



Assessment of Freshwater Crayfish (Malacostraca: Astacidae) in Protected Aquatic Basins in Bulgaria

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Abstract: This study explores the distribution and status of the stone crayfish *Austropotamobius torrentium* and the noble crayfish *Astacus astacus* within Natura 2000 protected areas in Bulgaria. Totally, 121 live crayfish were caught, with *A. torrentium* mainly found at altitudes between 410 and 1317 m a.s.l., particularly between 300 and 900 m. The highest population density of stone crayfish was observed in Ograzhden – Maleshevo, Osogovska Planina and Belasitsa Mountains. *Astacus astacus* was detected in the Rabrovo Protected Area only.

Key words: Distribution, *Austropotamobius torrentium*, *Astacus astacus*

Introduction

Decapod crayfish are the most complex crustaceans. There are 9280 known species of 206 families (TODOROV 2021). The family Astacidae Latreille, 1802 includes four genera: *Astacus* Fabricius, 1775, *Austropotamobius* Skorikov, 1907, *Pacifastacus* Bott, 1950 and *Pontastacus* Bott, 1950. They inhabit the waters of North America, Asia and Europe. Five native species have been established in Europe (MACHINO & HOLDICH 2006, PÖCKL et al. 2006, SOUTY-GROSSET et al. 2006, HOLDICH et al. 2009, BÁNKI et al. 2023): noble crayfish *Astacus astacus* (Linnaeus, 1758), narrow-clawed crayfish *Pontastacus leptodactylus* (Eschscholtz, 1823), Caspian crayfish *Pontastacus pachypus* (Rathke, 1837), white-clawed crayfish *Austropotamobius pallipes* (Lereboullet, 1858) and stone crayfish *Austropotamobius torrentium* (Schrank, 1803). In Bulgaria, three native species of crayfish are found: *A. astacus*, *P. leptodactylus* and *A. torrentium*, as well as one species of freshwater crab *Potamon* (*Pontipotamon*) *ibericum* (Bieberstein, 1808) (BECHEV 2000,

2004, STOYNOV et al. 2013, TRICHKOVA et al. 2013, TODOROV et al. 2014, BÁNKI et al. 2023).

The noble crayfish *A. astacus* is considered widespread in Bulgaria. It has been reported many times across the country (BULGURKOV 1961, KUZAROV et al. 1972, RUSSEV et al. 1975, SUBCHEV 1978, JANEVA & RUSSEV 1985, ISLAM et al. 1986, KOVACHEV & UZUNOV 1986, RUSSEV & YANEVA 1986, SUBCHEV & STANIMIROVA, 1986, 1998, JANEVA 1987, JANEVA & RUSSEV 1997, KOVACHEV et al. 1999, ZAIKOV et al. 2010b, STOYNOV et al. 2013, TRICHKOVA et al. 2013). It has been assessed for the IUCN Red List of Threatened Species in 2010 and is listed as “Vulnerable” under Criteria A2ad (EDSMAN et al. 2010).

The stone crayfish *A. torrentium* is widespread in the upper and middle courses of rivers and small mountain streams, mainly in South-west Bulgaria, Western Rhodopes, Western and Central Stara Planina Mts. and Sredna Gora Mts. It is poorly represented in the Predbalkan and Eastern Balkan Mts. and absent in Eastern Rhodopes Mts., Sakar Mt., Strandzha Mt. and the Danube River Plain (BULGURKOV 1961, SUBCHEV & STANIMIROVA 1986, 1998,

SUBCHEV 1987, JANEVA & RUSSEV 1997; HUBENOVA et al. 2010, ZAIKOV et al. 2010a, ZAIKOV et al. 2011b, STOYNOV et al. 2013, TRICHKOVA et al. 2013). The species is not categorised in the Red Book of the Republic of Bulgaria (GOLEMANSKI 2015) but is categorised as “Data Deficient” in the IUCN Red List, with a tendency for the population of the species to decrease (FÜREDER et al. 2010).

The studies on the distribution of the studied species began during the 20th century (BULGURKOV 1961, SUBCHEV & STANIMIROVA 1998). In recent years, new localities have been discovered and their distribution data have been updated (BECHEV 2000, 2004, SUBCHEV 2001, HUBENOVA et al. 2002, ZAIKOV 2004, ZAIKOV & HUBENOVA 2007, ZAIKOV et al. 2010a, b, ZAIKOV et al. 2011a, b, TODOROV et al. 2014).

The goal of this study is to enhance and enrich the existing data pool, thus providing an updated comprehensive overview of the distribution of stone and noble crayfish in the Natura 2000 protected areas in Bulgaria, building upon the groundwork laid by TODOROV et al. (2014).

Materials and Methods

The two species of crayfish were caught using the standard method of manual capture during the day (MACHINO & FÜREDER 2005). The presence of the species in rivers or streams was performed by hand capture and direct observation during a transect walk as prescribed by the National System for Biodiversity Monitoring (NSMSB 2019). The chosen sample transects along the river basins were walked during the day, moving against the current of rivers to avoid stirring up the water and for better visibility. Along each transect, all suitable shelters for crayfish (under rocks, undercut banks and vegetation) were checked, with crayfish being caught by hand or using a hydrobiological net. The sample units for monitoring are permanent sample transects with a length of 100 m and a width of 1 m (100 m²) used to determine the abundance of crayfish (ind./m²).

When monitoring a specific river, at least one transect in the upper, middle and lower courses were selected, thus recording the presence and number of the respective species in separate sectors of the river in order to make a more accurate estimate of the size of the population in a given river. The transect walk was recorded with a GPS, which allowed to be visualised on a map, with GPS points being taken at the start and the end. After the crayfish were identified and counted, they were released back to the locations where they were caught.

Results

During the period May 2020 – June 2022, 121 alive crayfish were caught (*A. torrentium* – 110, *A. astacus* – 10, *P. leptodactylus* – 1). The study covered 219 transects in 56 rivers and streams in 28 Natura 2000 protected areas in Bulgaria (Table 1, Fig. 1), thus providing a comprehensive overview of the distribution of the species in these regions. Data on the abundance and frequency of occurrence of *A. torrentium* in protected areas are presented in Table 2.

The localities where alive specimens were caught were located in 27 rivers from 12 protected areas. The number of dead individuals was four: stone crayfish and at places, exuviae, body remnants and claws (unspecified species) were found. Predator faeces with visibly distinguishable crayfish parts were identified in the Bunovska River. The largest population was established in the Osogovska Planina protected area (BG0001011), where 39 alive stone crayfish individuals were observed.

Austropotamobius torrentium was found at altitudes from 410 m (Koznichka River) to 1317 m a.s.l. (Skokova River). BULGURKOV (1964) recorded the species at altitudes from 200–300 to 1700 m a.s.l. while SUBCHEV & STANIMIROVA (1998) reported the lowest records at altitudes from 100–200 m a.s.l. to 1600 m a.s.l. In the present study, based on the total number of transects, the species was mostly found at altitudes from 300 to 900 m a.s.l. (5.9% of the total number of transects) and less frequently from 1000 to 1300 m a.s.l. (5.0%). The stone crayfish was not found at altitudes below 200 m and above 1300 m a.s.l. According to TODOROV et al. (2014), *A. torrentium* was found across an altitude range from 189 m to 1342 m a.s.l., predominantly inhabiting areas between 300 and 900 m a.s.l.

Narrow-clawed crayfish were found at an altitude of 170 m a.s.l. in the Chernyalka River (N43.19783° E24.32985°). Although this species is typically found at 0–200 m a.s.l. (BULGURKOV 1964, SUBCHEV & STANIMIROVA 1998), examples of records up to 858 m a.s.l. have been noted, presumably due to releases from aquacultures (ZAIKOV et al. 2009).

The data on the average abundance of *A. torrentium* from the studied protected areas showed the highest abundance in Ograzhden – Maleshevo (0.056 ind./m²), Osogovska Planina (0.026 ind./m²) and Belasitsa Mts. (0.017 ind./m²). The frequency of occurrence was highest (100%) in Belasitsa, Vrachanski Balkan, Ograzhden – Maleshevo and Osogovska Planina.

Table 1. List of studied protected areas and rivers, with the localities where crayfish have been recorded.

Protected areas	Date	Locality	Geographical coordinates	Altitude (m a.s.l.)	No. of specimens in transect
Belasitsa BG000167	5.6.2020	Petrichka River	N41.37257° E23.20846°; N41.37030° E23.20910°	1245-1300	<i>A. torrentium</i> (6 alive)
	6.6.2020	Kamenashka River	N41.36093° E23.07212°; N41.35903° E23.07313°	978-1100	<i>A. torrentium</i> (5 alive)
	7.6.2020	Strumeshnitsa River	N41.39415° E22.970911; N41.39269° E22.967323	945-996	<i>A. torrentium</i> (4 alive)
Vrachanski Balkan BG000166	6.6.2020	Lipnica River	N43.02682° E23.747797; N43.02530° E23.743492°	1100-1145	<i>A. torrentium</i> (4 alive)
Etropole-Bailovo BG0001043	9.6.2020	Kalugeritsa River	N42.65465° E23.90941°; N42.65425° E23.90568°	610-636	<i>A. torrentium</i> (2 alive)
	10.6.2020	Bunovska River	N42.72055° E23.93024°; N42.72327° E23.93056°	712-730	0
	10.6.2020	Bunovska River	N42.72955° E23.93032°; N42.73235° E23.92977°	790-810	<i>A. torrentium</i> (1 alive + unidentified remnants in faecal samples)
	16.4.2022	Ginska River	N43.10066° E23.10353°; N43.10339° E23.10359°	1100-1138	<i>A. torrentium</i> (2 alive + claw of unidentified species)
Zapadna Stara Planina and Predbalkan BG0001040	22.6.2020	Brezovska River	N42.96303° E23.48689°; N42.96326° E23.48794°	815-850	0
	22.6.2020	Brezovska River	N42.96485° E23.49089°; N42.96689° E23.49332°	821-850	0
	23.6.2020	Gabrovnitsa River	N42.98186° E23.50026°; N42.98167° E23.50400°	745-750	<i>A. torrentium</i> (1 alive + 2 dead)
Iskarski Proлом – Rzhana BG0001042	23.6.2020	Gabrovnitsa River	N42.98143° E23.50499°; N42.98077° E23.50862°	733-750	<i>A. torrentium</i> (1 alive + 1 dead) + exuviae (unidentified)
Karlukovo BG0001014	24.6.2020	Gabrovnitsa River	N43.00397° E23.47478°; N43.00148° E23.47331°	609-620	<i>A. torrentium</i> (2 alive)
	24.6.2020	Vetrenskidol River	N43.00015° E23.47190°; N43.00040° E23.46774°	637-650	<i>A. torrentium</i> (5 alive)
	30.6.2020	Rachene River	N43.22728° E23.90932°; N43.22736° E23.90560°	290-300	0
Konyavska Planina BG0000298	3.7.2020	Koznichka River	N42.33587° E22.90200°; N42.33644° E22.90189°	399-437	<i>A. torrentium</i> (15 alive)
	3.7.2020	Koznichka River	N42.33866° E22.90103°; N42.34080° E22.90047°	415-437	<i>A. torrentium</i> (5 alive)
	4.7.2020	Madzharitsa River	N42.38904° E22.85362°; N42.39220° E22.85380°	1329-1373	0
Kresna – Ilindentsi BG0000366	13.5.2020	Shashka River	N41.64862° E23.24197°; N41.64983° E23.24458°	190-280	0
	21.5.2020	Vlahinska River	N41.73771° E23.22735°; N41.73780° E23.22983°	455-500	0
	15.4.2022	Sharaliiska River	N41.72123° E23.29072°; N41.72171° E23.29431°	1080-1119	0
	12.6.2020	Stara River	N41.74110° E23.114191; N41.73895° E23.11087°	734-780	<i>A. torrentium</i> (1 alive)
Ograzhden – Maleshevo BG0000224	8.6.2020	Lipnitsa River	N41.36010° E23.01764°; N41.35863° E23.01676°	1189-1200	<i>A. torrentium</i> (17 alive)

Table 1. Continuation.

Protected areas	Date	Locality	Geographical coordinates	Altitude (m a.s.l.)	No. of specimens in transect
Osogovska Planina BG0001011	19.6.2020	Skokova River	N42.17759° E22.68022°; N42.17679° E22.67665°	1290-1317	<i>A. torrentium</i> (4 alive)
	13.6.2020	Rechitsa River	N42.11024° E22.84062°; N42.10802° E22.83735°	1090-1100	<i>A. torrentium</i> (8 alive)
	20.6.2020	Novoselska River	N42.19500° E22.67804°; N42.19310° E22.67874°	1267-1300	<i>A. torrentium</i> (6 alive)
	20.6.2020	Novoselska River	N42.19017° E22.67985°; N42.18792° E22.67996°	1199-1221	<i>A. torrentium</i> (12 alive)
	13.6.2020	Rechitsa River	N42.10795° E22.83702°; N42.10546° E22.83928°	1050-1100	<i>A. torrentium</i> (9 alive)
	20.5.2022	Luda Kamchiya River	N42.78503° E26.52571°; N42.78533° E26.52500°	350-400	0
	6.5.2020	Gradinishka River	N41.76663° E23.702215°; N41.76759° E23.705602°	750-801	0
	26.5.2020	Beli Iskar River	N42.24734° E23.54087°; N42.25091° E23.54106°	1100-1200	0
Rila BG0000495	5.5.2020	Eshekhidre River	N41.66798° E24.26882°; N41.67037° E24.26595°	1000-1150	0
	5.5.2020	Karadjadere (Saмена River)	N41.67061° E24.20993°; N41.67130° E24.20636°	1189-1258	<i>A. torrentium</i> (5 alive)
	5.5.2020	Kochooludere River	N41.67597° E24.20232°; N41.67794° E24.20152°	1210-1254	0
	5.5.2020	Vacha River	N41.70703° E24.40970°; N41.70408° E24.40798°	560-736	0
	5.5.2020	Vacha River	N41.70125° E24.40053°; N41.70092° E24.40037°	690-754	0
	6.5.2020	Kochooludere River	N41.68669° E24.19313°; N41.68969° E24.19311°	1290-1330	0
	7.5.2020	Cherna Mesta River	N42.05311° E23.72933°; N42.05446° E23.72886°	900-1003	0
	8.5.2020	Dospat River	N41.81349° E23.90637°; N41.81644° E23.90176°	1210-1256	0
Rodopi – Sredni BG0001031	8.5.2020	Dospat River	N41.81667° E23.90128°; N41.81717° E23.89914°	1100-1256	0
	29.4.2022	Kayaklika River	N42.01150° E25.28393°; N42.01370° E25.28638°	90-100	0
	30.4.2022	Mrachemishka River	N42.54163° E24.94078°; N42.54045° E24.94418°	300-360	0
	6.5.2020	Burovitsa River	N41.43754° E23.68911°; N41.43657° E23.69212°	710-768	0
	11.5.2020	Petrovska River	N41.41882° E23.54436°; N41.41620° E23.54906°	615-633	<i>A. torrentium</i> (7 alive + 1 dead)
	11.5.2020	Pirinska Bistritsa River	N41.50285° E23.50413°; N41.50096° E23.50135°	220-289	0
	11.5.2020	Pirinska Bistritsa River	N41.50099° E23.50124°; N41.49989° E23.49771°	240-290	0
	11.5.2020	Pirinska Bistritsa River	N41.49912° E23.49640°; N41.49696° E23.49460°	245-289	0

Table 1. Continuation.

Protected areas	Date	Locality	Geographical coordinates	Altitude (m a.s.l.)	No. of specimens in transect
Sredna Gora BG0001389	9.6.2020	Topolnitsa River	N42.50263° E23.99712°; N42.50519° E23.99708°	400-416	0
	11.6.2020	Eleńska River	N42.70573° E24.22967°; N42.70887° E24.22900°	670-700	0
	11.6.2020	Topolnitsa River	N42.69287° E24.27021°; N42.69099° E24.27280°	700-720	claw (unidentified)
	23.4.2022	Kriva River	N42.61889° E24.37581°; N42.61772° E24.37944°	1000-1014	0
	23.4.2022	Popska River	N42.62102° E24.37169°; N42.61984° E24.36872°	990-1026	0
	23.4.2022	Shirineiska River	N42.60830° E24.37518°; N42.60575° E24.37366°	1000-1032	0
	24.4.2022	Stryama River	N42.68977° E24.57207°; N42.69059° E24.56840°	399-418	0
	24.4.2022	Varlshnica River	N42.68944° E24.44624°; N42.68632° E24.44523°	600-680	<i>A. torrentium</i> (1 alive)
	18.7.2020	Chernyalka River	N43.33060° E24.54889°; N43.32933° E24.54839°	150-170	<i>P. leptodactylus</i>
	19.7.2020	Karadzha Dere river	N42.72027° E24.63267°; N42.72294° E24.63333°	700-720	<i>A. torrentium</i> (7 alive)
Tsentrallen Balkan – Buffer BG0001493	25.4.2022	Damla Dere River	N42.72498° E24.58540°; N42.72759° E24.58440°	510-539	0
	25.4.2022	Kavakla Dere River	N42.73152° E24.59443°; N42.73425° E24.59482°	500-522	0
Yadenitsa BG0001386	1.5.2022	Tundzha River	N42.62712° E24.96619°; N42.62989° E24.96705°	630-666	0
	1.5.2022	Byalata River	N42.61365° E24.95094°; N42.61544° E24.94808°	300-323	0
	7.5.2020	Yadenitsa River	N42.10107° E23.89004°; N42.10204° E23.88843°	1120-1135	0
	2.5.2022	Gabrovnica River	N42.62608° E25.23348°; N42.62809° E25.23082°	330-360	0
	17.7.2020	Osam River	N43.62369° E24.85177°; N43.62649° E24.85101°	29-30	0
	29.6.2020	Ogosta River	N43.50236° E23.36280°; N43.49998° E23.36435°	100-110	0
	29.6.2020	Ogosta River	N43.49982° E23.36439°; N43.49727° E23.36383°	100-110	0
	15.6.2020	Rabrovska River	N44.01834° E22.61080°; N44.01985° E22.61374°	100-103	<i>A. astacus</i> (10 alive)
	16.6.2020	Lom River	N43.69777° E23.07871°; N43.69736° E23.07586°	70-89	0
	16.6.2020	Lom River	N43.72079° E23.15774°; N43.72108° E23.15385°	89-90	0
Reka Yantra BG0000610	27.5.2022	Yantra River	N43.20899° E25.73172°; N43.20670° E25.73807°	45-58	0
Fakiyska Reka BG0000230	3.6.2022	Fakiyska River	N42.36223° E27.41278°; N42.35931° E27.41420°	22-24	0
Tsitritsa BG0000509	16.6.2020	Tsitritsa River	N43.57568° E23.23983°; N43.57538° E23.23595°	100-140	0
	16.6.2020	Tsitritsa River	N43.66119° E23.42387°; N43.65887° E23.42279°	80-90	0

Table 2. Abundance of *Austropotamobius torrentium* in protected areas.

Protected areas	No. of observed specimens	Abundance (ind./m ²)	No. of transects with crayfish	No. of examined transects	Frequency of occurrence (%)
Belasitsa BG000167	15	0.017	9	9	100.0
Vrachanski Balkan BG000166	4	0.013	3	3	100.0
Etropole – Bailovo BG0001043	3	0.003	6	9	66.7
Zapadna Stara Planina i Predbalkan BG0001040	3	0.01	2	3	66.7
Iskarski Prolom – Rzhana BG0001042	11	0.006	4	18	22.2
Kresna – Ilindentsi BG0000366	1	0.00083	1	12	8.3
Ograzhden – Maleshevo BG0000224	17	0.056	3	3	100.0
Osogovska Planina BG0001011	39	0.026	15	15	100.0
Rodopi – Zapadni BG0001030	5	0.003	2	18	11.1
Sreden Pirin – Alibotush BG0001028	8	0.0053	3	15	20.0
Sredna Gora Mts BG0001389	2	0.001	2	18	10.5
Tsentralen Balkan – Buffer BG0001493	7	0.004	2	15	13.3

Astacus astacus was found with ten alive specimens in only one protected area – Rabrovo (BG0000339). The average abundance was 0.03 ind./m² and the frequency of occurrence was 100%.

Discussion

In this study, *A. torrentium* was registered in 12 out of 28 Natura 2000 protected areas. The species was represented by a relatively small number of individuals (110), found in 24 out of 55 studied rivers and streams. The data showed that there was a relatively limited and uneven distribution in Bulgaria and its populations were characterised by relatively low abundance. The abundance of *A. torrentium* was higher in areas characterised by a rocky bottom and the presence of pieces of wood, serving as a refuge for this crayfish species. This result supports previous observations (PÖCKL & STREISSL 2005) showing a correlation between such environmental characteristics and the abundance of *A. torrentium*. According to TODOROV et al. (2014), the species is extremely rare or completely absent in the open parts of rivers and areas with predominant coniferous vegetation.

The present studies showed that the distribution of the species was limited and uneven throughout the country and its populations were characterised by relatively low abundance (0.00083–0.056 ind./m²). According to PEHLIVANOV & BISERKOV (2010), there is also a trend of limited distribution of stone crayfish compared to the middle and the end of the 20th century.

In this study, no mixing of populations of *A. torrentium* and *A. astacus* was identified. However, co-occurrence of the two species had been reported in another study (STOYNOV et al. 2013).

The presence of the noble crayfish in the Rabrovo (BG0000339) protected area, Rabrovska River, is reported by TRICHKOVA et al. (2013) and TODOROV (2014). The occurrence of the narrow-clawed crayfish in Chernyalka River (Studenets protected area) was reported by RUSSEV et al. (1998) and TODOROV (2014). These findings confirm the importance of ongoing studies for understanding and conserving crayfish populations in Bulgaria, especially within protected areas.

This study covered 28 protected areas in Bulgaria; in 14 of them, no specimens of the three na-



A



B



C



D



E



F

Fig 1. A–B. Common and ventral view of an individual of *Austropotamobius torrentium* from Karadjadere (Sarnena River): claws broad with coarse granulation, brownish on top and beige underneath. Rostrum short and blunt, with a triangular shape. There is one pair of postorbital tubercles and carapace smooth, without cervical spines. C–D. Common and ventral view of an individual of *Astacus astacus* from Rabrovska River: rostrum elongated and sharpened, with parallel or trapezoidal non-serrated lateral edges. There are two pairs of postorbital tubercles, with a few spines behind the cervical groove. E–F. Dorsal view of an individual of *Pontastacus leptodactylus* from Chernyalka River: rostrum elongated and sharp, with parallel and serrated lateral edges. There are many spines around and behind the cervical groove.

tive crayfish species were found. In 12 of these areas, only *A. torrentium* was present, with its current distribution differing in some zones compared to the data by TODOROV et al. (2014). In the protected area of Vrachanski Balkan (BG0000166), according to the data of TODOROV et al. (2014), no specimens were found along six transects; the present studies showed a population with low density, with four recorded alive specimens in three transects. In the protected area of Karlukovo (BG0001014), neither by TODOROV et al. (2014) nor by the present observations any specimens were found. In the protected area of Konyavska Planina (BG0000298), according to TODOROV et al. (2014), 13 live specimens were recorded from 18 transects, while recent observations show no presence of this species. In the protected area of Reka Gorna Luda Kamchiya (BG0000136), a significant decrease in the number of alive specimens was observed: from six according to TODOROV et al. (2014) to none found in recent years. In the protected areas of Rila (BG0000495) and Rodopi-Sredni (BG0001031), both latest observations and those by TODOROV et al. (2014) showed no presence of alive specimens. In the protected areas of Reka Mesta (BG0001021), Yadenitsa (BG0001386) and Koprinka Reservoir (BG0000261), recent observations did not show the presence of noble crayfish, thus contrasting with the data of TODOROV et al. (2014). No presence of crayfish was reported in the protected areas of Nikopolsko Plato (BG0000247), Portitovci – Vladimirovo (BG0000517), Fakiyska Reka (BG0000230), Tsibritsa (BG0000509) (MOEW 2022) as well as in Reka Lom (BG0000503) and Reka Yantra (BG0000610) (TODOROV et al. 2014). These results represent the dynamics in the populations across different zones. Some zones show a decrease in the number of alive specimens, while others indicate an increase. In some zones, no specimens were found which could be due to various factors, including environmental changes or human impact. The main threats observed during the present study include water pollution from industrial waste and domestic wastewater.

The results of this study do not reveal the presence of invasive crayfish species in the country, which is encouraging news. However, the situation requires constant attention as such species have already been observed in neighbouring countries like Serbia, Romania and Greece. E.g., *Faxonius limosus* (Rafinesque, 1817) documented in Bulgaria (TODOROV et al. 2020) and *Pacifastacus leniusculus* (Dana, 1852) spotted in Greece and Serbia are clear examples of this. Studies by PÖCKL et al. (2006), KOUTRAKIS et al. (2007), HOLDICH et al. (2009),

ZORIĆ et al. (2020) and HORVATOVIĆ et al. (2022) confirm the need to remain vigilant and continue monitoring these species to prevent their potential spread in further countries.

The identified threats, coupled with the potential emergence of new ones, necessitate proactive initiatives to mitigate and forestall future challenges. The insights gained by the present study could act as a stepping-stone for more comprehensive surveillance of the crayfish populations and could serve to evaluate the status of species conservation in Bulgaria with heightened precision.

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References

- BÁNKI O., ROSKOV Y., DÖRING, M., OWER G., VANDEPITTE L., HOBERN D., REMSEN D., SCHALK P., DEWALT R. E., KEPING M., MILLER J., ORRELL T., AALBU R., ABBOTT J., ADLARD R., ADRIAENSSENS E. M., AEDO C., AESCHT E., AKKARI N., et al. 2023. Catalog of Life Checklist (Version 2023-03-09). Catalog of Life. <https://doi.org/10.48580/dfrt>
- BECHEV D. 2000. New localities of *Potamon fluviatilis* (Herbst) (Crustacea: Decapoda) in Bulgaria. *Travaux Scientifiques de l'Universite de Plovdiv Animalia* 36: 95–96.
- BECHEV D. 2004. The freshwater crab (Crustacea: Decapoda: Potamidae) in the Eastern Rhodopes (Bulgaria). In: *Biodiversity of Bulgaria*, Vol. 2, pp. 49–51.
- BULGURKOV K. 1961. Systematik, Biologie und Zoogeographische Verbreitung der Süßwasserkrebse der Familien Astacidae und Potamonidae in Bulgarien. *Bulletin de l'Institut de Zoologie et Musee* 10: 165–192. (In Bulgarian, Russian and German summaries).
- BULGURKOV K. 1964. *Astacus pachypus* Rathke – a new species of crayfish for the Bulgarian fauna. *Proceedings of Fishery Institute Varna* 5: 45–47. (In Bulgarian, Russian and German summaries).
- EDSMAN L., FÜREDER L., GHERARDI F. & SOUTY-GROSSET C. 2010. *Astacus astacus*. The IUCN Red List of Threatened Species 2010: e. T2191A9338388.
- FÜREDER L., GHERARDI F. & SOUTY-GROSSET C. 2010. *Austropotamobius torrentium*. In IUCN Red List of Threatened Species. Version 2010.4. (pp. 0-0). International Union for Conservation of Nature and Natural Resources.
- GOLEMANSKI V. (Ed.) 2015. Red Data Book of the Republic of Bulgaria. Volume 2. Animals, 2nd Edition. BAS & MOEW, Sofia. (In Bulgarian).
- HOLDICH D. M., REYNOLDS J. D., SOUTY-GROSSET C. & SIBLEY P. J. 2009. A review of the ever-increasing threat to European crayfish from non-indigenous crayfish species. *Knowledge and Management of Aquatic Ecosystems* 11: 394–395.
- HUBENOVA T., VASILEVA P. & ZAIKOV A. 2002. Characteristics of fecundity of Narrow-clawed Crayfish (*Astacus leptodactylus* Esch.) population in Kardjali Reservoir with a view to their economic exploitation. *Bulgarian Journal of Agricultural Science* 8: 301–306.

- HORVATOVIĆ M., RANKOVIĆ M., MILIĆ D., MILJANOVIĆ B. & BAJIĆ A. 2022. The first record of signal crayfish, *Pacifastacus leniusculus* (Dana, 1852) and its projected expansion in Serbia under global climate change. *Biologia Serbica* 44(2).
- HUBENOVA T., VASILEVA P. & ZAIKOV A. 2010. Fecundity of stone crayfish *Austropotamobius torrentium* from two different populations in Bulgaria. *Bulgarian Journal of Agricultural Science* 16: 387–393.
- ISLAM S., UZUNOV Y. & KOVACHEV S. 1986. Composition and distribution of the macrozoobenthos of the river Struma. *Hydrobiology (Bulgarian Academy of Sciences)* 28: 15–35. (In Bulgarian, with English summary).
- JANEVA I. J. & RUSSEV B. K. 1985. Trends in the change of the hydrobiological and saprobiological condition of the Tundzha River. II. May and November 1981. *Hydrobiology (Bulgarian Academy of Sciences)* 26: 15–36. (In Bulgarian).
- JANEVA I. 1987. The zoobenthos of the river Vit. I. Composition, structure and dynamics of the zoocoenoses. *Hydrobiology (Bulgarian Academy of Sciences)* 31: 37–64. (In Bulgarian, with English summary).
- JANEVA I. J. & RUSSEV B. K. 1997. Veränderungen der Artenzusammensetzung und Güteklasse des bulgarischen Donauzuflusses Jantra nach dem Makrozoobenthon. *Lauterbornia* 31: 1–16.
- KOVACHEV S. G. & UZUNOV Y. I. 1986. Formation of macroinvertebrate communities in the course of the biological selfpurification of the Mesta River. *Archiv für Hydrobiologie. Supplementband. Monographische Beiträge* 72(4): 427–526.
- KOVACHEV S., STOICHEV S. & HAINADJIEVA V. 1999. The zoobenthos of several lakes along the Northern Bulgarian Black Sea Coast. *Lauterbornia* 35: 33–38.
- KOUTRAKIS E., PERDIKARIS C., MACHINO Y., SAVVIDIS G. & MARGARIS N. 2007. Distribution, recent mortalities and conservation measures of crayfish in Hellenic fresh waters. *Bulletin Français de la Pêche et de la Pisciculture* 385: 25–44.
- KOZAROV G., MICHAILOVA P. & SUBCHEV M. 1972. Studies on Branchiobdellidae (Oligochaeta, Annelida) in Bulgaria. *Annuaire de l'Université de Sofia, Faculté de biologie* 64(1): 77–89. (In Bulgarian).
- MACHINO Y. & FÜREDER L. 2005. How to find a stone crayfish *Austropotamobius torrentium* (Schrank, 1803): A biogeographic study in Europe. *Bulletin Français de la Pêche et de la Pisciculture, (376–377):* 507–577.
- MACHINO Y. & HOLDICH D. M. 2006. Distribution of crayfish in Europe and adjacent countries: updates and comments. *Freshwater Crayfish* 15: 292–323.
- MOEW 2022. Natura 2000 – Information system for protected areas from ecological network; <https://natura2000.egov.bg/EsriBg.Natura.Public.Web.App>
- NSMSB 2019. National Biodiversity Monitoring System. https://eea.government.bg/bg/bio/nsmbr/prakticheskoro-rakovodstvo-metodiki-za-monitoring-i-otsenka/Crustacea_Method.pdf
- PÖCKL M. & STREISSL F. 2005. *Austropotamobius torrentium* as an indicator for habitat quality in running waters? *Bulletin Français de la Pêche et de la Pisciculture (376–377):* 743–758.
- PÖCKL M., HOLDICH D. M. & PENNERSTORFER J. 2006. Identifying native and alien crayfish species in Europe. *Craynet, Guglar Cross Media, Melk, Austria, 47 p.*
- PEHLIVANOV L. & BISERKOV V. 2010. Development of the national ecological network Natura 2000, stage 2009. BAS: 1–6. (In Bulgarian).
- RUSSEV B. & JANEVA I. 1975. Hydrofaunistic studies on some Rhodope reservoirs. In: *Fauna of the Rhodopes*. Sofia: Bulgarian Academy of Sciences, pp. 11–39. (In Bulgarian).
- RUSSEV B. & JANEVA I. 1986. Hydrobiological review of the right Danube tributary Tsibritsa. *Hydrobiology* 28: 36–45. (In Bulgarian).
- RUSSEV B., PETROVA A., JANEVA I. & ANDREEV S. 1998. Diversity of zooplankton and zoobenthos in the Danube River, its tributaries, and adjacent water bodies. In: *Bulgaria's Biological Diversity: Conservation Status and Needs Assessment. Vol. II*. Sofia & Moscow: Pensoft, pp. 263–292.
- SUBCHEV M. 1978. A new branchiobdellid – *Branchiobdella kozarovi* sp. n. (Oligochaeta, Branchiobdellidae) from Bulgaria. *Acta Zoologica Bulgarica* 9: 78–80.
- SUBCHEV M. 1987. Freshwater crayfish and their multicellular epibionts. In: *Contemporary Achievements of Bulgarian Zoology*. Sofia, Bulgarian Academy of Sciences: 67–69. (In Bulgarian).
- SUBCHEV M. 2001. *Astacus torrentium* (Crustacea: Decapoda) and its epibionts of genus *Branchiobdella* (Annelida). In: Beron P. (ed.), *Biodiversity of Kresna Gorge (SW Bulgaria)*. National Museum of Natural History & Institute of Zoology, BAS, Sofia, pp. 49–51. (In Bulgarian).
- SUBCHEV M. & STANIMIROVA L. S. 1986. The epibiont on crayfishes *Hystricosoma chappuisi* Michaelsen, 1926 (Oligochaeta, Aelosomatidae) – new species for Bulgarian fauna. *Acta Zoologica Bulgarica* 32: 66–68. (In Bulgarian, Russian and English summaries).
- SUBCHEV M. & STANIMIROVA L. 1998. Distribution of freshwater crayfish (Crustacea: Astacidae) and the epibionts of the genus *Branchiobdella* (Annelida: Branchiobdellidae), *Hystricosoma chappuisi* Michaelsen, 1926 (Annelida: Oligochaeta) and *Nitocrella divaricata* (Crustacea: Copepoda) in Bulgaria. *Historia Naturalis Bulgarica* 9: 5–18. (In Bulgarian, English summary).
- SOUTY-GROSSET C., HAFFNER P., REYNOLDS J. D., NOEL P. Y. & HOLDICH D. M. 2006. Atlas of crayfish in Europe. Paris: Muséum national d'Histoire naturelle. 188 pp.
- STOYNOV E., PARVANOV D. & GROZDANOV A. 2013. Distribution of crayfish and crabs in the upper reaches of the Kamchiya River, Bulgaria. *Bulgarian Journal of Agricultural Science* 19(2): 250–254.
- TODOROV M. 2014. Methodology for Monitoring Species of the Class Crustacea. In: *The National System for Monitoring of Biodiversity*. Executive Environment Agency (EEA), pp. 1–35. Retrieved from http://eea.government.bg/bg/bio/nsmbr/prakticheskoro-rakovodstvo-metodiki-za-monitoring-i-otsenka/Crustacea_Method.pdf
- TODOROV M., ANTONOVA V., HUBENOV Z., IHTIMANSKA M., KENDEROV L., TRICHKOVA T., VARADINOVA E. & DELTSHEV C. 2014. Distribution and current status of stone crayfish populations *Austropotamobius torrentium* (Decapoda: Astacidae) in Natura 2000 protected areas in Bulgaria. *Acta Zoologica Bulgarica* 66(2): 181–202.
- TODOROV M., TRICHKOVA T., HUBENOV Z. & JURAJDA P. 2020. *Faxonius limosus* (Rafinesque, 1817) (Decapoda: Cambaridae), a new invasive alien species of European Union concern in Bulgaria. *Acta Zoologica Bulgarica* 72: 113–121.
- TODOROV O. 2021. Atlas of Invertebrates. Regional Natural His-

- tory Museum – Plovdiv. 504 pp. (In Bulgarian).
- TRICHKOVA T., BOTEV I., HUBENOV Z., KENDEROV L., TODOROV M., KOZUHAROV D., DELTSHEV C. & FÜREDER L. 2013. Freshwater crayfish (Decapoda: Astacidae) distribution and conservation in Bulgaria. *Freshwater Crayfish*, 19(2): 243–248.
- ZAIKOV A. 2004. Investigation on the shelter competition between narrow-clawed crayfish (*Astacus leptodactylus* Esch.) and the river crab (*Potamon Tiberium* Bieb.). *Trav. Sci. Univ. Plovdiv, Animalia*, 40 (6): 26–35.
- ZAIKOV A. & HUBENOVA T. 2007. Status of Freshwater Crayfish in Bulgaria. In: Proceedings “III International Conference Fishery”, 1–3 February 2007, Belgrade, pp. 242–247.
- ZAIKOV A., HUBENOVA T. & VASILEVA P. 2009. Use of narrow-clawed crayfish (*Astacus leptodactylus*) in recreational and commercial fisheries and aquaculture in Bulgaria. EIFAC Occasional Paper No. 44, Rome, FAO.
- ZAIKOV A., HUBENOVA T., ILIEV I., VASILEVA P. & PISKOV I. 2010a. Investigation on stone crayfish *Austropotamobius torrentium* (Schrank, 1803) population in River Sarnena (Western Rhodope Mountains, Bulgaria). *ZooNotes* 10: 1–4. (In Bulgarian, English summary).
- ZAIKOV A., HUBENOVA T., ILIEV I. & PISKOV I. 2010b. Investigation on noble crayfish *Astacus astacus* (Linnaeus, 1758) population in River Razhdavets (Balkan Mountain, Bulgaria). *ZooNotes* 12: 1–4. (In Bulgarian, English summary).
- ZAIKOV A., HUBENOVA T., ILIEV I. & PISKOV I. 2011a. Study on the narrow-clawed crayfish *Astacus leptodactylus* Eschscholtz, 1823 (Crustacea: Decapoda: Astacidae) population in a sand-pit Lake near the village of Boshulya (Upper Thracian Lowland, Bulgaria) *ZooNotes* 17: 1–4. (In Bulgarian, English summary).
- ZAIKOV A., HUBENOVA T., ILIEV I., VASILEVA P. & PISKOV I. 2011b. Study on the stone crayfish *Austropotamobius torrentium* (Schrank, 1803) (Crustacea: Decapoda: Astacidae) population in the Dospat Dam (Western Rhodope Mountains, Bulgaria). *ZooNotes* 18: 1–5. (In Bulgarian, English summary).
- ZORIĆ K., ATANACKOVIĆ A., ILIĆ M., CSÁNYI B. & PAUNOVIĆ M. 2020. The spiny-cheek crayfish *Faxonius limosus* (Rafinesque, 1817) (Decapoda: Cambaridae) invades new areas in Serbian inland waters. *Acta Zoologica Bulgarica* 72(4): 623–627.

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