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NEW FINDINGS OF *Carabus hungaricus* IN WESTERN ROMANIA

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Abstract

Carabus hungaricus is a species of community interest, protected in Romania within Natura 2000 areas located in the southern, western, and northwestern regions of the country. The species` distribution in the southern and northwestern parts is restricted to sandy soils, while in the western region, it has been identified on a very small area near the Romania-Serbia border, close to the town of Jamu Mare. Near Timișoara, the species was first mentioned by Breuning in 1933 at Remetea Mică and Mașloc, locations where it has not been found since that time. In recent years, we have identified and monitored the presence of a population in the southwestern part of Timișoara, within the ROSCI0390 Sărăturile Diniaș area, on lands with habitat 1530, Pannonic salt steppes and salt marshes. The observations contribute to understanding the distribution of a species of conservation interest in Romania, highlighting the significance of a new distribution area that requires specific measures for its conservation.

Key words*: Carabus hungaricus, Pannonic salt steppes, Natura 2000, new distribution records, species conservation.*

INTRODUCTION

Despite their large size, the distribution of species within the genus *Carabus* and the occupancy of potential habitats are not fully understood due to their cryptic lifestyle at ground level and their predominantly nocturnal activity. The identification or reconfirmation of areas occupied by protected, rare, endemic, or allochthonous species represents a topic of great interest, as the outcomes directly influence the management strategies for species habitats.

For carabid beetles typical of xerophilous grasslands, agricultural practices - including chemical treatments, conversion of grasslands into arable land, and intensive grazing - significantly influence species distribution.

Carabus (Pachystus) hungaricus Fabricius, 1792 is a protected species under the EU Habitats Directive Annex II and IV, the Bern Convention Annex II, and is listed on the Red List of species in Cehia (Hejda et al., 2017), Bulgaria (Golemansky et al., 2011), Moldova (Erhan et al., 2016), Ukraine (Akimov, 2009) and Romania (Murariu et al., 2021).

The earliest report of this species in Romania was made by Breuning (1933), who described the form *frivaldskyanus* based on a female specimen from Timișoara (Temesvar). In addition to Timișoara, Breuning also mentioned an area approximately 30 km away in a straight line, known historically as Maslak-Remete, which corresponds to the present-day localities of Mașloc and Remetea Mică.

Until 1994, these were the only known records of *C. hungaricus* in Romania. In 1993, Lie (1995) discovered *C. hungaricus* between the localities of Jamu Mare and Lățunaș along the Semița Valley, which was subsequently designated as a protected area (ROSCI0425 Pădurea Șemița) primarily for the conservation of this species (Lie 1995, 1996, Stan 2024).

In 2014, a female specimen of *C. hungaricus* was found and photographed in southern Romania, approximately 300 km southeast of Timișoara, near the locality of Murta, Dolj County (Popescu & Iorgu, 2016) in ROSAC0045 Coridorul Jiului.

In 2016, Alfred Ș. Cicort-Lucaciu encountered the species on a road in northwestern Romania, connecting the localities of Sanislău and Horia, during a pedestrian survey on roadkill species inventory (Alfred, 2020). This area is situated approximately 220 km NNE of Timișoara within the ROSCI0020 Câmpia Careiului protected area, which extends along the Romanian-Hungarian border for about 40 km.

During the monitoring of Natura 2000 species in 2019 and 2020, a new population was

identified in southern Romania within the ROSCI0039 Ciuperceni - Desa protected area, approximately 250 km NE of Timișoara (Prunar et al., 2021).
This historical and recent distribution data underscore the fragmented and isolated populations of *C. hungaricus* within Romania, highlighting the need for targeted conservation strategies to ensure the species' long-term survival.

MATERIALS AND METHODS

The species was identified using Barber pitfall traps with a capacity of 250 ml. The traps were buried at ground level, and a protective cover was installed on one edge of the cup to reduce the influx of rainwater into the trap. Each cup was filled with 30-50 ml of 9-degree acetic acid. The collection dates are as follows: October 2, 2022; March 31, 2023 (one trap from the previous year); and October 26, 2024. During the three collection events, a total of 54 specimens of *C. hungaricus* were recorded. Specimens collected from the traps were blotted with absorbent paper and transported to the laboratory on the same day, where they were stored at –15°C for preservation. Before measurement, the specimens were thawed at room temperature.
The analyzed specimens are currently stored in the freezer at USV Timișoara, where they are available for future genetic studies.
The following morphometric parameters were recorded: body length (total length from mandibles to elytral apex), pronotum median length (length along the central axis) pronotum lateral length (maximum length along the lateral edge), pronotum width (maximum width across the pronotum), elytra length (total length from the base to the apex), elytra width: maximum width of the elytra). Two ratios were calculated to assess body proportions: pronotum ratio = median length/width and elytra ratio = length/width. Descriptive statistics were calculated for all morphometric variables, including mean, standard deviation, and range. Shapiro-Wilk test was used to assess the normality of each variable. All statistical analyses were performed using Python (v3.9) and Seaborn (v0.11) for data visualization. For the analysis of distribution according to soil types, the study utilized the vector GIS data map of soils in Romania, processed using ArcGIS Pro 3.3.2.

RESULTS AND DISCUSSIONS

Context

Despite the inclusion of the species *C. hungaricus* in the standard ROSCI0115 Mlaștina Satchinez documentation, it has not been observed in Timiș County for nearly a century, with the exception of the Jamu Mare area. The last recorded near Timișoara sighting dates back to Brauning's 1933 observation. In the last 20 years, sporadic surveys have been conducted to identify the presence of the species *C. hungaricus* in the western regions of Romania. These investigations have particularly focused on the meadows in the metropolitan area of Timișoara, as well as on the protected natural areas in Timiș County. Based on historical records, the species has been searched for unsuccessfully in the meadows between the localities of Mașloc and Remetea Mică, southwest of Bencecu de Jos, at various points in the vicinity of the localities of Bărăteaz and Satchinez, as well as north of Timișoara. As part of these investigations, in 2022, a new ecologically significant location was discovered between the localities of Sâmnihaiu Român and Diniaș, situated within the protected area ROSCI0390 Sărăturile Diniaș.

New findings

On October 2, 2022, four traps that had been installed two weeks prior in ROSCI0390 Sărăturile Diniaș (lat. 45.67330184, long. 21.01940183), placed near two areas covered with hygrophilous vegetation. The installed traps contained the following specimens of *C. hungaricus*: eight females and one male in trap I, one female in trap II, six females and one male in trap II, and two females in trap 4, alongside six *C. cancellatus* specimens. In total, 17 females and one male of *C. hungaricus* were recorded. The period was characterized by precipitation, resulting in the traps being filled with water. On March 31, 2023, a fifth trap, which had been overlooked the previous year, was discovered. This trap contained the remains of 15 *C. hungaricus*

individuals. To obtain an overview of the distribution of this species On October 17, 2024, ten traps were installed at a new location (lat. 45.68203920, long. 21.03448711), 1500 meters northeast of the previous site. The traps were collected on October 26, 2024, yielding a total of 14 females and 7 males of *C. hungaricus*, as well as one female of *C. coriaceus*.

Additionally, researchers performed biometric measurements on a sample of 14 males and 21 females, thereby contributing to the analyse of the morphological characteristics of this species.

Species habitat

According to the Integrated Management Plan for Natura 2000 Sites ROSPA0144 Uivar-Diniaș and ROSCI0390 Sărăturile Diniaș, approved by Ministerial Order in 2016, the area of natural and semi-natural grasslands in ROSPA0144 Uivar-Diniaș is 2250 ha, with the objective of doubling this area.

Decision 70 of 2022 from the Ministry of Environment, Waters, and Forests sets the target area for the Pannonian salt marshes and steppe (habitat 1530*) at 853.1 ha.

C. hungaricus was identified in the grassland areas located on both sides of road 591 A, between the localities of Sânmihaiu Român and Diniaș. According to the standard data form of ROSCI0390 Sărăturile Diniaș, 91.35% of the site is covered by pastures, totaling 961.5 ha, indicating that the entire pasture area is occupied by habitat 1530. It is highly likely that the species is present throughout most of this area; however, its distribution is not confined to the site's boundaries. During field observations, the species was also found outside the site in grasslands north of road 591a.

The soils at the locations of Murta, Ciuperceni-Desa, and Valea lui Mihai-Carei, where the species is present in Romania, are predominantly sandy soils and loamy sandy soils. The only exception is at the Jamu Mare-Lățunaș site, where the habitat is situated on: Vertisols (typical and chromic), Typical luvic brown soils and eroded luvic brown soils, Alluvial protosols and alluvial soils (including gleyed).

In ROSCI0390 Sărăturile Diniaș (Figure 1) the two points where the species was recorded are situated on: Solonetz soils, Gleyed cambic chernozem soils. This variation in soil types suggests a degree of ecological adaptability in *C. hungaricus*, potentially influencing its habitat selection and distribution patterns.

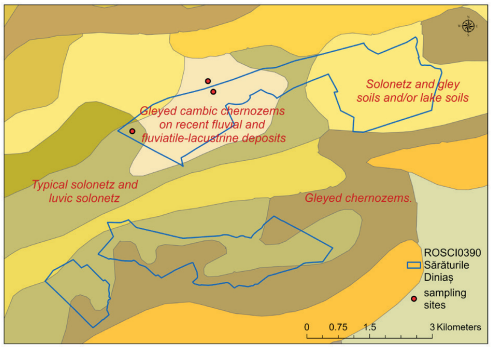

Figure 1. Soils in the distribution area of the species

Morfology

A total of 35 specimens were analyzed, consisting of 21 females and 14 males.

Females Body Length: Mean = 26.26 mm (Range: 24.67-29.26 mm)

Females Pronotum:

Median Length: Mean = 5.22 mm; Lateral Length: Mean = 5.78 mm; Width: Mean = 7.96 mm

Females Elytra:

Length: Mean = 16.95 mm; Width: Mean = 10.47 mm

Females Ratios:

Pronotum Ratio: Mean = 0.657; Elytra Ratio: Mean = 1.618; Males Body Length: Mean = 24.81 mm (Range: 23.25-26.20 mm)

Males Pronotum:

Median Length: Mean = 4.99 mm; Lateral Length: Mean = 5.56 mm; Width: Mean = 7.46 mm

Males Elytra:

Length: Mean = 15.64 mm; Width: Mean = 9.49 mm; Males Ratios:

Pronotum Ratio: Mean = 0.669

Elytra Ratio: Mean = 1.649

All variables followed a normal distribution ($p > 0.05$) except for females median pronotum length: $W = 0.882$, $p = 0.016$, slight deviation from normality.

Pronotum Ratio

Females: Mean = 0.657, SD = 0.018, relatively constant ratio, indicating a stable pronotum shape.

Males: Mean = 0.669, SD = 0.015, slightly higher, suggesting a more elongated pronotum.

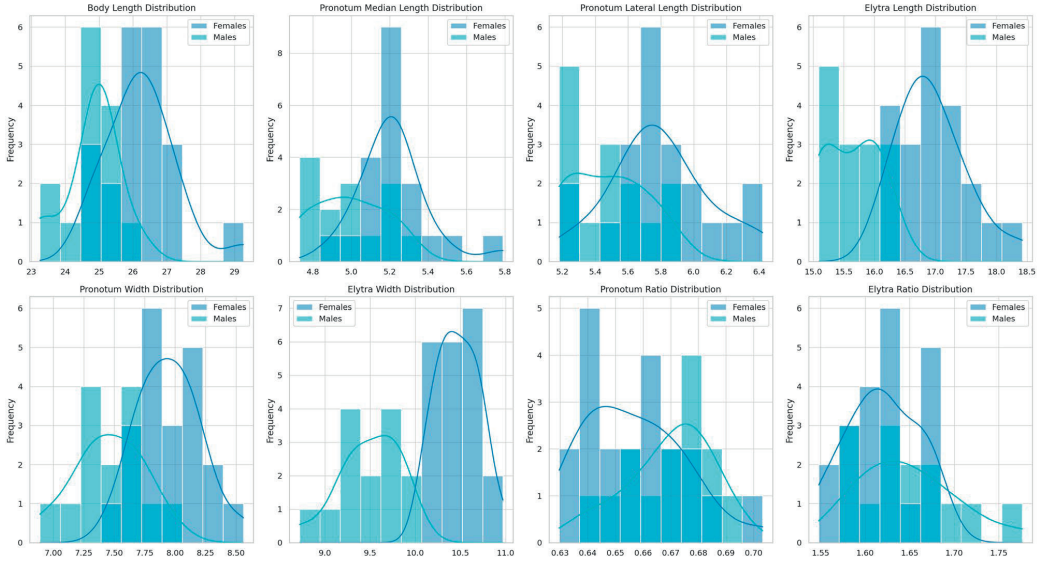

Figure 2. Morphometric Distribution of *Carabus hungaricus*

Figure 3 *C. hungaricus* from Dinias male 26.10.2024, Carei male 06.07.2020, Bratovoești female 15.10.2022 (Prunar F. legit.)

Elytra Ratio

Females: Mean = 1.618, SD = 0.040, consistent shape across specimens.

Males: Mean = 1.649, SD = 0.056, more variability, suggesting greater morphological diversity.

The distributions reveal clear sexual dimorphism, with females generally exhibiting larger body dimensions compared to males. Males, however, display slightly higher ratios, indicating a more elongated pronotum and elytra relative to their width. Additionally, the variability in the elytra ratio among males suggests a greater morphological diversity compared to females.

The blue color palette (Figure 2) effectively distinguishes between sexes, with darker blue representing males and lighter blue representing females. The distributions for all variables approximate normality, supporting the isometric growth pattern observed in the correlation analysisIn his 1933 description, Breuning identified the form known as *frivaldskyanus* based on a female specimen collected from Timișoara (Breuning, St. Von. 1933). This form is distinguished by its characteristic morphological features, notably the prominently large and well-defined primary fossae, which serve as distinctive diagnostic traits. Csiki (1946), lacking specimens of *frivaldskyanus*, was unable to confirm the form described by Breuning. Consequently, the authenticity of this form and the existence of the population in the Timișoara area remain a mystery. The body dimensions of the male specimens from the Jamu Mare population have an average length of 25.1 mm, while the females measure 26.6 mm. The elytra width is 9.5 mm in males and 10.8 mm in females (Barloy J. et al., 2006). The population identified in ROSCI0390 Sărăturile Diniaș zone, exhibits smaller average body dimensions compared to the population from Jamu Mare in ROSCI0425 Pădurea Șemița, with a 0.3 mm shorter body length for both females and males. Additionally, the elytra width is 0.3 mm narrower in females, while in males, the width remains identical. According to Csiki (1946), the dimensions of the form *viennensis* Kraatz from Hungary, particularly from the central area surrounding the Buda Mountains and extending westward to the Vienna Basin, range from 22 to 28 mm. Consequently, the males exhibit a shorter body length compared to the individuals collected at Diniaș zone, where the smallest recorded size is 23.2 mm.

By comparing the overall body shape, the roughness of the elytral sculpture, and the degree of primary fovea (Figure 3) marking in populations from Oltenia (Bratovoești), Banat (Diniaș), and Crișana (Carei), differences can be identified in the form referred to by Breuning (1933) as *frivaldskyanus*. Detailed comparisons of the populations from Banat with populations from other regions of Romania or neighboring countries are recommended for analyzing the status of this form.

Conservation in ROSCI0390 Sărăturile Diniaș

C. hungaricus is a species that in Hungary is typically found inhabiting sandy grasslands and dolomite grasslands (Bérces et al., 2008, Szel et al., 2006, Turin et al., 2003). It can be found in grasslands invaded by *Robinia pseudoacacia*; however, these trees pose a threat to *C. hungaricus* by increasing soil shading, which leads to a reduction in the herbaceous layer's ground cover (Prunar et al., 2021). At Jamu Mare, the species is present in shrubs dominated by *Prunus spinosa* or *Crataegus monogyna* and at the edge of *Robinia pseudoacacia* forests, but it is completely absent in pure *Robinia pseudoacacia* forests or in mixed forests (personal observations by Prunar F., Șemița Forest, and forests within ROSCI0020 Câmpia Careiului, ROSCI0039 Ciuperceni - Desa, and ROSAC0045 Coridorul Jiului). According to Cizek et al., (2012), *Carabus hungaricus* occurs more frequently in habitats with high litter cover, wood small-reed (*Calamagrostis epigejos*), tall grasses, herbs, higher humidity, and increased soil nitrogen content, while it tends to avoid areas dominated by feather grasses, short dicots, tussock grasses, and trees, as well as those with bare soil, elevated temperatures, high light exposure, and specific soil reaction conditions.

The main pressures and threats that may impact the habitats of the species within the protected area are those that could alter the characteristics of grassland and meadow habitats. These include the expansion of built-

up areas, changes in land use through conversion into arable land or the establishment of plantations, and the abandonment of land use, which can lead to natural reforestation. Grazing is beneficial for maintaining the habitat of the species; however, overgrazing, particularly through prolonged grazing on the same areas, is likely to have a negative impact due to the mechanical trampling of the insects or their potential prey. The carabus species found in association with *C. hungaricus* include *C. coriaceus* (one female) and *C. cancellatus* (four females and two males).

CONCLUSIONS

This study provides new insights into the distribution, habitat preferences, morphological diversity, and conservation status of *C. hungaricus* in Romania. The discovery of new populations in ROSCI0390 Sărăturile Diniaș underscores the importance of this site for the conservation of *C. hungaricus* and confirms the species' presence near Timișoara, consistent with the historical record by Breuning (1933). The identification of the species outside the protected area highlights the need to redefine the boundaries of the area and to implement appropriate measures to ensure habitat connectivity for grassland ecosystems. The habitats need for integrated conservation strategies that account for Natura 2000 species co-occurrence and habitat requirements. Integrated conservation strategies are recommended for species of interest within the grassland ecosystem, along with the continued inventory of grasslands within ROSPA0144 Uivar-Diniaș to evaluate the potential expansion of the ROSCI0390 Sărăturile Diniaș site for enhanced habitat protection of the species. The morphometric results indicate that the individuals from the Diniaș population have smaller body dimensions compared to those from the Jamu Mare population. This suggests the potential existence of morphological differences between the populations in the Timișoara region, which could support the validity of the form *frivaldskyanus* as described by Breuning (1933). To strengthen this hypothesis, it is recommended to conduct molecular analyses to explore the genetic differentiation and phylogenetic relationships among these populations. Such investigations would provide a deeper understanding of the evolutionary significance of these morphological differences and could potentially validate the taxonomic status of the *frivaldskyanus* form.

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