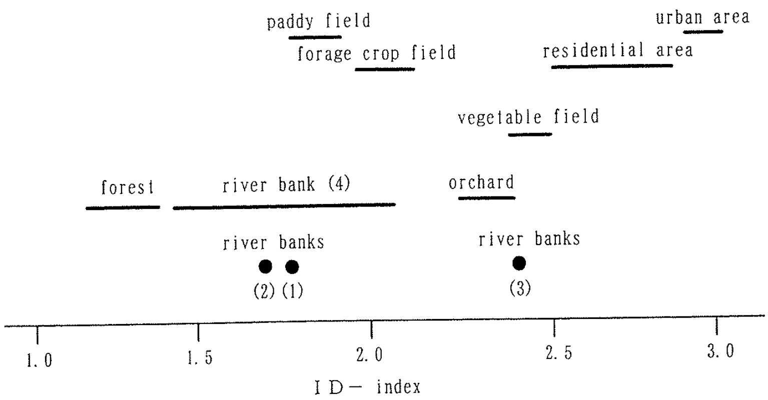

Fig. 6. ID-index of different habitats calculated on the ground beetles surveyed in Yamaguchi and Hiroshima Cities. Data of the river banks (1, 2, 3) are based on the present study, others are referable to Ishitani (1996).

the autumn was mainly formed by two autumn breeders, *Hr. niigatanus* and *Hr. tridens* (Fig. 5B).

4. ID-index

ID-index proposed by Ishitani (1996) using ground beetles was calculated on the present data as follows (Fig. 6): 1.75 at the site 1, 1.69 at the site 2 and 2.45 at the site 3. The value at the site 3 was high, indicating distinct disturbance.

Discussion

1. *Species composition*

The species composition of the three sites studied are strikingly different even though these sites are situated within a distance of 1.3 km along the same river system. The first 5 species are different in order of abundance at each site (Table 2). When we list 6 species from each site, *Amara chalcites* is the only one species common to all the sites. Of the species listed, *Dolichus halensis*, is common to the sites 1 and 2, and *Hr. tridens* is to the sites 1 and 3. Three species, *Am. chalcites*, *Hr. niigatanus* and *Ph. jessoensis*, are common to the sites 2 and 3. The data of species similarity (Table 3) has been affected by this distribution pattern.

The data reported by Ishii *et al.* (1996) also showed considerable difference in species composition of ground beetles at 13 sites on the river banks of the Yamato-gawa River flowing through Nara and Osaka Prefectures together with the common species at some sites. They listed 3 dominant species of ground beetles (Carabidae and Brachinidae) and Silphidae at each of the 13 sites. Among ground beetles of these dominant species, *Dolichus halensis* is common to 6 sites, *Carabus yaconinus* to 5 sites, and none to more than 6 sites.

Table 2. Number of individuals of the 5 abundant species of ground beetles at three sites on river banks (Yamaguchi City, pitfall catches, 1991–1995).[1]

Species	Site 1	Site 2	Site 3
Pterostichus microcephalus	0	224 (1)	1
Dolichus halensis	35 (4)	23 (4)	10
Amara chalcites	21	20 (5)	112 (1)
Am. gigantea	60 (3)	1	0
Harpalus eous	65 (2)	0	2
Hr. jureceki	4	4	20 (5)
Hr. niigatanus	0	20 (5)	53 (2)
Hr. sinicus	201 (1)	1	0
Hr. tridens	27 (5)	1	29 (3)
Chlaenius pallipes	0	45 (2)	0
Pheropsophus jessoemsis	0	25 (3)	23 (4)

[1] First 5 species in order of abundance in each of the three sites are listed. From the site 2, 6 species are listed since the same number of individuals of 2 species were collected.
For location of three sites and number of traps used, see text. Number in parentheses indicates the order of abundance in each site.

Table 3. Matrix of species diversity and similarity of the ground beetle faunas on river banks.[1]

	SID[3]	α-index[2]		
		Site 3	Site 2	Site 1
Site 1	4.5890	0.1244	0.0283	
Site 2	4.3047	0.1465		
Site 3	4.9992			

[1] For location of three sites, see text.
[2] Pianka's index of similarity (Pianka, 1973)
[3] Simpson's index of diversity (Simpson, 1949)

Since their trappings were made by smaller traps than those used in this study and operated between April and November, comparison should be made carefully. Major spring breeder, *Pt. microcephalus* and *Am. chalcites*, were listed as the 1st and 3rd most frequently caught species in this study, while these were not collected by them probably because of no trappings in the spring.

The present data is different from those recorded on a river bank in Hiroshima (Ishitani, 1996). The river running through the plain area in the suburbs of Hiroshima City has a similar nature to that in the present study. The first 5 species in order of abundance in Yamaguchi are not the same the first 5 species in Hiroshima. Two species among them in Hiroshima are listed as the tenth and twelfth in the abundance order in Yamaguchi, respectively. When the whole ground beetle faunas were almost the same in both areas, this difference should be explained by the difference of the respective habitats of the river banks.

In contrast to the ground beetle faunas of Japanese river banks, a long river in Europe shows rather similar fauna among the different sites and the fauna changes continuously with distance from the upper to the lower reaches. PLACHTER (1986) made collectings at 10 sites on the banks of the Isar River, Germany, ranging 196 km from the Alps to the Danube River. Of the 79 species caught, 15 species are common to 6–10 sites (1 species is common to 10 sites, 4 species to 9, 3 species to 8, 5 species to 7 and 2 species to 6). This result obtained in the larger area showed considerable similarity between the sites. He also mentioned that the fauna along the river changed continuously with distance from the first alpine location to the tenth, the lowest one. This tendency was not seen in the Japanese rivers studied.

Following arguments could be made to explain the difference between the data from Europe and Japan, though the available data are scanty from both the areas. The former study covered a long distance while the latter covered one-fifth the length of the former (ISHII *et al.*, 1996) or only 1.3 km (present study). The present study should be considered a macroscopic investigation of one place. ISHII *et al.* (1996) covered substantial length but the river they studied runs along rural and urbanized areas except one place of well-wooded valley. It could be said that the sites had more diverse environments for the beetles despite of the shorter length of the rivers.

The results obtained in Japan showed variable faunas probably corresponding to difference of such environmental factors as vegetation, other arthropod faunas, micro-climate, soil condition (PERTTUNEN, 1951), and others. It is suspected that most sites on the Isar River may provide similar habitats to ground beetles inspite of its long distance.

The sites in this study were isolated by dikes with paved roads from surrounding urbanized areas and had the flows at the other side. The banks were not continuously formed along the flows but constructed for rather a short distance intermittently. This seems to suggest that movements of ground beetles and other arthropods between the sites and surrounding areas may be hindered to a considerable extent. On the contrary, ISHII *et al.* (1996) suggested that surrounding areas would serve as the source of insect supply on the river banks they studied.

When we compare the abundant species from the river banks (Table 2) with 10 abundant species in each of other habitats in the Yamaguchi area (YANO *et al.*, 1989; YAHIRO *et al.*, 1990, 1992; ISHITANI *et al.*, 1994), 6 species are common to those in the vineyard, 5 to those in the forage crop field, 4 to those in the paddy fields and 1 to those in the forest. This relationship is also found in Table 4 presenting similarity index.

It has been generally accepted that ground beetles are often narrowly adapted to particular habitats based on the surveys made in various agro-ecosystems and forest types (THIELE, 1977). It is also justified that ground beetle faunas of the river banks are variable in respective sites studied.

It seems worth noting that the numbers of species collected from river banks in different localities are similar as follows: 41 species in Yamaguchi, 31 species in Hiroshima (ISHITANI, 1996) and 44 species in the Yamato-gawa River (ISHII *et al.*, 1996). Lesser number in Hiroshima is probably due to the fact that only one site was studied. This may indicate a carrying capacity of the Japanese riparian ecosystem concerning ground beetles.

2. *Species diversity*

Different species composition and number of individuals collected in the three sites resulted in different species diversities. As seen in Table 1, the numbers of species caught at the sites 1 and 3 were almost the same and less than those at the site 2. The values of species diversity at the sites 1 and 3 are larger than that at the site 2. The site 3 is a part of the park for public recreation activities, and yet this site poor in vegetation has the highest diversity index.

Different food habits of ground beetles, oligophagous or polyphagous, are surmised to be responsible for its distribution. Since adequate data are not available, different species diversity or species composition found is not discussed further at present in relation to the food habit.

The similarity index is compared with those in other agro-ecosystems in the Yamaguchi area (Table 4). These agro-ecosystems are situated about 2.2 km apart from the site 3, being isolated from the latter by a hill 199 m in height. As shown in the table, the index of the site 1 and the forage crop field is the greatest, then those of the site 3 and the paddy fields, the site 3 and the vineyard

Table 4. Matrix of species similarity of the ground beetle faunas in different habitats.[1)]

	α-index[2)]		
	River banks		
	Site 1	Site 2	Site 3
Vineyard[3)]	0.2543	0.0851	0.5577
Forest[4)]	0.0239	0.0248	0.0097
Paddy field[5)]	0.1781	0.1627	0.5966
Forage crop field[6)]	0.9119	0.0165	0.0531

1) For location of three sites, see text.
2) Pianka's index of similarity (Pianka, 1973)
3) YANO *et al.*, 1989
4) YAHIRO *et al.*, 1990
5) YAHIRO *et al.*, 1992
6) ISHITANI *et al.*, 1994

and to the smallest of the site 3 and the forest. Judging from the data given by ISHITANI (1996) reporting on the ground beetles of the residential areas and other habitats besides the present data, it is apparent that the fauna of river banks is similar to those of agro-ecosystems than to such other habitats as forest or residential areas.

Plant species diversity was highest at the site 1 followed by the site 2. The value at the site 3 was distinctly lower than those at the other sites. Fourteen plant species found at the site 2 were far less than those at the site 1. At the site 2, species diversity of ground beetles was lowest but the number of species caught was largest. This indicates that ground beetle diversity does not primarily correlate with plant species diversity.

3. *Seasonal abundance*

Different species compositions of the ground beetles at the three sites made different overall seasonal abundance patterns in due course. Dominant species, however, showed almost the same seasonal pattern for each site when it occurred. Seasonal abundance of the dominant species on the river banks are compared with those in other habitats in the Yamaguchi area. Patterns shown by *Am. chalcites*, *Hr. sinicus*, and *Hr. tridens*, are almost the same on the river banks and the agro-ecosystems. However, the following difference can be pointed out: *Am. chalcites* showed two peaks in March to May and October to November on the river banks while a peak occurred in June in the vineyard (YANO *et al.*, 1989) and in April to June in the paddy fields (YAHIRO *et al.*, 1992). Spring activity of this species in the agro-ecosystems was seen later than that on the river banks. The phenology of vegetation in these agro-ecosystems may be related to this difference of ground beetle seasonality.

4. *ID-index*

ID-index of the sites 1 and 2 and that of the river bank in Hiroshima are almost the same. That of the site 3 is approaching to those of the residential areas and vegetable fields in Hiroshima. As this index indicates disturbance degree, the result well shows degree of disturbance of the present sites, namely, the value of the site 3 shows much disturbance which corresponds to its nature as a park. River banks illustrated in Fig. 6 are located on rivers running in urban areas and not on longer ones running through various areas. The index values of the river banks concerned still show wide range from less disturbance to rather high disturbance. This clearly indicates the nature or characteristics of the river banks. It should be mentioned that index of species diversity and ID-index are not recognized inclusively at present.

5. *Environmental indicators*

Ground beetle faunas found on the river banks and in other habitats in the Yamaguchi area showed that *Hr. niigatanus*, *Am. gigantea*, *Ch. pallipes*, *Ch. variicornis* and *Diplocheila zeelandica* are specific to the river banks. These species are not or rarely found in other habitats. On the other hand, the faunas found in the Hiroshima area show that *Am. macros*, *Am. simplicidens*, *Ch. variicornis*, *Hr. platynotus* and *Nebria lewisii* are specific to the river bank, though the first three species were rarely found in other habitats.

The river bank species found in Yamaguchi and Hiroshima areas are, however, not common except one species, *Ch. variicornis.* This species was not found abundantly in the Yamato-gawa River. *Pt. microcephalus* is unique in its distribution. It was most frequently caught in this study, and all the specimens except one were caught at the site 2. It was not frequently found in other habitats of agro-ecosystems in the Yamaguchi area, while the second and third species frequently caught on the river banks were also found in the vineyard and paddy fields. *Dl. halensis* was abundant at the sites 1 and 2, and was found at 6 sites in the Yamato-gawa River.

As can be understood from the different faunas of respective river banks, it is difficult to select indicator species of river banks. The species mentioned above are candidates of indicator species which will preferably be confirmed by further studies.

THIELE (1977) listed ground beetle species characteristic of dry, sandy grass areas in Europe. They are *Amara fulva*, *Am. infima*, *Harpalus rufus*, *Hr. neglectus*, *Hr. anvius*, *Carabus nemoralis* and others. PERTTUNEN (1951) reported that *Hr. serripes*, *Hr. punctatulus* and *Odacantha madanura* showed a clear initial dry response. Though these species are not distributed in Japan, their data are suggestive of the plausibility that species of genera *Amara* and *Harpalus*, and probably also some *Chlaenius* species, can be considered indicator species of dry, grassy river banks in Japan.

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