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Ground beetles (Coleoptera: Carabidae) from sparsely vegetated land ecosystems in Bulgaria

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Abstract. The study represents a survey of the data on species composition of the ground beetles occurring in the four major subtypes of sparsely vegetated land ecosystems, distributed on the territory of Bulgaria: i) coastal dunes and sandy shores; ii) coastal shingle; iii) screes; iv) inland cliffs, rock pavements and outcrops. A total of 145 species from 54 genera was established. The analysis of the life forms of the ground beetles showed a predominance of the zoophages (67%) over the mixophytophages (33%) with a ratio between these two classes reflecting the propinquity of these habitats to the desert zone of Middle Asia. The qualitative mathematical analysis divided ecosystems in two main groups – coastal and inland, and showed the potential role of altitude gradient, type of the substrate and vegetation for the distribution of ground beetles.

Key words: Carabidae, ground beetles, sparsely vegetated ecosystems, Bulgaria, life forms, gradient analysis.

Introduction

Sparsely vegetated habitats include a diversity of bare or sparsely vegetated rocks, cliffs, screes, volcanic deposits, moraines, glaciers and snow-fields, as well as weed communities of traditionally used arable land. Many of these are remote and little known, their location having provided some protection from many environmental threats. According to the European Red List of Habitats (Janssen et al. 2016) the main threats affecting sparsely vegetated habitats are: human intrusions and disturbances, mining (peat, sand, gravel extraction), urbanisation, roads and transportation. The most important threat for the snow-related habitats is the climate change, which affects the reduction to a considerable extent in recent past and which is very likely to continue in the near future. For the screes, rock outcrops and cliffs, the threats include mining, quarrying and infrastructure development like roads and other touristic infrastructure.

In general, sparsely vegetated habitats are dependent on strong geological or meteorological features and are very often considered azonal in most bioclimatic maps. However, there are strong geographic differences that have determined the characterisation of the habitat units with two variables generally used: rock type (whether ultramafic, base-rich or siliceous) and the biogeographic zone (Janssen et al. 2016).

In most cases, these habitats are hard to reach and to survey (therefore classified as Data Deficient). The knowledge about their fauna is not very rich, but it is known that the gravels represent the preferential habitat of numerous glacial relicts and endemic species (Růžička 2000, Nitzu et al. 2010). These specific invertebrate communities proved to be sensitive to the fluctuations of external environmental factors (Nitzu et al. 2014).

When a sufficient amount of information about species composition, taxonomic and ecological structure of the fauna in this peculiar type of ecosystems is collected, more explicit assessments and deductions about the state of the studied territories could be done allowing for more precise conclusions on the ecosystem services that they can offer to be specified.

The representatives of the family Carabidae are extremely various, well represented among the arthropod soil fauna (Gobbi & Fontaneto 2008) and important for the ecological research (Sakine 2006). The ecology of many of the species is well known, although for a lot of the ground beetles inhabiting hard to reach or hidden biotopes the data are however scarce.

The main objective of this work is to study species composition of the ground beetles occurring in the four major subtypes of sparsely vegetated ecosystems distributed on the territory of Bulgaria.

Material and Methods

Methodology and analysis of the data

The collection of the basic information includes several steps:

Step 1: Overview of the available literary sources (scientific publications, catalogs), containing summarised regional works for the Bulgarian carabid fauna and individual notes that give information about the species composition and single records of carabids. The data from personal observations, collections and field studies are also used.

Step 2: Detailed analysis of the ecological requirements of the species, which are subsequently assigned to lists corresponding to the subtypes of sparsely vegetated ecosystems (part of the species could be found in more than one subtype, and eurybionts inhabit all subtypes of ecosystems).

Step 3: Preparation of a list of the ground beetles, occurring in the different types of sparsely vegetated ecosystems in Bulgaria.

Field and laboratory work

Field work was carried out in the period 19 April – 9 September 2016 in different localities, described in **Appendix 1**. It included: 1) transect method with observations *in situ* and handpicking of material; 2) stationary method with „pitfall" traps made of plastic bottles, buried at the level of the ground surface, filled with a 50% solution of propylene glycol as a fixation fluid.

Captured animals were determined with the help of several main literary sources: Hůrka (1996), Arndt et al. (2011), Kryzhanovskij (unpublished data). Materials are deposited in the collections of the Institute of Biodiversity and Ecosystem Research (Bulgarian Academy of Sciences, Sofia).

Categorization of the species with respect to their life forms is done according to the classification of Sharova (1981). The systematic list follows Kryzhanovskij et al. (1995).

The software products CANOCO 4.5 (Ter Braak & Šmilauer 2002), PRIMER 6 (Clarke & Gorley 2005**)** and TWINSPAN (TWo-way

INdicator SPecies ANalysis) (Hill & Šmilauer 2005) for the mathematical processing of the data are used.

The indicator species for the habitat subtypes were determined in R (R, version 3.2.3) using the multipatt function in package indicspecies (De Càceres & Legendre 2009).

Typology of the sparsely vegetated ecosystems in Bulgaria

Sparsely vegetated lands include non-vegetated or sparsely vegetated habitats (naturally unvegetated areas). Often these ecosystems have extreme natural conditions that might support particular species. They include bare rocks, screes, dunes, beaches and sand plains.

The proposed typology of "Sparsely vegetated land ecosystems" corresponds with the ecosystem classification of MAES (Maes et al. 2013), combined with the European Nature Information System (EUNIS) habitat classification types. It is also related to some of CORINE Land Cover classes. The MAES ecosystem typology on Level 2 follows closely the EUNIS Level 1. The third level of the MAES typology corresponds therefore to the EUNIS level 2. The EUNIS level 2 will be the base for the assessment approach.

A selection of units of EUNIS classification on level 2 is proposed for detailed typology as level 3 for target ecosystem type. Rock and stony areas, such as screes and cliffs (except the costal ones) are selected. They correspond to levels "H2" and "H3" from EUNIS group "H" respectively. Additionally, as sparsely vegetated should be assumed also the sandy dunes, sandy shores and shingle beaches. They correspond to levels "B1" and "B2". A total number of 4 sparsely vegetated land subtypes is selected. Descriptions and relations to other classification systems of the proposed subtypes are presented in Table 1.

During the field trips the following habitat types were visited (according to Directive 92/43): 2110 Embryonic shifting dunes, 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes"), 2180 Wooded dunes (subtype 1); 1210 Annual vegetation of drift lines (subtype 2); 8110 Siliceous scree of the montane to snow levels, 8120 Calcareous and calcshist screes of the montane to alpine levels (subtype 3); 8210 Calcareous rocky slopes with chasmophytic vegetation, 8220 Siliceous rocky slopes with chasmophytic vegetation and 8230 Siliceous rock with pioneer vegetation (Sedo-Scleranthion, Sedo-albi Veronicion dillenii) (subtype 4) (Appendix 1).

Results

The preliminary analysis of the available literature indicates the presence of 72 species of ground beetles (Coleoptera: Carabidae), which can be found in different sparsely vegetated ecosystems. During the field surveys 80 carabid species were collected. This way the total list of the ground beetles from studied habitats comprises 145 encountered species belonging to 54 genera, which represent 19.5% of the species and 43% of the genera included in the full list of carabid species of Bulgaria (Teofilova & Guéorguiev, in prep.).

In Appendix 2 is given the check-list of all species of ground beetles with information about the life form which they refer to; their presence in the given subtype of sparsely vegetated ecosystem and the different localities, and the numbers of collected during the field trips specimens, are pointed out; individual code used in the mathematical analysis for each species is also supplied.

Sand-covered shorelines and dunes are spread along the Black Sea coast. Some fall into different regimes of protection, but in most of them a strong anthropogenic load from recreation is present, especially during the summer. For this ecosystem subtype a species composition of 69 carabid species is discovered, of which 47 were known from the literature while 22 species were established during the field trips.

Coastal shingle ecosystems have similar distribution and anthropogenic load situation. A total of 49 species is found in this subtype of ecosystems, of which 34 were known from the literature and 15 species were discovered during the field trips.

Screes predominantly occur in the mountain and high-mountain belts. Very few patches form in the lowland areas and have scattered distribution. For this ecosystem subtype are characteristic 30 species of ground beetles, of which 17 were known from the literature and 16 were collected during the field studies (three species overlap).

Table 1. Typology and descriptions of sparsely vegetated land ecosystem subtypes (Level 3) in Bulgaria.

Level			Description	Nomenclature
1	2	3		
Terrestrial	Sparsely vegetated ecosystems	Coastal dunes and sandy shores	Sand-covered shorelines of the Black Sea coast, fashioned by the action of the wind or waves. This group includes all types of dune system (embryonic, white, grey dunes, etc.) as well as the sandy beaches used for recreation. Vegetation cover vary from sparsely distributed individuals of *Eryngium maritimum*, *Cakile maritima*, *Salsola ruthenica*, etc., close to the water-line, through open and semi-open psammophyte communities, to closed communities rich of mosses and lichens in the inner parts.	EUNIS: B1 Directive 92/43: 2110; 2120; 2180
		Coastal shingle	Beaches covered by pebbles, or sometimes boulders, usually formed by the action of the waves. In some places with accumulations of drift material, sandy gravels and gravels rich in nitrogenous organic matter, occur very open, low formations of annuals and perennials.	EUNIS: B2 Directive 92/43: 1210
		Screes	Accumulations of boulders, stones, rock fragments, pebbles, gravels or finer material, of non-aeolian depositional origin, unvegetated, occupied by lichens or mosses, or colonized by sparse herbs or shrubs. Included screes and scree slopes produced by slope processes, moraines and drumlins originating from glacial deposition.	EUNIS: H2 Directive 92/43: 8110; 8120
		Inland cliffs, rock pavements and outcrops	Unvegetated, sparsely vegetated, and bryophyte- or lichen-vegetated cliffs, rock faces and rock pavements in the inland areas.	EUNIS: H3 Directive 92/43: 8210; 8220; 8230

Inland cliffs, rock pavements and outcrops are spread throughout the territory of the country. Large complexes of them are situated in the mountains of southern Bulgaria, and smaller ones are found in northern Bulgaria. Carabid communities include 73 species, of which only 21 were known from the literature and 57 were collected during the field studies (five species overlap). Thus, the species list of this ecosystem subtype was enriched with 52 species. Many of the established carabids are considered forest dwellers and it is possible that they penetrate from the surrounding forests, since many of the studied habitats from this ecosystem subtype are situated in the forest belts.

The dendrogram for splitting by similarity on the basis of qualitative (species) composition of ecosystems (Fig. 1) shows the establishment of two distinct groups: inland cliffs and screes separate on an average level of similarity (according to Zlotin 1975). In the second group, with a high level of similarity, are separated coastal ecosystems.

The TWINSPAN classification divided ecosystems in the same two groups – coastal and inland. It also separated the species in a similar way. The grouping of the species indicates that the type of the vegetation is of some importance. The inhabitants of coastal areas with no or very scarce vegetation (e.g. *Apotomus clypeonitens*, some *Bembidion* species, *Broscus semistriatus*, *Calomera littoralis*, *Cephalota* spp., most Dyschiriini, Pogonini, *Scarites laevigatus*, etc.) are concentrated at the top of the table, while at the bottom of it are the species attached to the partly shaded mountain slopes (e.g. *Abax carinatus*, *Amara lunicollis*, *Amara montivaga*, *Bembidion balcanicum*, *Bembidion dalmatinum*, *Bembidion monticola*, *Cicindela sylvicola*, *Myas chalybaeus*, *Nebria* spp., *Ophonus parallelus*, *Pterostichus niger*, etc.). In the middle of the table are the polytopic species (e.g. *Calathus melanocephalus*, *Carabus coriaceus*, *Cylindera trisignata*, *Ophonus cribricollis*, etc.) and eurybionts (e.g. *Bembidion lampros*, *Trechus quadristriatus*.). Some species with relatively wide ecological tolerance (e.g. *Brachinus crepitans*, *Cicindela campestris*, *Harpalus dimidiatus*, *Harpalus tardus*, *Poecilus cupreus*) are more or less evenly spread across the table, which was also found by Popov & Krusteva (1999) and Teofilova & Kodzabashev (2015).

The gradient analysis (CANOCO) of the individual subtypes of sparsely vegetated ecosystems, based on their carabid species composition, showed the specificity of the four subtypes and divided the species according to their presence in them (Fig. 2). It could be argued that there are serious differences in the carabid species composition and environmental conditions between the four subtypes. Therefore, it is hard to specify the gradients along the two ordination axes. It could be claimed that the first axis defines the differentiation of two distinct groups: inland and coastal ecosystems, as the dendrogram and the TWINSPAN analysis also showed. Probably this separation follows the gradient of altitude, as far as the sandy and shingle ecosystems are located around and slightly above the sea level, while the scree slopes and cliffs are found primarily in the inland mountainous regions.

As a possible second axis the specifics of the substrate can be considered. In sand ecosystems the substrate is highly homogeneous. To some extent this can be said about the cliff habitats too, although the substrate is of a quite different type. In shingle and scree habitats the nature of the substrate is different – includes both small and fine particles (and in many cases also soil), and larger fragments as well.

The ordination of the species (Fig. 2) clearly demonstrated their attachment to a particular type of habitat. In the intermediate groups the species occurring in two similar types of ecosystems united. For example, most of the representatives of the genera *Bembidion*, *Cephalota*, *Dyschirius* and *Dyschiriodes* were found in both types of coastal ecosystems, but there were also species occurring only in sand (*Bembidion striatum*, *Broscus semistriatus*, *Cicindela soluta*, *Omophron limbatum*) or only in shingle ecosystems (*Bembidion modestum*, *Bembidion scapulare*, *Thalassophilus longicornis*). *Amara bifrons* and *Amara consularis* were established only on the screes, while most of the species of the same genus were found in ecosystems of the type of the inland rocks. Clearly differentiated are the species, established only in the last subtype of sparsely vegetated ecosystems (i.g. *Amara lunicollis*, *Bembidion balcanicum*, *Carabus hortensis*, *Carabus scabrosus*, *Dixus* spp., *Cymindis* spp.).

As usual, in the centre of the graph were placed the unpretentious eurybionts (*Bembidion lampros*, *Trechus quadristriatus*), and polytopic species, occurring in more than two types of ecosystems (*Carabus coriaceus*, *Harpalus servus*, *Harpalus tardus*, etc.).

Indicator species analysis of the data from the field trip collections showed that *Harpalus autumnalis* is a confident indicator for sandy habitats ($p = 0.008$). *Cicindela sylvicola* appears to be strongly attached to screes ($p = 0.039$), and *Harpalus pumilus* ($p = 0.012$) is an indicator for coastal habitats (sand and shingle). The other species are distributed between the different ecosystem subtypes, but do not have such statistical significance. This is probably due to the manner of collection of the material (only single catches by hand in some of the places, or combined with pitfall traps in other places, but in different time of the day and in different months).

The analysis of the ground beetles life forms occurring in the whole complex of sparsely vegetated ecosystems showed predominance of the zoophages (97 species; 67%) over mixophytophages (48 species; 33%). There are 21 life forms of ground beetles – 15 zoophagous and 6 mixophytophagous. Similar ratio (68%: 32%) between the classes of life forms is considered typical for the desert zone of Middle Asia (Sharova 1981). Less relative is the ratio in the meadow-like steppes from the forest-steppe zone of Eurasia (65%: 35%).

A characteristic feature was the absence of representatives of the subclass Phytobios which are associated with the presence of vegetation cover (dendrobionts and hortobionts), but this fact was fully explainable given the nature of the studied types of habitats.

The largest share of the species belonged to the harpaloid geohortobionts from Class Mixophytophagous, followed by the surface & litter-dwelling stratobionts (series crevice-dwelling) from Class Zoophagous (Fig. 3).

The similarity between the four types of sparsely vegetated ecosystems, calculated on the basis of the life forms of the species found in the given type, showed the same pattern as the distribution according to the species composition. The only difference is that both groups (inland and coastal ecosystems) were separating on a high level of similarity

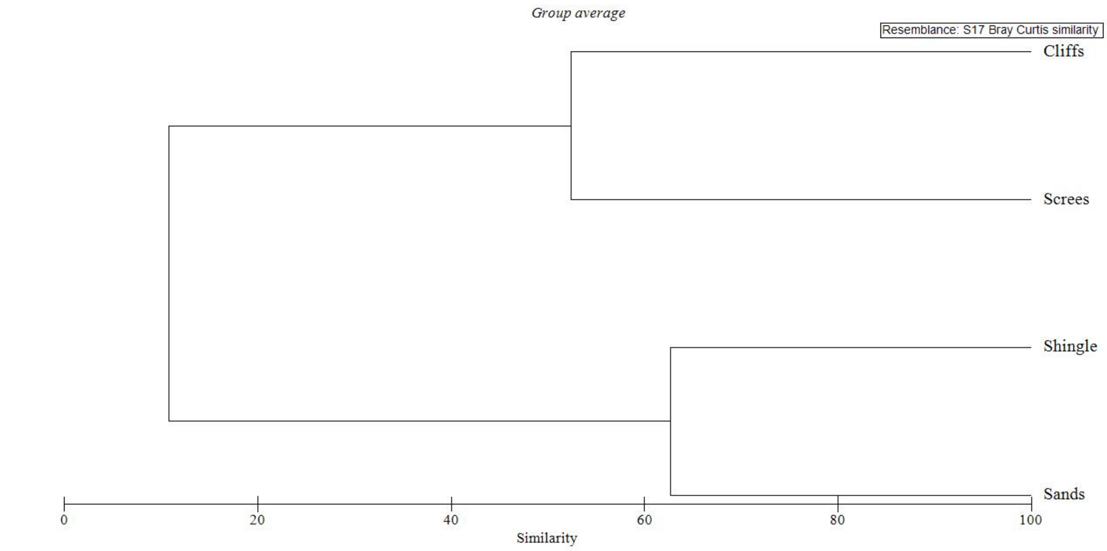

Figure 1. Brey-Curtis Similarity dendrogram based on the species richness.

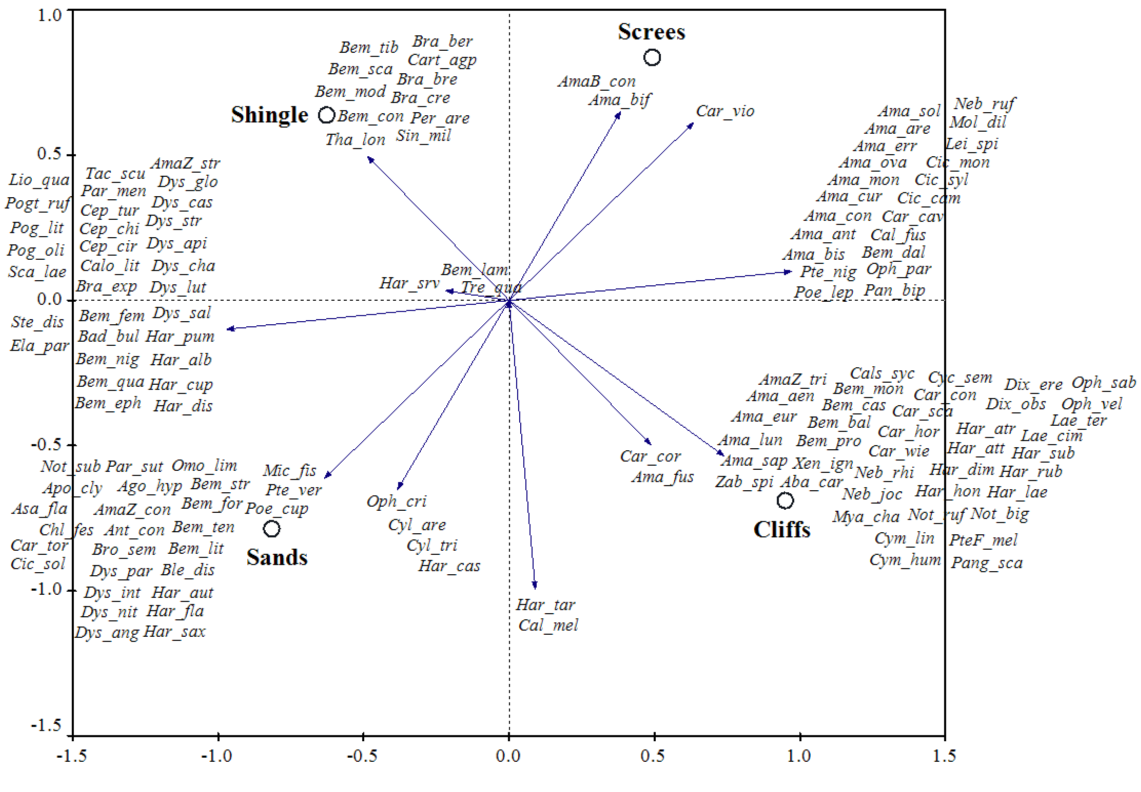

Figure 2. Qualitative PCA analysis of the four subtypes of sparsely vegetated ecosystems and the attendant species composition.

(according to Zlotin 1975). The dendrogram is not presented in the text because it is coinciding with the similarity graph on Fig. 1.

Results showed that the two coastal ecosystem subtypes shared the same dominant life form groups with some differences in their percentages (Fig. 4**)**: small digging geobionts represented 17% of all species in the sand ecosystems and 14% in the shingle; the same numbers for surface & litter-dwelling stratobionts were respectively 14% and 22%; flying epigeobionts represented respectively 10% and 12%; litter-dwelling stratobionts had respectively 7% and 10% of sand and shingle species; mixophytophagous harpaloid geohortobionts represented 14% and 10%, respectively. The litter & crevice-dwelling stratobionts also had a large share in sandy habitats (8%).

In the inland ecosystems the dominant life forms were the mixophytophagous harpaloid geohortobionts (respectively, 37% in the scree habitats and 29% in the group of the inland cliffs, rock pavements and outcrops), litter-dwelling stratobionts (respectively, 17% and 12%), large walking epi-

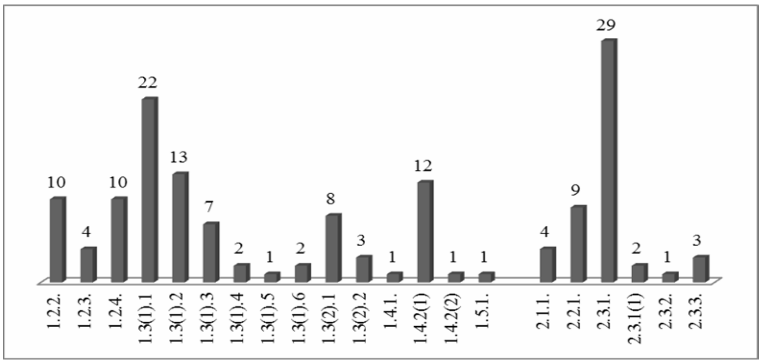

Figure 3. Number of species in the different life forms of the ground beetles from the four subtypes of sparsely vegetated ecosystems in Bulgaria. Explanations about the life form codes are given in the Appendix 2.

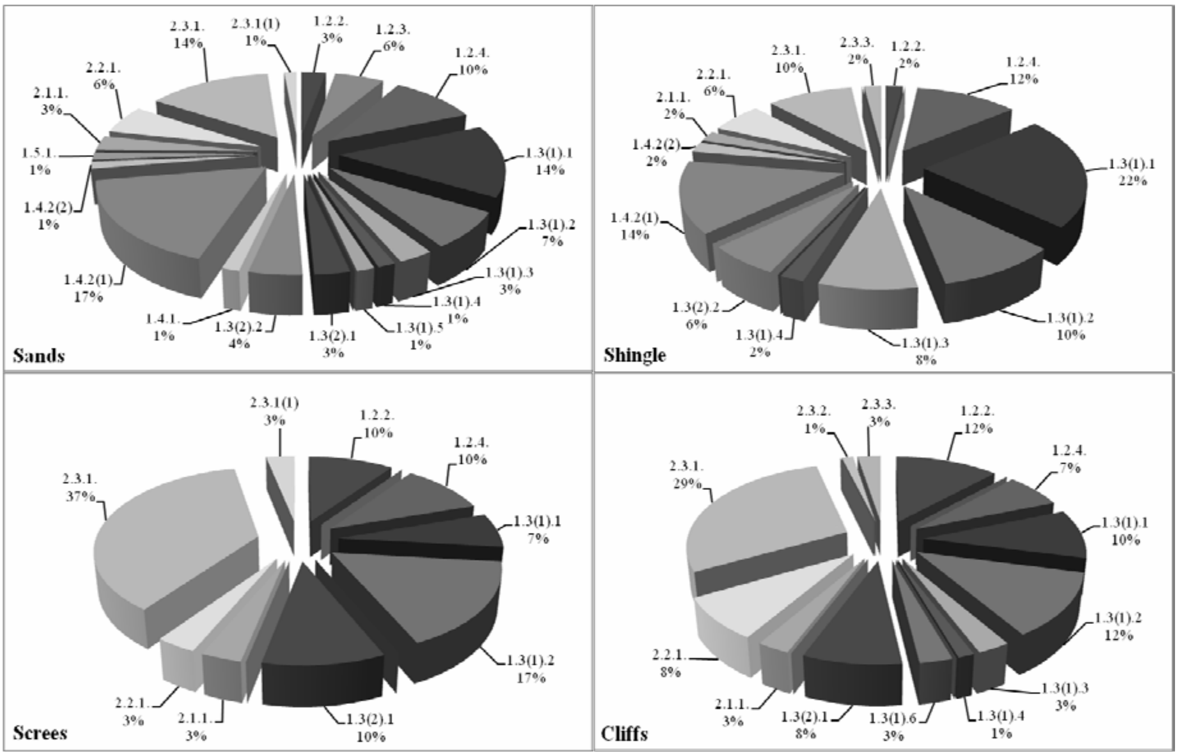

Figure 4. Life forms of the carabids from sparsely vegetated ecosystems in Bulgaria.

geobionts (respectively, 10% and 12%) and litter & soil-dwelling stratobionts (respectively, 10% and 8%) (Fig. 4). Large share in screes had also the flying epigeobionts (10%) and in the cliff habitats – surface & litter-dwelling stratobionts (10%).

Different spectrums of life forms, with different ratios between the main classes were established in the four ecosystem subtypes. In the first subtype the ratio of the zoophages to the mixophytophages is 76%: 24%. In the second subtype the proportion was respectively 80%: 20%. Similar ratio (77%: 23%) between the classes of life forms is approaching the established values for the forest meadows or glades of the forest-steppe zone of Eurasia. In the third subtype the numbers were respectively 54%: 46% while in the fourth the ratio was respectively 56%: 44%. These values are closest to the meadow-like steppes of the forest-steppe zone and to the dry-riverbed meadows of the landscape subzone of the coniferous-deciduous forests of Eurasia (57%: 43%) (Sharova 1981).

Zoophagous life form groups are normally more numerous. Small digging geobionts are all representatives of the tribe Dyschiriini. They are part of the most specialised digging forms, hiding and feeding in the soil crevices. The lack of a suitable substrate, as well as the lower humidity in sparsely vegetated inland ecosystems, are the reason geobionts are not found there.

Surface & litter-dwelling stratobionts represent most of the *Bembidion* and *Agonum* species, *Notiophilus*, *Panagaeus*, *Chlaenius*, which are litter-dwelling species living in the epigeic layers and they are not highly sensitive to the extreme manifestations of the soil and humidity regimes.

For the litter-dwelling stratobionts, which live hidden in the substrate (*Leistus*, *Nebria*, *Trechus*, *Thalassophilus*, *Perileptus*, *Blemus*, subgenus *Metallina*, *Calathus*, *Badister*), it is the presence of vegetal litter that is more important, rather than humidity conditions and soil type, so they are found in all types of ecosystems, but are more common in the inland sparsely vegetated ecosystems, where the amount of the vegetation is higher.

To the litter & soil-dwelling digging stratobionts relate most of the *Poecilus*, *Pterostichus*, *Abax* and *Molops* species, which hunt on the surface of the soil, and actively dig in the ground or litter for hiding. The high percentage of these forms in the inland ecosystems is mostly resulting from their presence in the neighbouring forests.

The group of the litter & crevice-dwelling stratobionts (*Microlestes*, *Cymindis*, *Brachinus*) is the most characteristic in the arid areas. In this case, it is best represented in shingle habitats.

Flying epigeobionts are the representatives of the tribe *Cicindelini*, for which flight is the main way of moving and catching agile, flying insect prey. They are well represented in all four types of sparsely vegetated ecosystems, which provide them with a suitable substrate for landing, devoid of rich vegetation.

Large walking epigeobionts (*Calosoma* spp., *Carabus* spp., *Cychrus* spp.) are usually mesophilous beetles, adapted to pedestrian migrations. Many of them are forest dwellers. The higher percentage of these forms in the inland ecosystems is mostly resulting from their presence in the neighbouring forests.

Pangus scaritides and most of the *Amara* and *Harpalus* species that are dependent on the vegetation cover belong to the mixophytophagous harpaloid geohortobionts. This explains their low presence in the coastal ecosystems, where the vegetation is in many cases completely missing.

Discussion

Most of the sparsely vegetated habitats are very susceptible to change and show little resilience, but have been little affected by direct human impact by virtue of their remoteness or inaccessibility. Many of the cliff habitats have functioned as refugia for plant species during the Ice Ages and other periods of changing conditions, and as a result nowadays they harbour high numbers of endemic relic species. These sparsely vegetated habitats are in general not very well recorded or studied and, even when the territorial data were completed, biodiversity data gaps were significant (Janssen et al. 2016).

Field observations of the sparsely vegetated ecosystems in Bulgaria contributed to the establishment of many new species and demonstrated a fairly rich set of ground beetles attached to these peculiar environmental conditions. Carabid fauna consists of 145 species from 54 genera. Most of them are typically living in open biotopes, but there are some typical forest species too, found mostly the mountain regions. A small proportion of the species are polytopic or eurytopic.

Classification and ordination divided ecosystems in two main groups – coastal and inland. The qualitative analysis of the carabids' species composition showed the potential role of the vegetation, the altitude gradient and the type of the substrate for the distribution of ground beetles, which in the ordination graph appeared respectively as the first and the second axis. Soil type, moisture and vegetation cover are noted as the most important factors determining the distribution of the ground beetles (e.g. Brygadyrenko 2015, Brygadyrenko 2016, Teofilova & Kodzhabashev 2015), but the present study supplements another environmental parameters to this list. Altitude and habitat types were the major abiotic parameters influencing the structure of the whole arthropod community in the study of Nitzu et al. (2014).

The established life forms of the ground beetles are characterized by a predominance of the zoophages (67%) over the mixophytophages (33%) with a ratio between these two classes reflecting the propinquity of the sparsely vegetated ecosystems in Bulgaria to the desert zone of Middle Asia. The established diversity of life forms (21 of 29) is consistent with the normal increase in the number of life forms in South and in desert areas (Sharova 1981), and also confirms the idea of the origin of the carabids in tropical, rather than temperate climate (Jeannel 1942, Sharova 1981).

Different spectra of life forms, with different ratios between the main classes were found in the four ecosystem subtypes, which stresses their peculiarity and uniqueness, but the close spectra of the sand and shingle ecosystems on the one hand, and the scree and the rock ecosystems on the other should also be noted.

The structure of the life forms in the coastal ecosystems showed high percentage of the surface & litter-dwelling stratobionts, litter-dwelling stratobionts and harpaloid geohortobionts, which was also typical for the seasonally wet and wet grasslands in Bulgaria (Teofilova 2018). The harpaloid geohortobionts constitute the largest share of the life forms established in the inland ecosystems, which was also found for the arid, mesic, salt and alpine/subalpine grasslands in Bulgaria (Teofilova 2018).

Mathematical processing of the data showed that the grouping of the ecosystems according to their taxonomic structure is not diverting from the grouping according to the ecological structure based on life forms, contrary to the grassland ecosystems in Bulgaria (Teofilova 2018).

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Appendix 1. List and description of the sampling sites and dates of visiting.

Appendix 2. List of Carabidae species from sparsely vegetated ecosystems in Bulgaria.

Appendix 1. List and description of the sampling sites and dates of visiting.

№	Locality	Altitude	Habitat code	Hand picking	Pitfall traps	GPS coordinates
	Northern Black Sea coast:					
1.	Evksinograd	8 m	1210 2110	19.IV.2016		43°13'03"N 27°59'34"E
2.	Kamchiya River, northern the mouth	4 m	2110 2120	19.IV.2016	19.IV – 16.V.2016	43°01'37"N 27°53'17"E
3.	Krapets vill.	4 m	1210		19.IV – 18.V.2016	43°36'43"N 28°34'08"E
4.	Zlatni Pyasatsi resort (Golden Sands)	1 m	2110	20.IV.2016		43°17'00"N 28°02'39"E
	Southern Black Sea coast:					
5.	S Kiten – camping "South"	5 m	2110 2180	27.IV.2016	27.IV – 7.VI.2016	42°13'34"N 27°46'37"E
6.	Lahana site (Pomorie south)	1 m	1210	07.VI.2016		42°33'22"N 27°34'10"E
7.	Primorsko – International Youth Center	3 m	2120		27.IV – 7.VI.2016	42°14'54"N 27°45'10"E
8.	Slanchev Bryag resort (Sunny Beach)	2 m	2110	25.IV.2016		42°42'33"N 27°43'58"E
9.	Tsarevo – Varvara beach	7 m	2110 2120	07.VI.2016		42°08'55"N 27°52'33"E
	Middle Danubian plain:					
10.	N Shirokovo vill.	151 m	8210	18.V.2016		43°33'25"N 25°56'20"E
11.	E Bazovets vill.	146 m	8210	19.V.2016		43°30'05"N 25°54'48"E
	Eastern Forebalkan:					
12.	NE Byala reka vill.	320 m	8210	20.V.2016		43°08'12"N 25°12'54"E
13.	S Lilyak vill.	453 m	8210	18.V.2016		43°12'37"N 26°28'23"E
	Western Forebalkan					
14.	SW Veslets vill.	605 m	8210	9.IX.2016		43°14'26"N 23°36'01"E
15.	NW Strupets vill.	213 m	8210	9.IX.2016		43°08'14" N 23°51'10"E
	Eastern Stara Planina Mts.:					
16.	S Polyatsite vill.	320 m	8210	17.V.2016		42°58'04"N 27°07'36"E
	Podbalkan:					
17.	N Mirkovo vill.	825 m	8210	14.V.2016		42°42'24"N 23°59'45"E
	Ihtimanska Sredna Gora Mts.:					
18.	W Petrich vill.	583 m	8210	20.V.2016		42°36'09"N 24°00'06"E
	Western Bulgaria:					
19.	N Eleshnitsa vill.	664 m	8210	13.VI.2016		42°45'05"N 23°37'50"E
	Osogovska planina Mts.					
20.	E Vetren vill.	1260 m	8120	28.VI.2016		42°04'14"N 22°46'38"E
	Kraishte region:					
21.	NW Sushitsa vill.	934 m	8120	27.VI.2016		42°29'29"N 22°37'48"E
	Rila Mts.:					
22.	N Belitsa	1053 m	8110	14.VII.2016		41°59'24''N 23°31'58''E
23.	Belishki skali site (Belitsa rocks)	1150 m	8110	14.VII.2016		42°00'17''N 23°31'24''E
24.	S Mala Tsarkva vill.	1405 m	8110 8220	16.VI.2016		42°14'27''N 23°31'08''E
25.	N Beli Iskar vill.	1153 m	8220	17.VI.2016		42°17'15''N 23°13'55''E
26.	E Rila, at the waterfall	618 m	8220	28.VI.2016		42°07'49"N 23°08'57"E
27.	S Sestrimo vill.	863 m	8220	13.VII.2016		42°12'10"N 23°54'36"E
28.	SW Kostenets vill.	1061 m	8110	15.VI.2016		42°14'44"N 23°47'54"E
	Pirin Mts.:					
29.	NE Brezhani vill.	743 m	8210	29.VI.2016		41°52'53"N 23°12'29"E
30.	SW Gotse Delchev	669 m	8210	29.VI.2016		41°33'22"N 23°43'10"E
	Eastern Rhodope Mts.:					
31.	S Kamenets vill.	405 m	8220	9.VI.2016		41°27'55"N 25°24'14"E
32.	W Ilinitsa vill.	606 m	8210	9.VI.2016		41°42'52"N 25°14'39"E
33.	S Rani list vill.	613 m	8210	28.IV.2016		41°40'20"N 25°24'19"E
34.	E Tatkovo vill.	290 m	8210	08.VI.2016		41°43'58"N 25°35'34"E
35.	S Shiroka polyana vill.	348 m	8210		28.IV – 19.VI.2016	41°48'15"N 25°24'28"E
	Western Rhodope Mts.:					
36.	N Slomyan, Nevyastata Peak	1510 m	8220	18.V, 18.VI.2016	18.V – 18.VI.2016	41°36'46"N 24°40'46"E
37.	N Slomyan, Sveti Georgi Peak	1643 m	8220	18.V.2016		41°36'27"N 24°42'01"E
38.	N Slomyan, quarter Ezerovo	1518 m	8220	18.V.2016		41°36'48"N 24°40'44"E
39.	N Hvoyna vill.	1080 m	8210	17.V.2016		41°53'04"N 24°41'00"E
40.	SE Pavelsko vill.	1100 m	8120 8210	17.V.2016		41°50'52"N 24°43'08"E
41.	E Ribnitsa vill.	1058 m	8220	19.V.2016		41°28'10"N 24°53'17"E
42.	N Varba vill.	1036 m	8220	19.V.2016		41°28'29"N 24°52'41"E
43.	S Kuklen vill.	760 m	8210	15.VI.2016		42°00'49"N 24°46'27"E
44.	NE Ravnogor vill.	1166 m	8220	29.VI.2016		41°58'27"N 24°25'37"E
45.	N Dedevo vill.	790 m	8220	30.VI.2016		42°00'37"N 24°39'44"E
46.	N Sitovo vill.	1205 m	8220	11.VII.2016		41°56'35''N 24°36'51''E
47.	NE Lilkovo vill.	1190 m	8110 8220	11.VII.2016		41°56'38''N 24°36'35''E
48.	N Boykovo vill.	724 m	8210	11.VII.2016		42°01'19''N 24°36'52''E

№	Locality	Altitude	Habitat code	Hand picking	Pitfall traps	GPS coordinates
49.	S Ustina vill.	580 m	8230	12.VII.2016		42º01'40''N 24º31'41''E
50.	E Krichim Dam	1650 m	8210 8220	12.VII.2016		41º53'26''N 24º30'48''E
51.	SW Semchinovo vill.	685 m	8210	13.VII.2016		42º10'19''N 24º03'58''E
52.	NE Gostun vill.	1166 m	8220	28.VI.2016		41º50'17''N 23º42'04''E

Appendix 2. List of Carabidae species from sparsely vegetated ecosystems in Bulgaria. Literary data and results from the field studies.

№	Species	Life form	Ecosystem subtypes				Records from the field investigations	Code
			Sand	Shingle	Scree	Cliff		
	Tribe Cicindellini							
1.	*Cylindera (Eugrapha) arenaria* (Fuesslin, 1775)	1.2.4	+	+		+		Cyl_are
2.	*Cylindera (Eugrapha) trisignata* (Dejean, 1822)	1.2.4	+	+		+		Cyl_tri
3.	*Cephalota (Taenidia) circumdata* (Dejean, 1822)	1.2.4	+	+				Cep_cir
4.	*Cephalota (Taenidia) chiloleuca* Fisher-Waldheim, 1820	1.2.4	+	+				Cep_chi
5.	*Cephalota (Cephalota) turcica* (Schaum, 1859)	1.2.4	+	+				Cep_tur
6.	*Calomera littoralis* (Fabricius, 1787)	1.2.4	+	+				Calo_lit
7.	*Cicindela (Cicindela) sylvicola* Latreille et Dejean, 1822	1.2.4			*	*	Belitsa (1n), Belishki skali (1n), Pavelsko (1n), Varba (2♀, 1♂, 2n)	Cic_syl
8.	*Cicindela (Cicindela) soluta* Latreille et Dejean, 1822	1.2.4	+					Cic_sol
9.	*Cicindela (Cicindela) campestris* Linnaeus, 1758	1.2.4			+ *	+ *	Mirkovo (1♀), Vetren (1n), Hvoyna (1♀, 2♂), Ribnitsa (1n), Semchinovo (1n), Varba (1n)	Cic_cam
10.	*Cicindela (Cicindela) monticola* Ménétries, 1832	1.2.4			+	+		Cic_mon
	Tribe Omophronini							
11.	*Omophron (Omophron) limbatum* (Fabricius, 1777)	1.5.1	+					Omo_lim
	Tribe Nebriini							
12.	*Leistus (Pogonophorus) spinibarbis* (Fabricius, 1775)	1.3(1).2			*	*	Pavelsko (1♂)	Lei_spi
13.	*Nebria (Eunebria) jockischi* Sturm, 1815	1.3(1).2				+		Neb_joc
14.	*Nebria (Boreonebria) rufescens* (Ström, 1768)	1.3(1).2			*	*	Mala Tsarkva (1♂)	Neb_ruf
15.	*Nebria (Alpaeonebria) rhilensis* J. Frivaldszky, 1879	1.3(1).2				+		Neb_rhi
	Tribe Notiophilini							
16.	*Notiophilus biguttatus* (Fabricius, 1779)	1.3(1).1				*	Ravnogor (1n)	Not_big
17.	*Notiophilus substriatus* C. R. Waterhouse, 1833	1.3(1).1	+					Not_sub
18.	*Notiophilus rufipes* Curtis, 1829	1.3(1).1				*	Ravnogor (1♂)	Not_ruf
	Tribe Carabini							
19.	*Calosoma (Calosoma) sycophanta* (Linnaeus, 1758)	1.2.2(1)				*	Krichim (1n)	Cals_syc
20.	*Carabus (Archicarabus) wiedemanni* Ménétriés, 1836	1.2.2				*	Shiroka polyana (2♀, 1♂)	Car_wie
21.	*Carabus (Tomocarabus) convexus* Fabricius, 1775	1.2.2				*	Nevyastata (1n)	Car_con
22.	*Carabus (Pachystus) cavernosus* Frivaldszky, 1835	1.2.2			*	+	Sushitsa (1n)	Car_cav
23.	*Carabus (Oreocarabus) hortensis* Linnaeus, 1758	1.2.2				*	Nevyastata (1♀, 1♂, 1n), Ravnogor (1n)	Car_hor
24.	*Carabus (Megodontus) violaceus* Linnaeus, 1758	1.2.2		+	*	+ *	Belishki skali (1n), Sestrimo (1n), Nevyastata (2♀, 2♂, 1n),	Car_vio
25.	*Carabus (Lamprostus) torosus* Frivaldszky, 1835	1.2.2	+					Car_tor
26.	*Carabus (Procrustes) coriaceus* Linnaeus, 1758	1.2.2	*		*	*	Tsarevo – Varvara (1♂), Polyatsite (1♂), Vetren (1n), Belishki skali (1n), Rila (1n), Sestrimo (1n), Gotse Delchev (1n), Shiroka polyana (2♀), Rani list (2♀, 4♂), Boykovo (1n), Nevyastata (3♀, 8♂), Semchinovo (1n), Sitovo (1n), Ustina (1n), Varba (1♂)	Car_cor
27.	*Carabus (Procerus) scabrosus* Olivier, 1789	1.2.2				*	Nevyastata (1n), Ravnogor (1n)	Car_sca
28.	*Cychrus semigranosus* Palliardi, 1825	1.2.2				*	Nevyastata (1n), Ustina (1n)	Cyc_sem
	Tribe Scaritini							
29.	*Scarites (Parallelomorphus) laevigatus* Fabricius, 1792	1.4.2(2)	+	+				Sca_lae
	Tribe Dyschiriini							
30.	*Dyschirius (Dyschirius) caspius* Putzeys, 1866	1.4.2(1)	+	+				Dys_cas
31.	*Dyschirius (Dyschirius) angustatus* (Ahrens, 1830)	1.4.2(1)	+					Dys_ang
32.	*Dyschirius (Chiridysus) strumosus* Erichson, 1837	1.4.2(1)	+	+				Dys_str
33.	*Dyschirius (Paradyschirius) parallelus* Motschulsky, 1844	1.4.2(1)	+					Dys_par
34.	*Dyschiriodes (Eudyschirius) globosus* Herbst, 1784	1.4.2(1)	+	+				Dys_glo

№	Species	Life form	Ecosystem subtypes				Records from the field investigations	Code
			Sand	Shingle	Scree	Cliff		
35.	*Dyschiriodes (Dyschiriodes) apicalis* Putzeys, 1846	1.4.2(1)	+	+				Dys_api
36.	*Dyschiriodes (Dyschiriodes) luticola* Chaudoir, 1850	1.4.2(1)	+	+				Dys_lut
37.	*Dyschiriodes (Dyschiriodes) chalybaeus* (Putzeys, 1846)	1.4.2(1)	+	+				Dys_cha
38.	*Dyschiriodes (Dyschiriodes) salinus* Schaum, 1843	1.4.2(1)	+	+				Dys_sal
39.	*Dyschiriodes (Dyschiriodes) nitidus* (Dejean, 1825)	1.4.2(1)	+					Dys_nit
40.	*Dyschiriodes (Dyschiriodes) intermedius* Putzeys, 1866	1.4.2(1)	+					Dys_int
	Tribe Broscini							
41.	*Broscus semistriatus* (Dejean, 1828)	1.4.1(2)	+					Bro_sem
	Tribe Apotomini							
42.	*Apotomus clypeonitens* Müller, 1943	1.4.1(1)	+					Apo_cly
	Tribe Trechini							
43.	*Thalassophilus longicornis* (Sturm, 1825)	1.3(1).2		+				Tha_lon
44.	*Perileptus (Perileptus) areolatus* (Creutzer, 1799)	1.3(1).2		+				Per_are
45.	*Blemus discus* (Fabricius, 1792)	1.3(1).2	+					Ble_dis
46.	*Trechus (Trechus) quadristriatus* (Schrank, 1781)	1.3(1).2	+	+	+	+		Tre_qua
	Tribe Tachyini							
47.	*Tachys (Tachys) scutellaris* (Stephens, 1828)	1.3(1).4	+	+				Tac_scu
48.	*Elaphropus (Tachyura) parvulus* (Dejean, 1831)	1.3(1).1	+	+				Ela_par
	Tribe Bembidiini							
49.	*Asaphidion flavipes* (Linnaeus, 1761)	1.2.3	+					Asa_fla
50.	*Bembidion (Odontium) striatum* (Fabricius, 1792)	1.2.3	+					Bem_str
51.	*Bembidion (Odontium) foraminosum* Sturm, 1825	1.2.3	+					Bem_for
52.	*Bembidion (Bracteon) litorale* (Olivier, 1790)	1.2.3	+					Bem_lit
53.	*Bembidion (Metallina) lampros* (Herbst, 1784)	1.3(1).2	+	+	+ *	+ *	Belishki skali (1n), Ustina (1n)	Bem_lam
54.	*Bembidion (Metallina) properans* (Stephens, 1828)	1.3(1).2				*	Gostun (1♀)	Bem_pro
55.	*Bembidion (Notaphemphanes) ephippium* (Marsham, 1802)	1.3(1).1	+	+				Bem_eph
56.	*Bembidion (Emphanes) tenellum* Erichson, 1837	1.3(1).1	+					Bem_ten
57.	*Bembidion (Bembidionetolitzkya) tibiale* (Duftschmid, 1812)	1.3(1).1		+				Bem_tib
58.	*Bembidion (Bembidionetolitzkya) concoeruleum* Netolitzsky, 1943	1.3(1).1		+				Bem_con
59.	*Bembidion (Lymnaeum) nigropiceum* (Marsham, 1802)	1.3(1).1	*	*			Evksinograd (1♀)	Bem_nig
60.	*Bembidion (Euperyphus) scapulare* Dejean, 1831	1.3(1).1		+				Bem_sca
61.	*Bembidion (Peryphus) femoratum* Sturm, 1825	1.3(1).1	+	+				Bem_fem
62.	*Bembidion (Ocydromus) modestum* (Fabricius, 1801)	1.3(1).1		+				Bem_mod
63.	*Bembidion (Ocyturanes) balcanicum* Apfelbeck, 1899	1.3(1).1				*	Rila (1♂), Nevyastata (2♀), Ribnitsa (1♂)	Bem_bal
64.	*Bembidion (Peryphanes) dalmatinum* Dejean, 1831	1.3(1).1			*	*	Kostenets (1♀), Dedevo (4♂)	Bem_dal
65.	*Bembidion (Peryphanes) castaneipenne* Jacquelin du Val, 1852	1.3(1).1				*	Dedevo (1♀), Kuklen (1♀, 1♂)	Bem_cas
66.	*Bembidion (Peryphiolus) monticola* Sturm, 1825	1.3(1).1				*	Dedevo (1♂)	Bem_mon
67.	*Bembidion (Microserrullula) quadricolle* (Motschulsky, 1844)	1.3(1).1	+	+				Bem_qua
68.	*Sinechostictus (Sinechostictus) millerianus* (Heyden, 1883)	1.3(1).1		+				Sin_mil
	Tribe Pogonini							
69.	*Pogonus (Pogonus) littoralis* (Duftschmid, 1812)	1.3(2).2	+	+				Pog_lit
70.	*Pogonus (Pogonus) olivaceus* Carret, 1903	1.3(2).2	+	+				Pog_oli
71.	*Pogonistes rufoaeneus* (Dejean, 1828)	1.3(2).2	+	+				Pogt_ruf
	Tribe Pterostichini							
72.	*Xenion ignitum* (Kraatz, 1875)	1.3(1).4				*	Sestrimo (1n), Boykovo (1n), Nevyastata (2♂)	Xen_ign
73.	*Myas (Myas) chalybaeus* (Palliardi, 1825)	1.3(2).1				*	Sestrimo (1n), Ustina (1n)	Mya_cha
74.	*Poecilus (Poecilus) cupreus* (Linnaeus, 1758)	1.3(2).1	*				Zlatni Pyasatsi (1♀, 1♂)	Poe_cup
75.	*Poecilus (Poecilus) lepidus* (Leske, 1785)	1.3(2).1			*	*	Mala Tsarkva (2♀)	Poe_lep
76.	*Pterostichus (Platysma) niger* (Schaller, 1783)	1.3(2).1			*	*	Kostenets (1♂), Lilkovo (1n), Sveti Georgi (1♂)	Pte_nig
77.	*Pterostichus (Argutor) vernalis* (Panzer, 1796)	1.3(2).1	*				Kiten (1♀)	Pte_ver
78.	*Pterostichus (Feronidius) melas* (Creutzer, 1799)	1.3(2).1				*	Byala reka (1♂)	PteF_mel
79.	*Abax (Abacopercus) carinatus* Duftschmid, 1812	1.3(2).1				*	Eleshnitsa (1♀)	Aba_car
80.	*Molops (Molops) dilatatus* Chaudoir, 1868	1.3(2).1			*	*	Mala Tsarkva (3♂), Ezerovo (1♂)	Mol_dil
	Tribe Sphodrini							
81.	*Calathus (Calathus) fuscipes* (Goeze, 1777)	1.3(1).2			*	*	Eleshnitsa (1♀), Belitsa (1n)	Cal_fus
82.	*Calathus (Neocalathus) melanocephalus* (Linnaeus, 1758)	1.3(1).2	*			*	Primorsko (1♂), Rila (1♂)	Cal_mel

№	Species	Life form	Ecosystem subtypes				Records from the field investigations	Code
			Sand	Shingle	Scree	Cliff		
83.	*Laemostenus (Pristonychus) terricola* (Herbst, 1784)	1.3(1).6				*	Rani list (1♂), Shiroka polyana (2♀), Nevyastata (1♀, 2♂)	Lae_ter
84.	*Laemostenus (Pristonychus) cimmerius* (Fischer von Waldheim, 1823)	1.3(1).6				*	Nevyastata (1♂)	Lae_cim
	Tribe Agonini							
85.	*Agonum (Olisares) hypocrita* (Apfelbeck, 1904)	1.3(1).1	*				Zlatni Pyasatsi (1♂)	Ago_hyp
	Tribe Zabrini							
86.	*Amara (Zezea) concinna* C. Zimmermann, 1832	2.2.1	+					AmaZ_con
87.	*Amara (Zezea) tricuspidata* Dejean, 1831	2.2.1				*	Beli Iskar (1♀), Semchinovo (1♀)	AmaZ_tri
88.	*Amara (Zezea) strandi* Lutshnik, 1933	2.2.1	+	+				AmaZ_str
89.	*Amara (Amara) aenea* (De Geer, 1774)	2.3.1				*	Sitovo (1n), Krichim (1n)	Ama_aen
90.	*Amara (Amara) anthobia* Villa, 1833	2.1.1			*	*	Belitsa (1n), Lilkovo (1n)	Ama_ant
91.	*Amara (Amara) convexior* Stephens, 1828	2.3.1			+	+		Ama_con
92.	*Amara (Amara) eurynota* (Panzer, 1796)	2.3.1				*	Ravnogor (1♀)	Ama_eur
93.	*Amara (Amara) ovata* (Fabricius, 1792)	2.3.1			+	+		Ama_ova
94.	*Amara (Amara) saphyrea* Dejean, 1828	2.2.1				+		Ama_sap
95.	*Amara (Amara) montivaga* Sturm, 1825	2.3.1			+	+		Ama_mon
96.	*Amara (Amara) curta* Dejean, 1828	2.3.1			+ *	+ *	Mala Tsarkva (1♂)	Ama_cur
97.	*Amara (Amara) lunicollis* Schiödte, 1837	2.1.1				*	Hvoyna (1♂), Nevyastata (1♂), Sveti Georgi (1♂)	Ama_lun
98.	*Amara (Celia) bifrons* (Gyllenhal, 1810)	2.3.1			+			Ama_bif
99.	*Amara (Celia) sollicita* Pantél, 1888	2.3.1			+	+		Ama_sol
100.	*Amara (Celia) arenaria* (Putzeys, 1865)	2.3.1			+	+		Ama_are
101.	*Amara (Amarocelia) erratica* (Duftschmid, 1812)	2.3.1			+	+		Ama_err
102.	*Amara (Xenocelia) fusca* Dejean, 1828	2.3.1	+		+	+		Ama_fus
103.	*Amara (Xenocelia) bischoffi* Jedlička, 1946	2.3.1			+	+		Ama_bis
104.	*Amara (Bradytus) consularis* (Duftschmid, 1812)	2.3.1(1)			+			AmaB_con
105.	*Zabrus (Pelor) spinipes* (Fabricius, 1798)	2.3.2				*	Petrich (1♀)	Zab_spi
	Tribe Harpalini							
106.	*Stenolophus (Stenolophus) discophorus* (Fischer-Waldheim, 1823)	2.1.1	*	*			Evksinograd (1♀)	Ste_dis
107.	*Anthracus consputus* (Duftschmid, 1812)	2.1.1	*				Zlatni Pyasatsi (1♀)	Ant_con
108.	*Parophonus (Parophonus) mendax* (Rossi, 1790)	2.2.1	*	*			Evksinograd (1♀)	Par_men
109.	*Harpalus (Harpalus) honestus* (Duftschmid, 1812)	2.3.1				*	Petrich (1♀), Nevyastata (2♂)	Har_hon
110.	*Harpalus (Harpalus) rubripes* (Duftschmid, 1812)	2.3.1				*	Strupets (1♀), Nevyastata (1♀)	Har_rub
111.	*Harpalus (Harpalus) attenuatus* Stephens, 1828	2.3.1				*	Veslets (1♂)	Har_att
112.	*Harpalus (Harpalus) atratus* Latreille, 1804	2.3.1				*	Lilyak (1♀), Rani list (1♂)	Har_atr
113.	*Harpalus (Harpalus) laevipes* Zetterstedt, 1828	2.3.1				*	Gostun (1♂)	Har_lae
114.	*Harpalus (Harpalus) pumilus* Sturm, 1818	2.3.1	*	*			Evksinograd (7♀, 1♂), Zlatni Pyasatsi (1♀), Slanchev Bryag (1♂)	Har_pum
115.	*Harpalus (Harpalus) servus* (Duftschmid, 1812)	2.3.1	+		+			Har_srv
116.	*Harpalus (Harpalus) subcylindricus* Dejean, 1829	2.3.1				*	Brezhani (1♂)	Har_sub
117.	*Harpalus (Harpalus) flavescens* (Piller et Mitterpacher, 1783)	2.3.1(1)	+					Har_fla
118.	*Harpalus (Harpalus) tardus* (Panzer, 1797)	2.3.1	*			*	Kiten (1♀), Rani list (1♂)	Har_tar
119.	*Harpalus (Harpalus) albanicus* Reitter, 1900	2.3.1	*	*			Evksinograd (1♂)	Har_alb
120.	*Harpalus (Harpalus) autumnalis* (Duftschmid, 1812)	2.3.1	*				Kamchiya (1♂), Kiten (2♀, 4♂), Primorsko (1♀, 4♂)	Har_aut
121.	*Harpalus (Harpalus) cupreus* Dejean, 1829	2.3.1	*	*			Evksinograd (1♂)	Har_cup
122.	*Harpalus (Harpalus) dimidiatus* (Rossi, 1790)	2.3.1				*	Brezhani (1♀), Shiroka polyana (2♂)	Har_dim
123.	*Harpalus (Harpalus) caspius* (Steven, 1806)	2.3.1	*	*		*	Evksinograd (2♀), Petrich (1♀)	Har_cas
124.	*Harpalus (Harpalus) distinguendus* (Duftschmid, 1812)	2.3.1	*	*			Kamchiya (2♂), Pomorie (1♀)	Har_dis
125.	*Harpalus (Harpalus) saxicola* Dejean, 1829	2.3.1	*				Kamchiya (1♂)	Har_sax
126.	*Ophonus (Metophonus) veluchianus* (G. Muller,1931)	2.2.1				*	Bazovets (2♂)	Oph_vel
127.	*Ophonus (Metophonus) parallelus* (Dejean, 1829)	2.2.1			+	+ *	Gotse Delchev (1♀)	Oph_par
128.	*Ophonus (Hesperophonus) cribricollis* Dejean, 1829	2.2.1	*	*		*	Krapets (1♂), Primorsko (1♀), Rani list (2♀)	Oph_cri
129.	*Ophonus (Ophonus) sabulicola* (Panzer, 1796)	2.2.1				*	Kamenets (1♂)	Oph_sab
130.	*Pangus scaritides* (Sturm, 1818)	2.3.1				*	Ilinitsa (1♀)	Pang_sca
131.	*Carterus (Pristocarterus) angustipennis* (Chaudoir, 1852)	2.3.3		*			Pomorie (1♂)	Cart_agp
132.	*Dixus eremita* (Dejean, 1825)	2.3.3				*	Tatkovo (1n)	Dix_ere
133.	*Dixus obscurus* (Dejean, 1825)	2.3.3				*	Tatkovo (1♂), Semchinovo (1n)	Dix_obs
	Tribe Panagaeini							
134.	*Panagaeus (Panagaeus) bipustulatus* (Fabricius, 1775)	1.3(1).1			*	*	Pavelsko (1♂)	Pan_bip

№	Species	Life form	Ecosystem subtypes				Records from the field investigations	Code
			Sand	Shingle	Scree	Cliff		
	Tribe Callistini							
135.	*Chlaenius (Chlaenius) festivus* (Panzer, 1796)	1.3(1).1	*				Tsarevo – Varvara (1♂)	Chl_fes
	Tribe Licinini							
136.	*Badister (Badister) bullatus* (Schrank, 1798)	1.3(1).2	*	*			Evksinograd (1♀)	Bad_bul
	Tribe Lebiini							
137.	*Paradromius (Paradromius) suturalis* (Motschulsky, 1844)	1.3(1).5	+					Par_sut
138.	*Microlestes fissuralis* (Reitter, 1901)	1.3(1).3	*				Tsarevo – Varvara (1♀)	Mic_fis
139.	*Lionychus (Lionychus) quadrillum* (Duftschmid, 1812)	1.3(1).1	+	+				Lio_qua
140.	*Cymindis (Cymindis) lineata* (Quensel, 1806)	1.3(1).3				*	Shirokovo (1♂)	Cym_lin
141.	*Cymindis (Cymindis) humeralis* (Geoffroy in Fourcroy, 1785)	1.3(1).3				*	Nevyastata (1♂)	Cym_hum
	Tribe Brachinini							
142.	*Brachinus (Brachinus) berytensis* Reiche et Saulcy, 1855	1.3(1).3		*			Pomorie (2♂)	Bra_ber
143.	*Brachinus (Brachinus) crepitans* (Linnaeus, 1758)	1.3(1).3		*			Krapets (1♀, 3♂)	Bra_cre
144.	*Brachinus (Brachynidius) explodens* Duftschmid, 1812	1.3(1).3	*	*			Evksinograd (1♀)	Bra_exp
145.	*Brachinus (Brachynolomus) brevicollis* Motschulsky, 1844	1.3(1).3		*			Krapets (2♀, 1♂)	Bra_bre
	Total:		69	49	30	73	80	

Explanations to the Appendix 2:

Column № 1. Consecutive number.

Column № 2. List of the species recorded from the four subtypes of sparsely vegetated ecosystems in Bulgaria.

Column № 3. Explanation to the indexes of the life forms:

The first figure in the index shows the class of life form, the second – the subclass, the third – the life form group. In brackets after the subclass the series is shown, when it exists.

Life form class 1. Zoophagous:

Life form subclass: 1.2 – Epigeobios; 1.3 – Stratobios; 1.4 – Geobios; 1.5 – Psammocolimbets.

Life form groups: 1.2.2 – large walking epigeobionts; 1.2.2(1) – large flying epigeobionts; 1.2.3 – running epigeobionts; 1.2.4 – flying epigeobionts; 1.3(1) – series crevice-dwelling stratobionts; 1.3(1).1 – surface & litter-dwelling; 1.3(1).2 – litter-dwelling; 1.3(1).3 – litter & crevice-dwelling; 1.3(1).4 – endogeobionts; 1.3(1).5 – litter & bark-dwelling; 1.3(1).6 – bothrobionts; 1.3(2) – series digging stratobionts; 1.3(2).1 – litter & soil-dwelling; 1.3(2).2 – litter & crevice-dwelling; 1.4.1 – running & digging geobionts; 1.4.1(1) – narrow-headed running & digging geobionts; 1.4.1(2) – wide-headed running & digging geobionts; 1.4.2 – digging geobionts 1.4.2(1) – small digging geobionts; 1.4.2(2) – large digging geobionts; 1.5.1 – shore psammobionts.

Life form class 2. Mixophytophagous:

Life form subclass: 2.1 – Stratobios; 2.2 – Stratohortobios; 2.3 – Geohortobios.

Life form groups: 2.1.1 – crevice-dwelling stratobionts; 2.2.1 – stratohortobionts; 2.3.1 – harpaloid geohortobionts; 2.3.1(1) – crevice-dwelling harpaloid geohortobionts; 2.3.2 – zabroid geohortobionts; 2.3.3 – dytomeoid geohortobionts.

Column № 4. Presence of the carabid species in the different subtypes of sparsely vegetated ecosystems: (+) marks presence according to the literary data and (*) marks field observations.

Column № 5. Localities and numbers of collected during the field trips ground beetles (♀ – female, ♂ – male, n – not determined).

Column № 6. Codes for the individual species, used in the mathematical analyses.