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MARBLE TROUT (*SALMO MARMORATUS*) AND BULLHEAD (*COTTUS GOBIO*) IN TWO SLOVENE RIVERS (ADRIATIC SEA BASIN)

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ABSTRACT

Population density, growth and condition of marble trout *Salmo marmoratus* Cuvier, 1829 in the river Trebuščica and bullhead *Cottus gobio* Linnaeus, 1758 in the river Bela were estimated. Ageing of bullhead could not be established due to its lack of scales. In the Trebuščica, marble trout is a dominant species, with high density of 955 specimens/ha and low biomass of 26 kg/ha. The youngest marble trout specimens (age groups 0 and 1) constitute 81% of the entire estimated population. The mean condition factor was low (0.83) with the highest growth rate of 6-15 cm long trout (1.56 and 0.86, respectively). For the conservation of this species, no further introduction of brown and rainbow trout is recommended and angling restrictions of marble trout applies. In the river Bela, about 86% (specimens/ha) and 35% (kg/ha) of the total fish population are represented by bullheads. Bullheads' density of 11,708 specimens/ha is the first record of such high density in Slovenia. The mean condition factor of bullhead was rather high (1.01).

Key words: marble trout, bullhead, population density, age, growth, condition, Slovenia

TROTA MARMORATA (*SALMO MARMORATUS*) E SCAZZONE (*COTTUS GOBIO*) IN DUE FIUMI IN SLOVENIA (BACINO ADRIATICO)

SINTESI

L'articolo riporta i dati inerenti la densità di popolazione, la crescita e la condizione della trota marmorata (*Salmo marmoratus* Cuvier, 1829) nel fiume Trebuščica e dello scazzone (*Cottus gobio* Linnaeus, 1758) nel fiume Bela. Per la trota marmorata sono state studiate anche le classi d'età. La trota marmorata è la specie dominante nel Trebuščica, con una densità molto alta pari a 955 individui per ha ed un basso valore di biomassa, 26 kg per ha. Gli individui più giovani di questa specie (classi d'età 0 e 1) rappresentano l'81% dell'intera popolazione stimata. L'indice di condizione medio è risultato basso, pari allo 0.83, con il più alto tasso di crescita delle trote di 6-15 cm (rispettivamente 1.56 e 0.86). Per la tutela di questa specie, gli autori raccomandano di evitare ulteriori introduzioni di esemplari di trota fario e trota iridea, nonché di applicare restrizioni alla pesca della trota marmorata. Nel fiume Bela lo scazzone rappresenta l'86% (esemplari per ha) ed il 35% (kg per ha) dell'intera popolazione ittica. La densità dello scazzone, pari a 11708 individui per ha, corrisponde alla densità più alta mai segnalata in Slovenia.

Parole chiave: trota marmorata, scazzone, densità di popolazione, età, crescita, condizione, Slovenia

INTRODUCTION

The marble trout (*Salmo marmoratus* Cuvier, 1829) is the second largest European, exclusively freshwater salmonid species. It inhabits fast running streams with gravel bottom, low summer water temperature and high dissolved oxygen content. Marble trout is endemic to the Adriatic Sea basin, listed in Annex II at "Council on the Conservation of Natural Habitats and of Wild Fauna and Flora" (Council Directive 92/43/EEC). In the Red Data List of the freshwater fish and lampreys of Slovenia (Povž, 1996), the species is listed as endangered and it is protected by the National and Regional laws. The marble trout has restricted geographical distribution in the basin of the Po in northern Italy and in the Adriatic basins of the former Yugoslavia and Albania (Crivelli *et al.*, 2000).

The bullhead (*Cottus gobio* Linnaeus, 1758) is a small benthic fish living in clear and well-oxygenated waters, inside the salmonid zone. Bullhead, too, is threatened by water pollution and stream regulation, and the species is listed in the Slovenian Red Data List (Povž, 1996) as vulnerable. It has been protected by the "Decree of Protection of Endangered Animal Species" (Official Journal R Slovenia No. 57/1993).

Data presented in this paper are part of a complex ichthyological investigation, commissioned and financed by the manager of the freshwater fish populations in these rivers - the Fishery Society of Tolmin. The aim of this investigation was to assess, on the basis of certain physical, chemical and biological features, the ecological condition of the streams and to implement the proposals for further fishery management. The fieldwork was conducted in September 1998 and March 1999, but due to the prolonged rainy period and devastating floods in November 1998, only the 1998 data are presented herewith. This work was read at the "International Symposium on Freshwater Fish Conservation: Options for the Future" held in Albufeira in Portugal (Šumer *et al.*, 2000).

Data presented in this paper are the very first on the marble trout and bullhead populations concerning the Bela and Trebušnica rivers. The condition factors of both species and instantaneous growth rates for marble trout have never been calculated before in this country.

MATERIAL AND METHODS

Study area

The river Bela is a north-western tributary of the river Nadiža. Only part of the Nadiža, with its source in Italy, flows along the Slovenian border area and joins the river Ter in Italy. The Bela, with its source at 1,140 m a.s.l., is only 6.29 km long and flows into the Nadiža at an altitude of about 300 m a.s.l. (Fig. 1). Unfortunately, there

are no data available on the drainage area, river hydrology, or water quality.

The Bela was regulated in 1930. Its upper course has few 1-2 m high artificial weirs. This part is the trout's nursery stream. In its lower 4 km long course angling is practised. The investigation was carried out on the site located about 1 km upstream of the Bela's mouth. The 70 m long net-blocked segment (471 m²) was selected to cover potential habitat types available to the dealt with fish species.

The river Trebušnica is a 16.4 km long south-western tributary of the Idrijca. Its source is at 1,125 m a.s.l. and joins the Idrijca at about 183 m a.s.l. (Fig. 1). Its catchment area covers 74 km². According to the Hydrometeorological Institute of Slovenia (1999 and 2000), the annual water level fluctuated from 0.45 - 0.63 m to the highest 3.27 m. Annual water discharge varied from 0.5 m³/s to 2.7 m³/s with the maximum of 58.7 m³/s. The upper 6 km of the Trebušnica is a sanctuary area, inhabited by genetically pure marble trout, followed by 1 km of nursery stream. The lower 9.4 km long course is used for angling.

The investigation was carried out on the site some 3.5 km upstream of the mouth. The 150 m long net-blocked segment (2,136 m²) was selected to cover potential habitat types available to the dealt with fish species.

Sampling and methods

Fish sampling was carried out on September 19, 1998. Fish were progressively captured and removed during three to four passes with DC electrofishing equipment until the last catch reached about 15% of the first catch. Sampled sections were blocked at the upper and lower ends with 6-mm seines. Captured fish were anaesthetised, identified, measured to the nearest mm (TL) and weighed to the nearest g. Ten to twenty scales were removed below the adipose fin and above the lateral line from each marble trout. Scales' annuli were examined at x 20-40 magnification, and annuli were identified following the criteria presented by Ricker (1968). The age of fish was presented as the age groups where age group 0 refers to the first year of life. Ageing of bullhead could not be estimated, as its body is not covered with scales.

The Zippin method (Higgins, 1985), where the numbers of fish in successive catches decrease ($n_1 > n_2 > n_3$ etc.), and the Carle-Strub method, where $n_1 > n_2 < n_3$ (Lobon-Cervia, 1984) were used to determine the fish density (specimens/ha) and biomass (kg/ha). Fulton's equation was used to calculate the condition factor $K = 100 W/L^3$ (Velasco *et al.*, 1990), where L is total length (cm) and W is wet weight (g). Mean value of K for each age group was estimated separately. Instantaneous growth rates for each age group of marble trout $G = Ln$

(W_{t+1}/W_t), where W is mean weight, were also calculated (Velasco *et al.*, 1990).

Dissolved oxygen, pH, nitrate (NO_3^-), nitrite (NO_2^-), ammonia ion (NH_4^+), phosphate (PO_4^{3-}), total hardness, alkalinity, temperature, conductivity, current velocity, water discharged, and total dissolved solids (TDS) were measured. Using the transect system described by Platts *et al.* (1983), stream physical features were measured at each investigated site. Bottom substrate particle sizes were determined according to Allan (1995).

For water quality determination (Surber sampler), benthic macroinvertebrates were analysed using biotic index - I.B.G.N. (Compagnat *et al.*, 1994), and their biomass was estimated by using wet weight.

RESULTS AND DISCUSSION

The lower part of the river Bela

In view of its physical and chemical water characteristics, the Bela is a small and torrential river with diverse

bottom stony substrate (Tab. 1). Thirty different macroinvertebrates taxa were found. Numerous small organisms were the main cause for its low estimated biomass of 11 kg/ha. Its water quality is 1st class (oligosaprobic). All determined chemical concentrations were below-regulated concentrations for unpolluted waters (Zupan *et al.*, 1996).

The Bela's lower course is inhabited by three salmonid species, one hybrid (*S. marmoratus* x *S. trutta* m. *fario*) and one species of the Cottidae family (Tab. 2).

C. gobio is a dominant species in the Bela, with 86% (specimens/ha) and 35% (kg/ha) of the total estimated fish population size. Such high density of *C. gobio* has not been recorded in any Slovene water so far. At the same time we could confirm the high density of both hybrids and introduced rainbow trout (*Oncorhynchus mykiss*). Between 45 and 67% of them were individuals of age groups 0 and 1. This is also the proof of a successful reproduction of the rainbow trout in the stream. The condition factors of these specimens were also high (0.95).

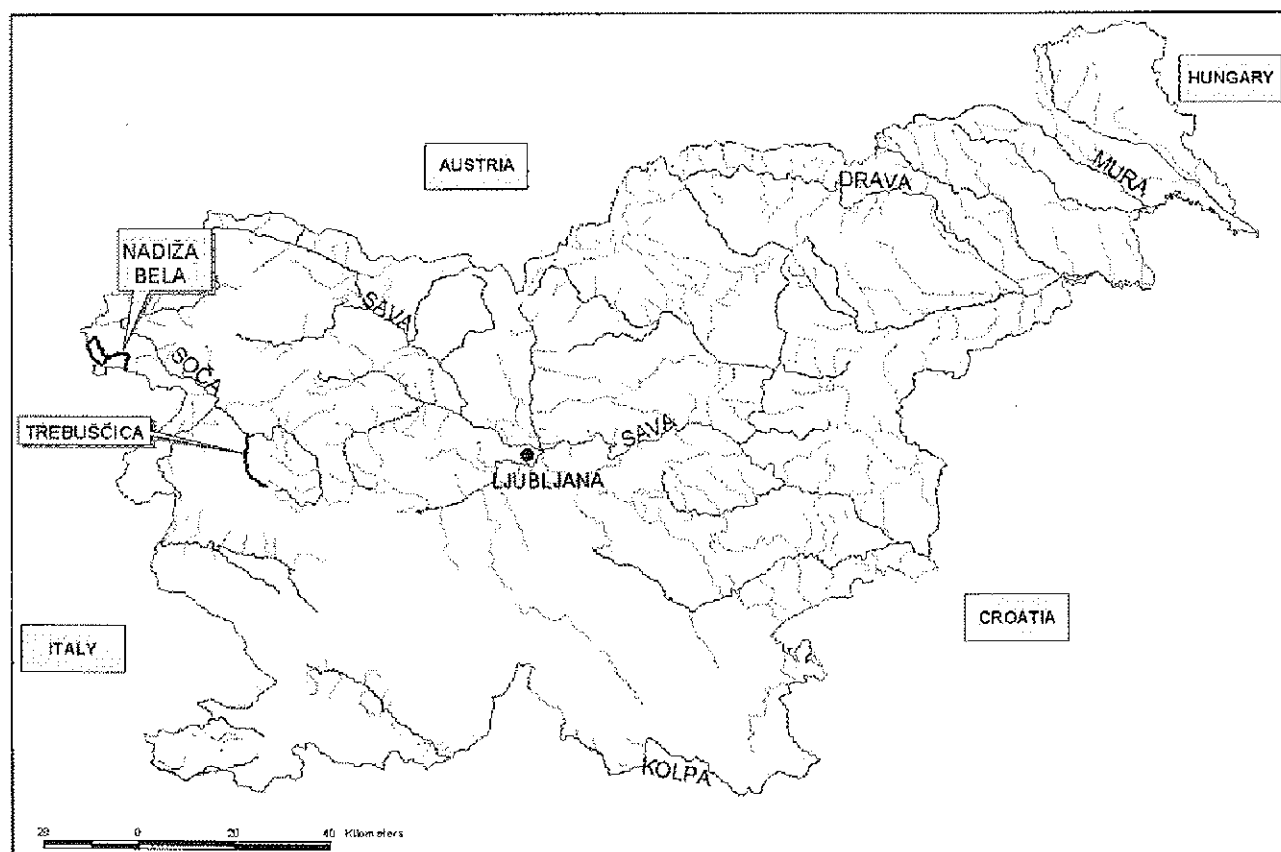


Fig. 1: Geographical location of the Bela and Trebušnica rivers in Slovenia.
Sl. 1: Geografska lega rek Bele in Trebuščice.

Tab. 1: Physical and chemical features of the Bela and Trebuščica rivers. Mean width (m) and depth (cm) with their range and bottom substrate particle sizes.

Tab. 1: Fizikalne in kemijske značilnosti rek Bele in Trebuščice. Povprečna širina (m) in globina (cm) obeh rek, razpon globine in širine ter velikost mineralnih delcev rečnega dna.

W (Min-Max)	D (Min-Max)	Bottom substrate (%)				O ₂ (mg l ⁻¹)	TDS (mg l ⁻¹)	pH	T (°C)	Conduc. (µS cm ⁻¹)	Velocity (m s ⁻¹)	Discharge (m ³ s ⁻¹)	Hardness (°N)
		Boulders	Cob- bles	Gravel	Sand								
RIVER BELA													
6.9 (5.8-10)	37.6 (25-54)	17.5	41.6	37.1	3.75	11	130	8.4	12.5	260	0.82	2.15	10.5
RIVER TREBUŠČICA													
11.11 (1.2-17.7)	32 (5-135)	0	30	63	7	11.4	130	8.7	10	280	0.61	1.6	11

Legend: W: mean width (m), D: mean depth (cm), Min-Max: minimum-maximum values, boulders >256 mm, cobbles: 64-256 mm, gravel: 2-64 mm, sand: 0.06-2 mm.

Legenda: W: povprečna širina (m), D: povprečna globina (cm), Min-Max: najnižje – najvišje vrednosti, veliki kamni >256 mm, večji prodniki: 64-256 mm, prod: 2-64 mm, pesek: 0,06-2 mm.

Tab. 2: Fish density (specimens/ha) and biomass (kg/ha) with ± 95% CI (± 95% Confidence interval) in the Bela and Trebuščica rivers.

Tab. 2: Gostota (število rib/ha) in biomasa (kg/ha) rib ± 95% CI (± 95% interval zaupanja) v Beli in Trebuščici.

Species	RIVER BELA		RIVER TREBUŠČICA	
	specimens/ha	kg/ha	specimens/ha	kg/ha
<i>S. marmoratus</i>	319 (±8)	7.7 (±1.8)	955 (±77)	25.6 (±1.9)
<i>S. t. m. fario.</i>	43 (±0)	12 (±0)	75 (±0)	4.2 (±0)
<i>S. t. m. fario</i> x <i>S. marmoratus</i>	1,940 (±29)	127.8 (±2.9)	585 (±11.5)	18.9 (±0.4)
<i>O. mykiss</i>	1,241 (±33)	74.6 (±5)	252 (±24)	11.7 (±0.8)
<i>Thymallus thymallus</i>			24 (±5)	2.7 (±0.9)
<i>Phoxinus phoxinus</i>			30 (±8)	0.6 (±0)
<i>Barbus caninus</i>			20 (±8)	1.1 (±0)
<i>C. gobio</i>	11,708 (±1,811)	75.2 (±0)		
TOTAL	13,619 (±745)	212 (±26)	1,926 (±58)	64.4 (±2.6)

Tab. 3: Mean body length, weight, condition factor, and growth rate of *Salmo marmoratus* from the river Trebuščica and of *Cottus gobio* from the river Bela.

Tab. 3: Povprečna telesna dolžina, teža, indeks kondicije in stopnja rasti soške postrvi *Salmo marmoratus* v reki Trebuščici in kaplja *Cottus gobio* v reki Beli.

Parameters	River Trebuščica - <i>S. marmoratus</i>						River Bela - <i>C. gobio</i>
	Age group (years)						
	0	1	2	3	4	7	
n	59	91	24	2	7	1	400
L	8(±1.24)	13.3(±1.06)	17.4 (±1.48)	21.8 (±1.06)	28 (±0.58)	41	9.1 (±2.17)
L-range	6-11.5	11.5-15	15.5-19.8	21-22.5	27-28.5		4.5-13.5
W	4.3 (±2.43)	20.3 (±4.93)	47.8 (±13.12)	85 (±18.38)	189.4 (±15.95)	700	8.9 (±5.38)
W-range	1.8-14	10-32	30-70	72-98	160-206		0.8-24
K	0.78 (±0.15)	0.85 (±0.07)	0.89 (±0.07)	0.82 (±0.06)	0.86 (±0.04)	1.02	1.01 (±0.13)
K-range	0.78-1.1	0.66-1.04	0.76-0.99	0.78-0.86	0.81-0.92		0.58-1.27
G	-	1.56	0.86	-	-		

Legend: n = number of fish caught, L = mean total length (cm) ±SD (standard deviation), W = mean weight (g) ±SD, K = mean condition factor ±SD, G = instantaneous growth rate of weight.

Legenda: n = število ujetih rib, L = povprečna totalna dolžina (cm) ±SD (standardna deviacija), W = povprečna teža (g) ±SD, K = povprečni indeks kondicije ±SD, G = trenutna stopnja rasti v teži.

According to Gaudin & Caillere (1990), *C. gobio* prefers shallow waters and slow to moderate current velocities, shaded areas and scarce emergent vegetation. They cite the results of other authors according to whom, quite on the contrary, the species can be found also in the zones where velocity is high. Its presence is dependent on substrate, the granulometry characterized by enough coarse elements.

The low banks of the Bela offer no overhanging vegetation and therefore no shaded areas. The river bed microhabitats had patches of algae, and occasionally *Fontinalis* sp. appeared. The number of caught bullheads was nearly the same along the entire sampling location, regardless of riffles and pools. According to Gaudin & Caillere (1990), *C. gobio* is indifferent to water depth (up to 6-9 m) but prefers coarse bottom material that gives it shelter. The Bela bottom material consists of rubbles and boulders as the main fish cover areas.

The length of the specimens (Tab. 3) was inside the length intervals cited by Oliva *et al.* (1968), Ladiges & Vogt (1979) and Terofal (1996). The mean condition bullheads' factor was rather high 1.01. According to the high population density and the estimated condition factor it appears that the Bela holds favourable environmental conditions for this species.

The river Trebuščica

In general, the lower course of the Trebuščica is wider than the Bela, characterized by more fluctuating water depth and stream width and less diverse bottom substrate (Tab. 1). Twenty different macroinvertebrates taxa were identified. Their low biomass (6 kg/ha) is among the lowest benthic biomasses recorded in the streams of the Adriatic Sea basin (with regard to the September sampling). Its water quality is 2nd class (betamesosaprobic). Surrounding areas are free of industry, but with more inhabitants, villages and arable land. In the Trebuščica, too, all determined chemical concentrations were below regulated concentrations for unpolluted waters (Zupan *et al.*, 1996).

Six fish species and a hybrid (*S. marmoratus* x *S. trutta* m. *fario*) of the families Salmonidae, Cyprinidae and Thymallidae inhabit the Trebuščica. *S. marmoratus* makes 49% of the Trebuščica's total estimated population density and 40% of its total biomass. Its population density is among the highest in the Slovenian Adriatic Sea basin streams (Tab. 2).

The estimated biomass was low due to high abundance (81%) of young fish (age groups 0 and 1). There were only few sexually mature specimens of age groups 3 and 4. In comparison with other salmonids, the condition factor of the marble trout was the lowest, while the growth rate of 6-15 cm long specimens was the highest (Tab. 3). The reason for the lowest condition factor may be associated with limited environmental conditions and introduced indigenous fish species occupying available ecological niches in the stream.

The relatively high abundance of young fish is due to the fishery management. From 1996 on, marble trout of size 9-15 cm have been intensively stocked. At the same time there is also a possibility of migrations from the upper course of the river, inhabited only with marble trout (sanctuary and nursery stream segments). There are numerous young fish, with very few catchable size adults.

In Slovenia, strong decline of this species has been recorded during the last 80 years. It is threatened by a permanent introduction of brown trout (*Salmo trutta*), water pollution, river regulation and reservoir constructions (Povž *et al.*, 1996). The marble trout is heavily affected by stocked alien Atlantic *S. trutta* and Danubian and/or Mediterranean *Salmo* species, and presently there are only few populations of marble trout that are believed to be unaffected by introgression (Delling *et al.*, 2000). By the end of the last century, brown trout of different origins have been introduced into geographical area where the marble trout occurs, quickly resulting in hybrid populations (Crivelli *et al.*, 2000). In the Adriatic basin of Slovenia, the first introductions took place in 1906 (Povž *et al.*, 1996). During the marble trout rehabilitation project, which began in 1993, eight genetically pure populations were discovered in headwater streams in the upper reaches of the Soča river in Slovenia, the Trebuščica being one of them. As a result of the first phase of this project, the prohibition on the release of *Salmo trutta* in the Soča watershed became effective in 1996 with the "Curricular for the ban of brown trout stocking in the Adriatic Sea basin, Slovenia" (Ministry of Agriculture, Forestry and Food, March 25th, 1996).

Both rivers are rather narrow with low water level (especially the Bela). According to the September data, the amount of food source is quite limited. The latter and the genetic conservation of marble trout were the most important reasons for the recommendation of a suitable management based on no introduction of other fish species and angling restrictions of marble trout.

SOŠKA POSTRV (*SALMO MARMORATUS*) IN KAPELJ (*COTTUS GOBIO*) V DVEH SLOVENSКИH REKAH SEVERNOJADRANSKEGA POVODJA

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POVZETEK

Avtorji pričujočega raziskovalnega dela so merili populacijsko gostoto, stopnjo rasti in kondicijsko stanje soške postrvi *Salmo marmoratus* Cuvier, 1829 v reki Trebuščici ter kaplja *Cottus gobio* Linnaeus, 1758 v reki Beli. Starostno strukturo so ugotavljali le pri soški postrvi. Soška postrv je v Trebuščici dominantna vrsta z visoko gostoto 955 osebkov/ha in nizko biomaso 26 kg/ha. Najmlajši osebki soške postrvi (starostna skupina med 0 in 1) sestavljajo 81% celotne ocenjene populacije. Povprečni indeks kondicije je bil nizek (0,83) z visoko stopnjo rasti 6-15 cm dolgih postrvi (1,56 oz. 0,86). Za zaščito avtohtone soške postrvi avtorji odsvetujejo nadaljnje vlaganje amerikkank in potočnih postrvi in hkrati vztrajajo pri omejitvah sportnega ulova soške postrvi. Kaplji v reki Beli sestavljajo kakih 86% (osebkov/ha) in 35% (kg/ha) celotne ribje populacije. Njihova gostota 11.708 osebkov/ha je najvišja, kar jih je bilo doslej zabeleženih v Sloveniji. Povprečni indeks kondicije kapljev je bil razmeroma visok (1,01).

Ključne besede: soška postrv, kapelj, populacijska gostota, starost, stopnja rasti, kondicijsko stanje, Slovenija

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