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Growth analysis of white mullet *Mugil curema* (Valenciennes, 1836) (Pisces: Mugilidae) in the Cuyutlán Lagoon, Colima, México

Análisis del crecimiento de la lebrancha *Mugil curema* (Valenciennes, 1836) (Pisces: Mugilidae) en la Laguna de Cuyutlán, Colima, México

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ABSTRACT

The parameters from von Bertalanffy's growth equation were estimated for *Mugil curema* located in Cuyutlan coastal lagoon in Colima, Mexico. Growth parameters were L_∞= 364.7 mm, W_∞ = 456.61 g, k = 0.219, t_o = -1.557, ($A_{0.95}$) = 15 years. Some important differences among growth rates of this species from other areas were observed. Significant differences in the growth rate between sexes were found: females: L_∞ = 365.8 mm, k = 0.221, t_o = -0.505; $A_{0.95}$ = 14 years; males: L_∞ = 322.0 mm, k = 0.251, t_o = -0.441, $A_{0.95}$ = 12 years.

Key words: *Mugil curema*, von Bertalanffy's equation, growth, longevity.

RESUMEN

En este estudio se estimaron las constantes de la ecuación de crecimiento de von Bertalanffy para la población de *Mugil curema* localizada en la laguna de Cuyutlán, Colima. Los resultados obtenidos fueron: L_∞ = 364.7 mm, W_∞ = 456.61 g, k = 0.219, t_o = -1.557, $A_{0.95}$ = 15 años. Se analizaron las diferencias en los parámetros del crecimiento de esta especie en relación a otras áreas. Se obtuvieron las diferencias en el crecimiento y la longevidad entre sexos de esta especie: hembras: L_∞ = 365.8 mm, k = 0.221, t_o = -0.505, $A_{0.95}$ = 14 años; machos: L_∞ = 322.0 mm, k= 0.251, t_o = -0.441, $A_{0.95}$ = 12 años.

Palabras clave: *Mugil curema*, ecuación de von Bertalanffy, crecimiento, longevidad.

INTRODUCCION

Mugil curema (Valenciennes) is basically an American specie found from Cape Cod, USA to Brazil in the Atlantic Ocean and from Bahia Magdalena, Mexico to Chile in the Pacific Ocean (Jordan & Everman, 1896). However, Alvarez (1976) has recorded *M. curema* off the western coast of Africa. The *M. curema* fishery has the 21st place in national importance in Mexico, the yearly catch of this mullet in 1999 was 7,282 metric tons. The commercial catch of white mullet in the Gulf of Mexico represents 97% (7,062 ton) and in the

Pacific Ocean 3% (219 ton) (SEMARNAP, 2000). In the Pacific, 44.7 % (98 ton) is obtained in the coast of Colima State and 55.3 % (121 ton) in Chiapas state (SEMARNAP, 2000). In the Cuyutlan Lagoon *M. curema* price ranges between 2 and 3 mexican pesos per kg. This activity gives employment to 400 fishermen (Cabral-Solís, 1999). Although this species represents an important food source in several countries, there are few studies on its ecology and population dynamics. Some parameters of their dynamics were analyzed by Angell (1973), Alvarez (1976, 1979 and 1981), Richards and Castagna (1976), Phillips *et al.* (1987), Pérez-Garcia and Ibáñez-Aguirre (1992), Ibáñez-Aguirre and Lleonart (1996), Ibáñez-Aguirre and Gallardo-Cabello (1996 a and b) and Ibáñez-Aguirre *et al.* (1999). The purpose of the present work is to propose a complete analysis on the growth characteristics of *M. curema* with regards to the length, weight, sex and longevity in the Cuyutlan Lagoon, Mexico.

MATERIAL AND METHODS

The specimens were obtained from the commercial fishery in the Cuyutlan Lagoon (103º 57' and 104 º 19' W; 18 º 57' and 19 º 50' N). The fishing gear was a gill net of 2.5 inches mesh (6.35 cm). Samples were obtained monthly from March 1997 to February 1998. The total length (measured to the nearest 1 mm, from the snout tip to the caudal fin extreme) for 4,482 organisms was registered, 60.28 % of which were females and 37.82 % males. For the growth study, two persons examined scales of 548 organisms independently with total lengths that ranged from 70 to 320 mm and weights with ranges from 3.43 to 318.64 g. Fifteen scales of each organism were cleaned and mounted between two slides and analyzed with transmitted light in a scale projector. The scale analysis allowed the identification of 6 age groups (age 0: 106.60 mm, standard error : 1.318; age 1: 153.20 mm, standard error: 1.757; age 2: 197.50 mm, standard error: 2.088; age 3: 231.30 mm, standard error: 2.015 ; age 4: 258.20 mm, standard error: 2.196; age 5: 276.00 mm, standard error: 2.464). The relationship between scale size and fish length was: scale width = 0.120*TL exp.0.773 and scale length = 0.208* TL exp. 0.607, the validation of the growth rings was made by three methods: a) analysis of the marginal increment; b) relationship between the scale size and the fish length and c) relationship between the fish size and the rings number (Espino-Barr *et al.* 2005). The mean length mentioned was employed for the calculation of the von Bertalanffy (1938) growth equation. L_∞, k and t_0 were obtained combining the methods of 1) Ford (1933), Walford (1946) and Gulland (1964), 2) Tomlinson and Abramson (1961), 3) Allen (1966), 4) Prager (1987) and 5) Beverton (1954). Growth was also calculated for each sex and the curves were obtained for each method and evaluated the goodness of fit with the sum of the square difference (Σe_i^2). Hotelling's T^2 test (Bernard, 1981) was used to compare growth curves of the two sexes. This test assumes that estimation of von Bertalanffy growth equation parameters for both groups were obtained from two normal distributions of joint probability, with three variables and one common variance. The total and eviscerated weight of 548 specimens (weighed to the nearest 0.1 g) was used for the growth analysis by weight. The function $W = a L^b$ was used to obtain weight-length relationship. Data for growth by length and the weight-length relationship were used to obtain the weight for each age. The growth for weight was obtained substituting L_t and L_∞ by W_t and W_∞, respectively in the von Bertalanffy equation. Taylor's equation (1958 and 1960) was used to calculate age limit or longevity (95% of L_∞).

RESULTS AND DISCUSSION

The values of L_∞ and k were similar (Table 1) between methods. The method that provides the greatest difference was that of Ford (1933), Walford (1946), and Gulland (1964). Use of the Beverton (1954) equation improved the calculated values compared with those obtained by Ford (1933), Walford (1946), Gulland (1964) and Allen (1966). With the methods of Tomlinson and Abramson (1961), and Prager (1987), the fit of the Beverton (1954) equation was not better.

The calculated curve that best fitted the observed values through scales corresponded to the parameters calculated with the Prager (1987) method. The calculated values of the length for different ages were obtained by using these parameters (Table 2) which in general showed improved calculated values. Figure 1 shows the theoretical growth curve

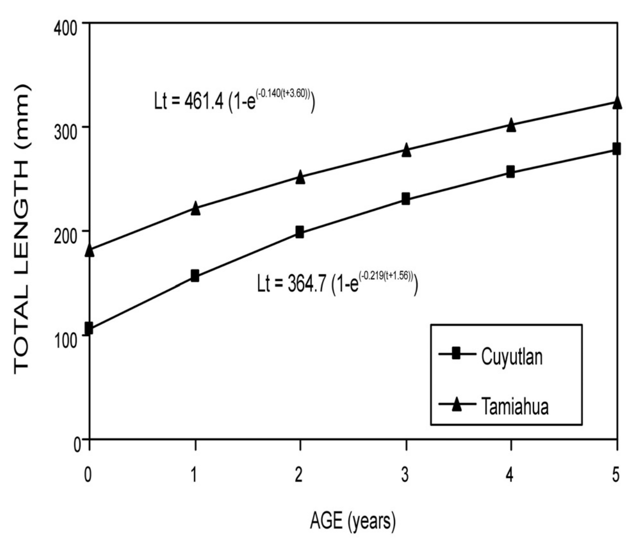

Fig. 1. Theoretical growth curve for *M. curema* in Cuyutlan and Tamiahua lagoons.

Table 1. Estimates of the constants of the von Bertalanffy growth equation for *M. curema* in the Cuyutlan Lagoon, according to the different methods.

Method	L_∞ (mm)	K	t_0	SD^2
Ford-Walford-Gulland	366.20	0.2127	-0.6387	0.2761
Beverton regression	366.20	0.2154	-0.5877	0.1903
Tomlinson and Abramson	364.19	0.2193	-0.5537	0.1827
Beverton regression	364.19	0.2188	-0.5635	0.1840
Allen	363.76	0.2206	-0.5528	0.1911
Beverton regression	363.76	0.2193	-0.5636	0.1851
Prager	364.70	0.2190	-1.5557	0.1809[1]
Beverton regression	364.70	0.2178	-0.5720	0.1869

[1] the best fit

for *M. curema* ages 0 to 5 years. A high increase in length was recorded during the first year, after which growth decreased markedly. Size increased by 50.93 mm TL between zero and first years; 41.04 mm between first and second years; 32.92 mm between second and third years; 26.44 mm between third and fourth years and 21.20 mm between fourth and fifth years. The decrease in growth after the first year on must be related to the first sexual maturity which occurs at 200 mm of total length (Cabral-Solís, 1999). Prager method (1987) was applied for growth determination between sexes because it presented the best fit for the growth calculation parameters of the species. The values of the von Bertalanffy growth equation are shown in Table 3. The k value in males was higher than in females, therefore males will reach L_∞ faster than females and the growth curve is more convex. Although differences of k value in males and females are very small, the mean length and mean weight at a same age are considerably higher in females than in males, so the L_∞ parameters define the growth differences between sexes (Table 2). The result from the multivariate analysis showed that females and males grow differently. The calculated value of T^2 (22.18) is considerably higher than the tabulated value of T^2 (11.71; $P<0.01$).

The relationship between length and weight tends to be isometric: $Wt = 1.065^{-5} (TL)^{2.979}$ for total weight ($t= 0.0135$, $P>0.05$) and $We = 1.1598^{-5} (TL)^{2.945}$ for eviscerated weight ($t= 0.0376$, $P>0.05$) (Figure 2).

The theoretical weight in relation to each age were: $Wt = 456.41\ (1-e^{(-0.219\ (t+1.557)})^{2.978}$ for total weight and $We = 406.71\ (1-e^{(-0.219\ (t+1.557)})^{2.945}$ for eviscerated weight (Fig. 3).

The species reached the 95% of L_∞ at 14.0 years, males at 12 and females at 15 (Table 3).

The values of the parameters of the von Bertalanffy growth equation for *M. curema* are shown in Table 3. The k values calculated in this study are higher than the reported by Ibáñez-Aguirre *et al.* (1999) and Alvarez (1979), but are lower than the reported by Richards and Castagna (1976) and Phillips *et al.* (1987). In general, the values of the relationship between length and weight in this study are similar to those presented by Angell (1973 = 2.84), Richards and Castagna (1976 = 2.90) and Ibáñez-Aguirre *et al.* (1999 = 2.75 and 2.94). The values of longevity for *M. curema* in different areas are shown in Table 3. The highest value was obtained by Alvarez (1979), i. e. 30 years in Cuba; the lowest values by Richards

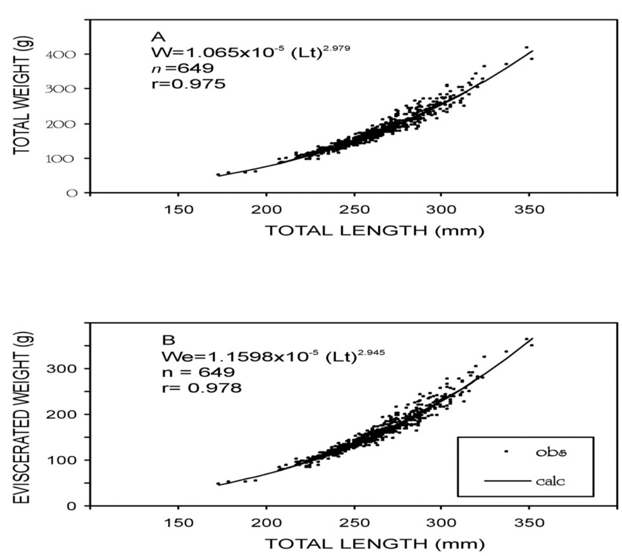

Fig. 2. Relation between weight and length of *M. curema*: (A) total weight; (B) eviscerated weight.

Table 2. Mean length (mm) mean weight (gr) for each age group (years) of *M. curema*.

	Mean Length			Mean Weight		
Age	Species	Females	Males	Species	Females	Males
0	105.37	103.50	97.73	11.30	10.71	9.03
1	156.30	155.51	147.51	36.57	36.02	30.78
2	197.34	197.21	186.24	73.25	73.10	61.64
3	230.26	230.64	216.38	115.98	116.55	96.37
4	256.70	257.44	239.82	160.33	161.72	13093
5	277.90	278.92	258.07	203.10	205.32	162.90

Table 3. Growth parameters of *M. curema* for other localities (modified from Ibáñez-Aguirre *et al*. 1999).

Authority	Locality	Method	Length	Sex	L_∞	k	t_0	$A_{0.95}$ 1)
This study	Cuyutlán, México	Scales	TL	F	365.8	0.221	-0.505	14.0
		Scales	TL	M	322.0	0.251	-0.441	12.0
		Scales	TL	Sp.	364.7	0.219	-1.557	15.0
Ibáñez *et al*., 1999	Tamiahua, Mexico	Otoliths	TL	F	454.6	0.14	-3.900	19.2
		Otoliths	TL	M	411.8	0.19	-3.000	14.0
		Otoliths	TL	Sp.	461.4	0.14	-3.600	18.7
Richards & Castagna, 1976	Virginia, USA	2)	TL3)	Sp.	403.4	0.78	-0.060	3.8
Alvarez, 1979	La Habana, Cuba	Spine	TL	Sp.	532.0	0.10	-5.900	30.0
Phillips *et al*., 1987	Costa Rica	2)	TL	Sp.	432.0	0.60	-0.244	5.0

1) These values of longevity were obtained in our study by the application of the Taylor method (1958) to the growth parameters given by the authors mentioned in this table. 2) Method not indicated. 3) For the conversion from fork length to TL, the equation given by Thompson et al. (1991) was used.

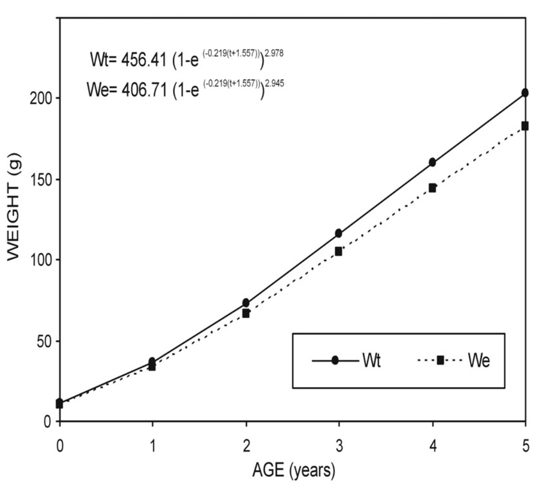

Fig. 3. Theoretical growth curve of *M. curema:* (Wt) total weight; (We) eviscerated weight.

and Castagna (1976) 3.8 years in Virginia and Phillips *et al.* (1987) 5 years in Costa Rica. The longevity values in this study are lower than those of Tamiahua Lagoon, because as Taylor (1958 and 1960) has shown, latitude, temperature, longevity and L_∞ have a direct proportional relation, while the k has an indirect proportional relation to the latitude and temperature. The temperature in Tamiahua lagoon goes from 10.3º C to 33º C (Ibañez-Aguire, 1995) and in Cuyutlan lagoon from 17.5º C to 34.2º C.(Cabral-Solís, 1999).

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