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LETTER:

NEW LOCALITY OF *PROTEUS ANGUINUS* IN THE AREA OF THE TABOR RIDGE NEAR GROSUPLJE, CENTRAL SLOVENIA

NOVO NAJDIŠČE ČLOVEŠKE RIBICE NA OBMOČJU TABORSKEGA HRBTA PRI GROSUPLJEM, OSREDNJA SLOVENIJA

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1. INTRODUCTION

Proteus anguinus (proteus) is endemic to the groundwaters of the Dinaric Karst in SE Europe. Since its underground habitat is mostly inaccessible, its exact distribution is still unknown. Until the beginning of the 19th century, human contact and acquaintance with this troglobiont and its habitat was based exclusively on specimens washed up from its subterranean habitat during floods (Aljančič et al., 2016).

With advanced research technology, the opportunities to study proteus habitat and ecology have expanded. For example, it was only in 1986, when the unique black pigmented subspecies, *Proteus anguinus parkelj* (Sket & Arntzen, 1994) was discovered during a systematic survey of a spring exploitation (Aljančič et al., 1986). Furthermore, modern caving techniques allow exploration of greater depths and thus access to underground water courses (Koller Šarić & Kovac-Konrad, 2017). Researchers are also using other techniques, including traps and visual observation in the dark with night vision devices. More recently, forensic analysis of proteus eDNA (environmental DNA) traces released in water have been successfully used to detect proteus and reveal the extent of its range and hidden subsurface biodiversity hotspots (Gorički et al., 2017).

Although the proteus habitat area in the Slovenian Dinaric Karst is considered very well explored, it still happens to discover new localities. For example, it is still common that during floods in karst areas, the rising waters wash proteus to the surface, from where they cannot return to their natural habitat, so new localities are revealed (Aljančič et al., 2016). This is also the case with the finding of proteus in the area of the Tabor Ridge near Grosuplje in central Slovenia. Based on this the present contribution is devoted to the hydrogeological and hydrological presentation of the site. As this is a new locality where proteus has previously not been sighted or otherwise known, the significance of the finding is emphasized.

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2. LOCATION, HYDROGEOLOGICAL AND HYDROLOGICAL CHARACTERISTICS OF THE TABOR RIDGE AREA

In the wider surroundings of the town of Grosuplje, in the northwest of the Dolenjska region (Lower Carniola), individual localities of proteus are known in the area of Stična and Višnja Gora, Radensko Polje, Krka and Dobrepolje (Figure 1). Specifically, these are the Šica spring and the Zatočna Jama cave system in Radensko Polje, Krška Jama and Podpeška Jama, and some other caves in Dobrepolje (Sket, 1997). Furthermore, the proteus was first discovered 260 years ago in the Vir spring near Stična and almost 200 years ago in the Krka River springs (Aljančič, 2019). Whereas in the area southwest of Grosuplje and more especially in the area of the Tabor Ridge there were no reports of the proteus occurrence so far.

The Tabor Ridge extends in a NW-SE direction between the settlements of Št. Jurij, Ponova vas and Cerovo (Figure 2). The rocks forming the ridge are bent into the Tabor syncline. The eastern slope of the hill is made of Upper Triassic dolomite, while the crest and the western slope are built of Lower Jurassic limestone. To the southwest the ridge is bounded by Triassic dolomite, dolomitic marl, and shale. To the west, north and east, the ridge is surrounded by Holocene deposits of red and brown clay soil and sandy loam (Buser, 1974; Gospodarič, 1987).

There is no surface running water on the Tabor Ridge, as precipitation immediately percolates through cracks and channels in the rock. There are no water-active caves either (Cave Registry, 2023). A surface water network has developed in the surrounding non-karst

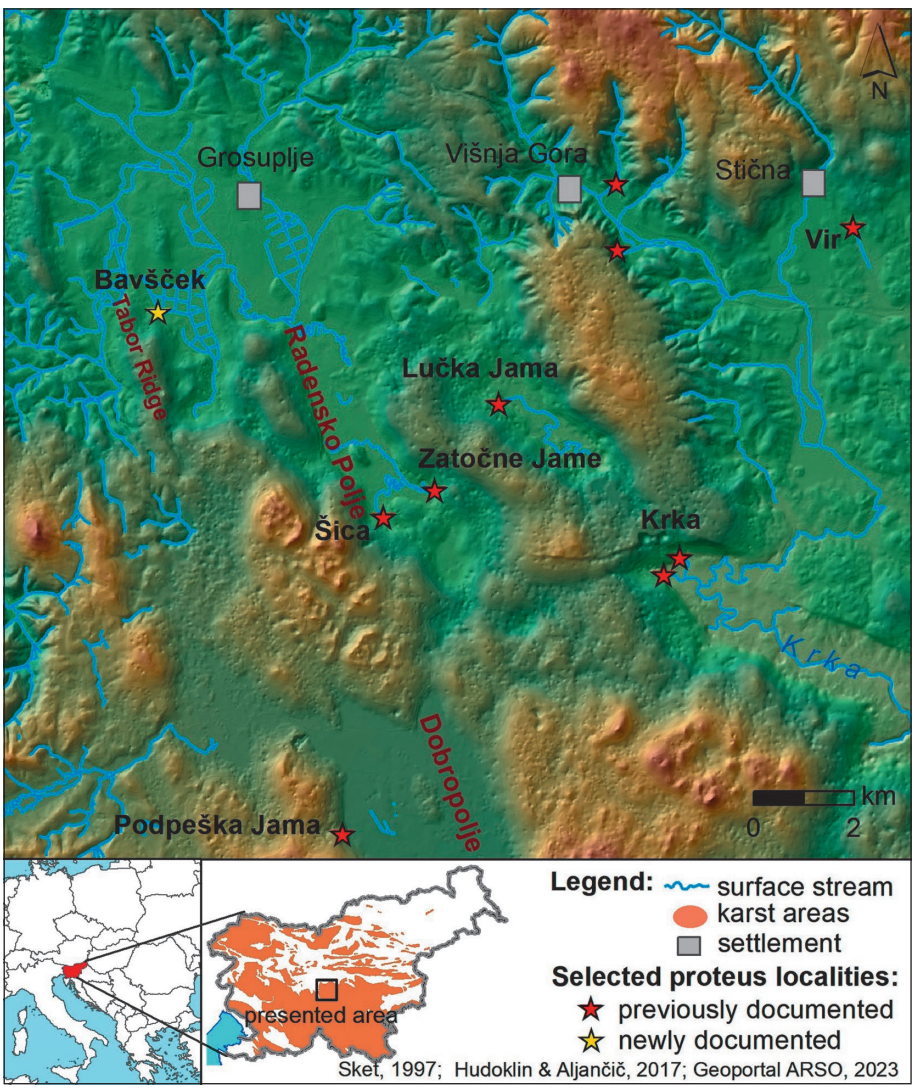

Figure 1: Location of the new and other selected Proteus anguinus localities in the northwestern Dolenjska region (Lower Carniola).

area. Surface waters sink near Škocjan, Rožnik, Male Lipljene, Medvedica villages and in the Krokarica riverbed (Meze, 1981). Karst springs occur on the eastern edge of the Tabor Ridge, where, in addition to water from the sinkholes, underground water also flows from the karst areas south of the Tabor Ridge. The largest of the springs is Podlomščica, which outflows at the southeasternmost area, followed to the north by the springs Mijavčev and Grudnov studenec, Izviri pri Trontlju, Bavšček and Bič.

Because few studies of water characteristics have been conducted in the area, and those that have been carried out have been done for short periods of time, the characteristics of underground water flow and connections are poorly known. From the available information, it appears that the springs under the Tabor Ridge differ significantly from each other, from which differences in the hydrological characteristics of the associated catchments can be deduced.

Podlomščica has the typical character of a karst spring. It springs in a pocket valley near the hamlet of Podlom, where two mills once stood. Along the right bank of the stream there are several smaller perma-

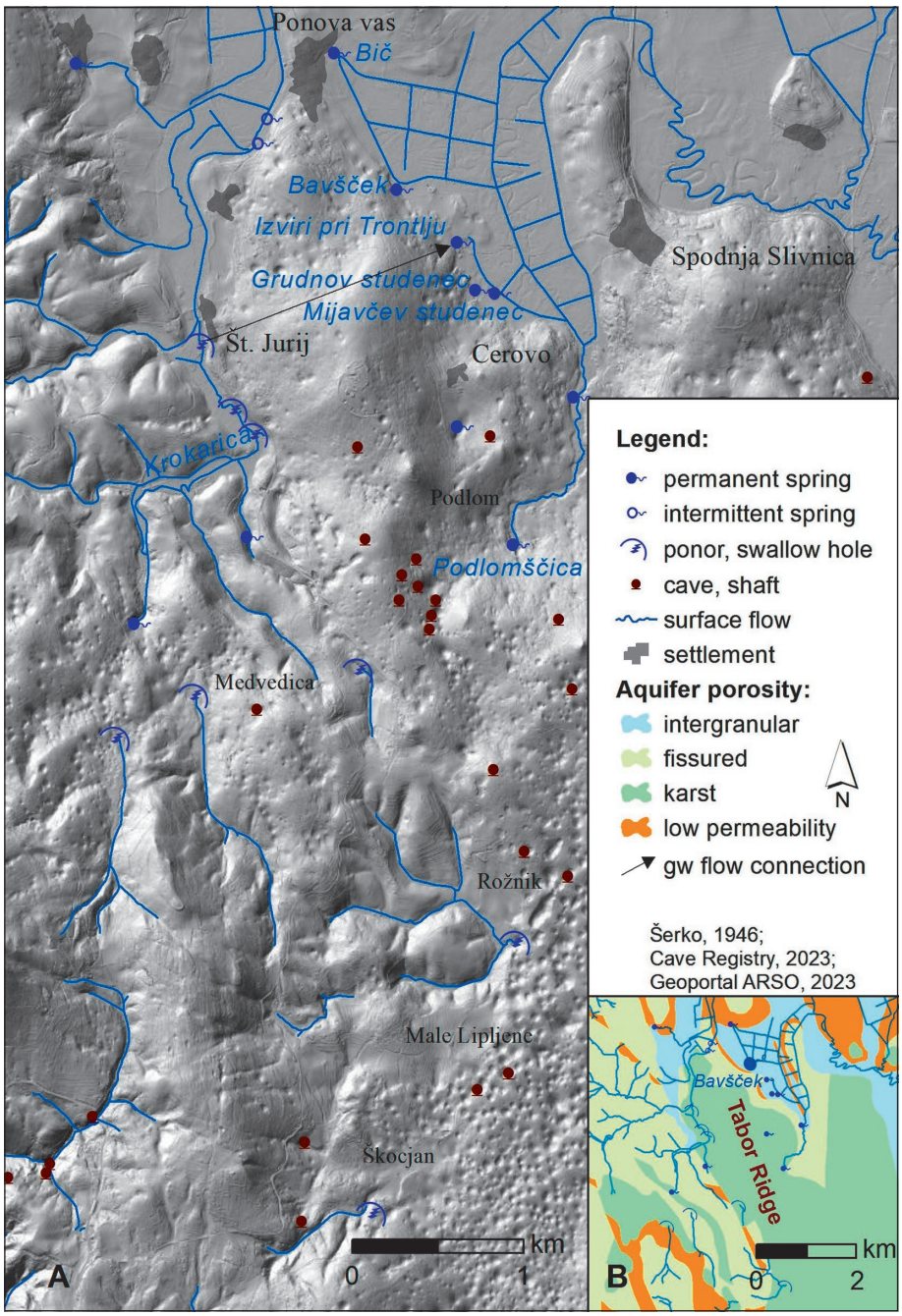

Figure 2: Hydrological (A) and hydrogeological (B) characteristics of the area.

nent and occasional springs. The water temperature is relatively stable (~10 °C). After heavy rains, the flow increases rapidly, and turbidity also increases. Based on manual measurements the electrical conductivity varies between 388 and 471 µS/cm. When the water level at the spring is low, only a few L/s barely noticeably flow to the surface; when the water level is high, discharges exceed 1.5 m^3/s. Then the water floods the road connecting the farm next to the spring with Spodnja Slivnica village (Gospodarič, 1987; Ravbar, 2006).

Grudnov and Mijavčev studenec are permanent springs near Cerovo, but at low water level they have very little water, which flows almost imperceptibly into the melioration channels. In Izviri pri Trontlju there are three permanent springs. The spring under the former house and the spring in the lake have very small discharges, while the spring slightly further north is the main water source. All three springs are artificially dammed. In the past they were used for the operation of a mill, then there was a fish farm, but now all these activities have been abandoned. Since the spring water flows into a reservoir, the discharges are difficult to measure, but the total flow is estimated to be more than 370 L/s at high waters. Compared to the neighbouring springs, the water temperature varies considerably (from 8.2 to 11.8 °C) and coincides with the temperature fluctuations of the Krokarica at the sinkhole by the school in Št. Jurij village. The electrical conductivity varies between 389 and 506 µS/cm, which bases on manual measurements (Gospodarič, 1987; Ravbar, 2006).

The Bavšček spring (Figure 3) outflows at the foothill of the Tabor Ridge below the houses of the upper part of the Ponova vas village. In the past, together with the Bič, it was an important source of water supply. Also the Bavšček has a pronounced karst hydrodynamic character, reacting to every precipitation event with short-term very high discharges, which occur shortly after heavy rainfall but also decrease very quickly. It is a permanent spring and reaches between a few L/s in low and more than 100 L/s in high water conditions. It has constant temperature around 10° C. The electrical conductivity varies between 480 and 613 µS/cm based on manual measurements. The Ca/Mg ratio indicates the influence of the dolomite in its catchment. Water quality analyses in the past have found elevated nitrates, chlorides, O-phosphates, and indicate organic water pollution due to unregulated sewage (Gospodarič, 1987; Ravbar, 2006). Bič used to be an abundant spring, but the amount of water has decreased due to melioration works, so it dries up in periods of drought.

So far, in the catchment area of the springs under the Tabor Ridge, a groundwater tracing was carried out in 1918, when ing. Pick injected 0.5 kg of uranine into the sinkhole in Št. Jurij and proved a connection with Izviri pri Trontlju (Figure 2). At a distance of 1.6 km and a gradient of 3.1‰, the apparent velocity of groundwater at mean water level was estimated to be 3.6 to 2.4 cm/s (Šerko, 1946).

Figure 3: The Bavšček spring at low waters (Photo: N. Ravbar).

3. FINDING AND ITS IMPORTANCE

After heavy rains during the night of June 6-7, 2023, kindergarten children found proteus in the Bavšček spring on June 8, brought to the surface by the rising water (Senica, 2023). The find was communicated to the managers of Županova Jama, who are very active locally in raising public awareness of the karst and its special features, and to the researchers of the Karst Research Institute ZRC SAZU. The specimen was then handed over to the Tular Cave Laboratory, which operates a recovery centre for injured proteus (Aljančič et al., 2017) on behalf of the Environmental Agency of the Republic of Slovenia.

As previously there were no known oral or written reports of the occurrence of proteus in any of the springs below the Tabor Ridge, the new locality is very important. Its location in the outermost northwest of the Dolenjska Karst marks the extreme boundary of the proteus habitat in the region in geographical and hydrogeological terms (Sket, 1997; Hudoklin & Aljančič, 2017). It is therefore not only particularly significant from a local perspective, but also regionally as it provides new insights into the knowledge of proteus distribution. The finding is also valuable because in an era of modern methods and techniques for determining biodiversity, and in which habitats are shrinking, we are still finding new localities in a natural way.

However, since Bavšček has slightly different hydrogeological characteristics than the other springs in the immediate vicinity, the question of how widespread the proteus habitat is in this area remains open. For this purpose, it would be useful to first determine the catchment areas of the individual springs. Furthermore, in the past, there have been indications of a threat to water quality from human activities, which need to be checked and, if necessary, the required measures introduced.

4. CONCLUSION

Proteus anguinus is an endemic species. It has been protected in Slovenia since 1951 and at the same time it belongs to the priority species according to the Habitats Directive, it is on the IUCN Red List of Threatened Species and it is one of the qualified species for Natura 2000. Since it is rare and endangered, we must do everything in our power to preserve it. Knowledge of its distribution and the size of individual populations is the basis for effective conservation measures to preserve proteus and its subterranean habitat. Therefore, discoveries such as the one described here are directly providing new proteus distribution information in Slovenia or in the Dinaric Karst range.

This contribution is the first documented discovery of proteus in the area of the Tabor Ridge near Grosuplje, or in the karst area southwest of Grosuplje. Moreover, the find represents the most northwestern locality of proteus in the Dolenjska region (Lower Carniola). Here the previously known hydrological characteristics of the spring, and the hydrogeological characteristics of the surrounding are described. Due to the importance of this find, further studies on the distribution of proteus throughout the Tabor Ridge and on the ecohydrological conditions of the subterranean habitat in this area are needed to contribute to a better understanding of the karst hydrogeology and ecology of proteus.

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