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The Assemblages and Seasonal Activity of the Above-ground Beetles (Coleoptera: Carabidae, Cicindelidae, Silphidae) in the Sikhote-Alin Mountains, Russian Far East

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극동러시아 시코테 알린산의 지표성 딱정벌레 군집 및 계절상

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ABSTRACT

The spatial distribution of the ground-beetles is studied in the Sokolovka River valley (Primorskii krai, Russia). Four complexes of the ground-beetles assemblages are recognizable: the meadows, the shores of river, the coniferous forests (native and after cutting), and the deciduous and coniferous-deciduous forest after fire and cutting. Seasonal activity of four species of family Carabidae (*Carabus venustus*, *C. hummeli*, *Pterostichus alacer*, *P. sutschanensis*) is discussed in detail. Species riches of above-ground beetles in pooled samples gently rise from spring to early summer with peak in June, and slowly decrease from July to September. The abundance of individuals in pooled samples rises from early May to June with peak in July; in August activity of beetles slumped (at about 10 times comparing with July); in September the abundance is extremely low.

Key words : Carabidae, Cicindelidae, Silphidae, seasonal activity

INTRODUCTION

The above-ground beetles (Coleoptera: Carabidae, Cicindelidae, Silphidae) are widely used as indicators of the changes in vegetation, soil properties and climate (Greenslade, 1973; Šustek, 1981; Niemelä *et al.*, 1988; Loereau, 1992; Lövei and Sunderland, 1996; Lucky *et al.*, 2002; Purtauf *et al.*, 2003; Grandchamp *et al.*, 2005; Latty *et al.*, 2006; Botes *et al.*, 2007; Magura and Ködöböcz, 2007; ElSayed and Nakamura, 2010). The species richness and preference to different habitats of ground-beetles in the Southern and Middle Sikhote-Alin Mountains were investigated recently (Kholin *et al.*, 2005; Shabalin, 2008a, b; Shabalin *et al.*, 2009a, b). The spatial distribution and seasonal activity of the above-ground beetles in the Sokolovka River valley (Primorskii krai, Russia) are discussed in present paper.

MATERIALS AND METHODS

Eight sample plots were established in the valley of Sokolovka River (right tributary of Ussuri River, Primorskii krai, Russian Far East). The different habitat types of the primary forests, forests after fire and logging, the shore of river, and grassland were studied (Table 1).

At each sampling site, 15 unbaited pitfall traps were installed as trapping tools and spaced about 1.5-2 m apart along a transect running each survey plot. The total number of traps in all sampling habitats was 120. Traps were installed in the soil to cover the period from early May till late September for two consecutive years (2007 and 2008). The sampling was carried out monthly in the same period for all study sites to eliminate the weather influence.

The traps consisted of transparent polyethylene beakers (Ø6 cm, capacity 200 mL). These beakers were primed on third with water and a few drops of ordinary detergent to reduce surface tension. The disturbance caused by placing the pitfall

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Table 1. Characteristic of the studied plots in the Sokolovka River valley (Primorskii krai, Russia)

N	Type of sample plot	Exposition	Vegetation
1	Native pine forest (=*Pinetum koraensis schisandroso-coryloso-nanoherboso-caricosum*)*	Slope WSW (27-32°), altitude 660 m	**Trees**: *Pinus koraensis* Siebold et Zucc., *Tilia taquetii* Rupr., *Picea ajanensis* (Lindl. et Gord.) Fisch. Ex Carr., *Betula platyphylla* Sukacz., *Abies nephrolepis* (Trautv.) Maxim., *Acer mono* Maxim., *Betula costata* Trautv., *Sorbus pochuashanensis* (Hance) Held., *Acer tegmentosum* Maxim., *Acer ukurunduense* Trautv. et Mey, *Cerasus maximowiczii* (Rupr.) Kom. **Bushes**: *Corylus mandshurica* Maxim. et Rupr., *Philadelphus tenuifolius* Rupr. ex Maxim., *Acer barbinerve* Maxim., *Eleutherococcus senticosus* (Rupr. et Maxim.) Maxim., *Eunomus pauciflora* Maxim., *Eunomus sacrosancta* Koidz., *Lonicera chrysantha* Turcz. ex Ledeb., *Rosa acicularis* Lindl., *Berberis amurensis* Rupr., *Ribes mandshuricum* (Maxim.) Kom., *Ribes maximoviczianum* Kom., *Schisandra chinensis* (Turcz.) Baill, *Actinidia kolomikta* (Maxim.) Maxim., *Vitis amurensis* Rupr.
2	Birch forest after fire in 1973 (=*Lespedezio bicoloris-Pinetum koraensis moehringietosum lateriflorae*)*	Slope SW, altitude 570 m	**Trees**: *Betula platyphylla* Sukacz., *Populus tremula* L., *Quercus mongolica* Fisch. ex Ledeb., *Acer mono* Maxim., *Salix caprea* L., *Salix taraikensis* Kimura, *Padus maackii* (Rup.) Kom., *Tilia taquetii* Rupr., *Sorbus pochuashanensis* (Hance) Held., *Abies nephrolepis* (Trautv.) Maxim., *Fraxinus mandshurica* Rupr., *Pinus koraensis* Siebold et Zucc., *Picea ajanensis* (Lindl. et Gord.) Fisch. Ex Carr. **Bushes**: *Eunomus pauciflora* Maxim., *Eunomus macroptera* Rupr., *Philadelphus tenuifolius* Rupr. ex Maxim., *Corylus mandshurica* Maxim. et Rupr., *Acer barbinerve* Maxim., *Eleutherococcus senticosus* (Rupr. et Maxim.) Maxim., *Sorbaria sorbifolia* (L.) A.Br., *Lonicera maximowiczii* (Rupr.) Regel, *Lonicera chrysantha* Turcz. ex Ledeb., *Rosa acicularis* Lindl., *Sambucus racemoca* L., *Berberis amurensis* Rupr., *Actinidia kolomikta* (Maxim.) Maxim., *Schisandra chinensis* (Turcz.) Baill
3	Pine-oak forest after fire in 1982 (=*Querceto-Pinetum Lespedezioso-rhododenroso-nanocaricosum*)*	Slope SW (15-25°), altitude 500-550 m	**Trees**: *Quercus mongolica* Fisch. ex Ledeb., *Pinus koraensis* Siebold et Zucc., *Tilia taquetii* Rupr., *Picea ajanensis* (Lindl. et Gord.) Fisch. Ex Carr., *Betula platyphylla* Sukacz., *Populus tremula* L., *Abies nephrolepis* (Trautv.) Maxim., *Acer mono* Maxim., *Cerasus maximowiczii* (Rupr.) Kom., *Fraxinus mandshurica* Rupr., *Populus koreana* Rehder, *Acer tegmentosum* Maxim., *Juglans mandshurica* Maxim., *Salix taraikensis* Kimura. **Bushes**: *Rhododendron mucronulatum* Turcz., *Corylus mandshurica* Maxim. et Rupr., *Schisandra chinensis* (Turcz.) Baill.
4	Fir forest after cutting in 1976 (=*Acereto tegmentosi-Piceeto-pinetum actinidioso-fruticoso-nemoriherboso-caricoso-filicosum*)*	Slope SW (10°), altitude 600 m	**Trees**: *Picea ajanensis* (Lindl. et Gord.) Fisch. Ex Carr., *Betula costata* Trautv., *Pinus koraensis* Siebold et Zucc., *Abies nephrolepis* (Trautv.) Maxim., *Tilia taquetii* Rupr., *Acer mono* Maxim., *Acer tegmentosum* Maxim., *Cerasus maximowiczii* (Rupr.) Kom., *Sorbus pochuashanensis* (Hance) Held. **Bushes**: *Corylus mandshurica* Maxim. et Rupr., *Philadelphus tenuifolius* Rupr. ex Maxim., *Acer barbinerve* Maxim., *Actinidia kolomikta* (Maxim.) Maxim., *Schisandra chinensis* (Turcz.) Baill, *Eunomus macroptera* Rupr., *Eunomus pauciflora* Maxim., *Lonicera chrysantha* Turcz. ex Ledeb., *Eleutherococcus senticosus* (Rupr. et Maxim.) Maxim.
5	Climax fir forest. (=*Acereto tegmentosi-Piceeto-pinetumnemoriherboso-caricoso-filicosum*)*	Slope W (15°), altitude 690 m	**Trees**: *Picea ajanensis* (Lindl. et Gord.) Fisch. Ex Carr., *Pinus koraensis* Siebold et Zucc., *Populus koreana* Rehder, *Tilia taquetii* Rupr., *Acer mono* Maxim., *Acer tegmentosum* Maxim. **Bushes**: *Corylus mandshurica* Maxim. et Rupr.
6	Coniferous-deciduous forest after cutting in winter 2007-2008	Slope W (10°), altitude 680 m	**Trees**: *Populus koreana* Rehder, *Betula costata* Trautv., *Tilia taquetii* Rupr., *Picea ajanensis* (Lindl. et Gord.) Fisch. Ex Carr., *Acer ukurunduense* Trautv. et Mey, *Acer tegmentosum* Maxim., *Abies nephrolepis* (Trautv.) Maxim. **Bushes**: *Acer barbinerve* Maxim., *Corylus mandshurica* Maxim. et Rupr., *Eleutherococcus senticosus* (Rupr. et Maxim.) Maxim., *Philadelphus tenuifolius* Rupr. ex Maxim., *Ribes mandshuricum* (Maxim.), *Sambucus racemoca* L., *Actinidia kolomikta* (Maxim.) Maxim., *Schisandra chinensis* (Turcz.) Baill.

Table 1. Continued

N	Type of sample plot	Exposition	Vegetation
7	Riverside	Plane, altitude 600 m	**Trees**: *Populus koreana* Rehder, *Pinus koraensis* Siebold et Zucc., *Fraxinus mandshurica* Rupr., *Ulmus laciniata* (Trautv.) Mayr, *Salix caprea* L., *Acer mono* Maxim. **Bushes**: *Philadelphus tenuifolius* Rupr. ex Maxim., *Eleutherococcus senticosus* (Rupr. et Maxim.) Maxim., *Acer barbinerve* Maxim., *Corylus mandshurica* Maxim. et Rupr., *Ribes mandshuricum* (Maxim.), *Sambucus racemoca* L., Kom., *Actinidia kolomikta* (Maxim.) Maxim., *Schisandra chinensis* (Turcz.) Baill.
8	Wormwood meadow	Plane, altitude 600 m	**Trees**: absent **Bushes**: *Sambucus racemoca* L., *Rubus comarovii* Nakai.

*The Latin names of the forest communities are given after Komarova (2003) and Komarova, Lovelius and Zhiltsov (2009).

traps was minimized and the vegetation around the traps was not cleared. The 'digging in' effect (Greenslade, 1973; Botes *et al.*, 2007) was thus considered negligible and the traps were set immediately. Traps were kept open for three consecutive days and then each trap was emptied from its content and the specimens caught were preserved in ethanol solution (70%) then brought back to the laboratory for identification, counting and sorting. To reduce the variability caused by sampling error, only one of the authors (S.A.S.) was responsible for making counts in this study.

The principal coordinate and cluster analysis based on the Jaccard's coefficient (Legendre and Legendre, 1983) was used to differentiate ground-beetle assemblages. The statistical tests were conducted using PAST, ver. 1.57 software running on Windows® XP (Hammer *et al.*, 2006).

The inclusion arrangements analysis was made according to Semkin and Kulikova (1981). It was calculated as follows:

$$K_{0(a;b)}=\frac{\mu(a\cap b)}{\mu(b)},$$

were $K_{0(a;b)}$ - measure of inclusions faunistic composition of sample plot b in a, $\mu(a\cap b)$ - number species common in sample plot a and b, $\mu(b)$ - number species in sample plot b.

RESULTS AND DISCUSSION

The ground-beetles assemblages

A total of 6,256 specimens of the families Carabidae (89 species), Cicindelidae (3 species), and Silphidae (11 species) were caught in the different localities in the Sokolovka River valley (Table 2). High variation in species richness among habitats was observed. The greatest number of above-ground beetle species was recorded in the Meadow and Riverside (51 and 49, respectively), while the lowest number was for the Native pine forest and forest cutting in winter 2007-2008 (20 species for each plot).

Fig. 1 shows the dendrogram formed by clustering of the sample plots according to the similarities of the above-ground beetles in 2007-2008 years. There is no obvious level of similarity where the sample plots separates into discrete clusters with each cluster representing a group of sites with the same above-beetles community. The separation has been made in an arbitrary manner guided by three requirements. Firstly, the minimum level of similarity must exceed 0.3. In this level three types of site (Riverside, Meadow, and different types of forest) was marked (Fig. 1). At the 0.4 level of similarity the fresh cutting forest (plot 6) is separated from other types of forest. At the next level of similarity (0.5) five types of site was observed: 1) Wormwood meadow (plot 8), 2) Riverside (plot 7), 3) Coniferous-deciduous forest after cutting in 2007-2008 (plot 6), 4) Birch forest and Pine-oak forest after fire (sample plots number 2 and 3), and 5) Coniferous climax, native and after cutting forests (plots number 1, 4, 5).

The method of principal coordinate analysis shows four complexes of ground-beetles assemblages (Fig. 2): I-Riverside, II-Meadow, III-Coniferous forests (climax, native and after cutting in 1976), and IV-fresh cutting forest, Birch and Pine-oak forests after fire.

The method of inclusion arrangements analysis shows (Fig. 3) that the Native pine forest (sample plot 1) is characterized by the banal and poor fauna. Beside undestroyed forests the most diverse assemblage of ground beetles is found in Fir forest after cutting in 1976 (sample plot 4). The beetle assemblage of the Climax fir forest (sample plot 5) takes the intermediate position between above mentioned ones, and consists of 27 species. Beside the forests after fire and logging the most diverse beetles assemblage is found in Birch forest (sample

Table 2. Above-ground beetles captured in eight sample plots by pitfall traps in the South Sikhote-Alin Mountains in 2007-2008

Species	Sample plots							
	1	2	3	4	5	6	7	8
Family Cicendelidae								
Cicindela sachalinensis A. Morawitz, 1862	–	–	–	–	–	–	+	+
Cicindela gracilis Pallas, 1775	–	–	–	–	–	–	–	+
Cicindela elisae Motschulsky, 1859	–	–	–	–	–	–	–	+
Family Carabidae								
Leistus niger Gebler, 1847	+	–	–	+	+	+	–	+
Nebria banksi Crotch, 1870	–	–	–	–	–	–	+	–
Notiophilus impressifrons A. Morawitz, 1862	+	–	+	+	–	–	–	–
Calosoma cyanescens Motschulsky, 1859	–	–	–	+	–	–	–	–
Carabus billbergi Mannerheim, 1827	+	+	+	+	+	+	–	+
Carabus schrenckii Motschulsky, 1860	–	+	+	–	–	+	+	+
Carabus venustus A. Morawitz, 1862	+	+	+	+	+	+	+	+
Carabus hummeli Fischer von Waldheim, 1823	+	+	+	+	+	+	+	+
Carabus gossarei Haury, 1879	–	+	+	+	+	+	–	+
Carabus canaliculatus Adams, 1812	–	+	+	+	+	+	–	+
Carabus vietinghoffi Adams, 1812	+	+	+	+	+	+	–	+
Carabus granulatus Linnaeus, 1758	–	–	–	–	–	–	+	–
Cychrus koltzei Roeschke, 1907	–	–	–	–	+	–	–	–
Elaphrus sibiricus (Motschulsky, 1844)	–	–	–	–	–	–	+	–
Epaphius densicornis Fischhuber, 1977	–	–	–	+	+	–	–	–
Asaphidion ussuriense Jedlička, 1965	–	–	–	–	–	–	+	–
Bembidion mandli Netolitzky, 1932	–	–	–	–	–	–	–	+
Bembidion difforme (Motschulsky, 1844)	–	–	–	–	–	–	+	–
Bembidion captivorum Netolitzky, 1943	–	–	–	–	–	–	+	–
Bembidion grapei Gyllenhal, 1827	–	–	–	–	–	+	–	–
Bembidion gebleri (Gebler, 1833)	–	–	–	–	–	–	+	–
Bembidion quadrimaculatum (Linnaeus, 1761)	–	–	–	–	–	–	–	+
Bembidion infuscatipenne Netolitzky, 1938	–	–	–	–	–	–	+	–
Bembidion gilvipes Sturm, 1825	–	–	–	–	–	–	+	–
Diplous depressus (Gebler, 1829)	–	–	–	–	–	–	+	–
Poecilus reflexicollis (Gebler, 1830)	–	–	–	–	+	–	–	+
Poecilus encopoleus Solsky, 1873	–	–	–	–	–	–	–	+
Poecilus fortipes Chaudoir, 1850	–	–	–	–	–	–	–	+
Pterostichus jankowskyi (Tschitschérine, 1897)	–	–	–	–	+	–	+	+
Pterostichus adstrictus Eschscholtz, 1823	+	+	–	+	+	+	+	+
Pterostichus alacer Morawitz, 1868	+	+	+	+	+	+	+	+
Pterostichus eobius (Tschitcherine, 1899)	+	–	–	+	+	–	+	–
Pterostichus interruptus Dejan, 1828	–	–	–	+	+	–	+	+
Pterostichus kurosawai Tanaka, 1958	–	+	–	–	–	–	+	–
Pterostichus labzuki Lafer, 1980	+	+	+	+	+	–	+	+
Pterostichus microcephalus Motschulsky, 1860	–	–	–	–	–	–	+	+
Pterostichus microps Heyden, 1887	–	–	–	+	–	+	–	–
Pterostichus morawitzianus (Lutchnik, 1922)	–	+	–	–	+	–	+	–
Pterostichus nigrita (Paykull, 1790)	–	–	–	–	–	–	+	–
Pterostichus solskyi (Chaudoir, 1878)	–	–	–	–	–	–	+	–
Pterostichus sotkaensis Jedlička, 1958	–	–	–	+	–	–	+	–
Pterostichus subovatum Motschulsky, 1862	–	+	–	–	–	–	–	–
Pterostichus sulcitarsis A. Morawitz, 1863	–	+	–	+	–	+	–	+
Pterostichus sutschanensis Jedlička, 1962	+	+	+	+	+	+	+	+
Pterostichus sp. 1	+	+	–	+	+	+	+	+
Pterostichus sp. 2	–	–	+	–	–	–	–	–
Agonum jemelianovi Lafer, 1992	–	–	–	–	–	–	+	–
Agonum bellicum Lutshnik, 1934	–	–	–	+	–	–	+	–
Agonum dolens (C.R. Sahlberg, 1827)	–	–	–	–	–	–	+	–
Agonum impressum (Panzer, 1797)	–	–	–	–	–	–	+	+
Agonum jurecekianum Jedlicka, 1952	–	–	–	–	–	–	–	+

Table 2. Continued

Species	Sample plots							
	1	2	3	4	5	6	7	8
Agonum subtruncatum (Motschulsky, 1860)	−	−	−	−	−	−	+	−
Platynus assimilis (Paykull, 1790)	−	−	−	−	−	−	+	−
Platynus nazarovi (Lafer, 1976)	−	−	−	−	−	−	+	−
Pristosia proxima (A. Morawitz, 1862)	−	−	−	+	+	−	−	+
Synuchus nordmanni (A. Morawitz, 1862)	−	−	−	−	−	−	−	+
Synuchus agonus (Tschitscherine, 1895)	+	+	+	+	+	+	−	−
Synuchus intermedius Lindroth, 1956	−	−	−	−	+	−	−	−
Synuchus rjabuchini Lafer, 1989	−	+	+	+	+	−	−	−
Synuchus vivalis (Illiger, 1798)	−	−	+	−	−	−	−	+
Synuchus congruus (A. Morawitz, 1862)	−	−	−	−	−	−	+	+
Amara communis (Panzer, 1797)	−	−	−	−	−	−	+	+
Amara lunicollis Schiødte, 1837	−	+	−	−	−	−	−	+
Amara orienticola Lutshnik, 1935	−	−	−	−	−	−	+	+
Amara ussuriensis Lutshnik, 1935	−	−	−	−	−	−	−	+
Amara brunnea (Gyllenhal, 1810)	−	−	−	−	−	+	−	−
Amara sichotana Lafer, 1978	−	−	−	−	−	+	−	−
Amara ovata (Fabricius, 1792)	−	−	−	−	−	−	+	−
Anisodactylus signatus (Panzer, 1797)	−	−	−	−	−	−	−	+
Bradycellus glabratus (Reitter, 1894)	+	+	−	−	+	−	−	+
Bradycellus laevicollis Poppius, 1907	−	−	−	−	−	−	−	+
Lioholus jedlickai Lafer, 1989	−	−	−	−	−	−	−	+
Harpalus latus (Linnaeus, 1758)	−	+	−	−	−	−	−	−
Harpalus tschiliensis Schauberge, 1929	−	−	−	−	−	−	−	−
Harpalus laevipes Zetterstedt, 1838	−	+	+	+	−	−	+	+
Harpalus major Motschulsky, 1850	−	−	+	−	−	−	−	−
Harpalus affinis (Schrank, 1781)	−	−	−	−	−	−	−	+
Harpalus bungii Chaudoir, 1844	−	−	−	−	−	−	−	+
Trichotichnus coruscus Tschitscherine, 1895	−	−	−	+	−	+	+	+
Chlaenius pallipes Gebler, 1823	−	−	−	−	−	−	+	+
Chlaenius circumductus Motschulsky, 1862	−	−	−	−	−	−	−	+
Lachnocrepis prolixus Bates, 1873	−	−	−	−	−	−	+	−
Dromius quadraticollis Morawitz, 1862	−	−	−	+	−	−	−	−
Microlestes minitilus (Goeze, 1777)	−	−	−	−	−	−	−	+
Cymindis laferi Sundukov, 1999	−	+	+	−	−	−	−	−
Cymindis vaporariorum (Linnaeus, 1758)	−	+	−	−	−	−	−	−
Family Silphidae								
Silpha perphorata Gebler, 1832	+	+	+	+	+	+	+	+
Phosphuga atrata (Linnaeus, 1758)	+	−	−	+	−	−	+	−
Dendroxena sexcarinata Motschulsky, 1860	−	−	−	+	−	−	+	−
Oiceoptoma thoracicum (Linnaeus, 1758)	−	+	−	+	−	−	+	−
Nicrophorus basalis Faldermann, 1835	−	−	−	−	−	−	−	+
Nicrophorus maculifrons Kraatz, 1877	−	−	−	+	−	−	−	−
Nicrophorus investigator Zetterstedt, 1824	+	+	+	+	−	−	−	+
Nicrophorus quadripunctatus Kraatz, 1877	+	+	+	+	−	−	−	+
Nicrophorus tenuipes Lewis, 1887	+	+	+	+	+	−	−	−
Nicrophorus vespilloides Herbst, 1783	+	+	−	+	+	−	+	+
Aclypea daurica (Gebler, 1832)	−	−	−	−	−	−	+	−
Totally	20	30	22	36	27	20	49	51

Abbreviations: 《+》- species present, 《−》- species absent; 1-8-number of sample plot as a Table 1.

plot 2). On the contrary, the fauna of Pine-oak forest after fire in 1982 (sample plot 3) is poor and originated from the nearest forests (Fig. 2). The beetles assemblage of fresh cutting site (sample plot 6) is forming by 20 casual species penetrated in this habitat from both forests and open areas. Difference of Riverside (sample plot 7) and Wormwood meadow (sample

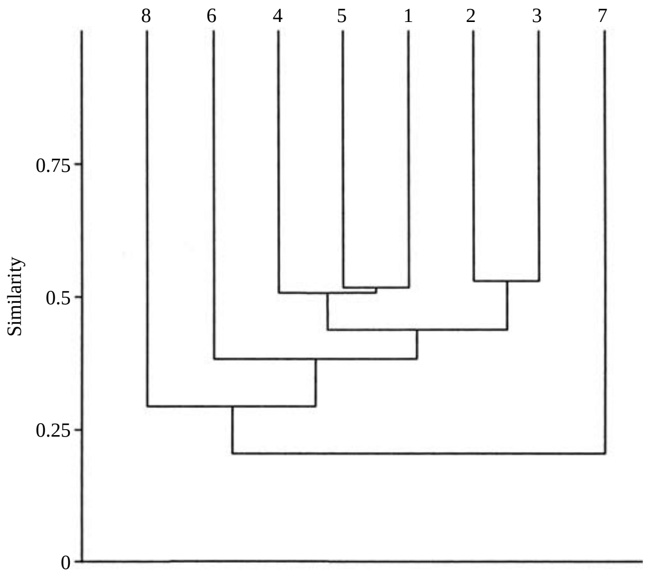

Fig. 1. The clustering of sample plots according to the similarities of their above-ground beetles faunas. Abbreviations of sample plots as in Table 1.

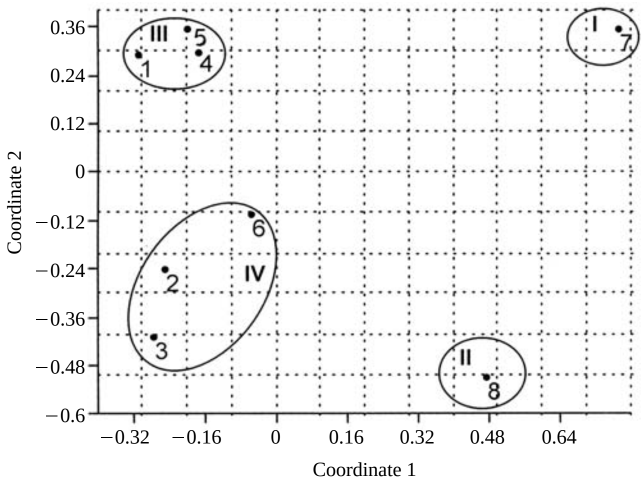

Fig. 2. Ordination of above-ground beetle assemblages of study sites in species space. Abbreviations of sample plots as in Table 1.

plot 8) depends on the presence of the species typical for these localities. For example, species of the genera *Amara*, *Harpalus*, and *Cicindela* are typical for grassland, while species of the genera *Agonum* and *Bembidion* are common for the shore of river.

Thus, four complexes of the ground-beetles assemblages are recognizable in the Sokolovka River valley: the meadows, the shores of river, the coniferous forests (native and after cutting), and the deciduous and coniferous-deciduous forest after fire and cutting. The species composition of beetles communities

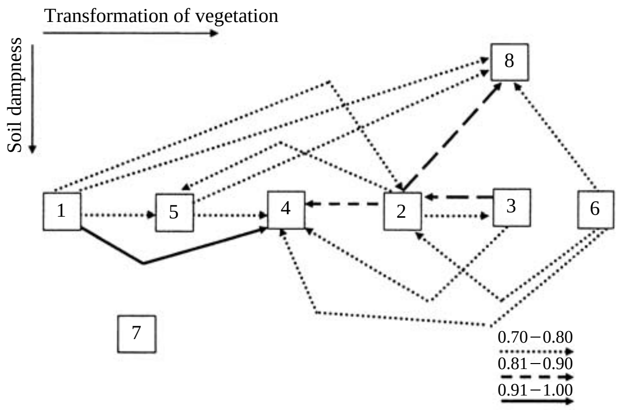

Fig. 3. The sampling localities plotted on the inclusion arrangements analysis according to their species composition ($\sigma >$ 0.70). Abbreviations of sample plots as in Table 1.

depend on the vegetation types, soil dampness, and level of insolation. The only suitable habitat for many species of above-ground beetles may be such specific micro-sites as snags, stumps, old trees. The most diverse assemblages are observed on the open sites (Wormwood meadow-51 species, and Riverside-49 species). In all probability the strong difference of the above-ground beetle communities of open habitats depends on soil dampness. The fauna of the undestroyed coniferous-deciduous forests is poor (Native Pine forest-20 species, Climax fir forest-27 species); the probable reason for the uniformity of the species composition of beetles is the low productivity of plants in native coniferous forest. The living condition is more variable in the Fir forest after cutting, which takes place about 35 years ago; therefore the beetles community is rich (36 species). Beside the forests after fire and cutting the most diverse beetles assemblage is found in Birch forest (30 species). In the Russian Far East the restoration of coniferous-deciduous forests after fire usually take place through the Birch or Aspen forest complexes. The beetle fauna of Birch forest is forming by the sources of neighboring open areas and coniferous-deciduous forests. On the contrary, the fauna of xerophyte Pine-oak forest originated from the nearest forests and consists of 22 species of beetles. The beetle community of fresh cutting site is forming by 20 casual species which penetrated from forest and open areas.

Seasonal activity of the model species in the Sikhote-Alin Mountains

Four species only (*Carabus venustus*, *C. hummeli*, *Pterostichus alacer*, and *P. sutschanensis*) has been collected in the majority of studied habitats. Namely these species are used

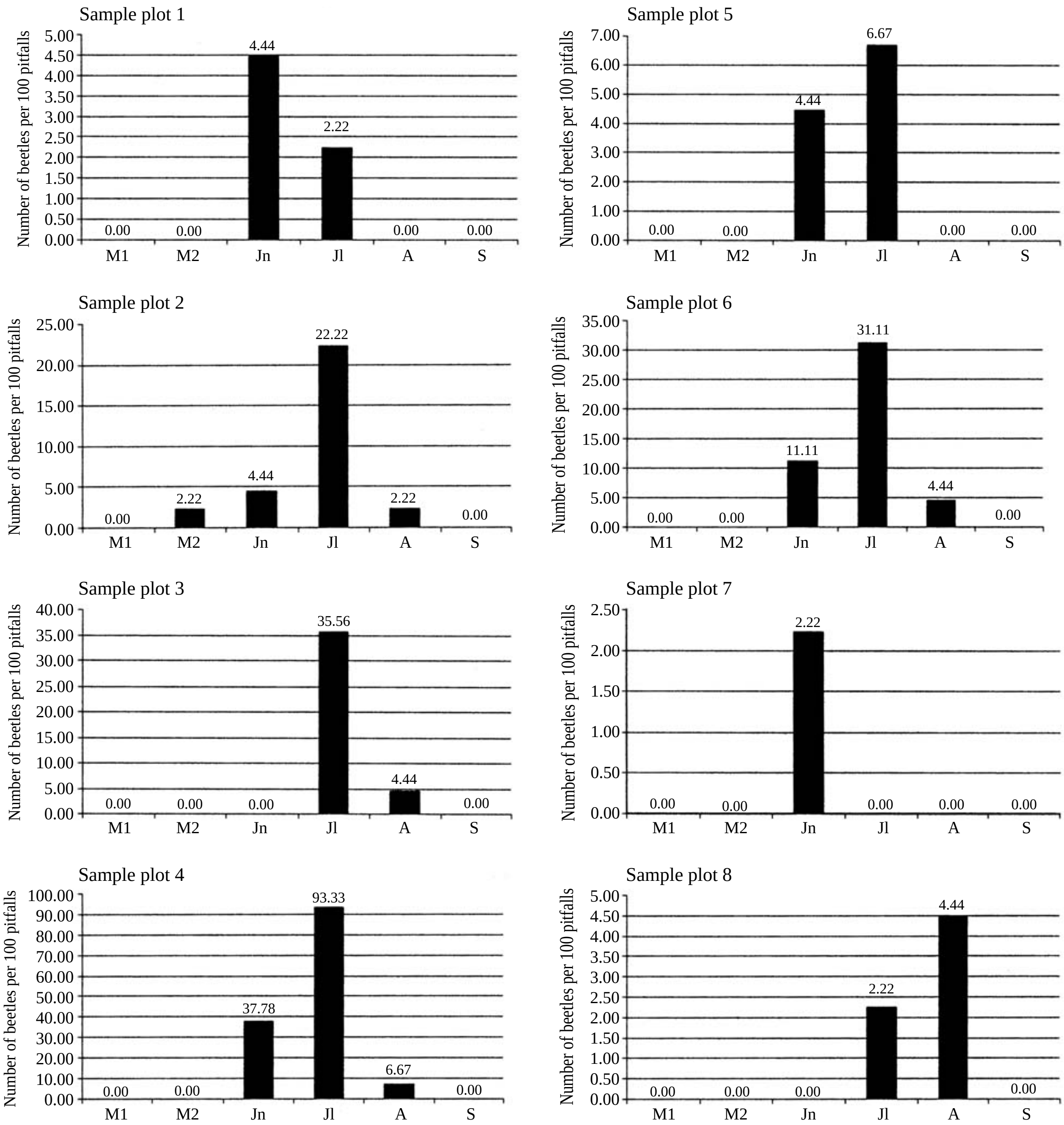

Fig. 4. Seasonal activity of *Carabus venustus* in studied habitats. Abbreviations of month: M1 - early May, M2 - late May, Jn - late June, Jl - late July, A - late August, S - late September; abbreviation of sample plots as in Table 1.

herein as model groups for study of the seasonal activity of carabid beetles in the Sikhote-Alin Mountains.

The imagines of *Carabus venustus* are active from the late May to August. The catching of this species in pitfall traps begins in late May in Birch forest (Fig. 4, sample plot 2). In June imagines of *C. venustus* are found in majority of studied habitats except Pine-oak forest and Meadow, but most abundant they are in the Fir forest after cutting (Fig. 4, plot 4). In July the peak of activity of this species is observed in the forest ecosystems (Fig. 4, plots 1-6), the beetles also find in Meadow, but absent in Riverside. In August the abundance of *C. venustus* decreases considerably in all studied habitats except meadows; in late September imagines completely disappear.

The imagines of *Carabus hummeli* was collected by pitfall traps from the late May to August. In the Native pine forest and Riverside this species was found in June only (Fig. 5, plots

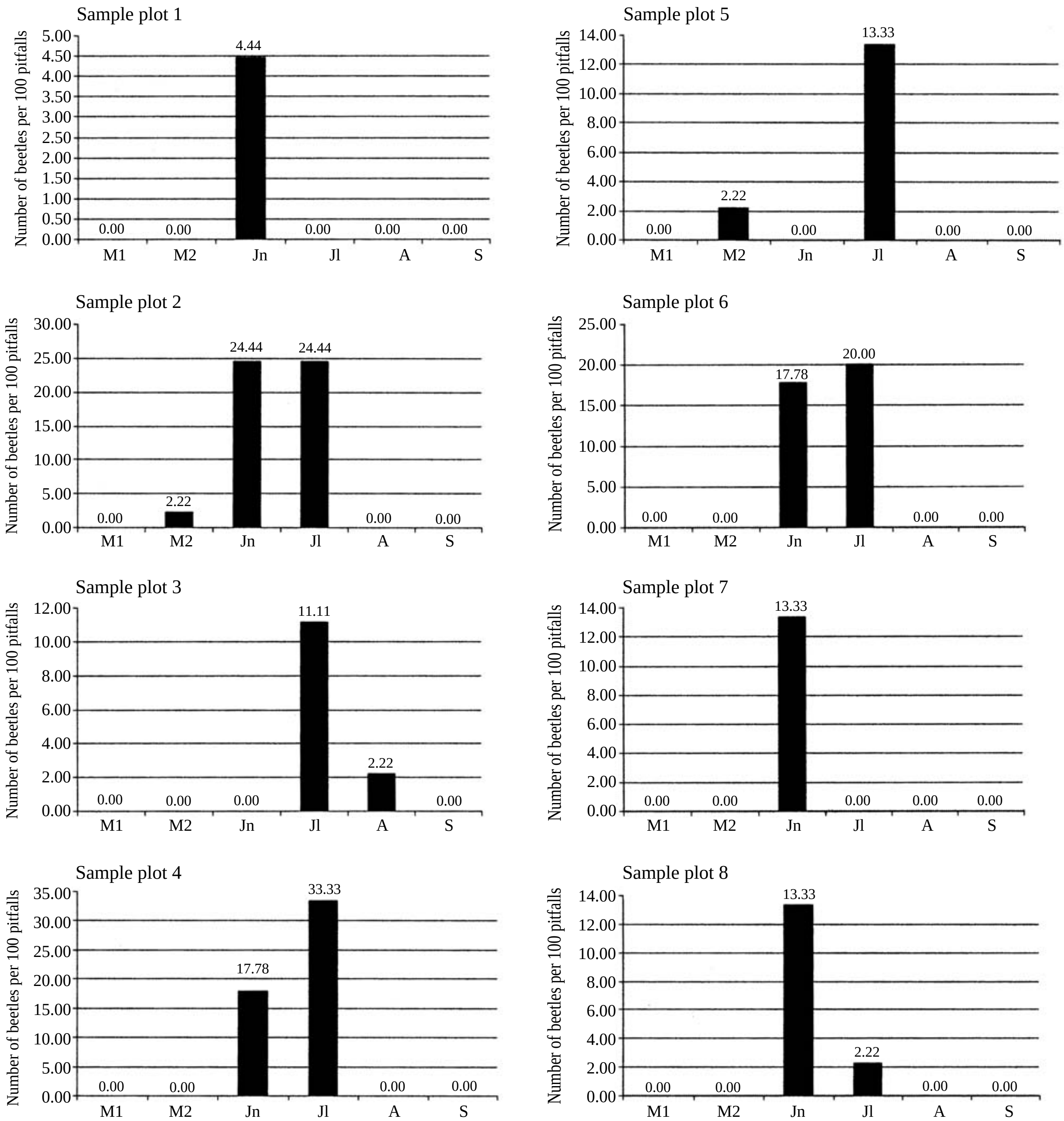

Fig. 5. Seasonal activity of *Carabus hummeli* in studied habitats. Abbreviations as in Fig. 4.

1, 7); in Fir forest after cutting, Fresh-cutting forest and Meadow imagines occurs in June and July (Fig. 5, plots 4, 6, 8); but in late August in the Climax fir forest only (Fig. 5, plot 3). In the majority of studied habitats peak of activity is observed in June and July.

In the majority of forest ecosystems *Pterostichus sutschanensis* are active from the early May to late August, with peak of activity in July and strong decreasing of abundance in August (Fig. 6, plots 1, 2, 4, 6). Spatial distribution of this species in open sites depends on weather condition. The abundance of *P. sutschanensis* in the shores of Sokolovka River increase from May to late June, but in late July and August this species disappear here (Fig. 6, plot 7). On the contrary, it was not found in meadows from late May to late June, but imagines are abundant here in late July (Fig. 6, plot 8). Probably, beetles of *P. sutschanensis* migrate from shores of river to meadows after

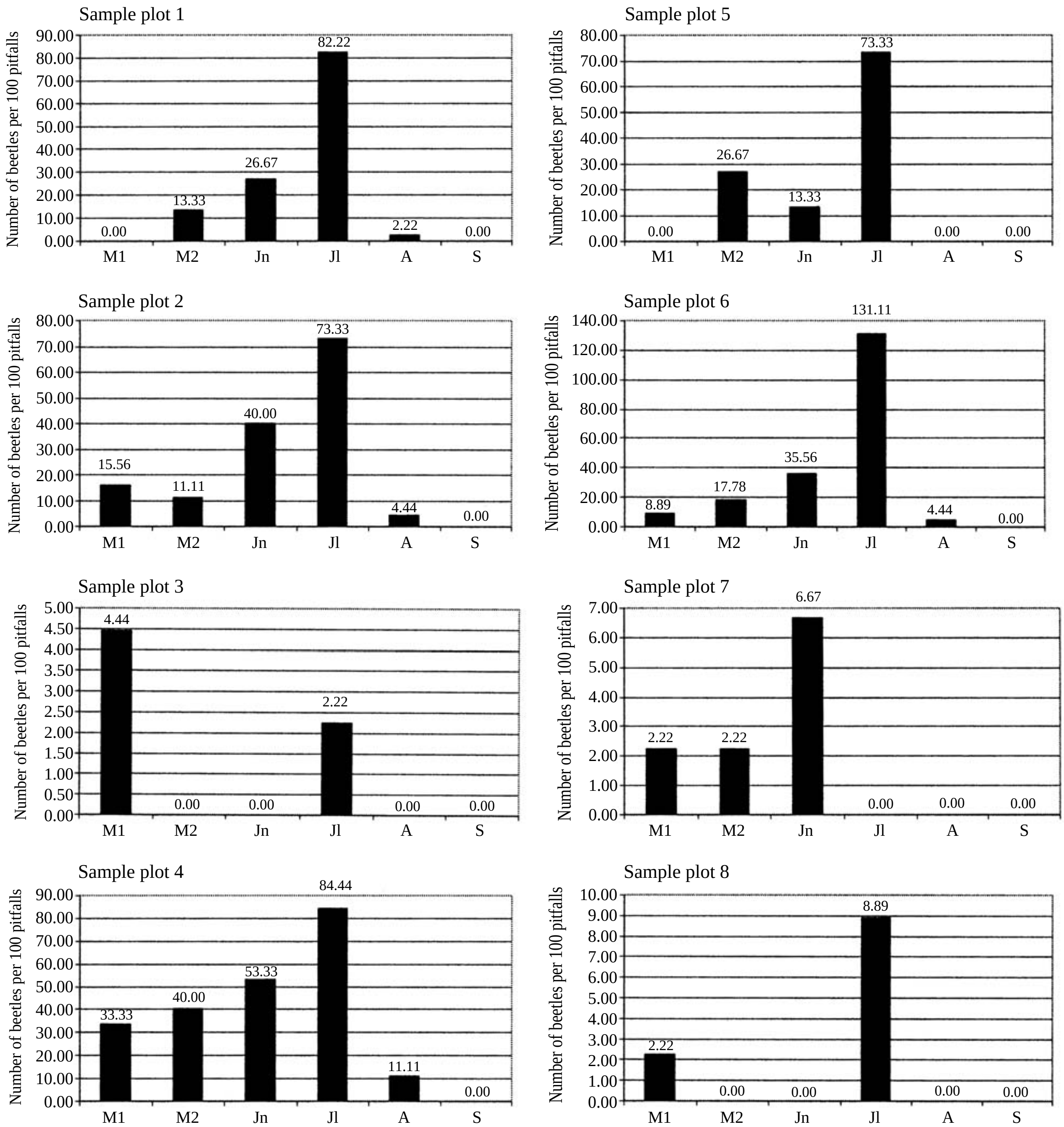

Fig. 6. Seasonal activity of *Pterostichus sutschanensis* in studied habitats. Abbreviations as in Fig. 4.

heavy rainfall in mid July.

Low abundance is characteristic feature of *Pterostichus alacer* in all studied habitats, but the imagines was most common in May and June (Fig. 7). Generally speaking, it is late spring - early summer species. Like in previous species, the migration of *Pterostichus alacer* from meadows to shores of river take place from late May to June, and in opposite direction after rains in July (Fig. 7, plots 7, 8).

Seasonal changes in the beetles communities

The change of species riches from May to September in pooled samples is shown in Fig. 8. The numbers of species increase from 28 in early May to 40 in June and decrease from 26 in late July to 18 in August. In late September five species of beetles was collected in the Wormwood meadow (*Bembidion mandli*, *Synuchus congruus*) and Riverside (*Agonum bellicum*,

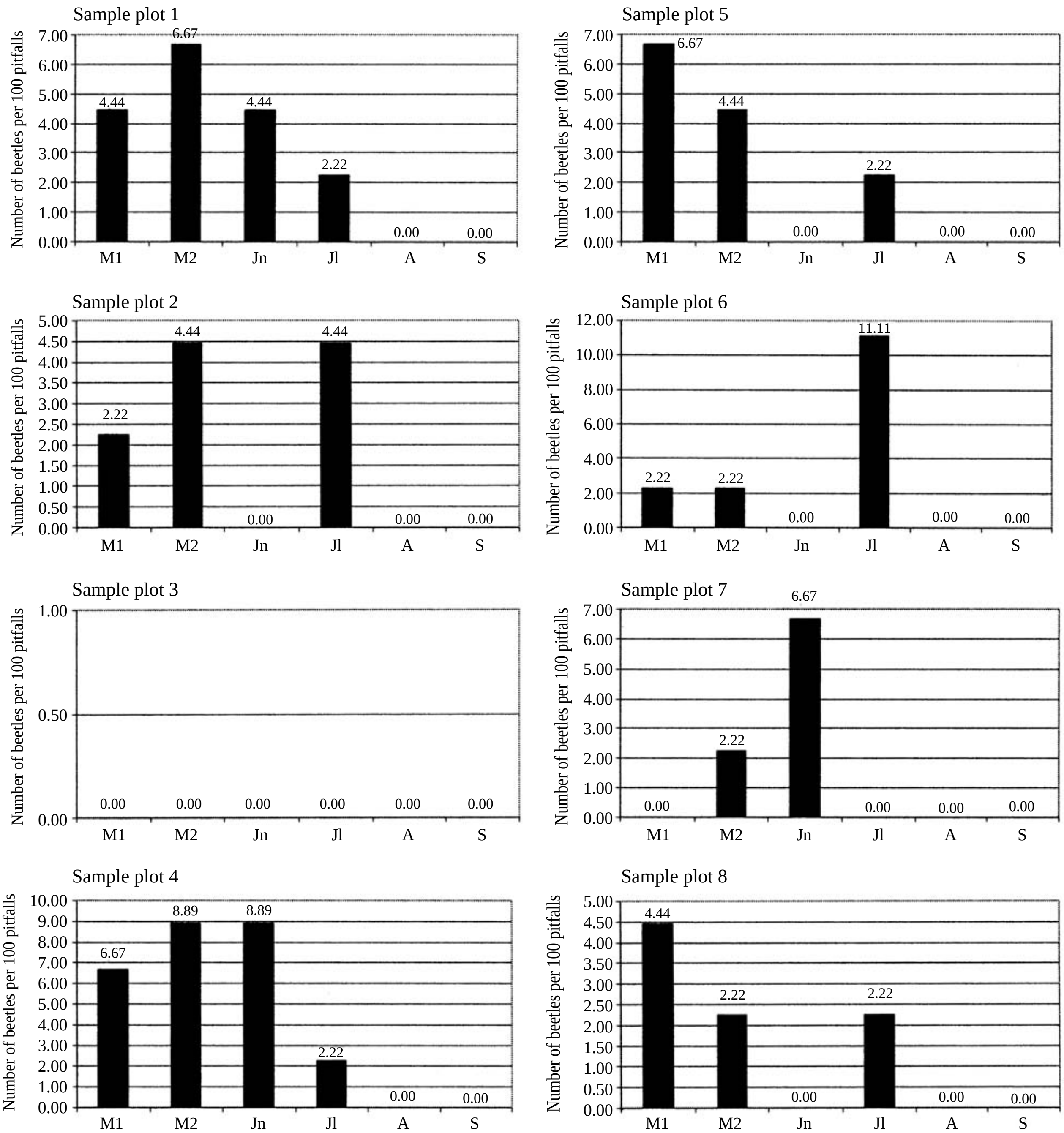

Fig. 7. Seasonal activity of *Pterostichus alacer* Morawitz in studied habitats. Abbreviations as in Fig. 4.

Bembidion captivorum, *Trichotichnus coruscus*, *Synuchus congruus*), i.e. in open places only; in all other studied habitats the imagines of beetles was not found. Thus, species riches of above-ground beetles in Sikhote-Alin Mountains gently rises from spring to early summer with peak in June and slowly decreases from July to September. The peak of species diversity of above-ground beetles in Europe was mentioned in August (Dennison and Hodkinson, 1984a, b; Loreau, 1988). It is the main difference of the seasonal activity of beetles in the opposite sides of temperate zone of Eurasian continent.

The abundance of above-ground beetles in pooled samples is shown in Fig. 9. The abundance of individuals rises from early May to June. In July the number of collected specimens is maximal. Thus, the peak of above-ground beetle abundance is observed in July, while the maximal species diversity is mentioned in June. Probably, it is a result of 'accumulation effect'. In August activity of above-ground beetles slumped (at about 10 times comparing with July). In September abun-

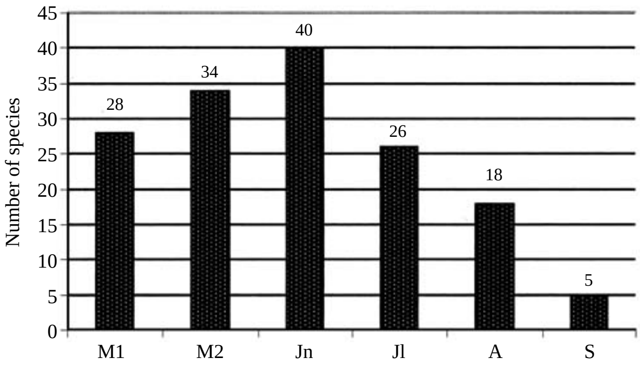

Fig. 8. The number of species of above-ground beetles to month. Abbreviations of month as in Fig. 4.

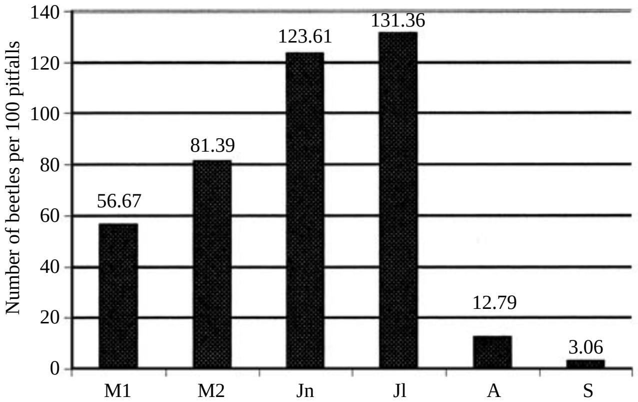

Fig. 9. The number of specimens of above-ground beetles per 100 pitfall-days to month. Abbreviations of month as in Fig. 4.

dance of above-ground beetles in the Sikhote-Alin Mountains is extremely low.

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