Biometric relationships of the fat sleeper *Dormitator maculatus* (Bloch, 1792) (Teleostei: Eleotridae) from Alvarado lagoon, Veracruz, Mexico

Relaciones biométricas del dormilón *Dormitator maculatus* (Bloch, 1972) (Teleostei: Eleotridae) de la Laguna de Alvarado, Veracruz, México

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ABSTRACT. Length-weight and eight biometric relationships for *Dormitator maculatus* in the Alvarado lagoon were evaluated for 500 specimens (252 females and 248 males), 23.7 - 143.9 cm TL and 0.95 - 59.1 g weight, sampled during May 2015 to May 2017, using traditional fishing gears. The *b* coefficient indicated isometric growth (b = 3.0195, r^2 > 0.9763, P < 0.05) for overall sample, females (b = 3.0507; r^2 > 0.989; P < 0.05) and males (b = 2.9953; r^2 > 0.9783 P < 0.05). Biometric relationships showed high correlation coefficients (r^2 > 0.9193 - 0.9992, P < 0.05) for the overall sample, females (r^2 > 0.9188 - 0.9981; P < 0.05) and males (r^2 > 0.9079 - 0.9995, P < 0.05). This study reports L-W and biometric relationships for the fat sleeper, these results will be useful to delineate a baseline for regulations and the sustainable fishery management of this fish species.
Key words: Biometry, eleotrid fish, Gulf of Mexico, fish growth, LWR parameters, regression models.

RESUMEN. Se evaluaron las relaciones de Peso-Longitud y biométricas de *D. maculatus* en la Laguna de Alvarado, para un total de 500 ejemplares (252 hembras y 248 machos), 23.7 - 143.9 cm LT y 0.95 - 59.1 g, recolectados en 10 localidades durante Mayo 2015 a Mayo 2017, utilizando artes de pesca tradicionales. El cálculo del coeficiente de correlación *b* indicó crecimiento de tipo isométrico (b = 3.0195, r^2 > 0.9763, P < 0.05) para la muestra total, hembras (b = 3.0507, r^2 > 0.989, P < 0.05) y machos (b = 2.9953, r^2 > 0.9783 P < 0.05). Las relaciones biométricas mostraron relaciones significativas para la población total (r^2 > 0.9193 - 0.9992, P < 0.05), hembras (r^2 > 0.9188 - 0.9981, P < 0.05) y machos (r^2 > 0.9079 - 0.9995, P < 0.05). En este estudio se reporta información sobre las relaciones biométricas de la naca, estos resultados servirán de línea base para el planteamiento de regulaciones y un manejo sustentable de la pesquería de esta especie de pez.
Palabras clave: Biometría, eleótridos, Golfo de México, crecimiento, parámetros de la regresión P-L, modelos de regresión.

INTRODUCTION

Alvarado lagoon (Mexico) is an estuarine-coastal ecosystem used by a variety of young and adult fish species as primary habitat or nursery grounds for feeding and spawn, making use of the available resources provided by this environment at different (seasonal) times (Franco-López *et al*. 1996, Cruz-Escalona *et al*. 2018). One of these fish species is the fat sleeper (locally named "naca") *Dormitator maculatus* (Blotch, 1792), an euryhaline fish species that commonly lives in fresh and salt waters of spring lagoons, muddy ponds, marshes, mangrove swamps and tidal pools in estuaries and coastal lagoons along the Western Atlantic coast, from New York (USA), including the Bahamas and Gulf of Mexico to southeastern Brazil (Nordlie and Haney 1993, Nordlie 2000, McEachran and Fechhelm 2005, Miller *et al*. 2005).

Fat sleepers regularly enter to Alvarado lagoon biotopes to feeding and spawn during the months of September to December, when local fishermen take advantage of the abundant presence of populations of this species, catching them almost to overexploitation due to the high demand and price that the female gonads reach in the local markets (Franco-López *et al*. 1996, 2020, Dávila-Camacho and Galaviz-Villa 2020). Ecologically, *D. maculatus* perform an important contribution to the structure and dynamic of the Alvarado lagoon food web, participating as an omnivorous consumer (primary and secondary), likewise as a prey of another fish species, birds, turtles and aquatic mammals (Nordlie 1981, Berra 2001, Jonna and Weinheimer 2003, Franco-López *et al*. 2020). Thus, the fat slepeer like other estuarine fish species could represent critical links in the food chains, between estuarine-lagoon biotopes and the adjacent coastal and marine ecosystems (Oberrecht 2014, González-Acosta *et al*. 2015).

Despite its commercial value and ecological importance, few studies have been conducted to the biological knowledge of the fat sleeper (Froese and Pauly 2021); some of them address eggs and larvae description (Flores-Coto and Zavala 1982), their ecological niche, feeding, reproduction and growth (Nordlie1981, 2000, Franco-López *et al*. 2020), environmental adaptation (Nordlie and Haney 1993), parasites (Montoya *et al*. 2004) and phylogenetic relationships (Galván-Quesada *et al*. 2016). Therefore, this study reports the LWR and eight biometric relationships: standard length [SL]-weight [LWR] and standard length-total length [SL-TL], SL-depth body [DB], DB-head length [HL] and mouth length-eye diameter [ML-ED] for *D. maculatus*; these results will be useful to delineate a baseline for regulations and the sustainable fishery management of this species in the Alvarado estuarine lagoon ecosystem.

MATERIALS AND METHODS

A total of 500 specimens (252 females and 248 males) of fat sleepers were sampled during May 2015 to May 2017 covering dry, rainy and windy seasons, in ten localities of the Alvarado lagoon (Figure 1), characterized by the presence of submerged vegetation over mud bottoms. A seine net 50 m length, 2.5 m high and 2.5 cm mesh size, was used for the caught of fish specimens, which were preserved in formalin 10% to be moved to the Laboratorio de Ecología of the Facultad de Estudios Superiores Iztacala-UNAM. The specimens were identified using the taxonomic keys of Castro-Aguirre *et al*. (1999) and McEachran and Fechhelm (2005).

All specimens were measured at their standard (SL) and total length (TL) as well as in other biometric characters: head [HL] and mouth length [ML], body depth [BD] and eye diameter [ED], using a fish measuring board (0.1 mm) and weighed using a digital scale (0.1 g). The sex of each specimen was determined through macroscopic observation of the gonads.

Length-weight relationship (LWR) was calculated using equation expressed as: $W = a\ TL^b$ (Le Cren 1951, Bagenal and Tesch 1978), were W = weight (g) and TL = Total length (cm), separately for females and males by transforming W and TL data to logarithmic values and fitting them to linear equation: $W = \log a + b \log TL$, using least squares method with *a* as the interception between the regression line and the y-axis, and *b* the slope of the

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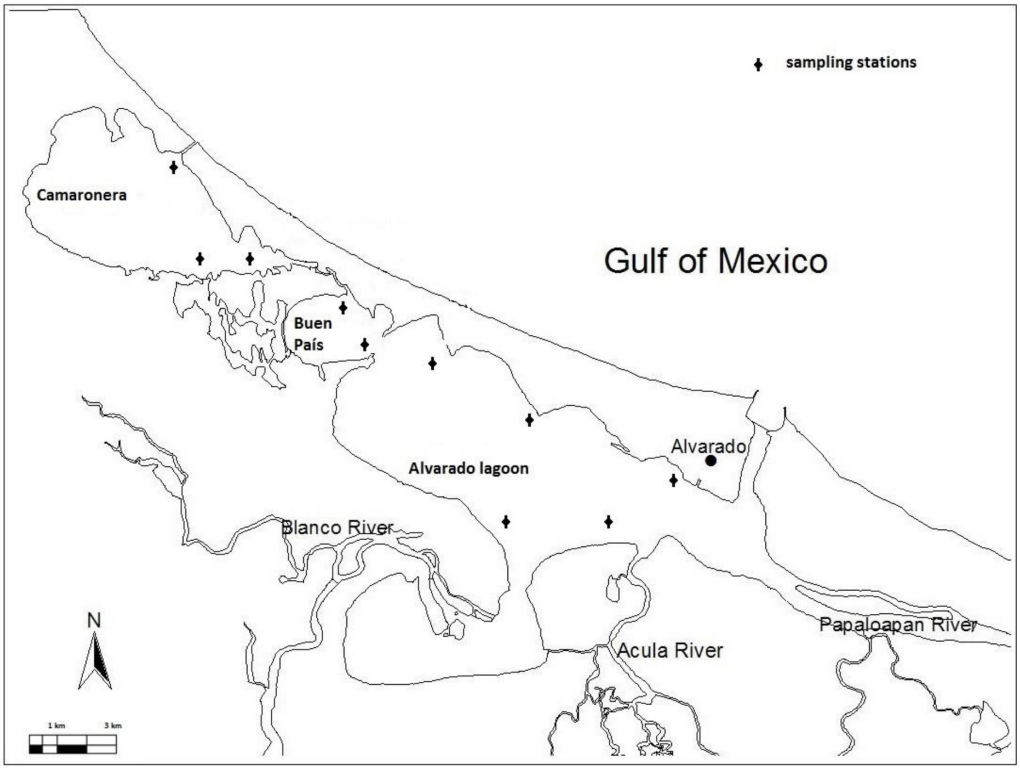

Figure 1. Sample locations in the Alvarado lagoon estuarine coastal system, Veracruz, Mexico.

regression line (López-Fuerte *et al*. 2016). In accordance with Froese *et al*. (2011), extreme data values were eliminated based on the analysis by graphing log-transformed length and weigh data. To assess whether the LWR *b*-values differs from those of indicative isometric growth (b = 3.0), a student's t-test was conducted (Zar, 2010). In addition, TL-SL and biometric relationship were analyzed by simple linear regression (TL or Y = a + b SL or X). The statistical significance level (r^2) was estimated and used as indicator of the quality of the linear regressions (Bolger and Connolly 1989).

RESULTS AND DISCUSSION

A total of 500 specimens of *D. maculatus* (23.7 - 143.9 mm TL, 19.3 -114.4 mm SL and 0.95 - 59.1 g weight) were caught through this study; the overall sample showed a significant positive power function between TL and W (r^2 = 0.9763), and between TL and SL (TL = 0.6509 + 0. 7778 SL; r^2 = 0.9992). Female fat sleepers (23.7 - 143.9 mm TL and 20.6 - 114.7 mm SL, 1.02 - 59.13 g weight) comprised 50.4% of the total sample and displayed a robust positive power function between TL and W (r^2 = 0.989), and between TL and SL (TL = 1.0437 + 0. 7772 SL; r^2 = 0.9981). Male fat sleepers (24.2 - 141.8 mm TL and 19.5 - 110.3 mm SL; 0.95 - 58.63 g weight) comprised 49.68% of the overall sample; males group showed a significant positive power function between TL and W (r^2 = 0.9783) and between TL and SL (TL = 0.252 + 0.7785 SL; r^2 = 0.9995).

Regression analyses describing the relation of TL and W derived a b value statistically equal to 3.0 for females (b = 3.0507: t-test, P < 0.05), males (b = 2.995, t-test, P > 0.05) and overall fish sample (b = 3.0195, t-test, P > 0.05), indicating isometric growth (Table 1). Moreover, the biometric relationships presented in table 2 were highly significant (P < 0.05) with all coefficients of determination values being > 0.9079; showing isometric growth for all cases.

Table 1. Length-weight and standar length-total length parameters of the fat sleeper *Dormitator maculatus*, in the Alvarado lagoon estuarine coastal system.

Sex	N	TL range (mm)	W range (g)	*a*	SE *a*	95% IC of *a*	*b*	SE *b*	95% IC of *b*	r^2	Ts	Growth type
Females	252	23.7 - 143.9	1.02 - 59.13	1.619^{-5}	0.0394	1.6119^{-5} - 0.0773	3.0507	0.0428	3.0507 - 0.038	0.989	1.18292	I
Males	248	24.2 - 141.8	0.95 - 58.63	2.199^{-5}	0.0599	2.199^{-5} - 0.1175	2.995	0.0529	2.995 - 0.0594	0.9783	- 0.0941	I
Pooled	500	23.7 - 143.9	0.95 - 59.1	3.734^{-5}	0.0419	3.0195 - 0.0139	3.0195	0.0712	3.7347^{-5} - 0.0821	0.9763	0.2735	I

n, number of specimens; TL, total length; W, weight; a, intercept; b, regression slope; IC, confidence intervals; r^2, coefficient of determination; Ts, t-student calculated.

Table 2. Biometric relationships for the fat sleeper in the Alvarado lagoon estuarine coastal system.

Sex	n	Equation	a	95% CI of a	b	95% CI of b	r^2
Females	252	TL = a+b SL	1.0437	1.0437 - 4.0025	0.7772	0.7785 - 0.041	0.9981
	252	TL = a+b DB	4.3725	4.3725 - 7.3189	0.2293	0.2293 - 0.0075	0.9351
	252	SL = a+b DB	4.2652	4.2625 - 8.2849	0.2922	0.2922 - 0.1078	0.9188
	252	SL = a+b HL	3.0619	3.0619 - 1.690	0.2744	0.2744 - 0.0219	0.9958
	252	HL = a+b ML	-0.3191	-0.3191 - 0.8952	0.3522	0.3523 - 0.0374	0.9927
	252	HL = a+b ED	-0.1928	-0.1928 - 0.7479	0.3067	0.3067 - 0.0312	0.9933
Males	248	TL = a+b SL	0.2520	0.2520 - 1.9112	0.7785	0.7785 - 0.0199	0.9995
	252	TL = a+b DB	4.8178	4.8178 - 7.4184	0.2051	0.2051 - 0.0773	0.9156
	252	SL = a+b DB	4.8308	4.8308 - 7.7702	0.2622	0.2922 - 0.1078	0.9079
	252	SL = a+b HL	3.2572	3.2572 - 1.6392	0.2699	0.2699 - 0.0218	0.9957
	252	HL = a+b ML	-0.3530	-0.3530 - 0.8366	0.3523	0.3523 - 0.0359	0.9932
	252	HL = a+b ED	-0.1715	-0.1715 - 1.4179	0.2983	0.2983 - 0.0609	0.9736
Pooled	500	TL = a+b SL	0.6509	0.6569 - 2.5244	0.7778	0.7778 - 0.0260	0.9992
	500	TL = a+b DB	4.5931	4.5931 - 7.2102	0.2173	0.2173 - 0.0745	0.9292
	500	SL = a+b DB	4.5211	4.5211 - 7.7526	0.2778	0.2778 - 0.1021	0.9193
	500	SL = a+b HL	3.1403	3.1403 - 1.0333	0.2725	0.2725 - 0.0136	0.9983
	500	HL = a+b ML	- 0.3475	-0.3475 - 0.7462	0.3528	0.3528 - 0.0316	0.9948
	500	HL = a+b ED	- 0.1954	-0.1954 - 0.9252	0.3031	0.3031 - 0.0392	0.9892

According to our knowledge, no information dealing on the length (L) - weight (W) and biometric relationships for *D. maculatus* are available in the literature (e. g. Froese and Pauly 2021). Considering that currently the population size of the fat sleeper is decreasing due to overfishing in the Alvarado lagoon (Franco-López *et al*. 2020, Dávila-Camacho and Galaviz-Villa 2020); thus, the estimation of LWRs parameters (*a* and *b*) are necessary for fishery management purposes of this species.

Through LWRs information it will be possible to study ontogenetic changes as well as other aspects of fish population dynamics like growth rates, age structure and condition index (Quist *et al*. 2012, Sandoval-Huerta *et al*. 2015); this is important to study aspects of the reproductive biology of *D. maculatus* which reach sexual maturity earlier at the beginning of their second year of life, and because its normal longevity is two or three years (Nordlie 2000).

All allometric coefficients (*b*) estimated in this study were within the expected range of 1.96 and 3.94 (Froese 2006), since the fat sleeper specimens were caught over different periods and locations, *a* and *b* parameters represent mean annual values; which range between those of 2.73 (females) and 3.09 to 3.35 (males) reported for its congener the Pacific fat sleeper *D. latifrons* (Richardson 1844) in the Central Mexican Pacific, varying in the type of growth from isometric (Rojas-Herrera *et al*. 2009) to allometric (Sandoval-Huerta *et al*. 2015).

In general, *b* values for females, males and overall sample statistically were not different from 3.0, indicating isometric growth for all cases; that is, the fish grows equal in length than in weight (Karachle and Stergiou 2012). This kind of growth reported here differs from the allometric growth reported by Dávila-Camacho and Galaviz-Villa (2020) for both sexes of *D. maculatus* in the Alvarado lagoon; such differences could be due to the sample size as well as the size frequency of the assessed specimens in both studies

To our best knowledge, this study presents for the first time basic information on eight biometric relationships for *D. maculatus*, which in all cases indicating isometric growth (all morphometric measures

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growth increases in the same proportion). Although no information on biometric relationships currently exists in the literature (e. g. Froese and Pauly 2021) and consequently there are not point of comparison. Our results will contribute to improve the knowledge and conservation of the fat sleeper *D. maculatus* throughout its distribution area, as well as to delineate a baseline for regulations and the sustainable fishery management of the fat sleeper in the estuarine ecosystem of Alvarado lagoon.

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