International Journal of Zoological Research 1 (1): 21-25, 2005
ISSN 1811-9778
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Age Determination of *Mugil curema* Valenciennes, 1836 (Pisces: Mugilidae) in the Cuyutlán Lagoon, Colima, México

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Abstract: This study deals with the age determination in scales of *Mugil curema*. Reading the scales allowed the identification of six age groups. The width of the growth rings decreases as the age increases. The growth of the scales is proportional to the fish growth. The period of highest growth rate takes place during the first months of life i.e. 106.6 mm. During the first year *M. curema* grows 46.6 and 44.3 mm the second year; 33.8 the third year; 26.9 the fourth and 17.8 mm the fifth year.

Key words: *Mugil curema*, age determination, scales, age validation, Mexican Pacific Ocean

INTRODUCTION

Age determination is one of the most important parameters for the description of the population structure and its dynamic behavior[1-3]. One of the best methods to study the age consists in the identification of the growth rings formed on the scales.

The marks formed on these structures correspond to periods of fast and slow growth, determined basically by food disponibility[4]. Marks related to reproduction and migrations can also be found on scales[5].

This study analyzes the morphologic and morphometric characteristics of *Mugil curema* scales and determines the time of formation of the growth bands as well as the age-length relationship.

MATERIALS AND METHODS

The specimens were obtained from the commercial fishery in the Cuyutlán Lagoon (Fig. 1). The fishing gear was a gill net of 2 ½ inches mesh size (6.35 cm). Samples were obtained monthly from March 1997 to February 1998. The total length was registered for 548 organisms. Lengths ranged from 70 to 320 mm and weight from 3.43 to 318.64 g. An average of 15 scales were taken from the area under the left pectoral fin, below the lateral line[6-8].

Following the method described by Holden and Raitt[7], the scales were washed and cleaned of any tissue stuck to them. Thereafter six to ten scales of each individual were placed between two slides which were sealed with adhesive tape and labeled.

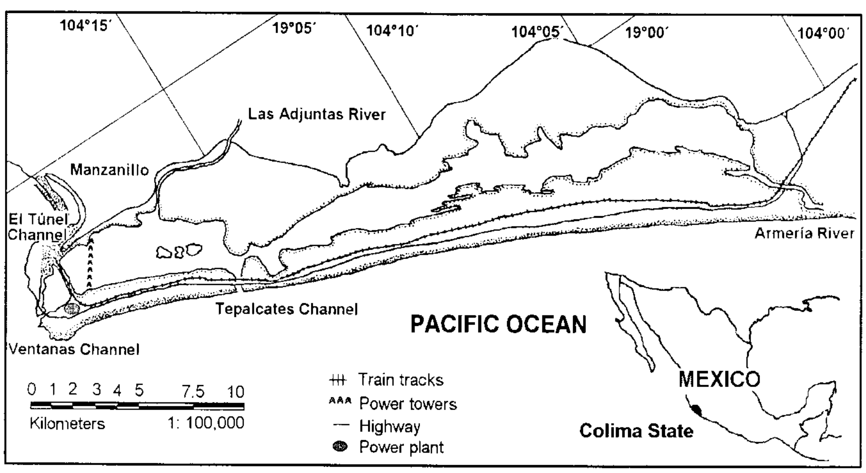

Fig. 1: Map of the Cuyutlán Lagoon, Colima, México

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Reading of the scales was carried out with the help of a micro projector Ken-A-Vision Tech A-II Model and a 16 mm objective to obtain a 30 X size. The scales were read independently by two different persons and the results were compared.

Lee's equation was applied for the backcalculation[9].

To validate the growth rings: a) the marginal increments were analyzed in monthly average; b) using the marginal increments only of the first three ages and c) a standardized value of the marginal increments[10]. ANOVAs were calculated to determine the month with the minimum marginal value, which shows the month when the annuli ring is formed.

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

RESULTS

Morphology of the scale: The scales of *M. curema* are catenoid, the length is contained between 1.16 and 1.49 times in the width. *M. curema* presents well defined rays, their number varies between four and ten. The focus is well defined and in an eccentric position due to the faster growth in the anterior area than in the posterior area. The growth rings are well defined and include fast and slow growth marks. The latter is seen as fine calcified crests around the scale. The ctenii are triangular in shape (Fig. 2).

Relationship between the length and width: The data shown in Table 1 represent the values of the length and width of the scale as its size increases and Fig. 3 is the relation graph represented by a exponential function with an allometric index k = 0.866. This relationship describes a negative allometric growth, where the form of the scale tends to get narrower as the scale length increases.

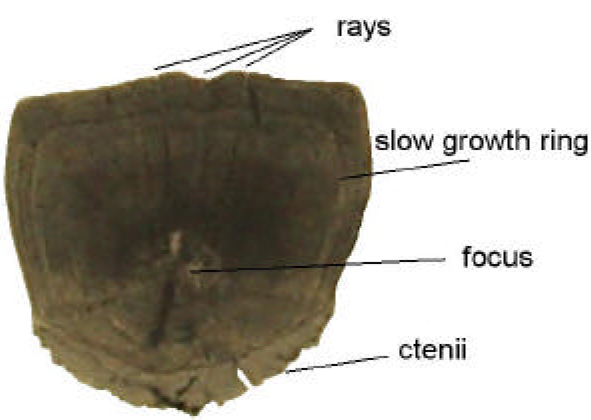

Fig. 2: *Mugil curema* scale

Table 1: Relationship between length classes, length and width of the scale of *Mugil curema*

Total length (mm)	Scale length (mm)	Scale width (mm)
70	2.74	3.19
80	2.98	3.54
90	3.20	3.88
100	3.41	4.21
110	3.61	4.53
120	3.80	4.84
130	3.99	5.15
140	4.18	5.46
150	4.36	5.75
160	4.53	6.05
170	4.70	6.34
180	4.87	6.63
190	5.03	6.91
200	5.19	7.19
210	5.34	7.46
220	5.50	7.74
230	5.65	8.01
240	5.79	8.28
250	5.94	8.54
260	6.08	8.81
270	6.22	9.07
280	6.36	9.32
290	6.50	9.58
300	6.63	9.84
310	6.77	10.09
320	6.90	10.34

Table 2: Relationship between age, growth rings width and width increments of *Mugil curema*

Age (years)	Width (mm)	Width increments (mm)
1	1.736	0.94
2	0.793	0.05
3	0.744	0.17
4	0.577	0.14
5	0.442	

Table 3: Relationship between age, length and growth increments of *M. curema*

Age (years)	Length (mm)	Growth increments (mm)
0	106.60	
1	153.20	46.60
2	197.50	44.30
3	231.30	33.80
4	258.20	26.90
5	276.00	17.80

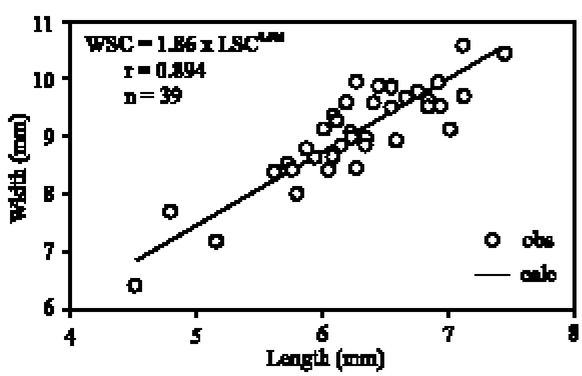

Fig. 3: Relationship between length (LSC) and width (WSC) of the scale of *M. curema*

Table 4: Mean length for each age of *M. curema* for different localities

Authority	Locality	Method	Length	0	1	2	3	4	5	6
This study	Cuyutlán, México	Scales	TL	106.6	153.20	197.50	231.30	258.20	276.00	
Ibanez-Aguirre *et al.*[18]	Tamiahua, Mexico	Otoliths	TL	184.2	220.50	252.10	279.60	303.40	324.10	
Richards and Castagna[19]	Virginia, USA	1)	TL2)		226.93	322.50	360.31	386.40	395.61	
Alvarez-Lajonchere[20]	La Habana, Cuba	Spine	TL		265.16	290.55	310.53	334.32		
Phillips *et al.*[17]	Costa Rica	1)	TL		227.20	319.60	370.31	398.15	413.42	421.80

1) Method not indicated, 2) For the conversion fork length to TL, the equation citedby Thompson *et al.*[21] was used.

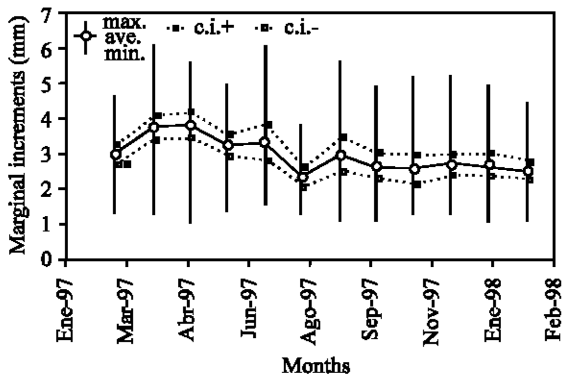

Fig. 4: Monthly values: maximum, average, minimum and confidence interval of the marginal increments in the scales of *M. curema*

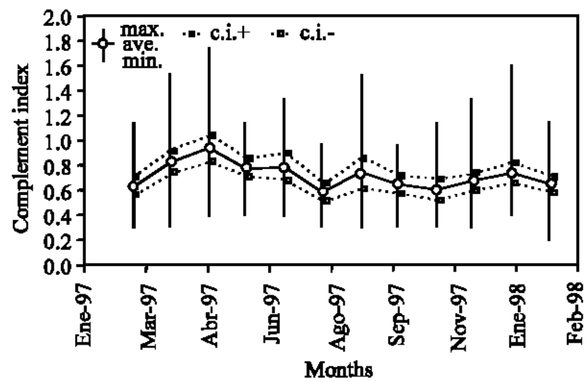

Fig. 6: Monthly values: maximum, average, minimum and confidence interval of the marginal increments by Tanaka's method

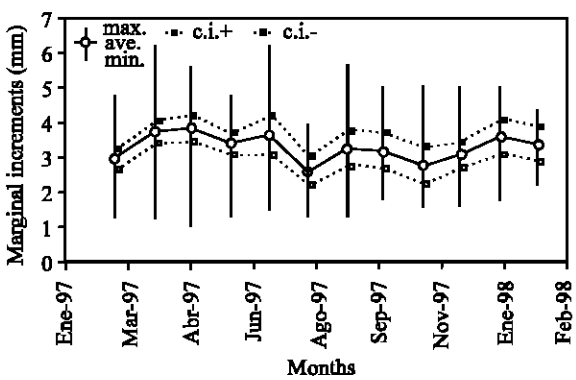

Fig. 5: Monthly values of the first three age groups: maximum, average, minimum and confidence interval of the marginal increments in the scales of *M. curema*

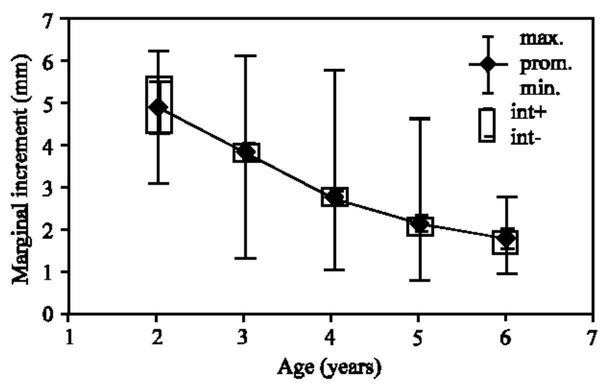

Fig. 7: Marginal increments of the scales per age: maximum, average, minimum and 95% of confidence interval

Structure of the growth rings: The monthly average width of each growth ring of the scales is summarized in Table 2. During the first year the scale grows 1.736 mm and its increment in the second year is 0.94 mm. The rest of the growth rings increments tend to decrease in width.

Validation of the growth rings

Analysis of the marginal increment: This determination was carried out monthly, using data of all the individuals, to ascertain the date when the growth mark is formed and establish its periodicity. Figure 4 depicts the average, maximum, minimum and standard deviation for each month. Figure 5 also shows the average, maximum, minimum and confidence interval for each month, but only for the marginal increments of the first three ages. Figure 6 shows the monthly marginal increments calculated as a complement index. In the three graphs, August shows the lowest values, which means that most of the individuals form their annuli. The confidence intervals show that during the first four months (March to June) the organism is in active growth.

Figure 7 shows the differences in growth through the marginal increments of different ages. The confidence intervals are statistically different from each other, except for groups five and six.

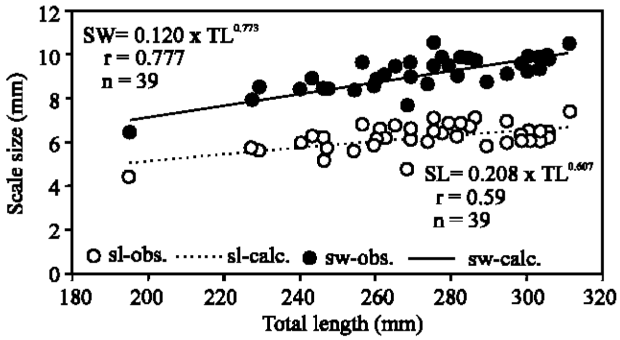

Fig. 8: Relationship between fish length (TL) and Scale Length (SL) and Scale Width (SW) of *Mugil curema*

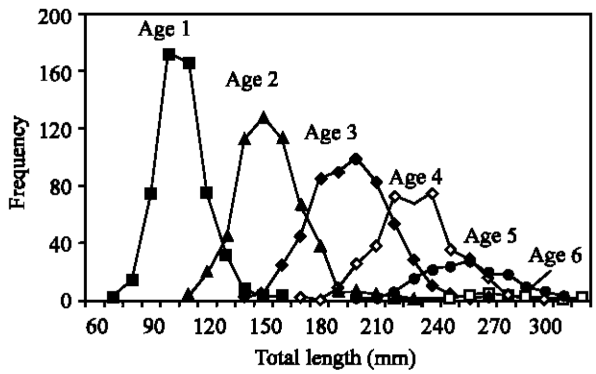

Fig. 9: Length distribution per age of *M. curema*

Relationship between scale size and fish length: Figure 8 shows the relation between the length and width of the scale and the length of the fish. The first tends to an isometric relationship with the length of the fish and can describe the growth.

Relationship between fish size and the number of rings: Figure 9 shows the frequency of length distribution for each age. As the organism grows, the frequency of organisms for each age decreases and the growth rate diminishes.

Age-length relationship: interpretation of the growth rings: Table 3 shows that during the first months of life a fast growth increment of around 106.6 mm occurs. In the first year growth begins to diminish with an increment of 46.6 mm; the second year, 44.3 mm the third 33.8; the fourth, 26.9 and the fifth year, 17.8 mm.

Table 4 shows the average sizes for each age group of *M. curema* in different localities.

DISCUSSION

The scales of *M. curema* in Cuyutlán are smaller than those of the same species and *M. cephalus* from the Tamiahua Lagoon. For example, in individuals of 340 mm of length, the distance between the center of the scale to the far side is 10 mm in *M. cephalus* and 8 mm in *M. curema* from Tamiahua and 7.15 mm in the Cuyutlán Lagoon. *M. curema* presents well defined rays in their scales, better than *M. cephalus* and their ctenni are rhomboidal shape while triangular in *M. cephalus*[11].

This study showed that the formation of the slow growing band coincides with the reproduction months as was established by Cabral-Solís[12] and Vidaurri[13] during August. Due to the fact that this species is catadromous, it is during this time the fish wears out faster, because it must migrate to the ocean to spawn. Ibáñez-Aguirre[14] observed a similar phenomena for *Mugil curema* in the Tamiahua Lagoon, Veracruz, México.

The confidence intervals of the marginal increments show that during the first four months (March to June) the organism is in active growth, coinciding with environmental changes which increase food disponibility when compared with other months of the year. In the beginning of July growth rate is reduced, the growth mark is formed and its activity is resumed after October.

Comparing the growth rates from several countries (Table 4), in Mexico *M. curema* reaches higher average sizes for each age group in the lagoon of Tamiahua, Veracruz than in the Cuyutlán Lagoon. That is, the organisms grow 77.6 mm more in Veracruz than in Colima for the age 0; 67.3 mm more for the age 1; 56.6 mm more for age 2; 48.3 mm more for age three; 45.2 mm more at the age of 4 and 48.1 mm more at age 5. These differences in growth are caused by the hydrological characteristics of each coastal lagoon, by food disponibility and by the effect of fishing exploitation[12,14].

It is also apparent that this fish reaches higher values at the same age as the latitude increases as has been seen in Virginia, USA and that the average size and the number of age groups diminish as the latitude decreases, as observed in La Habana, Cuba, which coincides with the findings of Taylor[15,16].

Nevertheless, the values and the number of age groups reported by Phillips *et al.*[17] in Costa Rica are the highest, which does not coincide with that mentioned previously.

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