Acta Soc. Zool. Bohem. **63**: 315–330, 1999
ISSN 1211-376X

Beetle communities (Insecta: Coleoptera) of rock debris on the Boreč hill (Czech Republic: České středohoří mts)

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Received December 19, 1998; accepted June 3, 1999
Published August 22, 1999

Abstract. Sixty seven beetle species (Coleoptera) in 3824 specimens were collected in rock debris of the Boreč hill (České středohoří mts, northern Bohemia, Czech Republic), in an all-year-round study in 1993–1994. Seven baited pitfall traps on the bottom margin (2), middle (2) and upper margin (3) of rock debris were serviced monthly. The majority of specimens was collected during vegetation season, with the maximum in October; the minimum of specimens was found in February. Comparison of monthly dominance is given. Using a WPGMA cluster analysis based on the Morisita's index of similarity, three main clusters are defined: 1. November, clustered separately from all other months of the year; 2. late spring-summer months (May–August) and 3. early spring (March–April) together with early autumnal (September–October) months. The Brillouin index of diversity decreases from the bottom to the upper margin of the rock debris, although the numbers of species are not significantly decreasing. Using the same procedure, samples from the central part of the rock debris clearly differ from those from marginal parts (bottom, upper margin). Seasonal abundance and spatial distribution of nine most abundant species is given for the following species (ordered from the most to the last abundant): *Catops picipes* (Fabricius, 1792), *Sciodrepoides watsoni watsoni* (Spence, 1815), *Choleva lederiana lederiana* Reitter, 1901, *Catops tristis tristis* (Panzer, 1794), *Catops subfuscus subfuscus* Kellner, 1846, *Bembidion stephensii* Crotch, 1866, *Pterostichus negligens* (Sturm, 1824), *Oxypoda vittata* Märkel, 1842 and *Omalium excavatum* Stephens, 1834.

Ecology, rock debris, seasonal abundance, spatial distribution, Coleoptera, Bohemia

INTRODUCTION

An exceptional type among Central European ecosystems, usually only minimally affected by human activities, is created by rock debris. Moreover, rock debris sometimes forms sites never covered by forests continually from the last glacial period (Růžička 1993). Usually, a specific microclimate is formed, suitable for many specific plant species with relict distribution (Pilous 1938, 1959, Kolbek 1983, Pujmanová 1988, 1989, 1990, Sádlo & Kolbek 1994) as well as invertebrates (Ložek 1954, Růžička 1988, 1989, 1990, 1994b, 1996b, Růžička et al. 1989, Christian 1993, Růžička & Zacharda 1994, Růžička et al. 1995, Čeřovský & Holec 1996).

The beetles inhabiting rock debris ecosystems were studied mostly in mountains (Obenberger 1952, Hůrka 1958, Martiš 1975, Molenda 1989, Růžička & Zacharda 1994), beetle communities of these ecosystems at lower altitudes are only poorly known (Růžička et al. 1989, Růžička 1996a).

The Boreč hill (449 m a. s. l.) is a part of the Kostomlatské středohoří mts, a western part of the České středohoří mts. The locality established as a national reserve in 1951 (Maršáková-Němejcová & Mihálik 1977) is well-known for the long time (Krejčí 1881, Šimr 1957, Kubát 1971) by its characteristic microclimatic features – the warm and wet exhalation from the top part cracks during colder winter months (in opportune conditions visible as white evaporation – Drahoš 1957); as well as the cold air exhalation and the presence of ice to late spring in the rock debris on the northern to north-eastern foot (Pilous 1959, Šimr 1964, Jíra 1966, Kubát 1971). This phenomenon is probably more complex than previously known, caused by crack connections reaching deep into the laccolith body of the hill (Váně 1992).

The locality has been the subject of several biological studies. Bryophytes were studied by Pilous (1959) and Pujmanová (1990), and molluscs were investigated by Ankert (1917) and Ložek (1954). A brief list of beetles was given by Novotný & Novotný (1966); the occurrence of two remarkable carabid beetles [*Leistus montanus* Stephens, 1827 and *Pterostichus negligens* (Sturm, 1824)] was recorded by Kubát (1971).

The aim of this study is to examine (1) the composition of beetle communities in rock debris and (2) the changes in the seasonal as well as spatial pattern of such communities.

AREA OF STUDY

The beetles were collected in the rock debris on the north-eastern slope of the Boreč hill (50°31'N 14°00'E), about 0.5 km south-west of the Režný Újezd village, mapping square code 5449d (see Pruner & Míka 1996), at 350 m a. s. l. The free area of the rock debris is about 130 m wide and 20 to 25 m long, with 25–35° declination. The rock debris is composed from flat stones (consisting from sodalitic trachyte), with the maximum diameter only a few centimetres on the upper margin and in several drifts in middle parts (Fig. 18), usually 10 to 30 cm in the middle and on the bottom margin. The bottom margin continually passes from the debris to a deciduous forest (with dominant *Sorbus*, *Betula*, *Quercus* and *Corylus* spp.), on the left side changed by a small, wet, unimproved pasture. Upper margin of the rock debris joins with a grassy slope with irregularly dispersed shrubs and individual *Pinus*, *Betula* and *Sorbus* trees, and again passes from the debris to a dry and warm grove covering the top parts of the hill.

The traps are labelled as No. I to No. VII throughout the text. The field numbers of individual traps (used on locality labels of the voucher specimens) are also given in square brackets. In total, seven traps were placed on the following sites:

(a) Two traps were situated on the bottom margin of the rock debris. *Trap No. I* [field number 4] was placed in the right part with an adjacent deciduous forest, ca. 2.5 m above the margin of the free rock debris, and ca. 30 cm deep between stones with the maximum size of 10–30 cm. *Trap No. II* [field number 10] was placed in the left part with an adjacent pasture, 10 cm deep under a big stone on the margin of the rock debris, and close to a fissure with cold exhalation.

(b) Two traps were placed in the middle part of the rock debris. *Trap No. III* [field number 5] was situated in the right part of the rock debris, ca. 6 m above the bottom margin of the rock debris, and ca. 30 cm deep between stones with the maximum size of 10–30 cm. *Trap No. IV* [field number 6] was placed in the central part, ca. 10 m above the bottom margin of the rock debris; in a tongue of larger, slowly scrolling stones, and ca. 30 cm deep between stones with maximum size 10–20 cm.

(c) Three traps were situated on the upper margin of the rock debris. *Trap No. V* [field number 7] was placed in a fine debris in the right part at the upper margin, 15 cm deep between stones with the maximum size of only 2–6 cm. *Trap No. VI* [field number 8] was placed ca. 2 m above the central part of the upper margin in a small but deep crevice, 15 cm deep between small stones, and close to a fissure with cold exhalation. *Trap No. VII* [field number 9] was placed in the left part of the upper margin; 20 cm deep between stones with the maximum size of 3–15 cm.

MATERIAL AND METHODS

The material was collected using pitfall traps with an outlet of 10 cm diameter, 9 cm deep. The traps were filled with 1 : 1 solution of water and ethylene glycol and covered with a net of mesh size 2 cm and a tin roof. Fish meat and ripened cheese were used as bait, placed in a smaller container (1.5 cm deep), and over-hung above the level of the preserve solution. The material was placed into 75% ethanol; a small part of voucher specimens was dry mounted and deposited in the author's collection. Some Staphylinidae are also deposited in collection of the Šarišské múzeum, Bardejov. The beetles were identified by the following specialists: Carabidae – Pavel Moravec; Ptinidae – Miroslav Mikát; Staphylinidae – Tomáš Jászay, Pavel Moravec (*Tachinus*), Lubomír Hromádka (*Philonthus*), Petr Štourač (*Quedius*), Matúš Kocian (*Mycetoporus*); Silphidae, Leiodidae, Dermestidae, Nitidulidae – Jan Růžička; Cryptophagidae – Miroslav Reška; Scarabaeidae – David Král; Dasytidae – Karel Majer. Species names are treated according to Jelínek (1993). A few remnants of specimens of Staphylinidae can be determined only as *Atheta* spp. 1 to 4.

The traps were exposed between April 22, 1993 and May 30, 1994; and serviced 13 times with approximately monthly intervals.

For the cluster analysis, the y = ln (x) transformation was applied to the measured data. The Morisita's index of similarity was selected as the suitable index for quantitative data, strictly recommended because it is not dependent on the sample size (Krebs 1989). Hierarchical cluster analysis in Q-mode (study of similarity between pairs of the rows in the input matrix, here months or traps; Sneath & Sokal 1973) was performed. A weighted pair-group method using arithmetic averages (WPGMA) was used; it is appropriate for quantitative data according to Sneath & Sokal (1973).

The Brillouin index was used to measure species diversity. Its adequacy for pitfall trap samples was justified by Krebs (1989).

The program NTSYS-pc 1.80 (Rohlf 1994) was used for the cluster analysis.

RESULTS

Altogether, 3824 adult specimens of 67 species of Coleoptera were trapped. The most abundant beetle family was Leiodidae with 2965 specimens in 17 species, followed by Staphylinidae (384 specimens in 29 species), Carabidae (327 specimens in only 3 species) and Silphidae (112 specimens in 6 species), and only 36 specimens belonged to other 6 families (Tables 1, 2).

Seasonal abundance

During the year, samples considerably fluctuated in total abundance of beetles (Fig. 1). During the vegetation season (March–October), there were higher numbers of specimens with the maximum in October. In winter months (December–February), the total numbers decreased with the minimum in February. The number of species exhibited similar pattern (Fig. 2). The Brillouin index of diversity reached the maximum in spring months (April–May, 1994), with the minimum in November (Fig. 2). The abundance of individual species during the year is treated in Table 1.

The monthly dominance structures (Fig. 16) can be characterised as follows:

January 1994: Three species represented almost 70% of the species community – *Catops tristis tristis* (28.6%), *Oxypoda vittata* (25%) and *Choleva lederiana lederiana* (17.9%).

February 1994: Species community was very poor, composed only of 7 species represented by 9 specimens; only *Catops tristis tristis* was present in more than a single specimen.

March 1994: The species community was dominated by *Oxypoda vittata* (45.7%), next were *Catops tristis tristis* (22.4%), *Choleva lederiana lederiana* (11.2%) and *Catops longulus* (6%).

April 1994: Four species of Leiodidae represented almost 70% of the species community: *Catops subfuscus subfuscus* (19.7%), *C. tristis tristis* (16.5%), *Choleva lederiana lederiana* (16%) and *Sciodrepoides watsoni watsoni* (16%). *Omalium excavatum* (10.1%) reached the maximal year abundance.

May 1994: Five species of Leiodidae represented almost 75% of the species community: *Sciodrepoides watsoni watsoni* (31.4%), *Choleva lederiana lederiana* (20.3%), *Catops picipes* (10.9%), *C. tristis tristis* (6.2%), *C. subfuscus subfuscus* (5.3%) and *Omalium excavatum* (5.8%).

May 1993: Similarly, the same 5 species of Leiodidae represented more than 70% of the species community: *Catops subfuscus subfuscus* (26.3%), *Choleva lederiana lederiana* (19.7%), *Sciodrepoides watsoni watsoni* (9.9%), *Catops tristis tristis* (9.5%) and *C. picipes* (6.8%). Almost 20% of the species community was composed in this period also by two species of Carabidae: *Bembidion stephensii* (14.1%) and *Pterostichus negligens* (5.6%).

June 1993: Six species of Leiodidae and Carabidae represented 90% of the species community: *Sciodrepoides watsoni watsoni* (19.8%), *Catops picipes* (17.6%), *Pterostichus negligens* (17.4%), *Bembidion stephensii* (17.1%), *Catops subfuscus subfuscus* (10.2%) and *Choleva lederiana lederiana* (8.1%).

Tab. 1. The summary abundance of individual species, monthly, the beetle communities of the rock debris on the Boreč hill, May 1993–May 1994

month species	May 93	Jun 93	Jul 93	Aug 93	Sep 93	Oct 93	Nov 93	Dec 93	Jan 94	Feb 94	Mar 94	Apr 94	May 94	total	total (%)
Catops picipes	35	74	47	187	152	188	24	0	0	0	0	0	49	756	19.77
Sciodrepoides w. watsoni	51	83	244	115	10	3	0	0	0	0	0	60	141	707	18.49
Choleva l. lederiana	102	34	32	11	17	121	46	5	5	1	13	60	91	538	14.07
Catops tristis tristis	49	18	10	41	46	186	2	3	8	3	26	62	28	482	12.60
Catops s. subfuscus	136	43	8	3	0	1	0	0	0	0	1	74	24	290	7.58
Bembidion stephensii	73	72	15	0	1	9	0	3	0	0	1	2	1	177	4.63
Pterostichus negligens	29	73	17	13	10	2	0	0	0	0	0	1	3	148	3.87
Oxypoda vittata	1	0	0	0	0	21	3	4	7	1	53	15	1	106	2.77
Omalium excavatum	8	5	1	1	2	1	0	0	0	0	4	38	26	86	2.25
Catops longulus	3	9	5	1	8	17	0	0	3	1	7	10	10	74	1.94
Atheta crassicornis	1	0	13	10	8	2	0	0	0	0	1	15	11	61	1.60
Catops f. fuliginosus	3	1	1	0	1	40	1	0	1	1	2	3	1	55	1.44
Aleochara curtula	6	0	0	23	1	0	0	0	0	0	0	0	6	36	0.94
Nicrophorus f. fossor	0	0	16	13	2	0	0	0	0	0	0	0	0	31	0.81
Nicrophorus vespilloides	2	0	1	11	9	0	0	0	0	0	0	0	5	28	0.73
Nicrophorus humator	2	0	0	0	2	0	0	0	0	0	2	3	8	17	0.44
Silpha carinata	1	3	2	2	8	0	0	0	0	0	0	0	1	17	0.44
Cryptophagus pallidus	0	0	0	0	16	0	0	0	0	0	0	0	0	16	0.42
Nicrophorus vespillo	1	1	0	1	0	1	0	0	0	0	0	2	10	16	0.42
Catops westi	0	0	0	0	0	0	0	0	0	0	0	6	9	15	0.39
Omalium caesum	5	0	0	1	1	1	0	2	0	0	0	4	0	14	0.37
Catops grandicollis	0	0	0	0	9	3	0	0	0	0	0	0	0	12	0.31
Atheta triangulum	0	0	0	0	0	0	4	4	1	1	0	0	0	10	0.26
Proteinus atomarius	0	0	3	1	3	0	0	0	0	0	0	1	1	9	0.24
Catops c. coracinus	0	1	1	2	0	0	0	0	0	0	0	2	2	8	0.21
Catops nigricans	0	0	0	0	2	5	1	0	0	0	0	0	0	8	0.21
Tachinus rufipennis	0	0	0	1	0	0	0	0	0	0	2	4	1	8	0.21
Cryptophagus pilosus	0	0	0	1	2	3	0	0	0	0	0	0	1	7	0.18
Choleva cisteloides	0	0	0	0	0	0	0	4	2	1	0	0	0	7	0.18
Atheta trinotata	1	0	0	1	0	0	0	0	0	0	0	4	1	7	0.18
Zyras humeralis	1	0	0	0	0	0	0	0	0	0	0	1	4	6	0.16
Atheta sodalis	1	0	0	0	1	0	0	0	0	0	0	1	2	5	0.13
Quedius mesomelinus	0	0	0	1	0	1	0	0	0	0	0	2	1	5	0.13
Catops chrysomeloides	1	0	0	0	0	3	0	0	0	0	0	0	0	4	0.10
Proteinus brachypterus	0	0	0	0	2	2	0	0	0	0	0	0	0	4	0.10
Danacea pallipes	0	1	0	0	1	0	0	0	0	0	0	1	0	3	0.08
Choleva o. oblonga	0	0	0	1	0	1	0	0	0	0	1	0	0	3	0.08
Ptomaphagus sericatus	1	0	2	0	0	0	0	0	0	0	0	0	0	3	0.08
Oiceoptoma thoracica	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0.08
Atheta britanniae	0	0	0	1	0	1	0	0	0	0	0	0	1	3	0.08
Atheta europaea	1	0	0	0	0	0	0	2	0	0	0	0	0	3	0.08
Mycetoporus bosnicus	1	0	0	0	0	1	0	0	0	0	1	0	0	3	0.08
Omalium rivulare	0	0	0	0	0	1	0	0	1	0	0	0	1	3	0.08
Abax parallelepipedus	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0.05
Nargus anisotomoides	0	0	0	0	0	1	0	0	0	0	0	0	1	2	0.05
Ptinus schlerethi	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0.05
Aleochara stichai	0	0	0	0	0	1	0	0	0	0	1	0	0	2	0.05
Liogluta granigera	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0.05
Philontus succicola	0	0	1	1	0	0	0	0	0	0	0	0	0	2	0.05
Cryptophagus acutangulus	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.03
Cryptophagus distinguendus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.03
Cryptophagus nitidulus	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.03

Tab. 1. Continued

month species	May 93	Jun 93	Jul 93	Aug 93	Sep 93	Oct 93	Nov 93	Dec 93	Jan 94	Feb 94	Mar 94	Apr 94	May 94	total	total (%)
Dermestes murinus	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.03
Ptomaphagus variicornis	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.03
Omosita discoidea	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.03
Ptinus pilosus	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.03
Epauloecus unicolor	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.03
Onthophagus joannae	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.03
Aleochara bipustulata	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.03
Aleochara sparsa	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0.03
Atheta brevicollis	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.03
Atheta marcida	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.03
Atheta sp. 1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.03
Atheta sp. 2	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.03
Atheta sp. 3	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.03
Atheta sp. 4	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.03
Stenus cf. *cicindeloides*	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.03
total number of specimens	518	420	423	445	316	618	81	27	28	9	116	375	448	3824	100.00

July 1993: Three species of Leiodidae represented more than 75% of the species community: *Sciodrepoides watsoni watsoni* was dominant (57.7%), followed by *Catops picipes* (11.1%) and *Choleva lederiana lederiana* (7.6%).

August 1993: Again, 3 species of Leiodidae represented more than 75% of the species community: *Catops picipes* was dominant (42%), followed by *Sciodrepoides watsoni watsoni* (25.8%) and *Catops tristis tristis* (9.2%). *Aleochara curtula* (5.1%) reached the maximal year abundance.

September 1993: Three species of Leiodidae represented almost 70% of the species community: *Catops picipes* was again dominant (48.1%), followed by *C. tristis tristis* (14.6%) and *Choleva lederiana lederiana* (5.4%). Only this month, *Cryptophagus pallidus* (5%) was present.

October 1993: Four species of Leiodidae represented more than 85% of the species community: *Catops picipes* (30.4%) and *C. tristis tristis* (30.1%) were most abundant, followed by *Choleva lederiana lederiana* (19.6%) and *Catops fuliginosus fuliginosus* (6.5%). This month, the maximum of the total number of specimens was reached.

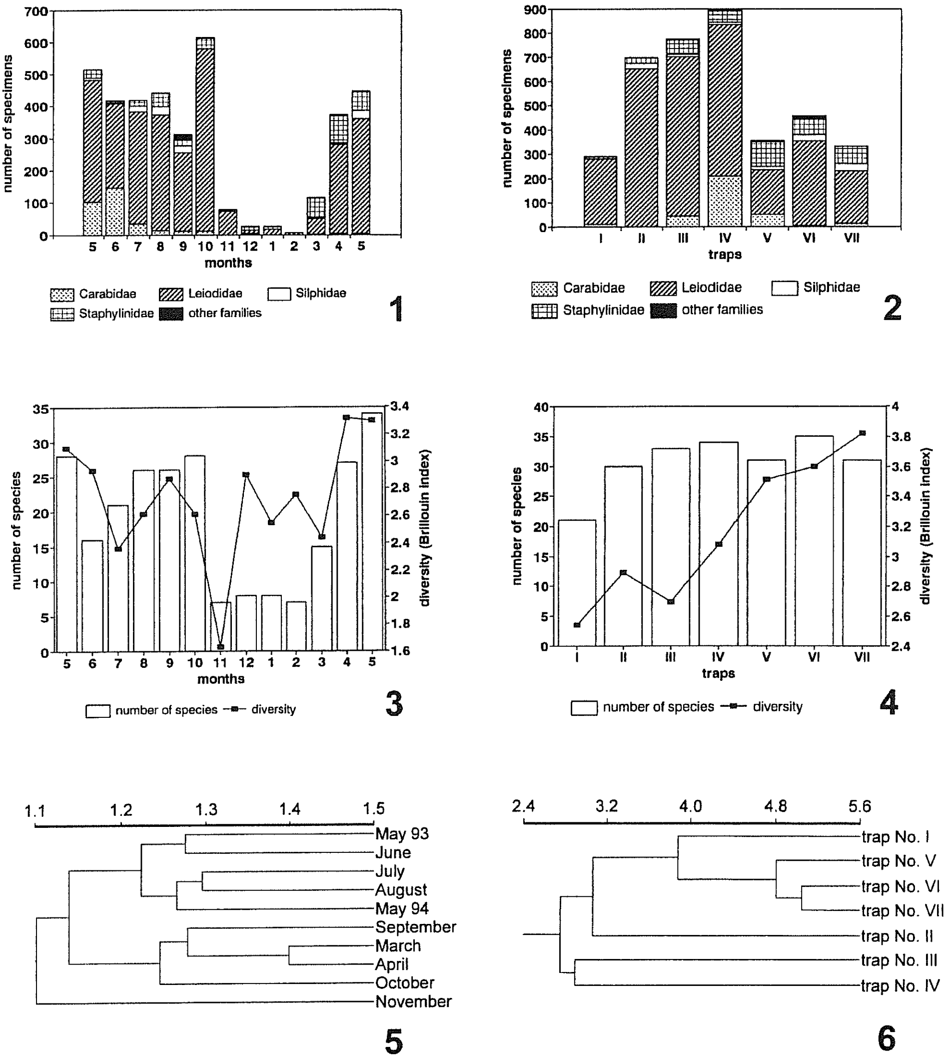
November 1993: Two species of Leiodidae represented more than 85% of the species community: *Choleva lederiana lederiana* was dominant (56.8%), followed by *Catops picipes* (29.6%).

December 1993: Four species of Leiodidae (2 species) and Staphylinidae (2 species) represented almost 65% of the species community: *Choleva lederiana lederiana* (18.5%), *C. cisteloides*, *Atheta triangulum* and *Oxypoda vittata* (all 14.8%).

Using a WPGMA cluster analysis based on the Morisita's index of similarity and ln-transformed data, three main clusters can be defined (Fig. 5): (1) November, which is clustered separately from all other months of the year; (2) late spring to summer months (May–August) and (3) early spring (March–April) and early autumn (September–October) months. The December–February samples were excluded from the analysis because of the low specimens numbers (see Table 1).

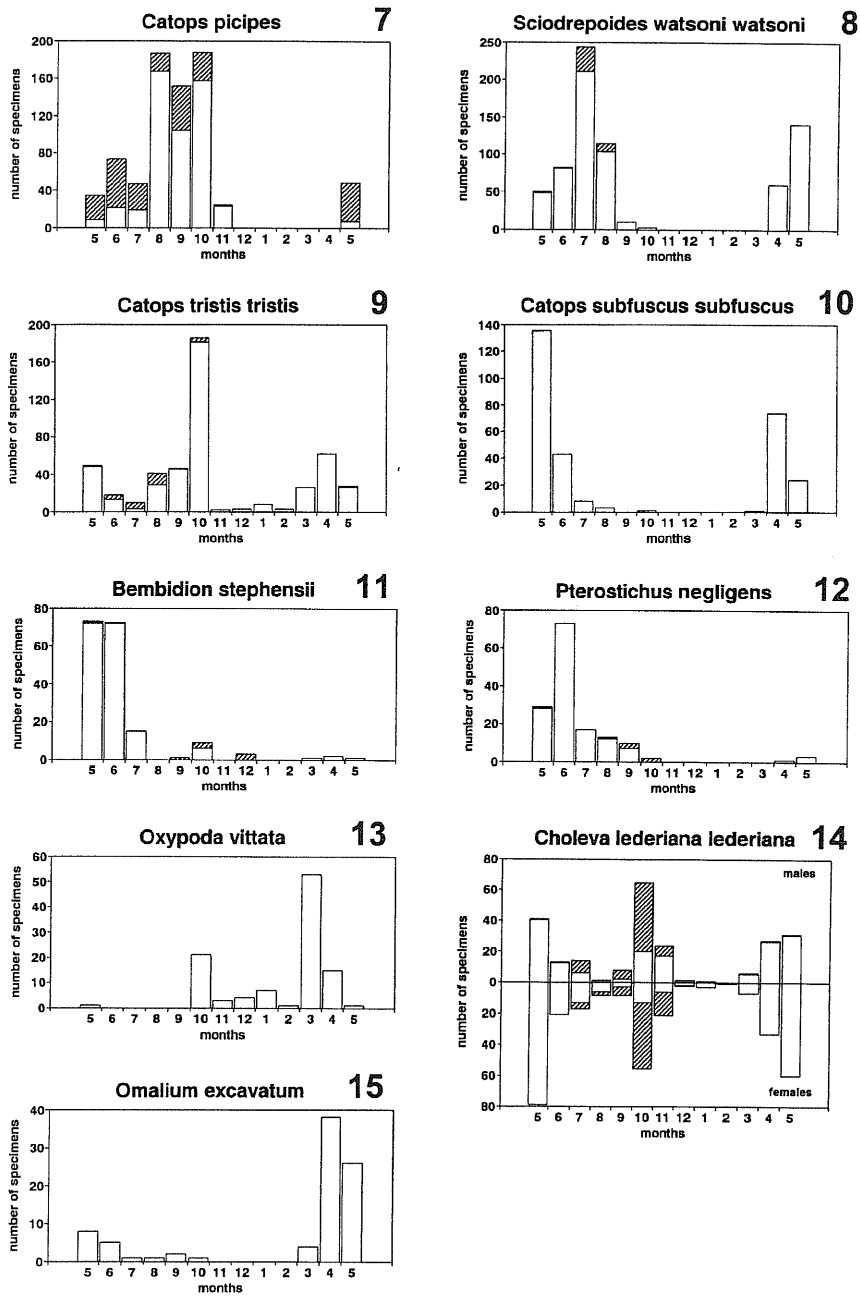
Trap preference

Individual traps situated in different positions in the rock debris differ in total abundances of beetles (Fig. 2). Most specimens were captured in the left bottom margin of the rock debris (trap No. II) adjacent to the pasture and in the central part of the rock debris (traps Nos. III and IV). The



Figs. 1–6. Beetle community of the rock debris in the Boreč hill, May 1993 – May 1994: 1 – total abundance of beetle families, monthly; 2 – total abundance of beetle families, individual traps; 3 – total number of species and the Brillouin index of diversity, monthly; 4 – total number of species and the Brillouin index, individual traps; 5 – cluster analysis (the Morisita's index of similarity, WPGMA; December–February samples excluded, see text for details), monthly; 6 – cluster analysis (the Morisita's index of similarity, WPGMA), individual traps.

minimum of specimens as well as the lowest number of species was trapped in the right bottom margin of the rock debris with adjacent deciduous forest (trap No. I, Figs 2, 4). The Brillouin index of diversity decreases from the bottom to the upper margin (Fig. 4; Spearman rank correlation coefficient $r_s = 0.964$, $n = 7$, $p < 0.01$) although the numbers of species are not decreasing significantly (Fig. 4; $r_s = 0.036$, $n = 7$, n. s.). The abundance of individual species in traps is given in Table 2.



Figs 7–15. Seasonal abundance of species in the beetle community of the rock debris on the Boreč hill, May 1993 – May 1994: 7 – *Catops picipes*, 8 – *Sciodrepoides watsoni watsoni*, 9 – *Catops tristis tristis*, 10 – *C. subfuscus subfuscus*, 11 – *Bembidion stephensii*, 12 – *Pterostichus negligens*, 13 – *Oxypoda vittata*, 14 – *Choleva lederiana lederiana*, 15 – *Omalium excavatum*. Hatching indicates percentage of teneral specimens.

Tab. 2. The summary abundance of individual species in traps, the beetle communities of the rock debris on the Boreč hill, May 1993–May 1994

trap No. species	family	I	II	III	IV	V	VI	VII	total	total (%)
Catops picipes (Fabricius, 1792)	Leiodidae	69	154	356	33	50	79	15	756	19.77
Sciodrepoides w. watsoni (Spence, 1815)	Leiodidae	11	81	118	260	69	108	60	707	18.49
Choleva l. lederiana Reitter, 1901	Leiodidae	121	103	59	161	2	65	27	538	14.07
Catops tristis tristis (Panzer, 1794)	Leiodidae	48	221	13	43	39	49	69	482	12.60
Catops s. subfuscus Kellner, 1846	Leiodidae	7	49	96	104	5	6	23	290	7.58
Bembidion stephensii Crotch, 1866	Carabidae	0	0	38	94	45	0	0	177	4.63
Pterostichus negligens (Sturm, 1824)	Carabidae	10	0	6	115	3	2	12	148	3.87
Oxypoda vittata Märkel, 1842	Staphylinidae	0	1	1	2	65	24	13	106	2.77
Omalium excavatum Stephens, 1834	Staphylinidae	0	2	41	32	6	5	0	86	2.25
Catops longulus Kellner, 1846	Leiodidae	5	19	10	14	8	11	7	74	1.94
Atheta crassicornis (Fabricius, 1792)	Staphylinidae	0	1	2	6	13	12	27	61	1.60
Catops f. fuliginosus Erichson, 1837	Leiodidae	3	12	3	2	8	18	9	55	1.44
Aleochara curtula (Goeze, 1777)	Staphylinidae	0	13	6	0	3	2	12	36	0.94
Nicrophorus f. fossor Erichson, 1837	Silphidae	0	1	4	2	0	19	5	31	0.81
Nicrophorus vespilloides Herbst, 1784	Silphidae	1	5	2	0	2	5	13	28	0.73
Nicrophorus humator Olivier, 1790	Silphidae	0	0	2	3	4	0	8	17	0.44
Silpha carinata Herbst, 1783	Silphidae	0	15	0	1	0	1	0	17	0.44
Cryptophagus pallidus Sturm, 1845	Cryptophagidae	0	0	2	2	0	12	0	16	0.42
Nicrophorus vespillo (Linneaus, 1758)	Silphidae	0	0	1	3	8	1	3	16	0.42
Catops westi Krogerus, 1931	Leiodidae	5	2	1	1	2	1	3	15	0.39
Omalium caesum Gravenhorst, 1806	Staphylinidae	2	1	0	0	1	9	1	14	0.37
Catops grandicollis Erichson, 1837	Leiodidae	0	1	0	0	0	6	5	12	0.31
Atheta triangulum (Kraatz, 1856)	Staphylinidae	0	1	0	0	6	0	3	10	0.26
Proteinus atomarius Erichson, 1840	Staphylinidae	0	1	0	1	0	2	5	9	0.24
Catops c. coracinus Kellner, 1846	Leiodidae	1	3	0	1	0	2	1	8	0.21
Catops nigricans (Spence, 1815)	Leiodidae	0	4	1	1	0	2	0	8	0.21
Tachinus rufipennis Gyllenhal, 1810	Staphylinidae	1	0	4	1	0	2	0	8	0.21
Cryptophagus pilosus Gyllenhal, 1828	Cryptophagidae	0	2	0	1	3	1	0	7	0.18
Choleva cisteloides (Frölich, 1799)	Leiodidae	0	2	0	3	1	1	0	7	0.18
Atheta trinotata (Kraatz, 1856)	Staphylinidae	1	1	0	0	0	4	1	7	0.18
Zyras humeralis (Gravenhorst, 1802)	Staphylinidae	0	0	1	1	4	0	0	6	0.16
Atheta sodalis (Erichson, 1837)	Staphylinidae	3	0	1	0	0	0	1	5	0.13
Quedius mesomelinus (Marsham, 1802)	Staphylinidae	1	0	1	2	0	0	1	5	0.13
Catops chrysomeloides (Panzer, 1798)	Leiodidae	0	1	1	0	0	2	0	4	0.10
Proteinus brachypterus (Fabricius, 1792)	Staphylinidae	0	0	0	0	0	1	3	4	0.10
Danacea pallipes (Panzer, 1793)	Dasytidae	0	0	1	1	1	0	0	3	0.08
Choleva oblonga oblonga Latreille, 1807	Leiodidae	1	0	0	2	0	0	0	3	0.08
Ptomaphagus sericatus (Chaudoir, 1845)	Leiodidae	0	0	1	1	1	0	0	3	0.08
Oiceoptoma thoracica (Linneaus, 1758)	Silphidae	0	1	0	0	0	0	2	3	0.08
Atheta britanniae Bernhauer et Scheerpeltz, 1926	Staphylinidae	0	0	0	0	0	0	3	3	0.08
Atheta europaea Likovský, 1984	Staphylinidae	0	0	0	0	0	2	1	3	0.08
Mycetoporus bosnicus Luze, 1901	Staphylinidae	0	1	2	0	0	0	0	3	0.08
Omalium rivulare (Paykull, 1789)	Staphylinidae	1	1	0	0	0	1	0	3	0.08
Abax parallelepipedus (Piller et Mitterpacher, 1783)	Carabidae	0	0	0	0	1	1	0	2	0.05
Nargus anisotomoides (Spence, 1815)	Leiodidae	1	0	1	0	0	0	0	2	0.05
Ptinus schlerethi Reitter, 1884	Ptinidae	0	0	1	1	0	0	0	2	0.05
Aleochara stichai Likovský, 1965	Staphylinidae	0	0	0	0	1	1	0	2	0.05
Liogluta granigera (Kiessenwetter, 1850)	Staphylinidae	0	0	2	0	0	0	0	2	0.05
Philontus succicola C. G. Thomson, 1860	Staphylinidae	0	1	0	1	0	0	0	2	0.05
Cryptophagus acutangulus Gyllenhall, 1828	Cryptophagidae	0	0	0	1	0	0	0	1	0.03

Tab. 2. Continued

trap No. species	family	I	II	III	IV	V	VI	VII	total	total (%)
Cryptophagus distinguendus Sturm, 1845	Cryptophagidae	0	0	1	0	0	0	0	1	0.03
Cryptophagus nitidulus Miller, 1858	Cryptophagidae	0	0	0	0	0	1	0	1	0.03
Dermestes murinus Linnaeus, 1758	Dermestidae	0	0	0	0	0	1	0	1	0.03
Ptomaphagus variicornis (Rosenhauer, 1847)	Leiodidae	0	1	0	0	0	0	0	1	0.03
Omosita discoidea (Fabricius, 1775)	Nitidulidae	0	0	0	1	0	0	0	1	0.03
Ptinus pilosus P. W. J. Müller, 1821	Ptinidae	0	0	0	0	0	0	1	1	0.03
Epauloecus unicolor (Piller et Mitterpacher, 1783)	Ptinidae	0	0	0	0	1	0	0	1	0.03
Onthophagus joannae Goljan, 1953	Scarabaeidae	0	0	0	0	1	0	0	1	0.03
Aleochara bipustulata (Linneaus, 1761)	Staphylinidae	0	0	0	0	1	0	0	1	0.03
Aleochara sparsa Heer, 1839	Staphylinidae	0	0	0	0	1	0	0	1	0.03
Atheta brevicollis (Baudi, 1848)	Staphylinidae	0	0	0	0	1	0	0	1	0.03
Atheta marcida (Erichson, 1837)	Staphylinidae	0	0	0	0	0	0	1	1	0.03
Atheta sp. 1	Staphylinidae	1	0	0	0	0	0	0	1	0.03
Atheta sp. 2	Staphylinidae	0	0	0	0	0	0	1	1	0.03
Atheta sp. 3	Staphylinidae	1	0	0	0	0	0	0	1	0.03
Atheta sp. 4	Staphylinidae	0	0	1	0	0	0	0	1	0.03
Stenus cf. *cicindeloides* (Schaller, 1783)	Staphylinidae	0	0	0	1	0	0	0	1	0.03
total number of specimens		294	701	780	898	356	459	336	3824	100.00

In the following, the dominance structure of individual traps (Fig. 17) is commented:

Trap No. I: Three species of Leiodidae represented 80% of the species community: *Choleva lederiana lederiana* was dominant (41.1%), followed by *Catops picipes* (23.5%) and *Catops tristis tristis* (16.3%).

Trap No. II: Five species represented almost 70% of the species community: *Catops tristis tristis* (31.5%, reached here the maximum of abundance compared with other traps), *C. picipes* (22%), *Choleva lederiana lederiana* (14.7%), *Sciodrepoides watsoni watsoni* (11.6%) and *Catops subfuscus subfuscus* (7%).

Trap No. III: Six species represented more than 90% of the species community: *Catops picipes* was dominant (45.6%), reaching here the maximum of abundance compared with other traps, followed by *Sciodrepoides watsoni watsoni* (15.1%), (12.3%), *Choleva lederiana lederiana* (7.6%), *Omalium excavatum* (5.3%) and *Bembidion stephensii* (4.9%).

Trap No. IV: Eight species represented almost 95% of the species community: *Sciodrepoides watsoni watsoni* (29%), *Choleva lederiana lederiana* (17.9%), *Pterostichus negligens* (12.8%), *Catops subfuscus subfuscus* (11.6%) and *Bembidion stephensii* (10.5%, reached the maximum of abundance here compared with other traps), followed by *Catops tristis tristis* (4.8%), *Catops picipes* (3.7%) and *Omalium excavatum* (3.6%).

Trap No. V: Five species represented 75% of the species community: *Sciodrepoides watsoni watsoni* (19.4%), *Oxypoda vittata* (18.3%, reached here the maximum of abundance compared with other traps), *Catops picipes* (14%), *Bembidion stephensii* (12.6%) and *Catops tristis tristis* (11%).

Trap No. VI: Five species represented more than 70% of the species community: *Sciodrepoides watsoni watsoni* (23.5%), *Catops picipes* (17.2%), *Choleva lederiana lederiana* (14.2%), *Catops tristis tristis* (10.7%) and *Oxypoda vittata* (5.2%).

Trap No. VII: Five species represented almost 60% of the species community: *Catops tristis tristis* (20.5%), *Sciodrepoides watsoni watsoni* (17.9%), *Choleva lederiana lederiana* (8%), *Atheta*

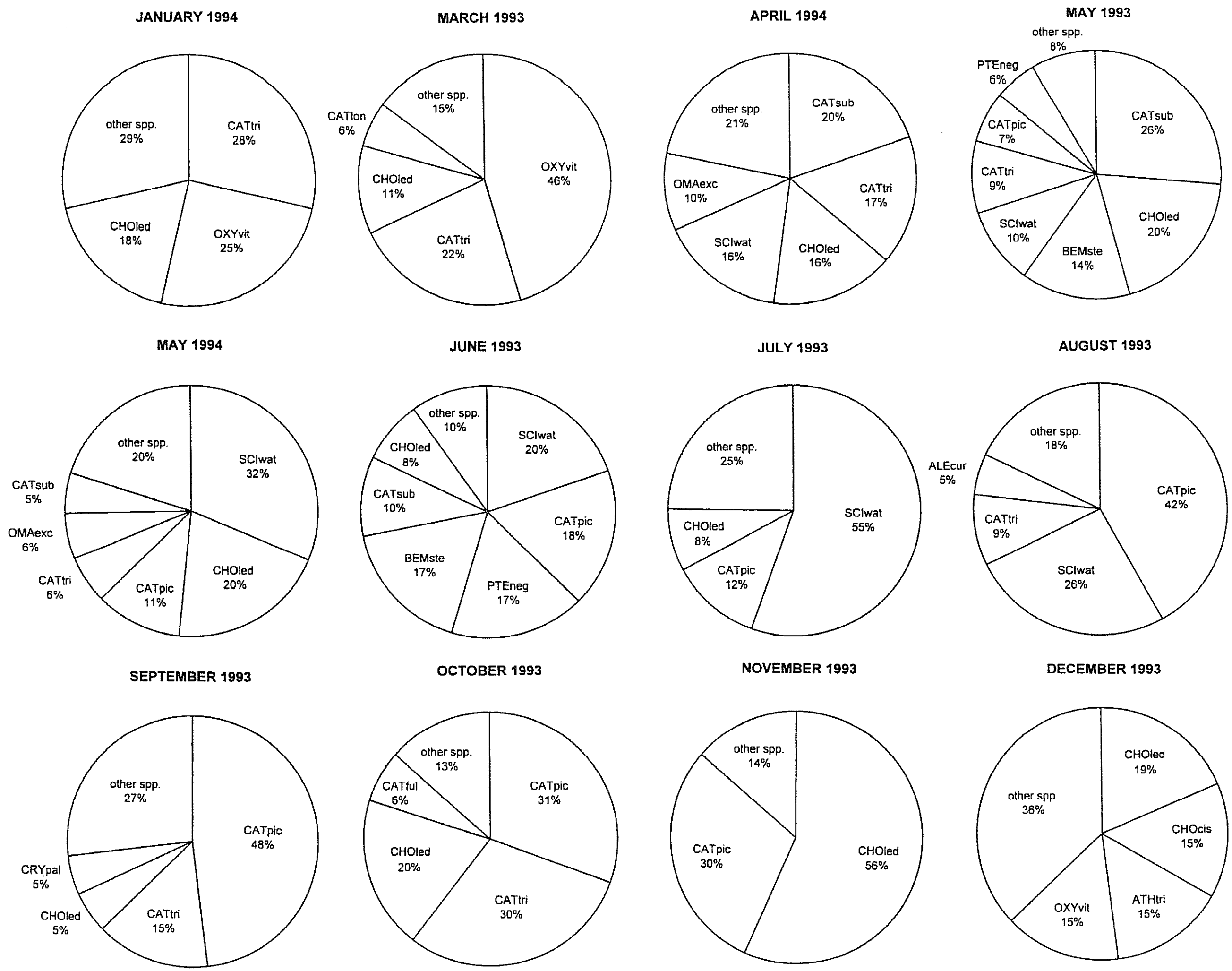

JANUARY 1994
other spp. 29%
CATtri 28%
CHOled 18%
OXYvit 25%
MARCH 1993
other spp. 15%
CATlon 6%
CHOled 11%
OXYvit 46%
CATtri 22%
APRIL 1994
other spp. 21%
CATsub 20%
OMAexc 10%
CATtri 17%
SCIwat 16%
CHOled 16%
MAY 1993
other spp. 8%
PTEneg 6%
CATpic 7%
CATsub 26%
CATtri 9%
SCIwat 10%
BEMste 14%
CHOled 20%
MAY 1994
other spp. 20%
SCIwat 32%
CATsub 5%
OMAexc 6%
CATtri 6%
CATpic 11%
CHOled 20%
JUNE 1993
other spp. 10%
CHOled 8%
SCIwat 20%
CATsub 10%
CATpic 18%
BEMste 17%
PTEneg 17%
JULY 1993
other spp. 25%
CHOled 8%
SCIwat 55%
CATpic 12%
AUGUST 1993
other spp. 18%
ALEcur 5%
CATpic 42%
CATtri 9%
SCIwat 26%
SEPTEMBER 1993
other spp. 27%
CATpic 48%
CRYpal 5%
CHOled 5%
CATtri 15%
OCTOBER 1993
other spp. 13%
CATful 6%
CATpic 31%
CHOled 20%
CATtri 30%
NOVEMBER 1993
other spp. 14%
CATpic 30%
CHOled 56%
DECEMBER 1993
CHOled 19%
other spp. 36%
CHOcis 15%
OXYvit 15%
ATHtri 15%

Fig. 16. Dominance structures (relative abundances; May 1993 to May 1994, sample of February 1993 omitted) in the beetle community of the rock debris on the Boreč hill, monthly. Abbreviations: ALEcur – *Aleochara curtula*, ATHtri – *Atheta triangulum*, BEMste – *Bembidion stephensii*, CATful – *Catops fuliginosus fuliginosus*, CATlon – *Catops longulus*, CATpic – *Catops picipes*, CATsub – *Catops subfuscus subfuscus*, CATtri – *Catops tristis tristis*, CHOcis – *Choleva cisteloides*, CHOled – *Choleva lederiana lederiana*, CRYpal – *Cryptophagus pallidus*, OMAexc – *Omalium excavatum*, OXYvit – *Oxypoda vittata*, PTEneg – *Pterostichus negligens*, SCIwat – *Sciodrepoides watsoni watsoni*.

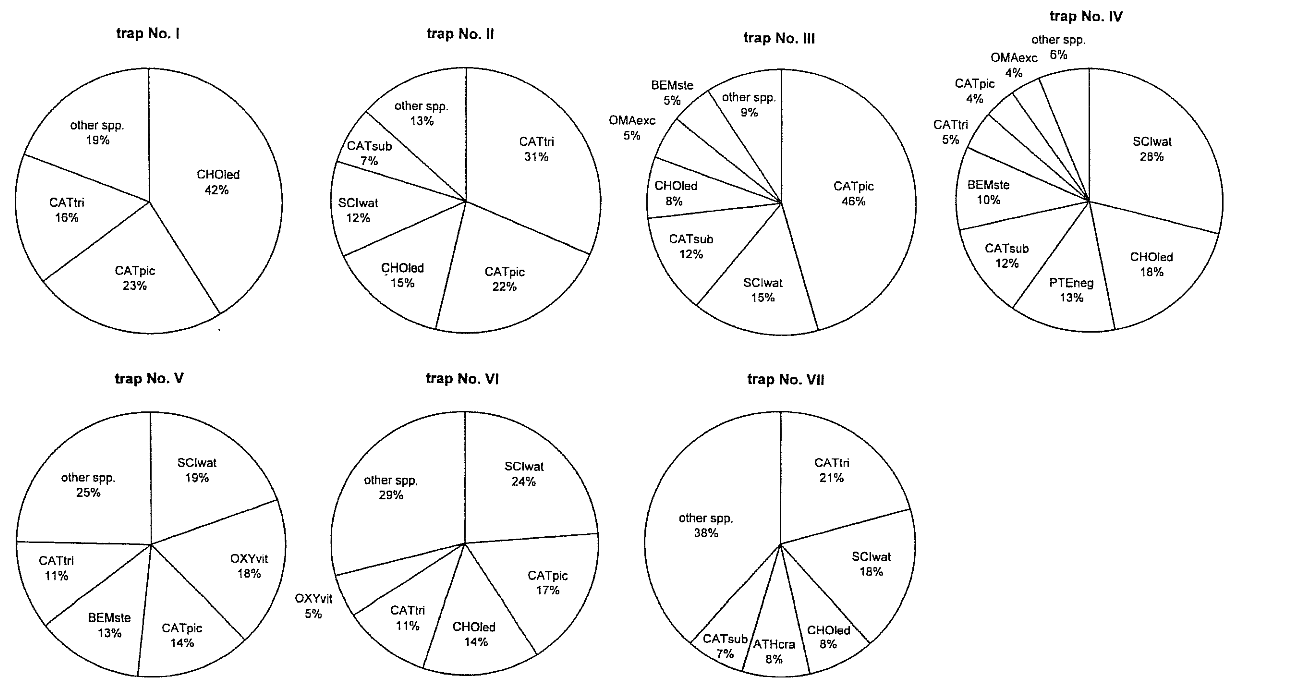


Fig. 17. Dominance structures (relative abundances) in the beetle community of the rock debris on the Boreč hill, May 1993 – May 1994, individual traps. Abbreviations: ATHcra – *Atheta crassicornis*, BEMste – *Bembidion stephensii*, CATpic – *Catops picipes*, CATsub – *Catops subfuscus subfuscus*, CATtri – *Catops tristis tristis*, CHOled – *Choleva lederiana lederiana*, OMAexc – *Omalium excavatum*, OXYvit – *Oxypoda vittata*, PTEneg – *Pterostichus negligens*, SCIwat – *Sciodrepoides watsoni watsoni*.

crassicornis (8%, reached here the maximum of abundance compared with other traps) and *Catops subfuscus subfuscus* (6.9%).

Using a WPGMA cluster analysis based on the Morisita's index of similarity and ln-transformed data, two main clusters of traps can be defined (Fig. 6): (1) traps from the central part (traps Nos. III and IV) and (2) traps from the marginal parts of the rock debris. Moreover, the traps from the upper margin (traps Nos. V–VII) are very closely branched in the second cluster, and further clustered with trap No. II and trap No. I from the bottom margin of the rock debris (Fig. 6).

Seasonal and spatial structure of abundance of frequent species

The nine most abundant species (each with at least 75 specimens, exceeding 2% of relative abundance) are sorted in the order of total abundance. In Figs 7–15, seasonal abundance of species (with percentage of teneral specimens indicated) is figured. The spatial abundance of species can be seen also in Table 2.

Catops picipes (Leiodidae): adult specimens were present from May to November, with a wide peak in August–October. The species breeds in late autumn, with preimaginal stages in winter months; teneral adults were present during almost the whole vegetation season (Růžička 1994; Fig. 7). In the traps, the species dominated in the middle part of the rock debris (namely in trap No. III) and also on the bottom margin, adjacent to the pasture (trap No. II).

Sciodrepoides watsoni watsoni (Leiodidae): adult specimens were present from April to October, with a single peak in July; teneral specimens were present mostly in July–August (Fig. 8). This species was most abundant in the middle part (traps Nos. III and IV) and also in the central part of the upper margin of the rock debris (trap No. VI).

Choleva lederiana lederiana (Leiodidae): the species was recently discovered in several cold rock debris ecosystems in northern Bohemia (J. Růžička & J. Vávra, unpubl.), and the data on the seasonal abundance of Central European populations are presented here for the first time and in a more detailed form than for other species, with male and female specimens figured separately. The adults were present during all months of the year, with two peaks in April–May and October–November, with teneral adults from July to November (Fig. 14). The pattern indicates bimodal adult activity with breeding in the late spring, and with over-wintering adults of the filial generation. The species was most abundant in the middle part (especially in trap No. IV) and in the bottom part of the rock debris (traps Nos. I and II).

Catops tristis tristis (Leiodidae): together with the previous species, adults were present during all months of the year, with a distinct peak in October (Fig. 9). The species was most abundant in the bottom part of the rock debris, adjacent to the pasture (trap No. II).

Catops subfuscus subfuscus (Leiodidae): adults were present from March to October, with a wide peak in April–June (Fig. 10). The species was most abundant in the middle part of the rock debris (traps Nos. III and IV).

Bembidion stephensii (Carabidae): adults were present from March to December, with a peak in May–June; teneral adults were present mostly in September–December (Fig. 11). The species was present in middle parts (traps Nos. III and IV) and in the upper part of the rock debris, between smaller stones (trap No. V).

Pterostichus negligens (Carabidae): adults were present from April to October, with a peak in May–June; teneral adults were present mostly in August–October, a few also in May (Fig. 12). The species was most abundant in the middle part of rock debris (especially, trap No. IV).

Oxypoda vittata (Staphylinidae): adults were present in October–May, more abundantly in October and March–April (Fig. 13). The species was most abundant in the upper part of the rock debris (traps Nos. V–VII).

Fig. 18. The general aspect of the rock debris, north-eastern slope of the Boreč hill, the České středohoří mts.

Omalium excavatum (Staphylinidae): adults were present from March to October, with peak in April–May (Fig. 15). The species was most abundant in the middle part of the rock debris (traps Nos. III and IV).

DISCUSSION

In this paper, an all-year-round seasonal abundance pattern of beetles in rock debris is presented for the first time. However, this pattern is generally similar to that found in the all-year-round study of coprophagous beetle community on pastures in south-western Germany (Waßmer 1994). Results differ slightly from those observed in western Germany in beetle communities from forested habitats, taken by unbaited pitfall traps (Köhler 1996: 199–200). Namely, main differences can be observed in the size of samples from the late fall (the highest number of specimens found in this study was achieved in October). These differences should be probably strongly influenced by the different microclimate of the rock debris ecosystems. The surface of the rock debris is not frozen at that time unlike the soil surface in open landscape (J. Růžička pers. obs.).

The fact that the Brillouin index of diversity has the decreasing tendency from bottom to upper margin of rock debris although the numbers of species are not significantly decreasing, is interesting. The differences observed should be influenced by various microclimatic conditions as well as by the proportions of stones along the vertical gradient of the rock debris (Růžička 1993). Similar differences were found for several spider and mite species in rock debris ecosystems (Růžička et al. 1995, Čeřovský & Holec 1996).

The seasonal abundance of most dominant species of Leiodidae is similar to the pattern observed by Růžička (1994a) in central Bohemia, and that of *Pterostichus negligens* corresponds to the results published by Martiš (1975) from the Krkonoše mts.

The pattern of seasonal abundance of *Choleva lederiana lederiana* is similar to that described by Biström & Hippa (1987) from the Torhola cave in south-western Finland but differs strictly from the known pattern of *C. lederiana holsatica* Benick et Ihssen in Benick, 1937 in Segeberger Höhle, a deep cave system in northern Germany, where the maximum peaks of adult activity occur in January–March and July–August, and the population reproduces mainly during winter months (Heun 1955, Zwick 1966). These differences can be related with the changes of food availability for this supposed generalist scavenger, with the possible maximum of food in rock debris or shallow caves during the vegetation season. A reversed pattern can be observed in deep cave systems, with maximum of food supply (mainly guano) produced during winter by hibernating bats (Ipsen 1997).

Acknowledgements

I am obliged to Pavel Moravec from the Administration of the České středohoří Protected Lanscape Area (Litoměřice) for his valuable help during the field work and sorting the collected material. The following persons kindly identified part of the material (more details listed in Materials and methods): Lubomír Hromádka (Praha), Tomáš Jászay (Bardejov), Matúš Kocian (Praha), David Král (Praha), Karel Majer (Brno), Pavel Moravec (Litoměřice), Miroslav Mikát (Hradec Králové), Petr Štourač (Praha) and the late Miroslav Reška. David Boukal (České Budějovice), David Král (Praha) and Jan Vitner (Praha) read earlier drafts and made helpful comments.

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