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Determination of age and growth of the striped seabream *Lithognathus mormyrus* (Sparidae) in the Canarian archipelago by otolith readings and backcalculation*

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SUMMARY: The age and growth of the striped seabream *Lithognathus mormyrus* caught off the Canary Islands (central-east Atlantic) from January to December 1999 were studied. A total of 496 individuals, ranging in size between 113 and 350 mm total length, were examined. Otoliths clearly showed the ring pattern common to teleost fishes. One year's growth was made up of one opaque and one translucent ring. The opaque ring was deposited during the summer months and the translucent one during the winter months. Fish aged 0-8 years old were found. The von Bertalanffy growth parameters for all fish were: L_∞=427 mm, k=0.19 year^{-1}, and t_0=1.46 year. The otolith readings for estimating age and growth were confirmed by using the backcalculation method.

Key words: *Lithognathus mormyrus,* age, growth, otolith readings, backcalculation, Canary Islands.

INTRODUCTION

The striped seabream *Lithognathus mormyrus* (Linnaeus, 1758) is a marine fish belonging to the Sparidae family. It is a demersal species living in groups over various types of sea bottoms, especially rocky, sand and seagrass beds, at depths ranging from 0 to 150 m. This species is distributed in the eastern Atlantic and in the western Indian Ocean. In the eastern Atlantic, it occurs from the Bay of Biscay to the Cape of Good Hope, and around the Canaries and Cape Verde. It is also present in the Mediterranean, Black, Azov and Red seas. In the western Indian Ocean, it occurs on the Natal coast (Smith and Smith, 1986; Bauchot and Hureau, 1990; Harmelin-Vivien *et al.*, 1995).

In the Canary Islands, the striped seabream is one of the main target species of the demersal small-scale fishery (Pajuelo, 1997). This species is caught at depths ranging between 10 and 100 m with traps. It is captured all year round with seasonal differences in landings. Catches of striped seabream have been declining in this area during the last few years.

Despite its fishing importance, the striped seabream has never been the object of investigation in the Canary Islands. The present work investigated

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the age and growth of the striped seabream off the Canary Islands to obtain growth estimates, which are important input parameters for stock assessment techniques and will provide an insight into the life-history of this species. The importance of this study is enhanced by the fact that only three articles on the age and growth of the species have been published (Suau, 1970; Kraljević *et al*., 1995, 1996).

MATERIALS AND METHODS

A total of 496 individuals of striped seabream were collected from commercial catches of the artisanal fleet from January to December 1999. Fish were caught with traps deployed on the bottom at depths of 10-90 m off Gran Canaria (Canary Islands).

For each fish, the total length (TL, mm) was measured, the sex was determined (male, female or intersexual), and the sagittal otoliths were removed.

Age was determined by counting the annual growth rings on the otoliths. Whole otoliths were placed in glycerin and examined under a compound microscope (15 x) with reflected light against a dark background. Counts for each otolith were performed three times. Readings for given otoliths were accepted only when two agreed. An index of average percent error was used to compare the accuracy of the determination (Beamish and Fournier, 1981). Ageing was validated indirectly by means of the analysis of the evolution of the mean monthly marginal increments. The marginal increment (MI, 0.01 mm) was measured as the distance from the outer margin of the outermost translucent ring to the periphery of the otolith. Measurements were always made along the longest axis of the piece. Once the annual periodicity of the rings was confirmed, individuals were assigned to the corresponding age classes beginning with the date of capture and considering 1 September as the birthdate. The von Bertalanffy growth curve was fitted to the data of the resulting age-length key by means of Marquardt's algorithm for non-linear least squares parameter estimation (Saila *et al.*, 1988).

The backcalculation method was applied as an independent means of validating the otolith-based age determinations (Morales-Nin, 1989). Backcalculation analysis was undertaken using a method described by Francis (1990). The radius of the ith band (RI, 0.01 mm), the distance from the centre of the otolith to the outer edge of the translucent ring, and the radius of the otolith at capture (R, 0.01 mm), i.e. the distance from the centre of the otolith to the periphery, were measured. Measurements were always made along the longest axis of the otolith. The size of an individual when the ith band was laid down (SI, mm) was calculated as $SI=(RI/R)^b TL$, where b is a constant derived from the power function which describes the relationship between the radius of the otolith and the total length of the fish (Francis, 1990). The von Bertalanffy growth curve was fitted to the backcalculated mean length at age by means of Marquardt's algorithm for non-linear least squares parameter estimation (Saila *et al.*, 1988). The growth parameters obtained for males, females and all individuals were compared statistically by means of Hotelling's T^2-test (Bernard, 1981).

To compare the growth parameters obtained in the present papers with those reported by other authors for the same species, the growth performance index (θ) was used (Pauly, 1991). This index has the form: $\theta = 2 \log_{10} L_\infty + \log_{10} k$, where k is the growth coefficient, and L_∞ is the asymptotic length.

RESULTS

Of the 496 individuals examined, 235 (47.4%) were males, 229 (46.2%) females, and 24 (4.8%) intersexuals. The sex of the remaining 8 (1.6%) individuals could not be identified macroscopically because they were immature and had very thin, translucent gonads.

The size range of the individuals was between 113 and 350 mm total length. Males ranged in size from 201 to 350 mm, females from 199 to 350 mm, and intersexuals from 217 to 323 mm. The length of immature fish was comprised between 113 and 230 mm.

A concentric pattern of translucent and opaque zones was readily dintinguishable in the otoliths, and easily interpreted. Of the 496 otoliths examined, 17 (3.4%) were considered unreadable and therefore no age estimates were obtained from them. Of these otoliths, 6 were broken, and 11 had poorly defined growth zones. Of the remaining 479 otoliths, the readings were coincident at least twice in 452 (94.5%) but yielded conflicting ages in 27 (5.5%). The value of the index of average percent error was only 3.1%. Annual marks were equal in both the anterior and lateral otolith fields. Readings were equal in both left and rigth otoliths.

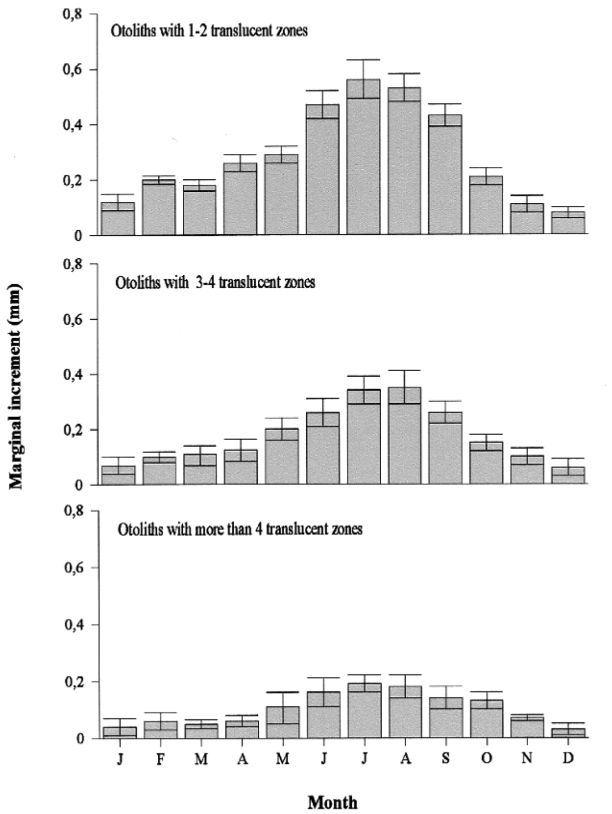

FIG. 1. – Mean monthly evolution of the marginal increment in the otoliths of striped seabream *L. mormyrus* off the Canary Islands.

The evolution of the mean monthly marginal increments in otoliths with one and two translucent zones, three and four translucent zones, and more than four translucent zones is shown in Figure 1. The same temporal variation pattern was recorded for the three cases. The highest values occurred between May and October, peaking during July-August. From November to April the values were low. Based on this, it was assumed that an opaque zone and its adjacent translucent zone were deposited on the otoliths each year. The values of increments on the otoliths decreased with the age of the fish.

Fish aged 0 to 8 year old were recorded (Table 1). Individuals attained over 50% of their maximum observed size during the second year of life. Growth parameters determined for males, females, and all individuals (males, females, immatures and intersexuals) are shown in Table 2. Significant differences in the growth parameters were found between males and females (Hotelling's T^2-test, $T^2=41.13> T_0{}^2_{0.05,3,425}=7.89$). The mean size of males was slightly smaller than the mean size of females at the same age.

Fish total length and otolith radius were closely correlated (Fig. 2). The total length and otolith radius were also estimated for males (LT=

TABLE 1. – Age-length key for all fish of striped seabream *L. mormyrus* off the Canary Islands.

Size (mm)	Age group (year)								
	0	I	II	III	IV	V	VI	VII	VIII
110	1								
120		1							
130	1								
140		1							
150		1							
160		1							
170			1						
180		1							
190			1						
200			2						
210			7	2					
220			4	14	2				
230			1	22	4				
240			2	29	7				
250				32	9	1			
260				16	30	4			
270				9	51	7			
280				3	46	7			
290					29	16	2		
300					8	25	3		
310						14	3		
320						9	6	1	
330						3	4	2	
340							1	3	1
350								1	1
n	2	5	18	127	186	86	19	7	2
x	122	159	205	244	275	302	323	341	350
sd	12	20	16	14	12	12	11	9	2

TABLE 2. – Parameters of the von Bertalanffy growth equation for males, females and all fish of striped seabream *L. mormyrus* off the Canary Islands estimated by otolith readings and backcalculation.

	L_∞(mm)	k (year^{-1})	t_0 (year)	n	r^2
Otolith readings					
Males	399	0.23	-0.99	219	0.965
Females	441	0.18	-1.25	210	0.953
All fish	427	0.19	-1.46	452	0.989
Backcalculation					
Males	377	0.24	-1.25	8	0.993
Females	409	0.21	-1.31	8	0.992
All fish	399	0.22	-1.14	8	0.995

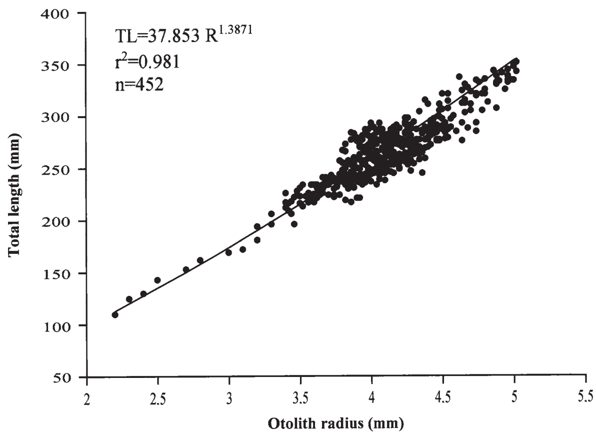

FIG. 2. – Relationship between the otolith radius and the total body length of striped seabream *L. mormyrus* off the Canary Islands.

$37.216R^{1.3842}$) and females ($LT=38.022R^{1.397}$) separately. Backcalculated total lengths at the end of each year of life by age group for all individuals are shown in Table 3. There was no indication of Rosa Lee´s phenomenon in which computed sizes at a given age tend to be smaller when derived from measurements on older fish (Francis, 1990). Observed lengths were slightly higher than backcalculated lengths for individual age groups. Growth parameters estimated from the mean backcalculated sizes at age for males, females, and all individuals are presented in Table 2. Significant differences in the growth parameters were found between males and females (Hotelling's T^2-test, $T^2=508.03> T_0{}^2{}_{0.05,3,12}=9.76$).

No significant differences between the growth parameters estimated by reading otoliths and using the backcalculation method were found in males (Hotelling's T^2-test, $T^2=7.08<T_0{}^2{}_{0.05,3,223}=7.93$), females ($T^2=6.97<T_0{}^2{}_{0.05,3,214}=7.93$), and all individuals ($T^2=6.03<T_0{}^2{}_{0.05,3,373}=7.89$).

DISCUSSION

In sparid species, age determination has often proved difficult as a consequence of the phenomenon of stacking of growth zones towards the otolith edge, especially in older fish (Buxton and Clarke, 1991, 1992; Smale and Punt, 1991; van der Walt and Beckley, 1997). However, in the striped seabream off the Canary Islands, the translucency of the otoliths allowed age to be determined with

TABLE 3. – Backcalculated total lengths at the end of each year of life by age group for all fish, males and females of striped seabream *L. mormyrus* off the Canary Islands.

Age	n	Age group (year)							
		I	II	III	IV	V	VI	VII	VIII
1	5	152							
2	18	150	205						
3	127	158	208	240					
4	186	151	204	242	269				
5	86	154	202	240	274	301			
6	19	157	203	237	272	298	320		
7	7	149	207	243	268	303	324	338	
8	2	153	202	239	271	302	321	337	346
Mean (all fish)		153	204	240	272	301	322	337	346
Annual growth increment		153	51	36	32	29	21	15	9
Annual growth increment (%)		44.2	14.7	10.4	9.3	8.4	6.1	4.3	2.6
Mean (males)		157	204	241	270	292	310	324	336
Annual growth increment		157	47	37	29	22	18	14	12
Annual growth increment (%)		46.6	13.9	11.0	8.7	6.6	5.4	4.2	3.6
Mean (females)		157	205	243	275	300	320	338	351
Annual growth increment		157	48	38	32	25	20	18	13
Annual growth increment (%)		44.7	13.7	10.8	9.2	7.1	5.7	5.1	3.7

relative ease. The oldest age estimated in this study is 8 years and the phenomenon of stacking is not evident.

Otoliths of the striped seabream of the Canarian archipelago show the ring pattern common to teleost fishes. One opaque and one translucent ring are deposited each year on the otoliths. These rings are formed owing to alternating periods of fast and slow growth (Williams and Bedford, 1974). Seasonal growth cycles might be related to physiological changes produced by factors such as the temperature or the food availability (Morales-Nin, 1989). In the otoliths of the striped seabream off the Canaries, the opaque rings are formed when the sea temperature reaches the highest values (24ºC, August) and the food is more abundant, and the translucent ones when the temperature reaches the lowest values (18ºC, February). The evidence presently available suggests that a seasonal temperature difference of 6ºC might be sufficient to cause ring formation (Morales-Nin and Ralston, 1990). Similar findings have been recorded in other studies carried out in the Canarian archipelago on other sparids, such as *Dentex gibbosus*, *Pagellus acarne*, *Pagellus erythrinus*, *Pagrus pagrus* and *Spondyliosoma cantharus* (Pajuelo and Lorenzo, 1995, 1996, 1998, 1999, 2000).

The proportionality between fish growth and otolith size increase allows backcalculation to be used to determine the growth. The results obtained by backcalculation were very satisfactory and confirmed the estimations of the age and growth of the striped seabream of the Canary Islands by otolith readings. Because the ring formation is regular and therefore the otoliths can be used for age determination, and because the fish length and otolith size are closely correlated, it is judged valid to permit the use of measurements to previously formed marks to backcalculate the growth history (Bagenal and Tesch, 1978; Barlett *et al.*, 1984; Campana, 1990; Francis, 1990).

The striped seabream off the Canary Islands has a relatively short life (8 years). Kraljević *et al.* (1995, 1996) also found that this species may attain an age of 8 years in the Adriatic Sea, and Suau (1970) examined 7-year-old specimens from the Spanish Mediterranean coast.

In the Canarian archipelago, the striped seabream grows relatively fast during the first few years of life, attaining approximately fifty percent of its maximum length during the second year. After the second year, the annual growth rate drops rapidly, related to sexual maturity, since in the studied area individuals are mature by the second year of life (unpublished data). Hence, energy seems to be diverted to reproduction (June-December), with less energy available for somatic growth. The difference in growth between sexes, with females reaching a slightly larger length than males at the same age, is a characteristic of the protandric species such as the striped seabream (Besseau and Bruslé-Sicard, 1991, 1995). Alekseev (1983) and Shapiro (1984) pointed out that the mean size of sex-reversed fish is slightly greater than that of males of the same age. Therefore, the difference in size between males and females of the same age cannot be considered as evidence of an intersexual difference in growth rates because males and females are the same specimens at different stages of sexual succession and the largest males in an age group may be the first to revert.

The growth parameters of the striped seabream off the Canary Islands are very similar to those obtained by Suau (1970) and Kraljević *et al.* (1995, 1996) for *L. mormyrus* on the Spanish Mediterranean coast (L_∞=332 mm, k=0.275 yr^{-1}) and in the Adriatic sea (L_∞=362 cm, k=0.297 yr^{-1}) respectively. The growth performance index obtained for the striped seabream of the Canary Islands (θ=4.53) is very similar to that estimated from the growth parameters given by Suau (1970) on the Spanish Mediterranean coast (θ=4.48) and Kraljević *et al.* (1995, 1996) in the Adriatic Sea (θ=4.59).

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REFERENCES

Alekseev, F.E. – 1983. Hermaphroditism in porgies (Perciformes, Sparidae). 2. Sexual structured of the populations mechanism of its formation and evolution in scups, *Pagrus pagrus, P. orphus, P. ehrenbergi* and *P. auriga*. *J. Ichthyol.*, 23: 61-73.

Bagenal, T.B. and F.W. Tesch. – 1978. Age and growth. In: T.B. Bagenal (ed.) *Methods for assessment of fish production in fresh waters*, pp. 101-136. Blackwell Scientific Publications, Oxford.

Bartlett, J.R., P.F. Randerson, R. Williams and D.M. Ellis. – 1984. The use of analysis of covariance in the back-calculation of growth in fish. *J. Fish Biol.*, 24: 201-213.

Bauchot, M.L. and J.C. Hureau. – 1990. Sparidae. In: J.C. Quero, J.C. Hureau, C. Karrer, A. Post and S. Saldanha (eds.) *Check List of the Fishes of the Eastern Tropical Atlantic, Clofeta II*, pp. 790-812. UNESCO, Paris.

Beamish, R.J. and D.A. Fournier. – 1981. A method for comparing the precision of a set of age determination. *Can. J. Fish. Aquat. Sci.*, 38: 982-983.

Bernard, D.R. – 1981. Multivariate analysis as a means of comparing growth in fish. *Can. J. Fish. Aquat. Sci*., 38: 233-236.

Besseau, L. and S. Bruslé-Sicard. – 1991. Sex inversion in a protandric hermaphrodite *Lithognathus mormyrus* L (1758) (Teleostei: Sparidae): histocitological peculiarities. In: P.A. Scott, J.P. Sumpter, D.E. Kime and M.S. Rolfe (eds.) *Proceedings of the 4th International Symposium on Reproductive Physiology of Fish*, pp 1-95. University of East Anglia, Norwich.

Besseau, L. and S. Bruslé-Sicard. – 1995. Plasticity of gonad development in hermaphroditic sparids: ovotestis ontogeny in a protandric species, *Lithognathus mormyrus*. *Env. Biol. Fish.*, 43: 255-267.

Buxton, C.D. and J.R. Clarke. – 1991. The biology of the white musselcracker *Sparadon durbanensis* (Pisces: Sparidae) on the eastern Cape coast, South Africa. *S. Afr. J. Zool.*, 10: 285-296.

Buxton, C.D. and J.R. Clarke. – 1992. The biology of the bronze bream *Pachymetopon grande* (Teleostei: Sparidae) from the south-east Cape coast, South Africa*. S. Afr. J. Zool.*, 27: 21-32.

Campana, S.E. – 1990. How reliable are growth back-calculations based on otoliths?. *Can. J. Fish. Aquat. Sci.*, 47: 2219-2227.

Francis, R.I.C.C. – 1990. Back-calculation of fish length: a critical review. *J. Fish Biol.*, 36: 883-902.

Harmelin-Vivien, M.L., J.G. Harmelin and V. Leboulleux. – 1995. Microhabitat requirements for settlement of juvenile sparid fish on Mediterranean rocky shores. *Hidrobiologia*, 300-301: 309-320.

Kraljević, M., J. Dulčić, A. Pallaoro, P. Cetinić and J. Jug-Dujaković. – 1995. Sexual maturation, age and growth of striped sea bream, *Lithognathus mormyrus* L., on the east of the Adriatic Sea. *J. Appl. Ichthyol.*, 11: 1-8.

Kraljević, M., J. Dulčić, P. Cetenić and A. Pallaoro. – 1996. Age, growth and mortality of the striped seabream, *Lithognathus mormyrus* L., in the northen Adriatic. *Fish. Res.*, 28: 361-370.

Morales-Nin, B. – 1989. Growth determination of tropical fish by means of otolith interpretation and length frequency analysis. *Aquat. Living Resour.*, 2: 241-254.

Morales-Nin, B. and S. Ralston. – 1990. Age and growth of *Lutjanus kasmira* (Forskal) in Hawaiian waters. *J. Fish Biol.*, 36: 191-203.

Pajuelo, J.G. – 1997. *La pesquería artesanal canaria de especies demersales: análisis y ensayo de dos modelos de evaluación.* Doctoral thesis. Universidad de Las Palmas de Gran Canaria.

Pajuelo, J.G. and J.M. Lorenzo. – 1995. Biological parameters reflecting the current state of the exploited pink dentex *Dentex gibbosus* (Pisces: Sparidae) population off the Canary Islands. *S. Afr. J. Mar. Sci.*, 16: 311-319.

Pajuelo, J.G. and J.M. Lorenzo. – 1996. Life history of the red porgy *Pagrus pagrus* (Teleostei: Sparidae) off the Canary Islands, central east Atlantic. *Fish. Res.*, 28: 163-177.

Pajuelo, J.G. and J.M. Lorenzo. – 1998. Population biology of the common pandora *Pagellus erythrinus* (Pisces: Sparidae) off the Canary Islands. *Fish. Res.*, 36: 75-86.

Pajuelo, J.G. and J.M. Lorenzo. – 1999. Life history of black seabream, *Spondyliosoma cantharus*, off the Canary Islands, Central-east Atlantic. *Env. Biol. Fish.*, 54: 325-336.

Pajuelo, J.G. and J.M. Lorenzo. – 2000. Reproduction, age, growth and mortality of axillary seabream, *Pagellus acarne* (Sparidae), from the Canarian archipelago. *J. Appl. Ichthyol.*, 16: 41-47.

Pauly, D. – 1991. Growth performance in fishes: rigorous description of patterns as a basis for understanding causal mechanisms. *Aquabyte*, 4: 3-6.

Saila, S.B., C.W. Recksiek and H. Prager. – 1988. Basic fishery science programs. A compendium of microcomputer programs and manual of operation. *Develop. Aquacul. Fish. Sci.*, 18: 1-230.

Shapiro, D.Y. – 1984. Sex reversal and sociodemographic process in coral reef fishes. In: G.W. Potts and R.J. Woottom (eds.), *Fish Reproduction, Strategies and Tactics*, pp. 103-117. Academic Press, London.

Smale, M.J. and A.E. Punt. – 1991. Age and growth of the red steenbras *Petrus rupestris* (Pisces: Sparidae) on the south-east coast of South Africa. *S. Afr. J. Mar. Sci.*, 10: 131-139.

Smith, J.L.B. and M.M. Smith. – 1986. Sparidae. In: M.M. Smith and P.C. Heemstra. (eds.) *Smiths' sea fishes*, pp. 580-594. Spring-Verlag, Berlin.

Suau, P. – 1970. Contribución al estudio de la biología de *Lithognahtus (=Pagellus) mormyrus* L. (Peces espáridos). *Inv. Pesq.*, 34: 237-265.

van der Walt, B.A. and L.E. Beckley. – 1997. Age and growth of *Sarpa salpa* (Pisces: Sparidae) off the east coast of south Africa. *Fish. Res.,* 31: 241-248.

Williams, T. and B.C. Bedford. – 1974. The use of otoliths for age determination. In: T.B. Bagenal (eds.) *The Ageing of Fish*, pp 114-123. Unwin Brothers, Surrey.

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