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# Length-Mass Relationship in Chub (*Leuciscus cephalus*) from Five Croatian Rivers

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**SUMMARY**

The length-mass relationship of chub in five Croatian rivers was investigated. According to that relationship the rivers were divided into three groups. During their first years in the warm rivers of the Pannonian valley (Lonja and Bednja), the chub have high condition factor which comes down to an average (1.21±0.10 and 1.29±0.10) when the entire life is taken into consideration. For that reason its allometric factor b is lower than 3 (2.875 and 2.872). Long vegetation period of these rivers ensures the best CF as well as the best growth in length.

The chub from the Kupa and Dobra rivers that flow down the mountain slopes, were slower in growth up to the fourth year, when they reached CF around 1.2. Likewise, their average values of condition factor were 1.10±0.10 and 1.08±0.17 and their allometric b factor was higher than 3 (3.240 and 3.369 respectively).

The worst conditions for both - length and mass growth of chub were in the river Lika. Being cooler and oligotrophic mountainous river, the average CF value was 0.99±0.08 and b factor was 2.670.

The length-mass relationship of the five chub populations investigated are a precise reflection of the overall environmental conditions of the rivers they inhabit.

**KEY WORDS**

**growth, chub, length-mass relationship, Leuciscus, Croatia**

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# Dužinsko-maseni odnosi klenova (*Leuciscus cephalus*) iz pet hrvatskih rijeka

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**SAŽETAK**

Odnos dužinskog i masenog rasta klenova proučavan je u pet hrvatskih rijeka. One prema tom odnosu mogu biti svrstane u tri skupine. U toplim nizinskim rijekama Lonji i Bednji klenovi u prvim godinama života imaju visoke faktore kondicije, koji prosječno kroz cijeli život iznose 1.21±0.10 i 1.29±0.10. Zbog toga im alometrijski faktor b ima vrijednost manju od 3 (2.875 i 2.872). Dug vegetacijski period u ovim rijekama omogućuje najbolji i dužinski rast i faktor kondicije.

Klenovi iz rijeka prijelaznog područja, Kupe i Dobre, nakon početnog sporijeg rasta, od četvrte godine života dostižu faktore kondicije oko 1.2, tako da su im ukupne prosječne vrijedosti 1.10±0.10 i 1.08±0.17. Zbog toga im je i alometrijski faktor b veći od 3 (3.240 i 3. 369).

Hladna i oligotrofna planinska rijeka Lika ima najslabije uvjete za rast klena i u dužinu i u masu, s prosječnim faktorom kondicije 0.99±0.08, te b vrijednosti 2.670.

Dužinsko-maseni odnos pet ispitivanih populacija klenova pokazao je jasan odraz ukupnog stanja u rijekama koje nastavaju.

**KLJUČNE RIJEČI**

**rast, klen, dužinsko-maseni odnos, Leuciscus, Hrvatska**

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## INTRODUCTION

Besides a well known fact about morphometric measures of fish being important in all aquaculture investigations (e.g. Treer, 1985; Safner et al., 1998), it is essential to know the length-mass relationship when assessing and comparing the state of different water bodies (i. e. Prem Kumar et al., 1984; Prenski, 1984; Dulčić et al., 1994; Kraljević et al., 1994). As the length of the fish is the parameter more stable than the mass, there are more papers dealing with the length growth of chub only (i.e. Hickley and Dexter, 1979; Simonović et al., 1997; Treer et al., 1997, 1998). However, there are also investigations where both length and mass parameters in chub are dealt with (Geldiay and Balik, 1973; Habeković et al., 1993). Feeling "at home" in different river sections as well as in stagnant waters and feeding on animal as well as on plant organisms (Vuković, Ivanović, 1971) the chub is a very useful species when comparing different habitats.

The rivers from different parts of western Croatia are investigated in this research. The influence on chub populations whether those rivers flow through the cold mountainous part of the country or across warmer lowlands have been looked into through length-mass relationship and the condition factor.

## MATERIALS AND METHODS

Data on chub growth in Croatia was collected from five locations: the Bednja river, the Lika river, middle section of the Dobra river and the upper sections of the Lonja and Kupa rivers (Fig. 1). The conditions in these rivers are shown in Table 1.

Length and mass data (Table 2) of 252 chub were analyzed: 87 specimens were from the Dobra river, 108 from the Bednja, 24 from the Lika, 20 from the Kupa and 13 from the Lonja. All the specimens were caught by electric gear during the growing season under physiologically equal conditions.

Total length was measured with the precision of 1 mm and mass of 1 g. The age was determined on the scales by annuli. The length-mass relationships were counted for each age group.

Allometric length-mass relationship was described by the following equation:

$$W = aL^b$$

where: W = mass in grams
L = total length in centimeters
a = constant
b = constant described as allometric or length-mass factor

Condition factor (CF) was calculated as:

$$CF = WL^{-3}10^2$$


Figure 1. The locations of investigated rivers

## RESULTS AND DISCUSSION

The investigated rivers, except in their position and climatic influence, differ in their chemical and biological composition, as well (Table 1). The Lonja and Bednja from the Pannonian valley have the biggest amount of organic matter shown through the highest COD values. The Dobra and Kupa rivers, although flowing through the mountainous slopes still have significant quantities of benthic organisms, while the cold Lika river is the poorest in all investigated parameters.

The parameters of allometric length-mass relationship are presented in Table 2. All of them vary between 2.670 and 3.369. Being within 2.5 and 4.0 these values are considered the fish growth's limit (Hile, 1936; Martin, 1945). It is evident that b values in the rivers Dobra and Kupa are higher than 3. Chub in those rivers grew better in the mass than in the length (Fig. 2). As the result of lower masses of chub in those rivers during their first years (Table 3), the CF during the same period is also low - bellow 1. Towards the fourth year, the chub gain in mass and obtain the CF values of the fish from other rivers - around 1.2 (Fig. 3), which corresponds to the statement by Beverton and Holt (1957) that instances of marked deviation from isometric growth in adult fish are rare.

Lower than 3 CF values of chub from the Lonja and Bednja rivers do not mean the chub was in bad condition. On the contrary, the chub's first years in those rivers started with considerably high masses and its CF values stabilized in the adulthood around 1.2. As the chub in these two rivers was also characterized by the best growth in length (Treer et al., 1998), it is needless to say that the environmental conditions of those rivers suited chub the best.

As the river Lika is the only unfavorable river for chub's growth in both - mass and length, the investigated rivers can be divided into three groups: the lowland rivers Lonja and Bednja with good chub growth right from the hatching; the Kupa and Dobra rivers on the mountain slopes where chub, after a poor start, averages its growth values in adult stage; and finally the mountainous river Lika where conditions are unfavorable for the growth of chub all the way through. Among other parameters, (some of which are mentioned in Table 1), the temperature is also an important one to tell the difference. Highest temperatures along with longest vegetation period characterize the rivers of the Pannonian valley-Lonja and Bednja. On the other hand, high CF values, but poor growth in length of chub from the Sava river (Habeković et al., 1993) can be juxtaposed to the regime of the river Kupa as well as to the.springs of Pinarbasi originated stream in Turkey (Geldiay and Balik, 1973)

As growth of fish in length and mass belong to the morphometric traits, their heritabilities ($h^2$) are generally low (Tave, 1993). This is particularly true for the

**Table 1.** Some chemical and biological parameters from the investigated rivers: chemical oxygen demand in mg $KMnO_4 \cdot l^{-1}$ (COD), $NH_4^+$, $NO_3^-$ and $PO_4^{3-}$ in $mg \cdot l^{-1}$ and benthic invertebrates in $g \cdot m^{-2}$ (min-max)

| Parameters | Dobra | Bednja | Lika | Kupa | Lonja |
|---|---|---|---|---|---|
| COD | 4.7-6.7 | 5.7-36.4 | 0.0-16.8 | 1.9-5.4 | 5.7-12.0 |
| $NH_4^+$ | 0.06-0.07 | 0.12-1.47 | 0.02-0.30 | 0.05-0.05 | 0.12-0.26 |
| $NO_3^-$ | 0.16-0.47 | 0.05-0.49 | 0.00-0.09 | 0.03-0.15 | 0.08-0.16 |
| $PO_4^{3-}$ | 0.03-0.23 | 0.07-2.76 | 0.01-0.18 | 0.01-0.03 | 0.03-0.18 |
| benthos | 5.10-16.09 | 3.34-45.56 | 0.00-010 | 1.83-4.47 | 0.72-2.79 |

**Table 2.** The constants of the length-mass curve (a. b). related coefficient of correlation ( r ) and the number of analyzed chub ( n ) from the investigated rivers.

| | Dobra | Bednja | Lika | Kupa | Lonja |
|---|---|---|---|---|---|
| length-mass constant a | 0.0038 | 0.0185 | 0.0267 | 0.0055 | 0.0169 |
| length-mass constant b | 3.369 | 2.872 | 2.670 | 3.240 | 2.875 |
| correlation coefficient r | 0.999 | 0.999 | 0.995 | 0.999 | 0.999 |
| number of chub n | 87 | 108 | 24 | 20 | 13 |

**Table 3.** Condition factors (CF) of analyzed chub according to age from the investigated rivers

| Age | Dobra | Bednja | Lika | Kupa | Lonja |
|---|---|---|---|---|---|
| 0+ | 0.78 | 1.52 | - | - | 1.36 |
| 1+ | 0.89 | 1.34 | 0.90 | 0.97 | 1.26 |
| 2+ | 1.08 | 1.23 | - | 1.03 | 1.20 |
| 3+ | 1.13 | 1.26 | 0.98 | 1.08 | - |
| 4+ | 1.19 | 1.25 | 0.94 | 1.25 | 1.10 |
| 5+ | 1.28 | 1.15 | 1.12 | 1.15 | 1.11 |
| 6+ | 1.23 | 1.27 | - | - | - |
| 7+ | - | 1.26 | - | - | - |
| Mean | 1.08 | 1.29 | 0.99 | 1.10 | 1.21 |
| SD | 0.17 | 0.10 | 0.08 | 0.10 | 0.10 |

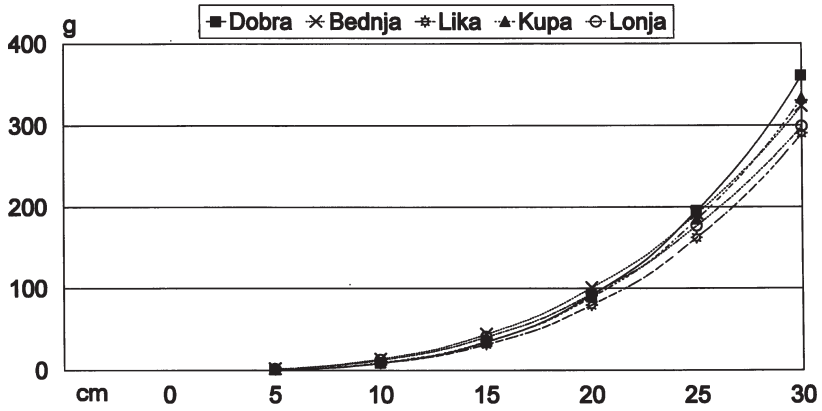


**Figure 2.** Length-mass relationship of five investigated chub populations

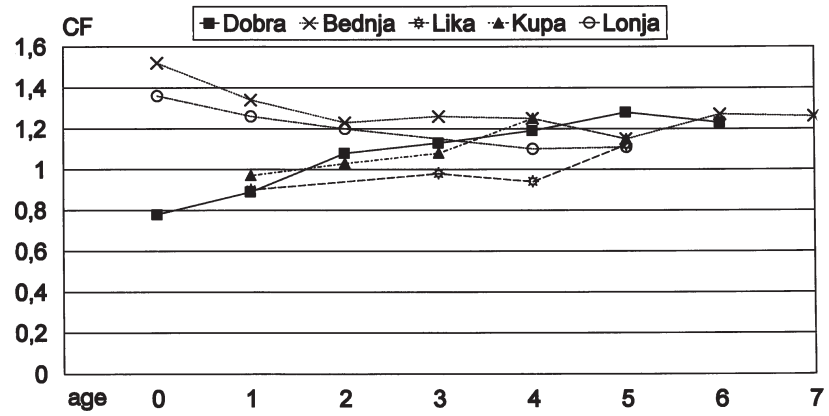


**Figure 3.** Condition factor (CF) of five investigated chub populations

combined parameters, as the condition factor (Gunnes and Gjedrem, 1978, 1981; Gjerde and Gjedrem, 1984; Gjerde, 1989). So, it is hard to accept that b value of length-mass relationship is to a greater extent the result of genetic influences and as such use it to differentiate fish populations (Le Cren, 1951). As Frost (1945) had already quoted, all of the growth parameters (CF, b value, L∞, K) are first of all the results of the environmental conditions that rule over a certain water body, and as proven by the results of this paper, those conditions are powerful means in comparing various water habitats.

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