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# PRELIMINARY INSIGHT INTO AGE AND GROWTH OF THE IBERIAN CHUB (LEUCISCUS PYRENAICUS) IN THE SORRAIA SYSTEM

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Abstract

An investigation of age and growth in the Iberian chub *Leuciscus pyrenaicus* Günther, 1868 revealed a seasonal growth pattern, with annulus formation restricted to a short period of the year (May/June). Maximum ages were 6+ for both sexes. During and after the third year females grew at faster rates than males, and the most important decrease in growth rates occurred between age II and III in males and between age III and IV in females. Mean back-calculated standard lengths of III and IV age classes were significantly higher in the River Sorraia. Mean weights of I and II age classes were higher in Sor stream whereas the individuals from III ad IV age classes were heavier in the River Sorraia. Shifts in growth rates are discussed in relation to seasonal and spatial variations in the environmental conditions as well as to sexual maturity.

## Introduction

The Iberian chub *Leuciscus pyrenaicus* is widely distributed, occurring in almost all catchments of southern Portugal (Almaça 1965). Nevertheless information on its growth patterns is limited to Spanish populations (Lobon-Cervia 1982a, Lobon-Cervia & Sostoa 1987, Rodriguez & Granado 1991).

The aim of the present study is to provide the first description of growth in Portuguese populations of Iberian chub. In doing so, our investigation will address the validation of age using scales and examine the patterns of longitudinal and ponderal growth with age and between sexes. Samples from populations in River Sorraia and one of its tributaries (Sor stream) were compared to assess eventual differences on linear and ponderal growth.

## Material and Methods

The study was conducted in the Sorraia catchment (Fig. 1). The R. Sorraia flows for about 77 km through an alluvial plain with a mean altitude of 200 m and discharges into the upper part of the Tejo estuary. The Sor stream is the Sorraia's largest tributary and is about 100 km in length. Water discharge is highly variable through the year, reaching a maximum in February and a minimum in summer months (July-September) coincident with the minimum and maximum temperatures (Table 1). The River Sorraia contained water year round, whereas the Sor often dries up partially during summer becoming intermittent in character.

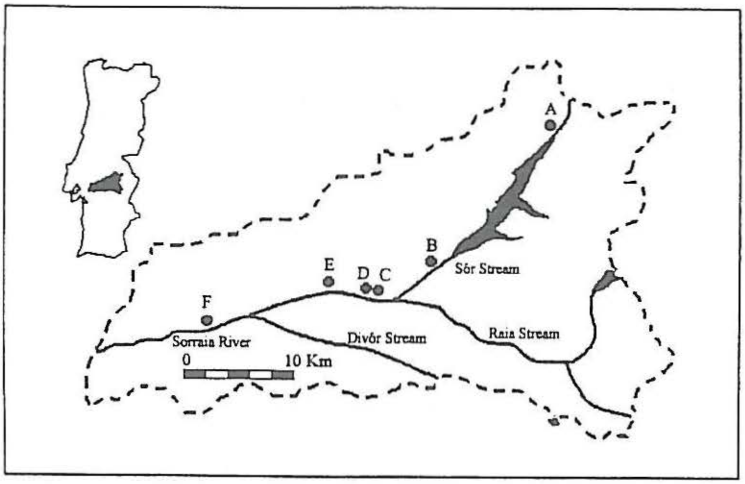


**Fig. 1.** Sampling sites in the River Sorraia catchment.

The banks are covered with *Salix* spp. and the major macrophytic species are *Myriophyllum aquaticum*, *Ceratophyllum demersum* and *Potamogeton fluitans*. In addition to chub, eight other cyprinids occur. These are the barbel *Barbus bocagei*, the roach „*Rutilus alburnoides* complex", the nase *Chondrostoma polylepis*, the gudgeon *Gobio gobio*, the carp *Cyprinus carpio*, the goldfish *Carassius auratus*, the arched mouth nase *Chondrostoma lusitanicum* and the long snouted barbel *Barbus comiza* (Collares-Pereira et al., in press).

**Table 1.** Characteristics of the Sor Stream and of the River Sorraia (*Instituto da Agua, unpublished data)

| Parameters | Sor Stream | River Sorraia |
|---|---|---|
| Max. water temperature (°C) | 29.1 | 22.0 |
| Min. water temperature (°C) | 11.1 | 9.3 |
| Max. water discharge ($m^3s^{-1}$)* | 11.0 | 99.2 |
| Min. water discharge ($m^3s^{-1}$)* | 0.2 | 0.4 |
| Max. water flow ($10^3 m^3$)* | 29 330 | 240 061 |
| Min. water flow ($10^3 m^3$)* | 579 | 973 |
| Flow regime (summer) | Continuous/Intermittent | Continuous |

Specimens were captured by electrofishing (350 V, 3-4 A, D.C.) in a 50 m section at site D monthly from November 1987 to November 1988, then at sites A, B, C, E and F in October 1991 using the same sampling procedure. All sampled specimens measured for both total (TL), standard length (SL) to within 1 mm, weighted to within 0.1 g and sexed when possible by gonadal examination. Four to six scales from the left side of the body below the dorsal fin were removed and examined at 50x magnification to determine age. Total scale radius and the distance from focus to each annulus were measured in latero-dorsal field. The use of scales for age and growth studies was validated as recommended by C r a g g -H i n e & J o n e s (1969) and H e l l a w e l l (1974) by observations on the annuli formation pattern, which was assessed by the calculation of the marginal growth index for 1+ and older chub scales according to L o b o n - C e r v i a (1982b). A SPH (scale proportional hypothesis) method (F r a n c i s 1990) was used for back-calculating standard length for each age and sex. The von Bertalanffy growth model (von B e r t a l a n f f y 1957) was fitted to the back-calculated lengths for both sexes. To fit this model, a non-linear least-squares regression with Marquardt's algorithm (M a r q u a r d t 1963) as implemented in the program FISHPARM of the package Fisheries Science Applications System (S a i l a et al. 1988) was performed. Weights-at-age were obtained by converting the back-calculated lengths into weights using length-weight relationships regressions. Because chub were caught during the whole year and presented different stages of gonad development, the gonad weight was subtracted to the total observed weighted values in the calculations of length-weight regression coefficients, which were obtained according to L e C r e n (1951). Annual instantaneous growth rates (R i c k e r 1958) were estimated using the mean weights obtained for each age and sex. An Wilcoxon rank sum test for two groups (S o k a l & R o h l f 1981) was carried out to test for variations in mean back-calculated standard lengths and in the mean weights-at-age between sexes and between rivers.

## Results

Monthly scale readings performed in 143 chubs (17 fish were rejected because presented only regenerated scales) showed that annuli were formed once a year between May and June, thus confirming the validity of the use of the scales for age and growth studies. Scale growth pattern was divisible into three periods: rapid growth (May/June-July); slow growth (August-October); no growth (November-May). The slow growth period was coincident with the maximum temperatures and the minimum water discharge values. Maximum ages were 6+ for both sexes. False checks were present in 45.1% of specimens including individuals of age 2+ and the older age classes. Growth variations between sexes

**Table 2.** Mean back-calculated standard lengths (mm) and mean length increments (in parentheses) at age of males and females Iberian chub (*, $0.05<p<0.02$; **, $0.01<p<0.001$; ----, no test due to insufficient numbers)

| Age (Years) | Males (N=53) | Females (N=44) | Z |
|---|---|---|---|
| I | 34.8(34.8) | 34.0(34.0) | 0.330 |
| II | 72.4(37.6) | 69.9(35.9) | 1.117 |
| III | 99.4(27.0) | 113.3(43.3) | * 2.893 |
| IV | 123.5(24.1) | 143.0(29.7) | ** 3.497 |
| V | 146.5(23.0) | 172.0(29.0) | * 2.558 |
| VI | 163.8(17.3) | 190.6(18.6) | ---- |

**Table 3.** Coefficients of the von Bertalanffy equation for male and female Iberian chub

| | $L_\infty$ | K | $T_0$ |
|---|---|---|---|
| Males | 236.1 | 0.20 | 0.20 |
| Females | 293.4 | 0.17 | 0.33 |

were only assessed in 53 males and in 44 females because it was impossible to sex 63 individuals, which ranged from 42 to 80 mm SL, due to the small gonadal development. There were no significant differences in mean back-calculated standard lengths between sexes in the first two years (Table 2). However, after age III, female back-calculated standard lengths were significantly larger. Growth rates for males reached a maximum at age II, showing a strong decline at age III. Conversely, the growth rates in females after age II were always bigger than in males, and the strongest decline in growth rates was observed at age IV. Further confirmation of the observed differences in growth rates was obtained by calculating the ultimate length $L_\infty$ by fitting the back-calculated standard lengths to the von Bertalanffy growth model (Table 3). The length-weight relationship was calculated separately for $0\text{-}2^+$ (sexes combined), $3^+$ and older males

**Table 4.** Length-weight regression coefficients of Iberian chub (r, correlation coefficient;*, significant for $p<0.001$)

| | Log a | b | r | F |
|---|---|---|---|---|
| Both sexes $0\text{-}2^+$ | -5.011 | 3.161 | 0.99 | 2135.75* |
| Males $\geq 3^+$ | -4.209 | 2.771 | 0.96 | 395.75* |
| Females $\geq 3^+$ | -4.960 | 3.136 | 0.98 | 967.77* |

and $3^+$ and older females (Table 4). No significant differences between mean weights were found in the first two years. Conversely, during and after age III females are significantly heavier than males. This fact is also confirmed by the highest values of the length-weight regression coefficients obtained for 3+ and older females. Instantaneous growth rates in both sexes were maximum between ages I and II. The strongest decline in instantaneous growth rates occurred in males between age II and III, whereas in females it occurred between age III and IV (Table 5).

The growth of fish from Sor stream and from Sorraia River was assessed by combining individuals of both sexes from sites A and B and from C, E and F, respectively. Back-calculations were performed in 36 individuals from Sor stream and in 59 fish from River Sorraia. The remaining 11 and 37 specimens from Sor stream and River Sorraia, respectively, were rejected because they presented only regenerate scales. No significant differences were found between the mean back-calculated standard lengths in I and II age classes from Sor stream and Sorraia river. However, specimens from III and IV ages classes in Sorraia river were significantly larger than the individuals collected in Sor stream (Table 6). Length-weight regression coefficients obtained for River Sorraia and Sor specimens (ages and sexes combined) are represented in Table 7. Individuals from

**Table 5.** Mean weights-at-age (g) and instantaneous growth rates (in parentheses) of males and females Iberian chub (*, p<0.05;**, p<0.001; ----, no test due to insufficient numbers)

| AGE (years) | MALES (N=53) | | FEMALES (N=44) | | Z |
|---|---|---|---|---|---|
| I | 0.89 | | 0.81 | | -0.091 |
| | | (2.22) | | (2.30) | |
| II | 8.19 | | 8.05 | | -0.888 |
| | | (0.93) | | (1.44) | |
| III | 20.81 | | 34.02 | | **-2.581 |
| | | (0.64) | | (0.63) | |
| IV | 39.84 | | 63.90 | | **-3.495 |
| | | (0.47) | | (0.47) | |
| V | 63.88 | | 101.94 | | *-2.192 |
| | | (0.32) | | (0.37) | |
| VI | 87.63 | | 147.19 | | ---- |

**Table 6.** Mean back-calculated standard lengths (mm) and mean length increments (in parentheses) at age of Iberian chub from Sor stream and the River Sorraia (*, 0.1<p<0.05; **, 0.05<p<0.02)

| Age (years) | Sor Stream 20 ♂ / 16 ♀ | River Sorraia 38 ♂ / 21 ♀ | Z |
|---|---|---|---|
| I | 39.6(39.6) | 39.7(39.7) | 0.611 |
| II | 63.5(23.9) | 64.6(24.9) | 0.500 |
| III | 94.6(31.1) | 101.2(36.6) | *1.596 |
| IV | 111.6(17.0) | 125.6(24.4) | **2.006 |

**Table 7.** Length-weight regression coefficients of Iberian chub from Sor stream and the River Sorraia (r, correlation coefficient; *, p<0.001)

| | Log a | b | r | F |
|---|---|---|---|---|
| Sor Stream | -4.526 | 2.936 | 0.89 | 128.85* |
| Sorraia River | -4.793 | 3.044 | 0.99 | 6843.82* |

I and II age classes presented higher weights in Sor stream. Conversely, the mean weights in III and IV age classes are higher in Sorraia river fish. However, significant differences in mean weights were only found in IV age class (Table 8).

**Table 8.** Mean weights-at-age (g) and instantaneous growth rates (figure in parentheses) of Iberian chub from Sor stream and the River Sorraia (*, p<0.05)

| Age (years) | Sor Stream 20 ♂ / 16 ♀ | | River Sorraia 38 ♂ / 21 ♀ | | Z |
|---|---|---|---|---|---|
| I | 1.55 | | 1.50 | | -2.125 |
| | | (1.40) | | (1.32) | |
| II | 6.33 | | 5.62 | | -0.884 |
| | | (1.07) | | (1.28) | |
| III | 18.40 | | 20.41 | | -0.874 |
| | | (0.74) | | (0.72) | |
| IV | 38.89 | | 41.91 | | *1.715 |

## Discussion

Seasonal scale growth pattern in Iberian chub of the Sorraia catchment was similar to that observed by Lobon-Cervia (1982a) and Lobon-Cervia & Sostoa (1987). The false checks observed in 45.1% of the studied chubs may be due to the small scale growth rates observed from August to October, which can be related with the lack of food availability and the low concentrations of dissolved oxygen (see Coble 1970). In fact, in small southern Iberian rivers environmental conditions in summer may become critical for fish because the flow is strongly reduced and high temperatures lead to oxygen depletion. These adverse conditions, accompanied by an increase in fish density result on a decrease in food resources, which limit the growth of fish during this period and leads to the formation of false checks. The observed seasonal growth pattern also reflected these effects (Herrera et al. 1988, Herrera & Fernandez-Delgado 1992). In spite of the improvement of the environmental conditions with the first rains in October/November the growth stopped because the temperature is not favourable for growth at this time of the year. Mann (1991) stated that lower temperature thresholds for cyprinid growth are between 12-15°C. Only in spring, when temperatures and water discharge assumed intermediate values, the most favourable conditions for chub growth seemed to be attained.

The strongest growth rates decrease observed between age II and III in males and between age III and IV in females may be related with sexual maturity. In fact, Lobon-Cervia (1982a) verified that chub from both sexes attained the first sexual maturity at age III, coinciding with the strongest decrease in growth rate. This decrease was more accentuated in males than in females. In most cyprinid species females generally become sexually mature one year later than the males (Mann 1991) and the same situation may occur in the Sorraia populations. The highest growth rates, presented by age III and older females may be due to the fact that natural selection, once they are sexually mature, favours those with larger growth rates, because larger females are more fecund than smaller. A similar selection process for males is not necessary as even small individuals produce enough sperm to fertilise eggs of many females (Mann 1991).

The differences observed between the growth rates of III and IV age classes can be explained by the more adverse environmental conditions in the Sor stream, which occur mainly during summer months. The adverse conditions affect small fish less than they do to large fish (Magalhães 1993), and consequently small fish present similar growth rates at both sites. Whereas, larger fish have higher growth rates in the River Sorraia where environmental conditions are comparatively more stable. A similar pattern was observed by Rincon & Lobon-Cervia (1989) in the roach *Rutilus arcasii* with differences in growth rates between populations occurring only in older age classes.

Long-term investigations in future are needed to: 1) better understand the physiological mechanisms leading to age and sex shifts in growth rates, both in length and weight; 2) quantify to what extent abiotic (e.g. temperature, oxygen levels) and biotic factors (e.g. competition, predation-risk, food availability) affect growth.

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