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Data on the distribution of a protected crayfish, *Austropotamobius torrentium*, in the Jiu Gorge National Park, Carpathian Mountains, Romania

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Abstract. Between 2018 and 2021, we identified four new locations for the distribution of the crayfish species *Austropotamobius torrentium* in Romania. All four populations were found in small streams with mountainous characteristics, on both sides of the Jiu River, in the Jiu Gorge National Park, Romania. Individuals were present at altitudes between 481 and 495 de m. Even though our search for the stone crayfish was extended to other suitable streams in the park, no other population was found there. Thus, the stone crayfish seems to be presently isolated in some small-sized tributaries from the upper part of Jiu River Gorge, following a similar distribution pattern as a fish species with the same environmental requirements. All these habitats meet *A. torrentium*'s survival requirements for now. Nevertheless, they could be severely affected by the hydro-technical works taking place in the region, with severe effects on the survival of the crayfish. Because this crayfish species is rare and protected, its presence is extremely important for the protected area. At the same time, at least as important for the protected area is to ensure its survival in the region.

Keywords: protected area, aquatic habitats, conservation, biodiversity, faunistic studies.

Introduction

Austropotamobius torrentium is a protected crayfish species in Romania (O.U.G. 57/2007). According to earlier data, four crayfish species are present in the country (Pârvulescu 2009). Still, recently a new species was described, *A. biharensis*, which is endemic to the Apuseni Mountains and has a very small distribution range (Pârvulescu 2019). *A. torrentium* has the second smallest distribution range among the crayfish species native to Romania (Pârvulescu 2009). Moreover, *A. torrentium* is related to restrictive ecological conditions, as it is present in small mountainous watercourses with rocky substratum (e.g., Streissl & Hödl 2002, Pöckl & Streissl 2005, Vlach et al. 2009, Pârvulescu & Zaharia 2013, Pârvulescu et al. 2011), usually in karstic areas (Pârvulescu & Zaharia 2013, Pârvulescu et al. 2013). However, a stone crayfish population was recently identified in a plain area in southwestern Romania, in an unlikely habitat based on the distribution of other *A.torrentium* populations in the country (Groza et al. 2021). Nevertheless, this population does not necessarily indicate high ecological plasticity of *A. torrentium*; on the contrary, it is a relict of a situation from the region's past, like other species present in the area in the same conditions (see in Groza et al. 2021). Thus, *A. torrentium* indicates good habitat conditions in running waters (Pöckl & Streissl 2005). Consequently, the presence of this species is essential in protected areas, as generally, in Romania, protected areas ensure good habitat conditions for *A. torrentium* (Pârvulescu et al. 2020).

The Jiu Gorge National Park - JGNP is a protected area situated in the south-western part of the Carpathian Mountains, where rich biodiversity was highlighted in different studies (e.g., Petrescu et al. 2004, Covaciu-Marcov et al. 2009, Dobre et al. 2009, Tomescu et al. 2011, Telcean et al. 2017, Cicort-Lucaciu et al. 2020). Nevertheless, *A. torrentium* was mentioned in this protected area only once, approximately 100 years ago, in 1925 (Călinescu 1929). The stone crayfish was encountered on the main course of the Jiu River, in the Lainici area, where it was considered abundant (Călinescu 1929). Probably, this report is responsible for the species` inclusion in the protected area`s standard data form (ROSCI0063 standard Natura 2000 data form). Subsequently, *A. torrentium* was not mentioned in the region, even though in 2004, it was searched in the gorge in two main tributaries of the Jiu River (Petrescu et al. 2004). However, the stone crayfish is present in the park's neighboring areas, even immediately upstream of the park in some Jiu River tributaries (Pârvulescu & Petrescu 2010, Pârvulescu & Zaharia 2013, Groza & Mireşan 2017). Moreover, most aquatic habitats in JGNP have similar features to those required by the species. Also, by its zoogeography and ecology, the stone crayfish have favorable conditions in the region.

Based on the abovementioned, we hypothesized that *A. torrentium* should have a broader distribution in JGNP. This hypothesis is also sustained by the recent identification of new distribution records of some species with zoogeographic or conservation importance both in JGNP (Covaciu-Marcov et al. 2009, Ile & Sucea 2018, Sucea 2019, Covaciu-Marcov & Sucea 2021) or in its vicinity (Covaciu-Marcov et al. 2012, Maier & Cadar 2021). Thus, our objective was to investigate the distribution of *A. torrentium* in JGNP.

Material and Methods

Fieldwork was performed between the years 2018-2021. We investigated most of the Jiu River tributaries in JGNP, mainly the small-sized ones, which correspond with this species` requirements (Streissl & Hödl 2002, Pöckl & Streissl 2005, Todorov et al. 2014). Thus, we started our search at the river's entrance in the gorge and ended it in the most southern part of the park. Because the investigated watercourses were small, with a depth of no more than 0.5m, the crayfish were searched by hand, under rocks, or in other shelters, as described in the literature (Pârvulescu & Petrescu 2010). Smaller rocks were lifted, but for the larger stones, which could not be moved, the crayfish were searched by driving our hand into the burrow as far as possible. Each watercourse was investigated for 30 minutes. If after 30 minutes we did not encounter any crayfish, we moved to another watercourse. The stone crayfish were determined on-site following the morphological features indicated in the literature (Pârvulescu

2009, 2019). The crayfish were not affected by our procedures, as in each case, they were released back into their habitats, and most often, they were not even touched. In some cases, we took photos of the individuals and their habitats. We also noted the number of adults and juveniles and if they presented morphological anomalies.

Results

We identified stone crayfish (Figure 1) in four locations in JGNP, namely in Strâmba, Strâmbuța, Brădișor, and Dumitra valleys (Table 1). All four watercourses are situated in the upper part of JGNP (Figure 2), close to its northern limit, towards the Petroşani Basin. Three of the streams are located on the west side (Strâmba, Strâmbuța, Dumitra), while the fourth one is located on the east side of the Jiu River (Brădișor). In addition to the streams mentioned above, *A. torrentium* was also searched in nine other watercourses with similar characteristics from JGNP, situated on the park's entire length. But even though we used the same method, we did not succeed in finding any individual. The four watercourses populated by *A. torrentium* are situated between 481 and 495 meters a.s.l. (Table 1). However, the stone crayfish was not found in some upstream tributaries located near the park's most northern limit. We observed 49 stone crayfish individuals, but their number differed between the habitats (Table 1).

All four watercourses populated by *A. torrentium* are small-sized streams (Figure 3); they have a width between 0.5 and 1 m and a maximum depth of 0.5m (except for occasional floods). The water flows fast. The substrate is made of different-sized rocks, ranging from a few centimeters to half a meter in diameter, but in Dumitra valley, there are also sandy areas. In most cases, the slope of these streams is very steep. We did not encounter fish in the watercourses populated by the stone crayfish. Nevertheless, on Dumitra, we identified otter excrements with crayfish remains on the water shores. In all watercourses, we identified individuals without one claw (sometimes even without both claws).

Figure 1. *Austropotamobius torrentium* individual from the Jiu Gorge National Park (Dumitra Valley)

Table 1. Distribution of *Austropotamobius torrentium* in the Jiu Gorge National Park.

Location	Geographic coordinates	Altitude(m)	Date	Number of individuals
Strâmba valley	45º21'06.07''N // 23º22'44.04''E	495	29 IX 2018	3
			27 VIII 2020	7
Strâmbuța valley	45º20'41.53''N // 23º22'42.75''E	482	21 VIII 2018	6
			27 VIII 2020	13
			26 VIII 2021	2
Brădișor valley	45º20'43.86''N // 23º22'57.03''E	489	26 VIII 2021	4
Dumitra valley	45º17'55.50''N // 23º22'39.90''E	481	8 IX 2021	14

Discussion

The presence of the stone crayfish is associated most of the time with some characteristics of the aquatic habitats, especially with higher water speed and the existence of suitable stones in the substrate (Streissl & Hödl 2002, Pöckl & Streissl 2005). Increased survival of the species is linked to a higher number of shelters in the water (Streissl & Hödl 2002), and the small watercourses in JGNP had numerous rocks of different sizes. In JGNP, the requirements of this species are satisfied in most of the Jiu River tributaries, but still, the stone crayfish is present only in a small part of the protected area.

Thus, *A. torrentium* seems to be present only in the northern part of the park, where it was identified only at altitudes close to 500 m, which is considered exactly the most favorable altitude for this species in Romania (Pârvulescu & Zaharia 2013). Even though we also investigated the middle and even the lowest part of JGNP with similar conditions, we did not encounter any stone crayfish. Thus, the distribution of *A. torrentium* in JGNP is similar to the distribution of *Cottus gobio* (Telcean et al. 2017), a protected fish species (O.U.G. 57/2007), connected to cold, mountain waters (Bănărescu 1964). *Cottus gobio* is present in only one stream from the upper part of JGNP (Telcean et al. 2017). Thus, the two species have similar ecological requirements, approximately the same distribution in JGNP, and the same importance for the protected area.

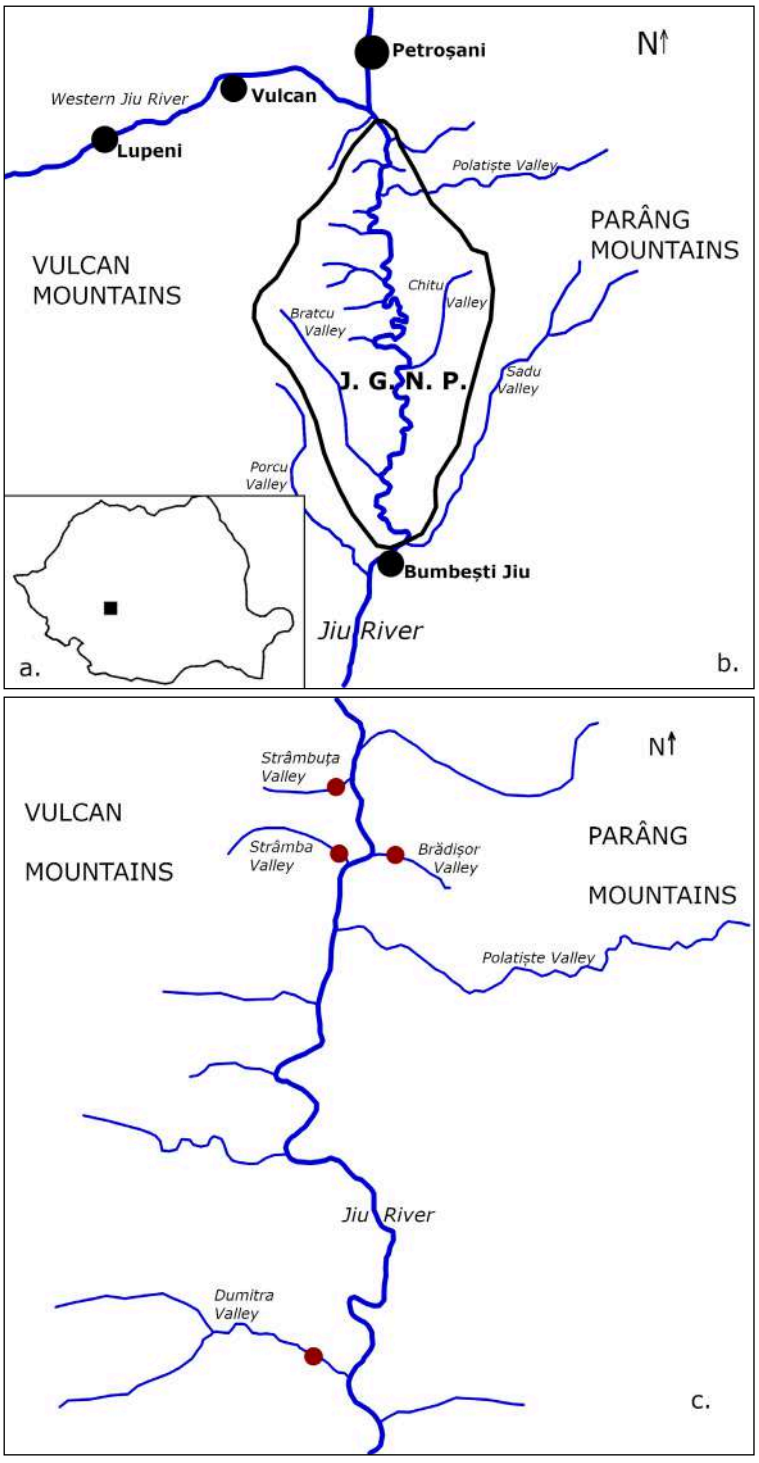

Figure 2. Distribution map of *Astropotamobius torrentium* in the Jiu Gorge National Park; a. Location of the park in Romania; b. Location of the park in the neighboring region (blue lines – watercourses, black lines – limits of the park, black circles – localities); c. Detailed map of the park's northern region with the distribution records of the crayfish (red circles).

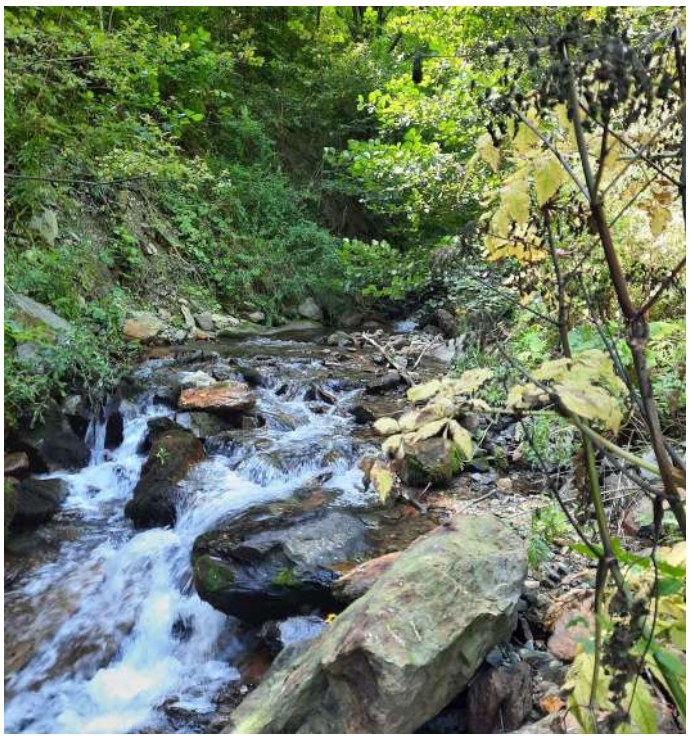

Figure 3. *Austropotamobius torrentium* habitat in the Jiu Gorge National Park (Dumitra Valley)

In JGNP, also in the case of the herpetofauna, mountain species are present only at high altitudes, higher than in other regions in Romania (Covaciu-Marcov et al. 2009). However, the absence of *A. torrentium* from the lower areas of JGNP is unexpected since the habitats here have seemingly suitable conditions (like the ones upstream), and the species was encountered in the past in the Jiu River main courses, in the central area of the gorge (Călinescu 1929). Moreover, the stone crayfish was recently found by chance in a plain in the southern area of the Oltenia region in an atypical habitat (Groza et al. 2021). Probably, the species was also present in the lower sectors of the Jiu River gorge in the past, but it seems that some environmental changes pushed it more and more upstream. In contrast, the areas in the southern Oltenia region are refuge areas, where relict populations still survive, both in the case of *A. torrentium* (Groza et al. 2021) and in the case of other species (Ferenți & Covaciu-Marcov 2014, 2018 Covaciu-Marcov et al. 2017, Cupșa et al. 2021), although they disappeared from other regions.

During the summer, the water temperature of the Jiu River in the gorge is high, affecting some of the fish species in the area (Telcean et al. 2017). High water temperatures probably negatively affect the stone crayfish, which is usually present in cold waters (Maguire et al. 2002) and is sensitive to the oxygen deficit in the water (Pârvulescu et al. 2011). At the same time, the Jiu River Gorge's middle area is considered the northern barrier in the region for some southern reptile species considered sub-Mediterranean elements (Covaciu-Marcov et al. 2009). Also, the lower (southern) areas of JGNP are much more affected by human activities than its upper areas (Covaciu-Marcov et al. 2009, Tomescu et al. 2011, Cicort-Lucaciu et al 2020). Although this human alteration is the most visible in the terrestrial environment, it can also be observed in the case of fish (Telcean et al. 2017). Anyway, the alteration of the terrestrial environment and especially of the forest in the lower parts of JGNP (Cicort-Lucaciu et al. 2020), certainly affected the aquatic fauna, including the stone crayfish populations, as their presence is seemingly linked to watercourses surrounded by broad-leaf forests, especially beech forests (Todorov et al. 2014). Probably, this is one of the causes that determined the disappearance of the stone crayfish from the central areas of JGNP, where it was considered abundant in the past (Călinescu 1929). Thus, the presence of *A. torrentium* populations exclusively in the upper part of JGNP might be explained at least partially through the perspective of the region's specific features, even if not through the peculiarities of the entire Oltenia region. However, it is more difficult to explain the absence of the species from the watercourses between the area populated in JGNP and its distribution range in the Petroşani Basin, where it was previously mentioned (Pârvulescu & Petrescu 2010, Groza & Mireşan 2017). In those watercourses, the stone crayfish probably disappeared because of a punctual human impact from a recent past, or the number of individuals is so reduced because we did not find them from misfortune. The disappearance of some stone crayfish populations from the courses of the main rivers in the Oltenia region was already reported 100 years ago, and it was attributed to human activities (Călinescu et al. 1929).

Austropotamobius torrentium individuals move only short distances (Pöckl & Streissl 2005). Thus, most probably, the four populations in JGNP are isolated from each other. The main course of the Jiu River is the only connection between the crayfish habitats, and it was heavily affected by the pollution caused by the coal mines from the Petroşani Basin in the past (e.g., Barbu 2008, Iordache et al. 2015). Probably, in

the period when the Jiu River was polluted because of the mining activities, *A. torrentium* survived exactly in the habitats it occupies nowadays, just like the fish species in JGNP (Telcean et al. 2017). But unlike fish, *A. torrentium* is a species with reduced mobility related to restrictive ecological conditions (Streissl & Hödl 2002, Pöckl & Streissl 2005, Vlach et al. 2009, Todorov et al. 2014); therefore, it did not re-colonize the Jiu River after the pollution has stopped. Thus, the stone crayfish populations in JGNP are now isolated on the small-sized watercourses they populate.

In the habitats populated by the stone crayfish, the fish were absent. This fact is beneficial for *A. torrentium* because different species of crayfish fall prey to a lot of fish species (see in Dorn & Mittelbach 1999). Nevertheless, predators were present in their habitats, as at least in Dumitra valley, they were consumed by otters. As proof, we found crayfish remains in otter excrements, as otters are known to consume crayfish (e.g., Adrian & Delibes 1987, Sulkava 1996). Because in the area there are numerous otters (personal observation), it is possible that they had a severe impact on crayfish. But because both species are protected (O.U.G. 57/2007), there is no way to prioritize their importance in the environment and take measures to limit their impact. Also, the number of stone crayfish without claws is relatively high. Nevertheless, they are not necessarily caused by predators because generally, the crayfish could make those wounds in competition, a fact amplified by the increase of crayfish density (e.g., Wood et al. 2020). *Austropotamobius torrentium* was the only crayfish species identified in JGNP. In Romania the invasive crayfish species *Faxonius limosus* was identified in the Danube (Pârvulescu et al. 2009) and probably already eliminated a stone crayfish population (Groza et al. 2021). Nevertheless, the invasive species is not present in JGNP, and it seems unlikely that the species colonized the park because of its mountain relief. Thus, *Faxonius limosus* is related to other types of habitats, as its entry into the Carpathian Mountains area is limited by climatic factors (Bonk & Bobrek 2020). This fact probably indicates that *A. torrentium* has a good chance of surviving in JGNP. Nevertheless, in the protected area, the aquatic habitats are the most exposed nowadays because some hydro-technical works will transform and drastically reduce the Jiu River flow over the entire length of the gorge (e.g., Carpa et al. 2017, Telcean et al. 2017). Generally, the small watercourses will not be affected by these. Nevertheless, Dumitra valley will be affected as a micro-hydropower plant will be built at its confluence with the Jiu River. Even if the other three habitats are not directly affected, the change in the river water flow will certainly affect the region`s ecological balance (Telcean et al. 2017), which will impact the stone crayfish. Thus, the crayfish populations that have just been identified are at risk of disappearing in the near future, just as other rare and protected species recently identified in different regions of Romania (Covaciu-Marcov et al. 2018).

Our findings add important points to the distribution map of *A. torrentium* in Romania, especially since the crayfish was discovered in a protected area. Compared with the only previous record, which dates back to almost 100 years ago (Călinescu 1929), the range of the species in the gorge seems to have been greatly reduced because of direct and indirect human activities (coal mine pollution and deforestations). The four populations confirm that in JGNP, the biodiversity is still insufficiently known (Sucea 2019). This is proved by the continuous identification of new species in JGNP (Covaciu-Marcov et al. 2009, Ile & Sucea 2018, Sucea 2019) and its vicinity (Covaciu-Marcov et al. 2012, Maier & Cadar 2021), highlighting the necessity of future studies.

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