

Rediscovery of *Carabus (Hygrocarabus) variolosus nodulosus* Creutzer, 1799 on Shar Planina Mt.

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Abstract



This paper presents records of the rediscovery of *Carabus (Hygrocarabus) variolosus nodulosus* Creutzer, 1799 in Shar Planina Mt. (Ljuboten massif) after almost 100 years (North Macedonia and Kosovo). The taxonomic status, habitat preference, biogeography and conservation status are discussed. The species was found along small brooks in a beech forest landscape which falls well into the habitat-preference model of the species. The population on Shar Planina is very isolated (100 km from the nearest populations on the Balkan Peninsula) and it is most probably a product of the latest glaciation.

Key words: Ground beetles, *Carabus variolosus nodulosus*, biogeography, taxonomy, EU Habitats Directive

Introduction

There is an increasing interest in the species *Carabus variolosus* Fabricius, 1787 primarily due to its conservation status, unresolved taxonomy, specific ecology, behavioral peculiarities and indicator value leading to its inclusion between the species of Natura 2000 network in Europe (Turin et al. 2003; Mossakowski et al. 2020; Tyszecka et al. 2023). Recently, new studies of *Carabus variolosus* were carried out on the Balkan Peninsula which revealed new valuable data for its distribution, ecology and conservation status (Kulijer et al. 2019; Bekchiev et al. 2022).

C. variolosus is a very peculiar species that lives on the banks of mountain streams. The adults feed in the water and are active at night. They are active from April to June when they reproduce. The laid eggs hatch after two months. The offspring appear in August, and the young remain in the same place, where they overwinter in rotting wood or buried in the ground (Drovenik and Pirnat 2003).

The southernmost record of *C. variolosus nodulosus* in Europe was published from Ljuboten (Shar Planina Mt.) almost one century ago (Breuning 1926). Considerable research effort was devoted to this species and its rediscovery on Shar Planina Mt. in the past decades (Hristovski et al. 1996, 2002; Hristovski and Guéorguiev 2015). The present paper presents the first two findings of the species in Kosovo and North Macedonia after almost 100 years.

Materials and methods

The research in Kosovo part of Ljuboten was performed in 2022 by pitfall trapping along a stream in a beech forest.

The research of the part of Ljuboten massif that belongs to North Macedonia was carried out in 2023 by active searching and pitfall trapping. Pitfall traps (5 traps per site) were set in two wetland sites: epirhithral

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stream in beech forest and alkaline fen at a timberline. Material from North Macedonia is kept in cSH (collection of Slavcho Hristovski), while the specimen from Kosovo is deposited in the collection Bércecs, Hungary.

Results and Discussion

With the field research conducted in 2022 (Kosovo) and 2023 (North Macedonia) we were able to collect two specimens of *Carabus (Hygrocarabus) variolosus nodulosus* from Shar Planina.

Studied material from Shar Planina

Kosovo, Shar Planina Mt., tributary stream of Dubravaska Reka (N42.236614°, E21.168668°), 960 m a.s.l., stream in beech forest, traps, 07.07.2022 – 09.07.2022, 1 male leg. G. Mesaroš (coll. Bércecs, Hungary)

North Macedonia, Shar Planina Mt, tributary stream of Ljubotenska Reka (N42.170790°, E21.107261°), 1250 m a.s.l., stream in beech forest, traps, 16.06-03.09.2023, 1 female, leg. S. Hristovski & M. Komnenov (coll. S. Hristovski) (Fig. 1).



Figure 1. *Carabus variolosus nodulosus* Creutzer, 1799 (female specimen from Ljuboten, North Macedonia) (photo: S. Hristovski)

The species for both Kosovo and North Macedonia is known only from Ljuboten (Ćurčić et al. 2007; Hristovski and Guéorguiev 2015).

One of the authors of this paper (G. Mesaroš) managed to collect specimens from other sites in Serbia, which are presented on the map of distribution. All of the specimens collected by G. Mesaroš were sent for molecular analysis (coll. Bércecs, Hungary).

Taxonomic status

There are two major taxa in the subgenus *Hygrocarabus* C.G.Thomson, 1875 present in Europe: *Carabus*

(*Hygrocarabus variolosus variolosus* Fabricius, 1787 and *Carabus (Hygrocarabus) variolosus nodulosus* Creutzer, 1799. Sometimes, these taxa are treated as subspecies (Breuning 1937; Löbl and Löbl 2017), semispecies (Casale et al. 1982), but lately more so as distinct species (Turin et al. 2003; Mossakowski et al. 2020). Both of these taxa are confined to Europe but their distribution ranges overlap to a considerable extent: *C. variolosus variolosus* is the “eastern” taxon distributed from Central Europe, Alps, Carpathians and Stara Planina while *C. variolosus nodulosus* is “western” taxon with distribution in Central Europe, Alps and west parts of the Balkans (Breuning 1926). Serbia is the only European country with both taxa (Ćurčić et al. 2007; Kulijer et al. 2019).

Apfelbeck (1904) reported presence of *v. hydrophilus* Reitter, 1896 and *v. costulifer* Fleischer 1898 in the Bosnian and Bulgarian populations, but he concluded that these are only individual variations in the elytral sculptures.

For the time being, we consider the population from Shar Planina (Ljuboten) as part of *Carabus (Hygrocarabus) variolosus nodulosus* Creutzer, 1799 i.e. the western taxon. The first record for Ljuboten is also published as *Carabus variolosus nodulosus* (Breuning 1926) as well as all of the consequent revisions (Breuning 1937; Turin et al. 2003).

Habitat

C. variolosus nodulosus is stenotopic, silvicolous, extremely hygrophilous and hydrophilous species. It inhabits shores of small stony, mostly montane rivers and brooks, in marshy and wooded sites where it hides under submerged stones, branches or decayed stumps (Pavićević and Mesaroš 1997; Turin et al. 2003; Jurc et al. 2008). Both of the localities on Ljuboten fit well into the general habitat-preference model of the species – small brooks in a beech forest landscape.

Both of the specimens were collected in similar habitat. The male specimen from Kosovo was collected along an intermittent stream in a beech forest. The stream bed was covered by beech leaf litter. The vegetation along the banks consisted of *Petasites hybridus* (L.) G. Gaertn. & al., *Equisetum pratense* Ehrh., *Geranium robertianum* L., *Rubus* sp., *Oxalis acetosella* L., *Veronica beccabunga* L., etc. The site of the female specimen collected on Macedonian side had small but permanent stream. The vegetation was dominated by *Petasites hybridus* but also the following species were noted: *Chaerophyllum hirsutum* L., *Salix eleagnos* Scop., *Urtica dioica* L., *Mentha longifolia* (L.) L., etc. (Fig. 2).

The bedrock on both of the sites is silicate schists. However, large parts of Ljuboten massif are composed of limestone but we believe that the silicate bedrock provides conditions for development of more suited habitats for *C. variolosus nodulosus* (due to soil-water properties and surface run-off).

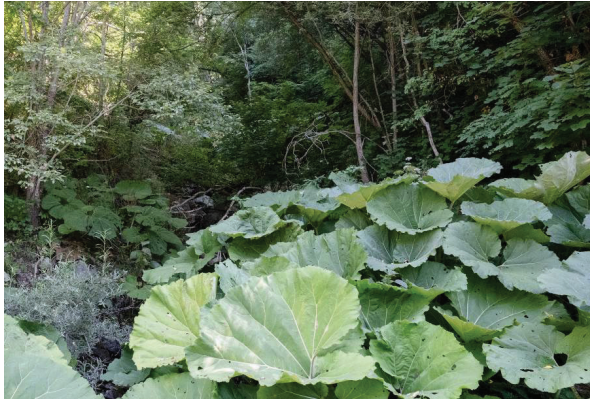


Figure 2. Habitat of *Carabus variolosus nodulosus* Creutzer, 1799 on Ljuboten (North Macedonia) (photo: S. Hristovski)

Biogeography, conservation and threat status

Carabus variolosus nodulosus on the Balkan Peninsula is distributed in Slovenia, Croatia, Serbia, Bosnia and Herzegovina, Bulgaria, Kosovo and North Macedonia (Apfelbeck 1904; Breuning 1937; Šerić Jelaska et al. 2004; Ćurčić et al. 2007; Kulijer et al. 2019; Bekchiev et al. 2022). The population on Ljuboten is over 100 km in distance from the nearest population in Serbia – Ostrozub Mt. (Mesaroš, unpublished data). It is about 200 km distant from the nearest population in Bosnia and Herzegovina (Čemerno, Višegrad). Approximately the same distance is to the Bulgarian population of *C. variolosus variolosus* on Stara Planina (Fig. 3). There are no data for the presence of the species in Montenegro or Albania i.e. areas between populations in Ser-

bia and Bosnia and Herzegovina and the one on Shar Planina (Ljuboten). Thus, we consider the population on Shar Planina very isolated and it is most probably a product of the latest glaciation. In fact, the whole *Carabus variolosus* complex is considered as glacial relict which was supported by studies of populations in Germany that showed clear genetic separation in response to the adaptation to different refugial conditions during the Last Glacial Maximum (Matern et al. 2008, 2010; Mossakowski et al. 2020).

C. variolosus is included in Annexes II and IV of the European Union's (EU) Habitats Directive (1992) with the amendment in 2004. There is a certain debate whether the taxon “*nodulosus*” should be included in the interpretation of *Carabus variolosus* per EU Habitats Directive. There are several arguments that support the inclusion of “*nodulosus*” in the interpretation of “*variolosus*”: similar ecology, unresolved taxonomic status, “*nodulosus*” was considered as a subspecies of “*variolosus*” during the proposal in 2004 to the EU Habitats Directive, etc. (Drovenik and Pirnat 2003; Müller-Kroehling 2006, 2014; ETC/BD 2011; Kulijer et al. 2019). We strongly support this point of view which was adopted by the majority of countries of the European Union.

C. variolosus is considered as an indicator of well-preserved habitats. The main threat for the species is the destruction of its habitats, while climate change, particularly in the south presents additional threat (Kulijer et al. 2019).

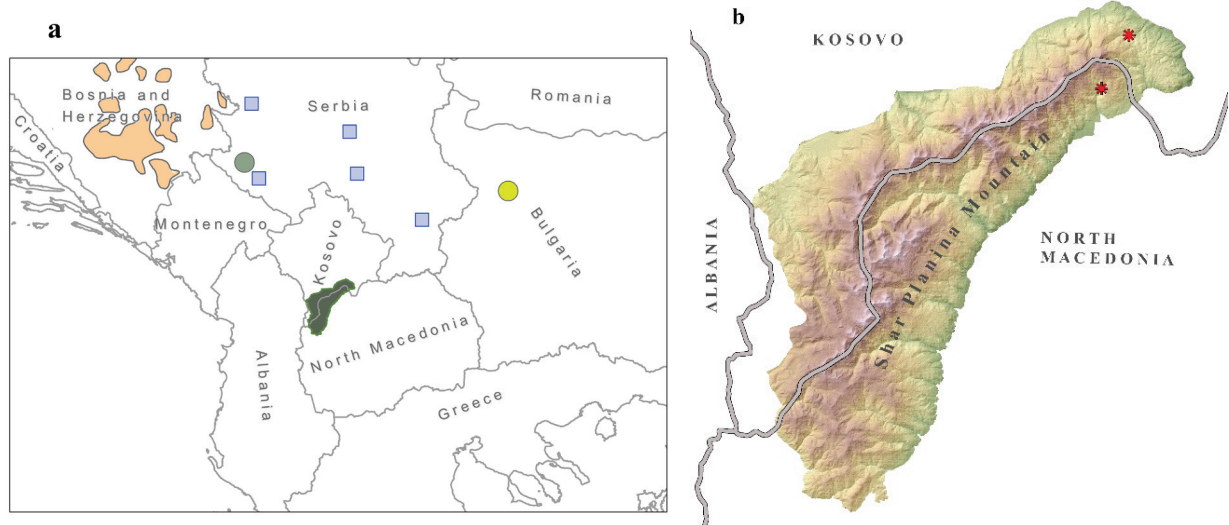


Figure 3. Distribution of *Carabus variolosus* on a) Balkan Peninsula: green area – Shar Planina Mt., brown areas represent known populations in Bosnia and Herzegovina (Kulijer et al. 2019), green circle (Wohlberedt-Triebes 1909) and blue squares (Mesaroš, unpublished data) from Serbia and yellow circle (Bekchiev et al. 2022) from Bulgaria and b) Shar Planina Mt.

Conclusions

We rediscovered *Carabus (Hygrocarabus) variolosus nodulosus* Creutzer, 1799 on two localities on Shar Planina Mt. (Ljuboten massif) after almost 100 years. Thus, it is confirmed for the faunas of both North Macedonia and Kosovo. These findings represent the southern-most records of the species in Europe. Both of the localities on Shar Planina fit well into the general habitat-preference of the species – small brooks in a beech forest landscape. We consider the population on Shar Planina very isolated (100km from the nearest populations on the Balkan Peninsula) and it is most probably a product of the latest glaciation. *Carabus (Hygrocarabus) variolosus nodulosus* Creutzer, 1799 should be considered as part of the Annex II and Annex IV of the European Union's Habitats Directive under the broader taxon of *Carabus variolosus* (Natura 2000 species code 4014), and should be included in the biodiversity law of North Macedonia.

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