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THE GROUND BEETLES (COLEOPTERA: CARABIDAE) ASSEMBLAGES ON THE MURAVJEV-AMURSKY PENINSULA, RUSSIAN FAR EAST

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Six assemblages of the ground beetles are recognized and described in the natural and anthropogenic ecosystems of the Muravjev-Amursky peninsula. The ecological differentiation of carabid beetles assemblages becomes apparent in the number of species and composition of species, and remains permanent for a studied period. The species diversity of assemblages does not tend to decrease under anthropogenic press.

KEY WORDS: beetles, Carabidae, assemblage, anthropogenic and natural ecosystems, Russian Far East.

С. К. Холин[1], С. Ю. Стороженко[1], В. С. Сидоренко[1], Г. Ш. Лафер[1], С. Танабе[2]. Ассамблеи жужелиц (Coleoptera: Carabidae) полуострова Муравьев-Амурский, Дальний Восток // Дальневосточный энтомолог. 2005. N 156. С. 1-11.

Выявлены и описаны шесть ассамблей жужелиц в естественных и нарушенных биотопах п-ова Муравьев-Амурский. Экологическая дифференциация комплексов жужелиц проявляется как в количестве видов, так и в видовом составе, и сохраняется на протяжении ряда лет. Показано, что видовое богатство ассамблей не всегда снижается при антропогенном воздействии.

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INTRODUCTION

The ground beetles are one of the most common objects to study the spatial distribution, structure and diversity of the soil animal communities in the boreal zone (Chernov, 1975; Thiele, 1977; Striganova & Porjadina, 2005). A check-list of 208 species from 52 genera of the families Cicindelidae and Carabidae of the local fauna of the Muravjev-Amursky peninsula has been published recently (Lafer, 2005), but the composition and structure of carabid communities in different biotops are still unknown. Therefore the main purpose of the present paper is to recognize and to describe the ground beetles assemblages in the natural and anthropogenic ecosystems of the Muravjev-Amursky peninsula.

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MATERIAL AND METHODS

The study was carried out on the Muravjev-Amursky peninsula, which is located in the southern part of Primorskii krai (Russia). This area lies in the temperate zone and covered mostly with mixed broadleaved and coniferous forest (so called “blackfir” forest) (Kurentzova, 1968; Krestov, 2003). The trees’ species composition in forests is highly variable and depends on local conditions. The large Russian city Vladivostok is situated on the peninsula, therefore the vegetation is prone to anthropogenic damage.

In 2003-2005 13 sites were established in the suburbs of Vladivostok (Fig. 1). These sites included different habitat types of primary forests, oak forests, mixed deciduous forests, shores of small rivers and grasslands, among which one grassland was situated in a village (so called “dacha region”), and one mixed deciduous forest was situated in a city park (Table 1).

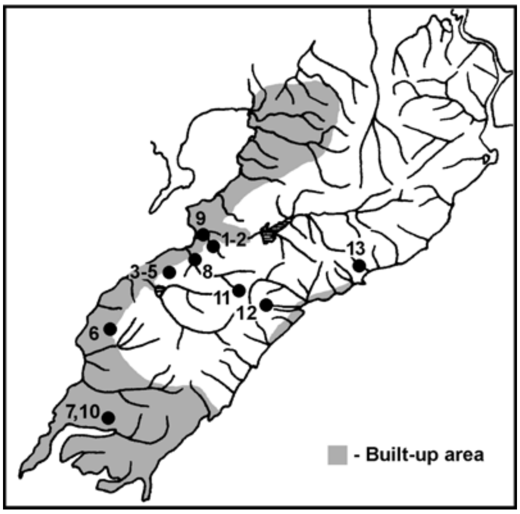

Fig. 1. The location of the study area and sampling sites on the Muravjev-Amursky peninsula. For more details see Table 1.

Table 1. Characteristics of the study localities

Locality	Year	Biotop	Ground
1	2003	Wet grassland	Clay, dense grass
1a	2004		
2	2003	Deciduous forest edge	Loam with gravel, tree waste
2a	2004		
3	2003	Deciduous forest after fire forcing on the top of hill	Humus soil with small stones, tree waste
3a	2004		
4	2003	Mixed coniferous-deciduous forest on the slope of hill	Humus soil, tree waste, no grass
4a	2004		
5	2003	Mixed coniferous-deciduous forest on the slope of hill	Humus soil, tree waste, no grass
5a	2004		
6	2003	Oak mixed deciduous forest	Thin layer of humus with small stones, loam, tree waste
6a	2004		
7	2003	City park with deciduous trees	Humus soil, litter, dense grass
7a	2004		
8	2004	Shore of small river in mixed coniferous-deciduous forest	Gravelly and stony
8a	2005		
9	2004	Manufactured grassland in the village with horticultural crops	Thick layer of humus
9a	2005		
10	2004	City park with deciduous trees	Dry and very dense ground without humus
11	2005	Glade in mixed deciduous forest with power line	Humus soil, litter, grass and shrubs
12	2005	Mixed deciduous forest on the bottom of valley	Humus soil, tree waste
13	2005	Shore of small river in mixed deciduous forest	Gravelly and stony

The pitfall-traps were used as a sampling method. Plastic jars (diameter 65 mm, volume 200 ml, depth 9.5 cm) were partially filled with water and detergent, and fifteen traps (1.5-2 m apart) were placed in row on each sampling site. Sampling period on every site was 24 hours. The sampling was carried out monthly from May up October on the same day for all study sites. All the collected beetles have been determinated by G. Sh. Lafer and deposited in the Institute of Biology and Soil Science, Far East Branch of the Russian Academy of Sciences (Vladivostok).

The obtained data was analysed by using the Margalef 's (1), Shannon's (2), and evenness (3) indices of biological diversity, and a principal coordinate analysis based on the Jaccard's coefficient for similarity estimations (4) was used to differentiate ground beetle assemblages (Legendre & Legendre, 1983):

$D_{Mg} = (S–1) / \ln N$ **(1),**

$H' = -\sum P_i \ln P_i$ **(2)**,

$\mathrm{Var}(H') = (\sum P_i \ln^2 P_i - (H')^2) / N + (S-1) / 2N^2$,

$J' = H' / \ln S$ **(3)**,

$\mathrm{Var}(J') = \mathrm{Var}(H') / \ln^2 S$,

$D_J = a / (a+b+c)$ **(4)**

where S is number of species in sample, N – number of specimens in sample, P_i – the proportion of species i in sample, a – the number of species common to both samples and b and c are the number of species occurring on each of the site, D_{Mg} – index of species diversity by Margalef, H' – Shannon's index, J' – evenness index, *Var* – variance of estimation, D_J – Jaccard's coefficient.

RESULTS

A total of 2074 specimens were caught in the different localities (Tables 2, 3). A hundred species of carabid beetles were collected in the all sites during 2003-2005, comprising about 50 % of the species diversity of Muravjev-Amursky peninsula. The number of species on studied sites varied from 4 to 31 in different years. The species diversity was most significant for samplings of wet grassland (31 species), edge of deciduous forest (30 species) and manufactored grassland (31 species), thus, the Margalef's index of species diversity for these sites is very high too (Table 3).

Five dominat species, those that comprise 42% of the total individuals in the whole sampling, were the following: *Bembidion poppii captivorum*, *Agonum mandli*, *Carabus billbergi*, *Pterostichus vladivostokensis*, *Nebria coreica*. First species, *B. poppii captivorum*, was dominant only in the river shores (45-70%), *A. mandli* on the decidous forest edge (37-45%), *C. billbergi* in the oak forest (48-62%), *P. vladivostokensis* in the mixed deciduous forest (41-54%) and *N. coreica* in the wet grassland (40%). Remainder species had low abundances in all localities (Fig. 2).

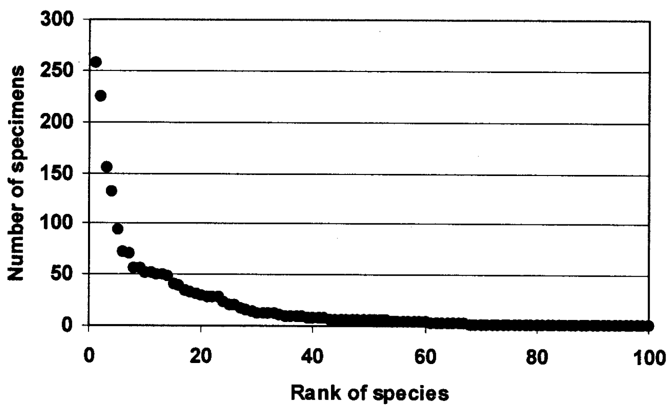

Fig. 2. Ranked species-abundance curve for total sample of ground beetles.

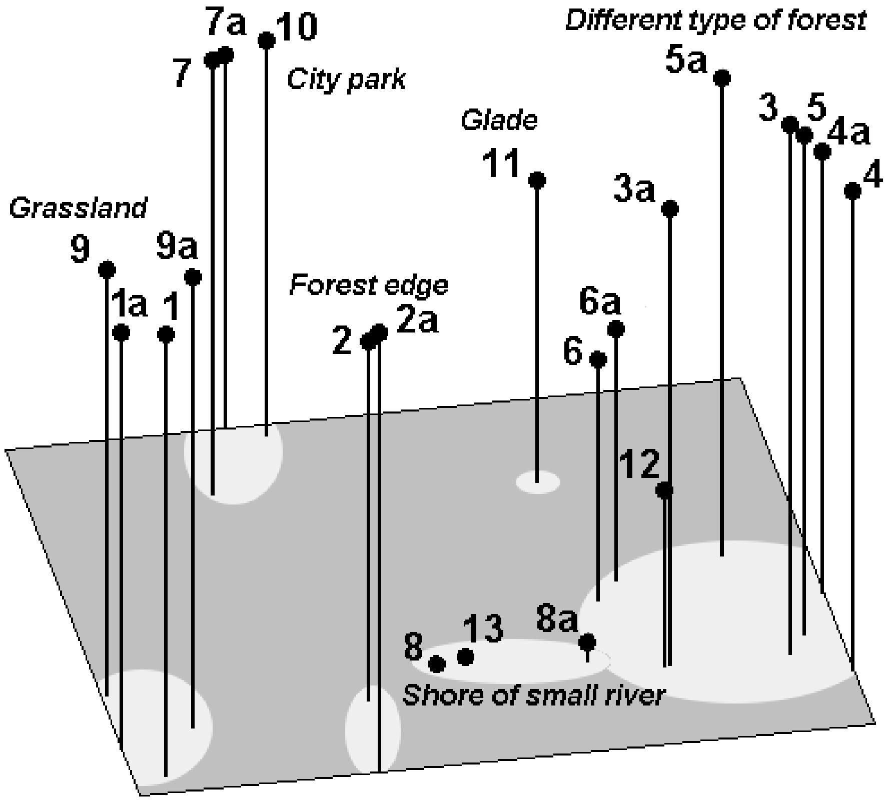

Fig. 3. The sampling localities plotted on the 1st, 2nd and 3rd axis of the principal co-ordinate analysis according to their species composition.

The major environmental factors appearing to determine the distribution of ground beetle assemblages are the substratum type, disturbance and soil moisture, all of which are also important determinants of the distribution of plant communities (Thiele, 1977).

The points of each samples (localities) are plotted against the three PCA axes in Fig. 3. The localities from similar habitats tend to form six clusters. Axis 1 tended to have the different type forests with the lowest scores, and the “grassland” localities with highest: number of species would seem to be important to this axis (a positive correlation between number of species and localities scores: $r=0.76$, $p<0.00001$). Axis 2 was possible related to degree anthropogenic pressure, with the city park localities at the most lower points on this axis. Axis 3 distinguished river shore samples in particular and may be related to substrat characteristics: most other localities were not gravelly or stony. These points lie towards the lower end of this axis.

Table 2. Number of carabid beetles sampled in sampling localities on the Murajev-

Species	Sampling						
	1	1a	2	2a	3	3a	4
Notiophilus impressifrons	0	0	0	0	0	1	0
Leistus niger	0	0	0	1	0	0	2
Nebria subdilatata	0	0	0	0	0	0	0
Nebria coreica	44	9	27	10	0	0	0
Nebria ochotica	0	0	0	0	0	0	0
Carabus schrencki	0	0	0	0	0	0	1
Carabus canaliculatus careniger	0	0	0	0	0	0	0
Carabus granulatus ussuriensis	2	10	1	1	0	0	0
Carabus smaragdinus	0	0	0	0	0	1	0
Carabus arvensis	0	0	0	0	0	0	0
Carabus venustus	0	0	0	0	12	0	19
Carabus vietinghoffi	0	0	0	0	0	0	0
Carabus hummeli	0	0	0	0	0	0	0
Carabus billbergi	0	0	4	6	0	0	0
Diplous depressus	0	0	0	0	0	0	0
Patrobus septentrionis	4	1	0	0	0	0	0
Asaphidion semilucidum	0	1	0	0	0	0	0
Asaphidion ussuriense	0	0	1	1	0	3	0
Bembidion mandli	0	0	0	0	0	0	0
Bembidion (*Diplocampa*) sp.	0	3	0	0	0	0	0
Bembidion elevatum lamprosimile	0	0	0	1	0	4	1
Bembidion semipunctatum	0	0	0	0	0	0	0
Bembidion grapei	0	0	0	0	0	0	0
Bembidion poppii captivorum	0	0	0	0	0	0	0
Bembidion serorum	2	0	0	0	0	0	0
Bembidion tetraporum	0	0	0	0	0	0	0
Bembidion gebleri persuasum	0	0	0	0	0	0	0
Bembidion infuscatipenne	0	0	0	0	0	0	0
Epaphius arsenjevi	1	0	0	0	0	0	0
Epaphius dorsistriatus	1	27	5	0	0	0	0
Trechus apicalis	0	0	0	0	0	0	0
Trechus sp. (? *sikhotealinensis* Ueno et Lafer)	0	0	0	1	0	0	0
Blemus discus	2	15	14	4	0	0	0
Poecilus encopoleus	0	0	0	0	0	0	0
Poecilus reflexicollis	0	1	1	0	0	1	0
Pterostichus sulcitarsis	0	1	0	0	0	0	0
Pterostichus aberrans	0	21	0	2	0	0	0
Pterostichus neglectus	0	0	0	0	0	1	0
Pterostichus subovatus	0	0	0	0	0	0	0
Pterostichus prolongatus	5	17	2	1	0	0	0
Pterostichus sutschanensis	0	0	0	2	0	0	16
Pterostichus vladivostokensis	0	0	7	10	5	1	42
Pterostichus microps	0	0	0	0	0	0	0
Pterostichus nigrita	4	3	2	2	0	0	0
Pterostichus rotundangulus	3	25	1	6	0	0	0
Pterostichus interruptus	0	0	0	0	0	0	2
Pterostichus eobius	0	0	0	0	0	0	1
Pterostichus jankowskii	0	0	0	4	0	0	0
Pterostichus longinquus	0	1	0	0	0	0	0
Pterostichus eschscholtzi fortis	0	0	0	0	0	0	0

Amursky peninsula (order of species are given after Lafer, 2005)

locality														
4a	5	5a	6	6a	7	7a	8	8a	9	9a	10	11	12	13
0	1	0	0	6	0	0	0	0	0	0	0	0	0	0
1	3	0	0	0	0	0	0	1	0	0	0	0	1	0
0	0	0	0	0	0	0	14	7	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	3	0	0	0	0
0	0	0	0	0	0	0	45	11	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	2	1	4	0	0	7	0	2	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	8	1	0	0	0	0	0	0	0	0	0	0
4	12	1	0	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0	4	0	0	0	0	0	2	0	0	0	0	0	0	0
1	0	0	42	43	21	5	0	0	0	0	1	2	7	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	1	12	3	0	0	0	0	4	1	0	0
0	0	0	5	15	0	0	1	0	0	0	0	0	2	0
0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	1	0	0	1	0	0	0	0	0	0	4
0	0	0	0	0	0	0	98	67	0	0	0	0	0	93
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	5	2	0	0	0	0	0	0
0	0	0	0	0	0	0	1	7	0	0	0	0	0	1
0	0	0	0	0	0	0	8	6	0	0	0	0	0	14
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	15	4	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	2	1	0	0	0	0
0	0	0	0	0	0	0	0	0	6	1	0	0	0	0
0	0	0	0	0	0	2	0	1	2	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	3	0	1	0	0	1	1	0	0	0	1
0	0	0	0	0	2	0	0	0	22	3	0	0	0	0
9	14	9	0	0	0	0	0	0	0	0	0	0	0	0
16	32	22	7	5	0	0	1	3	0	0	0	0	4	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	1	0	0	0	1	0
1	0	0	1	1	0	0	0	2	0	0	0	1	1	1
0	0	1	0	0	0	0	1	1	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	2	1	0	0	0	1

Table 2 (continued)

Species	Sampling						
	1	1a	2	2a	3	3a	4
Pterostichus niger	0	0	0	0	0	0	0
Pterostichus microcephalus	0	0	0	0	0	0	0
Pterostichus aereipennis	0	0	3	3	4	5	15
Pterostichus alacer	0	0	0	2	0	0	0
Pterostichus orientalis	0	3	26	32	0	0	0
Agonum gracilipes	0	0	0	0	0	0	0
Agonum jankowskii	0	0	0	2	0	0	0
Agonum mandli	15	12	84	95	0	0	0
Agonum sculptipes	6	2	0	3	0	0	0
Agonum bellicum	0	1	0	21	0	0	0
Agonum gracile	0	0	7	0	0	0	0
Agonum fallax	0	1	1	4	0	0	0
Agonum assimile	0	1	0	25	0	0	0
Calathus halensis	1	6	1	0	0	0	0
Synuchus melantho	0	0	0	0	0	0	0
Synuchus intermedius	0	0	0	0	1	0	0
Synuchus orbicollis	1	3	0	0	0	0	0
Synuchus agonus	0	0	0	0	0	0	0
Synuchus chinensis	0	0	0	0	0	0	0
Synuchus congruus	0	0	0	0	0	0	0
Synuchus nivalis	0	0	0	0	0	0	0
Amara communis	0	1	0	1	0	0	0
Amara familiaris	0	0	0	0	0	0	0
Amara lunicollis	0	0	0	0	0	0	0
Amara magnicollis	0	0	0	0	0	0	0
Amara nitida orienticola	0	0	0	1	0	3	0
Amara ovata	0	0	0	0	0	1	0
Amara similata	0	0	0	0	0	0	0
Amara ussuriensis	0	0	0	0	0	0	0
Amara amplipennis	0	5	0	0	0	0	0
Amara aurichalcea	1	0	0	0	0	0	0
Amara mikae	1	1	0	0	0	0	0
Amara pseudosimplicidens	1	0	1	1	0	0	0
Amara plebeja	0	0	0	0	0	0	0
Curtonotus gonioderus	0	0	0	0	0	0	0
Anisodactylus signatus	0	0	0	0	0	0	0
Harpalus latus ussuricus	0	0	0	1	0	0	0
Pseudoophonus capito	1	2	0	0	0	0	0
Pseudoophonus eous	0	0	0	0	0	0	0
Pseudoophonus jureceki	0	0	0	0	0	0	0
Pseudoophonus tridens	0	0	0	0	0	0	0
Pseudoophonus ussuriensis	15	28	0	7	0	0	0
Trichotichnus coruscus	1	1	0	3	0	0	0
Trichotichnus nishioi	0	0	0	0	0	0	0
Bradycellus glabratus	0	0	1	0	0	1	1
Bradycellus curtulus	0	0	0	0	0	0	0
Lioholus jedlickai	0	1	0	0	0	0	0
Chlaenius pallipes	1	2	0	0	0	0	0
Lachnocrepis prolixus	0	1	0	0	0	0	0
Oodes integer	0	0	0	0	0	0	0

locality														
4a	5	5a	6	6a	7	7a	8	8a	9	9a	10	11	12	13
1	3	3	0	6	0	0	0	2	0	0	0	0	5	0
0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	0	1	4	0	0	1	0	0	0	0	0	1	0
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	13	2	0	0	0	0	1	2
0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0	0	1	0	1	0	6	9	2	2	1	0	12	1	0
0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
0	0	0	0	0	2	0	0	0	4	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	1	0	2	0	2	0	0	4	2	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	2	2	0	5	0	2	0	0	0
0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
0	0	0	0	0	1	20	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1	0	1	0	0	7	12	1	0	2	0	4	8	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	2	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	2	0	1	1	2	1	1	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	3	0	0	0	1
0	0	0	0	0	1	0	0	0	2	0	0	0	0	0
0	0	0	0	0	3	14	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	2	1	0	0	0	0
0	0	0	0	0	5	8	5	0	2	0	0	0	0	5
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	2	0	0	0	0
0	0	0	0	0	6	3	0	0	5	7	2	0	0	0
0	0	0	0	0	0	0	0	0	5	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

Table 3. Characteristics of the samples from different localities on the Muravjev-Amursky peninsula

Locality	P*	S	N	D_{Mg}	H'	Var (H')	J'	Var (J')
1	60	21	112	4.239	2.173	0.015	0.714	0.002
1a	75	**31**	206	**5.631**	2.783	0.005	0.810	0.0004
2	60	19	189	3.434	1.910	0.009	0.649	0.001
2a	75	**30**	253	**5.241**	2.361	0.008	0.694	0.001
3	60	4	22	0.971	1.118	0.022	0.806	0.011
3a	75	11	22	3.235	2.174	0.030	0.906	0.005
4	60	10	100	1.954	1.598	0.009	0.694	0.002
4a	75	9	39	2.457	1.671	0.024	0.760	0.005
5	60	10	75	2.085	1.724	0.013	0.749	0.003
5a	75	10	41	2.424	1.492	0.035	0.648	0.007
6	60	9	68	1.896	1.327	0.021	0.604	0.004
6a	75	14	90	2.889	1.809	0.017	0.686	0.002
7	60	18	74	3.950	2.371	0.015	0.820	0.002
7a	60	15	84	3.160	2.307	0.009	0.852	0.001
8	75	23	221	4.075	1.954	0.009	0.623	0.001
8a	45	17	118	3.354	1.739	0.018	0.614	0.002
9	75	**31**	109	**6.395**	**2.955**	0.011	0.860	0.001
9a	45	17	34	4.537	2.590	0.022	0.914	0.003
10	60	9	18	2.768	2.043	0.029	**0.930**	0.006
11	45	11	33	2.860	1.879	0.033	0.784	0.006
12	45	15	33	4.004	2.420	0.023	0.894	0.003
13	45	17	133	3.272	1.295	0.018	0.457	0.002
Total	1365	100	2074	12.963	3.563	0.001	0.770	0.00004

* - number of pitfull traps per day.

Six assemblages were identified due to analysis of the ground beetles species composition of 13 sites on the Muravjev-Amursky peninsula, as follows: 1) different type of forest, 2) shore of small river usually shaded by trees, 3) forest edge, 4) glade, 5) city park, 6) wet and manufactured grassland (Fig. 3). The ecological differentiation of carabid beetles assemblages becomes apparent in the number of species and species composition. Carabid assemblage structure did not tend to change significantly between years. The species diversity of assemblages does not always decrease under anthropogenic press. For example, the number of species in the different types of forest is 2-3 times less than in the city park or manufactured grassland. Moreover, the most diversed carabid fauna is found in the forest edge and wet grasslands (Table 3). Originality of the river shore assemblage is defined by the riparian *Bembidion* species.

The species collected in this study provides a rich database for more detailed research on the ecology and life history of individual species. Moreover, this data can be used to distinguish and classify major habitat groups, however more extensive collecting is needed to produce a detailed interpretable classification within major habitats.

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