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New Highest Altitudes for Some Ground Beetles (Coleoptera: Carabidae) From the Western Rhodopes Mts. (Bulgaria)

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Abstract. As result of a monitoring survey in the Western Rhodopes Mts. were established nine representatives of the Bulgarian carabid fauna, for which there are no currently published data demonstrating their presence at such a high altitude. These are *Abax carinatus*, *Asaphidion flavipes*, *Bembidion stephensii*, *Harpalus attenuatus*, *Harpalus pumilus*, *Microlestes apterus*, *Paradromius linearis*, *Poecilus cupreus* and *Pterostichus leonisi*. Five of them were collected on the territory of Grashtitsa Village, another three – near Krastava Village, and one species was found in both localities (both representing new highest altitude records). The establishment of these new altitudes warns about the movement of the species in height. Given the role of the ground beetles as bioindicators, and on the background of the worldwide environmental trends, we might conclude that this fact is a result of the global climate changes, combined with the presence of some anthropogenic load in the studied region.

Key words: Carabidae, anthropogenic load, bioindication, areal changes.

Introduction

Global or local climatic changes are frequently mentioned as one of the reasons for shifts in geographic ranges of the species. However, anthropogenic factors (i.g. pollution, intensification of agriculture, changes in land use, etc.) also took place. There is a general problem of separating climatic effects from human effects in interpreting biological patterns (ALEKSANDROWICZ, 2011).

The droughting, as result of climatic and anthropogenic changes, has led to serious detrimental changes in the faunistic complexes with possible unforeseen alterations and trends in the future. A key characteristic is the expansion of the northern limits of distribution of some historically southern species (ALEKSANDROWICZ, 2011; OHLEMÜLLER *et al.*, 2006).

The effects of the global climate changes, along with the pollution of the environment, are registered on the territory of Bulgaria too. The country falls within the area of droughting. The total amount of the precipitation and river runoff are decreasing with characteristic minima (droughts) in 4 – 5 years. The areas occupied by more xerophytic plant species are increasing. The state of the ecosystems consisting of cold resistant and hygrophilous forest species is deteriorating. Further warming and droughting of the climate would have an extremely adverse impact on the species and habitat diversity in Bulgaria (MOEW, 2005; RAEV & TINCEV, 2015).

Drought and even desertification processes are most intensively occurring in the regions where the effect of the anthropogenic impacts supplements the natural arid conditions (BRAGINA, 2004). Such impacts are the massive plowing of virgin lands (especially around the middle of the 20th century), the regulation of watercourses and the distortion

of water balance in the territory, and the surge of the anthropogenic press with the influx of population and unregulated tourism.

Ground beetles (Coleoptera: Carabidae) are one of the best studied groups of invertebrates with regards to their taxonomy and phylogeny, geographical distribution, habitat preferences, ecological requirements and adaptations. Epigean and hypogean carabid beetles are proved to be excellent and „multitask" indicators of climate change. Moreover, their response time to climate changes seems to be shorter than for plants (BRANDMAYR & PIZZOLOTTO, 2016). Given the fact that the water in the soil is the ecological factor, which has the greatest influence on the ground beetle fauna (EYRE & LUFF, 1990), it could be expected that the drought processes will affect especially adversely the distribution of the carabids.

Western Rhodopes Mts. are very interesting from a research point of view. Thanks to the specific climate many typical habitats have being preserved, as well as numerous glacial relicts and endemic species. The region is well studied in terms of the carabid fauna, although the last purposive and thorough study was conducted before more than 10 years (GUÉORGUIEV & LOBO, 2006). The establishment of new records about the altitudinal ranges of the species may be resulting from insufficient exploration, but given the long-term research interest to the mountain and the availability of relatively rich information about the ecology of these species, it can be expected that these new findings derived from the expansion of their range in altitudinal direction.

Materials and Methods

The material was collected during a monitoring survey in the Western Rhodopes Mts.

Almost entire territory, with the exception of the most southern and southwestern parts, fall within the Transitional climate zone. The climate is mountainous version of the transitional one, with average annual temperatures between 10°C and 5°C, which decrease with increasing of the altitude. The Rhodopes Mts. are one of the faunistically richest areas in Europe.

The ground beetles were collected in 2015 and 2016 – 2017, respectively, in the vicinity of the village of Krastava (1209 m; 41°56'25"N, 23°51'49"E), and in the Grashtitsa hamlet, in the land of the village of Stoykite (1340 m a.s.l.; 41°39'05"N, 24°37'04"E). Pitfall traps were used, respectively, with salt-vinegar saturated solution and with formaldehyde.

The material is deposited in the IBER – Bulgarian Academy of Sciences, Sofia.

Results

During the whole study a total of 97 ground beetle species was found, of which 58 in the area of Krastava and 61 in Grashtitsa. As result of the investigation were established nine representatives of the Bulgarian carabid fauna, for which there are no currently published data demonstrating their presence at such a high altitude. Five of them were collected on the territory of Grashtitsa, another three – near Krastava, and one species was found in both localities (both representing new highest altitude records). These new findings represent almost 10% of all established during the study species.

The establishment of these species for the first time on such a height is possible to be due to inadequate studies in the area, but given the long-standing interest of many researchers to the Rhodopes Mts., it could be concluded that these species have changed their area. These were:

Asaphidion flavipes (Linnaeus, 1761)

The highest known so far in Bulgaria locality is at about 1200 m a.s.l. in the region of the town of Trigrad (also in the Western Rhodopes Mts.).

Range type: Western Palearctic.

Biotopic preferences: Mesohygrophilous. Inhabits the clayey banks of slowly flowing or small standing water reservoirs, swamps and marshes. Also in humid meadows and swampy forests.

Material examined: Grashtitsa (1♀, 1♂).

Bembidion (Peryphanes) stephensii stephensii Crotch, 1866

The highest known so far in Bulgaria locality is at about 1150 m a.s.l. The highest known so far locality in the Western Rhodopes

Mts. is at 1050 m a.s.l. in the region of the town of Batak.

Range type: European.

Biotopic preferences: Mesohygrophilous. Mostly found on river and lake shores, often on cliffs.

Material examined: Krastava (1♀, 1♂); Grashtitsa (3♀♀).

Poecilus (Poecilus) cupreus cupreus (Linnaeus, 1758)

The highest known so far in Bulgaria locality is at about 1300 m a.s.l. The highest known so far locality in the Western Rhodopes Mts. is in the regions of the towns of Trigrad and Sarnitsa, both at about 1200 m a.s.l.

Range type: Euroasiatic (steppe).

Biotopic preferences: Mesophilous. Inhabits open areas with dense grass vegetation, agrocoenoses and highly anthropogenic areas. Rarely in forests. Common.

Material examined: Grashtitsa (29♀♀, 30♂♂).

Pterostichus (Argutor) leonisi Apfelbeck, 1904

So far known in Bulgaria up to approximately 300 m a.s.l. For the Rhodopes Mts. there are only unconfirmed sources (see GUÉORGUIEV & LOBO, 2006).

Range type: Central and Eastern European.

Biotopic preferences: Hygrophilous. Found in very moist, seasonally flooded and swampy forests, as well as on the banks of rivers and lakes.

Material examined: Krastava (1♀).

Abax (Abacopercus) carinatus carinatus Duftschmid, 1812

The highest known so far in Bulgaria locality is at about 1300 m a.s.l. The highest known so far locality in the Western Rhodopes Mts. is at 1185 m a.s.l. in the region of Barutin.

Range type: Central and Eastern European.

Biotopic preferences: Typical mesophilous species. Inhabits a variety of forest ecosystems. Common.

Material examined: Grashtitsa (1♀).

Harpalus (Harpalus) attenuatus Stephens, 1828

The highest known so far in Bulgaria locality is at 1180 m a.s.l. at Magareshki Dol River near Borino Village (also in the Western Rhodopes Mts.).

Range type: European-Neareastern-Mediterranean.

Biotopic preferences: Mesophilous. Inhabits mainly mesoxerophytic forest communities on sandy soils.

Material examined: Krastava (1♂).

Harpalus (Harpalus) pumilus Sturm, 1818

The highest known so far in Bulgaria locality is at about 1000 m a.s.l. The highest known so far locality in the Western Rhodopes Mts. is at 540 m a.s.l. in the region of Ognyanovo Village.

Range type: European and Central Asian.

Biotopic preferences: Xerophilous. Inhabits open biotopes with sandy soils, including agrocoenoses.

Material examined: Krastava (1♀, 1♂).

Paradromius (Manodromius) linearis (Olivier, 1795)

The highest known so far in Bulgaria locality is at about 1000 m a.s.l. The highest known so far locality in the Western Rhodopes Mts. is at about 300 m a.s.l. in the region of Asenovgrad Town.

Range type: Western Palearctic.

Biotopic preferences: Mesohygrophilous. Found in moist meadows, swamps, marshes, as well as on the banks of rivers and lakes.

Material examined: Grashtitsa (1♂).

Microlestes apterus Holdhaus, 1912

So far known in Bulgaria up to approximately 300 m a.s.l. This species has never been established in the Rhodopes Mts. so far.

Range type: Balkan subendemic.

Biotopic preferences: Mesoxerophilous. Inhabits open biotopes, mostly dry meadows.

Material examined: Grashtitsa (1♀, 2♂).

Discussion

A wide variety of vertebrate and invertebrate species has moved northwards and uphill in response to the global warming. These changes have already been documented across Eurasia (DUDKO & IVANOV, 2006; OHLEMÜLLER *et al.*, 2006; BESPALOV *et al.*, 2010; ALEKSANDROWICZ, 2011; TEOFILOVA *et al.*, 2015).

Hygrophilous carabid beetles with smaller body sizes, as *Asaphidion flavipes*, *Bembidion stephensii*, *Paradromius linearis* and *Pterostichus leonisi* are proved to be more vulnerable (NIEMELÄ *et al.*, 2002). Therefore, the change in their habitats towards lower humidity levels could cause alterations in their geographical ranges. Probably the change in the areal namely of these species should be considered as the most emphatic signal for a change in the environmental conditions in their habitats. It is likely that the new environmental settings have proved to be too unfavourable for these sensitive and generally stenotopic species, and they migrated following their primary mesohygrophily.

The typical forest species like *Abax carinatus* are highly vulnerable to the change and degradation of the forest areas. Many studies show the displacement of the autochthonous European nemoral complex by the more plastic species of steppe origin (DESENDER & TURIN, 1989; KODZHABASHEV & PENEV, 2006; ALEKSANDROWICZ, 2011; TEOFILOVA *et al.*, 2015). Of particular importance is that the distortions among the species associated with mature and old forests is possible to detect correctly almost five years after the intervention in the forests, as the changes in populations occur in about 2 – 4 years (JACOBS *et al.*, 2008). Therefore, the recommendations for forest management, aimed at the conservation of biodiversity, but based on short-term studies, in the best case would be incomplete, and at worst would have been catastrophic for the maintenance of the species in the managed landscapes.

Usually the studied region falls into forest zone E, according to De Martonne aridity index (RAEV & TINCEV, 2015), characterised by low vulnerability level with optimal moisture conditions. The unsustainable use of the forest resources, however, is a fact in many places in the Western Rhodopes Mts. There has been a change in the age structure, canopy, hidrotermic conditions and, in some places, also in the species composition of the forests, as a result of conducted clear-cuttings and subsequent successional changes. It is possible that these processes have influenced the distribution of the typical forest mesophile *Abax carinatus*. Forest specialists do not develop well in areas affected even by moderate levels of anthropogenization. Usually in urbanized areas generalists or species of open habitats displace them (VENN *et al.*, 2003; MAGURA *et al.*, 2008; BARANOVÁ *et al.*, 2013).

Species from the European-Asian (steppe) complex, as *Poecilus cupreus*, often indicate for the presence of natural and semi-natural steppes and very often constitute an essential element of the fauna of the arable lands, as well as lands recently deprived of the autochthonous ligneous vegetation. At these newly created habitats and at the early successional stages dominate species able to fly and to adapt to a wide range of environmental conditions (BRANDLE *et al.*, 2000). These are mostly eurytopic species. In this case as eurybiont of the open areas can also be noted *Harpalus pumilus*.

Rare species require more time for colonization than common species, because the number of dispersing individuals is smaller (VERHAGEN *et al.*, 2008). With the raise of the anthropogenic load the proportion of open living forms and ecologically plastic eurybionts increases (NIEMELÄ *et al.*, 2002; GORGIEVSKA *et al.*, 2009, etc.). To some extent, the same is true of some representatives of the Mediterranean complex, as is the *Harpalus attenuatus*.

The most vulnerable species are those with small geographical ranges (HUGHES *et al.*, 1997). Thus, the change in the habitats leads to further pressure of the rare, priority species, at the expense of those with wide distribution. Species with limited distribution in this case appear to be *Pterostichus leonisi*, *Abax carinatus* and the Balkan subendemic *Microlestes apterus*.

The nine mentioned ground beetle species differ in terms of zoogeography and habitat preferences, which emphasizes the complexity of the problem with the shifting of geographical ranges.

Over the past decades intensified processes of secondary xerophytization have been seen, a possible consequence of global climate changes and destruction of the natural ligneous vegetation with changes in its species and age structure. This successional degradation is strongly reflecting on the contemporary state of the fauna, which manifests through species impoverishment, severe dystrophy of the zoocoenoses and substitution of natural communities with ecologically plastic, invasive elements.

In such conditions, species try to escape these new severe environmental situations, and in many cases, they leave or change their present areals moving northwards or higher in the mountains. It is proved that populations shift elevation ranges to track suitable climate rather than adapting to novel conditions (HUA & WIENS, 2013). Although scarce, there are examples for this in some studies from Bulgaria concerning the carabid fauna (KODZHABASHEV & PENEV, 2006; TEOFILOVA *et al.*, 2015; JOCQUE *et al.*, 2016) or other groups of animals (e.g. Lyubomirova, 2012 – pers. com.). There are also evidences for the "Mediterranization" of the Heteroptera fauna of Austria (RABITSCH, 2008). In most cases, however, similar signs for areal changes remain unnoticed by the authors.

The establishment of new altitudes for these nine carabid species warns about the movement of the species in height. Knowing that carabids signal effects caused by climate change (ASHWORTH, 1996; BRANDMAYR & PIZZOLOTTO, 2016), and on the background of the worldwide environmental trends, it can be concluded that this fact is a result of the global climate changes. It also proves the presence of some anthropogenic load in the studied region.

Forest ecosystems in Bulgaria currently are subjected to increasing negative climatic influence (RAEV & TINCEV, 2015). If the observed tendency for the moving of the species in altitude is a short-term phenomenon or it comes to the general trend linked to the multiannual climate change? Future detailed studies in the area could bring more clarity and perhaps hope.

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