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Short communication

The condition of allochtonous fishes in the Mediterranean Vransko Lake

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Introduction

Fish introductions were a popular tool of fishery management during the 19th and most of the 20th century, aiming mainly to enhance productivity. With this objective in mind the Croatian Mediterranean Vransko Lake, only one kilometer from the Adriatic Sea (Fig. 1), was stocked after WWII with common carp from the Danube area in order to reduce food shortages. At the time, the lake was inhabited mainly by euryhaline native fish species together with some euryhaline marine species that occasionally entered the channel connecting the lake to the sea. Eventually, intentionally or by chance, a number of other freshwater species from the Danube area of northern Croatia were also introduced into the lake. As a consequence, the ichthyofauna of the lake has changed and now consists of nine euryhaline species and eight introduced freshwater species (Mrakovčić, 2004).

Competition for food and habitat became an important factor in structuring this fish community, since environmental factors largely determine the distribution and resource partitioning among organisms, their growth and mortality (Krebs, 1994). Very soon after the first introductions the allochtonous ichthyofauna represented a much larger portion of both commercial and experimental catches. For years, more than 97% of all catches consisted of four introduced species: rudd (*Scardinius erythrophthalmus*), Prussian carp (*Carassius gibelio*), common carp (*Cyprinus carpio*) and European catfish (*Silurus glanis*) (Treer et al., 2009b). Thus, the aim of this paper was to ascertain their present condition in this oligotrophic lake located close to and partially linked with the Adriatic Sea (Mediterranean).

Material and methods

Sampling of fish in the lake was performed three times during the vegetation period in 2008 (12 June, 16 July, and 1 October), after the target fish species had reached their optimal condition in the yearly cycle. Trammel nets (25 m), which remained stationary overnight for 12 hours, were used at three locations along the lake (Fig. 1). The fish were immediately measured for total length in cm (L) and weight in grams (W).

To establish length-weight relationships $W = aL^b$ was applied (Ricker,1975), where W = weight in grams, L = total

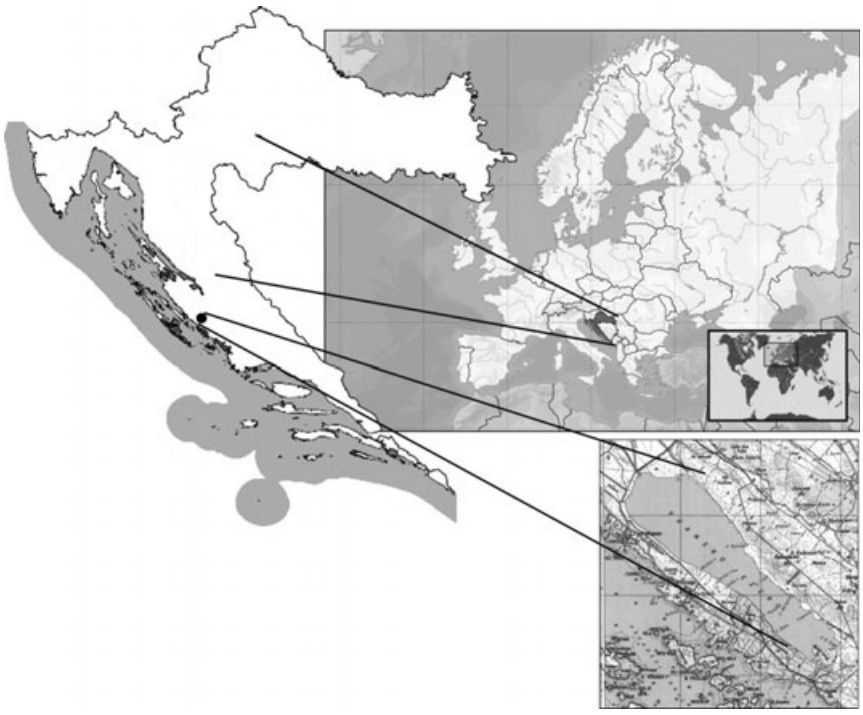

Fig. 1. Location of Vransko Lake and sampling sites

Table 1
Number of specimens caught (n), length span (L min–max), condition factor (CF), and value b from length–weight equation for investigated species caught in 2008 (*result of small length range of fish caught, which was under 5 cm). Average condition factors from Croatia for these species (CF Ø) presented for comparison (Treer et al., 2009a)

Species	n	L min–max (cm)	CF	CF Ø	b
Scardinius erythrophthalmus	87	25.0–42.0	1.65	1.081	3.5403
Carassius gibelio	15	37.5–42.3	2.02	1.791	(4.3001)*
Cyprinus carpio	6	54.4–65.0	1.40	1.640	3.2276
Silurus glanis	7	50.0–118.2	0.63	0.586	3.739

Table 2
Ratio of fish mass (%) of main freshwater fish species in total fish catch by commercial gear, Vransko Lake, over past six decades (Mrakovčić, 2004; Ržaničanin et al., 1986; Treer, 1989)

	% of catch			
Species	1950	1985	2004	2008
Cyprinus carpio	89.1	5.2	12.5	13.4
Carassius gibelio	–	61.3	58.1	13.8
Scardinius erythrophthalmus	–	–	14.9	47.1
Silurus glanis	–	31.3	6.9	23.1
Total	89.1	97.8	97.8	97.6

length in cm, and a and b were the constants. The condition factor (CF) was calculated as:

$$CF = W \cdot L^{-3} \cdot 100$$

Results

Altogether 115 fish specimens of these four species were caught; most numerous was rudd (n = 87), and only six common carp (Table 1). The condition factors for all species were relatively high except for common carp (CF = 1.40), which was lower than average for Croatia (Treer et al., 2009a). After the common carp introduction and its almost 90% dominance for two decades, Prussian carp and rudd were introduced in the late 1980s. Since then, these latter two species have constituted over 60% of the catch, while that of common carp dropped to about 13% (Table 2).

Discussion

The freshwater Vransko Lake (3000 ha, average depth 2 m) is very close to the Adriatic Sea, but isolated from other freshwater bodies populated with many endemic fish species of the Dalmatian division, the most specific of all the Euro-Mediterranean subregions (Economidis and Banarescu, 1991). Moreover, the lake is quite some distance from the Danube River system (separated by a high mountain range and several hundred kilometers). Thus, fish invasion of the lake is primarily anthropogenic, whereby common carp and mosquito fish (*Gambusia affinis*) were intentionally introduced while some other species (e.g. European catfish) were accidental introductions along with common carp. Anglers purportedly introduced other invasive species, mainly as bait for carnivorous fish (Treer, 1989). This geographical barrier, as mentioned by Copp et al. (2005), could be the main reason why invasive species such as Balon's ruffe (*Gymnocephalus baloni*) and bighead goby (*Neogobius kessleri*), although present in northern Croatia (Povz et al., 1997; Kovac et al., 2009), have not reached Vransko Lake.

The opportunistic strategy of Prussian carp and its ability to establish large, viable and persistent populations (Leonardos et al., 2008) was at work. However, this competition did not significantly influenced the CF of common carp, as it was still in the range of values (CF = 1.24–1.46) registered in the 1960s (Treer et al., 2003) and the beginning of the 1980s (CF = 1.15–1.40) (Treer et al., 1995). They are also comparable to those of wild common carp from central Europe [1.48–1.51 (Steffens, 1964); and 1.31–1.43 (Unterüberbacher, 1963)], higher than those found in some Australian waters (1.13–1.25) (Adámek, 2002) and lower than those in the Turkish Karakaya Dam Lake (1.640–2.093) (Ozmen et al., 2006).

On the other hand, the CFs of Prussian carp (CF = 2.02) and rudd (CF = 1.65) appeared to be significantly higher than those from some other Mediterranean lakes, such as 1.86 in the Greek Lake Chimaditis (Leonardos et al., 2008) and 1.21 in Turkish Lake Sapanca (Tarkan, 2006), respectively. A study in 71 Danish lakes showed that body weight of cyprinids increased significantly with a decrease in the phosphorus content (Jeppesen et al., 2000), while Tsoumani et al. (2006) calculated the equation for 12 Greek lakes, showing significant negative correlation between the trophic state of the water and the b values from the length-weight relationship. This is attributed to the food preferences of small vs large specimens, because in eutrophic lakes the abundance of large zooplankton, preferred by large specimens, is frequently reduced and is reflected in the fish growth. Vransko Lake is oligotrophic (Treer, 1988), with the relatively large calanoid copepod *Calanipeda acquae-dulcis* as the dominant zooplankton species (Treer, 1990).

This fact is confirmed by the high b values of the species in Vransko Lake. However, the b value for Prussian carp is unrealistically high (b = 4.3), most likely a result of the small length range caught, which was less than five centimeters. At any rate, all b values were positively allometric, while those for rudd (b = 3.54) and European catfish (b = 3.17) exceeded the maximum in FishBase, of 3.48 and 3.00, respectively (Froese and Pauly, 2009), although Özcan (2008) registered one even much higher (b = 3.568) in seven specimens of European catfish, as in the present study. European catfish owes its good condition to the good state of the cyprinid prey in Vransko Lake. These b values are higher for common carp, Prussian carp and rudd, and are similar in European catfish to the averages obtained for Croatian waters (2.895; 3.285; 3.410 and 3.034, respectively) (Treer et al., 2008).

Since the late 1940s, introduced fish species have been dominant in Vransko Lake. Despite its oligotrophy, the lake provides appropriate living conditions for these species because they benefit from the mild climate and prolonged vegetation period.

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