Available online at http://www.journalijdr.com

ISSN: 2230-9926

IJDR

International Journal of Development Research

Vol. 11, Issue, 02, pp.44435-44441, February, 2021

https://doi.org/10.37118/ijdr.21046.02.2021

RESEARCH ARTICLE **OPEN ACCESS**

POPULATION STRUCTURE OF THE THOMAS SEA CATFISH, *Notarius grandicassis* (VALENCIENNES, 1840 [SILURIFORMES: ARIIDAE]), CAUGHT ON THE WESTERN COAST OF THE STATE OF MARANHÃO, BRAZIL

Gleison Andrade Campos[1], Marcelo Henrique Lopes Silva[1], James Werllen de Jesus Azevedo[2], Leonardo Silva Soares[3,4], Adilson Matheus Borges Machado[2] and Antonio Carlos Leal de Castro[1,3,4]*

[1]Universidade Federal do Maranhão, Departamento de Oceanografia e Limnologia, Laboratório de Ictiologia e Recursos Pesqueiros (Avenida dos Portugueses, 1966, Bacanga – CEP: 65080-840 – São Luís – MA – Brazil); [2]Universidade Federal do Maranhão, Coordenação do Curso de Engenharia de Pesca (Estrada Pinheiro-Pacas, km 10, 65200-000, Pinheiro, Maranhão, Brasil); [3]Universidade Federal do Maranhão, Departamento de Oceanografia e Limnologia, Programa de Pós-Graduação em Desenvolvimento e Meio Ambiente (Avenida dos Portugueses, 1966, Bacanga – CEP: 65080-840 – São Luís – MA – Brazil); [4]Universidade Federal do Maranhão, Programa de Pós-Graduação em *Saúde e Ambiente (Praça Madre Deus, nº* 2, CEP:65.025-560, Bairro Madre Deus, São Luis-MA – Brazil).

ARTICLE INFO

Article History:

Received 10th December, 2020
Received in revised form
15th December, 2020
Accepted 22nd January, 2021
Published online 24th February, 2021

Key Words:

Amazon coast; Length/weight ratio; Notarius grandicassis; Relative condition factor.

Corresponding author:
Antonio Carlos Leal de Castro

ABSTRACT

The Thomas sea catfish, *Notarius grandicassis*, belongs to the family Ariidae and is one of the most exploited species on the western coast of the state of Maranhão, Brazil. The scarcity of studies on this fishing resource underscores the need for information on the population structure and biological aspects of the species. The aim of the present study was to collect information on the population structure and condition factor of N. grandicassis. Specimens were collected during campaigns on the western coast of Maranhão (01º 02' to 2º 10'S and 45º 58' to 44º 21'W) from April 2012 to August 2013 using drift gillnets. In the lab, total length (Lt), total weight (Wt), and gonad differentiation were determined for each individual. These data were processed to acquire population structure and reproduction parameters. The sample was composed of 499 individuals (85 males and 414 females); the largest (69 cm) and smallest (27.4 cm) individuals were both females. The highest frequency of captured individuals was in the 42.4 to 47.4 cm class interval. The weight/length relationship revealed a type of positive allometric growth, with Wt = 0.0056 Lt3.07 for males and Wt = 0.0066 Lt3.02 for females. The relative condition factor revealed the same pattern for both sexes in April 2012 and May 2013, demonstrating better conditions in this period.

Citation: Gleison Andrade Campos, Marcelo Henrique Lopes Silva, James Werllen de Jesus Azevedo, Leonardo Silva Soares, Adilson Matheus Borges Machado and Antonio Carlos Leal de Castro, 2021. "Population structure of the thomas sea catfish, *notarius grandicassis* (valenciennes, 1840 [siluriformes: ariidae]), caught on the western coast of the state of maranhão, Brazil", *International Journal of Development Research*, 11, (02), 44435-44441

INTRODUCTION

Fishing in Brazil is an activity of considerable social and economic importance in terms of both food production and as a source of livelihood for millions of people, although marine fishery production has experienced a sharp decline attributed to overfishing (Haimovici *et al*., 2014). The fact that fisheries are an integral part of human activities in coastal zones creates multiple interactions and underscores the need for an integrated approach to coastal management in order to separate the effects of fishing from all other anthropogenic factors (Blaber, 2000; Blaber, 2013). Marine and estuarine environments on the northern coast of Brazil generally exhibit high productivity and a considerable diversity of fishes, which is likely due to the important contribution of organic matter associated with the broad continental shelf, the amount of nutrients carried by Nittrouer and Demaster, 1996). These environments sustain an important biomass of fishery resources, especially demersal organisms, many of which are commercially exploited, although their potential and the carrying capacity of stocks remain unknown (Isaac, 2006). On the coast of the state of Maranhão, fishery production occurs exclusively by the artisanal fishing fleet, involving vessels with low autonomy and fishing efforts concentrated in estuaries, bays, and shallow coastal waters (Silva *et al*., 2018). Among the fishery resources on the western coast of the state, the Thomas sea catfish, *Notarius grandicassis* (Valenciennes, 1840), stands out due to the large amount caught. This species was recently revised considering the geographic variation in its morphological traits (Marceniuk *et al*., 2017). According to Betancur *et al*. (2015), *N. grandicassis* occurs in the northeastern portion of South America, with distribution from Barranquilla, Colombia, to the state of Paraná, Brazil. It is commonly found in shallow coastal waters at depths ≥ 35 m and in estuarine areas, where the species is captured as bycatch in mackerel and pink shrimp fisheries. Despite the enormous potential for consumption and commercialization, little is known regarding the biology and population structure of the species. Such information is valuable for management actions and as the basis for studies on stock assessments, recruitment, and mortality. Therefore, the aim of the present paper was to provide important estimates of the population parameters for *N. grandicassis* and contribute to the maintenance of the exploited stock at sustainable biomass levels.

MATERIAL AND METHODS

Study site: This study was conducted on the northwestern coast of the state of Maranhão in estuarine areas of Lençóis Bay surrounding Lençóis Island (01º18'S to 01º19'S; 44º51'W to 44º53'W) (Figure 1). Lençóis Island is located in the Maiau archipelago on the coast of the municipality of Cururupu (eastern Amazon region), which is the eco-tourism center of the Guarás Forest (Castro *et al*., 2018).

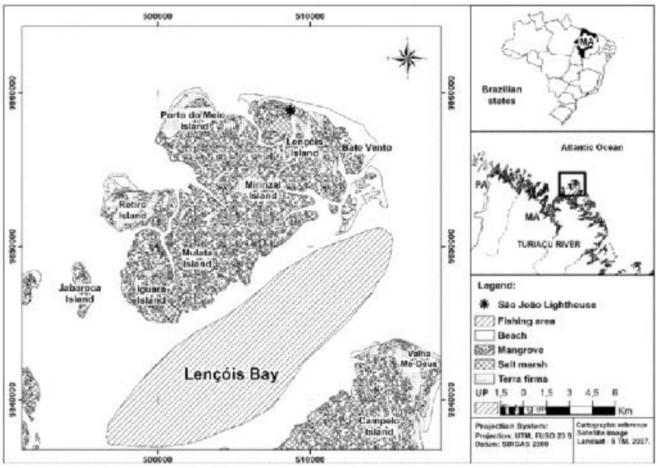


Figure 1. Location of Lençóis Bay and catch area for *Notarius grandicass*is (hatched line)

The oceanographic conditions of the continental shelf in the region are influenced by the Brazilian Equatorial Current, which is driven by the tropical trade winds that predominate in the region, generating a macrotidal coastline (Hayes, 1979; Marceniuk *et al*., 2017). A semi-diurnal tidal cycle occurs in this estuarine region, with spring tides ranging from 4.0 to 5.5 m (Castro *et al*., 2018). The climate is hot and humid, with an average temperature of 28.5°C and mean annual precipitation of 1,900 mm (INMET, 2019) divided between a rainy season from January to June and a dry season from July to December. The landscape consists of mangrove vegetation composed of *Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa*, which constitute the dominant structure in most tropical estuaries. The tallest mangroves are concentrated in the northeastern and southeastern sectors of Lençóis Island, with *R. mangle* trees reaching 25 meters and dominating the local landscape (AZEVEDO *et al*., 2017).

Data collection: Samples were taken bimonthly between April 2012 and August 2013 through purchases from fishermen in the region. The fishermen used floating drift gillnets with a mesh size of 100 mm between adjacent knots, 40 meshes in height, and 2,500 meters in length. All catches were performed in the evening from 18:00 to 24:00 h, with the vessels operating in an area of approximately 110 km^2 at depths of 10 to 15 meters. Captured individuals were packed in ice in plastic bags labeled with the date and catch site, conserved on ice, and taken to the laboratory. Voucher material was deposited at the Ichthyology Collection of the Department of Oceanography and Limnology of the Federal University of Maranhão, Brazil. In the laboratory, the specimens were identified based on Figueiredo and Meneses (2000), Marceniuk (2005), and Cervigón *et al*. (1993). Basic morphological measurements were taken for each specimen, including total length (cm) and body weight (g). To characterize the sex and maturity stage of the gonads, observations were performed of macroscopic reproductive characteristics of the ovaries and testicles, with the determination of the following stages of development (Ungaro, 2008; Bazzoli, 2003; Nikolsky, 1963).

Females

Immature: sexual organs very small, usually shorter than 1/4 of body cavity, situated close to vertebral column. Ovary transparent, colorless, or grey. Eggs not visible to the naked eye.

Maturing: ovary pinkish-yellow in color with granular appearance, about 2/3 the length of the body cavity. Eggs visible to the naked eye through the ovarian tunica, which is not yet translucent. Eggs not expelled under light pressure.

Mature: ovary orangish-pink in color, with conspicuous superficial blood vessels, 2/3 to full length of the body cavity. Large transparent, ripe eggs clearly visible, and can be expelled under light pressure. In a more advanced condition, eggs escape freely.

Spent: reddish ovary shrunk to about 1/2 length of the body cavity. Flaccid ovarian walls. Ovary may contain remnants of disintegrating opaque and/or translucent eggs.

Males

Immature: small, filiform, translucent testicles; isolated, microscopically present primary spermatogonia; some secondary sperm cysts and primary spermatocytes.

Initial maturation: developed testicles, lobulated in shape; membrane breaks with certain pressure, eliminating milky, viscous sperm. Microscopically, testicles present cysts with germline cells in different stages of development, with primary and secondary spermatogonia as well as primary and secondary spermatocytes; small amount of sperm observed in lumen of seminiferous tubules.

Advanced maturation: turgid, whitish testicles, occupying large part of the celomatic cavity; membrane breaks with weak pressure, eliminating sperm, less viscous than in previous stage; microscopically, primary spermatocytes and secondary spermatogonia observed, along with spermatozoa-laden seminiferous tubules.

Resting: flaccid testicles, with hemorrhagic appearance; membrane does not break with pressure; microscopically, seminiferous tubules with open lumen, which may contain residual spermatozoa and wall composed only of spermatogonia.

The population length structure was obtained from the frequency distribution of the total length classes of the sampled individuals and the sex ratio was determined by comparing the observed frequency of males and females using the chi-squared (χ^2) test, with the level of significance set to $\alpha = 0.05$. The definition of class intervals followed the recommendation in which the range of length groups for a length frequency histogram generally depends on the maximum and minimum length of the fish and the number of individuals measured (Zale *et al*., 2012). The weight-length relationship (WLR) was estimated for males and females separately using the potential equation: $Wt = a\ Lt^b$, in which Wt is total weight, Lt is total length, the *a* coefficient is related to body shape, and the *b* regression coefficient is indicative of growth type. These variables were estimated using the least squares method (Castro *et al*., 2018). The coefficient of determination (r^2) was used as an indicator of the goodness of fit of the linear regression (Zar, 2010). The relationships obtained for males and females were compared by initially performing a homogeneity test of variances. Next, the parallelism test (*b* test) and the intercept test (*a* test) were applied (ANCOVA) to determine whether the lines were coincident or not. The relative condition factor (K_{rel}) was estimated monthly, for the different seasons (rainy, dry, and transition) and by length class (Class 1: $\geq 27.4 < 42.4$ cm; Class 2: $\geq 42.4 < 57.4$ cm; Class 3: ≥ 57.4 cm) from the weight/length relationship expressed by $K_{rel} = W/aL^b$ and was analyzed to compare the observed weight of an individual to the average weight for a given length (FROESE, 2006). The data were subjected to two-way ANOVA to test for possible season and size interactions. One-way ANOVA was used for the comparison of K_{rel} among sampling months, followed by Tukey's test. For cases in which the presuppositions of homoscedasticity were not met, the Kruskal-Wallis test was used, followed by the Mann-Whitney for pairwise comparisons. All analyses were processed using the PAST statistical program, version 3.14 (Hammer, 2001), with α = 0.05.

RESULTS

A total of 499 individuals of *N. grandicassis* were analyzed (85 males and 414 females). Total length ranged from 28.6 to 59.5 cm for males (mean: 44.3 ± 6.9 cm) and 27.4 to 69.0 cm for females (mean: 46.9 ± 7.1 cm). The modal length covered the class range from 42.4 to 47.4 cm (Figure 2). The sum of the total weight recorded during the study was 386.48 kg (mean: 0.774 ± 0.410 kg). Minimum, mean, and maximum values of length and weight and respective standard deviation values are shown in Table 1. The sex proportion revealed a predominance of females in all sampling months, except in August 2013 (Table 2), when males predominated. The chi-squared (χ^2) test confirmed the significant predominance of females (4.8:1.0).

The proportion between juveniles and adults by sex and for each sampling month is shown in Figure 3. Juveniles predominated for both sexes throughout the sampling period, with a total predominance of juvenile males in April 2012, May 2012, June 2012, September 2012, July 2013, and August 2013. Juvenile females predominated in May 2012, June 2012, May 2013, and July 2013. The relation obtained in the scatterplot assumes a potential type model (Figure 4A and 4B), following the behavior of most teleosts, adjusted by the following equations: $Wt = 0.0056\ Lt^{3.0765}$ (males) and $Wt = 0.0066\ Lt^{3.0283}$ (females). The results show isometric growth tending towards positive allometry in both sexes. The values of the equation were submitted to logarithmic transformation and were adjusted for a linear function, resulting in the following equations:

$\ln Wt = 5.1911 + 3.0765 \ln Lt$ for males
$\ln Wt = 5.0212 + 3.0283 \ln Lt$ for females.

The coefficient of determination (R^2), which expresses the percentage of variation in weight as a function of length, was 0.97 for males and 0.95 for females. These values demonstrate the excellent fit of the regression model to the variables analyzed and indicate that changes in length in males and females account for 97% and 95% of the variation in body weight, respectively.

Table 1. Variation in weight (kg) and length (cm) for *Notarius grandicassis* in the period between April 2012 and August 2013. (Wtmax – maximum weight obtained; Wtmean – monthly mean weight; Wtmin – minimum weight found; Ltmax – maximum length obtained; Wtmean – monthly mean length; Ltmin – minimum length found)

Month	Sex	Wtmax (Kg)	Wtmean (Kg)	Wtmin (Kg)	Deviation	Ltmax (cm)	Ltmean (cm)	Ltmin (cm)	Deviation
April	Male	1.130	0.644	0.257	0.361	54.4	42.56	31.6	9.26
	Female	2.085	0.897	0.318	0.441	64.7	33.6	48.3	8.12
May	Male	0.738	0.491	0.268	0.146	46.5	40.4	32.7	4.32
	Female	2.139	0.752	0.351	0.316	64.3	46.5	36.5	5.14
June	Male	0.568	0.426	0.240	0.122	44.1	39.100	32.6	3.91
	Female	2.278	0.774	0.269	0.433	66.7	45.9	33.7	7.51
September	Male	0.424	0.421	0.418	0.003	38.5	38.2	37.8	0.40
	Female	1.737	0.746	0.329	0.326	60.4	45.8	36.7	6.46
October	Male	-	-	-	-	-	-	-	-
	Female	2.014	1.277	0.848	0.372	64	55.2	49	4.81
November	Male	1.279	0.713	0.184	0.271	52.6	44.4	28.6	6.17
	Female	1.374	0.716	0.328	0.254	57	45.6	35.6	5.32
December	Male	-	-	-	-	-	-	-	-
	Female	1.079	0.614	0.141	0.244	53.6	43.1	27.4	7.08
May	Male	0.922	0.645	0.541	0.158	49	44.6	42.9	2.49
	Female	1.034	0.684	0.485	0.117	51.4	45	40.3	2.33
June	Male	-	-	-	-	-	-	-	-
	Female	2.525	1.441	0.169	0.857	69	56.61	45.6	9.91
July	Male	1.351	0.857	0.406	0.368	54	46.9	38	6.55
	Female	1.788	0.992	0.466	0.444	58	48.5	40.4	6.29
August	Male	1.620	1.069	0.489	0.290	59.5	51.8	41.4	4.60
	Female	1.351	1.269	1.206	0.074	56.6	55.5	54.8	0.95

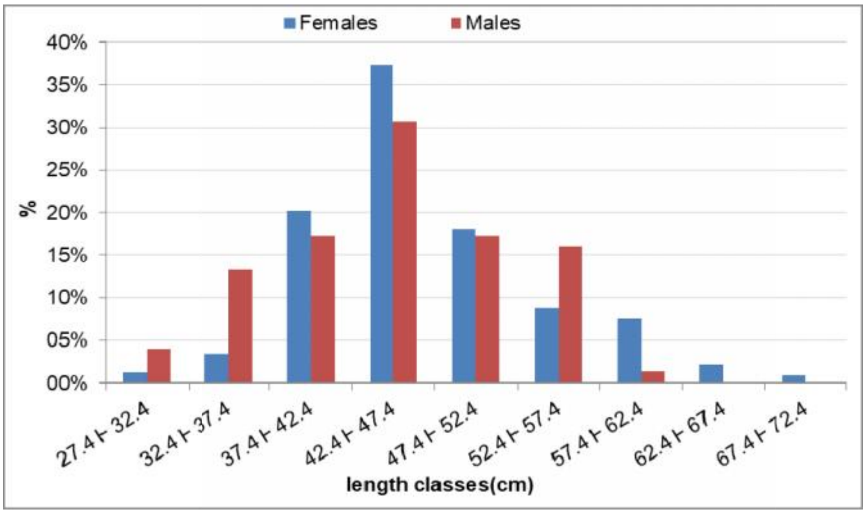


Figure 2. Frequency distribution by total length (cm) class interval for *N. grandicassis* caught in Lençóis Bay, state of Maranhão, Brazil

Table 2. Monthly proportion of females and males of *N. grandicassis* caught on the western coast of the state of Maranhão, Brazil, with respective chi-squared (^{2}) results

Month	Absolute Freq.	Nº of Males	%	Nº of Females	%	Expected Freq.	^{2}
Apr 2012	48	5	10.42	43	89.58	24	30.08*
May 2012	90	19	21.11	71	78.89	45	30.04*
Jun 2012	90	8	8.89	82	91.11	45	60.84*
Sep 2012	42	3	7.14	39	92.86	21	30.86*
Oct 2012	9	0	0.00	9	100.00	4.5	9.00*
Nov 2012	73	24	32.88	49	67.12	36.5	8.56*
Dec 2012	25	0	0.00	25	100.00	12.5	25.00*
May 2013	68	5	7.35	63	92.65	34	49.47*
Jun 2013	10	0	0.00	10	100.00	5	10.00*
Jul 2013	26	6	23.08	20	76.92	13	7.54*
Aug 2013	18	15	83.33	3	16.67	9	8.00*
TOTAL	499	85	17.0	414	83.0	249.5	216.92*

*significant at 5% level

^{2} 0.05 = 3.841.

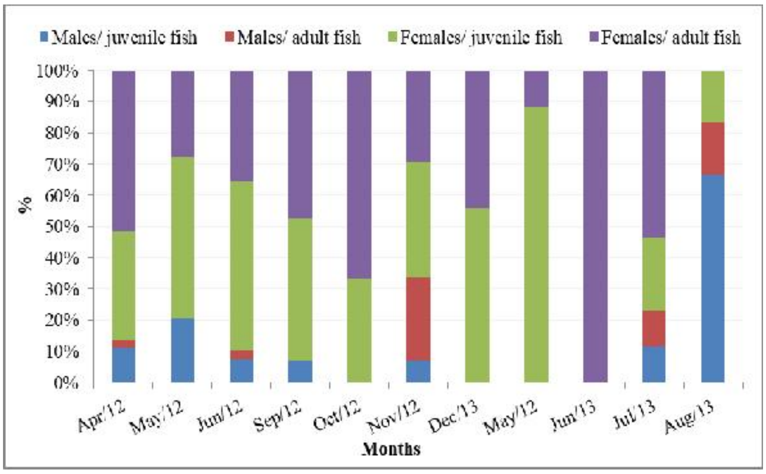


Figure 3. Proportion of juveniles and adults of *N. grandicassis* caught in Lençóis Bay, state of Maranhão, Brazil

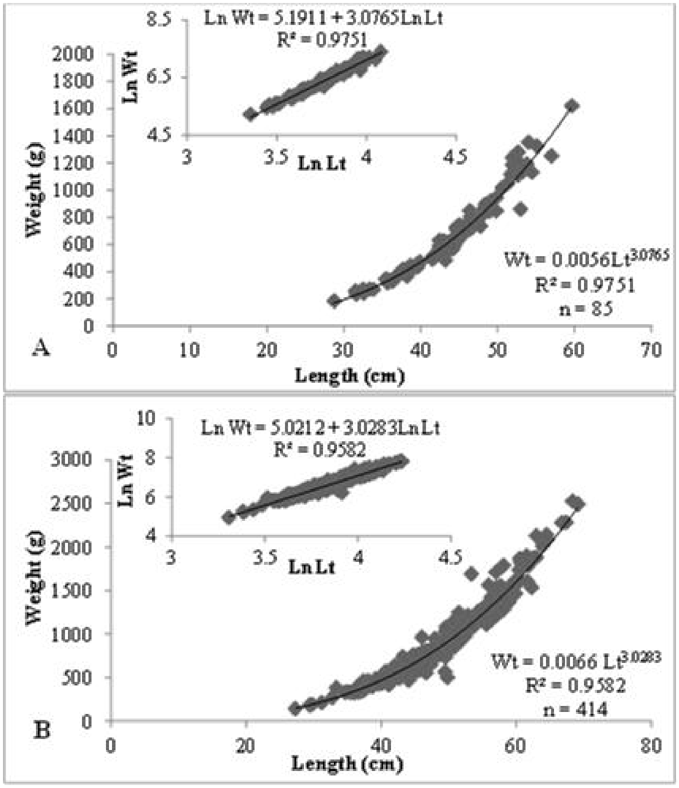


Figure 4. Total weight/total length relationship with respective linear transformation for males (A) and females (B) of *N. grandicassis* caught in Lençóis Bay, state of Maranhão, Brazil

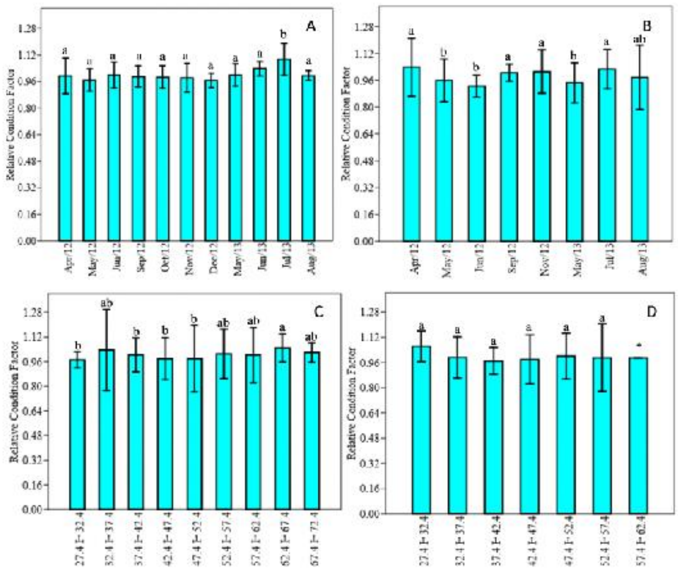
The values of the *a* and *b* coefficients obtained for males and females were compared using ANCOVA, which revealed a significant difference between these coefficients, thereby not enabling the calculation of the regression for grouped individuals.

Table 3. Parameter of linear regressions referring to weight-length relationship of *N. grandicassis* caught on the western coast of the state of Maranhão, Brazil

Sex/ Parameters	A	B	a	co	R2	r	N
Males	5.1911	3.0765	0.0056	P<0.05	0.97	0.96	85
Females	5.0212	3.0283	0.0066		0.95	0.95	414

A= log value of intercept; B= angular coefficient; a= numeric value of intercept; co= result of ANCOVA between angular coefficients; R^2= coefficient of determination; r= Pearson's linear correlation; N= number of individuals.

The relative condition factor (K_{rel}) was calculated for each sampling month and by length class interval (cm), the mean of which was 0.993 ± 0.082 for females and 0.986 ± 0.076 for males. The t-test revealed no significant difference in the mean condition factor between sexes ($t = -0.703$; $p = 0.482$). The K_{rel} of the females was highest in May 2013, June 2013, and peaked in July 2013 (transition period between the rainy and dry seasons), whereas the lowest values were found in May 2012 and December 2010. For males, the highest values were found in April 2012 and July 2013; however, values above 1.0 were also found in the dry months (September 2012 and November 2012), whereas the lowest values were found in May 2012, June 20112, and May 2013. One-way ANOVA revealed significant differences among sampling months regarding the relative condition factor for both males and females. For males, values were significantly higher in April 2012, September 2012, November 2012, and July 2012 in comparison to May 2012, June 2012, and May 2013 ($F = 2.46$; $df = 7$; $p = 0.025$). For females, the value in July 2013 was higher than the values of all other sampling months ($F = 4.733$; $df = 10$; $p < 0.000$). Regarding the evaluation of K_{rel} per total length class, the lowest values for females of *N. grandicassis* caught in estuaries in the state of Maranhão were found in the smallest length class (27.4 ⊢ 32.4 cm), followed by intermediate classes (42.4 ⊢ 47.4 and 47.4 ⊢ 52.4 cm). The highest relative condition factor values occurred in the second smallest class (32.4 ⊢ 37.4 cm) and the largest total length classes (62.4 ⊢ 67.4 and 67.4 ⊢ 72.4 cm). In general, only the smallest length class and intermediate sizes had K_{rel} values lower than 1.0 (Figure 5).



*length class represented by single individual, impeding statistical comparisons.

Figure 5. Relative condition factor per sampling month and by size class (cm) for females (A, C) and males (B, D) of *N. grandicassis* caught in Lençóis Bay, state of Maranhão, Brazil. Blue histogram represents mean and bars indicate standard deviation. Different letters denote significant difference at 5% level

For males, the lowest relative condition factors were found in the intermediate classes, with K_{rel} values lower than 0.98. In the other classes, the relative condition factor was higher than 0.99. The Kruskal-Wallis test followed by the pairwise comparisons using the Mann-Whitney test for females indicated significant differences between the 62.4 ⊢ 67.4 cm class and the intermediate sizes (37.4 to 52.4 cm) (KW – $p < 0.05$) and the smallest length class (27.4 ⊢ 32.4 cm). For males, no significant difference in the relative condition factor was found as a function of the length of the individuals (KW – $p > 0.05$). Two-way ANOVA revealed significant differences among females regarding the K_{rel} value as a function of size class ($F = 3.595$; $df = 2$; $p = 0.02$) and season ($F = 3.807$; $df = 2$; $p = 0.02$). The interaction between the two factors also revealed statistically significant differences ($F = 3.142$; $df = 4$; $p = 0.01$). Integrating the two factors, the condition factors suggest that *N. grandicassis* caught in estuaries on the coast of the state of Maranhão, Brazil, has a greater accumulation of fat in the transition period in both the size 2 group [the intermediate classes (≥ 42.4 < 57.4 cm)] and size 3 group [larger classes (≥ 57.4 cm)]. For smaller classes (≥27.4 < 42.4), the relative condition factor was higher in the rainy period (Figure 6).

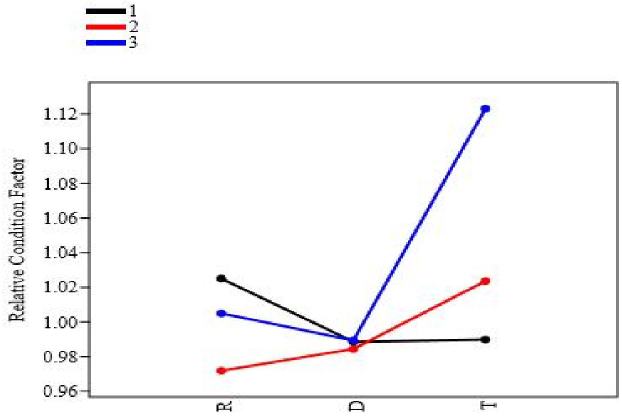


Figure 6. Variation in relative condition factor throughout seasonal period [rainy (R), dry (D), and transition (T)] as a function of different size classes (1: ≥ 27.4 < 42.4 cm; 2: ≥ 42.4 < 57.4 cm; 3: ≥ 57.4 cm) for *N. grandicassis* caught in Lençóis Bay, state of Maranhão, Brazil

DISCUSSION

The *N. grandicassis* population has considerable commercial importance on the coast of the state of Maranhão and females of the species are known to be more abundant than males. This same situation has been reported for other representatives of the family Ariidae (Pinheiro *et al*., 2006; Azevedo and Castro, 2008; Queiroga *et al*. 2012; Zavala-Leal *et al*. 2019). Departure from the 1:1 sex ratio is not expected for most fish species, although some populations may exhibit strong bias in this ratio. Such differences may be attributed to various causes, such as the influence of temperature on sex determination, selective mortality by sex through differential predation, as well as distinct sexual behavior, growth rates, or expected longevity (Vicentini and Araujo, 2003; Azevedo *et al*., 2017). Thus, *N. grandicassis* is believed to be sensitive to different abiotic factors and aspects intrinsic to the species that result in a significant predominance of females (4.8:1.0). Vazzoler (1996) points out that the sex proportion of a species is influenced by factors such as mortality, growth, and environmental events associated with the life cycle. This information can assist studies on reproductive aspects and population structure and even indicate adaptation to the food supply, with a predominance of females when food is abundant and the opposite in regions where food is limited (Nikolsky, 1969). Feeding activity in this case may exert an influence on metabolism through hormonal activity, which could eventually result in changes of individuals of a certain sex. The weight-length relationship indicated that *N. grandicassis* caught in estuaries on the coast of the state of Maranhão exhibits positive allometric growth (b> 3.0), meaning that there is a greater gain in weight than length, which is common among fishes (Froese, 2006). Similar results have been reported for other representatives of the family Ariidae caught in both the Atlantic and Pacific Oceans (Cantanhêde *et al*., 2007; Azevedo and Castro, 2008; Zavala-Leal *et al*., 2019). Weight-length relationships in fishes are affected by factors such as environmental conditions, gonad maturity stages, sex, stomach fullness, health condition, season, population, and differences within species. In the present study, the b coefficient values found for *N. grandicassis* indicate that the species exhibited an increase in weight proportional to length. Moreover, the values were within the limits indicated by Le Cren (1951) and Froese (2006), who report a b coefficient range of 2.5 to 4.0. Consistent patterns of allometric growth are rare and should be supplemented with an analysis of the phases of growth as well as a discussion on the potential evolutionary benefits associated with ontogenetic changes in body proportion (Froese *et al*., 2014). The condition factor is often used to evaluate the reproductive period of fishes, along with other indices such as the gonadosomatic and hepatosomatic relationship (González-Castro and Minos 2016). Thus, as the lowest condition factor values occurred in December for females and in May and June for males, there is evidence that *N. grandicassis* performs its reproductive activities at the beginning of the rainy season (December to April) and protection of the offspring through oral incubation by males must occur after this period (May to June), generating a misalignment in the variation in the relative condition factor for males and females in terms of lower and higher peaks, with a single alignment found in July. According to Chaves (1994), the reduction in condition factor values in males may be explained by mouthbrooding, which completely occupies the oropharyngeal cavity.

Studying a species of the family Ariidae, *Sciades herzbergii* (Bloch, 1794), in northeastern Brazil, Queiroga *et al*. (2012) found decreasing condition factor values in the period from December to February for both males and females, also indicating oral incubation by males. The results were very similar to the condition factor pattern found for *N. grandicassis* in the Amazon region, although the extent was somewhat longer for the performance of reproductive activities in the present study, likely due to the greater productivity of the study area. Studying Bagre panamensis (Gill, 1863) in the Gulf of California, Zavala-Leal *et al*. (2019) reported the reproductive period of the species to be from May to August, which is characterized by high precipitation and low salinity. The breeding season for the majority of catfish occurs between spring and early autumn, which coincides with the hottest period of the year, resulting in an increase in both water temperature and precipitation (Mendoza-Carranza and Hernández-Franyutti, 2005). When evaluated by class interval, the relative condition factor was higher ($\geq$ 1.0) in the smallest and largest individuals, whereas individuals in the intermediate class sizes had lower relative condition factor values (< 1.0). This may be explained by the fact that the energy reserves in juveniles are not yet destined for gonadal development and are directed more toward growth. In larger individuals, the higher values may be associated with more efficient strategies in the search for food and flight from predators, resulting in lower energy expenditure. In intermediate classes, activities are known to be directed at the reproductive aspects of the species. Mahmood *et al*. (2012) found no variation as a function of different size classes for Ilisha melastoma (Bloch and Schneider, 1801) caught in Pakistan, which the authors points out as being contrary to what was expected. Two-way ANOVA indicated greater energy reserves for juveniles in the rainy season, as there is a tendency toward low participation in reproductive activities in this class. In larger individuals, greater accumulation of fat occurs in the transition period (July).

CONCLUSION

The results of the present study demonstrate that *N. grandicassis* apparently has a reproduction period from December to April that may extend to June due to the post-spawning care performed by males of the species, resulting in a considerable, cyclic drop in the condition factor for this sex. *N. grandicassis* caught in Lençóis Bay in the state of Maranhão, Brazil, has positive allometric growth and a significant predominance of females. This study makes a substantial contribution that an assist in the appropriate management of this species on the Amazon coast, as records of evaluations for representatives of the family Ariidae are practically nonexistent.

REFERENCES

Azevedo JWJ, Castro ACL (2008). Relação peso-comprimento e fator de condição do Uritinga, Hexanematichthys proops, (Valenciennes, 1840) (Siluriformes, Ariidae), capturado no litoral ocidental do Maranhão. Boletim do Laboratório de Hidrobiologia, São Luís, 21(1):75-82.

Azevedo JWJ, Castro ACL, Silva MHL (2017). Length-weight relation, condition factor and gonadosomatic index of the whitemouth croaker, Micropogonias furnieri (Desmarest, 1823) (Actinopterygii: Sciaenidae), caught in Lençóis Bay, state of Maranhão, eastern Amazon, Brazil. Brazilian Journal of Oceanography. São Paulo, 65(1):1-8.

Bazzoli N (2003). Parâmetros reprodutivos de peixes de interesse comercial na região de Pirapora. In: Godinho HP, Godinho AL (Org.). Águas, peixes e pescadores do São Francisco da Minas Gerais. Belo Horizonte: PUC Minas. 291-306.

Betancur R, Marceniuk AP, Giarrizzo T, Fredou FL, Knudsen, S (2015). Notarius grandicassis. The IUCN Red List of Threatened Species 2015: e.T197018A2477881.

Blaber SJM (2000). Tropical Estuarine Fishes: Ecology, Exploitation and Conservation. Blackwell Science. Oxford: 372 pp.

Blaber SJM (2013). Fishes and fisheries in tropical estuaries: The last 10 years. Estuarine, Coastal and Shelf Science. 135:57-65.

Camargo M, Isaac-Nahum VJ (2001). Os peixes estuarinos da região Norte do Brasil: lista de espécies e considerações sobre sua distribuição geográfica. Boletim do Museu Paraense de História Natural e Ethnographia, 17:133–157.

Cantanhêde G, Castro ACL, Gubiani EA (2007). Biologia reprodutiva de Hexanematichthys proops (Siluriformes, Ariidae) no litoral ocidental maranhense. Iheringia. Série Zoologia, 97(4):498-504.

Castro ACL, Azevedo JWJ, Ferreira HRS, Soares LS, Pinheiro-Júnior JR, Smith LMR, Silva MHL (2018). Feeding activity of the cayenne pompano Trachinotus cayennensis (Cuvier 1832) (Perciformes, Carangidae) in estuaries on the western coast of the state of Maranhão, Brazil. Braz. J. Biol., 79(2):311-320.

Cervigón F, Cipriani R, Fisher W, Garibaldi L, Hendrickx M, Lemus AJ, Márquez R, Poutiers JM, Robaina, G, Rodriquez, B (1993). Field guide to the commercial marine and brackish-water resources of the northern coast of South America. Rome: Series- FAO species identification sheets for fishery purposes. 513 p.

Chaves PTC (1994). Uma incubação de ovos e larvas em Genidens genidens (Valenciennes) (Siluriformes, Ariidae) da Baía de Guaratuba, Paraná, Brasil. Revista Brasileira de Zoologia, 11:641-648.

Figueiredo JL, Menezes NA (2000). Manual de peixes marinhos do sudeste do Brasil. VI. Teleostei (5). São Paulo: Museu de Zoologia da USP. 116p.

Froese R (2006). Lei do cubo, fator de condição e relações de comprimento e peso: história, meta-análise e recomendações. Journal of Applied Ichthyology. 22:241-253.

Froese R, Thorson JT, Reyes Jr RBA (2014). Bayesian approach for estimating length-weight relationships in fishes. Journal of Applied Ichthyology, 30:78-85.

González-Castro M, Minos G (2016). Sexuality and reproduction of mugilidae. In: Crosetti D and S. Blaber (eds). Biology, ecology and culture of grey mullets (mugilidae), 227-263. CRC Press, Boca Raton.

Haimovici M, Andriguetto Filho JM, Sunye PS, Martins AS (2014). Padrões das dinâmicas de transformação em pescarias marinhas e estuarinas do Brasil (1960-2010). In: HAIMOVICI, M., Andriguetto Filho JM, Sunye, PS (org.). A pesca marinha e estuarina no Brasil: estudos de caso multidisciplinares. Rio Grande: editora da FURG.

Hammer Ø, Harper DAT, Ryan PD (2001). PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontol. Electron., 4:1-9.

Hayes M (1979). Barrier Island Morphology as a Function of Tidal and Wave Regime. In book: Barrier Islands, Chapter: I, Editors: S.P. Leatherman, 1-27.

INMET - Instituto Nacional de Meteorologia. Banco de Dados Meteorológicos para Ensino e Pesquisa – plataforma BDMEP. Available from: www.inmet.gov.br/portal/index.php?r=bdmep/bdmep. Access: Jul/2020.

Isaac-Nahum VJ (2006). Explotação e manejo dos recursos pesqueiros do litoral amazônico: um desafio para o futuro. Ciência e Cultura. São Paulo, 58:33-36.

Le Cren ED (1951). The lenght-weight relationship and seasonal cycle in gonad weight and conditions in the perch Perca fluviatilis. Journal of Animal Ecology, London, 20(2):201-219.

Mahmood K, Ayub Z, Moazzam M, Siddiqui G. (2012). Length-Weight Relationship and Condition Factor of Ilisha melastoma (Clupeiformes: Pristigasteridae) Off Pakistan. Pakistan J. Zool., 44:71-77.

Marceniuk AP (2005). Chave para identificação das espécies de bagres marinhos (Siluriformes, Ariidae) da costa brasileira. Boletim do Instituto de Pesca, São Paulo, 31(2):89-101.

Marceniuk AP, Siccha-Ramirez R, Barthem RB, Wosiacki WB (2017). Redescription of Notarius grandicassis and Notarius parmocassis (Siluriformes; Ariidae), with insights into morphological plasticity and evidence of incipient speciation. Systematics and Biodiversity, 15(3):274-289.

Mendoza-Carranza M, Hernández-Franyutti A (2005). Annual reproductive cycle of gafftopsail catfish, Bagre marinus (Ariidae) in a tropical coastal environment in the Gulf of Mexico. Hidrobiológica. 15(3): 275-282.

Nikolsky GV (1963). The ecology of fishes. Academic Press, London.

Nikolsky GV (1969). Theory of fish population dynamics. Endinburgh: Oliver , Boyd.

Nittrouer CA, DeMaster DJ (1996). The Amazon shelf setting: tropical, energetic, and influenced by a large river. Continental Shelf Research. 16:553–573.

Pinheiro P, Broadhurst MK, Hazin FHV, Bezerra T, Hamilton S (2006). Reproduction in Bagre marinus (Ariidae) of Pernambuco, northeastern Brazil. Journal of Applied Ichthyology, 22:189-192.

Queiroga FR, Golzio JE, Dos Santos RB, Martins TO, Vendel AL (2012). Reproductive biology of Sciades herzbergii (Siluriformes: Ariidae) in a tropical estuary in Brazil. Zoologia. 29(5):397-404.

Silva MHL, Torres Júnior AR, Castro ACL, Azevedo JWJ, Ferreira CFC, Cardoso RL, Nunes JLS, Carvalho-Neta, RNF (2018). Fish assemblage structure in a port region of the Amazonic coast. Iheringia. Série Zoologia, 108, e2018018. Epub June 11.

Ungaro N (2008). Field manual on macroscopic identification of maturity stages for the Mediterranean fishery resources. GCP/RER/ITA/MSM-TD-21. MedSudMed Technical Documents No 21:34.

Vazzoler AEAM (1996). Biologia da reprodução de peixes teleósteos: teoria e prática. Maringá, PR: EDUEM.

Vicentini RN, Araújo FG (2003). Sex ratio and size structure of Micropogonias furnieri (Desmarest, 1823) (Perciformes, Sciaenidae) in Sepetiba Bay, Rio de Janeiro, Brazil. Brazilian Journal of Biology. 63:559-566.

Zale AV, Parrish HDL, Sutton TM (2012). Fisheries techniques. Maryland: American Fisheries Society. 1069 p.

Zar JH (2010). Biostatistical analysis. 5th Edition, Prentice-Hall/Pearson, Upper Saddle River, xiii. 944 p.

Zavala-Leal I, Palacios-Salgado D., Ruiz-Velazco M., Nieto-Navarro JT, Cadena-Roa MA, Domínguez-Ojeda D, Pacheco-Vega JM, Valdez-González F (2019). Reproductive period chihuil sea catfish Bagre panamensis (Siluriformes: Ariidae) inhabiting the southeast Gulf of California. Revista de biología marina y oceanografía, 54:21-27.

****