

## Observations on the olm *Proteus anguinus* population of the Vrelo Vruljak System (Eastern Herzegovina, Bosnia and Herzegovina)

### Opazovanja populacij močerila *Proteus anguinus* v sistemu izvira Vruljak (vzhodna Hercegovina, Bosna in Hercegovina)

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The Vruljak System is one of the most valuable and vulnerable *Proteus anguinus* habitats in the Trebišnjica River Basin (Bosnia and Herzegovina, Eastern Herzegovina). The amazing density of aquatic invertebrates results in a healthy population of olms. The easy logistics and the high density of animals make the Vruljak System a good location for trial experiments. The highest known location where the water enters the Vruljak System is the Ždrijelovići ponor zone of the Ljubomirsko Polje, from where the water flows down to the level of Popovo Polje and emerges again at the north-west end of Popovo Polje (sometimes

referred to as Trebinjsko Polje). Most of this water surfaces from temporary springs in the comparatively small closed depression of Vruljsko Polje during floods, forming an intermittent lake and then disappearing into numerous swallow-holes. The system then joins the Trebišnjica River in the Gorica district through two larger and several smaller spring caves (Lewarne et al. 2010). Most of the studies and ideas presented here are at an early stage and, therefore, the preliminary results are not enough for solid scientific conclusions.

The accessible lower end of the Vruljak System (Vruljak 1 Cave and Vruljak 2 Cave) is situated right under the edge of the city on the right side of the Trebišnjica River and has side passages that are most probably directly connected with the surface and are, therefore, vulnerable to anthropogenic influence (Fig. 1.). To prove such information, the traditional field method is dye testing, which gives precise data on the source locations and also provides some information on the nature of the connecting passages. Dye testing needs a lot of manpower, special conditions and perfect timing. In the case of a complex system, the results can be largely affected by the chosen water conditions and therefore can only be interpreted according to those water conditions. To gain long term information, we installed water temperature loggers (Tinytag Aquatic 2 by Omni Instruments) in various but well defined passages. A one-year long trial with a sampling frequency of



**Figure 1.** Positions of the Vruljak 1 Cave and Vruljak 2 Cave in Trebinje, Gorica District. The white arrows represent flow directions.

**Slika 1.** Položaj jam Vruljak 1 in Vruljak 2 v Trebinju, območje Gorica. Bele puščice prikazujejo smer toka.

one reading every 16 minutes showed that water temperatures differ in different branches (Lewarne 2016). The main passages showed a balanced curve, while the side passages reacted more promptly to surface weather conditions, indicating a direct connection to the surface. Based on the preliminary results, we plan to install more loggers to increase the resolution of the data. Although the temperature data cannot prove direct swallow-hole connections and cannot provide information on the exact location of the water origin, with precise cave and surface maps to support the hydrological data, we believe we will be able to assume more accurately the possible water and pollution sources affecting the water quality in the caves.

Over the last decade of monitoring the Vruljak 1 Cave, we have witnessed several occasions when trout (mostly brown trout *Salmo trutta*), entrapped in the cave, actively hunted for olms utilizing the help of diver lights (Fig. 2.). We have no information on how successfully they can hunt in complete darkness, but since the cave is regularly visited by divers we considered it as a serious threat. As an obvious solution, each year we eliminated the trout from the cave by hunting them with a speargun. In this way we could keep the number of trout inside the cave at a minimum level, but a permanent solution was needed since the artificially regulated surface water regime allowed new fish to enter the cave year by year. In 2015, we eliminated eight trout from the cave and examined their stomach contents, in which we found: *Troglocaris* sp. (n = 29), *Niphargus balcanicus* (n = 11), *Niphargus vjetrenicensis* (n = 2), *Metohia carinata* (n = 1), *Theodoxus subterrelictus* (n = 16), *Asellus aquaticus* (n = 3). The result of the stomach content analysis showed that direct predation is not the only threat, but by eating troglobionts, trout are also strong competitors of the natural top predators. The Vruljak 1 Cave is connected with the Trebišnjica River via an approximately 50 metre long surface stream that serves as a natural corridor for fish from the river to the cave during high water levels. In 2015, we constructed two dams from the stones found in the streambed. The dams are loose so they do not elevate the natural water level in the cave, but are relatively wide (0.5 metres) so they make a hard-to-pass barrier for big fish like adult trout. In 2016, we could not detect any newcomer trout in the cave, which means that the stone dams in such cases can be a good solution with minimal alteration of the natural environment,

although better conclusions can only be drawn after a longer monitoring period.



**Figure 2.** Trout grabbing the olm *Proteus anguinus* (photo: B. Lerner).

**Slika 2.** Postrv, ki drži močerila *Proteus anguinus* (foto: B. Lerner).

The common minnow *Phoxinus phoxinus* inhabits the cave entrances especially during dry periods, but can also be seen in deeper parts of the caves. During a monitoring dive in 2016 we witnessed an olm eating a common minnow (Fig. 3.). We did not witness the actual hunting and catching, but as the fish looked intact and fresh we can assume that it was actively caught while still alive. This observation shows that the surface dwelling common minnow or other small-sized fish can at least occasionally play an important role in the diet of olms (Lewarne & Balázs 2016).



**Figure 3.** The olm *Proteus anguinus* eating a Common minnow (photo: M. Mede).

**Slika 3.** Močeril *Proteus anguinus*, ki je pisanca (foto: M. Mede).

The Vruljak 2 Cave starts with approximately 15 metres of dry passage and the underwater part of the cave begins with a lake where abundant hypogean fauna can be found, including olms. This setup makes the cave a perfect location for an observatory. Our idea was to build a camera system capable of recording the behaviour of olms without disturbance. Therefore we installed an underwater infrared (IR) camera system in the lake in spots where olms are always present. An obvious technical problem with the usage of IR technology underwater is that the longer the wavelength of the light, the greater its adsorption by the water, therefore the IR spectrum fades away quickly. To overcome this problem we installed strong IR lights in waterproof casings together with the cameras. By 2016, the camera system was ready for testing and the test was successful. The final goal is to have the system permanently running and to connect it to the internet so researchers and even the wider public can have a view on the natural behaviour of the olms.

We started a mark and recapture study on the olm population of the Vruljak 1 Cave in 2010 using a Visible Implant Elastomer (VIE) tagging system (by NorthWest Marine Technology) (Balázs et al. 2015). We chose this tagging method because it does not require removing the animals from their original positions. Since we were highly concerned about the possible impact of the method on the health of the olms, we only tagged seven individuals for a five-year trial period. During these five years we observed the tagged individuals several times and did not detect any problems. Therefore, in 2015 we considered to continue the experiment by increasing the number of tagged animals. In May 2016 we tagged 19 additional adult olms (Fig. 4). In total, we now have 26 tagged individuals in a well-defined 200 metre long passage. We already have some recapture data suggesting high site fidelity, but even with this increased number of tagged individuals it will take some more years to gather enough data to draw firm conclusions.



**Figure 4.** Tagging with Visible Implant Elastomer (photo: B. Lerner).

**Slika 4.** Označevanje s tehniko Visible Implant Elastomer (foto: B. Lerner).

#### References

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