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Rediscovery of *Assyriella rechingeri* (Fuchs et Käufel, 1936) (Gastropoda Helicidae) in Karpathos Island (Dodecanese, Greece)

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ABSTRACT The aim of this work is to confirm the occurrence of several living populations of *Assyriella rechingeri* (Fuchs et Käufel, 1936) (Gastropoda Helicidae) in Karpathos Island (Dodecanese, Greece) since the species was believed to be extinct in the past by some authors due to the discovery of only subfossils specimens. Its systematic status and the sympatry with *Levantina spiriplana* (Glaubrecht, 1993) and *L. malziana* (L. Pfeiffer, 1861) are discussed.

KEY WORDS *Assyriella rechingeri*; endemism; Kali Limni.

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INTRODUCTION

Assyriella rechingeri (Fuchs et Käufel, 1936) (Helicidae family, Helicinae subfamily, Helicini tribe) is part of a group of conchologically similar genera found between the central Mediterranean to Middle East and the Caucasus, which are close relative of the genus *Helix* Linnaeus, 1758. These genera are: *Maltzanella* P. Hesse, 1917; *Lindholmiola* P. Hesse, 1977; *Levantina* Kobelt, 1871; *Assyriella* Hesse, 1908; *Gyrostomella* Hesse, 1911, *Isaurica* Kobelt, 1901; *Codringtonia* Kobelt, 1898 (Hesse, 1920; Boettger & Wenz, 1921; Subai, 1994).

Hesse (1908) had proposed the taxon *Assyriella* as a section of the *Levantina* for the species "*guttata* Olivier, 1804". *Levantina* had been split into the subgenera *Codringtonia*, *Isaurica* and *Levantina* s. str., and the latter was split into *Assyriella*, *Levantina* and *Gyrostoma* sections for shell anatomy reasons. Subsequently, Hesse (1918) elevated *Assyriella* to the rank of subgenus close to *Levantina* s. str. and *Gyrostomella* (instead of *Gyrostoma*). As knowledge of species, localities, distribution areas and systematic position of the supraspecific taxa mentioned above increased, *Assyriella* was treated as a separate genus (Glaubrecht 1993a, 1993b; Subai, 1994). Molecular data are in Korabek et al. (2014).

Currently, *Assyriella* is considered paraphyletic with respect to *Levantina* (Korábek et al., 2014). The supraspecific taxa *Codringtonia*, *Isaurica*, *Assyriella* and *Levantina* evidently developed from a common root, just like the North African *Gyrostomella*. Schütt stated that Southeastern Anatolia was the radiation centre of the genus *Assyriella* (Schütt & Subai, 1996). From here it may have spread in the Middle East and westward in some islands as Cyprus and Karpathos (Akbayin et al., 2001). The spreading of genus *Assyriella* towards west and south took place following the isolation and separation of *Codringtonia*, *Isaurica* and *Levantina* genera (Schütt & Subai, 1996). Eustatic fluctuations in sea level, especially during the Messinian period

(6 Ma), allowed the ancestors of *Assyriella* to cross the Mid Aegean Trench (MAT) in the Aegean and to colonize the Peloponnese, whose further development isolated the *Codringtonia* genus. Subsequently, sea level rise and tectonic uplift isolated the *Isaurica* genus. The very disjoint distribution of the *Levantina* genus on some Aegean islands and on the Syrian-Israeli mainland dates back to a subsequent lowering of the sea level during a Pleistocene glaciation (Pfannenstiel, 1944). The lowering of the coastline up to 200 m allowed migrations of freshwater and terrestrial molluscs along the Mediterranean coast favouring the spreading of the genus *Assyriella*. Furthermore, volcanic eruptions in the southern part of the Caucasus favoured the isolation of population with the emergence of geographically isolated species toward east (Schütt & Subai, 1996).

The genus *Assyriella* Hesse, 1909 includes 13 species: *A. bellardii* (Mousson, 1854), *A. ceratomma* (Pfeiffer, 1856), *A. cilicica* (Kobelt, 1895), *A. djulfensis* (Dubois de Montpéreux, 1840), *A. escheriana* (Bourguignat, 1864), *A. guttata*, *A. kurdistana* (Pfeiffer, 1862), *A. mardinensis* (Kobelt, 1900), *A. naegelei* (Kobelt, 1901), *A. ninivita* (Galland, 1885), *A. rechingeri* (Fuchs & Käufel, 1936), *A. thospitis* Schütt et Subai, 1996 and *A. vanensis* Schütt et Subai, 1996. *Assyriella guttata* (from the Gulf of Iskenderun to Mersin), *A. bellardii* (Cyprus) and *A. rechingeri* are the westernmost representatives of the genus.

Assyriella rechingeri is an exclusive endemic species of Karpathos Island in the Dodecanese Archipelago (Greece) and perhaps is a relic population of the *Assyriella* group. The relic occurrence of *A. rechingeri* on Karpathos and *A. bellardii* on Cyprus suggests that *Assyriella* was once more widely distributed in the eastern Mediterranean as it is even today (Schütt & Subai, 1996) and can also be interpreted as allospecies of a widely distributed *A. guttata* superspecies (Glaubrecht, 1994). It could be argued that the *Assyriella* populations were separated from the *Assyriella* distributional area (Eastern Anatolia) after Miocene due to climatic and geological changes. Palaeogeographical data reveal that Karpathos was detached from the island chain of Rhodes and thus from the mainland of Asia Minor as early as in the late Miocene (5–6 Ma). Thus, the ancestors of *rechingeri* must have reached the island by this time. Karpathos was reintegrated with the mainland during the Messinian salinity crisis (5–6 Ma) and was joined with Rhodes and Anatolia in Lower Pliocene (Daams & Van der Weerd, 1980), but presumably remained isolated at the end of the middle Pliocene and during the whole Pleistocene (Dermitzakis, 1991). This isolation would have led the *Assyriella* population of Karpathos and Cyprus to an evolutionary change and to an adaptation to different environmental conditions. Hence, *A. rechingeri* on Karpathos and *bellardii* on Cyprus can be construed as vicarious taxa of the *Assyriella* species group. A similar disjoint distribution in the eastern Mediterranean can be observed in *Levantina spiriplana* (Glaubrecht, 1993). The Eastern Mediterranean land snails *Levantina* displays a disjunct range spanning the Middle East (Levant), Cyprus, few locations along the Aegean Turkish coast between Bodrum and Datça, the islands of Rhodes and Karpathos and a few surrounding islets (Dodecanese). In the Levant, it is represented by two species parapatrically distributed: *L. caesareana* (Mousson, 1854) in the north and *L. hierosolyma* (Mousson, 1854) in the south. In the Dodecanese *L. spiriplana* and *L. malziana* (L. Pfeiffer, 1861) occur together (Ketmaier & Glaubrecht, 2015). In Karpathos, both species are parapatrically distributed, and leave in sympatry with *A. rechingeri* sharing area up to 500 m a.s.l.

MATERIALS AND METHODS

Study area

Karpathos is the second largest Dodecanese island after Rhodes and lies in the SE Aegean Sea, halfway between Crete and Rhodes (39 km from Crete and 25 km from Rhodes). The island is 49 km long and 15 km wide and covers an area of 302.15 square kilometres. Together with Kasos and Armathia in the southwest, the nearby Saria in the north and several offshore islets, Karpathos forms the Karpathos Archipelago and is a constituent part of the South Aegean Island Arc (Greuter et al., 1983). The three larger islands contain widespread mountainous areas with some higher peaks, culminating on Karpathos in the Kali

Limni (1215 m), on Kasos in the Megalo Prionas (601 m), and on Saria in the Pachy Vouno (629 m) (Grano & Cattaneo, 2019). On Karpathos the only flat areas are near Afiartis in the south, near Lastos in the centre, and Avlona in the north. Karpathos is built up of limestone and dolomitic limestone (Jurassic-Eocene) in the northernmost part, flysch (Eocene) in most of the northern and the southern part, Neogene deposit in the southernmost area. The central part of the island corresponding to the Kali Limni Mountain complex, the area near Menetes (south) and Pigadia (south-east), are constituted by the Kalilimni Unit, a parautochthonous carbonate platform (Jurassic-Eocene) overlaid by the Xindothio Unit (Triassic-Cretaceous) almost built up of ophiolites (Cordey & Quillévéré, 2019).

Methods

Our naturalistic research has been carried out on Karpathos twice, the first from 28 July to 17 August 2019 and the second from 10 August to 17 August 2020. During the second session (2020) *A. rechingeri* was found in four different areas. For an optimal research, the entire island has been only visited on foot along roads, paths, and streams. Only empty shells were found in several sites - which are mentioned below - therefore only a conchological study of the specimens was possible to perform. The shells were cleaned with water and a brush after being soaked for about two minutes in a solution with 60% water (H2O) and 40% NaClO. The specimens are kept in the private collection of one of the authors (MG, Rome, Italy). For the taxonomy of this species the Fauna Europaea Project (Bank, 2017) and MolluscaBase (2021) has been followed.

The collected material is of 12 specimens of which 5 examined (Table 1). The shell variables shown in Fig. 1 were measured on the specimens in millimeters with a calliper of 1/100 mm precision. A–B: Shell Height (ShH); A–C: Spire Height (SpH); D–G: Shell Diameter (ShD); E–F: Truncation Width (TrW); E–G: Aperture Width (ApW); H–I: Aperture Height (ApH).

The specimens of the Figs. 2–4 are from Profitis Ilias (35°37’20’’N - 27°08’09’’E 500 m), the specimen of the Fig. 5 is from Profitis Ilias (35°37’20’’N - 27°08’09’’E 500 m) (Fig. 2), and the specimen of the Fig. 6 is from Kali Limni (35°35’42’’N - 27°07’25’’E 1100 m).

RESULTS

Assyriella rechingeri (Fuchs et Käufel, 1936)

1936. *Levantina* (*Codringtonia*) *rechingeri* Fuchs & Käufel, Arch. Naturgesch., (NF) 5 (4): 658, Abb. XI, F. 35 A–C, locus typicus: Insel Karpathos: Gipfelstock des Kalolimni, 800–1000 m. Holotypus: NMW 535 (lost).

1939. *Codringtonia* (*Isaurica*) *rechingeri*, - K. L. Pfeiffer & Wächtler, Arch. Molluskenkunde, 71 (2/3): 57, Abb. 10c (as *Isaurica rechingeri*).

1987. *Codringtonia intusplicata rechingeri*, - Zilch, Arch. Molluskenkunde, 117 (1986) (4/6): 245.

1994. *Assyriella rechingeri*, - Glaubrecht, Verh. naturwiss. Ver. Hamburg, (NF) 34: 373, F. 1 (Karte), F. 2 (shell).

Shell dirty white with yellowish hue, with five brown colour bands, often interrupted by white zigzag lines, but blurrier than in *L. spiriplana*. Smooth, white aperture with a short and distinct callus at the columellar base, peristome well reflected, sharp, with margins connected by a thin parietal layer, umbilicus narrow and deep, partly covered by the reflected columellar margin. The size is 15.5–21 x 31–38 mm. Named in honour of the Austrian botanist and phytogeografer Karl Heinz Rechingher (Wien 16 October 1906 - Wien 30 December 1998).

Based on a single heavily corroded specimen collected in 1935 by Rechinger on the Kali Limni massif, the species was initially described as *Levantina* (*Codringtonia*) *rechingeri* Fuchs et Käufel, 1936, type locality “*Karpathos, Kalolimni mountain peak region, 800–1000 m*” (Fuchs & Käufel, 1936). The holotype is deposited in the Naturhistorisches Museum of Wien MNW 535 (lost, Schütt & Subai 1996). Subsequently, Pfeiffer found other specimens (Pfeiffer & Wächtler, 1939) and based on the shell morphology and on biogeographical reasons, suggested to assign the taxon to *Isaurica* Kobelt, 1901 rather than to the Greek *Codringtonia* Kobelt, 1898. Later, Glaubrecht (1994) assigned *rechingeri* from Karpathos to the *Assyriella* genus, as already supposed by Subai (1994), highlighting the differences with *Isaurica*. The latter differs from *rechingeri* by several features such as the larger and spherical shell, the diameter-to-callus length ratio, and the umbilical region always com-

pletely covered. Instead, *rechingeri* shows a reinforced, everted aperture lip and the umbilicus almost entirely open. Furthermore, all *rechingeri* shells show a tooth-like protuberance on the lower lip that is less pronounced in the *Isaurica* forms (Glaubrecht, 1994). This tooth like projection and broadly everted aperture lip, as in *rechingeri,* are features only for the genus *Assyriella,* especially for its type species *A. guttata* and for *A. bellardii.* In addition, both the latter two species have a conspicuous, at most half-covered, umbilicus. It is worth noting that *Assyriella* like *Levantina* and the northern African *Gyrostomella* includes snails displaying either a wide-open umbilicus or an almost covered umbilical region. In *Assyriella* as in *Levantina* the discrepancy between umbilicate and non-umbilicate forms is still regarded relevant enough to justify different species assignments (Glaubrecht, 1994; Ketmaier & Glaubrecht, 2015).

Assyriella rechingeri is considered CR, Critically Endangered, in the EU Red List. The AnimalBase database www.animalbase.uni-goettingen.de report: "*Rare, usually only subfossil shells are found. It is not known if live animals are still present somewhere, and if yes, by which factors they are threatened. Glaubrecht 1994 suspected that the species was extinct*".

DISCUSSION

The specimens from Kali Limni are significantly smaller than those of Profitis Ilias (Figs. 2–6). The specimens have been found at different

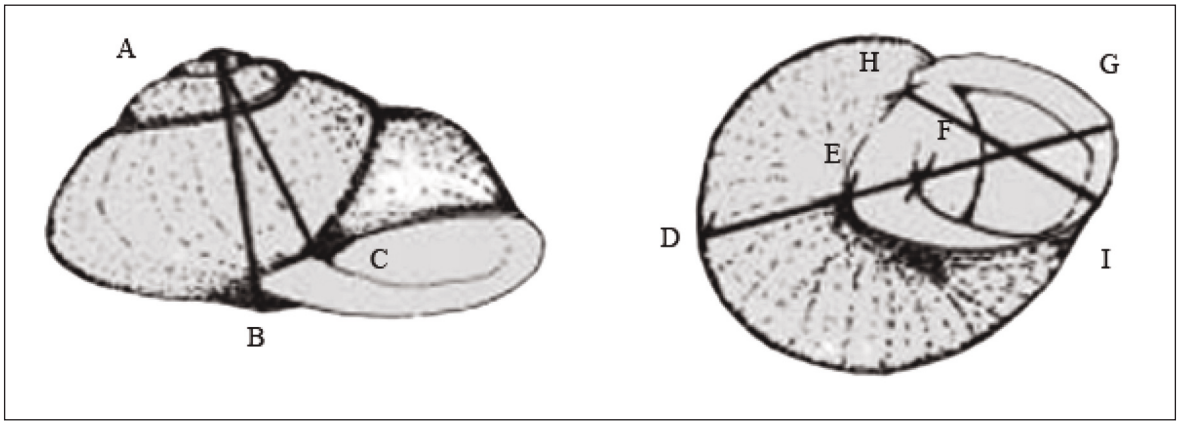

Figure 1. Measurements of shell variables (modified by Akbayin et al., 2001).

Shell variable (mm)	A	B	C	D	E
Shell diameter (ShD)	30.5	28.0	31.0	36.0	37.5
Shell Height (ShH)	13.0	13.0	14.5	17.0	18.0
Aperture Height (ApH)	16.0	14.0	15.5	19.0	19.5
Aperture Width (ApW)	16.5	17.0	18.0	21.0	21.5
Spire Height (SpH)	12.0	13.0	13.5	16.0	16.5
Truncation Width (TrW)	2.0	2.5	2.5	3.0	4.0

Table 1. Measured variables of five specimens of *Assyriella rechingeri* (see text).

Figures 2–6. *Assyriella rechingeri* from Karpatos island. Figs. 2–4: Profitis Ilias.
Fig. 5: Profitis Ilias. Fig. 6: Kali Limni.

altitudes (from 500 to 1100 m a.s.l.) in several sites all included in the Kali Limni massif: Mt. Kali Limni, Mt. Kollas and Mt. Profitis Ilias, Also the specimens collected by Pfeiffer (1937) and by Glaubrecht (1989), come all from Mt. Kali Limni and from the mountainous reliefs in the nearby as Mt. Melloura (south-east of Lastos), Mt. Kollas and Mt. Volada (Glaubrecht, 1994). We confirm as stated by Glaubrecht (1994), that it seems to be no evidence of the presence of the species in other parts of the island. *Assyriella rechingeri* lives in sympatry in Karpathos with *L. spiriplana* (Olivier, 1801) and *L. malziana*, which show a parapatric distribution. Both the latter species are abundantly present throughout the island with the exception for the Kali Limni from 500 to maximum height. Our discovery of some specimens of *A. rechingeri* together with *L. spiriplana* on Mt. Kollas at an altitude of 500 m would suggest an overlap between the distribution range of both species. However, from 500 m up to the summit of Mt. Kali Limni, the area is occupied only by *A. rechingeri*. Previous competition with *Levantina* genus may have caused the limited distribution of *A. rechingeri* in the Kali Limni massif (Glaubrecht, 1994). Competition between these related species, with a probably similar ecological niche, would have involved a specialization of *A. rechingeri* to occupy a niche characterized by specific climatic (higher altitude) and edaphic conditions. It is noteworthy that on Cyprus we have the same situation, as both the aforementioned species of *Levantina* occur in sympatry with *A. bellardii* Mousson, 1854 (Glaubrecht, 1994).

CONCLUSIONS

The summer period during which our research took place did not allow us to find live specimens of *A. rechingeri*. However, numerous specimens were found in excellent condition and therefore recently died. In addition, some specimens were also

Figure 7. Entrance of the burrow of *Rattus rattus* predator of molluscs (Karpatos island).

Figure 8. Limestone quarries and roads on the eastern slope of the Mt. Kollas (Karpatos island).

encountered at the entrance of the numerous burrows of *Rattus rattus* (Linnaeus, 1758) predators of molluscs in arid environments (Fig. 7). Glaubrecht (1994) hypothesized that *A. rechingeri* may be extinct, fortunately, we can claim that this species is not extinct even if its presence is rare with a very localized distribution. It could be a relic species and deserves to be overlooked like many other species of land snails, animals and rare and endemic plants that occur in Karpathos and in particular on the Kali Limni massif. In the last year (pers. obs.) limestone quarries and roads have been built on the eastern flank of the Mt. Kollas (Fig. 8). The tourism sector is increasingly developing in Karpathos and this involves the extraction of large quantities of limestone for the construction of new buildings and hotels. This represents a serious damage for the environment since peculiar habitats for the fauna and for endemic plants have already been eradicated.

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