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Ground beetles (Coleoptera: Carabidae) from the region of Cape Emine (central Bulgarian Black sea coast). Part III. Spatial distribution and gradient analysis

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Abstract. The ground beetle fauna of the area of Cape Emine was studied. Over the period 2010 – 2012 adult carabid beetles were collected. The investigation was carried out at 13 sampling sites and pitfall traps were used. During the study altogether 12618 specimens were captured. Mathematical processing of the data by gradient analysis with methods for classification and ordination of the communities was performed. Analysis of distribution of the zoogeographical categories and life forms was done. The primary role of the humidity and vegetation as ecological factors affecting the distribution of the communities of ground beetles was proven.

Keywords: Carabidae, Cape Emine, gradient analysis, ordination, classification

Introduction

All species occur in a characteristic, limited range of habitats and within their range they tend to be most abundant around their particular environmental optimum. The composition of biotic communities thus changes along the environmental gradients.

Mathematical methods in ecology aim at carrying out numerical analyses of environmental data, and determination and interpretation of their multidimensional structure. In the gradient analysis the significance of the gradients of the environment (conditions, within which a biological object may exist) is determined by means of complex mathematical methods (Ter Braak 1994). Gradients are useful abstraction for explaining the distribution of organisms in space and time (Austin 1985).

Methods of the classification perform an objective grouping of the species in similar communities. This serves for separation of the data into groups of similar samples and underlies in resource management and implementation of conservation policies. Ordination is the tool for exploratory analysis of community data with no prior information about the environment and is used for arranging of the samples on individual axes, which reflects the general trends or gradients among the data. Ordination is helping in understanding the organism-environment relationships. Direct methods use the data about the species and the environment and indirect methods use only the data about the species (Ter Braak 1994).

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Practical application of the ordination is related to the management of ecosystems, for example, a given habitat management with a view to achieving the desired conditions in the future, and also with management experiments and recovery efforts towards disturbed environment.

Cape Emine is included within the protected zones BG0001004 „Emine – Irakli" under Directive 92/43 for the protection of natural habitats and wild flora and fauna, and BG0002043 „Emine" under Directive 79/409 for the protection of birds. The geostrategic location of the studied territory, its diverse topography and the contingent climate contributed to the mixing of the representatives of various ecological and biogeographical complexes, which has led to the formation of peculiar biocoenoses.

This study aims to analyze the effect of the local gradients on the spatial differentiation of the ground beetle communities, life forms and chorotypes within the context of their use in site assessment and conservation ecology.

Material and Methods

In connection with the participation in a project for biological monitoring studies in the area of Cape Emine, a series of observations and samplings were carried out in 2010 – 2012. Ground beetles were collected with terrestrial pitfall traps (Barber 1931; Hertz 1927; Dahl 1896). The traps were made of plastic bottles, buried at the level of the ground surface. As fixation fluid a 4 – 10% solution of formaldehyde was used. In all sampling areas 10 – 14 pitfall traps were set. The total number of the traps was 126.

The investigation was performed at 13 different sampling sites (Table 1). Further on in the text, the abbreviated expressions given in the Table 1 were used. In seven of the sampling areas were conducted full catches in 2010 and 2011 (in spring, summer and autumn), as well as additional samplings in 2012 (in spring and autumn). In the remaining areas samplings did not cover the full period of research, and therefore the analysis of the spatial distribution of the carabids was based on the number of the caught specimens for 100 trapdays.

Specimens were identified according to: Kryzhanovskij (unpublished data), Arndt *et al.* (2011), Lindroth (1974), Hůrka (1996), Reitter (2006), Trautner & Geigenmüller (1987) and are deposited in the Carabidae collection of the Institute of Biodiversity and Ecosystem Research (BAS).

Two methods of the gradient analysis were used – classification and ordination. Classification of the studied communities was done with the TWINSPAN (TWo-way INdicator SPecies ANalysis) statistical program for multidimensional factorial analysis (Hill & Šmilauer 2005). As a splitting method, it is released from the disadvantages giving too much weight to the statistical artifacts related to the size of the sample (Minkova 2002).

Ordination is a method for removing the subjectivity in describing and assessing the assemblages. It is a complex, multidimensional statistical analysis, which uses the combination of the species composition in the communities and the distribution of the populations under the environmental conditions (Ter Braak 1994). In this study the software product CANOCO 4.5 was used (Ter Braak & Šmilauer 2002).

Table 1. Abbreviations, description and location (altitude a. s. l. and geographic coordinates) of the sampling sites. **Ir** is used for all samples in the Irakli site; **V** is used for the two samples from the Military base southern from the town of Obzor; **R** is used for the sampling sites near the signal repeaters, located northern from the Irakli site.

Abbr.	Description of the sampling site	Altitude	Coord.
IrL	An abandoned vineyard in the Irakli site, with initial stages of a autochthonous forest recovering succession	26–34 m	N 42º45' E 27º53'
IrD	Oak forest (*Quercus* spp.) near the Irakli site	45–54 m	N 42º45' E 27º53'
IrB	Shore ecotone, immediately upon the rocky edge above the sea shore in Irakli, near a mixed pine-oak forest	38–47 m	N 42º45' E 27º53'
IrV	Along the shore of the Vaya river, unaffected by the “cleansing” of the river bed (in 2007), with typical wet riparian habitats and rich and abundant vegetation	14–15 m	N 42º45' E 27º52'
IrN1	In the ecotone between farmlands and the shore of the Vaya river, among dense grass-shrub ruderal and weed vegetation, at the edge of the wheat field	14–15 m	N 42º45' E 27º52'
IrN2	In newly formed wheat field coenose beside the Vaya river, near the main road E87	19–20 m	N 42º45' E 27º52'
Ir2e	In the ecotone between IrN2 and the river	19–20 m	N 42º45' E 27º52'
VBd	Domuskolak gully, with traps located on the open path from the oak forest to the beach and in the mouth of a brook drying up in summer	8–13 m	N 42º47' E 27º53'
VBb	Black Pine plantation with accompanying bush-grass vegetation	13–25 m	N 42º47' E 27º53'
Rs	Steppe-like habitat at the crest meadow above site Rd, near the signal repeaters	114–117 m	N 42º46' E 27º53'
Rd	Old oak forest with dense undergrowth of spiny shrubs and moderately xerothermic conditions	112–121 m	N 42º46' E 27º53'
Rn	In the newly formed wheat field agrocoenose at the place of the former steppe-like habitat (Rs)	131–134 m	N 42º46' E 27º52'
Rne	In the ecotone between Rn and the small island with remained natural grass-shrub vegetation	131–134 m	N 42º46' E 27º52'

Results

During the study altogether 12618 specimens were captured. They belong to 134 species, 46 genera, 18 tribes, 3 subfamilies.

The largest number of both species and specimens was established in the steppe-like habitat (Rs), and the lowest – in the pine plantation (VBb). Poor species composition seems to be typical for pine cultures, as similar patterns are found for pine forest assemblages in other studies too (Hengeveld 1980; Niemelä 1993; Rainio 2009; Balog *et al.* 2012), while the richest species composition of the steppe-like habitat is likely resulting from the presence of some extrazonal (i.e. forest) and intrazonal (halophilic) and Mediterranean species (Putchkov 2011). Thirty seven species (28%) were represented by only one individual. Similar percentage does not appear to be unusual, as it is also established by other authors

(Coddington *et al.* 2009; Ferro *et al.* 2012). We found the largest number of such species in the sampling sites IrV (9 species), Rs (8 species) and VBd (7 species).

The most abundant species were *Chlaenius nitidulus* (with 1927 indvs.), *Nebria brevicollis* (1890 indvs.), *Carabus coriaceus* (1240 indvs.), *Brachinus crepitans* (1213 indvs.), *Pterostichus melas* (880 indvs.), *Calathus fuscipes* (623 indvs.) and *Harpalus dimidiatus* (555 indvs.).

For further information about species composition, taxonomic and community structure etc., see Teofilova (2015) and Teofilova *et al.* (2015).

Classification of the assemblages

In the Appendix are given the results of the 3-levels TWINSPAN classification. On the first level of division two groups divide – IrV and IrN1 form the right group, with an indicator species *Carabus cancellatus*, and all the other sampling sites are included in the left group. On the second level of division also two groups are separated, and it can be argued that in the right group predominate forests and mixed biotopes with indicator species *Leistus rufomarginatus*, and in the left – the open biotopes, where *Brachinus crepitans* is an indicator. On the third level four groups divide. The abandoned vineyard (IrL) detach in a private group, and IrN2 and the sampling sites near the signal repeaters (Rd, Rs) are united in a common group with the indicator *Notiophilus interstitialis*. The final groups of assemblages are classified into five end groups, arranged from open and dry (the left part of the table) to humid and accompanied by high vegetation (the right part), as it was also found for other areas of the Black Sea coast (Popov & Krusteva 1999). The number of the assemblages in the TWINSPAN groups varies between one and four. Eight distributional species groups are formed at the third level of the TWINSPAN division.

The grouping of the species indicates that the type of the vegetation is not of that importance, although there is some separation of the species: from associated with open habitats, throughout eurybionts, to forest dwellers. Determinative, however, is the importance of the humidity, as far as at the top of the table are concentrated the inhabitants of dry areas, and at the bottom – the ones attached to higher humidity. In the last TWINSPAN species group are focused the most rare riverine species caught near the banks of the Vaya River. Some species or groups of species with a relatively wide ecological tolerance are more or less evenly spread across the table. The same pattern is found by Popov & Krusteva (1999) too.

Ordination of the data

The data from the ordination of the sampling sites show strong dispersion of the studied communities and ecological groups of carabids, which spoke of the relative heterogeneity of the landscapes. We found a grouping of the sampling sites near the signal repeaters (R). The biotope in the abandoned vineyard (IrL) clearly distinguishes from the rest in the full two-year catches (Fig. 1).

When analyzing the data from the trapdays, we found a peculiar separation of the riverside biotope (IrV) (Fig. 2). Ordination data indicates that humid sites were tending to the left site of the graphic.

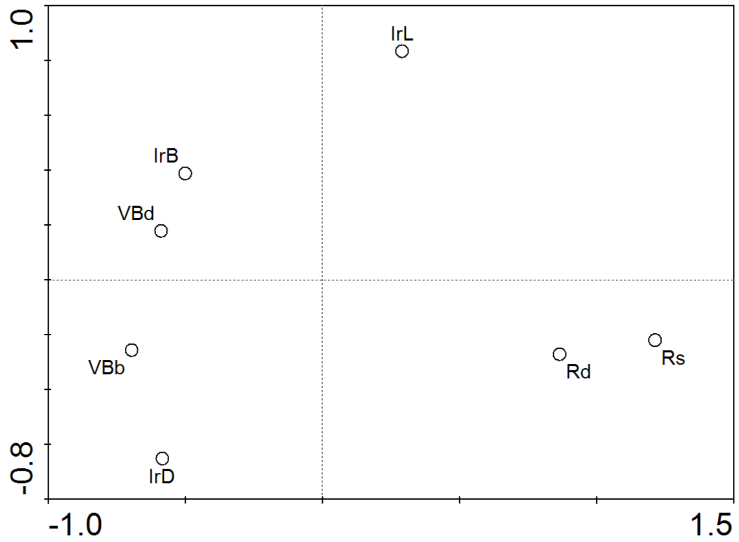

Fig. 1. PCA distribution of the sampling sites with full two-year catches.

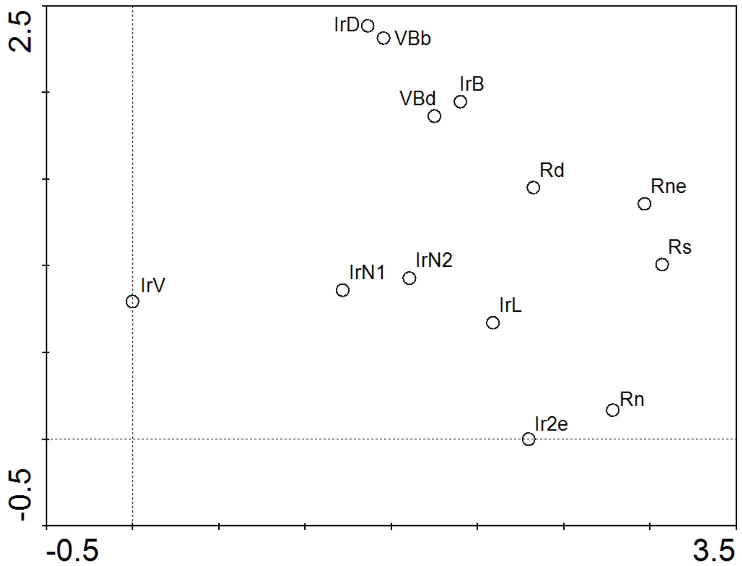

Fig. 2. DCA analysis of the trapdays data for all of the sampling sites.

We performed an analysis of the distribution of the data in relation to the two of the most important environmental factors influencing the spatial distribution of the ground beetles – humidity and vegetation. Fig. 3 shows the relations of the species to the grades of humidity and vegetative cover.

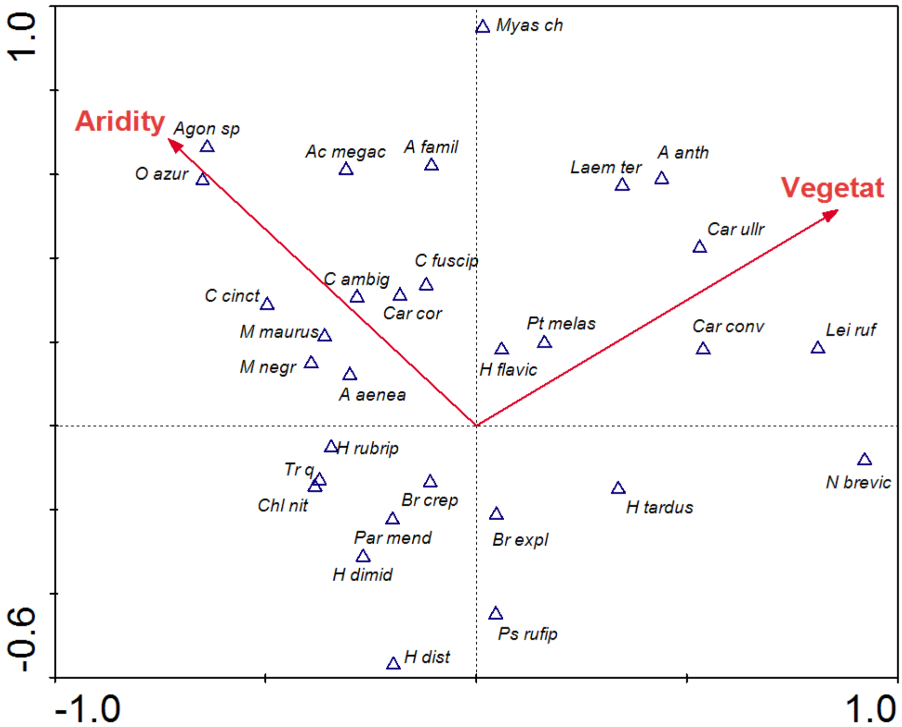

Fig. 3. Distribution of the permanent species in relation to the humidity and vegetation. The analysis included only the permanent species – those with a frequency above 50% (see TEOFILOVA 2015): A aenea – *Amara aenea*; A anth – *Amara anthobia*; A famil – *Amara familiaris*; Ac megac – *Acinopus megacephalus*; Agon sp – *Agonum (Europhilus)* sp.; Br crep – *Brachinus crepitans*; Br expl – *Brachinus explodens*; C ambig – *Calathus ambiguus*; C cinct – *Calathus cinctus*; C fuscip – *Calathus fuscipes*; Car conv – *Carabus convexus*; Car cor – *Carabus coriaceus*; Car ullr – *Carabus ullrichi*; Chl nit – *Chlaenius nitidulus*; H dimid – *Harpalus dimidiatus*; H dist – *Harpalus distinguendus*; H flavic – *Harpalus flavicornis*; H rubrip – *Harpalus rubripes*; H tardus – *Harpalus tardus*; Laem ter – *Laemostenus terricola*; Lei ruf – *Leistus rufomarginatus*; M maurus – *Microlestes maurus*; M minut – *Microlestes minutulus*; Myas ch – *Myas chalybaeus*; N brevic – *Nebria brevicollis*; O azur – *Ophonus azureus*; Par mend – *Parophonus mendax*; Ps rufip – *Pseudoophonus rufipes*; Pt melas – *Pterostichus melas*; Tr q – *Trechus quadristriatus*.

Fig. 4 shows the distribution of the sampling sites in relation to the same environmental gradients. The assemblages from the steppe-like habitat (Rs), the abandoned vineyard (IrL) and the shore ecotone (IrB) seemed to tend to more arid environmental conditions. The agrocoenoses and their adjacent ecotone areas, in turn, were forming an autonomous group of open habitats. In that group we also found the VBd site, which was probably due to the mixing of species, resulting from the specific border location of that sampling site. The habitats with the greatest affection to higher (forest) vegetation and humidity were the shore of the Vaya River (IrV) and one of the oak forests (Rd).

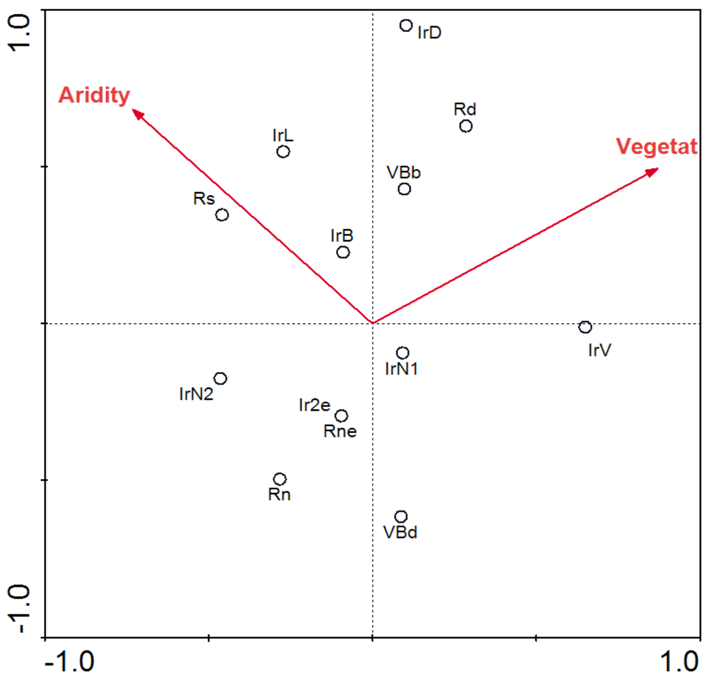

Fig. 4. Ordination of the sampling sites in relation to the humidity and vegetation. The calculations were performed by the use of the results from all of the sampling sites and all of the catches, standardized through the recalculation of the data as number of specimens per 100 trapdays.

We found that there is a relation between the zoogeographical categories and the environmental conditions in the individual sampling sites (Fig. 5). Clearly visible is the attachment of the Mediterranean species to the arid areas with low vegetative cover. Mostly forest-dwelling representatives from the European and Euro-Siberian categories show affection to the sampling sites with predominantly ligneous forest or forest-shrub vegetation.

From the analysis of the distribution of the life form subclasses (Fig. 6) we concluded that the mixophytophagous geobionts and stratohortobionts prefer open and anthropogenically impacted landscapes – the steppe-like habitat, the abandoned vineyard, wheat fields. Zoophagous beetles, in turn, are dependent on the forest habitats. The exception is the situation of IrN1, probably due to the proximity of the bank of the Vaya River and the possible resulting from that mixing of the data.

PCA ordination analysis of the distribution of the life form groups (Fig. 7) showed the connection between the steppe-like habitat and the representatives of the class Mixophytophagous. The high species diversity of the genera *Harpalus* and *Ophonus* contribute to the grouping of the categories stratohortobionts and harpaloid geohortobionts with this habitat. The abundance of the representatives of the genera *Cymindis* and *Brachinus*, in turn, attach this sampling site with the zoophagous litter & crevice-dwelling stratobionts. With VBd are connected the flying epigeobionts of the genus *Cicindela*, and with IrL – the living in crevices litter & bark-dwelling stratobiontis of the genus *Paradromius*, single specimen of which was found only in this sampling site. We established the greatest variety of life forms connected with the Vaya River, where a large number of rare species was found too: small geobiontis, with only representative *Dyschirius rufipes*; running epigeobionts *Asaphidion flavipes*; endogeobionts living in crevices of the *Tachys* sp. type; surface & litter-dwelling stratobionts living in crevices, represented by the genera *Nebria*, *Notiophilus*, *Bembidion*, *Anchomenus*, *Chlaenius* and others.

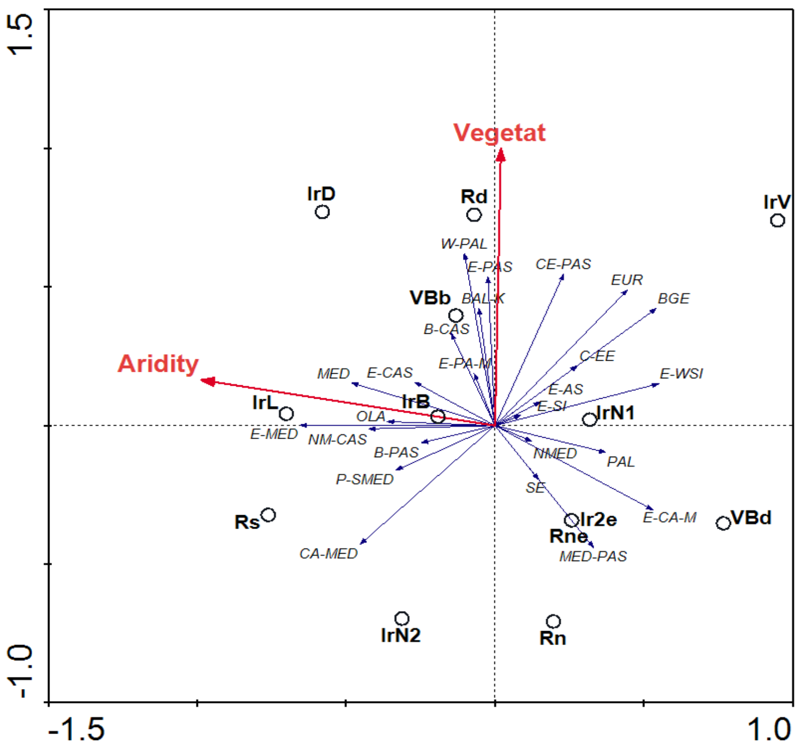

Fig. 5. Distribution of the chorotypes: OLA – Holarctic; PAL – Palearctic; W-PAL – Western Palearctic; E-SI – Eurosiberian; E-WSI – European-Westsiberian; EUR – European; E-PAS – European-Neareastern; CE-PAS – Central European and Neareastern; C-EE – Central and Eastern European; BAL-K – Balkan-Carpathian; E-AS – Euroasiatic steppe complex; E-CAS – European and Central Asian; B-CAS – Balkan and Central Asian; B-PAS – Balkan-Neareastern (+ Balkan-Anatolian); E-CA-M – European-Centralasian-Mediterranean; E-PA-M – European-Neareastern-Mediterranean; CA-MED – Mediterranean-Centralasian; MED-PAS – Mediterranean-Neareastern; MED – Mediterranean; E-MED – Eastmediterranean; P-SMED – Pontic-Submediterranean; SE – South European; NMED – Northmediterranean; NM-CAS – Northmediterranean-Centralasian; BGE – Bulgarian endemic.

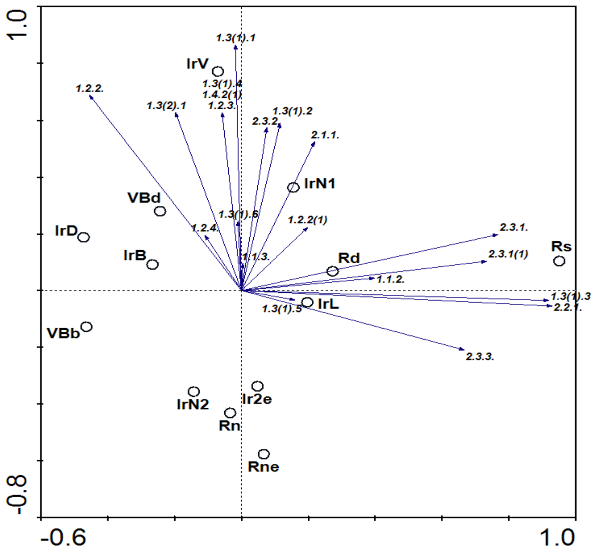

Fig. 6. PCA distribution of the sampling sites and the subclasses of life forms (according to Sharova 1981): Z_Phytob – Zoophagous phytobionts; Z_Strat – Zoophagous stratobionts; M_Strat – Mixophytophagous stratobionts; M_Short – Mixophytophagous stratohortobionts; M_Geoh – Mixophytophagous geobionts.

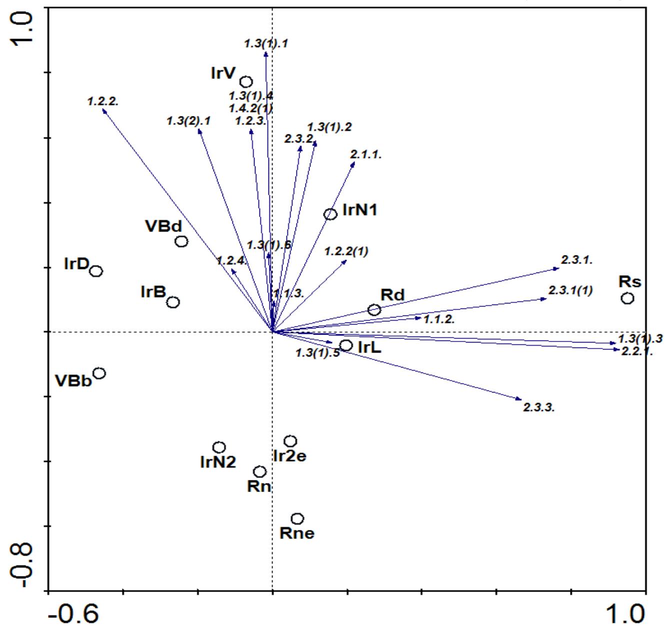

Fig. 7. PCA distribution of the sampling sites and categories of life forms (according to SHAROVA 1981): *Life form class 1. Zoophagous.* Life form subclass: 1.1 – Phytobios; 1.2 – Epigeobios; 1.3 – Stratobios; 1.4 – Geobios. Life form groups: 1.1.2 – stem-dwelling hortobionts; 1.1.3 – leaf-dwelling dendrohortobionts; 1.2.2 – large walking epigeobionts; 1.2.2(1) – large walking dendroepigeobionts; 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).1 – litter & soil-dwelling; 1.4.2(1) – large digging geobionts. *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.

Discussion

During the study we found the presence of rich carabid fauna in the region of Cape Emine. Each of the studied sampling sites showed peculiar characteristics in the species composition of the complexes. The differences are probably a result of the interaction between the climatic characteristics, humidity and edaphic conditions, and the structure of the vegetation – key factors for the formation of the species composition of the carabid communities (Thiele 1977; Kryzhanovskij 1983; Antvogel & Bonn 2001; Eyre *et al.* 2005, etc.).

TWINSPAN analysis demonstrated the classification of the habitat groups from open and dry to forest and humid. Cluster analysis of the taxonomic similarity between the ground beetle communities also showed that the grouping of the clusters somewhat follows the humidity gradient (Teofilova 2015). Such pattern is also found for two areas of the northern and southern Black Sea coast by Popov & Krusteva (1999), while the stronger influence of anthropogenic impacts is characteristic for the agrocoenoses near the city of Sofia (Kostova 2004).

Ordination graphics showed the grouping of the sampling areas in the military base (VBb and VBd) with the shore ecotone (IrB) and the oak forest near Irakli (IrD), speaking of similar environmental conditions in these habitats. Such a grouping is also proved by the analysis of the taxonomic similarity of the assemblages (Teofilova 2015). Thus, some separation of the open habitats from the mixed and those with forest and forest-shrub vegetation is presented. This way, the ordination groupings confirm the definite importance of the vegetation as an ecological factor, also established by the classification methods of analysis by TWINSPAN.

The potentially crucial role of the type of the vegetation and the humidity conditions on the distribution of ground beetles is also confirmed by ordination analysis of Popov & Krusteva (1999).

We established great species diversity near the bank of the Vaya River, which matched with the assumption of the primary hygromesophylous preferences of the ground beetles (Kryzhanovskij 1983; Sharova 1981). Some typical forest dwellers like *Myas chalybaeus* were also found here, probably due to the fact, that the species was caught in the part of the river, which was not affected by the correction of the river bed and vegetation “cleansing” conducted in 2007, and the original forest was preserved. This contributed to the greater heterogeneity of this habitat, which increases the species richness of the carabid communities, probably because of the greater variety of microhabitats and the related increase in the number of ecological niches (Baiocchi *et al.* 2007).

Coastal vegetation appeared to be a natural bio-corridor and refugium for the hygrophilous mountainous and riverine component. The fauna of these habitats is considered not affected or slightly influenced by the anthropogenic activity. It includes hygrophilous and mesohygrophilous species, some of which with a limited range of habitation (*Tachys fulvicollis*, *Carabus cancellatus*, *Carabus ullrichi*).

Given the fact that the natural river valleys and periodically inundated coastal forests are becoming increasingly rare in whole Europe (Tomiałojć & Dyrcz 1993), the efforts for the conservation of the biological diversity should be directed towards the conservation and restoration of this type of habitats and the restriction of their anthropogenization (Teofilova *et al.* 2012).

Conclusions

The data from the ordination of the sampling areas show strong dispersion of the studied communities and ecological groups of ground beetles, which reflects the relative heterogeneity of the landscapes.

There is some separation of the open biotopes from the mixed and those with forest and forest-shrub vegetation, confirming the determining significance of the vegetation as an ecological factor.

The correspondence analysis in relation to the gradients of humidity and vegetation demonstrates the separation of the sampling sites to: attached to arid conditions, associated with open biotopes, and dependent on the structure of the vegetation cover.

Distribution of the zoogeographical categories shows the attachment of the Mediterranean species to dry areas with low vegetative cover, while European and European-Siberian categories show predilection to the areas with predominantly forest or forest-shrub vegetation.

The ordination of the life forms proves that mixophyitophagous geobionts and stratohortobionts are attached to the open and anthropogenically impacted terrains, while zoophages are dependent on the forest habitats. The greatest variety of life forms is connected with the banks of the Vaya River.

Gradient analysis with methods for classification and ordination proves the primary role of humidity and vegetation as major environmental gradients, testifies to the relative heterogeneity of the landscapes in the region, and gives clarity for the affections of the zoogeographical categories and life forms to specific environmental conditions.

The proper tracking of the gradient of the humidity may give correct information also on the distribution of the vegetation, which would be beneficial for the imposition of measures for preservation of the species of conservation significance. Particular attention should be paid to “mixed” habitats, where a combination of different environmental conditions is seen, as well as the riverside habitats.

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Appendix. TWINSPAN classification of ground beetle assemblages from the region of Cape Emine, according to their species composition. The order of the groups of species follows the TWINSPAN analysis, and within the groups the species are in taxonomic order, following the system of Kryzhanovskij at al. 1995. Vertical lines separate TWINSPAN assemblage groups, horizontal lines separate carabid species distributional groups (I – VIII). Thick lines represent first level of division, broken lines – second level, and points – third level. *1*: 0 – 0.9%; *2*: 1.0 – 3.9%; *3*: 4.0 – 9.9%; *4*: 10.0 – 19.9%; *5*: 20.0 – 100.0%.

Species	**Classification of ground beetle assemblages**													**Sp. totals**	**Sp. group**
	Ir2e	**Rn**	**Rne**	**IrN 2**	**Rs**	**Rd**	**IrD**	**IrB**	**VBd**	**VBb**	**IrL**	**IrV**	**IrN 1**		
Notiophilus interstitialis				*1*	*1*	*1*								3	I
Notiophilus danieli						*1*								1	
Bembidion castaneipenne	*1*	*1*												2	
Calathus melanocephalus	*1*	-	-	*1*	*1*	*1*	-	*1*	*1*	-	-	-	-	64	
Gynandromorphus etruscus	-	*1*	*1*	-	*1*	-	-	-	-	-	-	-	-	5	
Harpalus hospes	*1*	*1*	-	-	*1*	-	-	-	-	*1*	-	-	-	33	
Ophonus puncticeps	-	-	-	-	*1*	*1*	-	-	-	-	*1*	-	-	10	
Ophonus azureus	*1*	*1*	*1*	-	*1*	*1*	-	*1*	*1*	-	*1*	-	*1*	118	
Ophonus sabulicola	*1*	-	*1*	-	*1*	*1*	-	-	-	-	*1*	-	-	40	
Ophonus oblongus	-	*1*	-	-	*1*	-	-	-	-	-	-	-	-	3	
Carterus rufipes	-	-	*1*	-	*1*	-	-	-	-	-	-	-	-	5	
Ditomus calydonius	-	*1*	*1*	-	*1*	*1*	-	*1*	-	-	-	-	-	16	
Chlaenius nitidulus	*1*	*1*	*5*	*1*	*4*	*1*	*1*	*1*	-	*1*	*1*	-	*2*	1927	
Philorhizus notatus	-	-	*1*	*1*	*1*	*1*	-	-	-	-	-	-	-	5	
Microlestes fissuralis	*1*	-	-	*1*	*1*	-	-	-	-	-	*1*	-	-	12	
Microlestes fulvibasis	-	-	-	*1*	*1*	-	-	-	-	-	-	-	-	3	
Microlestes minutulus	*1*	-	-	*1*	*1*	*1*	-	*1*	-	-	*1*	-	-	64	
Cymindis ornata	-	-	-	-	*1*	*1*	-	*1*	-	-	-	-	-	11	
Brachinus alexandri	-	-	*1*	-	*1*	-	-	-	-	-	-	-	-	15	
Brachinus brevicollis	-	-	-	-	*1*	*1*	-	-	-	-	-	-	-	36	
Brachinus ejaculans	-	-	-	-	*1*	*1*	-	-	-	-	-	-	-	4	
Cicindela germanica	-	-	-	-	-	-	-	-	*1*	-	-	-	-	1	II
Cicindela campestris	-	-	-	-	-	-	-	-	*1*	-	*1*	-	-	7	
Calsoma sycophanta	-	-	-	-	*1*	*1*	-	*1*	*1*	-	-	-	-	126	
Calsoma inquisitor	-	-	-	*1*	*1*	*1*	*1*	*1*	*1*	-	-	-	-	65	
Carabus scabriusculus	-	-	-	-	-	*1*	*1*	*1*	*1*	-	-	-	-	67	
Carabus montivagus	-	-	-	-	-	-	*1*	-	-	-	-	-	-	3	
Carabus intricatus	-	-	-	-	-	-	-	-	*1*	-	-	-	-	1	
Cychrus semigranosus	-	-	-	-	-	-	-	-	*1*	*1*	-	-	-	11	
Trechus quadristriatus	*2*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	-	319	
Bembidion lunulatum	-	-	-	-	-	-	-	*1*	*1*	*1*	-	-	-	6	
Bembidion subfasciatum	-	-	-	-	-	-	-	-	*1*	-	-	-	-	1	
Bembidion articulatum	-	-	-	-	-	-	-	-	*1*	-	-	-	-	1	
Calathus ambiguus	*1*	-	-	-	*1*	*1*	-	*1*	*1*	*1*	*1*	-	-	29	
Calathus cinctus	-	-	-	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	-	-	140	
Laemostenus terricola	-	-	-	-	*1*	*1*	*1*	*1*	*1*	*1*	*1*	-	-	86	
Amara aenea	*1*	*1*	*1*	*1*	*1*	*1*	-	*1*	*1*	*1*	*1*	-	*1*	48	
Amara lucida	-	-	-	-	*1*	-	-	-	-	-	*1*	-	-	2	
Harpalus attenuatus	-	-	-	-	*1*	*1*	*1*	*1*	-	-	*1*	-	-	39	
Ophonus ardosiacus	-	-	-	-	*1*	-	-	-	-	-	*1*	-	-	9	
Dixus obscurus	-	-	-	-	-	*1*	-	*1*	-	-	*1*	-	-	3	
Dinodes decipiens	-	-	-	-	*1*	-	-	-	-	-	*1*	-	-	3	
Lebia cyanocephala	-	-	-	-	-	*1*	-	*1*	-	-	-	-	-	2	
Carabus coriaceus	*1*	*1*	*2*	*2*	*2*	*1*	*1*	*2*	*1*	*1*	*1*	*1*	*2*	1240	III
Myas chalybaeus	-	-	-	*1*	*1*	*1*	*1*	*1*	-	*1*	-	*1*	-	66	
Pterostichus melas	*1*	*1*	*3*	*1*	-	*1*	*2*	*1*	*1*	*1*	*1*	*2*	*2*	880	
Calathus distinguendus	-	-	-	-	*1*	*1*	-	-	-	*1*	-	-	*1*	62	
Calathus fuscipes	*1*	-	*1*	*1*	*2*	*2*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	623	
Calathus longicollis	-	-	-	-	*1*	*1*	-	-	-	-	*1*	*1*	-	36	

Agonum (Europhilus) sp.	-	*1*	*1*	-	*1*	*1*	-	-	*1*	-	*1*	-	*1*	147	
Parophonus mendax	*1*	*1*	*1*	*1*	*1*	*1*	-	-	-	-	*1*	*1*	*1*	48	
Pseudoophonus rufipes	*1*	-	*1*	-	-	*1*	-	*1*	*1*	-	-	-	*1*	17	
Harpalus rubripes	*1*	*1*	-	-	*1*	*1*	*1*	-	*1*	-	*1*	-	*1*	21	
Harpalus serripes	*1*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	3	
Harpalus tardus	*1*	-	-	*1*	-	*1*	*1*	-	*1*	*1*	*1*	*1*	*1*	49	
Harpalus dimidiatus	*3*	*2*	*1*	*1*	*2*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	555	
Harpalus distinguendus	*1*	*1*	*1*	-	*1*	*1*	-	*1*	-	-	*1*	*1*	-	22	
Acinopus megacephalus	*1*	-	-	*1*	*1*	*1*	*1*	*1*	*1*	-	*1*	*1*	*1*	277	
Microlestes maurus	*1*	*1*	-	-	*1*	*1*	-	*1*	-	-	*1*	*1*	*1*	51	
Microlestes negrita	*1*	*1*	*1*	*1*	*1*	*1*	-	*1*	*1*	*1*	*1*	*1*	*1*	96	
Brachinus berytensis	-	*1*	*1*	-	*1*	*1*	-	-	-	-	*1*	-	*1*	22	
Brachinus crepitans	*1*	*1*	*4*	*2*	*2*	*2*	-	-	-	-	-	*1*	*4*	1213	
Brachinus explodens	*1*	-	*1*	*1*	*1*	*1*	-	-	-	-	-	*1*	*1*	79	
Leistus rufomarginatus	-	-	-	-	-	*1*	*1*	*1*	*1*	*1*	-	*1*	*1*	49	
Notiophilus rufipes	-	-	-	-	-	*1*	*1*	*1*	-	*1*	-	*1*	*1*	79	
Carabus ullrichi	*1*	-	-	*1*	-	-	*1*	*1*	*1*	-	*1*	*1*	*1*	147	
Carabus convexus	*1*	-	-	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*2*	*1*	288	IV
Bembidion dalmatinum	-	*1*	-	-	-	-	*1*	*1*	-	-	-	-	*1*	6	
Amara anthobia	-	-	-	-	*1*	*1*	*1*	*1*	-	*1*	*1*	*1*	-	28	
Amara familiaris	-	-	-	-	*1*	*1*	-	*1*	*1*	*1*	*1*	-	*1*	19	
Harpalus cupreus	*1*	*1*	*1*	-	-	-	*1*	-	-	-	-	*1*	*1*	26	V
Amara ingenua	-	-	-	*1*	-	-	-	-	-	-	-	-	*1*	2	
Scybalicus oblongiusculus	-	-	-	-	*1*	-	-	-	-	-	-	-	*1*	2	VI
Harpalus albanicus	-	-	-	-	*1*	-	-	-	-	-	-	*1*	-	4	
Brachinus psophia	-	-	*3*	*1*	*1*	*1*	-	-	-	-	-	*1*	*3*	458	
Nebria brevicollis	*1*	-	-	*1*	-	-	*1*	*1*	*1*	*1*	*1*	*5*	*4*	1890	
Trechus crucifer	-	-	-	-	-	-	*1*	-	-	-	-	-	*1*	1	
Amara communis	-	-	-	-	*1*	-	-	-	*1*	-	-	-	*1*	6	VII
Harpalus flavicornis	-	*1*	*1*	-	-	-	*1*	-	*1*	-	*1*	*1*	*1*	108	
Ophonus similis	-	-	-	-	*1*	-	-	-	-	*1*	-	-	*1*	5	
Carabus cancellatus	-	-	-	-	-	-	-	-	-	-	-	*1*	*1*	30	
Dyschirius rufipes	-	-	-	-	-	-	-	-	-	-	-	*1*	-	1	
Tachys fulvicollis	-	-	-	-	-	-	-	-	-	-	-	*1*	-	1	
Porotachys bisulcatus	-	-	-	-	-	-	-	-	-	-	-	*1*	-	2	
Asaphidion flavipes	-	-	-	-	-	-	-	-	-	-	-	*1*	-	57	
Bembidion lampros	-	-	-	-	-	-	*1*	-	-	-	-	*1*	*1*	42	
Bembidion properans	-	-	*1*	-	-	-	-	-	-	-	-	*1*	*1*	5	
Bembidion inoptatum	-	-	-	-	-	-	-	-	-	-	-	*1*	-	1	
Bembidion combustum	-	-	-	-	-	-	-	-	-	-	-	*1*	-	1	
Stomis pumicatus	-	-	-	-	-	-	-	-	-	-	-	*1*		3	
Poecilus cupreus	-	-	*1*	-	-	-	-	-	-	-	-	*1*	*1*	3	VIII
Pterostichus nigrita	-	-	-	-	-	-	-	-	-	-	-	-	*1*	1	
Pterostichus merkli	-	-	-	-	-	-	-	-	-	-	-	*1*	-	4	
Abax carinatus	-	-	-	-	-	-	-	-	-	-	-	*1*	-	1	
Anchomenus dorsalis	-	-	-	-	-	-	-	-	*1*	-	-	*3*	*2*	399	
Parophonus laeviceps	-	*1*	-	-	-	-	-	-	-	-	-	*1*	*1*	4	
Ophonus nitidulus	-	-	-	-	*1*	-	-	-	-	-	-	*1*	*1*	6	
Chlaenius festivus	-	-	-	-	-	-	-	-	-	-	-	*1*	*1*	12	
Syntomus obscuroguttatus	-	-	*1*	-	-	*1*	-	-	-	-	*1*	*1*	*1*	10	
Syntomus pallipes	-	-	-	-	-	-	-	-	*1*	-	-	*1*	*1*	5	
Indicator species	***Br crep***											***Car canc***			
				Not int											
							Lei ruf								