

## 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

Manuel Gallardo-Cabello<sup>1</sup>, Esther Cabral-Solís<sup>2</sup>,  
Elaine Espino-Barr<sup>2</sup> and Ana Laura Ibáñez-Aguirre<sup>3</sup>

<sup>1</sup>Instituto de Ciencias del Mar y Limnología, UNAM, Apartado Postal 70-305, C.P. 04510, México, D.F., e-mail gallardo@mar.icmyl.unam.mx

<sup>2</sup>CRIP-Manzanillo, INP, Playa Ventanas s/n, Manzanillo, Colima, 28200, México, Tel: 01 (314) 33 32 37 50; Fax: 01(314) 33 32 37 51; e-mail: teltal@hotmail.com; elespino@bay.net.mx

<sup>3</sup>Universidad Autónoma Metropolitana-Iztapalapa, Apartado Postal 55-535, C.P. 09340 México, D.F., e-mail ana@xanum.uam.mx

Gallardo-Cabello M., E. Cabral-Solís, E. Espino-Barr and A. L. Ibáñez-Aguirre. 2005. Growth analysis of white mullet *Mugil curema* (Valenciennes, 1836) (Pisces: Mugilidae) in the Cuyutlán Lagoon, Colima, México. *Hidrobiológica* 15 (3): 321-325.

### 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  $L_{\infty} = 364.7$  mm,  $W_{\infty} = 456.61$  g,  $k = 0.219$ ,  $t_0 = -1.557$ , ( $A_{0.95}$ ) = 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:  $L_{\infty} = 365.8$  mm,  $k = 0.221$ ,  $t_0 = -0.505$ ;  $A_{0.95} = 14$  years; males:  $L_{\infty} = 322.0$  mm,  $k = 0.251$ ,  $t_0 = -0.441$ ,  $A_{0.95} = 12$  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:  $L_{\infty} = 364.7$  mm,  $W_{\infty} = 456.61$  g,  $k = 0.219$ ,  $t_0 = -1.557$ ,  $A_{0.95} = 15$  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:  $L_{\infty} = 365.8$  mm,  $k = 0.221$ ,  $t_0 = -0.505$ ,  $A_{0.95} = 14$  años; machos:  $L_{\infty} = 322.0$  mm,  $k = 0.251$ ,  $t_0 = -0.441$ ,  $A_{0.95} = 12$  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-García and Ibáñez-Aguirre (1992), Ibáñez-Aguirre and Leonart (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 (103° 57' and 104 ° 19' W; 18 ° 57' and 19 ° 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.  $L_{\infty}$ ,  $k$  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 ( $\Sigma e_i^2$ ). 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  $L_{\infty}$  by  $W_t$  and  $W_{\infty}$ , respectively in the von Bertalanffy equation. Taylor's equation (1958 and 1960) was used to calculate age limit or longevity (95% of  $L_{\infty}$ ).

## RESULTS AND DISCUSSION

The values of  $L_{\infty}$  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

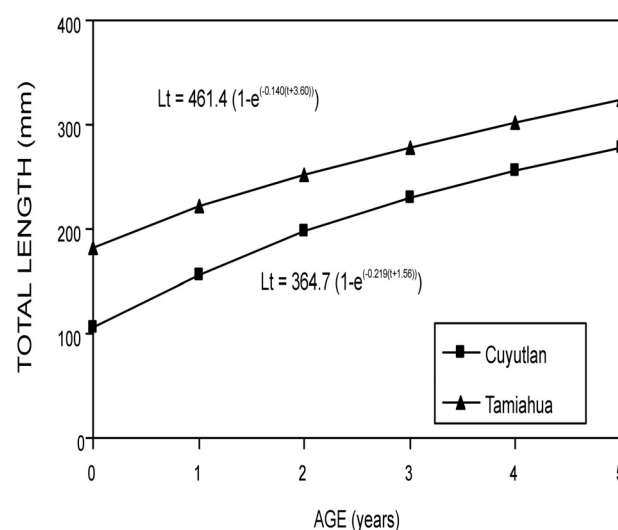


Fig. 1. Theoretical growth curve for *M. curema* in Cuyutlan and Tamiahua lagoons.

Growth of white mullet *Mugil curema*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	$L_{\infty}$ (mm)	K	$t_0$	SD <sup>2</sup>
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	0.18091
Beverton regression	364.70	0.2178	-0.5720	0.1869

<sup>1</sup> 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  $L_{\infty}$  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  $L_{\infty}$  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:  $Wt = 1.065 \times 10^{-5} (TL)^{2.979}$  for total weight ( $t = 0.0135$ ,  $P > 0.05$ ) and  $We = 1.1598 \times 10^{-5} (TL)^{2.945}$  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  $L_{\infty}$  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

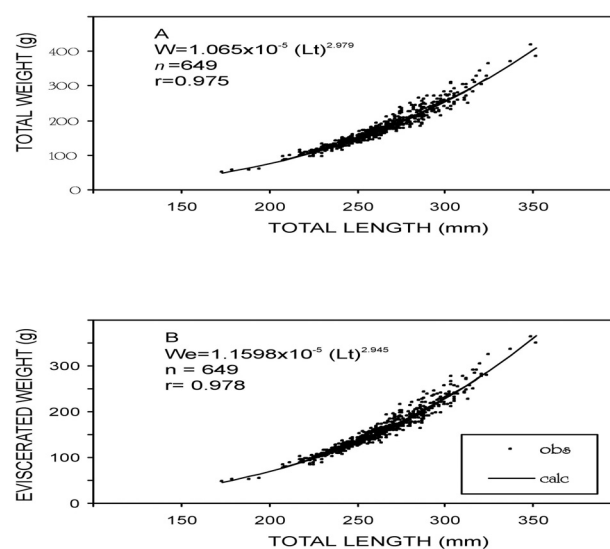
Fig. 2. Relation between weight and length of *M. curema*: (A) total weight; (B) eviscerated weight.

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

Age	Species	Mean Length		Mean Weight		
		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	130.93
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	$L_{\infty}$	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 <i>et al.</i> , 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)	TL <sup>3)</sup>	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 <i>et al.</i> , 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.

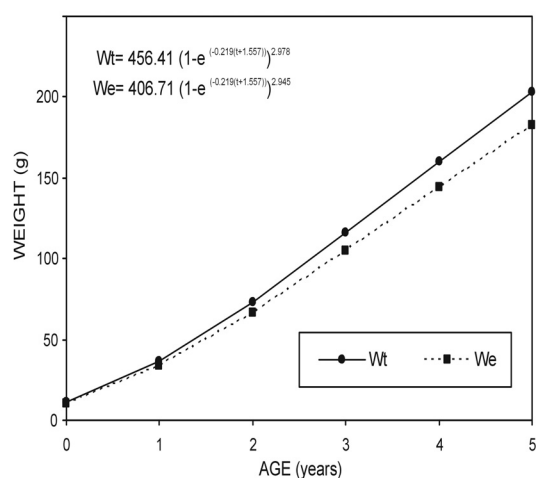


Fig. 3. Theoretical growth curve of *M. curema*: (Wt) total weight; (We) eviscerated weight.

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  $L_{\infty}$  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 10.3° C to 33° C (Ibáñez-Aguirre, 1995) and in Cuyutlan lagoon from 17.5° C to 34.2° C. (Cabral-Solís, 1999).

## ACKNOWLEDGEMENTS

The authors wish to thank Dr. José Luis Gómez Márquez who provided helpful comments and suggestions on the manuscript.

## REFERENCES

- ALLEN, K. R. 1966. A method of fitting growth curves of the von Bertalanffy type to observed data. *Journal Fisheries Research Board Canada* 23(3):163-277.
- ALVAREZ, L. S. 1976. Contribución al ciclo de vida de *Mugil curema* Valenciennes in Cuvier et Valenciennes, 1836 (Pisces: Mugilidae). *Ciencias Serie 8, Revista Investigaciones Marinas* 28:1-130.
- ALVAREZ, L. S. 1979. Estudios de las lisas (Pisces, Mugilidae) en Cuba con especial atención al género *Mugil* Linne; la biología pesquera de las especies predominantes y la evaluación de sus potencialidades para ser sometidas a cultivo. Resumen de tesis doctoral. Universidad de la Habana, Facultad de Biología. Centro de Investigaciones Marinas, pp. 5 - 11
- ALVAREZ, L. S. 1981. Determinación de la edad y del crecimiento de *Mugil curema*, *M. hospes*, *M. trichodon* y *M. liza*. *Revista de Investigaciones Marinas* 2:142-162.
- ANGELL, C.L. 1973. Algunos aspectos de la biología de la lisa *Mugil curema* Valenciennes en aguas hipersalinas del nororiente de Venezuela. Memorias. *Sociedad Ciencias Naturales* 96: 223-37.
- BERNARD, D.R., 1981. Multivariate analysis as a means of comparing growth in fish. *Journal of Fisheries and Aquatic Science* 38: 233-236
- BEVERTON, R.J.H. 1954. Notes on the use of theoretical models in the study of the dynamics of exploited fish populations, United States Fisheries Wildlife Service, Fisheries Laboratory, Beaufort, Misc. Contribution., 2:181 p.
- CABRAL-SOLÍS, E.G. 1999. Estudio sobre el crecimiento y aspectos reproductivos de la lebrancha *Mugil curema* Cuvier y Valenciennes, 1836, en la laguna de Cuyutlán, Colima. Tesis de Maestría en Ciencias, Universidad de Colima, 91 p.
- ESPINO-BARR, E., CABRAL-SOLÍS, E.G., GALLARDO-CABELLO, M. & A.L. IBÁÑEZ-AGUIRRE. 2005. Age determination of *Mugil curema* Valenciennes, 1836 (Pisces: Mugilidae) in the Cuyutlán Lagoon, Colima, México. *International Journal of Zoological Research* 1 (1): 21-25,
- FORD, E. 1933. An account of the herring investigations conducted at Plymouth during the years from 1924 to 1933. *Journal Marine Biological Association*. United Kingdom (new series.) 19:305-384.
- GULLAND, J.A. 1964. Manual of methods of fish population analysis. FAO *Fisheries Technical Paper* 40, 60 pp.
- IBÁÑEZ-AGUIRRE, A.L. 1995. Algunos aspectos de la dinámica de poblaciones de *Mugil cephalus* (Linneo, 1758) y *M. curema* (Valenciennes, 1836) (Pisces: Mugilidae) en la laguna de Tamiahua, Veracruz. Tesis de Doctorado en Ciencias (Biología), Facultad de Ciencias, UNAM. México 216 p
- IBÁÑEZ-AGUIRRE, A.L. & J. LLEONART. 1996. Relative growth and comparative morphometrics of *Mugil cephalus* L. and *M. curema* V. in the Gulf of Mexico. *Scientia Marina* 60(2-3):361-368.
- IBÁÑEZ-AGUIRRE, A.L. & M. GALLARDO-CABELLO, 1996 a. Total and natural mortality of *Mugil cephalus* and *M. curema* (Pisces: Mugilidae), in Tamiahua Lagoon, Veracruz. I. Selectivity. *Hidrobiológica* 6(1-2):9-16.
- IBÁÑEZ-AGUIRRE, A.L. AND M. GALLARDO-CABELLO. 1996 b. Age determination of the grey mullet *Mugil cephalus* L. and the white mullet *M. curema* V. (Pisces: Mugilidae) in Tamiahua lagoon, Veracruz. *Ciencias Marinas* 22 (3):329-345.
- IBÁÑEZ-AGUIRRE, A.L., GALLARDO-CABELLO, M. & X. CHIAPPA-CARRARA. 1999. Growth analysis of striped mullet, *Mugil cephalus*, and white mullet, *M. curema* (Pisces: Mugilidae), in the Gulf of Mexico. *Fisheries Bulletin* 97: 861-872.
- JORDAN, D.S. & B.W. EVERMAN, 1896. The fishes of the North and Middle America. *Bulletin United States Natural Museum* 1-4(47): 1-3313, 958 figs.
- PÉREZ-GARCÍA, M. & A.L. IBÁÑEZ-AGUIRRE. 1992. Morfometría de los peces *Mugil cephalus* y *M. curema* (Mugiliformes- Mugilidae) en Veracruz, México. *Revista Biología Tropical* 40(3):335-339.
- PHILLIPS, P., Y. ASTORGA, C. HIDALGO, & A. VILLAREAL. 1987. El cultivo de la lisa, *Mugil curema* (Pisces: Mugilidae), en el área del Golfo de Nicoya, Costa Rica. *Revista Latinoamericana Acuicultura* 31:17-56
- PRAGER, M.H., 1987. Nonlinear parameter estimation for fisheries (Fishparm), version 2.1S. Elsevier Scientific Publications Co., Bronxville, N.Y.
- RICHARDS, C.E., & M. CASTAGNA. 1976. Distribution, growth and predation of juvenile white mullet (*Mugil curema*) in ocean-side waters of Virginia's eastern shore. *Chesapeake Science* 17(4):308-9
- SEMARNAP. 2000. Anuario estadístico de pesca 1999. Secretaría de Medio Ambiente, Recursos naturales y Pesca. 271 pp.
- TAYLOR, C.C. 1958. Cod growth and temperature. *Journal du Conseil* 23(3):366-370.
- TAYLOR, C.C. 1960. Temperature, growth and mortality – the Pacific cockle. *Journal du Conseil* 26(1):117-124.
- TOMLINSON, P.K. & N.J. ABRAMSON. 1961. Fitting a von Bertalanffy growth curve by least squares. *Fisheries Bulletin* 116(1):3-69.
- VON BERTALANFFY, L. 1938. A quantitative theory of organic growth (inquiries on growth laws. II). *Human Biology* 10(2):181-213.
- WALFORD, L.A. 1946. A new graphic method of describing the growth of animals. *Biological Bulletin* 90(2):141-147.

Recibido: 29 de mayo de 2004

Aceptado: 31 de marzo de 2005

