



**MINISTRY OF ENVIRONMENT AND SPATIAL PLANNING
ENVIRONMENTAL PROTECTION AGENCY OF KOSOVO
KOSOVO INSTITUTE FOR NATURE PROTECTION**

REPORT

**Preliminary research on the distribution of the invasive species
(*Procambarus clarkii*) in groundwater in Kosovo**



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Introduction

The Louisiana red crayfish (*Procambarus clarkii*) is an invasive alien species native to North America. It has spread widely in the inland waters of the Italian Peninsula since 1989, when it escaped from a farm in Piedmont, becoming one of the main threats to aquatic ecosystems.

The first report of this species in caves was published by Mazza et al. (2014) and refers to two caves in Portugal (present since 2007) and several cavities in the Monti Pisani in Tuscany (discovered in 2011). A few years later, a second case of groundwater colonization was documented in Grotta degli Ausi in the Lazio region, where dozens of specimens of this species were recorded inside the cavity (Di Russo et al., 2017). In collaboration with the Regional Directorate for Natural Capital, Parks and Protected Areas of the Lazio Region, an initial eradication attempt was made using the "removal method". Abundance estimates calculated with this method, and alternatively with the classic "mark and recapture" method, ranged between 40 and 60 individuals. Currently, a third case (the second in Lazio) affects the groundwater of the cave-resurgence Capo d'Acqua in the municipality of Amaseno.

The Louisiana red crayfish was introduced to Europe in the 1970s in Portugal and in the 1980s in Italy. Since then, it has colonized most freshwater surface water systems in both countries. In Portugal, it was first observed in the caves of the Sicó massif and the Estremenho massif. In Italy, it was found in the caves of Monti Pisani. The presence of *Procambarus clarkii* in caves is significant, representing a new threat to groundwater ecosystems due to potential negative impacts.

The international initiative for monitoring the invasive species *Procambarus clarkii* (*Louisiana red crayfish*) in the groundwater ecosystems of Kosovo was carried out within the framework of a project coordinated by the Italian organization Tetide APS and supported by the International Union of Speleology.¹

The main project partners have included research, speleological and limnological organizations from several countries in the region and the Mediterranean, such as:

Italy: University of L'Aquila, Department of Environmental Sciences, Department of Biology and Biotechnology, "La Sapienza" University of Rome.

Greece: Commission for Cave Protection under the Hellenic Federation of Speleology.

Israel: Israeli Center for Cave Research; Zooplankton Ecology Laboratory at the National Institute of Oceanography, Israel Oceanographic and Limnological Research (IOLR).

Croatia: Croatian Speleological Federation.

Kosova: Kosovo Institute for Nature Protection (KINP), represented at the national level by Mr. F. Bajraktari, who led and coordinated the monitoring activities in the territory of Kosovo.

¹ Tetide APS. "International project 'Monitoring the spread of the Louisiana red crayfish (*Procambarus clarkii*) in groundwater'." 5 maj 2025. <https://www.tetideaps.it/progetti>.

The main objective of the project was to research and assess the distribution of the invasive species ***Procambarus clarkii*** (*Louisiana red crayfish*) in karst and groundwater systems, with the aim of protecting native biodiversity and developing measures for the management and protection of sensitive habitats.

The project also aimed to promote the exchange of experiences and best practices, with the goal of continuously improving monitoring and control strategies. The project contributed to promoting the exploration, study and protection of caves and karst systems. This project not only aimed to contribute to the conservation of groundwater ecosystems, but also provided a unique opportunity for educational, technical and scientific cooperation among participating countries with biodiversity experts, biologists and scientific institutions.

Procambarus clarkii is considered one of the most problematic invasive species in Europe because it: competes with native freshwater crayfish species; damages aquatic habitats by burrowing into banks; transmits crayfish plague (*Aphanomyces astaci*), which is highly destructive to native European crayfish; and negatively impacts biodiversity, agriculture and water infrastructure.

Legal basis

This collaborative project is based on the Law on Nature Protection No. 03/L-233, Article 91, which prohibits the introduction of alien wild species into nature in the territory of the Republic of Kosovo and into ecosystems in which they do not naturally occur, and Article 92 on unintentional introduction: If alien species are unintentionally introduced into the territory of the Republic of Kosovo, or if there is a reasonable suspicion that such introduction will occur, the Minister shall prescribe by ordinance the action measures for the purpose of eradication or prevention of further spread of the introduced alien species.²

Within the framework of the European legal basis, Regulation (EU) on Invasive Species No. 1143/2014 constitutes the main act that defines measures for the prevention and management of the introduction and spread of invasive alien species in the territory of the European Union.³ These documents aim to protect the biodiversity, ecosystems and economy of the European Union from the negative impacts of these species through an approach based on prevention, early detection, eradication and long-term management.⁴

² Law on Nature Protection No. 03/L-233.

³ European Parliament and Council of the European Union. (2014). Regulation (EU) No 1143/2014 of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species. Official Journal of the European Union, L317, 35–55

⁴ European Commission. (2016). Commission Implementing Regulation (EU) 2016/1141 adopting a list of invasive alien species of Union concern. Official Journal of the European Union, L189, 4–8.

In the list of species of concern for the European Union, adopted by Implementing Regulation (EU) 2016/1141, *Procambarus clarkii* is also included, which means that the restrictions and obligations provided for in the relevant European legislation apply to this species.⁵

According to this legislation, Member States must implement measures to restrict the import, keeping, breeding, transport, trade, and intentional release of the species included in the list. It also requires the establishment of surveillance systems, early detection, and rapid eradication of new populations, while, in cases where eradication is no longer possible, measures are provided for the control and containment of the species and the restoration of affected ecosystems.⁶

Methodology

The methodology of this research included standardized scientific monitoring, selection of research areas based on hydrological and geomorphological characteristics, sampling frequency and duration, the use of selective traps to protect native species, as well as the assessment of the biological and chemical parameters of this invasive species.

The training and presentation of the research methodology were initially held in Rome, Italy, in July 2025, with the participation of Ms. Andonita Bućinca, PhD candidate at the University of Prishtina and former specialist for water monitoring at the Environmental Protection Agency of Kosovo; Ms. Egzona Koca, fauna officer at the Kosovo Institute for Nature Protection; and Ms. Nexhmije Kambari, biodiversity officer (flora) at the Kosovo Institute for Nature Protection.

During this period, they engaged in fieldwork with professors from the University of Rome, and consultations were also conducted with experts in the field of caves, who provided professional knowledge and specialized assessments regarding the presence and impact of invasive species.

Following the completion of the visit to Rome, a team was formed for the research activities in Kosovo; the team also included Ms. Diellza Lajci, an official from the Kosovo Hydrometeorological Institute.

The research activities began on 10 September 2025, starting with monitoring at Flladi Cave, in Panorc, Malisheva – a protected natural monument of speleological significance with the presence of groundwater; they then continued at Radac Cave and subsequently in the area above Perlepnice Lake.

⁵ European Commission. 2016. Commission Implementing Regulation (EU) 2016/1141 adopting a list of invasive alien species of Union concern. Official Journal of the European Union, L 189, 4–8.

⁶ European Parliament and Council of the European Union. 2014. Regulation (EU) No 1143/2014 of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species. Official Journal of the European Union, L 317, 35–55.

Work Tools

The following equipment was used during the fieldwork:

- Nets (fish nets) for capturing crayfish and conducting surveys in shallow waters, including caves, in a conical or cylindrical shape, closed at one end, allowing crayfish to enter but preventing them from escaping. The net material was durable nylon resistant to water and abrasion, strong and water-resistant, usually with large mesh openings to allow water flow and prevent injury to the invasive crayfish.
- The nets were attached to a rope fixed to a 30 cm nail and lowered in such a way that they were partially submerged, allowing the survival of any non-target species captured (amphibians, microfauna, crustaceans, and others present at the monitoring sites).
- Hand nets for surveying the biodiversity present in the water.
- Gloves (to prevent injuries from crayfish claws).
- Plastic containers with lids for sample collection.
- Bait for placement in the nets (chestnuts).
- Bandages for wrapping the bait-trap.
- 96% alcohol.
- Recording equipment: field notebook and sample labels for coding and documentation.
- Measuring equipment for chemical analyses of water (pH, temperature, oxygen, conductivity), a thermometer, and a simple pH meter.
- GPS for recording locations.
- Personal equipment for fieldwork: long waterproof boots, waterproof clothing, cave jacket, gloves, and protective equipment (protective helmet with light).

The traps used to capture the *Louisiana red crayfish* were designed to minimize the capture of other species. The mesh size was adapted to allow smaller species to pass through and to reduce the impact on native fauna. Captured non-target species were immediately identified and released into their natural habitats without causing harm. This approach ensured that the monitoring activities were conducted in accordance with the principles of biodiversity protection.

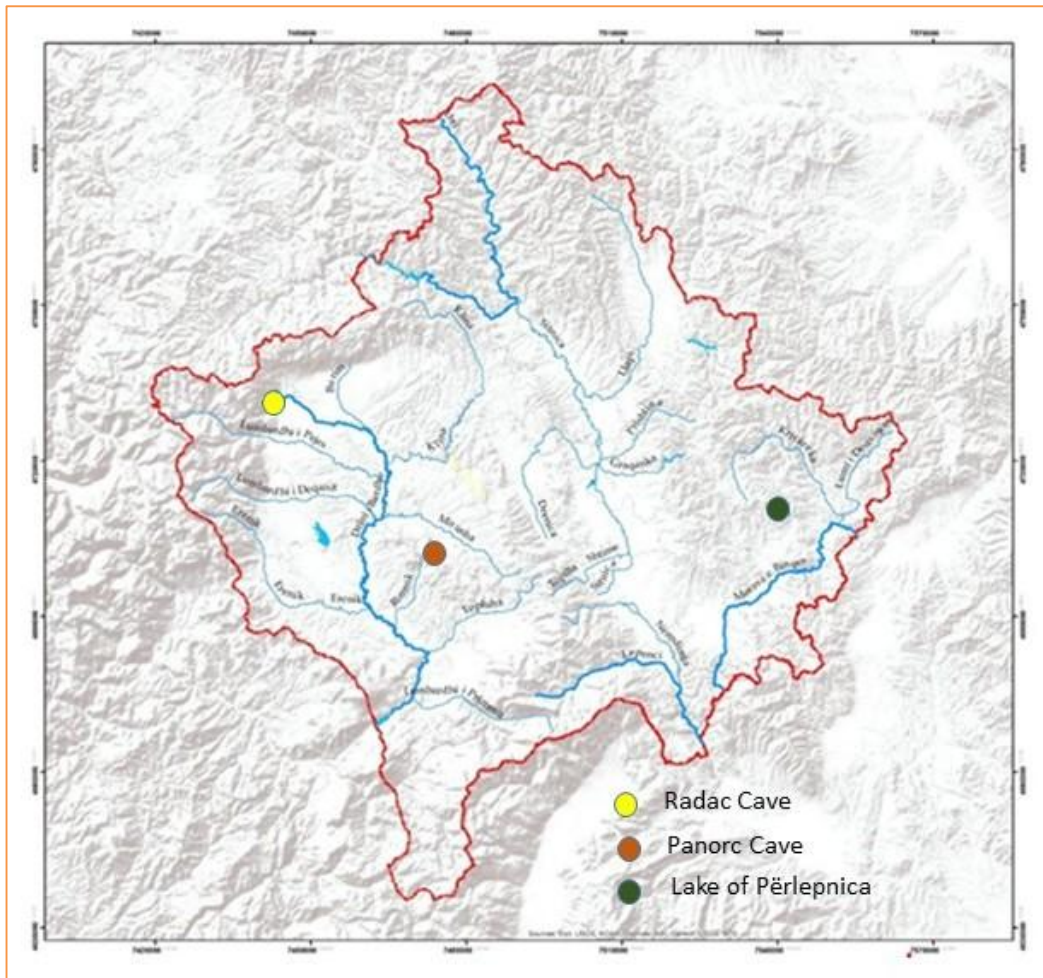
Data analysis

To simplify the processing of the results, a table was prepared. The data collected and archived in an MS Excel file will be subjected to analysis of variance (SAS, 2010). Differences between the means will be tested using the DUNCAN test (SAS, 2010). Further analyses will be conducted to determine whether there are differences in size and pigmentation between the species found in the cave and those found on the surface.

The entire proposed methodology and work tools are in accordance with the Statutes, Internal Regulations, and Code of Ethics of the International Union of Speleology (UIS), and we declare our commitment to the proper reporting and dissemination of the results.

Description of the preliminary researched areas in Kosova

Prior to the placement of the traps, preliminary assessments of the sampling sites were conducted to identify the presence of native species and organisms adapted to living in underground waters, such as caves. These species are generally restricted to underground environments and often have specific adaptations, such as the absence of pigmentation and eyes. The areas where preliminary field research was conducted are presented below, as a result of a careful scientific research process.



Map 1. *Map of the Preliminary Study Area*

Panorc Cave

The research activity for monitoring this invasive species in Kosovo began at the “Flladi Cave” in Panorc, a protected natural monument of speleological significance (Natural Monument – IUCN Category III), protected by law in 2014. Panorc Cave is located in the southern part of the village of Panorc, in the Municipality of Malisheva, specifically on the northern slopes of Mount Okovan (977 m). The cave entrance has a northern exposure and is located at an elevation of approximately 580 m above sea level. The cave has developed in Upper Cretaceous rudist limestone and is predisposed by lithological and tectonic elements. Several meters below the cave entrance, there are two water springs which, most likely, are hydrologically connected to the cave. The cave has a permanent water flow with significant fluctuations in water discharge. The explored part of the cave is characterized by karst cavities (voids) of considerable dimensions, but not by a particularly rich abundance of speleological formations. Significant deposits of gravel with heterogeneous lithological composition can be observed on the channel floor.⁷

Radac Cave (Sleeping Beauty)

Radac Cave is located near the village of Radac, close to the source of the White Drin River, approximately 11 km northwest of Peja. It is a karst cave formed through the erosive and chemical action of groundwater on limestone rocks. The length of the explored passages reaches approximately 1,420 m, while the cave is characterized by a rich abundance of stalactites, stalagmites, columns, and particularly calcite pools, which are considered its most characteristic feature. Bat colonies of ecological importance have also been recorded in the cave.^{8,9} The cave represents an important habitat for underground fauna and bats. The Red Book of Fauna of the Republic of Kosovo emphasizes that some organisms associated with this habitat have a very limited distribution and are sensitive to changes in the cave’s microclimate. For this reason, continuous protection measures and monitoring of tourism activities are recommended.¹⁰

The cave is one of the most well-known speleological attractions in Kosovo and is also known as the “Sleeping Beauty.” Its location near the source of the White Drin River makes it an important destination for nature tourism and environmental education.

⁷ Environmental Protection Agency of Kosovo (KEPA). Natural Heritage Values of Kosovo. Prishtina, 2005.

⁸ Environmental Protection Agency of Kosovo (KEPA). *Report on the State of Nature*. Prishtina, 2010.

⁹ Environmental Protection Agency of Kosovo (KEPA). *Profile of Protected Areas*..

¹⁰ Environmental Protection Agency of Kosovo (KEPA). *Red Book of Fauna of the Republic of Kosovo*. Prishtina, 2018.

Above Perlepnice Lake

Perlepnice Lake is an artificial reservoir constructed in 1966 on the Perlepnice River for drinking water supply and irrigation. It is located in the eastern part of Kosovo, within the territory of the Municipality of Gjilan, and represents one of the most important water reservoirs in the region. The lake's catchment area covers 70.8 km², while the stored water volume reaches approximately 4.2 million m³, with an average flow rate of 0.55 m³/s. In addition to its hydrotechnical function, the lake is also important for recreation, fishing, and biodiversity. The catchment area is characterized by hilly-mountainous terrain and is fed by several mountain streams, including the Osoj Stream.¹¹

Osoj Stream

Osoj Stream is one of the small mountain tributaries that flow into the catchment area of Perlepnice Lake. It originates in the forested areas of Gollak and plays an important role in supplying the lake with water, transporting sediments, and maintaining aquatic ecosystems. The stream and the surrounding habitats represent important components of local biodiversity, with natural vegetation and fauna characteristic of the mountainous ecosystems of Kosovo. The area surrounding Perlepnice Lake and Osoj Stream is characterized by oak and beech forests; mediterranean and continental shrublands; important habitats for birds, mammals, and amphibians; ecological corridors along watercourses.¹²

Impact of the invasive species *Procambarus clarkii* on groundwater

This species is known for its ability to adapt and spread in different aquatic environments, threatening local biodiversity and natural ecosystems, including through damage to natural habitats, competition with local species, and changes in the structure of biological communities. Its spread into groundwater presents a new challenge, as these environments are difficult to monitor and may serve as pathways for the faster spread of invasive species.

This species has environmental tolerance, aggressive behavior, and rapid reproduction, making it capable of colonizing and dominating environments with specific conditions.

It is mainly found in small water sources within caves, where water temperature remains stable and cold throughout the year. These conditions are well suited to the species' adaptation, as it can survive even under low oxygen levels.

¹¹ Environmental Protection Agency of Kosovo (KEPA). *Professional Justification for the Declaration of the "Guri i Hoxhës with the River Gorge and Perlepnice Lake" Area as a Protected Natural Area*. Prishtina, 2026.

¹² Environmental Protection Agency of Kosovo (KEPA). *Professional Justification for the Declaration of the "Guri i Hoxhës with the River Gorge and Perlepnice Lake" Area as a Protected Natural Area*. Prishtina, 2026.

Procambarus clarkii is mainly omnivorous, feeding on organic materials, including plants in caves, algae, aquatic insects, and organic debris.

Despite the limited conditions within caves, this species is able to reproduce successfully, taking advantage of more favorable seasons. Females carry the eggs on their abdomen for an extended period until they develop into larvae. This invasive species can negatively affect natural communities by competing for resources with local cave species and altering the structure of the ecosystem. The presence of this invasive species in Latium Cave in Italy is an interesting example of how a non-native species can adapt to and affect a particular natural habitat, highlighting the need for management and further studies on its ecological impact.

Morphological identification of the species

Procambarus clarkii belongs to the order *Decapoda* and the family *Cambaridae*. It is a freshwater crayfish species that can be identified based on several distinctive morphological characteristics.¹³

The body is cylindrical and covered by a hard carapace. In adult individuals, the cephalothorax is distinctly granular and bears numerous small tubercles, as well as characteristic spines. The rostrum is long, with straight and converging margins, and terminates in a triangular tip. The chelae are relatively long and narrow, with characteristic tubercles, including prominent bright-red tubercles on the palm and fingers. The dorsal surface of the carapace has a narrow to nearly obliterated areola.¹⁴ Adult individuals are generally dark red, sometimes with brownish shades, and may have a characteristic dark or black wedge-shaped stripe on the abdomen. Juveniles are generally grey and may have dark wavy lines, and therefore their identification based solely on coloration can be more difficult.¹⁵ The species has two pairs of antennae, including long antennae that serve important sensory functions. The eyes are located on movable stalks, as is typical of crayfish. The standard identification characteristics described in the available taxonomic sources focus instead on the rostrum, carapace, areola, chelae, coloration, and other appendages.¹⁶

Adults generally range from approximately 5.5 to 12 cm in total length. Sexual identification can also be based on morphological characteristics. In sexually mature males, characteristic hooks are

¹³ **FAO (2009).** *Procambarus clarkii* (Girard, 1852) – *Cultured Aquatic Species Fact Sheet*. Food and Agriculture Organization of the United Nations.

¹⁴ **U.S. Geological Survey (USGS) (2026).** *Procambarus clarkii* (Girard, 1852): *Nonindigenous Aquatic Species Database*. Revision date: July 13, 2026.

¹⁵ **FAO (2009).** *Procambarus clarkii* (Girard, 1852) – *Cultured Aquatic Species Fact Sheet*. Food and Agriculture Organization of the United Nations.

¹⁶ **U.S. Geological Survey (USGS) (2026).** *Procambarus clarkii* (Girard, 1852): *Nonindigenous Aquatic Species Database*. Revision date: July 13, 2026.

present on the ischia of the third and fourth pairs of walking legs, while the structure of the first pleopods provides additional diagnostic characteristics for identifying mature males.¹⁷



Photo 1. Louisiana red Crayfish (*Procambarus clarkii*)

¹⁷ U.S. Geological Survey (USGS) (2026). *Procambarus clarkii* (Girard, 1852): Nonindigenous Aquatic Species Database. Revision date: July 13, 2026.

Results

During the monitoring period conducted at the three locations included in the study, namely **Panorc Cave**, **Radac Cave**, and the area above **Perlepnice Lake**, the presence of the Louisiana red crayfish was not recorded.

At all locations, the number of individuals captured per trap was 0, and the presence of the target species was therefore not confirmed in the collected samples.

At **Panorc Cave**, monitoring was conducted during September 2025 in an area with moderately easy access, with a municipal road and a habitat assessed as clean.

At **Radac Cave**, the activities were conducted during October 2025 under more difficult access conditions, in a spring area characterized as clean.

Meanwhile, in the area above **Perlepnice Lake**, monitoring was conducted in spring, specifically during May 2026, which revealed visible pollution in the field, but no presence of the invasive species was recorded.

The average temperatures recorded during the activities were 11.1°C at Panorc Cave, 8.1°C at Radac Cave, and 16.8°C above Perlepnice Lake. For all locations, there were no data on captured individuals or on morphological, morphometric, and biometric parameters due to the absence of biological samples of the target species (*table 1*).

Based on the data collected during the field research, it can be concluded that, at this stage of the research, the presence of this invasive species has not been confirmed at the monitored locations in Kosovo. However, since the research was limited to only a few sampling points, continued monitoring is necessary for a more comprehensive assessment of the potential distribution of the species and habitat conditions in underground and surface waters. For more details on the study parameters and the results obtained at each location, please refer to Tables 1 and 2, where the complete data on the biological analyses and monitoring conditions are presented.

The results of the biological analyses for all three locations are presented in Table 1.

Biological Parameters of Interest for the Study	Panorc Cave – Malisheva, September 2025	Radavc Cave, October 2025	Above Perlepnice Lake, May 2026
GPS coordinates	X= 46° 89' 22 Y= 47° 04' 060"	X= 42° 32' 20 Y= 21° 30' 55"	X= 42° 32' 20 Y= 21° 30' 55"
Elevation above sea level	581°	568°	323°
Site accessibility	moderately easy	difficult	difficult
Road type	municipal	municipal	public
Streambed width and distance between banks			
Distance from the nearest surface water body			
Time of trap placement	10:40	14:10	12:05
Time of trap collection	11:00	12:00	14:00
Number of traps used	1	1	1
Number of traps collected	0	0	0
Average, maximum, and minimum temperature	11.1	8.1	16.8
Total weight of captured individuals	0	0	0
Number of individuals captured per trap	0	0	0
Non-target species captured	0	0	0
Non-target species released	0	0	0
Any observations regarding the habitat	clean	source area - clean	visible presence of pollution
Presence or absence of visible <i>Procambarus clarkii</i> burrows	0	0	0
Total length of captured individuals	0	0	0
Weight of captured individuals	0	0	0
Morphological parameters	0	0	0
Morphometric parameters	0	0	0
Biometric parameters	0	0	0

The results of the chemical analyses conducted by the Kosovo Hydrometeorological Institute for all three locations are presented in Table 2.

Results of the chemical analyses					Panorc Cave – Malisheva, September 2025		Radavc Cave, October 2025	Above Perlepnicë Lake, May 2026
					Point 1	Point 2	Point 1	Point 1
	Unit of measurment	Testing method	IKMN	Results		Results	Results	
Physical parameters								
1	Time	h	0:00	-	10:40	11:05	14:10	12.:05
2	Weather	M	vrojtim	-				
3	Water temperature	TU	OC	DIN 38404-C4	11.1	12.1	8.1	16.8
4	Odour	Ar	nuhatje	-				
5	Turbidity	TUR	NTU	ISO 7027:1999	4.76	0.06	1.21	20.3
6	Electrical conductivity	?	?Scm-1	ISO 7027:1999	590	640	275	508
7	Total dissolved solids	MTT	mg/L	ISO 7027:1999	295	320	137.5	254
8	Hydrogen ion concentration	pH	0-14	ISO 10523:2008	7.3	7.3	7.9	8
9	Redox potential	ORP	mV	ISO 10523:2008	-56.3	-56.8	-68.4	-71.8
Chemical parameters								
10	Dissolved oxygen	O2	mg/L	ISO 5814:2012	6.54	6.45	6.6	7.93
11	O ₂ saturation	ng.O2	%	ISO 5814:2012	65	66.1	68.6	82
12	Total suspended solids	MTS	mg/L	EN 872	<2.5	<2.5	<2.5	<0.1
13	Chemical oxygen demand	SHKO	mg/L	EN 1899:2016	3	3.7	<1.0	2.5
14	Biochemical oxygen demand	SHBO5	mg/L	EN 1899-2:2016	1.6	1.8	<0.1	1.1
15	Total organic carbon	KTO	mg/L	APHA 5310	0.5	1	<0.1	0.7
16	Nitrates	NO3-	mg/L	ISO 7890-3:1988	8.9	9	2	0.8
17	Detergents	DET	mg/L	ISO 2870:2009	<0.5	<0.5	<0.5	<0.5
18	Phosphate ion	PO43-	mg/L	ISO 6878:2008	0.7	0.9	0.1	<0.09
19	Ammonium ion	NH4+	mg/L	ISO 7150-1:2020	0.09	0.09		0.11
20	Nitrite ion	NO2-	mg/L	ISO 6777:2023	0.09	0.07		0.07
21	Sulfate ion	SO42-	mg/L	APHA 4500-SO42- E	22	25	10	35
22	Chloride ions	Cl-	mg/L	ISO 9297:2008	12.78	14.2	9.301	11.05
23	Total hardness	FP	mg/L	ISO 6059:2016	17.75	19.21	7.5	14.17
24	M-alkalinity	Ma	mg/L	ISO 9963-1:1994	5,8	6.04	2.36	4.46
25	Calcium ions	Ca+	mg/L	ISO 6058:1984	81.3	96.9	51.3	36.1
26	Magnesium ions	Mg+	mg/L	ISO 6058:1984	27.7	24.5	1.5	9.2
27	Bicarbonate ions	HCO3-	mg/l	ISO 9963-1:1994	353.8	368.44	143.96	272.06
28	Potassium ions	Na+	mg/l	ISO 9964-3:1993	0.6	0.7	1.2	2.4
29	Sodium ions	K+	mg/l	ISO 9964-3:1993	5.5	6.1	3.6	8.2

Fieldwork images from the preliminary research conducted in Kosovo



Photos 2 & 3. *Panorc Cave,*

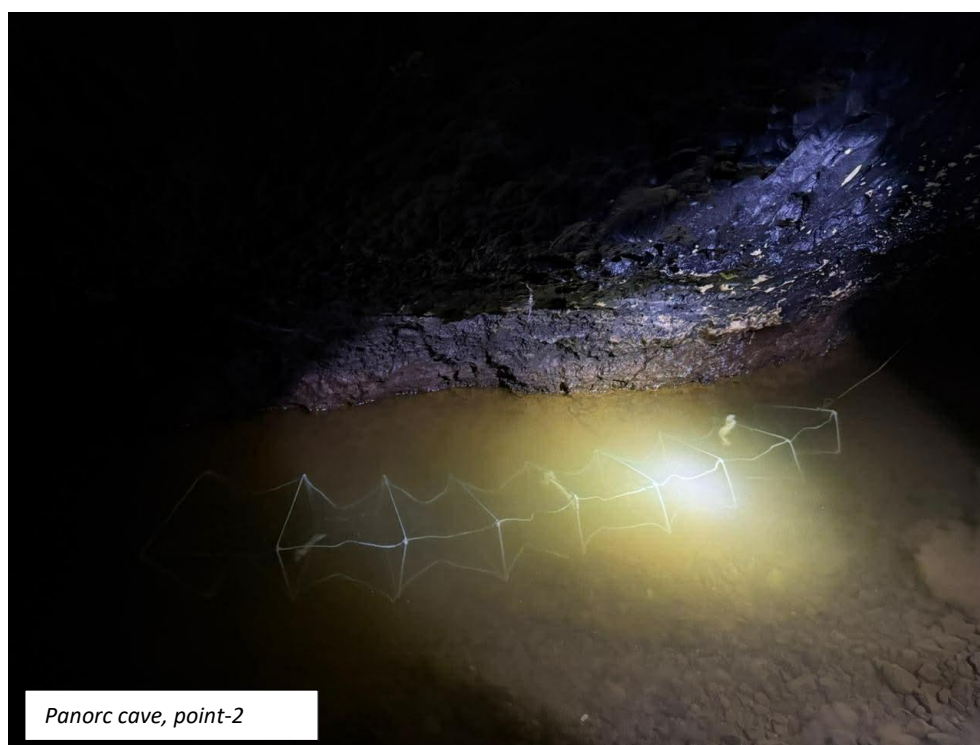


Photo 4. *Panorc Cave,*



Photo 5. Radac Cave (Sleeping Beauty),



Photo 5. Location above Perlepnice Lake

Proposed measures

Strengthen continuous monitoring of the spread of *Procambarus clarkii* in Kosovo and prioritize the identification of areas at high risk of further spread.

In the event that the presence of this species is recorded in Kosovo, active control measures should be implemented, including the systematic capture and physical removal of individuals, particularly in sensitive habitats and in areas where the species occurs at high densities. Barriers and preventive measures should be established to limit the spread of the species into new aquatic systems, including underground habitats and hydrological connection points. Awareness-raising and public communication measures should be used to address the ecological, agricultural, and infrastructural risks caused by this species, with particular emphasis on preventing its spread through trade and human activities.

Responsible Institutions

Ministry of Environment and Spatial Planning (MESP) represents the central authority responsible for the development of policies, strategies, and the legal framework in the field of environment, ensuring inter-institutional coordination and the implementation of national and international standards for the environment and nature.

Environmental Protection Agency (KEPA), specifically the **Kosovo Institute for Nature Protection**, acts as a supporting institution, engaging in monitoring the state of the nature, assessing impacts, and reporting relevant data, which serve as a basis for decision-making. It also plays a key role in reporting activities that may have negative impacts on biodiversity.

Public and private universities, through their research and academic institutes, make a significant contribution through the development of scientific studies, analyses, and research projects, providing professional expertise and innovative solutions for the sustainable management of natural resources.

Local authorities have direct responsibility for the practical implementation of policies, territorial management, and taking environmental measures, being closer to communities and specific local issues.

Civil society organizations play an important role in raising public awareness and undertaking local initiatives for the protection of the environment, nature, and biodiversity, contributing to the improvement of quality of life and sustainable development.

Recommendations

Given that the research covered only several areas, it is recommended that the scope of the study be expanded in the future to include other areas, in order to provide a more complete and realistic overview of the presence or absence of this invasive species in Kosovo.

Responsible institutions in Kosovo should adopt a structured approach at the level of preventing the introduction of new invasive species, early detection and rapid response to initial cases, as well as the control and containment of species that have already become established. This is in line with EU obligations and practices, under which Member States are required to address pathways of introduction, develop monitoring systems, and take measures for rapid response or management of widely spread species.

Cooperation with scientific and environmental institutions is recommended, with the aim of developing a comprehensive, sustainable, and effective approach to the management of invasive species.

Awareness-raising activities should be organized for the public and local authorities, highlighting the risks associated with the spread of invasive species and practical measures for their prevention, early detection, and control.

Cooperation with biodiversity experts, biologists, and scientific institutions should be strengthened to ensure that capture, monitoring, and management strategies are implemented with minimal impact on native species and without compromising the balance of the ecosystem.

Referencat

1. Bajraktari, Fadil. Hanxhari, Romeo. Çadraku, Hazir. *The speleological heritage of Kosovo*. Revista Studime Albanologjike, 2/2024, Universiteti i Tiranës. Fakulteti i Historisë dhe i Filologjisë. Tiranë, 2024. <https://doi.org/10.70827/zlvc8492>
2. Bajraktari, Fadil. *Historiku dhe analiza e hulumtimeve speleologjike në Kosovë (1960 - 2025)*. Revista Studime Albanologjike, 2/2025, Universiteti i Tiranës. Fakulteti i Historisë dhe i Filologjisë. Tiranë, 2026. <https://doi.org/10.70827/zlvc8492>
3. Bajraktari, Fadil. Behrami, Sami. Katallozi, Fatos. *Shpëllat e Kosovës*. ProGEO-Kosova. Prishtinë, 2010.
4. Tetide APS. "International project 'Monitoring the spread of the Louisiana red crayfish (*Procambarus clarkii*) in groundwater.'" Maj 2025.
5. Law on Nature Protection No. 03/L-233.
6. European Parliament and Council of the European Union. (2014). *Regulation (EU) No 1143/2014 of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species*. Official Journal of the European Union, L317, 35–55.
7. European Commission. (2016). *Commission Implementing Regulation (EU) 2016/1141 adopting a list of invasive alien species of Union concern*. Official Journal of the European Union, L189, 4–8.
8. European Commission. 2016. *Commission Implementing Regulation (EU) 2016/1141 adopting a list of invasive alien species of Union concern*. Official Journal of the European Union, L 189, 4–8.
9. European Parliament and Council of the European Union. 2014. *Regulation (EU) No 1143/2014 of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species*. Official Journal of the European Union, L 317, 35–55.
10. Environmental Protection Agency of Kosovo (KEPA). *Natural Heritage Values of Kosovo*. Prishtina, 2005.
11. Environmental Protection Agency of Kosovo (KEPA). *Report on the State of Nature*. Prishtina, 2010.
12. Environmental Protection Agency of Kosovo (KEPA). *Profile of Protected Areas*.
13. Environmental Protection Agency of Kosovo (KEPA). *Red Book of Fauna of the Republic of Kosovo*. Prishtina, 2018.
14. Environmental Protection Agency of Kosovo (KEPA). *Professional Justification for the Declaration of the "Guri i Hoxhës with the River Gorge and Perlepnice Lake" Area as a Protected Natural Area*. Prishtina, 2026.
15. Environmental Protection Agency of Kosovo (KEPA). *Professional Justification for the Declaration of the "Guri i Hoxhës with the River Gorge and Perlepnice Lake" Area as a Protected Natural Area*. Prishtina, 2026.
16. FAO (2009). *Procambarus clarkii* (Girard, 1852) – Cultured Aquatic Species Fact Sheet. Food and Agriculture Organization of the United Nations.

17. S. Geological Survey (USGS) (2026). *Procambarus clarkii* (Girard, 1852): *Nonindigenous Aquatic Species Database*. Revision date: July 13, 2026.
18. FAO (2009). *Procambarus clarkii* (Girard, 1852) – *Cultured Aquatic Species Fact Sheet*. Food and Agriculture Organization of the United Nations.
19. U.S. Geological Survey (USGS) (2026). *Procambarus clarkii* (Girard, 1852): *Nonindigenous Aquatic Species Database*. Revision date: July 13, 2026.
20. U.S. Geological Survey (USGS) (2026). *Procambarus clarkii* (Girard, 1852): *Nonindigenous Aquatic Species Database*. Revision date: July 13, 2026.