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MORPHOLOGICAL AND GEOGRAPHICAL APPROACH TO *Carabus hampei* IN THE APUSENI MOUNTAINS

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Abstract

Carabus hampei is a Natura 2000 species, primarily distributed within the inner Carpathian arc, predominantly in the hilly areas, but also, albeit in small, often isolated populations, found in alpine regions and lowland areas of Romania. Distinguishing it from Carabus rothi, Carabus incomptus, and Carabus comptus remains challenging, as morphological criteria are not always sufficient for reliable differentiation. In most cases, geographic distribution is used as a distinguishing criterion, but this is only effective in areas where the species` ranges do not overlap. The species identified as hampei in the Apuseni Mountains is morphologically difficult to distinguish from the alpine form of comptus, which occurs in Banat. Previous reports of hampei in this area are outdated, and our attempts to locate the species over the past decade were unsuccessful until 2021. A morphological comparison between hampei from the Apuseni Mountains and comptus was conducted to distinguish the two species. The confirmation of hampei in the Apuseni Mountains highlights the necessity for intensifying habitat inventory efforts in this region. The morphological findings should be further validated through future molecular genetic analyses.

Key words*: Apuseni Mountains, Carabus hampei, Carabus comptus, Natura 2000, Conservation.*

INTRODUCTION

The subgenus *Morphocarabus* is represented in Romania by the following species: *Carabus comptus* Dejean, 1831, *Carabus excellens* Fabricius, 1798, *Carabus hampei* Kuster, 1846, *Carabus kollari* Palliardi, 1825, *Carabus zawadzkii* Kraatz, 1854, and *Carabus rothi* Dejean, 1829, the latter also including the taxon *Carabus alutensis* Săvulescu, 1972 (Turin et al., 2003; Retezar & Szel, 2021; Brezina, 1999, 2003; Kleinfeld & Schütze, 1999; Stan, 2024). Deuve (2004) classifies *comptus, hampei, incompsus*, and *rothi* as subspecies of *Carabus rothi*. Brezina et al. (1999, 2003) and Löbl & Smetana (2017) classifie *Carabus alutensis, Carabus comptus, Carabus hampei, Carabus incompsus,* and *Carabus rothi* as subspecies of *Carabus kollari*. *C. comptus* is very similar to the smaller-sized forms of *C. hampei*, such as *C. hampei zilahiensis* Csiki, 1906 (Zalău, Sălaj County), *C. hampei eximius* Csiki, 1906 (Oradea, Bihor County), and *C. hampei ormayi* Reitter (Moiad, Jibou, Sălaj County; Micula, Satu Mare County). The form found in the mountainous region of the Bihor Mountains or the Apuseni Mountains has been classified over time as belonging either to the species *Carabus comptus* or to *Carabus hampei*. The Bihor Mountains constitute a subunit of the Apuseni Mountains, representing the highest mountain group within this range.

In the Apuseni Mountains, under the name *Carabus comptus*, the species was reported by Teodoreanu (1981) southwest of Padiș, in the upper basin of the Crișul Pietros River, on the right slope of the Galbena Valley at an altitude of 900 m. Birthler (1886) mentions *Carabus comptus* along the upper course of the Someșul Rece River at 900-1300 m, as well as along the Someșul Cald River (Barloy & Prunar, 2012). In the Lie Pompiliu collection, the specimens collected by Adalbert Takacs in Gilău were labeled as *Carabus comptus diffinis*, while the specimen from the Bihor Mountains, collected by Ede Merkl, and the specimen from Rimetea (Alba County), which has collection data but no recorded collector (*legit* unknown), were labeled as *Carabus comptus* (Stan, 2018).

Szel (1985), in the maps from his doctoral thesis, marks the presence of both *Carabus comptus* and *Carabus hampei diffinis* in the Apuseni

Mountains and regards the latter as resembling *mehelyanus*, a subspecies of *Carabus incompsus* from the Hășmaș Mountains region. The attribution of the *diffinis* form to *Carabus comptus* in Turin et al. (2003) and Brezina et al. (2003) is erroneous. According to Csiki (1946), *C. comptus* occurs in the Szörenyer Mountains (most likely referring to Muntele Mic), as well as in the Retezat and Bihor Mountains (Magaslak): "*Kommt im Szörenyer-Gebirge (Munte Mare), sowie im Retyezat- und Bihar-Gebirge (Magaslak)*". The distinction between *Carabus comptus*, *Carabus hampei*, and *Carabus diffinis* is primarily based on the curvature of the apex of the aedeagus and the morphology of the endophallus, while classical molecular markers (*ND5*, *COI I*, *cyt b*) indicate a low level of differentiation (Barloy et al., 2019). *C. hampei* has five primary intervals, while *C. comptus* has only four (Csiki, 1946). However, distinguishing the two species based on the number of intervals is not always clear. A clarification regarding the classification of *Morphocarabus* populations from the Apuseni Mountains and Bihor Mountains is provided by Retezar & Szel (2021), who examines the species of the subgenus *Morphocarabus* in the Carpathian Basin using a substantial collection of field samples.

The confusion arising from the morphological similarity between the two species is resolved by applying a geographical criterion, considering the Mureș River as the boundary separating their distribution areas. According to this criterion, *Carabus comptus* occurs south of the river, while *Carabus hampei diffinis* is found north of it.

MATERIALS AND METHODS

Over the past 15 years, we have conducted sporadic surveys to identify the presence of *Carabus hampei diffinis* in the Apuseni Mountains, focusing on forest and grassland habitats along the Aleu Valley, Galbena Valley, Crișul Pietros, Bălileasa Depression, Padeș Peak, Vârtop-Arieșeni, as well as along the course of Someșul Rece in the Gilău Mountains, a northeastern subunit of the Apuseni range. However, these surveys were unsuccessful, as no specimens of *C. hampei* were recorded during this period.

Through systematic inventories of coleopteran species carried out in the western sector of Apuseni National Park during 2021-2022, we identified *C. hampei* in two distinct areas. The sampling was conducted using Barber pitfall traps, consisting of 220 ml plastic cups buried at ground level, into which acetic acid at a concentration of 30-40 degrees was added, obtained by diluting technical-grade acetic acid (80% concentration). The acetic acid solution was added to approximately one-third of the cup's capacity.

The expeditions in which the species was identified took place on June 28, 2022, for trap installation, and on July 28, 2022, for trap retrieval. To protect the traps from rainwater, a cover was fashioned from cut sections of 2-liter PET bottles and secured with wooden sticks to prevent displacement by wind. Once installed, the cover allowed two entry points leading to the cup.

Additionally, direct searches were conducted by inspecting under stones, fallen logs, abandoned packaging, and other potential refuges.

The individuals collected from different altitudinal zones, and their measurements were recorded using a precision caliper to ensure accuracy. The analysis and visualization were conducted using Python's Pandas and Matplotlib libraries. The data were structured in a Pandas DataFrame, and box plots were generated using Matplotlib's boxplot function.

RESULTS AND DISCUSSIONS

Field findings

The systematic classification and species delimitation within the genus *Morphocarabus* have become increasingly challenging following the inclusion of *Carabus hampei* and *Carabus zawadszkii* in Annex II of the EU Habitats Directive. The taxonomic distinction of *C. hampei* from *C. rothi*, *C. incompsus*, and *C. comptus* remains uncertain, while the differentiation of *C. zawadszkii* from *C. seriatissimus* and *C. hampei* or C. *incompsus* is also subject to debate (Barloy et al., 2012, 2014; Dréano et al., 2015a, 2015b).

According to data from the European Nature Information System (*EUNIS*) database (European Environment Agency, 2024) and the updated 2024 standard data forms for Natura

2000 sites, *Carabus hampei* is a protected species in three Natura 2000 sites in Hungary and eleven sites in Romania. (EEA, 2004) However, its distribution in Romania is significantly broader, as *C. hampei* is widely spread within the Carpathian Arc (Prunar et al., 2009; Barloy & Prunar, 2012).

In the Apuseni Mountains, *C. hampei* is protected within four of the eleven designated sites: ROSCI0008 Betfia, located near the city of Oradea in the northwestern part of the Apuseni Mountains; ROSCI0016 Buteasa, situated near the Bihor Mountains and encompassing forest and montane grassland habitats; ROSCI0035 Cheile Turzii, an emblematic area of the Apuseni Mountains, characterized by spectacular limestone gorges and high biodiversity; and ROSCI0233 Someșul Rece, a site located in the Gilău Mountains, which form part of the Apuseni range, along the course of Someșul Rece. In 2021, using 20 Barber pitfall traps grouped into three zones near Buteasa Peak, we investigated the alpine grassland area and the *Pinus mugo* ecotone, but no *C. hampei* specimens were recorded.

During the first field expedition in June 2022, we identified an elytron of *C. hampei* among insect remains collected inside a household container that functioned as a pitfall trap (lat. 46.64387061, long. 22.68433190; 1688 m alt.) on the plateau near Șaua Cârligatele. Based on this discovery, we installed additional traps in the grasslands and *Pinus mugo* stands in the Șaua Vărășoaia and Șaua Cumpănățelul areas, as well as along the trail connecting these locations (Figure 1).

Figure 1. Habitat between Șaua Vărățoaia and Șaua Cumpănățelul (original)

Figure 2. *C. (Morphocarabus) hampei diffinis* Csiki, 1905
(foto Ardelean A., 28.06.2022, Piatra Arsă, Apuseni Mountains)

At the same time, Barber pitfall traps were also installed in Poiana Ponor (lat. 46.57458319, long. 22.71750135, 1130 m. alt.).

Upon checking the traps one month later, all investigated areas yielded a large number of specimens, except for Poiana Ponor, where only seven *C. hampei* individuals were recorded. The highest abundance was observed in the Piatra Arsă area, where a significant proportion of the traps captured more than ten individuals per trap. During the descent on June 28, after installing the traps, an active *C. hampei* individual was observed moving in direct sunlight through the grass. Subsequently, during the transect survey conducted for the collection of captures in July, additional individuals were found exhibiting similar behavior. This indicates that the species is active first at the end of June and continues throughout July. Given the altitude, it is highly likely that the adult activity period is significantly delayed compared to lowland and piedmont areas. Thus, late June and July appear to be appropriate periods for monitoring the species in this region.

Morphology

All captured individuals are entirely black, sometimes exhibiting bluish reflections and a blue or green elytral margin. Considering the criterion of the number of primary intervals, the collected specimens have five intervals, a characteristic that corresponds to the species *Carabus hampei* (Figure 2).

The morphological analysis of *Carabus hampei* was conducted based on morphometric measurements of both males and females. The dataset includes key body dimensions such as total body length, pronotum median length, elytra length, pronotum width, and elytra width. The morphometric data suggest that *C. hampei* exhibits a relatively homogeneous body structure with minor sexual dimorphism, primarily in elytral dimensions. The total body length of *C. hampei* exhibits slight variation between males and females. Males have an average body length of approximately 24.9 mm (± SD), while females present a slightly different mean value of 25.5 mm (± SD). The statistical analysis did not reveal significant differences between the sexes ($p > 0.05$). (Figure 3)

The pronotum median length ranges from 4.9 mm to 5.0 mm across individuals, with an average of 5.0 mm (± SD). Similarly, pronotum width varies between 7.0 mm and 6.9 mm, with a mean of 7.0 mm (± SD). The elytra measure an average of 15.4 mm in length and 9.6 mm in width for males, while in females, these values are slightly different, measuring 16.2 mm and 9.6 mm, respectively.

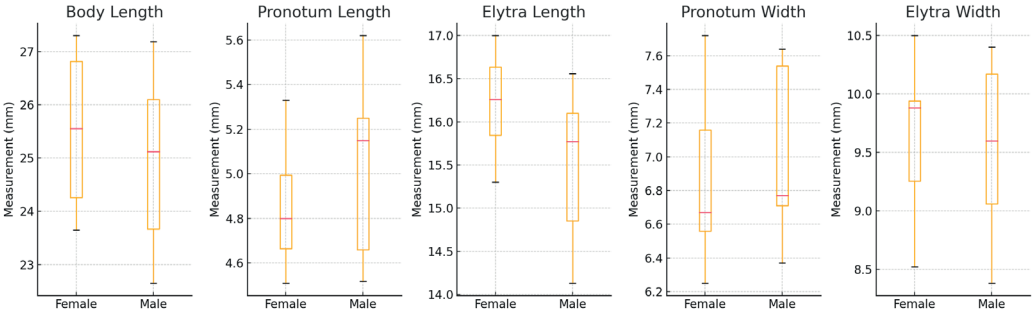

Figure 3. Boxplots of morphological measurement in *C. hampei*

It is important to note that the current measurements were conducted on a limited number of individuals. To obtain more robust conclusions, further analysis should be carried out on larger sample sizes, preferably grouped by altitudinal zones. Preliminary observations suggest that specimens from the Ic Ponor area tend to have larger body dimensions compared to those from the higher-altitude region of Șaua Cârligatele.

Beetles of Conservation Interest

On the standard form of the protected area ROSCI0002 Apuseni, updated in September 2024, two beetle species are mentioned: *Carabus variolosus* and *Rosalia alpina*. In

addition to these two species, during the inventory of beetle species in the western part of the Apuseni Mountains, within ROSCI0002 Apuseni, several new species have been identified, including *Carabus hampei*, *Rhysodes sulcatus*, *Morimus asper funereus*, *Cucujus cinnaberinus*, and *Lucanus cervus*. This highlights both the biodiversity value of the area and the need for continuous exploration to enhance knowledge and conservation of its natural heritage.

Conservation of *C. hampei* in ROSCI0002 Apuseni

The protected area ROSCI0002 Apuseni covers a surface of 75,876.5 ha, with 99.34% situated in the alpine biogeographical region. Despite efforts dispersed across different altitudes and ecosystem types, we found *C. hampei* only in the high-altitude zone, above 1000 m altitude, even though the species is not characteristic of mountainous areas, as some subspecies are present in lowland regions (e.g., *C. hampei ormayi* Reitter is found in the lowland area, Micula Forest, located approximately 10 km northeast of Satu Mare). Another characteristic of the species in this area is its presence in alpine grassland ecosystems dominated by *Vaccinium myrtillus* L. and *Vaccinium vitis-idaea* L., or along the edges of *Pinus mugo* shrublands and other tree species from lower altitudinal zones. Usually, *C. hampei* occurs in forest ecosystems in lowland and hilly areas, so this apparent preference for high-altitude grasslands has probably led some authors to mistakenly classify it as *C. comptus*.

Natural grasslands and pastures, which serve as habitats for the species in ROSCI0002 Apuseni, cover only 12.95% of the protected area's surface. A significant portion of these are located in areas where the species has not been found (e.g., Arieșeni and low-altitude grasslands). The species' habitat is well preserved, with the main identified threats being the afforestation of grasslands and habitat alterations caused by climate change.

CONCLUSIONS

The findings of this study confirm the presence of *Carabus hampei* in the Apuseni Mountains, providing an analysis of its distribution and differentiation from other related taxa that have been erroneously reported as present by various authors. These results contribute to a better understanding of the species' range, which has been debated due to historical misidentifications and morphological similarities. The identification of *C. hampei* in previously undocumented areas or those based on historical observations unverified by recent data underscores the necessity of systematic field investigations to verify the known distribution of this taxon. The discovery of *C. hampei* in the Apuseni Mountains has important conservation implications. The species is currently listed in several Natura 2000 sites, yet its actual distribution may be broader than previously documented. The identification of additional populations in this study suggests that conservation efforts should be expanded to include these newly confirmed habitats. Furthermore, habitat protection measures should be reinforced, particularly in areas vulnerable to disturbances. The identification of other protected beetle species (*Rhysodes sulcatus, Morimus asper funereus, Cucujus cinnaberinus,* and *Lucanus cervus*) during inventories highlights the biodiversity significance of the Apuseni Mountains. This study provides new insights into the distribution and morphological characteristics of *C. hampei* in the Apuseni Mountains. The integration of morphological, genetic, and ecological data will be fundamental in advancing our understanding of *C. hampei* and ensuring its long-term conservation in the Carpathian region.

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