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Diversity and Ecology of the Soil- and Litter-dwelling Invertebrates and the Plant Associations in the Habitats of the Saskhori Limestone Quarry and Adjacent Areas, Eastern Georgia, Caucasus

Zezva Asanidze[1], Tea Arabuli[2], Eter Maghradze[2], Lado Shavadze[2], Mariam Gogshelidze[2], Naia Modebadze[2], Eleonora Kiria[2], Nana Barnaveli[3] & Shalva Barjadze[2*]

[1]Institute of Ecology, Ilia State University, Giorgi Tsereteli 1, 0162, Tbilisi, Georgia
[2]Institute of Zoology, Ilia State University, Giorgi Tsereteli 3, 0162, Tbilisi, Georgia
[3]Department of Biology, Ivane Javakishvili Tbilisi State University, Universiteti 13, 0186, Tbilisi, Georgia

Abstract: This case study is aimed to investigate the invertebrate fauna and distribution features of the faunal and floral diversity in seven habitats represented on the territory of the Saskhori limestone quarry and its adjacent territories (Eastern Georgia, Caucasus). Totally, 122 species of invertebrates and 131 species of plants were registered. The isopod species *Chaetophiloscia hastata* Verhoeff, 1928 (Malacostraca: Isopoda) is recorded in Georgia for the first time. Three oribatid mites, i.e. *Lucoppia burrowsi* (Michael, 1890), *Microzetorchestes emeryi* (Coggi, 1898) and *Nothrus parvus* Sitnikova, 1975 (Arachnida: Oribatida), were recorded in Saskhori Quarry for the first time. Four invertebrate species were cosmopolitan and were found in all sampling sites. The ecological analysis demonstrated the difference in the vegetation and invertebrate diversity of the natural and degraded landscapes of the Saskhori Quarry differentiated by Principal Component Analysis (PCA). Cluster analysis based on the Jaccard similarity coefficient separated the diversity of the degraded landscapes (1) using combined data of the vegetation and invertebrate diversity and (2) using only the diversity data of invertebrates. The latter analyses, along with the other statistical methods used (SIMPER and ISA), proved the habitat specificity of the invertebrate species by revealing their specific distribution in the natural and degraded landscapes.

Key words: Semiarid landscapes; species richness; indicator species; vegetation; South Caucasus

Introduction

The Caucasus ecoregion is one of 36 worldwide wildlife hot-spot ecoregions identified based on their great species and ecosystem biodiversity, high endemism and high risk of biodiversity loss (Mayrs et al. 2000, Noss et al. 2015). Accordingly, the Republic of Georgia has devised a National Biodiversity Strategy and Action Plan of Development (National Biodiversity Strategy and Action Plan – Georgia, NBSAP, 2014–2020) that establishes high priorities for the development of inventories of animal species and resources.

The Saskhori quarry is located to the west of the Saskhori village (Mtskheta Municipality, Mt-

[*]Corresponding author: shalva.barjadze@iliauni.edu.ge

skheta-Mtianeti region, eastern Georgia). Mining in the quarry was started in 2018. Before our investigation, only oribatid mites (Arachnida: Oribatida) (51 species) were studied in the territory of this quarry (Murvanidze et Al. 2018). Other soil- and litter-dwelling invertebrates such as springtails (Collembola), arachnids (Arachnida: Araneae, Pseudoscorpiones and Opiliones), myriapods (Myriapoda: Diplopoda and Chilopoda), isopods (Malacostraca: Isopoda) and beetles (Insecta: Coleoptera) have not been studied in Saskhori quarry and adjacent territories. The abovementioned invertebrates are widely distributed and have an important role in the functioning of ecosystems. They participate in the processes of soil formation and most of them represent bioindicators of heavy metals pollution in the soil (Cortet et al. 1999, Fountain & Hopkin 2004, Avgin & Luff 2010).

The goal of this project was to conduct taxonomic, faunistic and ecological investigations of soil- and litter-dwelling invertebrates and their associations with vegetation in seven selected sites of Saskhori quarry and adjacent territories.

Materials and Methods

We placed sampling sites in various habitat types represented on the territory of the Saskhori limestone quarry and its adjacent areas, for reaching the maximum representativeness of the sample for the study area. The total number of sampling sites was seven (Fig. 1). Each site has been geo-referenced and structurally arranged for continuous sample collection during the active phenological period of the year: from February to August 2022. Soil and litter samples were collected in each selected site (sites 1-7). Isolation of invertebrates from the samples was made using Berlese and Winkler's extractors. The isolated invertebrates were preserved in 70 % and 96 % ethanol. In addition, pitfall traps with formalin were used for sampling invertebrates. Invertebrates' mounting and pinning process and species identification were conducted according to the relevant methodologies for each animal group.

Studied invertebrate groups are mites, spiders, harvestmen, pseudoscorpions, isopods, millipedes, centipedes, collembolans and beetles.

Sampling sites were visited thirteen times. We put the special focus of our study on the differentiation of the invertebrate diversity between the degraded and natural habitats in the study territory.

Vegetation diversity was sampled in each sampling site, in plots with a size of 5 × 5 m, in accordance with the sample size corresponding to the level of plant diversity in the semiarid shrublands in the Caucasus Ecoregion (Nakhutsrishvili et al. 2017). For the high representativeness of the sample, the vegetation was surveyed two times, in May and July, when the species richness reaches its maximum in semiarid habitats. We sampled plant species richness and abundance of each species of vascular plant in the vegetation survey plots using the methods based on the Braun-Blanquet scale (1932). The data on the plant species abundance were converted into percentage data following the methodology explained by Peet & Roberts (2013).

The plant species were identified following the plant identification keys provided in *Flora of Georgia* (Ketzkhoveli & Gagnidze 1965-2016). The modern plant taxonomic data were obtained from recent literature (Gagnidze et al. 2005, Davlianidze et al. 2018) and Web sources (Plant List 2010, GBIF 2022, Euro+Med 2006-2021).

Habitats were identified following the classification of the habitats of Georgia (Akhalkatsi & Tarkhnishvili 2012) and the classification of the European Nature Information System (EUNIS) (Davies et al. 2004).

Habitat and environmental characteristics of the localities of the placement of the sample collection sites on the territory of the limestone quarry in Saskhori and its adjacent areas are provided in Table 1.

In statistical analysis, we estimated the Shannon Diversity Index and Evenness of the vegetation diversity and diversity of the studied invertebrate groups for each sampling site. The estimated data were averaged to the unit of the sampling site in order to simplify the introduction of the results of the data analysis. In addition, the use of the ANOVA test was avoided in the recent step of the data analysis. One of the major reasons for this is the expectance of low within-group variability of the variables caused by the close allocation of the sampling plots on the site. We consider this approach as being correct due to the specificity of the report structure.

Sørensen–Dice index (Dice 1945, Sørensen 1948) index of the similarity of the diversity was used to compare the results of our study with the diversity data obtained from the literature sources concerning the diversity of the plant and invertebrate communities distributed on the territories of quarries and other strongly modified habitats. The index was converted into a percentage of the similarity by multiplying its numeric values by 100.

We used the method of the principal component analysis (PCA) for the ordination of the vegetation and invertebrate diversity measured in the sampling plots where PCs with the highest loads of

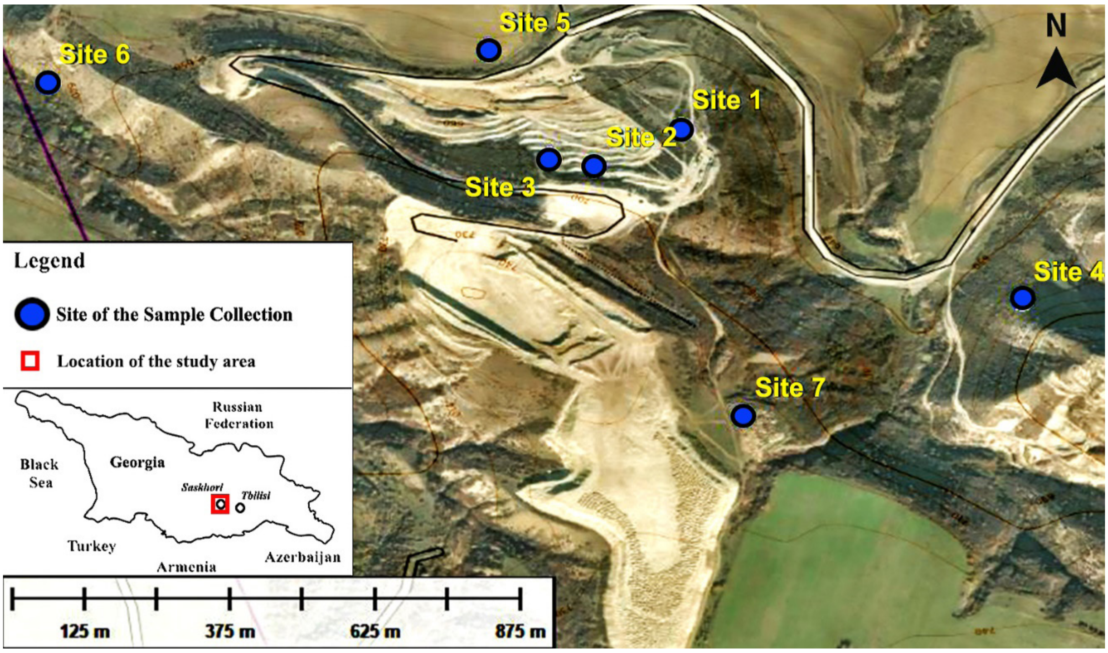

Fig. 1. Scheme of the distribution of sample collection sites on the territory of the limestone quarry in Saskhori and its adjacent areas.

Table 1. Environmental characteristics of the localities of the placement of the sample collection sites on the territory of the limestone quarry in Saskhori and its adjacent areas

Site ID	Latitude	Longitude	Geo-graphic position	Habitat	Landscape feature
1	41.84584	44.51863	N	Shibliak or Mediterranean-type deciduous drought-resistant shrubbery (similar to 'Pseudo-maquis' recognized by EUNIS habitat classification [habitat code [F5.3])	Shrubland in the adjacent area to the limestone quarry
2	41.84526	44.5173	N	Extremely degraded habitat poor in vegetation	Landscape with a bare surface of the limestone quarry (bedrock)
3	41.84536	44.51661	E	Xero-thermophilous oak forest (similar to the Meso- and eutrophic *Quercus*, *Carpinus*, *Fraxinus*, *Acer*, *Tilia*, *Ulmus*, and related woodland recognized by EUNIS habitat classification (habitat code: G 1. A)	Landscape with a degraded forest in the adjacent area to the limestone quarry
4	41.84706	44.51566	N	Shibliak or Mediterranean-type deciduous drought-resistant shrubbery (similar to 'Pseudo-maquis' recognized by EUNIS habitat classification [habitat code F5.3])	Shrubland in the adjacent area to the limestone quarry
5	41.84321	44.52392	SE	Rural and urban vegetation (similar to "Arable land with unmixed crops grown by low-intensity agricultural methods" recognized by EUNIS habitat classification [habitat code: I 1.3])	A landscape dominated by cropland – Almond garden
6	41.84655	44.50885	W	Mixed vegetation of the Oak-hornbeam woodland and Shibliak or Mediterranean-type deciduous drought-resistant shrubbery (similar to "Pseudomaquis" recognized by EUNIS habitat classification [habitat code [F5.3])	Degraded forest in small and dry ravine adjacent to the limestone quarry
7	41.84139	44.51961	S	Degraded habitat with floral elements of Bothriochloeto-Stipeto-Artemisieto steppes (similar to the Mediterranean tallgrass and wormwood (*Artemisia* sp.) steppes recognized by EUNIS habitat classification [habitat code: E1.3]	The landscape of the abandoned site of the limestone quarry with significantly modified steppe vegetation dominated by ruderal and invasive plants

the analysed variables were used as the ordination factors. PCA was done using abundance data of vegetation and invertebrate diversity.

We included united incidence data of plant and invertebrate species in the cluster analysis and conducted it using the algorithm of Unweighted Pair Group Method with Arithmetic Mean (UPGMA) and Jaccard similarity index as a method of distance measurement between the cluster groups. In the graph visualizing the results of this analysis, we also provided the average similarity of the diversity of a particular surveyed site to the beta diversity or the diversity registered in all surveyed sites. For this task, we averaged the Jaccard similarity index of individual sites showing their similarity to the other six sites and multiplied it by a hundred to convert it into a percentage value of the similarity.

The means of the variables used in the cluster analysis were compared using a two-tailed t-test between the cluster groups separated in the PCA. We also employed an analysis of the similarity percentages (SIMPER) (Clarke 1993) to assess the average percent contribution of separate plant and invertebrate species in the formation of the communities on the natural and degraded landscapes affected by the extraction of limestone.

Indicator Species Analysis (ISA) was used for the clearer attribution of the plant and invertebrate species to the clusters of the natural and degraded landscapes of the study area. In ISA, species indicator values (Ind. Val.) in percentage and the significance of correlations of the species were calculated using a randomization test with a bootstrap setting of 999 iterations. The species with an Ind. Val. lower than 0.6 % were removed from the results of the analysis to ensure the reliability of the results. The analysis followed the methodology of Dufrêne & Legendre (1997) and De Cáceres & Legendre (2009).

Statistical analysis and illustration of the results were conducted using the software PAST v. 4.40 (Hammer et al. 2001); SPSS v. 21 (Hinton et al. 2014), MS Excel 2020, and R studio 4.2.2 (R Core Team 2013, Roberts & Roberts 2016).

Results

Taxonomic diversity

During the investigations in Saskhori quarry and adjacent territories, we registered 122 species of invertebrates, of which 17 taxa of spiders; 8 centipedes, millipedes and collembolans, 26 beetles, 4 isopods and pseudoscorpions, 2 harvestmen and 45 oribatid mites. Totally, 131 species of plants were recorded in the studied territories, of which 18 species of woody plants, 15 species of grasses, 2 sedges, 8 legumes and 88 herbs (Appendix, Table A1).

The isopod *Chaetophiloscia hastata* Verhoeff, 1928 (Philosciidae) was recorded in Georgia for the first time (Shavadze et al. 2023). Besides, three oribatid mite species – *Lucoppia burrowsi* (Michael, 1890), *Microzetorchestes emeryi* (Coggi, 1898), and *Nothrus parvus* Sitnikova, 1975 were recorded in Saskhori Quarry for the first time. The maximum number of invertebrate species (52 species) was found at sites Nos. 1 and 7, followed by 48, 46 and 45 species in sites Nos. 6, 4 and 3, respectively. In addition, 40 and 28 species were registered at sites Nos. 5 and 2, respectively (see Appendix, Table A2). Expectedly, invertebrate species richness was higher on the landscapes including local natural habitats than in the degraded habitats of Saskhori quarry. Five invertebrate species, i.e. *Armadillidium vulgare* (Latreille, 1804) and *Trachelipus* sp. (Isopoda), *Phalangium punctipes* (Koch, 1879) (Symphypleona) as well as *Aleurodamaeus setosus* (Berlese, 1883) and *Scheloribates laevigatus* (Koch, 1835) (Oribatida), being cosmopolite species, were found in all sampling sites.

Ecological traits

The results of the PCA showed that the abundance of each individual invertebrate group had the greatest effect on the ordination of the sampling sites. It appeared to be an important factor for the ordination as most of the surveyed sites were occupied by a specific type of habitat (Table 1). Variables of the abundance of the invertebrate groups and the species richness of the herbaceous plants had the highest eigenvalues of loading on PC1 and PC2 (Table 2). The differences in the vegetation cover and the diversity of woody plants, grasses, sedges and herbs from the vegetation components as well as the diversity of invertebrate species represented by the Isopoda, Julida, Oribatida, Pseudoscorpiones and Chordeumatida had the discriminative impact on the separation of PCA clusters. In PCA, the first three PC, with eigenvalues > 20, explained 82.3 % of the variation of the diversity of the vegetation and habitat-specific invertebrates in the surveyed sites, with the first two accounting for 78.1% (Fig. 2).

PCA separated vegetation and invertebrates' diversity of the degraded habitats (Site 2 – limestone quarry; Site 5 – almond garden and Site 7 – abandoned limestone quarry) from that in the natural landscapes unaffected during the limestone mining (sites 1, 3, 4 and 6). Cluster A comprised closely allocated sites that were surveyed on the natural landscapes of the study area, and Cluster B united sites

Table 2. Results of the principal component analysis (PCA) and t-test (P values between A and B clusters). Significant values of loadings are shown in bold font in the table

Variables	PC 1	PC 2	PC 3	PC 4	PC 5	t-test
Woody plants	0.503	-0.189	0.001	0.015	-0.005	0.003**
Grasses & Sedges	-0.003	-0.684	-0.024	0.010	0.017	0.012*
Legumes	0.000	0.043	-0.013	-0.005	0.119	0.183
Herbs	-0.042	-0.572	-0.239	0.051	0.333	0.021*
Vegetation cover in the plot (%)	-0.095	**0.832**	-0.037	0.127	-0.370	0.002**
Coleoptera	0.002	0.025	-0.488	0.003	-0.018	0.143
Isopoda	**0.908**	-0.027	-0.087	-0.018	-0.121	0.001**
Sarcoptiformes	0.009	-0.045	0.400	0.036	-0.209	0.082
Araneae	-0.056	**0.972**	0.112	-0.152	-0.073	0.001**
Polydesmida	0.000	-0.060	-0.001	0.006	0.070	0.122
Julida	-0.020	-0.075	0.514	-0.002	-0.120	0.038*
Oribatida	-0.568	0.062	-0.020	-0.011	0.017	0.034*
Pseudoscorpiones	-0.006	**0.781**	0.102	0.112	0.431	0.013*
Entomobryomorpha	0.002	-0.018	0.104	-0.036	-0.158	0.332
Geophilomorpha	**0.612**	-0.042	0.018	-0.086	0.025	0.146
Chordeumatida	-0.021	-0.521	0.016	-0.388	0.003	0.018*
Opiliones	0.132	-0.063	0.002	0.321	-0.018	0.233
* Variability of the variable between A and B cluster groups is significant at a low level ($P \leq 0.05$) ** Variability of the variable between A and B cluster groups is significant at a high or medium level ($P \leq 0.001$ or 0.01)						

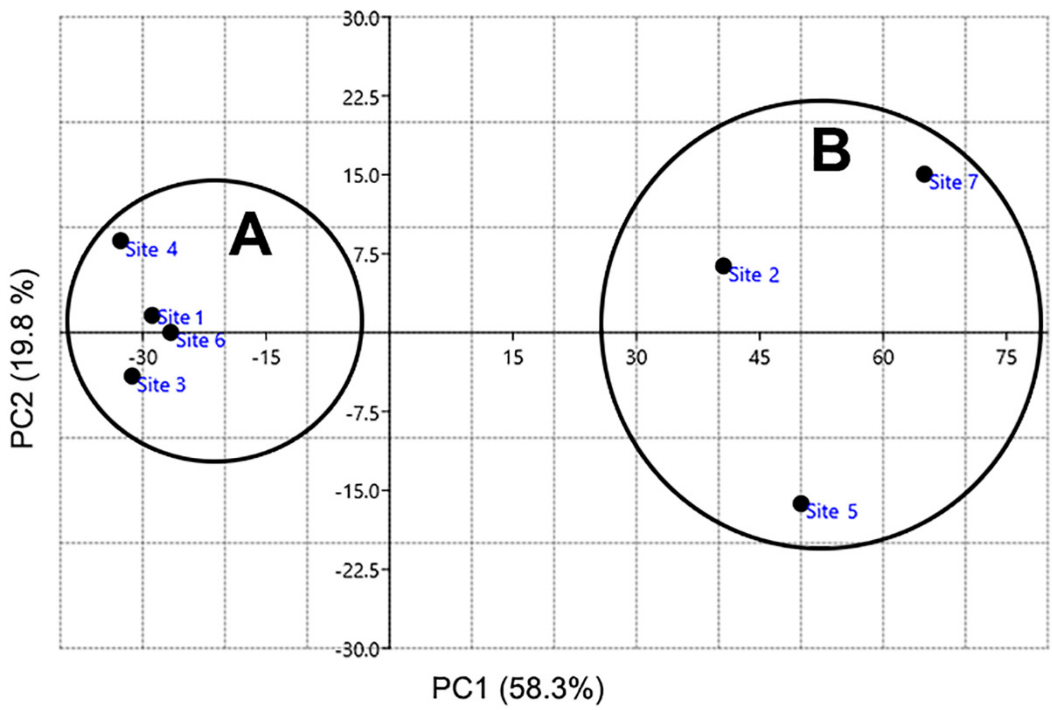

Fig. 2. Results of the principal component analysis (PCA): Ordination of the surveyed sites based on the diversity of the vegetation and habitat-specific invertebrates.

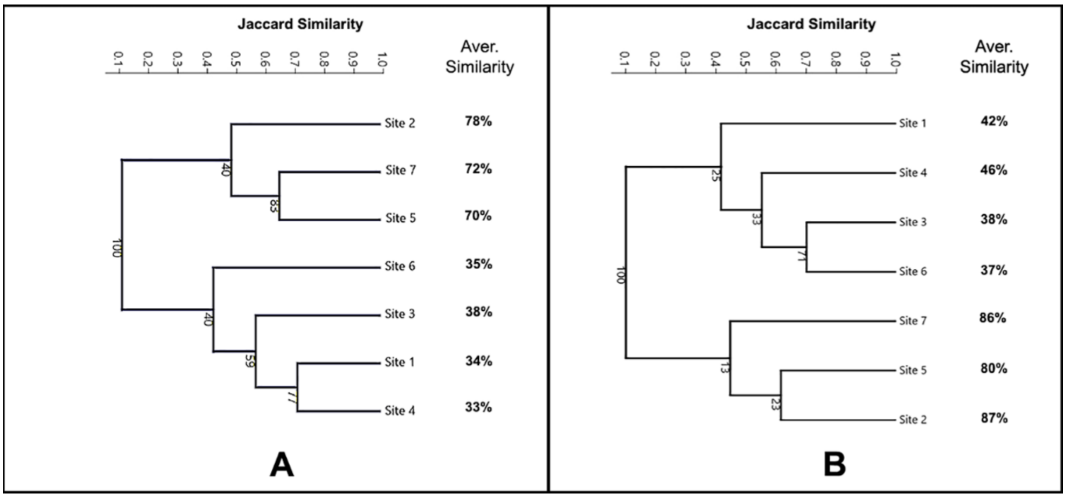

Fig. 3. Dendrograms of the relationship between the diversities of the surveyed sites. A. Dendrogram based on combined data of the invertebrate and vegetation diversity. B. Dendrogram based only on the invertebrate diversities.

surveyed on the degraded landscapes. Sites included in Cluster B were more scattered than in Cluster A, which indicates the existence of a weak relationship of the diversity between the sites of the degraded landscapes (Fig. 2).

T-test estimated significant variability of the vegetation cover ($P = 0.032$) and species richness of the vegetation groups (woody plant species, grasses, sedges, legumes and herbs) ($P \leq 0.01$) and low level or no variability of the abundance and incidence of the invertebrate classes ($P \geq 0.03$) (Table 2).

The results of the cluster analysis based on the Jaccard similarity coefficient of the combined data of the invertebrates and vegetation diversity (Dendrogram A) and particularly just of invertebrate diversity (Dendrogram B), also separated the diversity of the sites of the degraded landscapes from those of the natural landscapes (Fig. 3). Dendrogram A linked communities of the shrublands closer to each other (Sites 1 and 4) and slightly separated them from the communities of the oak-hornbeam (site 3) and woodland of the dry ravine (site 6) and united it in the group together. The results of the analysis related closer the plant and invertebrate communities of the site of the abandoned limestone quarry (site 7) to those of the almond garden (site 5) rather than the communities of the most recently affected landscape by the limestone mining (site 2); however, all these communities clustered in one group. The results of cluster analysis (Fig. 3, B) suggested the existence of a closer relation to the invertebrate diversity of the woodlands (sites 3 and 6) and a lower level of similarity of the invertebrates of shrublands (sites 1 and 4). It also showed the higher similarity of the invertebrate diversity between the sites of the almond garden and limestone quarry (sites 2 and 5) than with the abandoned limestone quarry (site 7).

Comparing the diversity of vegetation between the sites of the natural (PCA cluster A) and degraded (PCA cluster B) landscapes, the Jaccard coefficient was 31.7 % (coefficient value 0.317) and Sørensen–Dice coefficient was 54.8 % (coefficient value 0.548), showing rather low similarity of the vegetation between the two clusters. In the case of invertebrate diversity, the Jaccard coefficient was 48.3 % (coefficient value 0.483) and the Sørensen–Dice coefficient estimated 62.3 % (coefficient value 0.623) similarity between the clusters.

The results of SIMPER demonstrated that no particular plant and invertebrate species had significantly greater value than the remaining species in communities in both natural and degraded landscapes. However, the top 20 species of plants and invertebrates (Table 3) ranked the most common vegetation-forming plants and habitat-specific invertebrates in these landscapes. There were no prominent plant species with stronger contribution in the formation of the vegetation of degraded and natural landscapes as evidenced by the lack of strong differences in the mean values of the species contribution in these landscape types (Table 3). The first 14 plant species (Table 3) had higher importance in the formation of the vegetation community of natural landscapes; the last four species were most common in the degraded landscapes.

There was a similar tendency in the results of the SIMPER analysis of the species contribution of the invertebrate communities of the studied landscape types. The contribution values of the invertebrate species were not significantly different from

Table 3. The results of the similarity percentage analysis (SIMPER). The table provides 20-20 species of plants and invertebrates having the highest contribution to the formation of the vegetation community and invertebrate diversity of the natural and degraded landscapes

Taxon	Average dissimilarity	Contribution %	Cumulative %	Mean – Natural landscapes	Mean – Degraded landscapes
Part A. Plant species					
Stipa arabica	1.98	2.20	2.20	1.00	0.00
Brachypodium distachyon	1.98	2.20	4.40	1.00	0.00
Artemisia caucasica	1.62	1.80	6.20	0.75	0.00
Carex praecox	1.58	1.75	7.95	0.75	0.00
Astragalus hirtulus	1.46	1.62	9.57	0.75	0.00
Eremopyrum orientale	1.46	1.62	11.19	0.75	0.50
Lonicera caprifolium	1.46	1.62	12.81	0.75	0.00
Artemisia lercheana	1.46	1.62	14.42	0.75	0.00
Gentianella acuta	1.46	1.62	15.85	0.75	0.00
Daucus carota	1.29	1.43	17.28	0.75	0.00
Falcaria vulgaris	1.29	1.43	22.86	0.75	0.00
Aethusa cynapium	1.22	1.35	24.21	0.50	0.00
Setaria verticillata	1.22	1.35	25.56	0.50	0.00
Onobrychis miniata	1.22	1.35	18.69	0.50	0.00
Bupleurum exaltatum	1.27	1.41	20.10	0.00	1.00
Bunias orientalis	1.27	1.41	21.50	0.00	1.00
Centaurea solstitialis	1.27	1.41	26.92	0.00	1.00
Galium humifusum	1.22	1.35	28.21	0.00	1.00
Erysimum repandum	1.16	1.29	29.50	0.50	1.00
Part B. Habitat-specific invertebrates					
Phalangium punctipes	1.16	2.09	2.09	0.00	1.00
Anthelephila pedestris	1.16	2.09	4.17	1.00	0.00
Armadilidium vulgare	0.90	1.62	5.79	0.25	1.00
Lithobius cronebergii	0.90	1.62	7.41	0.75	0.00
Tectocepheus velatus	0.81	1.46	8.87	0.75	0.00
Haplozetes tenuifusus	0.79	1.43	10.30	0.00	0.67
Crypticus quisquilius	0.79	1.43	11.73	0.00	0.67
Carabus adamsi	0.79	1.43	13.16	0.00	0.67
Trox sp.	0.79	1.43	14.59	0.00	0.67
Calathus melanocephalus	0.78	1.41	16.00	0.00	0.67
Brachinus crepitans	0.78	1.41	17.40	0.00	0.67
Pseudotorynorrhina sp.	0.74	1.34	18.74	0.00	0.67
Minunthozetes pseudofusiger	0.74	1.34	20.08	0.00	0.67
Lucoppia burrowsi	0.74	1.34	21.42	0.00	0.67
Zetorchestes micronychus	0.70	1.26	22.67	0.75	0.33
Liacarus brevilamellatus	0.69	1.25	23.92	0.25	0.67
Scytodes thoracica	0.69	1.24	25.17	0.75	0.33
Opilio sp.	0.69	1.24	26.40	0.75	0.33

each other, which indicated that there were no prominent dominant species forming the invertebrate communities in the natural or degraded landscapes of Saskhori quarry (Table 3 B).

The results of ISA associated 11 plant species and 12 invertebrate species to the diversity of the natural landscapes and 9 taxa of plants and 12 taxa of invertebrates to the degraded landscapes (Table 4). The attributed species were the most representative of the linked ecotopes based on their ecology. However, they were also very specific to the biota of Georgia, occurring in dryland habitats having fragmented distribution patterns and occurring in the eastern part of the country.

Table 4. Results of indicator species analysis (ISA). P – significance of the attribution of the species to the clusters of the natural and degraded landscapes.

Habitat-specific invertebrates					**Plant species**				
Taxa	**Natural landscapes**		**Degraded**		**Taxa**	**Natural landscapes**		**Degraded**	
	Indicator values (%)	**P ≤**	**Indicator values (%)**	**P ≤**		**Indicator values (%)**	**P ≤**	**Indicator values (%)**	**P ≤**
Anthelephila pedestris	0.88	0.001	-	-	*Stipa capillata*	0.92	0.001	-	-
Lithobius erythrocephalus	0.76	0.001	-	-	*Brachypodium distachyon*	0.90	0.001	-	-
Phalangium punctipes	0.62	0.050	0.85	0.001	*Artemisia caucasica*	0.86	0.001	-	-
Armadilidium vulgare	0.87	0.001	0.71	0.01	*Carex praecox*	0.84	0.01	-	-
Crypticus quisquilius	-	-	0.83	0.001	*Eremopyrum orientale*	0.72	0.03	0.60	0.05
Neobisium sp. 2	-	-	0.82	0.001	*Astragalus hirtulus*	0.70	0.03	-	-
Hister quadrimaculatus	-	-	0.8	0.001	*Onobrychis angustifolia*	0.66	0.03	-	-
Trachelipus sp.	-	-	0.78	0.001	*Daucus carota*	0.64	0.05	-	-
Lithobius ferganensis	0.89	0.001	-	-	*Jasminum fruticans*	0.60	0.05	-	-
Carabus cf. *maurus*	-	-	0.76	0.01	*Paliurus spina-Christi*	0.60	0.05	-	-
Chthonius sp.	-	-	0.68	0.01	*Bupleurum exaltatum*	-	-	0.88	0.001
Tegenaria sp.	0.73	0.001	0.63	0.03	*Bunias orientalis*	-	-	0.87	0.001
Agriotes sp.	0.72	0.001	0.63	0.03	*Centaurea solstitialis*	-	-	0.75	0.001
Opilio sp.	0.68	0.030	0.62	0.05	*Carduus hamulosus*	-	-	0.74	0.01
Dysdera sp.	0.65	0.050	0.6	0.05	*Erysimum repandum*	-	-	0.7	0.03
Geophilus sp.	-	-	0.6	0.05	*Festuca varia*	0.68	0.03	0.68	0.03
Gnaphosa sp.	-	-	0.6	0.05	*Psephellus amblyolepis*	-	-	0.64	0.05
Harpalus rufipes	0.60	0.050	-	-	*Scutellaria orientalis*	-	-	0.63	0.05
Brachinus crepitans	0.60	0.050	-	-	*Galium humifusum*	-	-	0.63	0.05
Trochosa ruricola	0.60	0.050	-	-	*Agropyron pectinatum*	-	-	0.61	0.05
-	-	-	-	-	*Campanula hohenackeri*	-	-	0.61	0.05

Discussion

The ecological part of our study clearly demonstrated the difference in the vegetation and invertebrate diversity of the natural and degraded landscapes of the Saskhori limestone quarry. The results of the t-test of both plant and invertebrate groups as variables (Table 2) between the clusters differentiated by PCA (Fig. 2) showed a significant difference in vegetation and invertebrate diversity between natural and degraded landscapes. However, only some groups of plants and invertebrate show a high impact on the separation of the clusters of the natural and degraded landscapes; this is an expected result as these groups include species of diverse ecological requirements. The results of cluster analysis clearly show the habitat specificity of some invertebrates, which are linked to either natural or degraded landscapes (Fig. 2).

The results of SIMPER reveals plant and invertebrate species specific to the natural and degraded landscapes of the Saskhori limestone quarry. However, it also shows that the contribution values of the species included in the ranked list (Table 3) are not equal (in both plant and invertebrate communities). The results of the PCA also indicate the absence of a distinct dominant species in specific ecotopes and their communities. It can be explained by the sampling effect, in particular by the multiple samplings in different seasons, which increases the evenness in the unified database after the aggregation of the data.

The results of ISA create a clearer picture of the specific characteristics of the vegetation and invertebrate diversity in the natural and degraded landscapes of the study area by focusing on the most representative species of these landscapes (Table 4). The plant species aggregated to the sites of landscapes degraded due to anthropogenic activity (such as limestone mining and gardening) are *Bupleurum exaltatum*, *Bunias orientalis*, *Centaurea solstitialis*, *Carduus hamulosus*, *Erysimum repandum*, *Festuca varia*, *Psephellus amblyolepis*, *Scutellaria orientalis*, *Galium humifusum*, *Agropyron pectinatum* and *Campanula hohenackeri*. The invertebrate species characteristic for these degraded habitats are: *Geophilus* sp. (centipede), *Chthonius* sp., *Neobisium* sp. 2 (false scorpions), *Dysdera* sp., *Gnaphosa* sp. (spiders), *Opilio* sp., *Phalangium punctipes* (harvestmen), *Armadilidium vulgare*, *Trachelipus* sp. (isopods), *Carabus* cf. *maurus*, *Crypticus quisquilius* and *Hister quadrimaculatus* (beetles).

The cluster analysis (Fig. 3) based on the Jaccard's index shows that the diversity of the plant and invertebrate communities of the degraded landscapes (sites 2, 5 and 7) is higher, with values of the overall (β) diversity (the diversity registered in all sites of the study area) than compared to the natural landscapes. It means that the sites of degraded landscapes are inhabited by trivial species and the sites of the natural landscapes support higher proportion of unique species. It was probably the most expected result as the species with the strong physiological flexibility and phenotypic plasticity are mostly the cosmopolite species, which are well adapted to a wide range of environmental conditions (Chown & Terblanche 2006, Richards et al. 2006, Whitman & Ananthakrishnan 2009). The majority of these species, especially plants, gain a high rank also in the results of SIMPER analysis (Table 3), which determines the reliability of the results of both SIMPER and ISA. Plants and invertebrates associated with the degraded landscapes of the quarry are cosmopolite species occurring in a wide range of habitat and landscape types; however, they are also characteristic for the habitats of Georgia, as they are associated with the semiarid vegetation communities having fragmented distribution and occurring in the eastern part of the country. These species are pioneers or "winning species" in the competition for the assimilation of degraded habitats. Their discovery is one of the main results of our study as these species form the diversity of the primary succession of the vegetation and habitat-specific invertebrates on the degraded landscape with limestone-rich substrates, which are quite rare in Georgia as well as in the entire South Caucasus.

The information provided about quarries by Shetekauri & Shetekauri (2014) describes only the taxonomic diversity of the plant communities of the quarries of the Heidelberg Cement Company in Georgia. This information allows us to estimate the similarity of the diversity of the plant communities of the degraded landscape of Saskhori quarry with those of two other quarries mined by this company and their adjacent habitats in the eastern part of Georgia. According to this source, the vegetation of the habitats of the surroundings of the quarries at Dedophlistskaro, which are far east locality in the country, and Gardabani, which is located in the southeast part of Georgia, is dominated by the Shibliak or Mediterranean-type deciduous shrubbery, with fragments of the xerothermophilous oak forest. These are the most widespread vegetation of the dry types of woodlands, which occur in the surroundings of the Saskhori quarry (Table 1). Shetekauri & Shetekauri (2014) associate 126 plant species with the Dedophlistskaro and 168 species with the Gardabani dry type of woodlands, from which 54 species (36.7 %) are shared between the communities of these two sites. The similar vegetation of the Saskhori quarry shares 51 species (36.7 %) with the communities of Dedophlistskaro and 49 species (41.5 %) with the Gardabani sites (out of 110 species registered in similar plant communities during our study). The comparison also shows that all plant species associated with the degraded landscapes of the Saskhori quarry by the results of ISA (Table 4) are also represented in the communities of both limestone queries in Dedophlistskaro and Gardabani. This result once again supports out observations on the successfulness of cosmopolitan species in the interspecific competition for the occupation of the degraded landscape of the quarry.

The habitat-specific invertebrate taxa (Table 3) are widely distributed species and they should be found in different kind of habitats, including degraded ones such as quarries. It seems that widely distributed species are dominating in the degraded landscapes due their easer adaptation to harsh environmental conditions.

Our study is the first attempt of using the interdisciplinary approach to study the floristic and faunistic diversity of the Saskhori limestone quarry. It is highly desirable to continue with a repetitive study in the future years in order to observe the dynamics of changes in the vegetation and invertebrate diversity.

In addition, it should be mentioned that oribatid mite communities on post-industrial sand and manganese tailing sites, reclaimed areas, natural meadows and forests in the Chiatura region were studied and 89 mite species were revealed (Murvanidze et al. 2013). Based on Sorensen-Dice index, the similarity between oribatid mite complexes of Saskhori limestone quarry and Chiatura manganese mining area is 35.11 %. All shared oribatid species are widely distributed and, in our opinion, the degradation of the natural habitats might be the reason for their high similarity.

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Appendix

Table A1. Plant species from the Saskhori limestone quarry and adjacent areas

N	Plant Group	Species	Sites of the sample collection (Site ID)						
			1	2	3	4	5	6	7
1	Woody plants	*Acer laetum*	+	-	+	+	-	+	-
2	Woody plants	*Carpinus orientalis*	+	-	-	+	-	-	-
3	Woody plants	*Cotinus coggygria*	+	-	+	+	-	-	-
4	Woody plants	*Cotoneaster integerrimus*	+	-	-	-	-	+	-
5	Woody plants	*Crataegus orientalis*	-	-	+	+	-	-	-
6	Woody plants	*Ephedra procera*	-	-	+	+	-	-	-
7	Woody plants	*Jasminum fruticans*	-	-	+	-	-	-	-
8	Woody plants	*Juniperus communis (syn. J. oblonga)*	-	-	+	+	-	-	-
9	Woody plants	*Ligustrum vulgare*	-	-	-	-	-	+	-
10	Woody plants	*Lonicera caprifolium*	+	-	+	+	-	-	-
11	Woody plants	*Paliurus spina - Christi*	+	-	-	+	-	-	-
12	Woody plants	*Prunus spinosa*	-	-	-	-	+	-	-
13	Woody plants	*Prunus dulcis (syn. Amygdalus communis) / cultivated*	+	-	-	+	-	-	-
14	Woody plants	*Quercus petraea subsp. iberica*	-	-	-	+	-	-	-
15	Woody plants	*Rhamnus pallasii*	-	-	-	-	-	+	-
16	Woody plants	*Rosa cannina*	-	-	+	-	-	-	-
17	Woody plants	*Rosa spinosissima*	-	-	-	-	-	+	-
18	Woody plants	*Swida australis*	-	-	+	-	-	-	-
19	Grasses	*Agropyron pectinatum*	+	-	-	+	-	+	+
20	Grasses	*Bothriochloa ischaemum*	-	-	-	-	-	+	-
21	Grasses	*Brachipodium sylvaticum*	-	-	+	-	-	-	-

22	Grasses	*Brachypodium distachyon*	-	-	-	+	-	-	-
23	Grasses	*Bromus squarrosu*	-	-	-	-	-	-	+
24	Grasses	*Calamagrostis glomerata (Syn C. georgica)*	+	-	-	-	+	+	-
25	Grasses	*Dactylis glomerata*	-	-	+	-	-	-	+
26	Grasses	*Elytrigia repens*	-	-	+	+	-	-	-
27	Grasses	*Eremopyrum orientale*	+	-	+	+	-	-	-
28	Grasses	*Festuca varia*	-	+	-	-	+	-	-
29	Grasses	*Lolium temulentum*	-	-	-	-	-	+	-
30	Grasses	*Phleum pratense*	-	-	+	-	-	-	-
31	Grasses	*Setaria verticillata*	+	_-	-	-	-	+	-
32	Grasses	*Stipa arabica*	-	-	+	+	-	-	-
33	Grasses	*Stipa capillata*	-	-	-	-	+	-	-
34	Sedges	*Carex capitata*	-	-	-	+	-	-	-
35	Sedges	*Carex praecox*	-	-	-	-	+	-	-
36	Legumes	*Astragalus cyri*	-	-	-	+	-	-	-
37	Legumes	*Astragalus hirtulus*	-	-	+	-	-	+	-
38	Legumes	*Astragalus falcatus*	-	-	+	-	-	+	-
39	Legumes	*Lathyrus tuberosus*	+	-	-	-	-	+	-
40	Legumes	*Melilotus officinalis*	-	-	+	-	-	-	-
41	Legumes	*Onobrychis miniata*	+	-	-	-	-	+	-
42	Legumes	*Onobrychis angustifolia*	+	-	-	+	-	-	-
43	Legumes	*Trifolium pratense*	-	-	+	+	-	-	-
44	Herbs	*Adonis parviflora*	-	-	-	-	+	-	-
45	Herbs	*Aegopodium podagraria*	-	-	+	-	-	-	-
46	Herbs	*Aethusa cynapium*	+	-	-	-	-	+	-
47	Herbs	*Agrimonia eupatoria*	-	-	-	-	+	-	-
48	Herbs	*Ajuga chia*	-	-	+	-	-	-	-
49	Herbs	*Allium albidum*	-	-	-	-	-	+	-
50	Herbs	*Allium atroviolaceum*	-	-	+	-	-	-	-
51	Herbs	*Anacamptis pyramidalis*	-	-	-	+	-	-	-
52	Herbs	*Anchusa officinalis*	-	-	+	+	+	-	-
53	Herbs	*Anthemis candidissima*	-	-	+	-	-	-	-
54	Herbs	*Arctium lappa*	-	-	+	-	-	+	-
55	Herbs	*Artemisia caucasica*	-	-	-	-	+	-	-
56	Herbs	*Artemisia lercheana*	+	-	+	+	-	-	-
57	Herbs	*Asparagus verticillatus*	-	-	-	-	+	-	-
58	Herbs	*Atriplex patula*	-	-	-	-	-	-	+
59	Herbs	*Barbarea vulgaris*	+	-	-	-	-	-	-
60	Herbs	*Bunias orientalis*	-	-	+	-	-	+	+
61	Herbs	*Bupleurum exaltatum*	+	-	+	+	-	+	+
62	Herbs	*Campanula bononiensis*	-	-	-	+	-	-	-
63	Herbs	*Campanula hohenackeri*	-	+	-	-	+	-	-
64	Herbs	*Carduus hamulosus*	-	-	+	+	-	-	+
65	Herbs	*Carthamus lanatus*	+	-	-	+	-	+	+
66	Herbs	*Centaurea solstitialis*	-	-	+	+	-	-	-
67	Herbs	*Cerinthe minor*	-	-	-	+	+	+	-
68	Herbs	*Cichorium intybus*	-	-	-	-	-	+	-
69	Herbs	*Cirsium arvense*	-	-	-	-	+	-	+
70	Herbs	*Clinopodium vulgare*	-	-	-	-	+	-	-
71	Herbs	*Consolida orientalis*	-	-	+	+	-	-	-
72	Herbs	*Convolvulus cantabrica*	-	-	-	+	+	-	-
73	Herbs	*Crepis pannonica*	-	-	-	-	-	-	+
74	Herbs	*Cynoglossum officinale*	-	-	+	+	-	-	+
75	Herbs	*Daucus carota*	-	-	+	+	+	+	-
76	Herbs	*Dianthus crinitus*	-	-	-	-	+	-	-

77	Herbs	*Dictamnus caucasicus*	+	-	-	-	-	-	-
78	Herbs	*Echinops ruthenicus*	-	-	+	+	-	+	-
79	Herbs	*Echium russicum*	-	-	-	-	+	-	-
80	Herbs	*Eryngium caeruleum*	+	-	-	-	-	-	-
81	Herbs	*Erysimum repandum*	-	-	+	-	-	-	-
82	Herbs	*Erysimum hieracifolium*	+	-	+	-	-	+	-
83	Herbs	*Euphorbia seguieriana*	-	-	+	-	+	-	-
84	Herbs	*Euphrasia pectinata*	-	-	+	-	+	-	-
85	Herbs	*Falcaria vulgaris*	-	-	+	+	-	+	-
86	Herbs	*Galatella villosa*	-	-	-	-	+	-	-
87	Herbs	*Galinsoga parviflora*	-	-	-	+	-	+	-
88	Herbs	*Galium album*	+	-	-	-	-	-	-
89	Herbs	*Galium humifusum*	-	-	+	-	-	-	-
90	Herbs	*Gentiana macrophylla*	-	-	-	-	+	-	-
91	Herbs	*Gentianella acuta*	-	-	+	+	-	-	-
92	Herbs	*Glaucium corniculatum*	-	-	-	+	-	+	-
93	Herbs	*Globularia trichosantha*	-	-	+	+	-	-	-
94	Herbs	*Gypsophila stevenii*	+	-	-	+	-	+	-
95	Herbs	*Helichrysum plinthocalyx*	+	-	-	-	-	-	-
96	Herbs	*Hypericum perforatum*	-	-	-	-	+	+	-
97	Herbs	*Inula aspera*	-	-	+	-	-	-	-
98	Herbs	*Isatis costata*	-	-	-	-	-	-	+
99	Herbs	*Lactuca serriola*	-	-	+	+	-	-	-
100	Herbs	*Lapsana intermedia*	-	-	-	+	-	-	-
101	Herbs	*Linum austriacum*	-	-	-	-	+	-	-
102	Herbs	*Lycopsis arvensis*	-	-	-	-	+	-	-
103	Herbs	*Mentha arvensis*	-	-	-	-	-	-	+
104	Herbs	*Melampyrum arvense*	-	-	-	-	+	-	-
105	Herbs	*Origanum vulgare*	-	-	+	+	-	-	-
106	Herbs	*Ornithogalum pyrenaicum*	-	-	-	+	-	-	-
107	Herbs	*Papaver arenarium*	-	-	-	-	-	+	-
108	Herbs	*Petrorhagia prolifera*	-	-	-	-	+	-	-
109	Herbs	*Polygonum aviculare*	-	-	-	-	+	-	-
110	Herbs	*Prunella vulgaris*	-	-	+	+	-	-	-
111	Herbs	*Psephellus amblyolepis*	-	+	+	-	-	+	-
112	Herbs	*Psephellus carthalinicus*	-	-	-	-	+	-	-
113	Herbs	*Ranunculus repens*	+	-	-	-	-	-	-
114	Herbs	*Rhinanthus minor*	-	-	-	+	-	-	-
115	Herbs	*Rubia tinctorum*	-	-	+	-	-	+	-
116	Herbs	*Salvia viridis*	-	-	+	+	-	-	-
117	Herbs	*Sanguisorba officinalis*	+	-	-	-	-	-	-
118	Herbs	*Scorzonera idae*	-	-	+	-	-	+	-
119	Herbs	*Scutellaria orientalis*	-	+	+	-	-	-	-
120	Herbs	*Senecio vernalis*	-	-	-	-	+	-	-
121	Herbs	*Silybum marianum*	-	-	-	-	+	-	-
122	Herbs	*Sonchus arvensis*	+	-	+	+	-	+	-
123	Herbs	*Teucrium nuchense*	-	-	+	+	-	-	-
124	Herbs	*Teucrium polium*	-	-	+	+	-	-	-
125	Herbs	*Traagopogon serotinus*	-	-	-	-	+	-	-
126	Herbs	*Veronica officinalis*	-	-	-	-	+	-	-
127	Herbs	*Viola rupestris*	-	-	-	-	+	-	-
128	Herbs	*Xanthium spinosum*	-	-	-	+	-	-	-
129	Herbs	*Xeranthemum annuum*	-	-	+	-	-	-	-
130	Herbs	*Ziziphora acinos*	-	-	+	-	-	+	-
131	Herbs	*Urtica dioica*	-	-	+	-	-	+	-

Table A2. Invertebrate species from the Saskhori limestone quarry and adjacent areas

N	Family	Species	Sites of the sample collection (Site ID)						
Coleoptera			**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	Anthicidae	*Anthelephila pedestris* (Rossi, 1790)	-	-	-	-	-	+	+
2	Carabidae	*Brachinus crepitans* (L., 1758)	-	-	-	-	+	-	+
3	Carabidae	*Badister sodalis* (Duftschmid, 1812)	-	-	-	-	-	-	+
4	Carabidae	*Calathus melanocephalus* (L., 1758)	-	-	-	-	+	+	-
5	Carabidae	*Carabus adamsi* M.Adams, 1817	-	-	-	-	+	+	-
6	Carabidae	*Carabus* cf. *maurus* (Adams, 1817)	-	-	-	-	+	+	+
7	Carabidae	*Harpalus rufipes* (DeGeer, 1774)	-	-	-	-	-	-	+
8	Carabidae	*Olisthopus* sp.	+	-	-	-	-	+	-
9	Chrysomelidae	*Podagrica* sp.	-	-	-	-	-	-	+
10	Coccinellidae	*Coccinella septempunctata* (L., 1758)	-	-	-	-	+	-	-
11	Coccinellidae	*Coccinella novemnotata* Herbst, 1793	-	-	-	-	-	-	+
12	Curculionidae	*Anthonomus* sp.	-	-	+	-	-	-	-
13	Curculionidae	*Otiorhynchus* sp.	-	-	+	-	-	+	-
14	Curculionidae	*Polydrusus* sp.	-	-	-	+	-	-	-
15	Elateridae	*Agriotes* sp.	-	-	-	-	+	+	+
16	Histeridae	*Hister quadrimaculatus* (L., 1758)	+	-	-	-	+	+	+
17	Forficulidae	*Forficula* sp.	-	-	-	-	-	+	-
18	Lucanidae	*Dorcus parallelipipedus* (L., 1758)	-	-	-	-	-	+	-
19	Scarabaeidae	*Amphimallon solstitiale* (L., 1758)	-	-	-	-	-	-	+
20	Scarabaeidae	*Oryctes* sp.	-	-	-	-	-	-	+
21	Scarabaeidae	*protaetia* sp.	-	-	-	-	+	-	+
22	Silphidae	*Silpha* cf. *obscura* L., 1758	-	-	-	-	-	-	+
23	Tenebrionidae	*Dendarus* sp.	-	-	-	-	+	-	-
24	Tenebrionidae	*Crypticus quisquilius* (L., 1760)	-	-	-	-	+	-	-
25	Tenebrionidae	*Eleodes* sp.	-	-	-	-	-	-	+
26	Trogidae	*Trox* sp.	-	-	-	-	+	+	-
Geophilomorpha			**1**	**2**	**3**	**4**	**5**	**6**	7
27	Dignathodontidae	*Henia* cf. *brevis* Silvestri, 1896	-	-	-	+	-	-	-
28	Geophilidae	*Clinopodes caucasicus* (Sseliwanoff, 1884)	-	-	+	-	-	-	-
29	Geophilidae	*Geophilus* sp.	+	-	-	-	-	+	+
Lithobiomorpha			**1**	**2**	**3**	**4**	**5**	**6**	**7**
30	Lithobiidae	*Lithobius* sp.	-	-	-	-	-	-	+
31	Lithobiidae	*Lithobius aeruginosus* L. Koch, 1862	-	-	-	+	-	-	+
32	Lithobiidae	*Lithobius erythrocephalus* C.L. Koch, 1847	-	-	-	-	-	+	-
33	Lithobiidae	*Lithobius ferganensis* Trotzina, 1894	-	-	+	+	+	-	-
Scutigeromorpha			1	2	3	4	5	6	7
34	Scutigeridae	*Scutigera coleoptrata* L., 1758	-	+	-	-	-	-	-
Entomobryomorpha			1	2	3	4	5	6	7
35	Orchesellidae	*Orchesella* cf. *cincta* (L., 1758)	-	+	+	+	+	+	+
36	Entomobryidae	*Lepidocyrtus lignorum* (Fabricius, 1775)	-	+	+	-	-	-	+
37	Entomobryidae	*Entomobrya* cf. *quinquelineatus* C.Börner, 1901	+	-	-	-	-	-	-
38	Entomobryidae	*Seira domestica* (Nicolet, 1842)	-	-	-	-	+	-	-
39	Tomoceridae	*Tomocerus vulgaris* (Tullberg, 1871)	-	-	+	-	-	-	-
40	Isotomidae	*Isotomurus* sp.	+	-	+	-	+	-	-

Poduromorpha			**1**	**2**	**3**	**4**	**5**	**6**	**7**
41	Neanuridae	*Anurida* sp.	+	-	-	-	-	-	-
Symphypleona			**1**	**2**	**3**	**4**	**5**	**6**	**7**
42	Sminthuridae	*Sminthurus viridis* (L, 1758)	+	+	-	-	+	-	-
43	Phalangiidae	*Opilio* sp.	+	+	+	-	-	+	-
44	Phalangiidae	*Phalangium punctipes* (Koch, 1879)	+	+	+	+	+	+	+
Isopoda									
45	Armadillidiidae	*Armadillidium vulgare* (Latreille, 1804)	+	+	+	+	+	+	+
46	Trachelipodidae	*Trachelipus* sp.	+	+	+	+	+	+	+
47	Philosciidae	*Chaetophiloscia hastata* Verhoeff, 1929	+	-	-	+	-	-	-
48	Ligiidae	*Ligidium* sp.	+	-	-	+	-	-	-
Chordeumatida			**1**	**2**	**3**	**4**	**5**	**6**	**7**
49	Anthroleucosomatidae	*Metamastigophorophyllon* cf. *torsivum* Antić & Makarov, 2016	-	+	+	-	-	-	-
50	Anthroleucosomatidae	*Pseudoflagellophorella eskovi* Antić & Makarov, 2016	+	-	-	-	-	+	-
Polydesmida			**1**	2	3	4	5	6	7
51	Paradoxosomatidae	*Strongylosoma* sp.	-	-	-	-	-	+	-
Julida			**1**	**2**	3	4	5	6	7
52	Julidae	*Omobrachyiulus caucasicus* (Karsch, 1881)	-	-	-	-	-	+	-
53	Julidae	*Byzantorhopalum rossicum* (Timotheew, 1897)	-	-	+	-	-	-	-
54	Julidae	*Cylindroiulus* sp.	-	-	-	-	-	+	-
55	Julidae	*Leptoiulus tanymorphus* (Attems, 1901)	+	-	-	+	-	+	-
56	Julidae	*Syrioiulus adsharicus* (Lohmander, 1936)	-	-	-	+	-	-	+
Pseudoscorpiones			**1**	**2**	**3**	4	5	6	7
57	Neobisiidae	*Neobisium* sp. 1	+	+	+	+	+	+	-
58	Neobisiidae	*Neobisium* sp. 2	+	-	-	+	-	+	-
59	Atemnidae	*Atemnus politus* (Simon, 1878)	+	-	-	-	-	-	-
60	Chthoniidae	*Chthonius* sp.	+	-	-	+	-	+	-
Araneae			**1**	**2**	**3**	**4**	**5**	**6**	**7**
61	Agelenidae	*Tegenaria* sp.	-	-	+	+	-	+	+
62	Araneidae	*Araneus* sp.	-	-	-	-	-	+	-
63	Clubionidae	*Clubiona* sp.	-	-	+	+	+	+	+
64	Dysderidae	*Dysdera* cf. *spasskyi* Charitonov, 1956	+	-	+	+	-	+	-
65	Dysderidae	*Dysdera* sp.	+	+	+	+	+	+	+
66	Gnaphosidae	*Gnaphosa* sp.	+	-	-	+	+	+	+
67	Gnaphosidae	*Nomisia exornata* (C.L. Koch, 1839)	+	-	-	+	+	-	-
68	Lycosidae	*Hogna radiata* (Latreille, 1817)	-	-	-	+	-	-	-
69	Lycosidae	*Trochosa ruricola* (De Geer, 1778)	+	-	-	+	+	-	-
70	Lycosidae	*Trochosa* sp.	+	-	+	-	-	-	+
71	Lycosidae	*Thanatus* sp.	+	-	-	+	-	-	-
72	Salticidae	*Euophrys frontalis* (Walckenaer, 1802)	+	-	-	-	-	-	-
73	Scytodidae	*Scytodes thoracica* (Latreille, 1802)	-	+	+	+	-	+	-
74	Sparassidae	*Micrommata virescens* (Clerck, 1757)	-	-	-	-	-	+	-
75	Theridiidae	*Steatoda nobilis* (Thorell, 1875)	-	-	-	-	-	-	+
76	Thomisidae	*Ozyptila* sp.	+	-	+	+	+	+	+
77	Thomisidae	*Xysticus kochi* Thorell, 1872	+	-	+	+	-	+	+
Oribatida			**1**	**2**	**3**	**4**	**5**	**6**	**7**
78	Nothridae	*Nothrus parvus* Sitnikova, 1975	+	-	-	-	-	-	-

79	Crotoniidae	*Camisia horrida* (Hermann, 1804)	-	-	-	+	+	-	-
80	Crotoniidae	*Camisia lapponica* (Trägårdh, 1910)	+	-	+	-	-	-	-
81	Euphthiracaridae	*Acrotritia ardua* (Koch, 1841)	-	-	-	-	-	+	-
82	Phthiracaridae	*Phthiracarus lentulus* (Koch, 1841)	-	-	-	-	-	-	+
83	Phthiracaridae	*Steganacarus carinatus* (Koch, 1841)	+	+	+	+	-	+	+
84	Oppiidae	*Ramusella clavipectinata* (Michael, 1885)	+	-	-	-	-	-	+
85	Oppiidae	*Oppiella (Rhinoppia) hygrophila* (Mahunka, 1987)	+	-	-	-	-	-	+
86	Hermanniellidae	*Hermanniella punctulata* Berlese, 1908	-	-	+	+	+	-	-
87	Liacaridae	*Dorycranosus splendens* (Coggi, 1898)	+	+	+	-	+	-	-
88	Liacaridae	*Dorycranosus ovatus* Djaparidze, 1973	-	-	+	-	-	-	-
89	Liacaridae	*Liacarus brevilamellatus* Mihelcic, 1955	-	-	-	+	+	+	-
90	Liacaridae	*Liacarus coracinus* (Koch, 1841)	-	-	+	-	-	-	-
91	Gymnodamaeidae	*Arthrodamaeus femoratus* (C.L.Koch, 1840)	+	-	+	+	-	-	+
92	Aleurodamaeidae	*Aleurodamaeus setosus* (Berlese, 1883)	+	+	+	+	+	+	+
93	Damaeidae	*Metabelba monilipeda* Bulanova-Zachvatkina, 1965	-	-	-	-	+	-	-
94	Damaeidae	*Metabelba flagelliseta* Bulanova-Zachvatkina, 1965	-	-	-	-	-	-	+
95	Haplozetidae	*Haplozetes tenuifusus* (Berlese, 1916)	-	-	-	-	+	+	-
96	Scutoverticidae	*Scutovertex minutus* (Koch, 1835)	-	-	+	-	-	-	-
97	Plateremaeidae	*Lopheremaeus mirabilis* (Csiszár, 1962)	-	-	-	+	-	-	-
98	Amerobelbidae	*Amerobelba decedens* Berlese, 1908	-	-	-	-	+	-	-
99	Neoliodidae	*Liodes theleproctus* (Hermann, 1804)	-	+	-	+	+	-	-
100	Neoliodidae	*Poroliodes farinosus* (Koch, 1839)	+	-	-	-	-	-	-
101	Ceratozetidae	*Trichoribates naltschicki* (Shaldybina, 1971)	+	+	-	-	+	-	+
102	Ceratoppiidae	*Ceratoppia bipilis* (Hermann, 1804)	+	+	+	+	+	-	+
103	Zetorchestidae	*Microzetorchestes emeryi* (Coggi, 1898)	+	-	-	-	-	+	-
104	Zetorchestidae	*Zetorchestes micronychus* (Berlese, 1883)	-	+	+	+	-	-	+
105	Xenillidae	*Xenillus tegeocranus* (Hermann, 1804)	+	+	+	+	+	-	+
106	Oribatellidae	*Oribatella berlesei* (Michael, 1898)	-	-	-	-	-	-	+
107	Gustaviidae	*Gustavia microcephala* (Nicolet, 1855)	+	+	+	+	-	-	-
108	Scheloribatidae	*Scheloribates laevigatus* (Koch, 1835)	+	+	+	+	+	+	+
109	Phenopelopidae	*Eupelops acromios* (Hermann, 1804)	-	+	+	+	-	-	-
110	Phenopelopidae	*Eupelops torulosus* (Koch, 1839)	-	-	+	-	-	-	+
111	Phenopelopidae	*Eupelops occultus* (Koch, 1835)	-	+	-	-	-	-	-
112	Phenopelopidae	*Peloptulus phaenotus* (Koch, 1841)	+	-	+	-	-	-	-
113	Oribatulidae	*Lucoppia burrowsi* (Michael, 1890)	-	-	-	-	-	+	+
114	Oribatulidae	*Oribatula tibialis* (Nicolet, 1855)	+	+	+	+	-	+	+
115	Oribatulidae	*Oribatula (Zygoribatula) cognata* (Oudemans, 1902)	+	+	-	+	-	+	+
116	Oribatulidae	*Zygoribatula exilis* (Nicolet, 1855)	+	-	-	-	-	-	+
117	Punctoribatidae	*Punctoribates punctum* (Koch, 1839)	+	+	+	+	-	+	+
118	Punctoribatidae	*Minunthozetes pseudofusiger* (Schweizer, 1922)	-	-	-	-	-	+	+
119	Carabodidae	*Austrocarabodes foliaceisetus georgiensis* Murvanidze &Weigmann, 2007	+	-	+	-	-	-	-
120	Tectocepheidae	*Tectocepheus velatus* (Michael, 1880)	+	-	+	+	-	-	-
121	Galumnidae	*Pergalumna nervosa* (Berlese, 1914)	-	+	-	-	-	-	-
122	Galumnidae	*Galumna alata* (Hermann, 1804)	+	-	+	+	+	-	+