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Preliminary interpretation of growth ring on the otolith of *Boops boops* off Gran Canaria (Canary Islands)

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Abstract

A preliminary interpretation of the growth ring on the otolith of bogue *Boops boops* off the Canary Islands (Central-east Atlantic) was analyzed. Samples of fish ranging from 7.5 to 34 cm were obtained mainly by purse seine. Otoliths showed generally clear growth rings after they were toasted to highlight opaque rings from translucent. Otolith growth rings estimation in older specimens was difficult as a result of the phenomenon of stacking of growth zones towards the otolith margin. Regression coefficients of data recordered suggest that method used to read growth rings was satisfactory as preliminary study to the growth of *Boops boops* off the Canary Islands.

Keywords: *Boops boops*, Canary Islands, otolith, growth ring.

Resumen

La descripción y el estudio preliminar de la boga *Boops boops* se estudiaron en las Islas Canarias (Atlántico este y central). Los ejemplares examinados presentaron tallas entre 7,5 y 34 cm capturados mediante redes de cerco. Los otolitos mostraron de forma general unos anillos de crecimiento claros, después de haberlos tostado para resaltar los anillos opacos de los translúcidos. La estimación de los anillos de crecimiento en los individuos más grandes fue difícil, debido al fenómeno de apilamiento de las zonas de crecimiento hacia el margen de los otolitos. Los coeficientes de regresión de los datos registrados sugieren que el método utilizado para la lectura de los anillos de crecimiento fue satisfactorio como estudio preliminar para identificar e interpretar los anillos de crecimiento de *Boops boops* en las Islas Canarias.

Palabras clave: *Boops boops*, Islas Canarias, anillos de crecimiento, otolitos.

Introduction

The bogue (*Boops boops* Linné 1758) is a very common seabream (Sparidae) in Canary Islands coastal waters. This species lives mainly in the Eastern Atlantic, in an area reaching from Norway, where it is occasional, to Angola, and throughout the Mediterranean Sea including the Black Sea. It also occurs in the Western Atlantic in the Gulf of Mexico and the Caribbean Sea (Bauchot and Hureau, 1986). It is a gregarious semipelagic species found as deep as 300 m on a variety of bottoms, but is more common at depths <150 m, moving up to the surface during the night (Bauchot and Hureau, 1986; Sanches, 1992). In the Canary Islands the bogue has a low commercial and recreational value and is frequently discarded at sea (Borges et al., 2001), however, has an important role in ecological terms.

Although other studies on the biology of *B. boops* have been carried out, most were in the Mediterranean and were carried out in previous decades (Girardin, 1978, 1981; Anato and Ktari, 1983, 1986; Girardin and Quignard, 1986; Alegria- Hernández, 1989; Gordo, 1992). Previous age and growth studies were based on a variety of methodologies (scales, otoliths and length frequency analysis) as well as sampling methods (trawl and purse seine) and size ranges, resulting in a range of estimated von Bertalanffy parameters and different age structures (Girardin, 1978, 1981; Anato and Ktari, 1986; Girardin and Quignard, 1986; Alegria-Hernández, 1989; Gordo, 1992). Thus, maximum reported ages range from 3 (Girardin, 1978) to 11 years (Girardin and Quignard, 1986; Gordo, 1992).

Accurate knowledge about age and growth are required to manage bogue fisheries (Mills and Beamish, 1980; Panfili et al., 2002). However data on age and growth in Canarian waters, as opposed to other areas, are absent. Age information is important as it forms the basis for the calculations of growth and mortality rates and productivity estimates (Campana, 2001); therefore it is essential for fisheries management (Casselman, 1987; Cailliet et al., 2001). One of the main problems facing with age and growth estimates is the selection of the most suitable structure to age the fish. Scales have been used widely for age estimation, however the use of scales has been criticized mainly because the ages of older fish are frequently underestimated (Beamish and McFarlane, 1983; Carlander, 1987). Age determination using otoliths is thought to be more accurate because otoliths are not subjected to calcium re-absorption (Carlander, 1987). The present study aims to describe *B. boops* otoliths from Gran Canaria coastal waters, and a preliminary method to interpret otolith growth rings.

Material and methods

All specimens for this study were collected from January to March 2012 during purse seine fishing journeys in Gran Canaria coastal waters. *B. boops* was captured as discard from the commercial catches of a Canarian artisanal fleet. The analyses of the samples were completed immediately after landing. A pairs of sagitta otoliths were removed from each fish and cleaned in distilled water to remove organic material. For each fish, the total length was measured (mm), the total body weight was recorded (0.1 g), and the sex was determined macroscopically (male or female). Thus, otoliths lengths (anterior-posterior) were measured using a digital caliper with resolution to 0.01mm, and weighted (0.001 g). For otolith description, whole otoliths were immersed in distilled water and examined with a compound microscope under reflected light and on a black background. Before examination and description, otoliths wered toasted in order to achieve a greater growth rings alternation, and thus, facilitating their reading. The area selected for counting rings was the posterior region on the distal face of the otoliths, along the antero-posterior axis following Panfili and Morales-Nin (2002) and Wright et al. (2002) with the rostrum region used as the confirmation area. Otoliths were all read independently by two experienced researchers, with rings assigned when both researchers were in agreement.

To avoid subjectivity the readings were developed without any details of the fish being known in advance. The data obtained from each of the readings were recorded in independent files, following the nomenclature of the growth rings proposed by Morales-Nin (1987) and Morales-Nin and Panfili (2002).

To carry out the readings, a binocular magnifying glass was used (10X). Counts of otolith growth ring refer to one translucent or opaque zone. The otoliths were read using light reflected by the concave part on the upper side (distal face). By using this type of illumination, the opaque rings were observed more clearly than the rest of the otolith, and the translucent rings were seen to be darker. Previous to these readings, different liquids, which included sea water, ethanol and glycerol were used to enhance the growth rings. Burning techniques were also used to enhance the growth rings (McCurdy et al., 2002).

The efficiency of otolith reading estimations was quantified taking into consideration the per cent of readings that were discordant. Also estimates of ageing precision were determined using two methods: the index of average percentage error (Beamish and Fournier, 1981) and the coefficient of variation (Chang, 1982). Growth rings counts between readers were also compared using agebiased plot (Campana et al., 1995, Campana, 2001). Otolith parameters (number of rings) were graphically compared to fish parameters (total length). Values for otolith pairs (left and right otolith) for each specimen were used in graphical comparisons, however, if only one otolith had been measured (due to the companion otolith being broken) the measurement from a single otolith was utilized. Thus, otoliths length was compared with fish length in order to find relationships between both.

Results

There were a total of 200 individuals used for the otolith study, ranging from 7.5 to 34 cm. Among the adults, 89 (44.5%) were males, 108 (54%) were females and 3 (1.5%) were immatures. Otolith shape was elliptic with a dorsal margin irregular with a short wide protuberance in the middle. Sulcus acusticus was heterosulcoid, and ostial, was median. Ostium was funnel-like and shorter than the cauda. Cauda tubular was curved and strongly or markedly flexed posteriorly, ending close to the posterior-ventral margin. Anterior region was angled to peaked with rostrum broad, long and, slightly pointed; antirostrum was poorly developed or was very small, narrow and, pointed; excisura was wide without a notch or with a shallow notch. Posterior region was round.

For growth rings reading, a total of 200 pairs of *sagitta* otoliths were used, which include both sexes and the immature specimens. All of them were toasted in an oven between 10 and 15 seconds and 500- 600 ºC of temperature, depending of the size of the samples, to achieve the best growth rings alternation. Number of rings was successfully determined in 76% (146) of the fish examined using distilled water. The remaining 24% (54) pairs of otoliths were rejected because of disagreement between readers or because the otoliths were impossible to read. The index of average percent error (APE) of Beamish and Fournier (1981) was 5.85 and precision index based on the variation coefficient (CV) of Chang (1982) was 7.86 (Table 1).

Growth bands from 2 to 18 rings were observed on otoliths of *B. boops* (Table 2, 3 and 4) (Fig. 1). Correlation between fishes total length and number of otolith growth rings showed a moderate Pearson coefficient of r^2=0.731 (Fig. 2). With increasing length of the fish the correlation with the number of rings decreases. Otolith length and otolith weight were closely correlated (r^2=0.96) (Fig. 3).

Disagreement increased with number of rings between readers, as indicated by the larger standard errors for older ages, showing a pattern of underestimation of growth rings by the reader 2 (Fig. 4).

Discussion

Identification and interpretation of growth rings in sparids is difficult as a result of the phenomenon of stacking of growth zones towards the otolith margin, particularly in older fish (Buxton and Clarke, 1991; van der Walt and Beckley, 1997; Panfili and Morales-Nin, 2002). The translucency of *B. boops* otoliths from the Canarian archipelago allows reading most of these structures without the need of sectioning. Nevertheless, most otoliths require a toasted to achieve the best growth rings alternation. Otoliths of this sparid of Canarian archipelago show the ring pattern common to teleost fishes. One opaque and one translucent ring are laid down on the otoliths, allowing growth ring identification with relative ease. We assume that these rings are deposited owing to alternative periods of rapid and slow growth as a result of seasonal growth cycles. Seasonal growth cycles might be related to physiological changes produced by the influence of temperature, feeding regime and reproductive cycle (Morales-Nin and Ralston, 1990). Therefore, in our study can't be considered a pair of opaque and translucent rings as a year, because specimens were collected only during three months of winter season and was not carried out an otolith growth ring validation.

Some difficulties were found in reading the bogue otoliths, with marks that were frequently unclear and diffuse, leading to considerable uncertainty for a correct reading identification. The nucleus and the rings of individuals < 20 cm approximate were relatively clear, with generally compact opaque rings. However, difficulty in reading increased with age, with the first opaque rings tending to widen and to subdivide into a series of narrow growth rings. These contributed to the packing of growth rings, making the borders of the rings as well as the nucleus itself difficult to identify. On the other hand, the outer growth rings, although generally more compact, were also difficult to read in older fish due to the thickening of the otolith and to the narrowing of the deposition zone.

Problems of determining age in this species were also reported by Girardin (1978, 1981) for the Gulf of Lyon, Alegria- Hernández (1989) for the Adriatic Sea, and Gordo (1992) for the Portuguese coast. The difficulty found in otolith reading in the present study was not reflected in the degree of success, and 76% of the otoliths were read successfully. A large number of techniques are available in age studies, and the use of the whole otoliths toasted immersed in distilled water using a compound microscope could give reasonable results for the Canary Islands bogue, especially when considering the required precision and time required for each otolith.

In this study we obtained a precision range from 4.98% to 7.33% (APE) between the monthly readings, when the mean for all specimens was 5.85%, which is considered acceptable in studies based on otoliths. Values of CV are slightly above 7.86 %, where the most of the related studies carried out with a CV less than 7.60% (Campana, 2001). Reading precision between months shows lower results in February because there are a high proportion of big fish and thus more difficult to estimate growth rings. Precision reflects the degree of agreement among readers, and is not to be confused with accuracy, which relates to agreement with the true age of the fish (Campana, 2001). In a comparison between otolith readers, if the monthly samples contain different proportions of small fish, there will be apparent reading differences for each month. This is because there is greater relative precision in reading young fish otoliths than older. Decreased precision between readers showed in age-biased plot (Fig. 4) from around 10 rings estimation may be the result of packing rings phenomenon. Thus, we suggest the application of techniques such as transversal dissection and polishing for old specimens to improve the precision of readings.

Number of rings recorded aims to find relationships, as a preliminary study, with total length of the individuals. Since the ring formation is regular and, therefore, the otoliths can be used for age determination because fish length and number of growth rings are good correlated. The results obtained, taking into account the lack of annual variation in our sampling, cautiously suggest that otolith of bogue under the conditions analyzed can be used to validate and estimate the age and growth of *B. boops* off the Canary Islands.

References

Alegria-Hernández, V., 1989: Study on the age and growth of Bogue (*Boops boops* (L.)) from Central Adriatic Sea. Cybium 13, 281– 288.

Anato, C.B., Ktari, M.H., 1983: Reproduction de *Boops boops* (Linne, 1758) et de *Sarpa salpa* (Linné, 1758), Poissons, Téléostens, Sparidé s du Golfe de Tunis. Bull. Inst. Natn. Scient. Tech. Océanog. Peche Salammbo. 10, 49–53.Anato, C.B., Ktari, M.H., 1986: Age et croissance de *Boops boops* (Linné´ , 1758). Poisson téléosteen sparidae des cotes tunisiennes. Bull. Inst. Natn. Scient. Tech. Océanog. Peche Salammbo. 13, 33– 54.

Bauchot, M.L., Hureau, J.C., 1986: Sparidae. In: Fishes of the Northeastern Atlantic and the Mediterranean, vol. II. P.J.P. Whitehead, M.L. Bauchot, J.C. Hureau, J. Nielsen and E. Tortonese (Eds). UNESCO, Paris, pp. 883–907.

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

Beamish, R.J., McFarlane, G.A., 1983: The forgotten requirement of age validation in fisheries biology. Trans. Am. Fish. Soc. 112, 735–743.

Borges, T.C., Erzini, K.; Bentes, L.; Costa, M.E.; Gonçalves, J.M.S.; Lino, P.G.; Pais, C.; Ribeiro, J., 2001: By-catch and discarding practices in five Algarve (southern Portugal) me tiers. J. Appl. Ichthyol. 17, 104–114.

Buxton C.D., Clarke, J.R, 1991: The biology of the white musselcracker *Sparodon durbanensis* (Pisces: Sparidae) on the Eastern Cape coast, South Africa. S. Afr. J. Mar. Sci. 10, 285–296.

Cailliet, G.M., Andrews, A.H., Burton, E.J., Watters, D.L., Kline, D.E., Ferry-Graham, L.F., 2001: Age determination and validation studies of marine fishes: do deep-dwellers live longer? Exp. Ger. 36, 739–764.

Campana, S.E.. 2001: Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. J. Fish Biol. 59(2), 197–242.

Campana S.E., Annand, M.C., McMillan, J.I., 1995: Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124, 131–138.

Carlander, K.D., 1987: A History of Scale Age and Growth Studies of North American Freshwater Fish. In: Age and Growth of Fish, R.C Summerfelt and G.E. Hall (Eds.). lowa State University Press. Ames, lowa, pp. 3-14.

Casselman, J.M., 1987: Determination of Age and Growth. In: The Biology of Fish Growth, A.H. Weatherley and H. S. Gill (Eds.). Academic Press. London. pp. 209-242.

Chang, W.B., 1982: A statistical method for evaluating the reproducibility of age determinations. Can. J. Fish Aquat. Sci. 39, 1208–1210.

Girardin, M., 1978: Les Sparidae (Pisces, Teleostei) du Golfe du Lyon – Ecologie et Biogeographie. Diplome d'estudes approfundies d'ecologie generale et apliquée. Universite´ des Sciences et Techniques du Languedoc 146 pp.

Girardin, M., 1981: *Pagellus erythrinus* (Linnaeus, 1758) et *Boops boops* (Linnaeus, 1758) Sparidae (Pisces, Sparidae) du Golfe du Lyon. Ecobiologie. Prises commerciales et Mode` les de gestion. These de Docteur, Université´ des Sciences et Techniques du Languedoc, Montpellier, 295 pp.

Girardin, M., Quignard, G.-P., 1986: Croissance de *Boops boops* Linne´ 1758 (poissons, Sparidés) dans le Golfe du Lyon. J. Appl. Ichthyol. 2, 22–32.

Gordo, L.S., 1992: Contribuicao para o conhecimento da biologia e do estado de exploracao do stock de boga (*Boops boops* Linne´ . 1758) da costa portuguesa. Tese de Doutoramento, Lisboa, 361 pp.

McCurdy, W.J., Panfili, J., Meunier, F.J., Geffen, A.J., de Pontual, H.. 2002: Preparation of calcified structures.In: Manual of sclerochonology, J. Panfili, H. de Pontual, H. Troadec and P.J. Wright (Eds.). Ifremer-IRD edition. Brest. pp. 331–357.

Mills, K.H., Beamish, R.J., 1980: Comparison of flu-ray and scale age determinations for lake white fish (*Coregonus clupeaformis*) their implications for estimates of growth and annual survival. Can. J. Fish.Aquat. Sci.37,534–544.

Morales-Nin, B., 1987: Métodos de determinación de la edad en los osteictios en base a estructuras de crecimiento. Inf. Téc. Inst. Inv. Pesq. 143, 1-30.

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

Morales-Nin, B., Panfili. J., 2002: Age estimation. In: Manual of sclerochonology, J. Panfili, H. de Pontual, H. Troadec and P.J. Wright (Eds.). Ifremer-IRD edition. Brest. pp. 91–98.

Panfili, J., Morales-Nin, B., 2002: Influence of the shap and structure on the interpretation. In: Manual of sclerochonology, J. Panfili, H. de Pontual, H. Troadec and P.J. Wright (Eds.). Ifremer-IRD edition. Brest. pp. 105-113.

Panfili J., de Pontual. H., Troadec. J.-P., Wright. P.J., 2002:. Manual of Fish Sclerochronology. IFREMER-IRD co-edition. Brest. France: 464 pp.

Sanches, J.G., 1992: Guia para a Identificaçao do Pescado de Portugal, Submetido a Tamanho Mínimo de Captura. INIP, Publicaçao es Avulsa, Lisboa, 272 pp.

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

Wright, P.J., Panfili, J., Morales-Nin, B., Geffen, A.J., 2002: Otoliths. In: Manual of sclerochonology, J. Panfili, H. de Pontual, H. Troadec and P.J. Wright (Eds.). Ifremer-IRD edition. Brest. pp. 31–57.

Figures

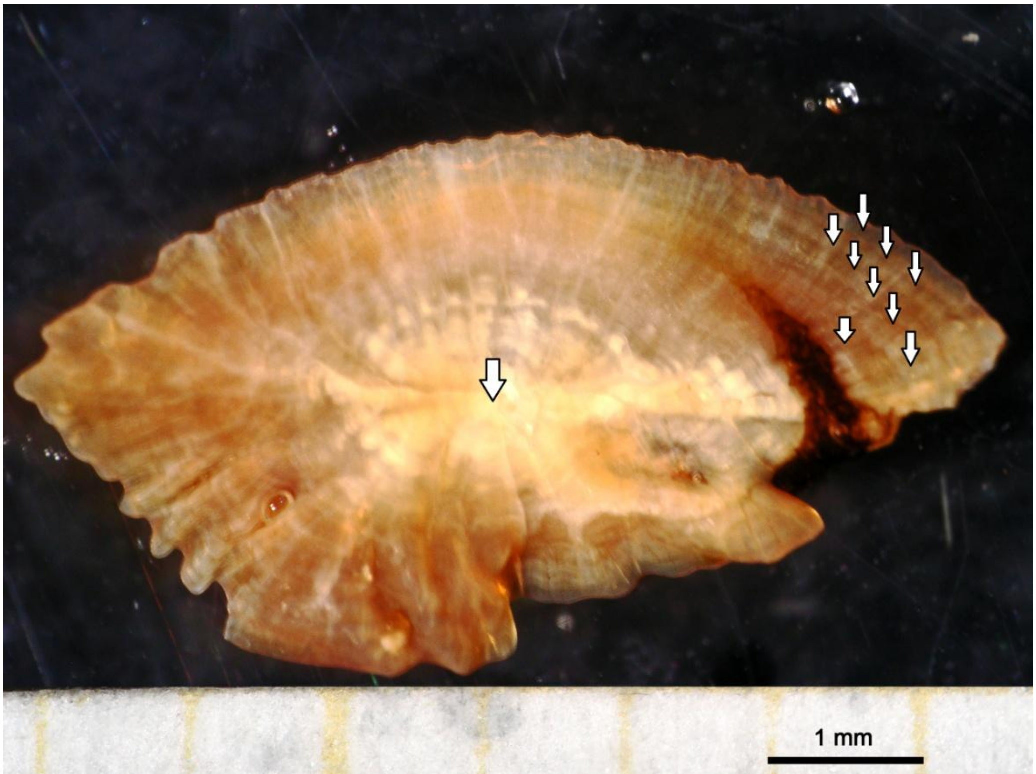

Fig. 1. View of *sagitta* otolith of *Boops boops* from a individual of 28 cm. Arrows shows growth rings in rostrum area.

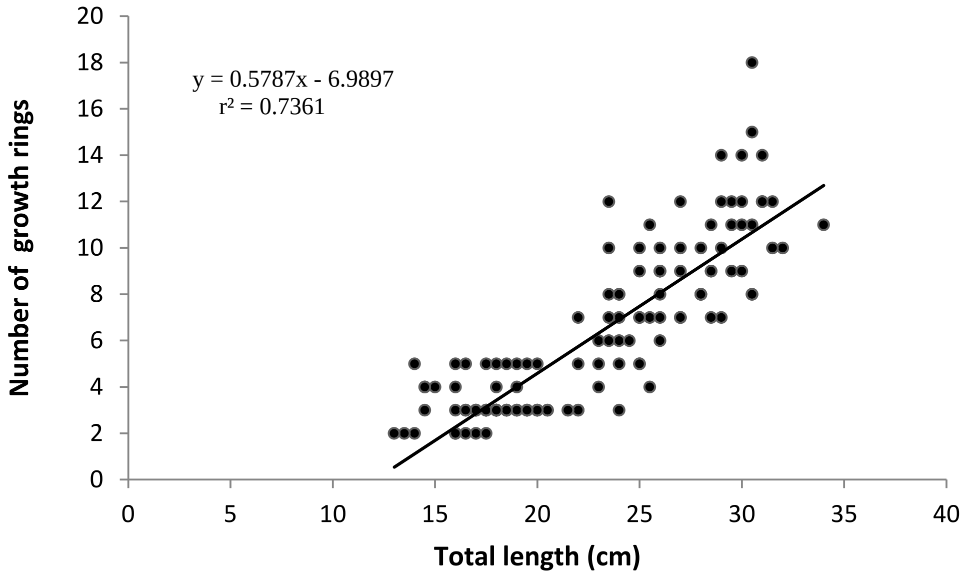

Fig. 2. Relationship between total length (cm) and number of growth rings for *Boops boops* off the Canary Islands.

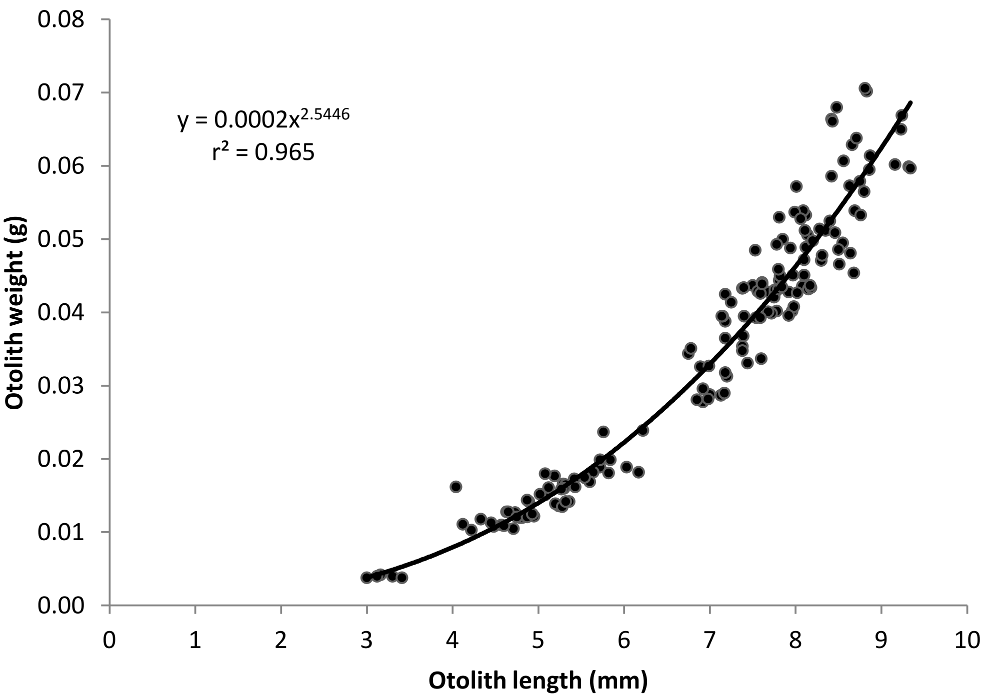

Fig. 3. Relationship between otolith weight (g) and otolith length (mm) for *Boops boops* off the Canary Islands

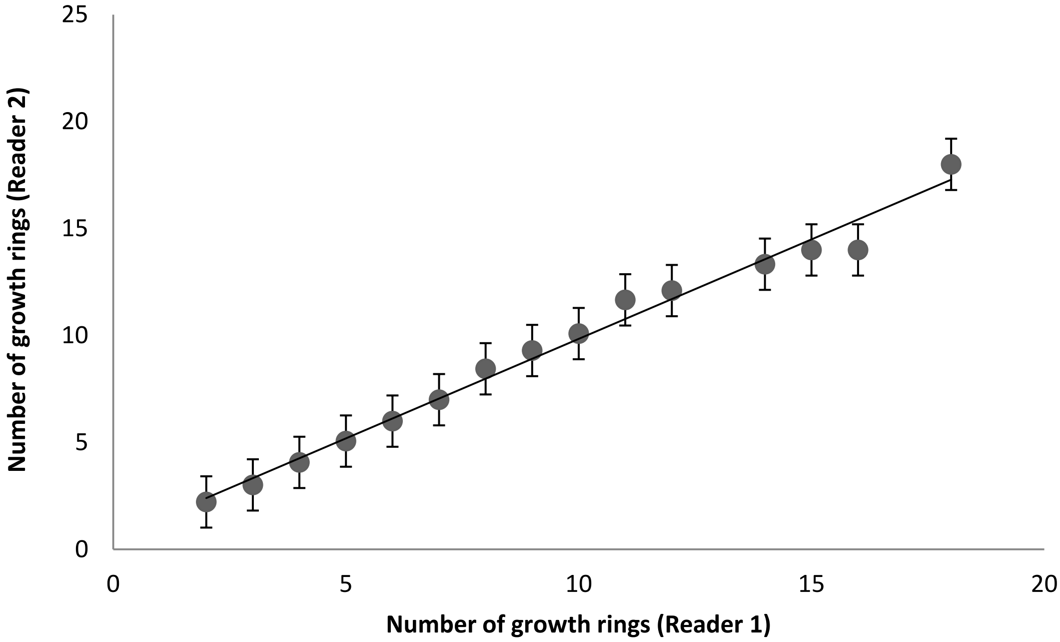

Fig 4. Age-biased plot between readers (mean number of growth rings and Sd) .

Tables

Table 1. Measures of precision between readers for growth rings on otoliths of *B. boops* off Canary Islands.

Reader 1*versus* reader 2 (N=200)				
Index	January	February	March	Mean
Coefficient of variation (%)[a]	6.72	9.81	7.05	**7.86**
Average percent error[b]	4.98	7.33	5.25	**5.85**

[a] from Chang (1982)
[b] from Beamish and Fournier (1981)

Table 2. Total length, sex and number of growth ring recorded in January for *Boops boops* off the Canary Islands.

Specimen ID	Sex (Male - Female)	Total lenght (cm)	Number rings
3	M	23.0	6
4	F	14.5	3
5	F	23.0	4
6	M	14.5	4
7	F	16.5	5
8	F	16.0	4
9	F	24.0	7
10	F	18.5	3
12	F	17.0	2
13	M	15.0	4
16	M	16.0	2
17	M	14.0	5
18	M	14.0	2
19	M	14.5	4
24	F	22.0	5
25	F	16.5	3
26	M	16.0	5
27	N	18.0	3
28	F	16.5	2
29	M	17.0	3
30	M	17.5	2
31	M	23.0	5
32	M	17.0	3
33	F	16.0	3
34	F	24.0	5
36	F	13.5	2
37	F	17.5	5
38	F	13.0	2
41	F	16.0	2
42	F	20.0	3
43	F	24.0	6
44	F	25.0	5
45	F	25.0	7
46	F	23.5	7
48	M	18.0	5

Table 3. Total length, sex and number of growth ring recorded in February for *Boops boops* off the Canary Islands

Specimen ID	Sex (Male - Female)	Total lenght (cm)	Number rings
2	F	30.5	8
3	M	29.5	11
4	F	30.0	14
8	F	28.0	10
9	F	32.0	10
11	M	30.5	11
12	F	31.0	14
14	F	31.5	12
15	M	29.0	10
16	M	28.0	8
17	M	24.0	8
19	M	29.0	7
20	F	28.5	11
21	F	28.0	8
24	F	29.5	12
25	F	29.0	12
27	N	27.0	7
28	F	28.5	9
30	M	25.0	9
31	M	26.0	9
33	F	25.5	7
36	F	30.5	18
37	F	34.0	11
38	F	30.5	15
39	N	27.0	9
40	F	28.5	9
41	F	31.0	12
43	F	31.0	12
44	F	29.5	9
45	F	27.0	12
46	F	28.0	8
47	M	30.0	9
48	M	31.5	10
49	F	29.0	14
50	M	28.5	7
76	F	26.0	7
77	N	25.0	10
78	F	26.0	9
79	N	23.5	10
83	F	26.0	10
84	N	23.5	12
85	F	23.5	8
86	M	25.0	7
87	F	22.0	3
88	F	30.0	12
90	N	25.5	11
91	F	27.0	10
92	N	30.0	11
96	F	27.0	7
99	F	30.5	8

Table 4. Total length, sex and number of growth ring recorded in March for *Boops boops* off the Canary Islands.

Specimen ID	Sex (Male - Female)	Total lenght (cm)	Number rings
1	F	22.0	3
2	M	21.5	3
3	F	27.0	7
4	F	26.0	9
5	F	19.0	3
6	F	18.0	3
8	M	18,0	3
9	F	19.5	3
10	M	20.5	3
12	F	22.0	7
13	F	20.5	3
14	F	19.0	5
15	F	19.0	3
17	F	16.5	3
18	M	18.0	3
19	F	17.5	3
20	F	19.5	3
21	F	17.5	3
23	F	20.0	3
24	F	26.0	8
25	F	20.0	3
27	F	20.0	3
29	F	21.5	3
30	M	19.5	5
31	F	19.5	3
32	M	18.5	3
33	F	20.5	3
35	F	19.0	3
37	M	17.5	3
38	F	25.0	5
39	F	24.0	3
40	F	18.0	3
42	M	18.5	3
43	M	18.5	5
44	F	23.5	6
45	M	17.5	3
46	F	17.0	3
48	M	17.0	3
50	F	24.0	8
51	M	18.5	3
52	F	17.0	3
53	M	18.0	3
54	F	18.0	4
55	M	20.0	3
56	F	18.0	3
57	F	18.0	3
58	M	17.5	3
59	M	16.5	3
60	M	20.0	5
61	F	19.5	3
62	F	19.0	3
63	F	26.0	6
66	M	17.5	3
68	F	25.5	4
69	M	18.0	3
70	F	18.0	3
71	M	18.5	3
72	F	18.0	3
73	F	19.0	4
74	M	19.5	3
75	M	24.5	6