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Age determination of *Anisotremus interruptus* (Perciformes: Haemulidae) by scale reading, in the coast of Colima, Mexico

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Abstract: This paper deals with the age determination in *Anisotremus interruptus* by reading of scales that allowed the identification of 9 age groups. The width of the growth rings diminishes as the age increases. The growth of the scales is proportional to the fish growth. The period of highest growth rate happens during the first year of life. During the first year *A. interruptus* grows 12.52 cm, the second year 4.95 cm and the third, 4.60 cm. The strategy of the quick growth during the first year of life allows *A. interruptus* to diminish the natural mortality.

Key words: *Anisotremus interruptus*, age determination, scales, back-calculation, age validation.

The Haemulidae family occupies the second place in the catch of the artisanal fishery in the coast of the state of Colima, Mexico (Cruz-Romero *et al.* 1993), being the “bacoco” or “burrito grunt” *Anisotremus interruptus* (Gill, 1863) the most important commercially (Fig. 1).

This species has been mentioned in the lists of Castro-Aguirre (1978), van der Heiden (1985), Ramírez-Rodríguez (1987a and b), Cruz-Romero *et al*. (1989), Ramírez-Rodríguez and Rodríguez (1990), Chávez-Ramos *et al.* (1994), Saucedo and Ramírez (1994). Cruz-Romero *et al.* (1993) studied the age and the growth of this species by the indirect method of length frequency. However, there are no other papers that analyze the parameters of the population dynamics of this species and the determination of the age by direct methods.

The direct methods for the determination of the age based on the interpretation of growth rings in hard structures as: scales, otoliths, vertebrae and opercula, among other, allow the determination of the age groups with a higher precision in comparison to the indirect methods of analysis of length frequency, eliminating most of the biases produced when the samples are small and with low periodicity and allowing the identification of the first age groups (Francis 1990, Eslava1991, Penalillo and Araya 1996, Campana 1999, Campana and Thorrold 2001).

The objectives of this study are to obtain data on the population’s structure, composition for ages, description of the scale and data on its length and width, time of formation of the growth bands, validation of the use of scales, relationship among the growth of the scale and of the fish and relationship between the age and length.

MATERIAL AND METHODS

During 10 days of every month in 1986, samplings of 300 individuals from the commercial

Fig. 1. *Anisotremus interruptus* “bacoco” (Gill, 1863), 36 cm length.

catch were taken in 4 localities in the coast of Colima (Fig. 2). On each individual the standard length (Ls) was measured and around 15 scales were taken from the area under the left pectoral fin, below the lateral line (Ehrhardt 1981, Holden and Raitt 1975, Ruiz-Durá *et al.* 1970), and stored in dry labeled envelopes.

Following the method described by Holden and Raitt (1975), the scales were washed to clean them of any tissue stuck to them. Later on 6 to 10 scales of each individual were put in between two slides, sealing them with adhesive tape and labeled.

The reading of the scales was carried out with the help of a transparency projector Kodak Ektagraphic with a 127mm lens (that increases the size of the scale 13.4 times). The scales were read by two different people independently and the results compared. The growth marks were identified based on the approaches mentioned by Joseph (1962).

Lee’s equation was applied for the back-calculation (Heald and Griffiths 1967).

To validate the growth rings the approaches suggested by Joseph (1962) were used, as well as Tanaka *et al.* (1981) method, described by Bullock *et al.* (1992), and Davis and West (1992) that standardize the values of the marginal increment.

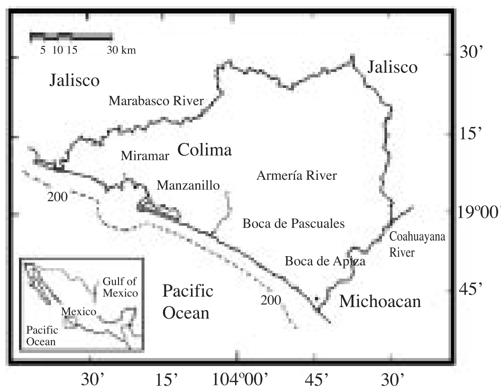

Fig. 2. Sampling area: Playita de Enmedio, Boquita de Miramar, Boca de Pascuales y Boca de Apiza.

Relationships were analyzed through the simple linear regression by the method of least squares.

RESULTS AND DISCUSSION

Morphology of the scale: the scales of Anisotremus interruptus are ctenoid, big, hard and in a rectangular shape (the length is contained around 1.4 times in the width). The anterior area is divided in sectors by very marked radios that converge in the focus, its number oscillates between 6 and 10. The anterior margin presents lobes and in some adults show serial fissures as marked bifurcations. The focus is very defined and in an eccentric position due to the faster growth in the anterior area in relation to the rear. The lateral borders are smooth. The growth rings are well defined and were interpreted as the formation of a double dark and continuous line defined by a clear and translucent space. The ctenii are in the rear area and are projected toward the posterior margin which is thinner and brittle in relation to the rest of the scale. The ctenii have a triangular shape (Fig. 3).

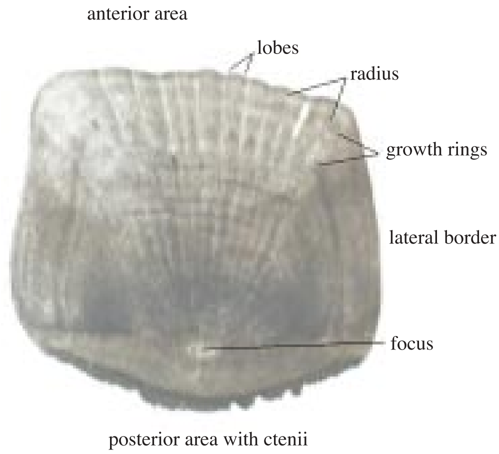

Fig. 3. *Anisotremus interruptus* scale.

Relationship between the length and width: the data are shown in Table 1 and Fig. 4 shows the graph with the relationship between the length and the width of the scale. The relationship is expressed by the exponent value or allometric index k= 0.905. This growth relationship is close to isometry, where the form of the scale stays constant without variations during its development.

Structure of the growth rings: the average value of the widths of the scales growth rings are observed in Table 2. The first band of growth, that is, the one that is formed after the focus is shown perfectly defined and totally developed, the difference between the width of the first and second rings is 0.939 cm, in the rest of the growth rings or annuli a progressive decrease of the width is observed.

Validation of the growth rings: five approaches suggested by Joseph (1962) were considered.

TABLE 1

Relationship between length classes, length and width of the scale of Anisotremus interruptus

Standard Length (cm)	Scale Length (cm)	Scale Width (cm)
15.00	0.64	0.97
17.00	0.72	1.08
19.00	0.79	1.18
21.00	0.87	1.28
23.00	0.94	1.38
25.00	1.02	1.47
27.00	1.09	1.57
29.00	1.16	1.66
31.00	1.24	1.76
33.00	1.31	1.85
35.00	1.38	1.94
37.00	1.45	2.03
39.00	1.52	2.12
41.00	1.59	2.21
43.00	1.66	2.29
45.00	1.73	2.38
47.00	1.80	2.47
49.00	1.87	2.55
51.00	1.94	2.64

TABLE 2

Mean width values of the growth rings of Anisotremus interruptus

Annuli	Annuli width W_t (cm)	$W_t - W_{t+1}$ (cm)
1	1.293	0.939
2	0.354	0.031
3	0.323	0.044
4	0.279	0.049
5	0.230	0.040
6	0.190	0.031
7	0.159	0.040
8	0.119	0.035
9	0.084	

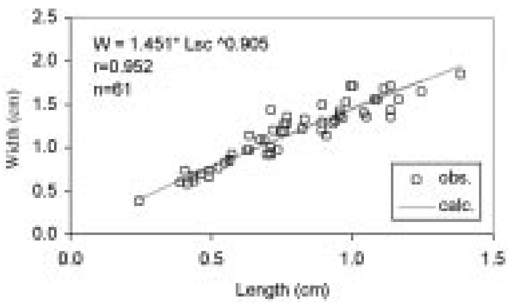

Fig. 4. Relationship between length (Lsc) and width (W) of *Anisotremus interruptus* scale.

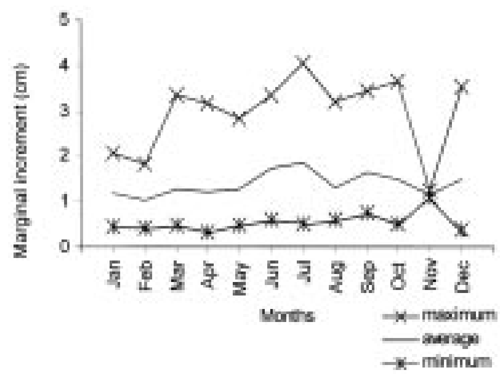

Fig. 5. Monthly values: maximum, average and minimum of the marginal increments in the scales.

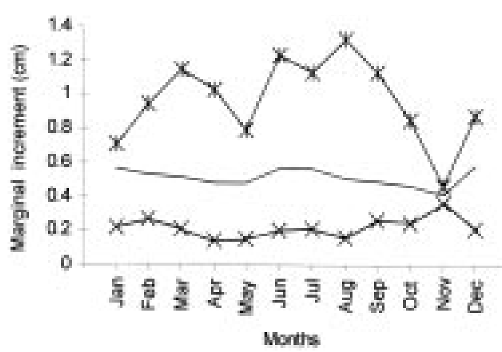

Fig. 6. Marginal increments of the scales, analysed by Tanaka method.

a) Analysis of the marginal increment.- This determination was carried out monthly for each individual, in order to determine the date in which the mark is formed and to validate the periodicity. The results presented are the maximum, average and minimum of every month (Fig. 5). During the whole year there is a wide distribution of data (except November that has a single value). The first two months of the year have a smaller variation than the rest of the months. April is the month that presents the smallest value in the margin in its line of minimum.

A similar graph was obtained for the method of Tanaka or complement index (Davis and West 1992), but with softened values. Also in the month of April the value is the lowest, but May presents the smallest value in the line of the averages (Fig. 6).

Since the scales in older organisms have a smaller marginal increment by the effect of the diminishing growth, a third exercise was carried out. When comparing these scales with those of younger organisms, the margin can be misevaluated. Due to this, the age groups were separated and only the individuals with 2 to 5 rings were used. Again, the graph (Fig. 7) has the same form that the two previous, but higher similarity with the Fig. 5, where the month with the smallest marginal increment is April. November has very little information, therefore should not be considered.

In spite of the big fluctuations that are observed in the marginal increment of the scales in every month of the year, the analysis of the minimum values gives information that validates the use of scales to determine the age in this species. The rings that were observed in the projections can be considered of annual rhythm, with the formation of the ring in the month of April.

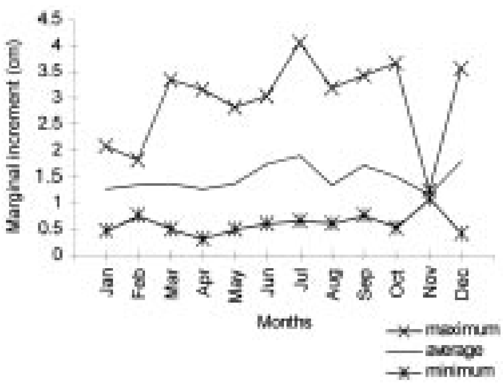

Fig. 7. Marginal increment analysis of the scales of individuals with 2 to 5 rings.

Relationship between the fish size and the number of rings.- The scales of the 272 analyzed individuals showed 9 rings. The values of the fish length and the number of observed rings are shown in the Fig. 8 a), and the values obtained by means of the back-calculation are in the Fig. 8 b). In both cases it is appreciated that the data have the same tendency.

Significant differences among the age groups.- It is observed in Fig. 9 that the confidence intervals show significant differences among the age groups, although toward the last ages some groups are overlapped because the increment in length is very small. Similar results are observed in Table 3.

The calculated values of age length are similar to those obtained by the back-calculation method.- The regression line with the average value of each age group of the Figs. 8a) and 8b) has a slope b= 0.979 and a correlation index r= 0.998 (Fig. 10). The hypothesis test *t* indicates that statistically this slope does not present significant difference with 1 (a= 0.05). This means that between both age groups, the observed values and the back-calculated data are the same for each age.

The annual increments of growth are distributed in a bell form.- The results of the increments of growth are observed in Table 4,

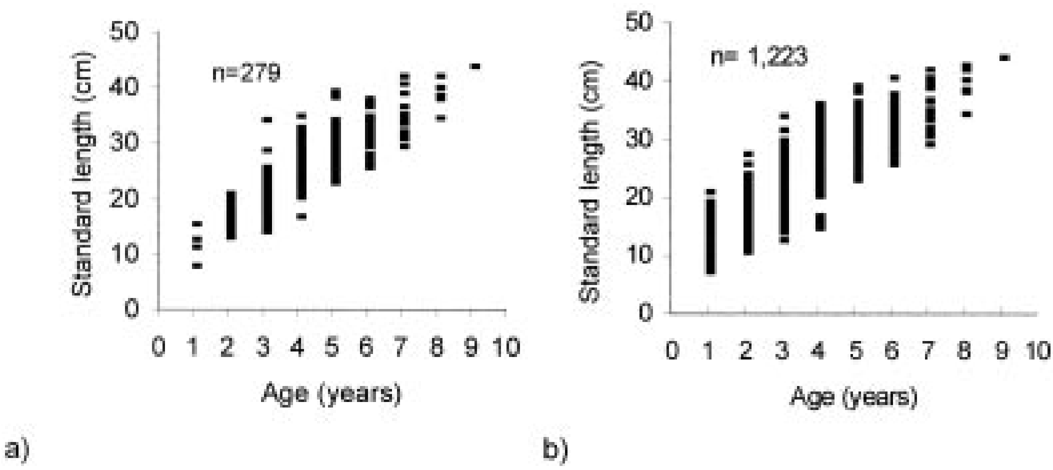

Fig. 8. Age – length relationship of *A. interruptus* of a) observed data and b) back-calculation by Lee's method.

TABLE 3
Age – length distribution of Anisotremus interruptus

Length	1	2	3	4	5	6	7	8	9	n	%
(cm)					Age (years)						
8	1									1	0.08
9	10									10	0.83
10	13									13	1.07
11	21									21	1.73
12	39	5								44	3.63
13	50	12								62	5.12
14	42	10	4							56	4.62
15	37	23	4							64	5.28
16	23	25	4	1						53	4.37
17	19	38	6	1						64	5.28
18	13	45	8							66	5.45
19	6	30	17							53	4.37
20	1	33	22	2						58	4.79
21	1	21	39	5						66	5.45
22	1	11	31	11						54	4.46
23		11	35	14	5					65	5.36
24		6	26	26	4					62	5.12
25		2	15	22	7	1				47	3.88
26		1	15	26	7	2				51	4.21
27			11	25	12	3				51	4.21
28		1	3	15	18	4				41	3.38
29			4	17	19	3	1			44	3.63
30			5	14	20	5	1			45	3.71
31				3	9	4	1			17	1.40
32			1	6	12	7	2			28	2.31
33				1	5	8	3			17	1.40
34			1	4	4	5	1	1		16	1.32
35				2	4	3	1			10	0.83
36				1	1	4	3			9	0.74
37						3				3	0.25
38					3	3	1	2		9	0.74
39					2		1			3	0.25
40						1	3	1		5	0.41
41										0	0.00
42							1	1		2	0.17
43								1		1	0.08
44									1	1	0.08
N	277	274	251	196	132	56	19	6	1	1212	100

and they refer to the centimeters of increase from an age to the following one.

A lineal regression describes the relationship between the growth of the scales and the fish. Fig. 11 shows this relationship as another validation to the use of this structure. The results show that there is a relationship between the size of the scale and the fish length, with a correlation index: r= 0.737, given by the variation of the data. The value of the allometric index k= 0.901 confirms the existence of a proportionality in the fish growth with regard to their scales and validates the use of scales as the hard part that has an increase of size as time goes by.

Relationship age-length: interpretation of the growth rings: Fig. 12 describes an exponential equation Le= $2.159*An^{0.699}$, where Le= length and An= rings, with r= 0.889. Table 4 shows that during the first year of life a quick growth increment, around 12 cm in one year is observed, in the second year the growth begins to diminish, with an increment of 5 cm, in the ages 3 to 6 the growth rate descends gradually until it stabilizes around 2 cm per year in the age 7.

Table 5 shows the average lengths in relation to the age of different hemulid species in the coasts of several countries.

In accordance with this Table, it is observed that the hemulids can present ages until 12 years. *Anisotremus interruptus* is one of the organisms that reaches a higher age, nine years, as *Haemulon aerolineatum* in the coast of South Atlantic Bight (Manooch and Barans 1979 in Darcy 1983) and it is only overcome by *Haemulon plumieri* that presents a twelve year-old age in the North and South of Carolina (Manooch 1976 in Darcy 1983).

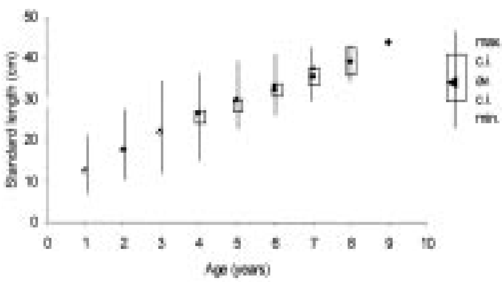

Fig. 9. Maximum (max.), average (av.), minimum (min.) and confidence intervals (c.i.) in the relation between age and length values of *Anisotremus interruptus*.

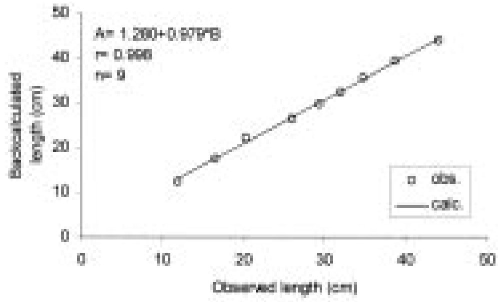

Fig. 10. Relationship between observed and calculated length.

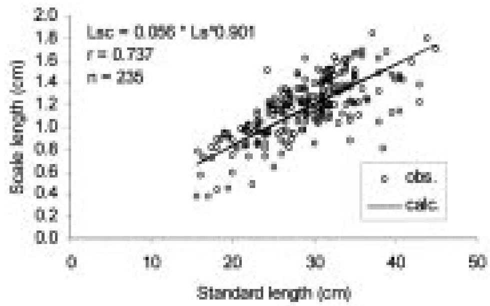

Fig. 11. Relationship between fish length and scale length of *Anisotremus interruptus* .

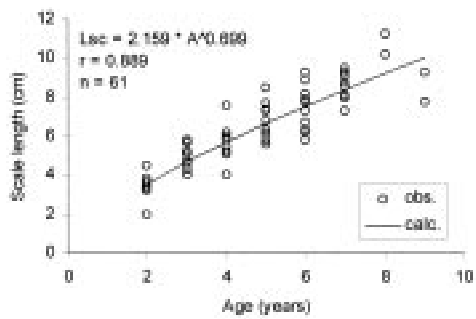

Fig. 12. Relationship between scale length and age of *Anisotremus interruptus.*

TABLE 4

Relationship between age, length and growth increments of A. interruptus

Age (years)	Length (cm)	Growth Increments (cm)
1	12.52	12.52
2	17.47	4.95
3	22.07	4.60
4	26.36	4.29
5	29.43	3.07
6	32.04	2.89
7	34.93	2.03
8	36.96	1.80
9	38.74	

TABLE 5

Mean length (mm) for each age for hemulids. This table was modified from Table 5 in Konchina (1977) (*) and Tables 9 and 13 in Darcy (1983) (**)

Species	Region	1	2	3	4	5	6	7	8	9	10	11	12
						Age (years)							
Brachydeuterus auritus	Nigeria (Raitt and Sagua 1966) *	-	145	159	175	-	-	-	-	-			
Haemulon aurolineatum	Bank of Campeche (Sauskan and Olayechea 1974) *	107	147	172	180	185	193	200	-	-			
Pomadasys hasta [1]	Gulf of Aden (Oven and Salekhova 1970) *	-		175	195	209	213		-	-			
P. hasta	Western India (Deshmukh 1973) *	246	344	465	524	569	-	-	-	-			
P. jubelini	West Africa (Alberdi 1971) *	160	230	300	-	-	-	-	-	-			
P. striatum	Gulf of Suez (Latif and Shenouda 1972) *	78	103	126	138	-	-	-	-	-			
H. aurolineatum	Bank of campeche (Sokolova 1965) **	89.4	124	152.1	172.2	189.4	202	-	-	-			
H. aurolineatum	Southeastern U.S. (Manooch and Barans, 1979) **	124.4	159.4	189.2	213.1	232.2	247.6	259.9	269.8	277.8			
H. plumieri	Campeche Bank (Kapote 1971) **	-	-	236	260	280	307						
H. plumieri	North and South Carolina (Manooch 1976) **	97	185	244	283	314	341	367	389	414	439	466	492
H. steindachneri	Venezuela (Eslava 1991)	175.15	186.95	204.7									
Anisotremus interruptus	Present analysis	125.2	174.69	220.7	263.5	294.3	320.03	349.3	369.6	387.6			

1. males

It is important to point out that the hemulids that reach higher ages, *A. interruptus, H. aurolineatum* and *H. plumieri*, correspond to organisms that are located at higher latitudes and therefore to lower temperatures in relation to the rest of the members of this family. In accordance with Taylor (1958 and 1960) the populations of the organisms that inhabit higher temperatures present lower ages as it is observed in *H. aerolineatum* in the Bank of Campeche (Sokolova 1965 and Souskan and Olayechea 1974 in Konchina 1977) with maximum ages of six and seven years old respectively, or *H. plumieri* that reaches six years in the same area (Kapote 1971 in Darcy 1983).

Anisotremus interruptus is one of the members of the Haemulidae family that presents a bigger size 387.6 mm at nine years old, and it is only overcome by *Haemulon plumieri* 492 mm at twelve (Manooch 1976 in Darcy 1983) and *Pomadasys hasta* 569 mm at five years on the West coast of India (Deshmukh 1973 in Konchina 1977).

It is also important to point out that the differences in relation to the ages and maximum lengths can be due to diverse factors as: the different methods applied for the age determination, direct or indirect methods or to the different strategies of survival of the organisms that live in different habitats, or due to the intensity of the fishing activity that can reduce the commercial sizes and ages of the individuals.

RESUMEN

En el presente estudio se analiza la determinación de la edad de *Anisotremus interruptus* por medio del análisis de sus escamas. El estudio de las mismas permitió la identificación de 9 grupos de edad. La amplitud de los anillos de crecimiento disminuye conforme se incrementa la edad del pez. El crecimiento de las escamas es proporcional al del pez. El periodo de mayor crecimiento en longitud se presenta durante el primer año de vida del organismo, en el que *A. interruptus* crece 12.52 cm, en el segundo año 4.95 cm y en el tercero 4.60 cm. La estrategia de crecimiento rápido durante el primer año de vida permite a este organismo disminuir la mortalidad natural.

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