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THE DEEPEST FINDING OF AN OLM (PROTEUS ANGUINUS): ZAGORSKA PEĆ, OGULIN, CROATIA

NAJGLOBLJA NAJDBA MOČERILA (PROTEUS ANGUINUS): ZAGORSKA PEĆ, OGULIN, HRVAŠKA

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Abstract UDC 597.92:551.435.85(497.5)

Petra Kovač Konrad & Katarina Koller Šarić: The deepest finding of an olm (Proteus anguinus): Zagorska peć, Ogulin, Croatia

During the field work in Zagorska peć cave in Croatia, the olm, Proteus anguinus Laurenti, 1768 was observed in a siphon at depth of 113 m. This was not only the first time that this troglobiotic amphibian was recorded at such depths but also the first time that its research was done by cave-divers in its natural environment, at depths greater than 50 m. As such research is dangerous and difficult there was no previous data on the vertical distribution of the olm in the cave system. Further *in situ* research will provide valuable insight into species' environmental preferences and behaviour.

Key words: deep dive, cave system, subterranean environment, the olm, vertical distribution.

Izvleček UDK 597.92:551.435.85(497.5)

Petra Kovač Konrad & Katarina Koller Šarić: Najgloblja najdba močerila (Proteus anguinus): Zagorska peć, Ogulin, Hrvaška

Močerila, Proteus anguinus Laurenti, 1768, smo med terenskim delom našli v sifonu jame Zagorska peć (Hrvaška), na globini 113 m. Poleg izjemne globine najdbe želimo poudariti, da gre za prvi primer opazovanja te jamske dvoživke v naravnem okolju, ki so ga jamski potapljači izvedli globlje od 50 m. Ker so tovrstni potopi nevarni in težavni, podatkov o vertikalni razporeditvi močerila v jamskih sistemih doslej še ni bilo. Nadaljnje raziskave in situ lahko prispevajo k boljšemu poznavanju močerilovih prednostnih okolij in vedenja.

Ključne besede: globoki potop, jamski sistem, podzemlje, močeril, vertikalna razporeditev.

INTRODUCTION

Croatia has a surface area of 56.594 km^2, of which the karst terrain covers 26.000 km^2, or 46 % (Gottstein Matočec *et al.* 2002). There are more than 7.000 registered caves in Croatia (Garašić 1991). Their phreatic parts have been poorly studied, mostly due to the high cost and unavailability of diving equipment. Unsystematic cave-diving surveys started in 1959 (Malinar 2015; Kovač Konrad & Buzjak 2011). Since specific and dangerous survey methods are necessary for surveillance of aquatic subterranean fauna (i.e. stygofauna) *in situ*, its research has not been systematically conducted.

Alongside many invertebrate groups adapted to subterranean habitats, fish and salamanders are the only obligate subterranean (i.e. troglobiotic) vertebrates (Barr & Holsinger 1985). While approximately 300 troglobiotic fish species have been reported so far (Romero *et al.* 2009), only 13 salamander species of the genus *Eurycea* Rafinesque, 1822, are widely distributed in eastern and south-central North America, and the olm, Proteus anguinus Laurenti, 1768, inhabits the European Dinaric karst (Chippindale 2000; Wiens *et al.* 2003).The olm inhabits groundwaters of the Dinaric karst, from Italy, through Slovenia, Croatia, and Bosnia and Herzegovina. (Kletečki *et al.* 1996; Sket 1997). Prior to the discovery of the first cave fish in the Danube-Aach system (Behrmann-Godel *et al.* 2017), it was the only European troglobiotic vertebrate (Parzefall *et al.* 1993). Most of the data about the biology, ecology and behaviour of the olm

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originate from observations done in an artificial environment (Dumas & Chris 1998; Vuitron *et al.* 2011). Consequently, even basic information about the vertical distribution of the olm in subterranean caves is still lacking. While there is some research of vertical distribution of cave invertebrates that live at great depths (Sendra & Reboleira 2012), there are no data about the vertical distribution of vertebrates in the phreatic environment (Sendra & Reboleira 2012). In Slovenia, the olm was found in Divje jezero (Idrija) at a depth of approximately 50 m (Krivic *et al.* 1983). Here we present the first study investigating the vertical distribution of the olm in Zagorska peć Cave in Croatia and the deepest ever record of this cave-dwelling vertebrate.

GEOLOGICAL AND GEOGRAPHICAL SETTING

Zagorska peć Cave (N: 45.19700°; E: 15.21983°, 350 m a.s.l.) is situated in the western central part of the Dinaric karst of Croatia, in a part of the Ogulin Zagorje region, Karlovac County, 8 km south from the town of Ogulin (Fig. 1). The whole area is an example of typical karst hydrogeology characterized by permanent springs at the western margin of the area (Kovač Konrad 2011). Within area we can distinguish true hydrogeological barriers, relative barriers, zones of shallow water in fractures, and zones consisting of deep permeable rocks (Bahun 1970). Zagorska peć is one of six caves within the region (Jalžić 2008) where the olm was found. Other localities include: cave Klisura, Rupečica Spring, Rupečica Ponor, cave-spring Zagorska Mrežnica, and Bistrac Spring (Jalžić 2008). Being the deepest cave makes Zagorska peć the most appropriate site to observe the vertical distribution of the olm.

The first cave-diving explorations of Zagorska peć Cave were conducted in 1999 when B. Jalžić and D. Lukačić dove to 22 m and confirmed the presence of the olm (Dečak-Barišić *et al.* 2008). During later cave-diving explorations Zagorska peć Cave and Bistrac Spring were recognised as the only known sites where the olm was found deeper than 50 m (Jalžić 2008).

The cave map (Fig. 2) shows that Zagorska peć Cave passages are branched, reaching a total length of 490 m. Main passage has a North-South direction. The pattern of the cave system is characterised by numerous fissures and their mutual intersections. A siphon starts in a lake at a depth of 10 m (Fig. 3), and it continues to a depth of 121 m. In the cave, stable hydrological conditions dominate for relatively long periods, excluding periods of intensive snow-melts or extremely long rainy periods when the cave is partially flooded for several days per year (Bojanić & Ivčić 1981) and it becomes an active spring.

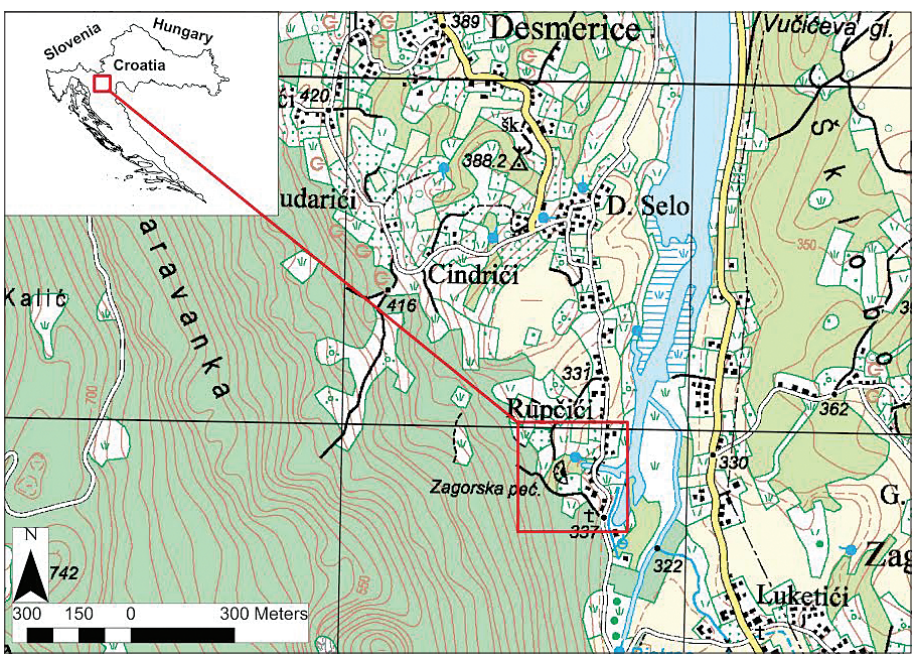

Fig. 1: Map of Croatia with the location of Zagorska peć Cave.

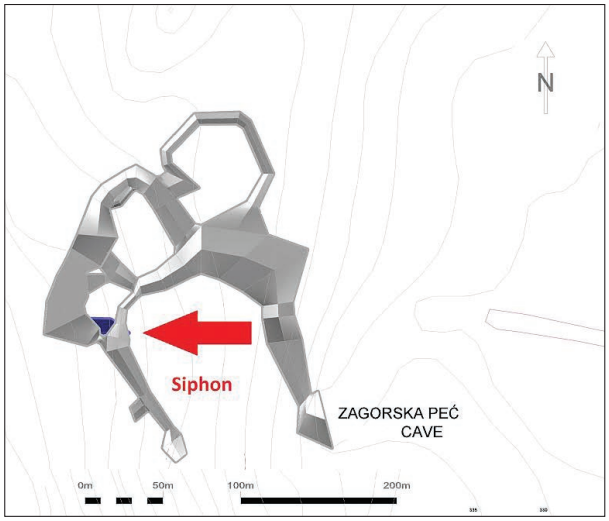

Fig. 2: Cave Map of Zagorska peć Cave, with location of the sampling site –siphon (archive of Caving section Željezničar).

Fig. 3: Lake with syphon (illuminated) in Zagorska peć Cave (Photo: M. Talaja).

METHODS

Field work in Zagorska peć Cave was conducted on 10. 12. 2016 and 31. 1. 2017 by Frederic Swierczynski, Petra Kovač Konrad and Peter Slokan. The research was carried out with the main purpose of collecting data for studies of vertical distribution of the olms. For the deep cave dives closed-circuit systems for diving (Innerspace Megalodon Model) and a mixture of helium, oxygen and nitrogen gases were used. The water temperature and depth were measured simultaneously with a diving computer (Suunto EON Steel). The depth of each olm was recorded on wet-note. Only olms detected at a 0.5-4 m distance from a safety line (2 mm polypropylene line positioned along the siphon which served as the transect line) were recorded. We recommend such consistent and standardised design of data collection for future dives in this and other caves.

RESULTS

Two successful cave dives deeper than 100 m (102 m, 121 m) were done in Zagorska peć Cave during the data collection. The water temperature during the dives was 8.8 °C. The morphology of the siphon does not change much from its start in the cave lake. It is on average 7×10 m wide, with a slight or no water current.

During each dive, 10 adult olms were found along the siphon safety line from 15 m down to a depth of 113 m (Tab. 1; Fig. 4). No individuals were noticed in the cave lake, however, neither on this nor on previous occasions. Cave crustaceans (Troglocaris sp., Niphargus sp., Monolistra sp.) were also present all the way down to the deepest parts of the siphon (121 m).

Tab. 1: Number of the olms, Proteus anguinus, and the depth at which they were recorded.

Date (total dive depth)	*Number of individuals*	*Depth (m)*
10. 12. 2016	2	15
(102 m)	1	21
	2	30
	1	40
	1	60
	2	70
	1	80
31. 1. 2017	2	40
(121m)	2	60
	2	80
	2	86
	1	98
	1	113

Fig. 4: Proteus anguinus at the depth of 113 m.

DISCUSSION

This is the first time that the olm, Proteus anguinus, was recorded at such a great depth and also the first time that its observations were done directly by cave divers in its natural environment, at depths greater than 50 m. So far, only two 100 m plus dives have been performed since such observations require long-term preparation and the dive itself is extremely difficult and dangerous. For deeper dives and possible discovery of the olm at greater depths, the continuation of the siphon should be explored first.

According to our observations, the depth and food sources (as the potential stress factors) have no substantial influence on the proteus' vertical distribution along the siphon of Zagorska peć Cave. Although caves are often held to be extremely energy-poor environments, this apparently doesn't apply to the aforementioned cave. In both dives olms were distributed approximately evenly along the safety line, in accordance with abundant invertebrates, their main source of food (Bizjak-Mali & Bulog 2004).

In both dives the olms were not recorded at the maximum dive depths. A possible reason could be the divers' complete focus on tying-off the safety line while reaching the maximum dive depth and the planned distance. Nevertheless, since the species was found at such a depth, we could conclude that the olm can withstand significant pressure. Biological structures and processes that allow this creature to dive so deep should also become subjects of future research.

Last but not least, factors like hydrological activity of certain parts of the cave system, its morphology, and sedimentation conditions, should also be considered in further exploration of the olm's vertical distribution.

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