GROWTH, LONGEVITY, AND MORTALITY OF THE LARGEMOUTH BASS <i>MICROPTERUS SALMOIDES</i> (LACÉPÈDE, 1802) IN A MEDITERRANEAN LAKE (ROME, ITALY)

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RÉSUMÉ. — Croissance, longévité et mortalité de l’Achigan à grande bouche <i>Micropterus salmoides</i> (Lacée, 1802) dans un lac méditerranéen (Rome, Italie).— L’objectif de notre étude est l’analyse de la structure et de la dynamique d’une population invasive de l’Achigan à grande bouche (<i>Micropterus salmoides</i> Lacée, 1802) dans un lac méditerranéen. La croissance a été décrite par les paramètres de Von Bertalanffy, eux-mêmes obtenus en utilisant les données « taille à l’âge ». Les valeurs moyennes des quatre classes d’âge observées (identifiées par la lecture des écailles) ont été analysées par la méthode analytique de Gulland & Holt, dans le but de calculer le paramètre de courbure (k = 0.49) et la longueur asymptotique (L<sub>∞</sub> = 31). Les paramètres de Von Bertalanffy ne semblent pas liés au dimorphisme sexuel car nous n’avons pas trouvé de différences dans la taille ou dans la structure de la population entre les deux sexes. La longévité observée est de cinq ans, mais peu de spécimens atteignent cet âge, du fait d’un taux élevé de mortalité liée à la pêche. La structure et la dynamique de cette population semblent révéler sa stabilité et sa capacité d’expansion, expressions des conditions favorables rencontrées par l’espèce sur le site d’étude. Les paramètres de croissance reflètent les capacités d’acclimatation de <i>Micropterus salmoides</i> dans un habitat qui n’est pas celui d’origine et montrent la plasticité de l’espèce, capable de coloniser de nombreux habitats tempérés et chauds à travers le monde et notamment les zones humides méditerranéennes.

SUMMARY. — The analysis of the structure and dynamics of an invasive population of the Largemouth Bass (<i>Micropterus salmoides</i> Lacée, 1802) in a Mediterranean wetland was the main goal of this study. Demographic potentialities were described by means of the von Bertalanffy parameters, the latter obtained using length-at-age data. The mean values of the observed four age classes (recognized by the scale reading) were analysed by the Gulland & Holt analytical method, in order to calculate the curvature parameter (k = 0.49) and the asymptotic length (L<sub>∞</sub> = 31). The von Bertalanffy parameters were not considered to be affected by sexual dimorphism since no between-sexes differences were found in size and population structure. Besides the two previous parameters, we computed longevity of 5 years, with only a limited number of Largemouth Bass reaching this age (due to a high fishing mortality rate). Structure and dynamics of this population seem to reveal its stability and spreading potential, as an expression of the favourable ecological conditions encountered in the study area. Growth parameters reflect the acclimation capability of <i>M. salmoides</i> in a non-native habitat and show the ecological plasticity of this species, capable of colonizing many temperate and warm habitats worldwide, Mediterranean wetlands included.

Transfaunation is considered as the first ecological danger, caused by the rapid and constant increase of species movement (Ruesink et al., 1995; Cox, 1999). This phenomenon developed and increased as a consequence of halieutic and aquaculture activities, emerging as one

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of the great problem in conservation (Sala et al., 2000) and representing the actual risk of a general alteration of the biological diversity through the ecosystem homogenization (Mack et al., 2000; Rahel, 2000).

Among all the invasive fish, the Largemouth Bass, Micropterus salmoides Lacépède, 1802, is estimated one of the 5 most introduced species in inland waters of several countries (Ladiges & Vogt, 1979; Welcomme, 1992). The Largemouth Bass is a centrarchid species native from North-American freshwater systems (from Canada to Florida and Mexico). It mainly inhabits lentic and lotic habitats showing particular preference for marshy environments and shallow waters of large lakes (Hickley et al., 1994).

*M. salmoides* has been shown to be successful in colonizing areas outside its native range (Weyl & Hecht, 1999). Recorded in North Italy for the first time more than 30 years ago (Tortonese, 1975), this species is now widespread in the whole national territory (Zerunian, 1980; Alessio, 1981, 1983; Lorenzoni et al., 2002a,b; Marinelli et al., 2004, 2006b,c), and can be considered as well naturalized in all the Italian inland waters (Zerunian, 2002). Although many records occur in the Italian literature (see Marinelli et al., 2007), fishermen continuously indicate the occurrence of *M. salmoides* in an increasing number of sites, attesting its fast colonization potential. In the past, due to its voracity, the Largemouth Bass was used as a control instrument for cyprinid species in artificialized water systems (Gandolfi et al., 1991). Unfortunately, fishing (introduction activities inclusive) was not always well-managed mainly due to a lack of information about the biology of fish in the lake Bracciano, where the Largemouth Bass was observed for the first time at the end of the last century (Marinelli et al., 2004).

*M. salmoides* has been described as an ichthyophagous fish (Heidinger, 1974; Lorenzoni et al., 2002a; Marinelli et al., 2007), although a shift of the diet habit occurs all during its life: from a zooplanktonic diet, during larvae phase, the feeding habit of juveniles is based on little invertebrates and finally the sub-adults and adults are piscivorous (see Nicola et al., 1996; Godinho & Ferreira, 1998; Garcia-Berthou, 2002). Moreover, *M. salmoides* seems to be an opportunistic predator with a diet depending on environment and feeding resources (He et al., 1994; Hickley et al., 1994; Godinho et al., 1997; Olson et al., 1998). It can contribute seriously to compromise the native fish communities (Lorenzoni et al., 2002a; Marinelli et al., 2006b), In fact, once acclimated, an exotic species can create serious problems for the native fish species (Holcik, 1991), overall whether it impacts upon their juveniles (Marinelli et al., 2006b) or its niche overlaps that of those native species (Gandolfi et al., 1991; Lorenzoni et al., 2002a; Marinelli et al., 2007).

Standing that introduction’s prevention of invasive species is “the only environmentally sound approach” (Gollasch & Leppäkoski, 1999), after the occurrence of an exotic species in a given habitat, eradication or mitigation activities seem to be a priority (Holdich et al., 1999). Although an early eradication may be carried out with little or superficial knowledge of the population biology of an alien species (Simberloff, 2003), in several cases the opportunity for rapid management activities is lost. In those cases, biological details on nuisance species, including population structure and dynamics, seem to be useful for developing effective tools for a maintenance management. Based on these premises, and considering the importance of understanding demography and population regulation to the theory of sustainable exploitation (Kokko & Lindström, 1998; Freckleton et al., 2003; Scalici et al., 2008), and biological control (see for example May et al., 1981; Tuyttens et al., 2000; Scalici & Gherardi, 2007; Scalici et al., 2007), this study aims to investigate aspects of the biology of Largemouth Bass. In particular, we focused our attention on population structure, growth, longevity, and mortality of *M. salmoides* estimated by using the fish stock assessment principles, in order to know the population status and dynamic properties of the Largemouth Bass in Mediterranean ecosystems. Determination of the age and assessment of dynamic potentialities are to be considered a crucial tool in fisheries biology for the formulation of management strategy (Britton et al., 2004). Our results are also compared with those of other Largemouth Bass populations in native and non-native countries, Italy inclusive.
STUDY AREA

The studied population inhabits the oligotrophic volcanic lake Bracciano, sited at 164 m a.s.l. within the Sabatini Mountains group (between 42°10' and 42°05’ N, and 12°10' and 12°17' E – Province of Rome). The lake has a perimeter of 31.5 km, a surface of 57.2 km², and a depth mean and max of 88.6 and 165 m, respectively. Its surface temperature (0-4 m) ranges between a minimum of 8°C in winter and a maximum of 26°C in summer, with an annual mean value of 13.5°C (± 5.7 standard deviation). Aquatic vegetation was constituted mainly by Characeae and secondarily by macrophytes, such as Potamogeton perfoliatus Linnaeus, 1753, Potamogeton lucens Linnaeus, 1753, Vallisneria spiralis Linnaeus, 1753, Myriophyllum spicatum Linnaeus, 1753, and Ceratophyllum demersum Linnaeus, 1753. Fish community is composed by different native and exotic species of ecological and conservation interest, such as (in alphabetical order of scientific name) Carassius carassius (Linnaeus, 1758), Cobitis taenia bilineata Canestrini, 1865, Cyprinus carpio Linnaeus, 1758, Gambusia holbrooki Girard, 1859, Lepomis gibbosus (Linnaeus, 1758), Rutilus rutilus (Bonaparte, 1837), Salaria fluviatilis (Asso, 1801), Scardinius erythrophthalmus (Linnaeus, 1758), Tinca tinca (Linnaeus, 1758), and of economic importance, such as (in alphabetical order of scientific name) Anguilla anguilla (Linnaeus, 1758), Atherina boyeri Risso, 1810, Coregonus lavaretus (Linnaeus, 1758), Esoc lucius Linnaeus, 1758, Mugil cephalus Linnaeus, 1758, Micropterus salmoides (Lacépède, 1802), and Perca fluviatilis Linnaeus, 1758 (Gibertini et al., 2004). A. anguilla, C. lavaretus, E. lucius, and M. cephalus are object of restocking activities funded by the Province of Rome. With regard to A. boyeri, its population is able to complete its life history whole in the lake Bracciano, without migrations toward the sea.

DATA COLLECTION AND ANALYTICAL PROCEDURES

The study was monthly carried out from October 2001 to September 2002, supported by professional halieutic activities. Samplings were carried out using fishes caught by trawls (with 2 cm square mesh and 30 m high) dragged on the lakeshore at the sunset. In this way, data for estimating population parameters were obtained by sampling the commercial catches, or more precisely, commercial landings. The basic principles for analysing such samples are the same as for research survey data. The major problem could be the sampling bias due to the difficulty to collect a random sample of a stock, since anglers always fish marketable sizes and try to find areas with the highest fish concentration. However, keeping in mind the source of bias and trying to stratify sampling to minimize the bias, it can be possible to use data from commercial fisheries in order to estimate population parameters (for a review on this topic see Gayanilo & Pauly, 1997). Moreover, in a recent study carried out in 20 Michigan lakes, Nate & Bremigan (2005) showed that for Largemouth Bass Von Bertalanffy growth parameters estimated from subsamples were not significantly biased.

Then, in order to carry out our study, we measured all the collected specimens on their body right side from the head tip to the caudal stalk [i.e. standard length = 0.05 cm, SL (Gandolfi et al., 1991; Sparre & Venema, 1996)]. Individuals malformed in the spinal column were rejected. For each specimen 3-7 scales from both sides were taken for age scale's reading according to Baglinière & Le Louarn, 1987. Then, given the absence of sexual dimorphism (see Alessio, 1981, 2006), sex was determined by a gonadic macroscopic inspection (successively used in other studies – see Marinelli et al., 2007). Body size measurements together with the age of each specimen were used to generate polymodal frequency distribution histograms and to obtain the monthly SL mean values for each age class. Then, SL mean values were used to evaluate the growth rate by the following Von Bertalanffy (1938) growth function (VBGF):

\[ L(t) = L_\infty \cdot \left(1 - \exp \left[-k \cdot \left(t - t_0\right)\right]\right) \]

where \( L(t) \) is the length at the age \( t \), \( L_\infty \) is the asymptotic length (i.e. the mean length the fish in a population would reach if they were to grow indefinitely), \( k \) is the curvature parameter (determining how fast fish approach \( L_\infty \)), and \( t_0 \) is the initial condition parameter [i.e. the time when fish have zero length, without meaning from a biological viewpoint, but being however an important component to draw the curve (Sparre & Venema, 1996)].

The Von Bertalanffy parameters were estimated by the Gulland & Holt (1959) method based on length-at-age data and on the concept that the growth rate declines linearly with length. This method consists of plotting the difference between the means of two adjacent (not necessarily consecutive) cohorts \((dL/dt)\) versus the mean of the same adjacent cohorts \([L(t)]\), in order to obtain the following linearized VBGF

\[ dL/dt = a + b \cdot L(t) \]

where the slope \( b \) with the changed sign is the curvature parameter \((k = -b)\) and the ratio between the intercept \((a)\) and the slope is the asymptotic length \((L_\infty = -a/b)\). Additionally the regression index \( R_s \) was calculated in order to determine the significance of the regression function.

Other aspects of the population dynamics were also analysed using the Von Bertalanffy parameters. The results obtained with the Gulland & Holt (1959) method have been used to evaluate how seasonality can affect the growth according to the equation (Pauly et al., 1992):

\[ L(t) = L_\infty \cdot \left(1 - \exp \left[-k \cdot \left(t - t_0\right) - \left(Ck/2\pi\right) \left(\sin2\pi \left(t - t_0\right) - \sin2\pi \left(t_0 - t_0\right)\right)\right]\right) \]

where two new parameters occur: \( C \), the amplitude of the curve (giving an estimate of the influence of the seasonality on the growth trend), and \( t_0 \), the summer point [referring to the onset of the first oscillation relative to \( t = 0 \) (see Sparre & Venema, 1996 for more details)].
Once the growth parameters were obtained, other population properties were evaluated. In particular, using \( k \) and \( L_\infty \), the growth performance index (\( \Phi \)) was computed by applying the equation (Pauly & Munro, 1984):

\[
\Phi = \log k + 2 \log L_\infty
\]

This index is used for comparing the growth performance of fish with similar shape in terms of their growth in length (Gayanilo & Pauly, 1997).

Subsequently the total mortality index (\( Z \), the sum of natural mortality and the mortality due to fishing) was obtained by the Powell-Wetherall Plot equation (Powell, 1979; Wetherall, 1986), based on the well-known equation of Beverton & Holt (1956), that computed the asymptotic length and the ratio between the mortality coefficient and the curvature parameter (\( Z/k \)) using length-frequency data. Natural mortality (\( M \)) is correlated with size (\( L_\infty \)), curvature parameter (\( k \)) and mean environmental temperature (\( T \), using the digital meter Multiline F/set-3 with an appropriate probe of immersion), by the following formula (see Pauly, 1980):

\[
\log M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log k + 0.463 \log T
\]

Mortality due to fishing (\( F \)) was then obtained subtracting \( M \) from \( Z \) and also expressed as percentage of the total mortality (= \( \frac{F}{Z} \) * 100).

Finally, the expected longevity (\( t_{\text{max}} \)) was computed from the equation (Gayanilo & Pauly 1997):

\[
t_{\text{max}} = (2.98/k) + t_0
\]

Then, we compared our results with other ones carried out on other native and invasive natural populations of \( M. \) salmoides.

**STATISTICAL ANALYSES**

The Von Bertalanffy growth parameters and their derivatives were calculated with the FAO-Iclarm Stock Assessment Tool (FISAT). All the statistical analyses were made using the STATISTICA Statsoft software version 7.0. The goodness of the female/male ratio was tested by the \( \chi^2 \) test, with the Yates correction. Data on body dimensions and age classes were first checked for normality and homogeneity of variance using the Kolmogorov-Smirnov test and, when necessary, were Log-transformed to remove heteroscedasticity. Then the SL mean values of the two sexes per age class were compared by Student t-test and F test for mean and variance respectively. The initial condition parameter was determined by using a non-linear regression analysis. Eventual differences among all the analysed populations were only described by eye and not tested since the different collection methods can affect statistical analyses according to Helser & Lai (2004) and Nate & Bremigan (2005).

**RESULTS**

**POPULATION STRUCTURE ANALYSIS**

During the study period, we collected a total of 207 specimens. Of the whole sample 97 were females (46.9%) and 110 males (53.1%), without any significant difference from the expected 1:1 sex ratio (\( \chi^2 = 2.44; \text{df} = 1; p > 0.05 \)).

After the scale reading, four age classes were observed, from 0+ to 3+, 1+ being the most abundant one (Tab. I). In Figure 1 the size-frequency distribution for each age class is shown.

**TABLE I**

<table>
<thead>
<tr>
<th>age class</th>
<th>sex</th>
<th>nb</th>
<th>%</th>
<th>sex ratio</th>
<th>SL mean (cm)</th>
<th>st.dev.</th>
<th>max (cm)</th>
<th>min (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+</td>
<td>F</td>
<td>12</td>
<td>12.37</td>
<td>0.7:1</td>
<td>16.5</td>
<td>0.5</td>
<td>16.9</td>
<td>13.4</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>18</td>
<td>16.36</td>
<td></td>
<td>15.7</td>
<td>0.9</td>
<td>18.1</td>
<td>14.1</td>
</tr>
<tr>
<td>1+</td>
<td>F</td>
<td>52</td>
<td>53.61</td>
<td>0.9:1</td>
<td>21.7</td>
<td>4.5</td>
<td>26.8</td>
<td>14.2</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>60</td>
<td>54.55</td>
<td></td>
<td>22.3</td>
<td>4.4</td>
<td>26.3</td>
<td>14.7</td>
</tr>
<tr>
<td>2+</td>
<td>F</td>
<td>19</td>
<td>19.59</td>
<td>0.8:1</td>
<td>24.3</td>
<td>3.9</td>
<td>28.4</td>
<td>21.3</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>23</td>
<td>20.91</td>
<td></td>
<td>25.2</td>
<td>3.8</td>
<td>27.6</td>
<td>19.5</td>
</tr>
<tr>
<td>3+</td>
<td>F</td>
<td>14</td>
<td>14.43</td>
<td>1.5:1</td>
<td>26.1</td>
<td>2.3</td>
<td>30</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>9</td>
<td>8.18</td>
<td></td>
<td>27.1</td>
<td>0.6</td>
<td>29.3</td>
<td>25.8</td>
</tr>
</tbody>
</table>
After the population structure determination we calculated again the sex ratio for each class: 1+ and 2+ did not show any significant differences between the number of females and males (0.8:1 and 0.9:1, χ² = 1.12, df = 1, p > 0.05, and χ² = 1.97, df = 1, p > 0.05, respectively), while the female/male ratio for the classes 0+ and 3+ differed significantly from 1:1 (0.5:1 with χ² = 19.4; df = 1; p < 0.01 and 1:0.7 with χ² = 12.1; df = 1; p < 0.05, respectively). A between sex comparison of Log-transformed SL data per class and sampling session did not show any significant differences for both mean values (after t-test, p was always > 0.05) and variance (after F-test, p was always > 0.05). In Figure 2 monthly mean values of SL and the respective standard deviations are shown according to age classes.

Figure 1. — Length-frequency diagram obtained using 1 cm interval of the standard length (SL) for the four observed age classes.

Figure 2. — Mean values of the standard length (SL) and standard deviations, according to age and sampling month.
Population Dynamics Analysis

Since there were no body size differences between sexes, we grouped the two sexes in order to use a single length-at-age data-set for evaluating the Von Bertalanffy parameters. Firstly, we calculated the regression function showed in Figure 3, from which it was possible to extrapolate the curvature parameter, \( k = 0.49 \pm 0.15 \text{ year}^{-1} \), the asymptotic length, \( L_\infty = 31.0 \pm 0.29 \text{ cm} \), the initial parameter, \( t_0 = -0.52 \pm 0.04 \), and the growth performance index, \( \Phi = 2.67 \). By using the previous population properties, we calculated the amplitude coefficient (\( C \)) and the summer point (\( t_s \)), equal to 0.31 and 0.12, respectively.

Moreover, values of the other dynamic parameters are the following: 1) \( Z = 1.901 \); 2) \( M = 0.774 \); 3) \( F \) and \( F\% = 1.127 \) and 59.26\%; 4) \( t_{\text{max}} = 5.56 \).

Figure 3. — Plot of the difference between the means of two adjacent cohorts (\( \frac{dL}{dt} \)) versus the mean of the same ones \( [L'(t)] \), according to the Gulland & Holt (1959) method, and regression analysis. The regression index \( R_s \) was significant for \( p < 0.05 \). Both \( y \) and \( x \) coordinates are in cm.

Growth Pattern Comparison

Our results on the VBGF and those ones obtained from literature are reported in Table II. Comparing the parameters among all the collected populations, it was possible to observe that the curvature parameter \( (k) \) and the asymptotic length \( (L_\infty) \) showed some differences among all the studied populations. Specifically, the asymptotic length computed in this study was smaller than the one obtained by other authors, whereas the same conditions were not met for the curvature parameter that is higher than those ones of other populations, in native and non-native habitats (see references in Tab. II). On the contrary the growth performance index showed very similar for all the analysed populations.

Discussion

The sample collected in this study was mostly composed of sexually mature individuals, i.e. individuals from 1+ to 3+ with SL longer than 19-20 cm according to Marinelli et al. (2007) who carried out macro- and microscopic analyses of the Largemouth Bass gonads from individuals of the same studied populations. The 1+ class was more abundantly represented. This peculiar population structure could reflect the recent introduction of \( M. \ salmoides \) in lake...
Bracciano, characterizing an expanding population (Lorenzoni et al., 2002b). The youngest class (0+) was probably under-represented due to the fishing method favouring larger individuals and avoiding the recruitment of specimens under 13 cm of standard length. Also the oldest class (3+) is represented by a low number of fishes, probably due to escapement thanks to their movement ability (reaching a depth of 40 m – Helfman, 1981) or mainly to the recent introduction in the lake, the first record being in 1998 (Marinelli et al., 2004).

Appreciable between-sexes differences were not found in size, but were in the population structure. In fact, as revealed by previous studies, *M. salmoides* age classes can vary in their number and structure across the analysed populations (Froese & Pauly, 1998; Lorenzoni et al., 1996; Lorenzoni et al., 2002b; Beamish et al., 2005; Marinelli et al., 2006c). Although the mean size values of each age class did not show substantial differences from other Italian studies (Zerunian, 1980; Alessio, 1981, 1983; Lorenzoni et al., 2002b), different authors distinguished several population structures, showing in some cases differences affected by sexual dimorphism (Froese & Pauly, 1998; Lorenzoni et al., 1996; Lorenzoni et al., 2002b; Helfser & Lai, 2004; Beamish et al., 2005). These types of results make difficult to explain why in a certain population number and structure of the age classes and dynamics are different for the two sexes (Lorenzoni et al., 2002b). In our study also the absence of sexual dimorphism in body size could probably be related to the low number of individuals in 0+ and 3+ classes.

With regard to the Von Bertalanffy parameters, the growth rate showed a high value little affected by the Mediterranean seasonality, as a near-zero value of the amplitude of the curve (C) and the summer point (tₜ) showed. In fact, the curvature parameter lightly decreases during the breeding period, in the lake Bracciano occurring from December to February (Marinelli et al., 2006a, 2007), rather than in spring and summer, as previously described in studies carried out on populations inhabiting native (Rosemblum et al., 1994) and non-native (Alessio, 1981, 1983; Lorenzoni et al., 2002b) habitats. The breeding period and the autumnal water

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**Table II**

*Comparison of the Von Bertalanffy parameters among the population reported in the literature (for all the populations studied by other authors, Φ and *tₘₐₓ* have been calculated in this study)*

<table>
<thead>
<tr>
<th>Study areas</th>
<th>Lₜ (cm)</th>
<th>k (year⁻¹)</th>
<th>t₀ (year)</th>
<th>Φ</th>
<th><em>tₘₐₓ</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Native</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lake Rebecca, Minnesota (USA)¹</td>
<td>50.5</td>
<td>0.31</td>
<td>0.41</td>
<td>2.90</td>
<td>10.02</td>
</tr>
<tr>
<td>Lake Rebecca, Minnesota (USA)¹</td>
<td>58.9</td>
<td>0.16</td>
<td>-0.30</td>
<td>2.74</td>
<td>18.33</td>
</tr>
<tr>
<td>Minnesota (USA)¹</td>
<td>61.5</td>
<td>0.20</td>
<td>-0.11</td>
<td>2.88</td>
<td>14.79</td>
</tr>
<tr>
<td>245 populations, from 28°N to 50°N, N-America²</td>
<td>36-80</td>
<td>0.09-0.67</td>
<td>nc</td>
<td>2.07-3.63</td>
<td>nc</td>
</tr>
<tr>
<td><strong>Introduced</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lake Shorenji, Japan¹</td>
<td>34.1</td>
<td>0.50</td>
<td>-0.07</td>
<td>2.76</td>
<td>5.91</td>
</tr>
<tr>
<td>Lake Yate, New Caledonia³</td>
<td>53.5</td>
<td>0.30</td>
<td>nc</td>
<td>2.93</td>
<td>nc</td>
</tr>
<tr>
<td>Montedoglio Reservoir³</td>
<td>57.3</td>
<td>0.28</td>
<td>-0.23</td>
<td>2.80</td>
<td>10.41</td>
</tr>
<tr>
<td>Lake Trasimeno³</td>
<td>51.0</td>
<td>0.28</td>
<td>-0.13</td>
<td>2.87</td>
<td>10.51</td>
</tr>
<tr>
<td>Lake Trasimeno, females⁴</td>
<td>46.9</td>
<td>0.33</td>
<td>0.06</td>
<td>2.86</td>
<td>8.97</td>
</tr>
<tr>
<td>Lake Trasimeno, males⁴</td>
<td>39.4</td>
<td>0.42</td>
<td>-0.02</td>
<td>2.81</td>
<td>7.08</td>
</tr>
<tr>
<td>Lake Manyame, Harare, Zimbabwe males⁵</td>
<td>37.2</td>
<td>0.66</td>
<td>nc</td>
<td>2.96</td>
<td>nc</td>
</tr>
<tr>
<td>Lake Manyame, Harare, Zimbabwe females⁵</td>
<td>48.2</td>
<td>0.41</td>
<td>nc</td>
<td>2.98</td>
<td>nc</td>
</tr>
<tr>
<td>Lake Bracciano⁶</td>
<td>31.9</td>
<td>0.51</td>
<td>-0.63</td>
<td>2.72</td>
<td>5.21</td>
</tr>
<tr>
<td>Lake Bracciano⁶ (present study)</td>
<td>31.0</td>
<td>0.49</td>
<td>-0.52</td>
<td>2.67</td>
<td>5.56</td>
</tr>
</tbody>
</table>

¹ Froese & Pauly 1998; ² Helser & Lai 2004; ³ Lorenzoni et al., 1996; ⁴ Lorenzoni et al., 2002b; ⁵ Beamish et al., 2005; ⁶ Marinelli et al., 2006c; nc = not calculated; for the other acronyms see the text.
temperature affect the feeding strategy of the Largemouth Bass (Heidinger, 1974; Alessio, 1983; Rosemb lum et al., 1994; Marinelli et al., 2006a, 2007), reducing its foraging activity, and subsequently growth.

Our results clearly indicate that Largemouth Bass has well acclimated in lake Bracciano, finding there favourable environment and trophic conditions for growing, in accordance with Marinelli et al. (2007) who describe a functional food strategy based on stomach contents analyses and the regular monitoring of gonad development of the Largemouth Bass in lake Bracciano.

An additional property that we found in the study population is its high mortality rate, overall that due to fishing. The last one provides evidences about a certain economic exploitation of this species, being today one of the most requested resource of the local market, just after the white fish C. lavaretus. Due to the lack of this type of information in literature, we are not able to develop a good comparison among all the analysed populations, although it should be interesting and useful for conservation purposes to know further aspects regarding the M. salmoides trade.

When compared with other studies on other populations of the same species (Tab. II), we obtained different values for some of the Von Bertalanffy’s growth parameters.

The asymptotic length and the curvature parameter showed differences among all the studied populations showing that, also for an opportunistic predator, capable to exploit any type of feeding resources (He et al., 1994; Hickley et al., 1994; Godinho et al., 1997; Olson et al., 1998; Lorenzoni et al., 2002a; Marinelli et al., 2006b, 2007), the body size and the growth pattern can be greatly influenced by climate and food availability [i.e. the status of the local resources (Beamish et al., 2005; Schultz & Leal, 2005)].

It can be noticed that the lowest expected longevity can be displayed by the Largemouth Bass mainly in its natural distribution range. In the analysed population the maximum longevity we computed was nearly 5 years, differently suggested by other authors as reported in Table II. Probably also the observed value of the expected longevity reflects the recent introduction of M. salmoides in lake Bracciano. But anyway the growth performance index is very similar for all the analysed populations, attesting that the species preserves the same growth model and potentialities in native habitats as in non-native ones (Beamish et al., 2005; Froese & Pauly, 1998; Helser & Lai, 2004; Lorenzoni et al., 1996, 2002b; Marinelli et al., 2006).

To deepen the comparison of our results with those cited in literature becomes more difficult, since the lack of important information about all the study areas, i.e. community structures, predation, competition, feeding resources and their status, water quality, water temperature trend, etc., and any type of conclusion remains purely speculative. This obviously will require considerable effort in order to collect additional information on these important variables.

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REFERENCES


