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Short communication

Condition of huchen (*Hucho hucho* Linnaeus, 1758) from the Croatian-Slovenian Kupa River

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Introduction

The huchen (*Hucho hucho*) is the top predator of salmonid waters in the Danube watershed. This species is sensitive to disturbances in its habitats (Clarke and Warwick, 1994) such as that of dam construction, river flow regulation and water pollution. On the IUCN Red List as endangered (EN), these threats and the present scientific data on *Hucho hucho* biology were addressed at the Second International *Hucho* Symposium organized in Łopuszna, Poland in September 2012, 24 years after the first symposium was held in Germany (Skalin, 1990).

Inhabiting rivers in north-western Croatia, which are direct or indirect tributaries of the Danube, the huchen also carries the same IUCN endangered (EN) status in Croatia (Mrakovčić et al., 2006). This is particularly true for the Drava River, where specimens over 30–40 kg were common before WWII; however, after a series of dams were built, now even small specimens are rarely caught (Mateš, 2005). The Kupa River, on the other hand, still has a vital huchen population. Regular stocking of fingerlings from a hatchery in Slovenia strengthens this population.

Most papers on huchen have mainly concerned genetics (e.g. Ocalewicz et al., 2008; Geist et al., 2009; Weiss et al., 2011) and habitat (Holzer, 2011; Ratschan and Schmall, 2011). Nevertheless, data on *H. hucho* growth and condition are limited. These parameters listed in the FishBase are for just one specimen (Froese and Pauly, 2013). Similarly, only one paper on this topic could be found in the Web of Science (Simonović et al., 2011). In Croatia, two not very recent papers were published on age-length relationships of *H. hucho* (Sabioncello et al., 1970; Pažur et al., 1982), but none on condition or length–weight relationships.

Fulton's condition factor (CF) is a well-established parameter in fishery management. Within a population this depends on a variety of internal (genetics, stages of development, shape) and external (e.g. food availability, water quality) parameters. It is also specific for each species (Fafioye and Oluajo, 2005; Froese, 2006; Treer et al., 2009). The objective of this paper was to study two similar relationships of top predatory fish such as the huchen; namely, the CF and fish length and length–weight relationships.

Materials and methods

Data were collected from huchen caught by angling from October to February for 5 years (2008–2012) in the Kupa River bordering Croatia and Slovenia. Initiating from karstic springs beneath the Risnjak mountains at 321 m a.s.l., the Kupa River is 296 km long before flowing into the Sava River at 98 m a.s.l. Continued presence of huchen has been noted upstream of the town of Ozalj (147 m a.s.l.), where there is a large dam. After capture, the fish were immediately measured for total length (TL) to the nearest 0.5 cm, weighed to the nearest 100 g, and selected specimens photographed. Immediately after data collection the specimens were released back into the river. Regulations do not allow anglers to mark the fish, thus, although small, there is the possibility that some specimens were caught more than once. Data were collected at rkm 37, between the villages of Gašparci and Blaževci (Fig. 1).

To establish the length–weight relationship the commonly used $W = aTL^b$ was applied (Ricker, 1975), where W = weight in grams, TL = total length in cm, and *a* and *b* are constants. Fulton's condition factor (CF) was calculated as:

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

To transfer standard lengths into total lengths the equation according to Andreji and Stráňai (2013) was used:

$$TL = 1.43844 + 1.07733SL.$$

Results

A total of 58 huchen specimens were caught with lengths varying between 70 and 116.5 cm and weights from 4.5 to 18 kg. Fishing season for huchen is open from 1 October to 15 February and minimum allowable catch size is 80 cm. The most common angling technique is active casting using artificial lures with a minimum allowed size of 18 cm (Anonymous, 2005). Such large lures attract only large fish, one of the reasons why our data set includes no fish smaller than 70 cm. Thus the results are representative of only a sample of large fish and not the entire population.

The length–weight relationship expressed negative allometric growth ($W = 1.4171$ $TL^{1.9230}$, $r^2 = 0.892$, $P < 0.01$;
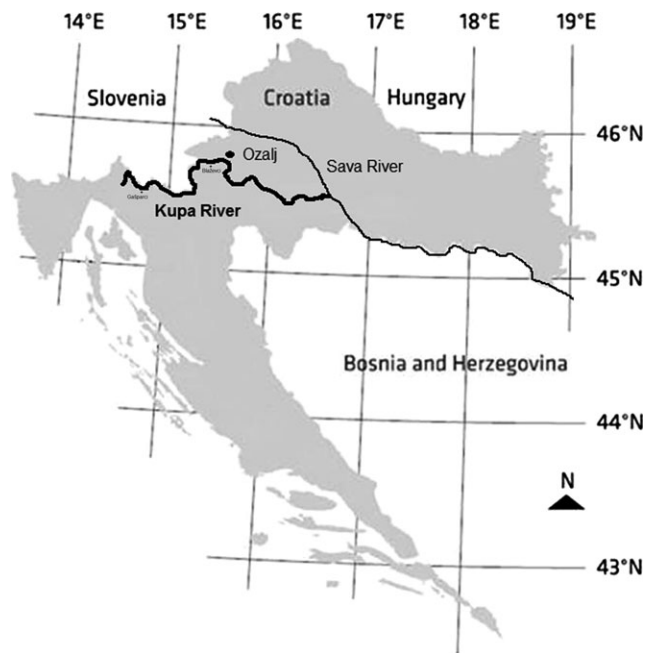
Fig. 1. Location of Kupa River. Solid black oval indicates 37 km section of the river between the villages Gašparci and Blaževci where *Hucho hucho* were caught

Fig. 3. Relationship between total length and condition factor of huchen from Kupa River. Values after the breakpoint are encircled

P < 0.01) when the *b*-value was lower than 3 (Fig. 3). The variation of CF was therefore very wide (CF = 1.1559; SD = 0.2051; range = 0.75–1.60). However, at the same breakpoint as for the *b* value (about 110 cm TL, Fig. 2), the CF changed the relationship from negative to positive.

Discussion

The *b* value appeared to be very low (only 1.923), fitting almost the lowest possible biological range. Such low values around 2, although rare, are not unusual, e.g. *b* = 1.970 for *Nerophis ophidion* (Ozaydin and Taskavak, 2006), *b* = 2.068 for *Odontamblyopus lacepedii* (Li et al., 2013), and *b* = 2.086 for *Sphyraena sphyraena* (Ceyhan et al., 2009). However, the low *b* value in this research cannot merely be explained by a lack of biologically optimal conditions for the oldest fish. Simonović et al. (2011) showed that huchen in the River Drina, at Bosnian-Serbian border, grew more rapidly in length than in weight during early growth stages. After reaching the standard length (107.45 cm TL) the huchen begins to grow more rapidly in weight than in length. Therefore, two length–weight relationships were counted – one up to the breakpoint at 98.4 cm SL and the other above 98.4 cm. It appeared that the *b* value was 2.187 at younger stages, while it increased to 3.910 in older stages. An investigation of the same population performed over 10 years ago reported this breakpoint at 110 cm SL (119.94 cm TL). Similarly, the fish from the Kupa River began to gain weight faster only when total length was about 110 cm (Fig. 2), although only few specimens attained such lengths. Low *b* values for the entire sample can be found in other studies, for example in the paper by Radević (1999), who noted 2.3238 in the Bosnian Vrbas River. Mikavica (1987) had also reported
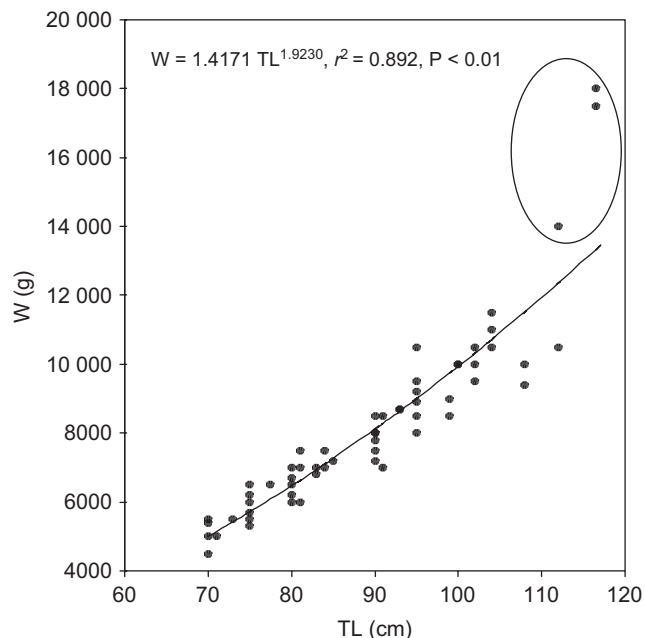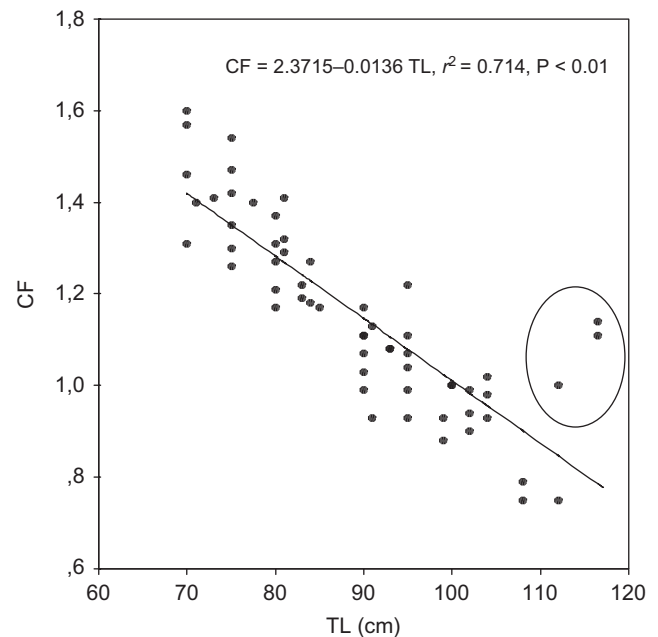

Fig. 2. Total length–weight relationship of huchen from the Kupa River. Values after the breakpoint are encircled

Fig. 2). When the two largest fish were excluded from the data set as outliers, the relationship was W = 1.4171 TL$^{1.7585}$ (r^2 = 0.906, P < 0.01).

The regression between CF and total length in the Kupa River was negative (CF = 2.3715–0.0136 TL, r^2 = 0.714,

a *b* value of 2.3255 for the Bosnian-Serbian Drina River. Nevertheless, Andreji and Stráňai (2013) registered a *b* value of 3.256 in an investigation of huchen on the Slovak Dunajec River, whereby the data could be explained by the large number of fish with lengths above the breakpoint length. While low *b* values were found in populations where maximum size was relatively low (as in the Vrbas, Drina and Kupa rivers), in the Dunajec River the *b* value was high and maximum size also high. Investigating 28 Austrian and Bavarian rivers, Ratschan (2012) proved that maximum size in huchen depends on the size of the river. In accordance with this statement is the fact that the largest huchen specimen ever caught in the Kupa (a relatively small river) was only 120 cm TL (Pažur et al., 1982). Therefore only limited numbers of fish with a length over the breakpoint can be caught.

For this reason Simonović et al. (2011) did separate counts (based on SL) for younger (CF = 1.074) and for older specimens (CF = 1.190). Nevertheless, as the CF of huchen changes continually with a change of length, these values were not informative enough. This is contrary to some other fish species whose CFs are considered stable throughout their lifespan, as Kangur (1996) and Treer et al. (2003) reported for bream (*Abramis brama*). Similarly, the investigations of other salmonid species, such as brown trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*), showed small variations in the condition factor throughout their life span (Pilecka-Rapacz, 2011; Caldarone et al., 2012). This type of growth in huchen (much faster in length than in weight) could be due to its more elongated body in comparison to other salmonid species (Vuković and Ivanović, 1971). The breakpoint in huchen growth type does not happen when a mature specimen nears 70 cm TL and is 5 years old, but only later, when the individual is approximately 8 years old (Simonović et al., 2011). The same authors also suggested that this later shift might have been related to the change in huchen reproductive characteristics affected by the population structure.

In summary, the specific conclusions of our research are: confirmation of the Simonović et al. (2011) findings that growth of huchen is unique compared to other species concerning length–weight relationship; confirmation of the Ratschan (2012) findings that maximum sizes of huchen specimen depend on the respective river size; that CF values change between the different length classes.

When applying these findings to huchen management it is important to know that the CF not only depends on environmental conditions, but also strongly on the length. This means that low CFs at certain lengths do not necessarily reflect sub-optimal habitat conditions, because huchen grow much faster in length (even to over 1 m TL) than in weight during the first years of their life.

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