

Karst groundwater biodiversity and habitats. Building in-situ virtual laboratories to assess the ecology of *Proteus anguinus* and its subterranean habitat throughout data platforms

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LifeWatch Slovenia (<https://lifewatch.zrc-sazu.si/>)

BACKGROUND

A better understanding of *Proteus anguinus* ecology, behaviour and the karst hydrogeology of its habitat are necessary for an effective conservation in karst landscape, linked to local anthropogenic pressure on the habitat. The karst landscape, once used mainly for grazing, underwent a fast transition to intensive agriculture, uncontrolled urbanization, development of industry and transport infrastructure, hydrotechnical works, mass tourism, etc. Because of their complex groundwater hydrogeology, karst landscapes, along with their natural resources and ecosystem services, are particularly vulnerable to these pressures.

HOW IT STARTED

Tular Cave Laboratory - a semi-natural and ex-situ facility was created in 1960 to observe the ecology and behavior of *Proteus anguinus*. Since 1989 several photos and IR video monitoring systems were developed and tested in the laboratory.

The map of Tular Cave Laboratory, Author Gregor Aljančič

Jamski laboratorij Tular

Biol. Marko Aljančič arranging pools in Tular Cave Laboratory, cca 1963, Photo from Tular Cave Laboratory collection

Early automated data collection on proteus' use space, using georeferenced static photos (Aljančič G. and Klemenčič G., 1989; Tular Cave Laboratory)

Analogue IR video of proteus reproduction in laboratory pools, (Tular Cave Laboratory, 1997-2007)

IR video monitoring of oviposition in Tular Cave Laboratory (Arecont Vision 5 megapixel camera, 4.5-13mm varifocal IR lens, 2009 - onward)

HOW IT'S GOING

Switching to the in-situ monitoring – research assessment and development of IR video monitor systems directly in the cave groundwater habitats and at karst springs.

Planina cave – hotspot of *Proteus anguinus* and subterranean biodiversity, Photo by Gregor Aljančič

Monitoring of *Proteus anguinus* habitat by challenging cave diving approach. Photos by Magdalena Aljančič

A. *Proteus anguinus anguinus* (white proteus) & B. *Proteus anguinus parkelj* (black proteus) Photos by Gregor Aljančič

Setting up the IR video monitoring system for the black proteus at the Ješevo spring, Bela krajina, Photo & video by Gregor Aljančič

Setting up camera traps at karst springs (Kaško lake, Pivka), Photo by Gregor Aljančič

WHAT WE PLAN

Given the vulnerable and difficult-to-access environment, karst scientists need new, non-invasive technologies to monitor and assess the current conservation status of subterranean species and their habitats. One of the most appropriate approaches for meeting this need is based on virtual laboratories (vLabs), currently most suitable platforms for integrating and linking AI and media technologies, life sciences, and research data. A Slovenian and Belgian multidisciplinary research team plans to set up two virtual laboratories dedicated to assessing the subterranean biodiversity and their karst habitat: i) **ProteusWatch vLab** and ii) **Karst Groundwater Habitats vLab**.

OPEN SCIENCE
REPRODUCIBLE RESEARCH

RI-SI-LifeWatch

BASIC INFO

Principal Investigator at ZRC SAZU: Tanja Pipan, PhD
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Collaborators: Alina Machidon, PhD, Magdalena Năpăruș-Aljančič, PhD, Jim Casaer, PhD, Gregor Aljančič, PhD

Partners: University of Ljubljana - Faculty of Natural Sciences and Mathematics (UM), Slovenian Forestry Institute (SIF), University of Ljubljana - Biogeography Faculty (ULB), etc.

The aim of the RI-SI-LifeWatch project (2019-2021) was to build a network for monitoring and collecting biodiversity and environmental data obtained and processed through the acquisition of high-performance research equipment.

ProteusWatch vLab is planned to be developed as an e-services access to infrared videos and images captured in the karst underground habitat of *Proteus anguinus*.

Setting IR camera trap in cave habitat of *Proteus anguinus* (foto by M. Biatnik)

I. Safe and Efficient Data Acquisition and Processing
The sensing process causing both energy-intensive and electromagnetic polluting. The environment raises additional concerns:
- Proteus is sensitive to the EM radiation
- Sensing in caves increases EM load

New technologies for both the sensing process and the computational part are needed to:

- develop new safe and highly efficient context-adaptive data acquisition methods
- implement Machine Learning and Deep Learning inference techniques

II. Agouti: A platform for processing and archiving camera-trap images:

- Online data management platform for camera trap studies (<https://www.agouti.eu>)
- Non-profit initiative of Wageningen University (the Netherlands) and Research Institute for Nature and Forest (INBO, Belgium)
- Provide a complete solution for organizations, students and professionals for camera trap data management. Community supported infrastructure and metadata standards (camtrapDP).

Karst Groundwater Habitats vLab is planned as an e-services that gives access to sensor data collected in the framework of the Slovenian LifeWatch project in order to explore and analyze these data. A user-friendly interface is planned to be built to interactively assess the karst groundwater quality and the possible pollution events that affect the cave and karst spring habitats.

Sampling of groundwater fauna, monitoring of ecological parameters in groundwater and images of subterranean animals (*Proteus anguinus*, *Leptodirus hocheworthii*, *Tritonectes celticus*, *Niphargus* sp.). Photos by Tanja Pipan, Slavko Poljak, Jurji Hajna, Magdalena Aljančič, and from the collections of Karst Research Institute ZRC SAZU