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Diversity of the land snail fauna of Llogara National Park (Albania) focusing on the distribution areal of *Chondrula lugorensis* A. J. Wagner, 1914 (Gastropoda Enidae)

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ABSTRACT Regular surveys of biodiversity are important for monitoring changes in the richness and species composition of mollusk fauna, especially in mountainous areas and fragmented and isolated habitats that are biodiversity hotspots, characterized by endemic species with isolated spread. This paper presents a list of the terrestrial mollusk fauna of Llogara National Park (Albania) and includes data on the distribution area of the endemic mollusk *Chondrula (Chondrula) lugorensis* Wagner, 1914. Snails and slugs were collected using visual searches and leaf litter collections during the spring and autumn seasons of 2020 and 2021. A total of 52 terrestrial gastropods were identified, representing 13 species from nine families. The study also sampled 24 individuals, both alive and deceased, of the endemic species *Chondrula (Chondrula) lugorensis* (Gastropoda Enidae), which allowed for creating a distribution map and identifying its habitat.

KEY WORDS *Chondrula lugorensis*; malacofauna; Llogara; endemic; land snail; Albania.

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INTRODUCTION

Terrestrial mollusks represent one of the most specious groups of terrestrial animals on Earth, with about 28,000 recognized species (MolluscaBase 2022) and an estimated number of undescribed taxa ranging between 11,000 and 40,000 (Lydeard et al., 2004; Rosenberg, 2014; Goudeli et al., 2021). The heterogeneous structure of the habitat and the geological fragmentation of the Balkan peninsula make it one of the major hotspots of terrestrial mollusk diversity in the Holarctic region (Fehér & Erőss, 2009; Neubert et al., 2019). Albania remains among the countries with the least data regarding terrestrial mollusk fauna, probably due to the geopolitical situation and the difficult accessibility of this country (Fehér & Erőss, 2009).

The chronological reconstruction of studies of terrestrial mollusk fauna in Albania dates to the first expeditions in the mid-19th century by SCHLÄFLI, Westerlund, Blanc, and Von Martens (Mousson, 1859; Martens, 1889; Westerlund & Blanc, 1879; Fehér & Erőss, 2009). In the early 20th century, a number of data from Apfelbeck, Buljubasić, Führer, Klaptocz, Petrović, Sturany, Wagner, Winneguth, and Wohlberedt were collected and presented in two monographs (Wohlberedt, 1909; Sturany & Wagner, 1915), followed by other publications during

the First and Second World Wars (Csiki, 1923; Kümmerle, 1926; Wagner, 1913; Wagner, 1919). Then followed by a limited number of studies during the period of the communist regime mainly published by the Academy of Sciences of Albania and the University of Shkodra, (Jaeckel et al., 1957; Jaeckel & Schmidt; 1961; Dhora, 1976; 1978a, b; 1981; 1983; 1985; 1988a, b; 1990).

After the political transition, the explorations of terrestrial mollusks fauna started again with some expeditions organized in collaboration between Albanian and Austrian researchers (Welter-Schultes 1996; Riedel & Welter-Schultes, 1996; Dhora & Welter-Schultes, 1996; 1999a; b). Until 1996, the fauna of terrestrial mollusks counted 237 species of terrestrial and freshwater mollusks for Albania (Dhora, 1994; 1995; 1995–96; 1997a; 1997b; 1997–2000; 1999a; 1999b; Dhora & Welter-Schultes, 1996). Until this moment 48 taxa have been described, among which some new species for the science have been reported (Subai 1997, 1999a, b; Dhora & Welter-Schultes, 1999a, b; Erőss et al., 1999, 2005, 2006; Riedel et al., 1999; Fehér et al., 2001; Fehér 2004; Fehér & Drimmer 2004; Subai & Fehér, 2006; Fehér & Erőss, 2009; Lika et al., 2021).

Therefore, in addition, we are presenting some data about the biodiversity of terrestrial mollusks of Llogara National Park. This paper also tries to re-present the distribution areal of the species *Chondrula lugorensis* Wagner, 1914 in the Llogara national park, described for the first time by Sturany & Wagner (1915) and recently reported by Dhora & Welter-Schultes (1996), Fehér & Erőss (2009) and Welter-Schultes (2012).

MATERIAL AND METHODS

Study area

Llogara National Park is located in the southwest region of Albania, along the Ceraunian Mountain range that stretches along the Ionian Sea. The Karaburun peninsula is located on the northeastern side of the Strait of Otranto, where the Adriatic Sea meets the Ionian Sea. While the floristic richness of the Karaburun-Çika Mts Protected Area has not been fully documented, this complex ecosystem is considered to be the most diverse part of Albania in terms of species with conservation interest. The National Park is home to nine endemic vascular plants, such as *Arenaria cikaea*, *Edraianthus caespitosus*, and *Dianthus sylvestris subsp. alboroseus*, *Hypericum haplophylloides, Limonium himariense, Noccaea cikaea, Reichardia albanica, Sesleria albanica,* and *Viola acrocerauniensis*. Additionally, the Llogara National Park is home to four endemic terrestrial mollusks, such as *Chondrula lugorensis*, *Allaegopis amphikypellon*, *Monacha emigrata senitshika*, and *Helicigona fuchsia*, as well as one endemic carabid, *Dorcadion albanicum*.

The Llogara National Park is also home to several globally threatened species, including the Horse Chestnut (*Aesculus hippocastanum*) and Autumn Snowdrop (*Galanthus reginae-olgae*). Six other species, namely *Fritillaria graeca, Anacamptis pyramidalis, Ruscus aculeatus, Ophrys helenae, Ophrys oestrifera*, and *Ramonda serbica*, are of great conservation interest due to their protection under the Habitat Directive (92/43/EEC) and Berne Convention.

The Park is also home to 52 plant species that are part of Albania's red list of protected flora, but the complete number of flora and fauna species is not yet fully known. The plant cover vegetation in the Llogara National Park is dominated by various habitat types, including vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp., stable xerothermophilous formations with *Buxus sempervirens* on rock slopes, Hellenic beech forests with *Abiesborisii-regis*, *Quercus ilex,* and *Quercus rotundifolia* forests, *Quercus macrolepis* forests, and High Oro-Mediterranean pine forests.

In addition to the diverse plant life, the LNP is also home to a rich variety of invertebrate and vertebrate species. The area is known to house 98 fish species (both freshwater and marine), 10 amphibian species, 28 species of reptiles, 105 species of birds (mostly in Orikumi lagoon), and 55 mammal species (Final Report on the Study on Landscape of Llogara National Park in Albania).

Survey methods

The surveys were conducted in the Llogara National Park area, including Cika Mountain and the Palasa River (Fig. 1), which contain native and non-native snails, both macro- and micro-mollusks, in a variety of habitats. Sampling was carried out from

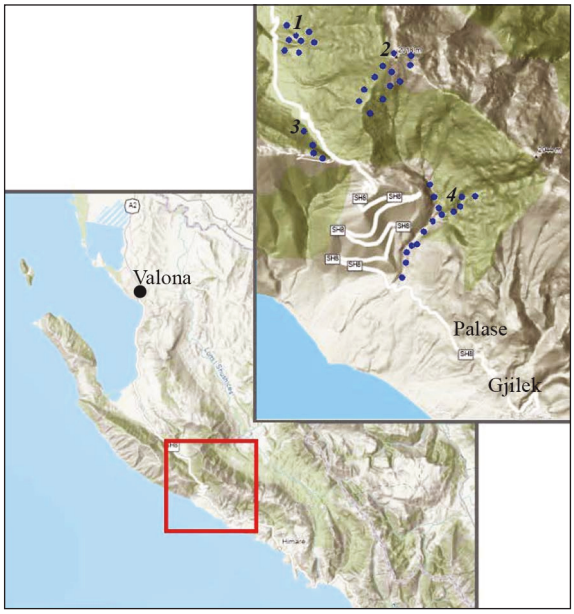

Figure 1. Map of the areas visited during the expeditions. 1. The path of Caesar; 2. Cika Maintain; 3. Panorama; 4. Palasa torrent.

Latitude	Longitude	Number of specimens
40°12.950'N	19° 36.380'E	2
40°12.830'N	19° 36.659'E	3
40°11.911'N	19° 35.498'E	1
40° 12.941'N	19° 36.421'E	1
40° 12.967'N	19° 36.554'E	3
40° 12.895'N	19° 36.474'E	2
40° 12.773'N	19° 36.705'E	1
40° 12.648'N	19° 36.945'E	2
40° 12.505'N	19° 37.608'E	3
40° 12.229'N	19° 35.529'E	1 (empty shell)
May be transported by water		
40° 11.956'N	19° 35.389'E	1 (empty shell)
May be transported by water		

Table 1. Location of sampled specimens (Llogara National Park, Albania).

February to September in 2020, and 2021. In each area, five sampling sites of 10 m^2 were selected, spaced at least 100 m from each other along a transect to maximize the number of different sampled microhabitats. The Cika mountain sites were visited three times as species had been previously reported in that area, while other sites were visited only once to confirm the presence or absence of the species. However, during two visits to the Cika mountain area and two other areas, *Chondrula lugorensis* was found (Table 1, Fig. 2).

Sampling began with a visual search of suitable microhabitats, including plants, by expert snail gatherers lasting 15 minutes with five people at each site. This was followed by collecting individuals at random within each site, including places with deep soil accumulation and around the bases of rocks and trees. All collected material was stored in 70% alcohol and taken to the laboratory for further processing. The samples collected using both methods were identified at the lowest possible taxonomic level, and in some cases, specimens were referred only to a family, subfamily, or genus. Any species readily identified in the field were simply counted.

The research was aided by students from the University "Ismail Qemali" Vlore, who were prepared for all stages of sampling, identification, and data collection on the species. Although it was often difficult to determine whether an individual died prior to collection or during storage, all samples were processed, and live and dead (shell only) counts were pooled, except for *Chondrula lugorensis*, which counts were divided into living and dead specimens. A subset of live specimens was stored in 95% ethanol as representative vouchers for future analysis. All vouchers have been cataloged and deposited in the "Ismail Qemali" University in Vlore.

RESULTS

During the four expeditions, 13 species belonging to nine different taxonomic groups were collected and identified. All specimens have been identified at the species level, with the exception of the genus *Montenegrina* which will be examined much more carefully before declaring the species (Table 2).

Most of the species were alive at the time of sampling, with the exception of some individuals, who preferred to sample only the shell for a minor

Species	The Path of Caesar	Cika Maintain	Palasa torrent	Panorama
Cochlostoma auritum (Rossmässler, 1837)	+	+		+
Cochlostoma tessellatum (Rossmässler, 1837)	+	+	+	+
Pomatias elegans (O.F. Müller, 1774)	+	+		+
Herilla illyrica (Möllendorff, 1899)			+	
Montenegrina sp. O. Boettger, 1877		+		+
Cernuella virgata (Da Costa, 1778)		+		
Helicodonta obvoluta (O.F. Müller, 1774)	+		+	
Aegopis acies (Férussac, 1832)			+	+
Aegopis septentrionalis laughofferi A.J. Wagner, 1914	+			+
Chondrula lugorensis A.J. Wagner, 1914		+		
Chondrula microtragus (Rossmässler, 1839)		+	+	
Lauria cylindracea (Da Costa, 1778)	+		+	
Radix peregra (O.F. Müller, 1774)	+		+	

Table 1. Mollusca fauna was identified in Llogara National Park in four different locations: 1. The path of Caesar; 2. Cika Maintain; 3. Panorama; 4. Palasa torrent.

impact on the population. All families are represented with a maximum of 2 species. The families with the greatest number of species are Zonitidae (2 species), Enidae (2), Cochlostomatidae (2), and Clausiliidae (2).

Data on Chondrula lugorensis *A.J. Wagner, 1914 distribution*

Chondrula (Chondrula) lugorensis, is a species of terrestrial Gastropoda in the family Enidae. First, this species was described in 1915 in an article published in the Memoranda of the Imperial Academy of Sciences, Mathematical and Scientific Class, where some of the terrestrial mollusk species found in Albania and its surroundings were described and reported (Sturany & Wagner, 1915).

According to Sturany and Wagner (1915) *C. lugorensis* is a small gastropod, 8–11 cm long and 3.5–4 cm large with a dirty yellowish-grey shell, translucent, yellowish opaque near the aperture, coarsely and irregularly striated, 8 weakly convex whorls, last whorl not descending before aperture, aperture simple without teeth, margin straight and thin, with a white lip inside, sometimes forming some teeth-like structures, margins connected at parietal side by a thin layer, but do not approach each other much, umbilicus very narrow (Fig. 2).

Later on, *C. lugorensis* was reported in several articles but in the same area of distribution (Dhora, 2002 a and b, 2004; Fehér & Erőss, 2009 a and b; Welter-Schultes, 2012).

The actual distribution of C. *lugorensis* known since now are*:*

Qafa e Llogarait (South Albanian coast)
Periferi Vlorë, Mali i Çikës, 2 km W
Maja e Qorrës along the ridge to Maja e Çikës, 1840 m a.s.l.,
Periferi Tepelene, ca. 1 km SE
Maja e Klogjurit, 1779 m a.s.l.,

Thanks to an assessment done in 2010 on the distribution area of this species, *C. lugorensis* was declared by the IUCN as a Near Threatened species according to Feher (2013). According to IUCN, the number of currently known locations is less than five, and the known area of occupancy (AOO) is less than 20 km^2 of occurrence (EOO), the number of locations, the number of subpopulations or the number of mature individuals are declining or extremely fluctuating. There is no major threat to this species; therefore, it is assessed as Near Threatened (NT), almost qualifying for Vulnerable D2. During the monitoring and sampling activities, about 20 individuals of *C. lugorensis* were sampled in four sites in the Cika mountain area (Fig. 3).

Figure 2. *Chondrula (Chondrula) lugorensis* Wagner, 1914 (photo by I. Nasto).

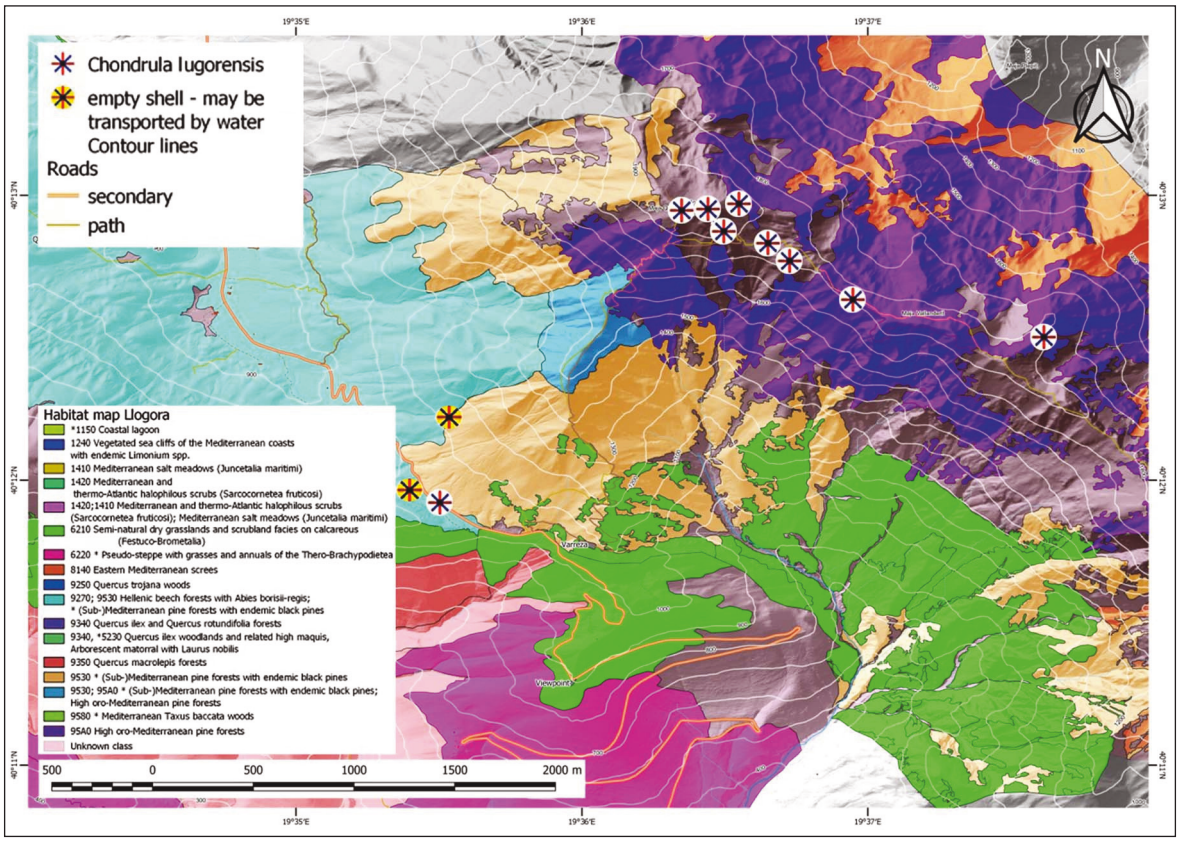

Figure 3. Map of the actual known distribution of (*C. lugorensis* Feher, (2013), ascertained from the sampling campaigns during 2019–2021 (Map created by Ronny Dobbelsteijn).

Most of the individuals sampled were chosen dead, due to the limitation of the impact on the population of the species. Live individuals of different sizes were sampled in order to clearly describe the species. The species was often accompanied by *Cochlostoma tessellatum* (Rossmässler, 1837) and *Herilla* sp.

Habitat and ecology

Currently, we know little about the ecology and habitat of *C. lugorensis* but knowing its distribution we can give some important characteristics of the habitat. *Chondrula lugorensis* is a typical mollusk associated with a karstic habitat. The distribution of the species is the same as it was evaluated in 2010. The distribution is compatible with the habitat of high Mediterranean pine forest but in the areas of rare forest, characterized by the vegetation of *Sesleria albanica*, *Festuca* sp., and other perennial Poaceae grasses. The species is usually located in humid areas consisting of limestone covered with moss, proof that the habitat is humid most of the time. So far it has been sampled only in limestone areas exposed to the northeast in order to maintain a constant temperature and humidity. This mollusk is often positioned vertically under the rocks of the limestone walls quite sheltered from the wind and sun.

Little is known of its biology, including breeding biology. There is a suggestion that the species breed throughout the year when conditions are suitable.

Often the species hides between roots and moss, and being the same color as the surrounding vegetation, it gives it the opportunity to blend in perfectly with the surrounding environment. In fact, no traces of consumption by animals such as insects or birds have been found. All the individuals found, both alive and dead, had the entire shell, not damaged by possible carnivores. Three damaged shells were found which were rated as very old and damaged by the decomposition process.

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