AGE AND GROWTH OF *Micropterus salmoides* Lacepède IN FOUR SOUTHERN PORTUGUESE RESERVOIRS

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ABSTRACT

The growth of *Micropterus salmoides* captured during the summer of 1990 in Pego do Altar, Santa Clara, Magos and Vale Cobrao reservoirs was determined. A variable growth was found in the four reservoirs. In the first year it was higher in Magos and V. Cobrao (presumably as a result of an efficient predation over *Lepomis gibbosus*) and in the second year in P. Altar and V. Cobrao (presumably as a result of a largest individual food abundance). At the end of the third year *M. salmoides* reached in all reservoirs more than 0.5 kg and 1 kg at the fourth year in P. Altar. The growth observed was higher than the american and european average, and similar to values found in southern U.S.A. The larger growth period existing in South Portugal is the major reason for the obtained growth values.

INTRODUCTION

The largemouth bass *Micropterus salmoides* was first introduced in Portugal in 1952 with a stock of fingerlings from the french aquaculture station of Clousioux. There had been a previous unsuccessful attempt of introduction with adults originated in the populations existing in the vulcanic Azores lagoons since 1898. At the time of the introduction the species already existed in Europe and later in Spain (1955-56), but its distribution and expansion are small and frequently restricted to cyprinicultures to control overpopulations.

In Portugal the species rapidly spread and occupied most reservoirs, especially in central and southern regions where it became very appreciated for human consumption and is presently the most valuable angling species. Following a period of expansion with large sized populations and/or individuals, the species now shows in many reservoirs depressed populations where few individuals and small sizes dominate, presumably because of overfishing and unfavourable ecological conditions. In spite of its commercial and angling value, no studies existed concerning the evolution and present state of bass populations. Mostly because of paleo-historic isolation, the portuguese southern fish fauna is characterized by a large number of endemic cyprinids and no typical ictiophagous species. Although conservationists have widely speculate about the heavy predation of black bass over endemic cyprinids, the only and recent existing studies point to preferential food habits similar to the continent of origin and consisting of the centrarchid *L. gibbosus* (pumpkinseed), the red crayfish *Procambarus clarkii* (both recently introduced in Portugal) and insects (Godinho, 1991; Godinho & Ferreira, 1990;

1993). In the North-american continent the species *M.salmoides* includes a northern and a southern sub-species, respectively *M.salmoides salmoides* (Lacepède) and *M.salmoides floridanus* (Le Seur), with different thermic preferences and growth potentialities (Heidinger, 1976). However, the genetic origin of the individuals from the aquaculture was also unknown. This study is a first approach to the growth of *M.salmoides* in Portugal.

MATERIALS AND METHODS

This study was conducted in four southern reservoirs with different size, trophic state and angling interest (Table I). All of them are used mainly for irrigation purposes with high water level fluctuations along crop seasons. Fish sampling was done between May and September, in littoral areas, by electrofishing and hook-and-line fishing. Age determination was done from the annual rings of scales (Jearld, 1983). Six to twelve scales were removed from the middle region of the body side, above the lateral line and under the dorsal fin. Scales were washed with xylol for fat elimination, emmersed in 10% sodium hydroxide for a day, rinsed in water and bound tightly between two slides. Besides determination of the annual marks number, the distance from focus to scale edge (Sc) and the distance from the focus to each *annuli* were measured. Total lenght (Lt) as well as total weight (Wt) were also determined for each individual. For the regression analysis between Wt and Lt, measurements were logarithmised. Determination of sex was done by gonad observation. Following Bagenal & Tesch (1978), the population medium total lenght was back-calculated and then converted to medium total weight by using the relation between the two dimensions of growth. This method is currently used to assess bass growth (Houser *et al*, 1975; Heidinger, 1976; Kilambi *et al*, 1978). Instantaneous population growth rate was determined according to Bagenal & Tesch(1978).

For the determination of the sub-species only individuals with more than 20 cm were considered and the following meristic characteristics were studied: number of scales in lateral line (LLS), number of scales above lateral line (ALLS), number of scales under lateral line (BLLS), number of facial scales (CS), number of scales in caudal peduncle (CPS) and number of 'cecci pillori' (CP).

Table I. General characteristics of the four studied reservoirs.

	Pego do Altar	Santa Clara	Magos	Vale Cobrao
Area (ha)	655	1986	124	110
Secchi Transparency (m)	1.6	6.8	0.8	0.7
Trophic state (*)	b)	a)	c)	b)
Emergent macrophytes	reduced	reduced	abundant	reduced
Submerged macrophytes	none	abundant	reduced	reduced
Angling value (**)	medium	high	medium	low
Number of fish captured	76	67	43	53

(*) a) oligotrophic; b) mesotrophic; c) eutrophic (**) assessed by bass anglers considering number and size of individuals captured during the fishing season.

RESULTS

The characteristics studied point to the sub-species *salmoides* as the origin of portuguese largemouth bass populations (Table II). This subspecies has a much wider distribution in North-America than the subspecies *floridanus*, restricted to the southern regions (MacCrimmon *et al.* 1975) and was the likeliest to exist in France. Individuals of *M.salmoides* with 1+, 2+ and 3+ years of age were captured in all reservoirs (Figure 1). However, 0+ individuals were captured only in Magos and V.Cobrao. Two aspects are probably responsible for this result: the selectivity of the capture methods and the influence of the reservoir size. Only individuals more than 20 cm of total lenght were captured with rod and artificial bait and this method was more intensely used in S.Clara were individuals less than one year old were not captured. Common electrofishing is well known to undersample small sizes (Copp, 1989; Reynolds, 1983). Also, in small reservoirs electrofishing is more effective because small sized fishes are more easily detected.

Table II. Comparison of meristic characteristics between the two existing sub-species and the portuguese sampled population. a)Chew,1975; b)Heidinger,1976. Averages between brackets.

	<i>M.salmoides</i> <i>salmoides</i>	<i>M.salmoides</i> <i>floridanus</i>	Portuguese populations
LLS (a)	58-72 (64.4)	67-77 (72.1)	60-72 (65.1)
ALLS (b)	6-10	6-11	7-9 (7.9)
BLLS (b)	13-19	14-23	15-19 (17.9)
CS (b)	8-13	10-14	9-11 (10.2)
CPS (b)	23-32	24-34	27-31 (28.4)
LLS+ALLS+			
BLLS+CS (b)	124-130(125.9)	135-141(136.8)	125-131(129.1)
CP (a)	13-35 (23.2)	26-53(36.8)	17-32 (24.5)

Figure 1. Age structure of the *M.salmoides* captured in the four studied reservoirs.

M.salmoides with more than four years old (4+) were captured only in P. Altar and in fact Heidinger (1976) states that the majority of a *M.salmoides* population in a reservoir has generally less than five years old. The male/female ratio in the youngest classes presented a value close to 1, decreasing in the classes 2+ and 3+

(Figure2). Individuals 4+ were exclusively feminine. As referred by Heidinger(1976) for american reservoirs, as a bass year class becomes older, the percentage of males decrease. Simple linear regression provided a good adjustment for the relation between Lt and Sc in all reservoirs (Table III). At the end of the first year, *M.salmoides* reached a medium lenght ranging from 13.91 to 17.03 cm, showing a highest growth in the smallest reservoirs, V.Cobrao and Magos (Table IV). Two years old *M.salmoides* presented an medium lenght ranging between 23.48 and 28.68 cm, with maximum values observed in P.Altar and V.Cobrao. At the end of the third year, medium lenght showed the smallest variation between reservoirs, with values ranging between 32.5 and 34.56 cm. Back-calculation for the fourth year could only be done for P.Altar (40.02 cm).

Figure 2. Sex-ratio of the *M.salmoides* captured in the four studied reservoirs.

Table III. a b and R values for the linear regressions between Lt-Sc * and ln(a), b and R values for the linear regression between ln(wt)-ln(Lt) **

	a*	ln(a)**	b*	b**	R*	R**
P. do Altar	-1.246	-4.711	2.926	3.159	0.952	0.996
S. Clara	2.805	-4.150	2.419	2.942	0.902	0.971
Magos	2.586	-4.470	2.385	3.091	0.921	0.998
V. Cobrao	1.578	-4.322	2.336	3.008	0.942	0.998

Table IV . Medium back-calculated total lenght and standard deviation for each year (cm)

	YEARS		1+		2+		3+		4+	
	x	SD	x	SD	x	SD	x	SD	x	SD
Pego do Altar (N = 60)	13.91	7.03	28.68	5.17	33.87	4.26	40.02	0.7		
Santa Clara (N = 47)	15.86	8.66	25.82	8.12	34.48	9.65				
Magos (N = 30)	17.03	10.44	23.48	7.23	32.50	0.5				
Vale Cobrao (N = 35)	16.5	12.35	28.06	2.18	34.56	4.02				

Simple linear regression provided a good adjustment for the relations between $\ln(W_t)$ and $\ln(L_t)$ in all reservoirs (Table III). Medium total weights are shown in Table V. The medium weight at the end of the first year ranged between 36.7 and 73.0 g and, at the end of the second year, between 197 and 362 g. At the end of the third year the medium length was higher than 500 g in all reservoirs and for the fourth year a converted weight of 1033 g was obtained for P.Altar. Population growth rate shows the highest variability and values between the first and second years (Table V).

Table V. Converted medium total weights (g) and instantaneous growth rate (g/yr) in the four reservoirs.

YEARS	I	II	III	IV
Pego do Altar g	36.77	361.50	611.35	1033.00
GR (g/yr)	2.29	0.53	0.53	
Santa Clara g	53.55	224.60	525.90	
GR (g/yr)	1.43	0.86		
Magos g	73.00	197.22	538.65	
GR (g/yr)	0.99	1.00		
Vale Cobrao g	60.92	300.88	563.07	
GR (g/yr)	1.60	0.68		

DISCUSSION

The growth of *M.salmoides* in the four studied reservoirs, expressed both as medium back-calculated total length and weight, showed the highest values during the first year in Magos and V.Cobrao reservoirs, and in the second year in P.Altar and V.Cobrao. However, by the end of the third year, the variability of dimensions decreased in all reservoirs and all values reached more than 32 cm and 500 g. In fact, the values obtained were higher than others found in Europe and South-Africa (Heidinger, 1976; Alésio, 1982), superior to the average for the north-american continent (Heidinger, 1976) and similar to values found in southern EUA, as in Lake Folsom, California (Geldern, 1975).

The growth of *M.salmoides* is dependent upon four main factors : the extent of the growth period, the type and quantity of ingested food, the genetic background of the individuals and the density of the population (Bennet, 1962; Heidinger, 1976; Weatherley & Gill, 1987). In North-America the period of growth, primarily determined by the water temperature, is pointed as the main reason for the growth differences between North and South (Bennet, 1962; Coutant, 1975; Heidinger, 1976). Growth starts with temperatures over 10 °C and reaches maximum values with temperatures over 25 °C (Coutant, 1975). These temperatures occur in periods larger than 10 months in portuguese southern waters and this extended growth period is probably the major reason for the high growth rates found. These temperature regimes are similar to the ones existing in southern U.S. In face of these thermic conditions, *M.salmoides salmoides* has, according to some authors, lower temperature optimum and inferior growth rates when compared with the subspecies *floridanus* (Chew, 1975; Childers, 1975). The growth values obtained were also different between reservoirs. As temperature regimes and favorable

growth period are similar in all southern reservoirs and the genetic background of the portuguese populations is the same, growth differences must be associated with other factors like density of predator or preys and food availability. *M. salmoides* density is strongly related to individual space and food availability (Bennet, 1962; Heidinger, 1975). Also important for growth is the feeding strategy and related environmental factors, like water transparency and the abundance of shelters and submerged macrophytes, which determine the detectability, evasibility and density of preys, as discussed in Godinho & Ferreira (1990; 1993). A high water transparency permits the detection of crayfish (Crowl, 1989) a less motile and easily catchable prey while low transparency and the abundance of macrophytes and shelters favours the consumption of motile preys like insects (especially Odonata adults) and pumpkinseed. A large consumption of macropreys in the first years, especially fish, is related to bigger growth rates (Aggus & Elliot, 1975). The smallest studied reservoirs, V.Cobrao and Magos, presented the bigger growth rates by the end of the first year. These are low depth, eutrophic bodies of water (Table I), used mainly for irrigation purposes, with soft slopes and straight shorelines. The water level variation greatly reduces water surface and volume, increasing the conspicuousness between predator and preys and favouring an efficient predation (Keith, 1975). Diets of individuals smaller than 20 cm from V.Cobrao and Magos included the largest fish components (Godinho, 1991; Godinho & Ferreira, 1990; 1993). Pego do Altar has also high water fluctuations but its greater depth and area do not result in this promiscuity between predator and preys. Larger growths can also be related to low densities of *M. salmoides* (Weatherley and Gill, 1987) resulting in a proportional increase of individual food availability, which most probably occurred in V.Cobrao and P.Altar during the second year of *M. salmoides*. Both reservoirs present a small number of small sized individuals captured and medium to small bass densities.

S.Clara is the only reservoir that presents high angling value and a well established population with abundant large sizes (>35 cm). The high density of the species could imply an increase in intraspecific competition and a lower growth rate, which nonetheless reached 0.86 g/year between the second and third years. S.Clara reservoir presents quite favourable ecological conditions for bass, including small water level fluctuations, high water transparency favouring sight preying, abundance of submerged vegetation that provides hidings during predation, insect food for early life stages of basses and protection for larvae and fingerlings. Nests are frequently made near submerged vegetation (Bruno *et al*, 1990). Less suspended matter is also important for nesting and egg survival (O'Brien, 1990). Magos reservoir presents moderate bass density, but only a small number of large sized individuals are captured by anglers. Angling pressure is quite strong because of Lisbon proximity and probably results in overfishing. Also, this is a reservoir presenting eutrophication problems with strong and erratic water level fluctuations, and bass captures vary greatly between years and within the same year. Southern portuguese waters present excellent potentialities for bass growth, although the ecological characteristics of most reservoirs can be partially unfavorable because of the excessive turbidity, strong water level fluctuations, unstructured shorelines and eutrophication, also pointed by O'Brien as existing in many north-american southern reservoirs. However, the high growth values found in Portugal are frequently associated with depressed populations with few individuals of large sizes, as expressed by the low angling value of these reservoirs. In 1981, the total biomass of

largemouth in P. Altar following a total dry-out was 0.33 kg/ha, a small value when compared to the average of 10 kg/ha (range 0.1-59.4 kg/ha) for 173 north-american reservoirs referred by Jenkins (1975).

Selective overfishing by the always increasing number of bass anglers has most probably decreased large sized basses (>20 cm) and promoted the increase of pumpkinseed populations. 'Stunted' populations of pumpkinseed have been observed to coexist in many reservoirs with depressed bass populations by one of the authors (F.G.). This species shows a considerable trophic overlap with small sized *M. salmoides*, as observed by Jimenez (1989) in central Spain. According to some authors (e.g. Bennet, 1962) pumpkinseed also consumes bass eggs, although studies in Portugal (Domingos & Costa, 1987) and Spain (Jimenez, 1989) do not completely support this idea. Largemouth bass is already the most important fish resource in southern portuguese reservoirs and growth potentialities found in this study justify the implement of fish and reservoir management directives that are virtually nonexistent in the present. Immediate measures for reservoirs with depressed populations could be the limitation of the number of captures per angler per day. However, the studies recently conducted emphasize the importance of the ecological particularities of each reservoir for bass biology and populations namely in what concerns food habits, feeding strategy and growth (Godinho, 1991; Godinho & Ferreira 1990, 1993). Besides immediate measures, a dynamic management strategy must be developed for each reservoir considering the respective multiple usage in course and according to the previous study of relevant limnological characteristics.

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