GROWTH AND MORTALITY OF BLACK BASS, *Micropterus salmoides* (PISCES, CENTRACHIDAE; LACAPÈDE, 1802) IN A RESERVOIR IN SOUTHERN BRAZIL

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ABSTRACT

The black bass, *Micropterus salmoides*, was introduced to Brazil from North America in 1922. Since then the species has been reared in aquaculture facilities intended to stock reservoirs as additions to native stocks available for angling. At present no scientific information on the biology of black bass in Brazilian waters is available. Since black bass dispersion may cause severe impacts on native Brazilian fish fauna, information on the basic biological parameters of this species is necessary. The objective of the present study is to provide information on the growth, age structure, and mortality of the species in a small reservoir in southern Brazil, where the species reproduces regularly. Based on scale readings, the von Bertalanffy growth curve was calculated and compared to the length-frequency distribution of the population. Both methods showed similar results. Maximum length was about 44 cm. The mean length at the end of the first year was 23.1 cm (s.d. = 13.88); at that of the second, 37.3 cm (s.d. = 12.52); and 41.4 cm (s.d. = 9.92) at the third. Oldest fish were three years old. The growth performance index ø' was 3.28 cm year^{-1}. Mortality increased from 0.16 year^{-1} between the first and the second cohort, to 0.8 year^{-1} between the second and third. The results show that black bass in Brazil grows faster than in its area of origin, but longevity is shorter and body shape, stouter. The cause of high mortality at a relatively early age may be connected with the loss of genetic diversity due to inbreeding of the Brazilian stocks, which originated from few introduced individuals a long time ago. The fact that black bass reproduces in reservoirs and grows rapidly may be considered a threat to conserving fish diversity in Brazilian ecosystems.

Key words: *Micropterus salmoides*, growth, mortality.

RESUMO

Crescimento e mortalidade do black bass, *Micropterus salmoides*, (Pisces, Centrachidae; Lacepède, 1802) num reservatório no sul do Brasil

O black bass, *Micropterus salmoides*, proveniente da América do Norte, foi introduzido no Brasil em 1922. A partir dessa data, a espécie foi criada na piscicultura brasileira para fins de soltura em açudes e reservatórios com o objetivo de sustentar a pesca amadora. Atualmente não há informações sobre a biologia da espécie em águas brasileiras. Como a dispersão da espécie em águas naturais pode causar impactos imprevisíveis, é necessário levantar dados sobre parâmetros básicos de sua biologia. O objetivo do presente trabalho é investigar o crescimento, a estrutura etária e a mortalidade da espécie num pequeno reservatório no sul do Brasil, onde ela se reproduz todos os anos. Por meio da leitura de escamas foi calculada a curva de crescimento von Bertalanffy e comparada à distribuição do comprimento. Ambos os métodos chegaram a resultados similares. O comprimento máximo foi de aproximadamente 44 cm. No primeiro ano de vida, o comprimento médio foi de 26,1 cm (d.p. = 13,88); no segundo, 37,3 cm (d.p. = 12,52); e no terceiro, 41,5 cm (d.p. = 9,92). O índice de performance de crescimento foi ø' = 3,28 cm ano^{-1}. A mortalidade Z aumentou aproximadamente quatro vezes, de 0,16 $anos^{-1}$ entre a primeira e a segunda coorte para 0,8 $anos^{-1}$ entre a segunda e a terceira coorte. Os resultados mostram que o black bass cresce mais rapidamente no Brasil e tende a ser mais enxuto que em sua área de origem, mas não atinge a longevidade dos espécimes nos Estados Unidos. A causa dessa mortalidade elevada é vista na provável diminuição da diversidade genética dos estoques brasileiros, originados de poucos indivíduos introduzidos muito tempo atrás. O fato de a espécie se reproduzir e crescer rapidamente em sistemas seminaturais pode ser considerado uma ameaça para a conservação dos ecossistemas brasileiros.

Palavras-chave: *Micropterus salmoides*, crescimento, mortalidade.

INTRODUCTION

The introduction of exotic species has major impacts on native fauna. On an international scale, such introductions contribute to the globalization of fauna, while on a regional scale they can lead to homogenization (Scott & Helfman, 2001; Zanatell & Rassam, 2002). Introduced species can cause complex changes in structure and function in the new ecosystem. Such impacts include a change of existing food webs, habitats, importation of new diseases and parasites, and competition with native species for food resources and space (Moyle & Cech Jr., 2000). Based on these facts, the Invasive Species Specialist Group compiled a "100 worst invasive species of the world" list, which includes the black bass (*Micropterus salmoides*) in the fish section (ISSG, 1999).

The black bass or largemouth bass is a North American species of the centrachid family. Its native distribution includes the area between the Hudson Bay basin and the St. Lawrence-Great Lakes basin to the Mississippi River basins, and the Atlantic drainages from North Carolina to Florida and northern Mexico (Page & Burr, 1991). It is commonly found in slow flowing, warm, and turbid rivers or lakes (Tomelleri & Eberle, 1990). Black bass is one of the favorite game fish of anglers who in the USA constitute an economically important sector responsible in 1996 for spending 38 billion dollars on equipment, travel, and other fishing-related expenses (United States Department of the Interior *et al.*, 1996). The black bass is a major predator, feeding on zooplankton, insects, and other invertebrates as juveniles, and preying on crustaceans, fish, and other small vertebrates as adults (Aloo & Dadzie, 1995; García-Berthou, 2002; Hickley *et al.*, 1994). Maximum recorded length is 97 cm (Page & Burr, 1991) and maximum weight is 10.09 kg (Tomelleri & Eberle, 1990).

The species was introduced for sport-fishing purposes in many countries like Japan (Yodo & Kimura, 1996), Kenya (Aloo & Dadzie, 1995), Mozambique (Weyl & Hecht, 1999), Italy (Lorenzoni *et al.*, 2002), Spain (Elvia & Almodóvar, 2001), and Portugal (Colares-Pereira *et al.*, 1999). In almost all of such countries, undesirable side effects on native fauna have been reported. *Micropterus salmoides* introduction to Brazil was documented by Godoy (1954). The species was introduced in 1922 by Jair Lins of Belo Horizonte. After several frustrated attempts he finally succeeded in his efforts to reproduce the species in captivity. Today the black bass is widely distributed in artificial systems like angling ponds, and semi-natural systems like reservoirs, from Rio de Janeiro to Rio Grande do Sul. In these systems black bass frequently form self-reproducing populations. No published scientific information about the dispersion of this species in Brazilian rivers and lakes is currently available, nor are publications on growth or other basic population parameters, which are essential for impact assessment of black bass on native fish communities.

The objective of this study was to analyze growth, age structure, and mortality of a black bass population in a small reservoir in São Leopoldo, RS, where the species was introduced in 1990 and reproduces regularly.

MATERIAL AND METHODS

Black bass were captured on two occasions in September 1999 and 2001 in a 2.7 ha reservoir on the campus of Universidade do Vale do Rio dos Sinos in São Leopoldo, southern Brazil (S29°47.75', W51°09.47'). The reservoir is located in the Rio dos Sinos watershed, Rio Grande do Sul.

In the first event, black bass were captured by electric fishing (700 V, max. 7 KW, direct current), using the hull of an aluminum boat as the cathode. On the second occasion, fish were captured with hook and line during an angling tournament.

All specimens were measured (total length and weight). From each individual, five to eight scales were collected from the body area between the lateral line and the dorsal fin (Devries & Frie, 1996). Scales were cleaned under running water and immersed in hydrogen peroxide (30%) to remove mucus and clear the structures. Damaged scales or scales with dubious annuli were discarded.

Growth was analyzed by scale reading and length frequency distribution. Scale reading followed Devries & Frie (1996) and used the radius of the annuli, total radius of the scale, and total length for back-calculation of fish length at different ages. The von Bertalanffy growth curve was calculated on the basis of back-calculated lengths applying the equation

$$L_t = L\infty(1 - e^{-K(t-to)})$$

where L_t predicts the length at age t (dimension: cm); $L\infty$ is the theoretical total maximum length, which may be attained at infinite high age (dimension: cm) (the growth curve approaches this value asymptotically); K varies between 0 and 1 and determines the approximation of the growth curve to $L\infty$ (dimension: year^{-1}) (the higher the value of K, the faster the approximation); t_o = theoretical age at length zero (dimension: years); and t_o is usually negative and considers that growth has already occurred between fecundation and hatching (Piscistat, 1991).

Since K cannot be used directly as the growth indicator because of its dimension year^{-1}, the index of growth performance ($ø' = \log_{10}K + 2\log_{10}L\infty$; dimension: cm year^{-1}) was also calculated to compare growth of the studied population with that of others (Froese & Pauly, 2000).

The length frequency distribution was used to identify cohorts. Mortality between cohorts was calculated by $N_0 = N_1 * e^{(-Z * \Delta t)}$, where N_0 and N_1 are the abundances of individuals in subsequent cohorts, Z is the total mortality rate, and Δt the time between the cohorts (= 1 year) (Froese & Pauly, 2000). Since Z is the sum of natural mortality and fishing mortality, fishing mortality was set to zero because no fishing was allowed in the reservoir, except for our experimental purpose.

The relation between fish weight and length is given by the equation $W = a*L^b$, where W is the weight and L is the length. The parameters a and b were calculated by linear regression between log W and log L (log W = a + b log L) (SPSS, 1999). Regression parameter b is a measure of stoutness, which means the tendency to attain higher weight at lower length. The regression parameters were compared to those of 60 populations in the U.S. and other countries, which were published in the Fishbase 2000 database (Froese & Pauly, 2000).

RESULTS

A total of 134 black bass was collected with a total length ranging between 21 cm and 46.6 cm, and weight of between 104.6 g and 1467.9 g. Readable scales could only be found on 64 fish. The equation of the von Bertalanffy growth curve was calculated to be $L_t = 43.91\ (1 - e^{-0.99(t-0.09)})$. Figure 1 displays the growth curve and shows the asymptotical approximation to $L\infty = 43.91$ cm.

Length frequency distribution was trimodal, with each mode representing the mean length of a cohort (Fig. 2). The mean length of each cohort based on the von Bertalanffy method and on length frequency distribution is shown in Table 1. The comparison of growth parameters $L\infty$, K, and ø' of the studied population with those of others indicates fast growth in Brazil but a lower maximum length compared to that of populations in the U.S.A. and other countries (Table 2).

Since length frequency distribution identified three nonoverlapping cohorts (Fig. 2), the mortality between them could be calculated. Between the first and the second year, mortality was Z = 0.16 year^{-1} and between the second and the third year mortality increased fourfold to Z = 0.8 year^{-1}.

The relation between weight and length is given by the equation log W = –2.32 + 3.28 L. In Fig. 3 regression weight-length parameters a and b are plotted with regression parameters of 60 populations worldwide. The position of the Brazilian population above the regression line at the right half of the graph indicates that individuals of the studied population have a stouter body shape than most of the other populations worldwide.

TABLE 1

Mean total length per year calculated by von-Bertalanffy-method and by length frequency distribution (modes); Std = standard deviation.

Age (years)	N	Total length (cm)	Std	Modes (cm)
1	64	26.1	13.88	27
2	18	37.31	12.52	37
3	2	41.46	9.92	42

TABLE 2

Comparison of von Bertalanffy growth parameters and growth index ø' of the Brazilian population and others; TL = Total length, SL = Standard length.

State/Country	Length measure	L_∞ (cm)	K ($year^{-1}$)	ø' (cm $year^{-1}$)	Author
RS/Brazil	TL	43.91	0.99	3.28	Present study
New York/USA	TL	52.90	0.22	2.79	Froese & Pauly (2000)
Minnesota/USA	TL	58.90	0.16	2.74	Froese & Pauly (2000)
Alabama/USA	TL	62.50	0.28	3.04	Froese & Pauly (2000)
Italy	TL	51	0.28	2.87	Froese & Pauly (2000)
Japan	SL	34.1	0.5	2.76	Froese & Pauly (2000)

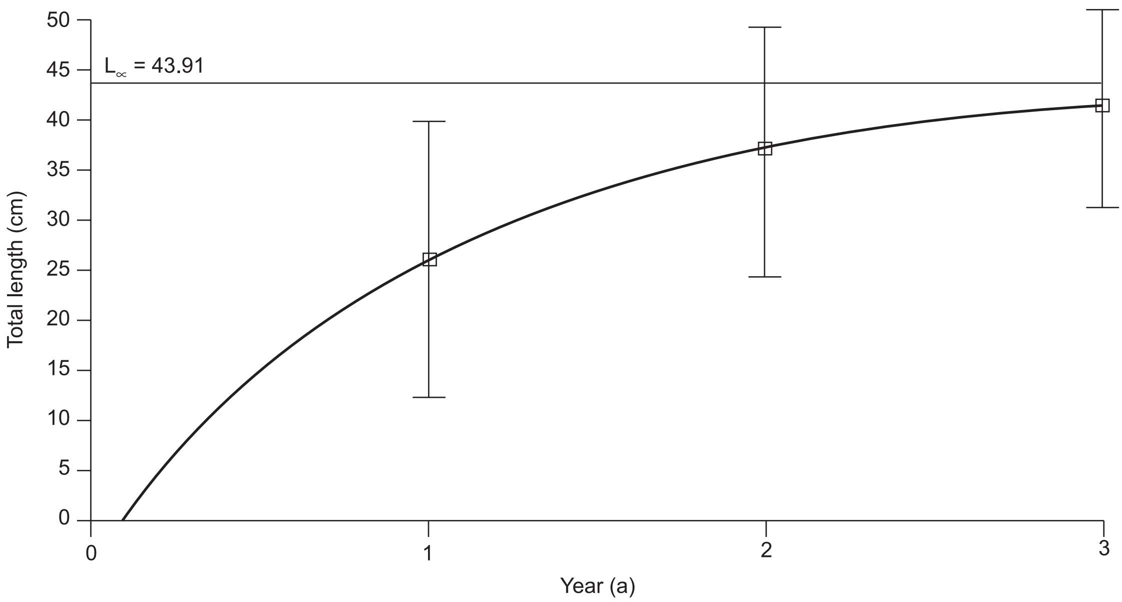

Fig. 1 — Von Bertalanffy growth curve (n = 64); vertical bars = standard error.

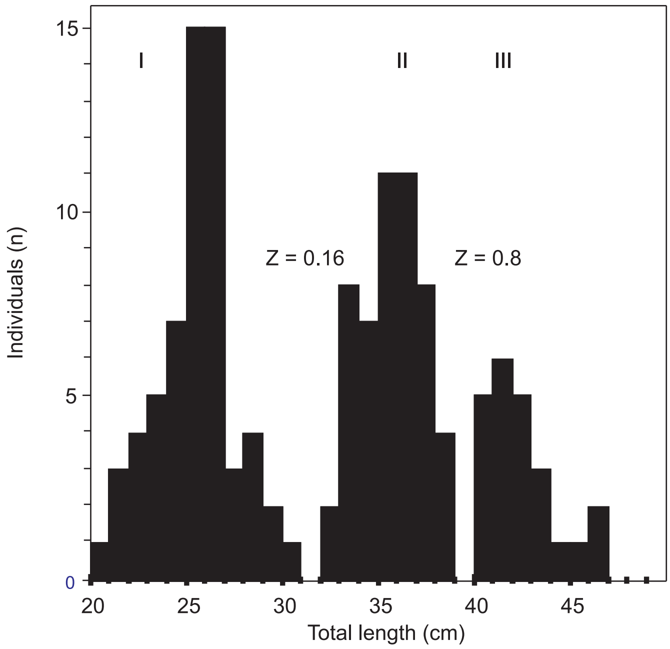

Fig. 2 — Length frequency distribution (n = 134); I, II, and III are subsequent cohorts, Z = Mortality between cohorts.

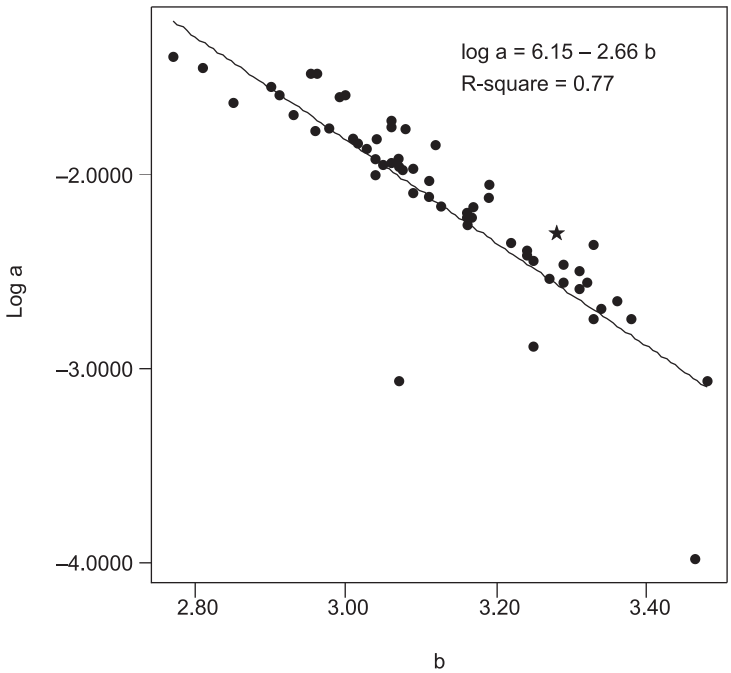

Fig. 3 — Comparison of length-weight regression parameters of the Brazilian population (★) with 60 (●) other parameters from Froese & Pauly (2000).

DISCUSSION

The von Bertalanffy growth curve, based on scale readings, was validated by the length frequency distribution of the same population. Both methods lead to similar results. The southern Brazilian population grows very fast, reaching a maximum age of three years and a maximum length of about 44 cm. The maximum observed length of 46.6 cm at capture corresponds well to the theoretical maximum length of 43.91 cm based on the von Bertalanffy growth model.

Growth parameter comparisons show that the Brazilian population studied grew faster than black bass populations in the original area of distribution. (This same observation was previously made by Godoy (1954).) However, fast growth does not result in a high maximum length and weight. In Brazil, the current black bass angling record nationally is 2550 g (Tabela oficial dos recordes brasileiros absolutos de pesca, 2003), only 1 kg more than the largest fish captured in the studied reservoir, where the species was introduced about 13 years ago.

Although the Brazilian population grows faster than others, longevity is reduced to only three years. In Mozambique, this introduced species attains five years (Weyl & Hecht, 1999), while reaching seven in both Italy and Japan (Lorenzoni *et al.*, 2002; Yodo & Kimura, 1996). Fourfold increased mortality between the second and the third cohorts is a strong indicator that fish older than three years die. However, the causes of this lower longevity in the studied stock are not well understood. It may be assumed that genetic diversity, particularly of the population under study but including Brazilian stocks in general, is reduced compared to that of native populations of the U. S. and Canada. Introductions were made with relatively few individuals more than 80 years ago. Even if additional fish were more recently imported from the U.S.A., relatively few fish gave rise to all Brazilian populations, so that inbreeding effects are highly probable. Furthermore, several studies carried out with salmonids link inbreeding with immunologic deficiencies, decreased female age at maturity, diminished number of oocytes, and mortality increase in aquaculture (Kincaid, 1976; Wang *et al.*, 2001). The negative effects accumulate with increasing age of the individuals (Su *et al.*, 1996). In natural populations of species threatened by extinction, low abundances of individuals and consequent reduction of genetic diversity is a constant concern. Particularly in species of high longevity and late maturity, e.g., sturgeons, inbreeding effects may contribute to population decrease of a species (Hay-Chmielewski, 1997; Wakeford, 2001).

The fact that black bass reproduces in semi-natural water bodies like reservoirs, and that the species grows fast, indicates the potential of establishing self-sustaining populations in natural water bodies. Several individuals, which local anglers refer to as “green fish”, have already been captured in Rio dos Sinos, to which the university reservoir is connected. In Rio Grande do Sul State’s mountainous area, which is partially located in the Rio dos Sinos watershed, black bass are frequently raised in tanks and small reservoirs for a local put-and-take fishery. The species has been caught in ichthyologic surveys in streams of this area (Fernando Becker, *Fundação Zoo-Botânica*, Rio Grande do Sul, personal communication), and some of these individuals have been included in the ichthyologic collection of the Catholic University (PUCRS) in Porto Alegre. One of them, a juvenile of 13 cm, may have originated through natural reproduction.

In conclusion, although Brazilian black bass do not attain the size and maximum age of black bass in their original area of distribution, their fast growth and ability to reproduce under semi-natural conditions make them likely candidates for further propagation in natural water bodies. However, the possible dispersion of the species can be considered a major threat to native fish communities. Moyle *et al.* (1987) referred to the consequences of alien fish introduction, which are unpredictable and can have severe negative impacts, as the Frankenstein effect.

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