

Bio-Indicators: Overview of some *Caelifera* species in the Republic of North Macedonia

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Abstract

Nine Orthoptera (*Caelifera*) species have been selected as bio-indicators applicable to the republic of North Macedonia. These species have been chosen to cover a wide range of biotopes and altitudes; six of them indicate par their presence a good quality of the environment, and three of them indicate by their overabundance a degradation of the environment. The species are described with their key information to use them as bio-indicators.

Keywords: *Insecta, Orthoptera, Caelifera, bio-indicators, Republic of North Macedonia*

Introduction

For more than forty years, grasshoppers have been widely used as bio-indicators (*e.g.* Gonseth, 2010; Guéguen, 1981,1989; Guéguen-Genest & Guéguen, 1987; Kenyeres et al., 2020; Kruess & Tscharnkte, 2002; Lemonnier-Darcemont, 2003; Lemonnier-Darcemont et al., 2018; Voisin, 1986; etc.). The species of this order occupy a very large set of plant formations and cover the entire food chain with phytophagous, omnivorous, entomophagous and detriophagous species. Furthermore, many of them are rather easy to catch and identify which makes them ideal biological material. By their presence some taxa indicate the good health of the biotopes where they live; other species, by their overabundance or their dominance among a multispecies population, can show the severe degradation of an environment. In this paper, we have taken the example of a few well-distributed species in the Republic of North Macedonia, which are characteristic of these different states.

Material and method

In this study, we have selected a few species that respond particularly well to changes linked to human activities. These targeted species have a wide European distribution and are also well distributed throughout North Macedonian territory. Furthermore, they are easily recognizable by some obvious morphological characters. It is therefore not necessary to catch them to identify them. Nine taxa have been chosen. Six of them, when they are among the main species of the Orthoptera population of their elective biotopes, indicate environments not degraded or only slightly affected by human activities and on the contrary indicate degradation when there is a significant decrease in their numbers. On the contrary, the three other species, when they form the major part, even sometimes the only species of the population of grasshoppers, show a deep imbalance of the environment.

Results

1. Species indicative of good environmental status.

In most stations where these species are well present, it is generally the entire grasshopper population that is diversified and usually includes a high number of taxa, rather rich in species of patrimonial interest. These species make it possible to make the first diagnosis, by their presence or on the contrary by their absence within the biotopes they most often occupy. For example, scrub formations or mesophilic meadows on forest edges and clearings (*Odontopodisma ssp.*), herbaceous steppes, or dry grasslands of the Mediterranean mountains (*Arcyptera microptera*, *Celes variabilis*), cold subalpine meadows (*Melanoplus frigidus*), hygrophilic meadows and wetlands (*Stethophyma grossum*).

When the abundance of these species decreases drastically, there is usually a decline in the richness of the entire population. We noticed that issue on some stations, for example in the Balkans or the south-east of France, after changes in the mode of agriculture: transition from traditional crops to a more intensive mode with significant use of chemical inputs (pesticides, herbicides, etc.), change in the farming method, from predominantly sheep pastoralism to cattle pastoralism in unsuitable biotopes, increase in pastoral pressure, etc.

Arcyptera microptera (Fischer von Waldheim, 1833).



Figure 1. *Arcyptera microptera* ♂. Raduša, Republic of North Macedonia. 26 June 2012

This medium-sized (17-42 mm) and brightly colored species is easily recognizable. Its distribution in Europe from Spain in the west to Russia in the east is rather fragmented. She has disappeared from the Czech Republic, Austria, Germany, and Slovenia (IUCN, 2020).

Ecology: although this thermo-xerophilic species likes hilly areas and dry grasslands with a steppe character, it is also found in mountainous regions with Mediterranean affinities, especially in the mountains of southwestern Europe and in the Balkans, up to an altitude of more than 1900 m. It is a relatively early species in season and adults are most visible from late May to August, with maximum occurrence between June and mid-July.

Note that in Russia this taxon is sometimes detrimental and cause damage to crops in cases of drought (Shurovenkov, 1963; Storozhenko, 1991; Latchinsky et al., 2002). This fact seems localized for this species with a fragmented distribution and very sensitive to the changes made in its elective biotopes and whose tendency is rather downward over the rest of its distribution area.

In the Republic of North Macedonia, *Arcyptera microptera* is found rather well in certain regions of the country and more particularly:

- Galicica mountain, southern slope of the massif where some Mediterranean influences are perceptible in grassy formations, well exposed to the sun, at least up to 1700 m asl.
- Around Stip in the center of the country, below 400 m asl in many post-cropping wastelands and steppe formations.
- In the south in the Prilep region, formations of steppe grasslands and dry meadows on the edges of oak groves from the lowland area up to about 1400 m altitudes.
- Near Kosovo, border in several steppe grasslands located between 400 m and 750 m elevation.

***Celes variabilis* (Pallas, 1771)**



Figure 2. *Celes variabilis* ♂. Raduša, Republic of North Macedonia. 25 June 2012

It is a medium-sized species (16-34 mm) with pink to red forewings only darkened at the apex. The male is easily recognized by his usually uniform black color. The female is more massive than the male and generally greyish brown color, rather homochromic with the environment. The range of this insect in Europe covers from eastern Spain to at least Ukraine in the east, with a very patchy distribution. Reported as extinct in the Czech Republic and Slovakia, it is classified as Near Threatened (NT) on the IUCN Red List (IUCN, 2020).

Ecology: this taxon prefers steppe formations, post-cultivation wastelands, dry meadows from lowland areas, and rises in mountains to over 1900 m. In the mountains, it often shares the same biotopes as *Arcyptera microptera*, but with an ecological valence that seems higher, at least in the southern Balkans. Adults are met from the end of May until August.

In the Republic of North Macedonia, the species has a mosaic distribution but occurs in the whole country. We note some beautiful populations in several regions of the country:

- North-west of the country, in the vicinity of Gostivar or Tetovo, especially on the border with Kosovo, in steppe character grasslands between 700 m and 1700 m altitude.
- Prilep area, steppe grasslands between 1000 m and 1400 m altitude.

- Around Stip, below 400 m asl in many post-cropping wastelands and steppe formations.

***Odontopodisma decipiens* Ramme, 1951 / *Odontopodisma albanica* Ramme, 1951.**

We have combined these two species because of their same indicator value of the status of the environment. In the Republic of Macedonia, their distribution is roughly separated. These two micropterous insects have a very similar shape, bright green color, and medium-size (*O. decipiens*: 14-24 mm; *O. albanica*: 13-21 mm). They can only be distinguished from each other by a few details that are only clearly visible under a magnifying glass.

Odontopodisma decipiens



Figure 3. Mating of *Odontopodisma decipiens*. Agios Pavlos, Greece. 23 July 2020

Insect whose distribution is mainly the Balkans. It reaches the west of Ukraine in its eastern limit and extends to Austria in the west. There is an isolated population in northern Italy attributed to the subspecies *O. decipiens insubrica* Nadig, 1980.

In the Republic of North Macedonia, the species is not very widespread but is nevertheless found in several places in the eastern half of the country and particularly: in the Belasica massif, the Zelenikovo region, the Lipkovo area.

Its biotopes are mainly bushy areas, in clearing or forest edge of mixed or deciduous forest, sometimes along a river and more often, we note the presence of *Rubus sp.* where individuals preferentially rest. Although the species have been reported upper, the altitudes we have noted are always below 900m and generally between 250 and 550 m. Adults are most mainly seen between late June and August.

Odontopodisma albanica

The Balkan endemic taxon is known from south-western Serbia, Montenegro, Albania, and the border between south-eastern Kosovo and north-western North Macedonia.

In the Republic of North Macedonia, it is classified as Vulnerable (VU) in the country's Red List (Lemonnier-Darcemont et al., 2014). It has only been recorded in the border region with Kosovo and Albania, in the northwest of the country: Mavrovo Massif, Mount Romano, where we found it above 1000 m altitude and up to about 1600 m asl. The biotopes occupied by this species are mainly edges

and clearings of fir and beech forests, and mountain mesophilic meadows close to forest formations. Adults appear between July and August.

***Stethophyma grossum* (Linnaeus, 1758)**



Figure 4. *Stethophyma grossum*. Hautes Alpes, France. August 2000

This Euro-Siberian species, whose distribution range extends from Spain to Siberia (Harz, 1975), is threatened in many regions due to the disappearance of its elective habitats (wetlands). Classified as Near Threatened (NT) on the Red Lists of Denmark, the United Kingdom, and the Czech Carpathians (Wind & Pihl, 2010; Kristin & Iorgu, 2014; Sutton, 2015), it is listed as vulnerable (VU) in Switzerland, Austria, and Poland (Liana, 2000; Berg et al., 2005; Monnerat et al., 2007). The German state of Baden-Württemberg considers it to be an "umbrella" species for conservation (IUCN, 2020).

In the Republic of North Macedonia this species is mentioned as endangered (EN) in the country's Red List (Lemonnier-Darcemont et al., 2014). Most of the data are old (Karaman, 1975; Chobanov & Mihajlova, 2010) and located in the lower lands, where we have not found it in recent years despite many investigations. Only one more recent data indicates its presence on the mountain of Deshat, in the Mavrovo area (V. krpach in Chobanov & Mihajlova, 2010). This hygrophilic taxon mainly colonizes humid meadows, mesophilic herbaceous formations near water, marshy areas, and peat bogs, from the plain up to more than 2000 m altitudes in the mountains. Most adults can be seen from July to September, depending on the altitudes.

***Melanoplus frigidus* (Boheman 1846)**



Figure 5. Mating of *Melanoplus frigidus*. Col Agnel, France. 18 September 2018

This species has a wide boreal-alpine distribution; it is a microthermal species and can be observed up to about 3000 m altitude. It is present in the high mountains of the Pyrenean Massif, the Alps, the Apennines, and the Balkans: Slovenia, Serbia, Macedonia, Greece, Bulgaria. In Austria (T. Zuna-Kratky *pers. comm.*, 2015 in IUCN 2020) and the south of its distribution range, its populations seem to be declining (P. Fontana *pers. Comm.*, 2015 in IUCN, 2020). Globally, the trend is declining (IUCN, 2020). The reasons are probably linked to global earth warming, but also to the development of anthropogenic activities in altitude (ski resorts, overgrazing, etc.), which drastically reduce its selective habitats.

In the Red List of species of the Republic of North Macedonia, *M. frigidus* is listed as vulnerable (VU) (Lemonnier-Darcemont et al., 2014). In the country, it is only known from the massif Jakupica where it lives the stony meadows near the ridges, between 2000 and 2400 m altitude.

2. Species indicative of degraded environmental status.

Although these insects can indicate different types of environmental degradation, the following observations made in the Republic of North Macedonia relate only to the effects of unsuitable pastoralism: overgrazing or the use of unsuitable livestock species.

It is important to know that it is not the presence of these species that indicates an imbalance in each environment but only their dominance or even their proliferation within the population of Orthoptera. The locusts (Caelifera), phytophagous, constitute the greatest biomass among all grasshoppers, under normal conditions. The number of bush-crickets, also named katydids, (a subset of Ensifera) is generally less important. Mainly omnivorous, sometimes carnivorous, and rarely phytophagous, they are often dependent on more heterogeneous plant structures and are therefore the first species to be impacted by the degradation of biotopes. Crickets (another subset of Ensifera) are in most cases less numerous and more difficult to quantify, due to more discreet behavior and lifestyles.

The degradation of the environment can only be started after an assessment established over several consecutive years of measurements. This is to avoid imputing any provisional predominance which may be due to some natural factors, such for example a particular weather season.

The sampling of grasshoppers usually makes it possible to classify several stages characteristic of this alteration:

1. Decrease in species richness and of species with low ecological valence. Strong regression of bush-crickets.
2. The population is reduced to banal species. Their relative abundance becomes unbalanced.
3. The dominance of some species is increasing. In extreme cases, we can see an outbreak concentrated on a single taxon. This leads to aberrant behaviors such as cannibalism among phytophagous, for lack of food resources.

***Calliptamus italicus* (Linnaeus, 1758)**



Figure 6. Cannibalism with *Calliptamus italicus*. Lykouria, Greece. 9 July 2019

Xerothermophilic locust widespread from western Europe, mainly in the Mediterranean region, northern Africa and, to central Asia and north-eastern Siberia. This species is one of the most cited for being subject to outbreaks in Europe with some phenomena of incomplete gregarization more particularly in the far eastern part of its range.

In the Republic of North Macedonia, this ubiquitous species occupies rather dry forest edges and glades, wasteland, dry and steppe meadows, but also sometimes mesophilic meadows up to at least 1800 m altitude. The best viewing period for adults is between late June and mid-September, depending on altitude.

***Dociostaurus brevicollis* (Eversmann, 1848)**



Figure 7. *Dociostaurus brevicollis* ♂. Vodno Mt, Republic of North Macedonia. 22 June 2012

Widely distributed grasshopper found from Austria to eastern Siberia, via the Balkans and Russia. This taxon is quite frequently cited to potentially proliferate (Nagy, 1994; Azhbenov et al., 2015) but without any evidence of gregarization.

In the Republic of Macedonia, the species is common and although it mainly appreciates short and stony meadows, steppe formations, wasteland, it also colonizes some clearings and dry forest edges. Its altitudinal range extends from lowland regions up to nearly 1800 m in the mountains. Adults appear to be more common between late June and mid-August, depending on altitude.

Pseudochorthippus parallelus (Zetterstedt, 1821)



Figure 8. *Pseudochorthippus parallelus* ♂ and ♀. Dardhë, Albania. 2 August 2014

This locust, which inhabits a large part of the Palaearctic Region, is one of the most common species in Europe. The indicator role of this species is observed especially in mountain regions impacted by too much pastoral load or poorly managed.

In the Republic of Macedonia, it is found from the bottom of the valleys, mainly in mesohygrophilic to hygrophilic conditions (dense meadows at the edge of watercourses, reed beds and wet meadows, herbaceous wastelands ...) and in the mountains, it reaches more than 2500 m altitudes and colonizes meadows and grasslands, clearings, and forest edges.

Discussion

The use of these indicator insects is a very effective tool for diagnosing changes in the status of quality of environments over the years regarding certain risks such as, for example, the inappropriate use of natural pastures by livestock or the transformation of traditional agricultural landscapes.

However, this qualitative vision alone does not make it possible to establish a precise diagnosis. To remedy this, we have developed a measurement method whose goal is to assign a health score to a given biotope, by studying its entire population of Orthoptera (Lemonnier-Darcemont et al., 2011).

Of course, these measurements should be weighted by climatic factors which can vary significantly from year to year and therefore influence the results, but these effects are usually temporary. Even if sometimes the climatic factor seems to be at the origin of the degradation of biodiversity, human activity is almost always underlying the phenomenon. This is particularly noticeable when we study the average evolution of the health of an environment with 5 years moving window for example.

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