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Some aspects of the biology of white mullet, *Mugil curema* (Osteichthyes, Mugilidae), in the northeastern region, Brazil

MOACIR FRANCO DE OLIVEIRA[1], EUDRIANO FLORÊNCIO DOS SANTOS COSTA[2], FÚLVIO AURÉLIO DE MORAIS FREIRE[3], JORGE EDUARDO LINS DE OLIVEIRA[3] & ANA CAROLINA LUCHIARI[3]

[1]*Universidade Federal Rural do Semi-Árido, Departamento de Ciências Animais, Mossoró, RN, Brazil, 59625-900.*
[2] *Universidade de São Paulo, Instituto Oceanográfico, Programa de Pós-graduação em Oceanografia Biológica, São Paulo, Brazil, CEP: 05508-120. E-mail: eudriano@usp.br*
[3]*Universidade Federal do Rio Grande do Norte, Centro de Biociências, , Praia de Mãe Luiza, s/n, Natal, RN, Brazil, CEP: 59014-100.*

Abstract. *Mugil curema*, known as white mullet, is one of the most important fish species from artisanal seine-net fisheries in Brazilian northeast region. In this study, white mullet population structures was studied in terms of length and weight, sex ratio, spawning period and size at first sexual maturity (L_{50}). Fish were collected using gillnets once a month from April/1996 to March/1997 at the Potengi river estuary, Rio Grande do Norte, Brazil. Fish were measured and weighted, and gonads were removed to define sex and sexual maturity stages. A total amount of 483 specimens of *M. curema* were captured. Females were larger (t = 3.69, df = 481, $p < 0.05$) and heavier (t =3.65, df = 481, $p<0.05$) than males. The overall sex ratio was 1M: 1.04 F ($\chi^2 = 0.072$; df = 1). The allometric coefficient indicated that both sexes exhibit a negative allometric growth. The proportion of ripe males and females sampled each month indicated that spawning may occur from November to March. The total length at first sexual maturity was estimated at 264 mm for males and 240 mm for females.

Key words: Mugilids, population structure, reproductive period, L_{50}, Brazil

Resumo. **Alguns aspectos da biologia da tainha, *Mugil curema* (Osteichthyes: Mugilidae), na região nordeste do Brasil.** A tainha, *Mugil curema*, é uma das espécies de peixes mais importante para pesca artesanal na região nordeste do Brasil. Em águas brasileiras, seu desenvolvimento ovariano é documentado com sincrônico, e sua desova como total. A estrutura da população em termos de peso e comprimento, proporção sexual, período de desova e o comprimento da primeira maturação sexual (L_{50}) foram estudados durante o período de abril / 1996 a março / 1997 no estuário do rio Potengi, Rio Grande do Norte, Brasil. Os espécimes de *M. curema* foram capturados mensalmente com o auxílio de uma rede de pesca do tipo tainheira. Os espécimes capturados foram medidos, pesados e as gônadas foram retiradas para determinação do sexo e estágio de maturação gonadal. No total foram capturados 483 espécimes de *M. curema*. Os exemplares fêmeas foram maiores (t = 3.69, df = 481, $p < 0.05$) e mais pesadas (t = 3.65, df = 481, $p < 0.05$) que os machos. A proporção sexual da população foi de 1M: 1.04 F ($\chi^2 = 0.072$; df = 1). A proporção de machos e fêmeas maduros capturados mensalmente indicou que a desova da tainha deve ocorrer no período de novembro a março. O comprimento da primeira maturação sexual foi estimado em 264 mm para os machos e 240 mm para as fêmeas.

Palavras chave: Mugilídeos, estrutura da população, desova, L_{50}, Brasil

Introduction

Mugil species, commonly known as mullets, are pelagic-coastal fishes worldwide distributed. This fish are valuable food sources and ecologically important as primary consumer at coastal and estuarine food chains, and also very representative species for rearing in fish farms (Collins 1985, El-Halfawy 2004, Thomson 1997, FAO 2005, Katsugawa *et al*. 2006). Although mugilids represent an important source of protein in many countries, studies on its ecology and population dynamics are scarce (Ibañez-Aguire *et al*. 1999). *Mugil curema* Valenciennes, 1833, commonly named as white mullet, is an economic resource that supports many small communities through both fishing and aquaculture (Alvarez-Lajonchere 1982, Gómez & Cervigón 1987); occurring in tropical and subtropical waters at Atlantic and Eastern Pacific Oceans (Thomson 1978, Menezes 1983, Ibañez-Aguire *et al*. 2006). It is an euryaline and eurythermic species found mainly at estuaries and inshore areas, spending most of the life cycle in protected areas. Sexually mature adults spawn at the sea after which the recruits migrate towards lagoons and estuaries (Ibañez-Aguire 1994, Nelson 1994).

M. curema constitute one of the major fishery species at the Potengi river estuary (Ramanathan *et. al.* 1980), one of the largest estuaries at Rio Grande do Norte State in Brazil. By reason of the poor literature information on this species biology, this study contribute to the knowledge of population dynamics necessary for a future development of the stock protection regulation to be used at the Brazilian northeast region, where there is high exploitation level. Thus, the aim of this study was to provide information on the biological aspects of *M. curema*, mainly about its population structure.

Materials and Methods

White mullet, *Mugil curema* Valenciennes, 1836, were collected from the Potengi river estuary, located in the Brazilian Northeast region, Rio Grande do Norte State (5° 45 '38.45" S and 35° 12' 17.71" W) (Fig. 1) three days per month from April 1996 to March 1997.

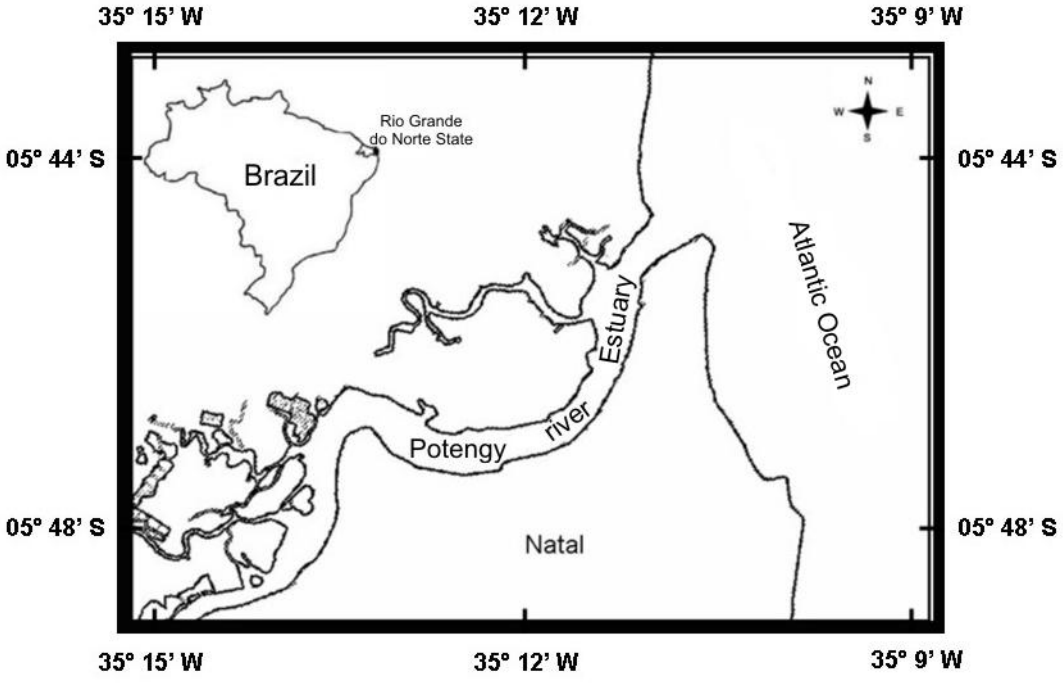

Figure 1. Studied area showing the location of Potengi river estuary, Natal, Rio Grande do Norte, Brazil.

Samples were collected every full moon and high tide by two fishermen in a canoe. The specimens were collected using gillnets of 160 to 180m length, 35 cm height and 6.0 mesh size. At the laboratory, all specimens collected were measured for total length (TL), to the nearest mm, with the

help of an ictiometer and total body weight (TW) to the nearest g. Sex determination was performed according to the maturity scales proposed by Vazzoler (1981, 1996).

The sex ratio was expressed as males: females, following the equation: Sex ratio = *M/F*; where *M* is the number of males and *F* is the number of females. Sex ratio was analysed by month and size interval (length classes). The reproductive period was defined by the presence of ripe females (Munro 1983). The pattern was further confirmed by the presence of ripe males collected together with females at the same sampling period (Luckhurst *et al*. 2000).

The mean size at first maturity (L_{50}) was graphically determined (Finucane & Collins 1986, Vegas-Cendejas *et al*. 1997) through adjust to a sigmoid curve, following the result of the logistic equation: $Y = 1/1+ e^{r(L-L50)}$, where L_{50} = length at which 50 % of the individuals are sexually mature and r = curve slope, based on the number and percentage of fish at stages II-IV (maturing, ripe and spent) and the length at which 50 % of the fish were mature estimated. The body size at which 50% of the fish reach reproductive maturity was considered the size at first maturity.

Data was verified for normality and homogeneity by Kolmogomov-Smirnov and Levene's tests (Zar 1999). For sex ratio, deviation from 1:1 null hypotheses were tested using the Chi-square analyse (χ^2). Student *t*-test was used to compare the total weight and length of females and males. Weight-length relationship, $Wt = aLt^b$, was transformed to natural logarithm (ln): $\ln Tw = \ln a + b\ln Tl$. Parameters *a* and *b* were calculated by least-square regression. The differences between *a* and *b* values from males and females growth curve were tested by ANCOVA. The *t-test* with a confidence interval of ± 95 % was performed to confirm whether the *b*- values obtained in the linear equation depart from the isometric value (3) following the equation: $t_s = b\text{-}3/ s_b$, where t_s is the *t-test* value, *b* the slope and s_b the standard error of the slope (Sokal & Rohlf, 1987). When *b* value was statistically equal to 3, growth was considered isometric. Conversely, positive or negative allometric growth occurred when the *b* value significantly differed from 3 (Ricker 1975, Erkoyuncu 1995, Ivo & Fonteles-Filho 1997). Throughout the text it was always considered a significance level of 0.05 for rejection of the null hypothesis.

Results

It was collected 483 white mullet, *M. curema*, individuals from April 1996 to March 1997. The total weight ranged from 20 to 264 g (average weight 210.4 ± 76.72 g) for males and 55 to 695 g (average weight 239.6 ± 96.50 g) for females. The total length of the males ranged from 116 to 374 mm (average length 272.8 ± 43.4 mm) and females ranged from 164 to 416mm (average length 286.6 ± 39.58 mm). There were significant differences in average length (t = 3.69, df = 481, $p < 0.05$) and weight (t = 3.65, df = 481, $p < 0.05$) of males and females. The distributions of the classes of total length and weight are shown in figure 2.

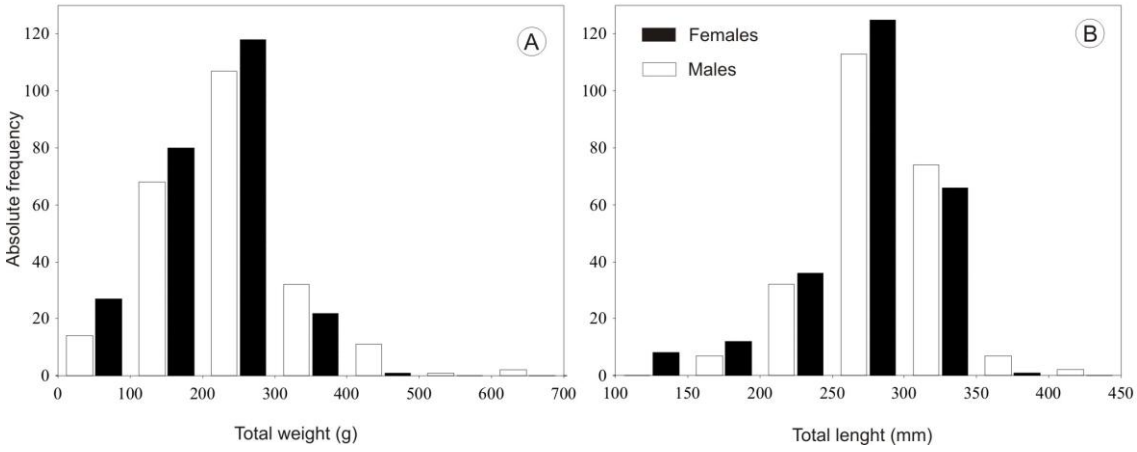

Figure 2. Distribution of white mullet (A) weight and (B) total length at the Potengi river estuary at Brazilian northeast region.

The length-weight function calculated for males and females were: $Wt_{(g)} = 0.00005^* Lt_{(mm)}^{2.7061}$ and $Wt_{(g)} = 0.00004^* Lt_{(mm)}^{2.7591}$, respectively. There was no statistical difference between *a* and *b*

parameters from male and female equation (ANCOVA, F = 1.03, df = 1, p > 0.05). The allometric coefficient (*b* values) found were: 2.7061 for males and 2.7591 for females. The *t-test* indicated that the *b*-values found for both sexes of *M. curema* departed significantly from the isometric value (3). The equation parameters of the weight-length relationship, the *t-test* results and the type of growth can be verified in table 1. The linear equation after ln- transformation and its respective residuals are shown in figure 3.

Table 1. Estimated parameters of weight-length relationship for *M. curema* from the Potengi river estuary, northeastern region, Brazil (*S.E.*: standard error; *a*: intercept; *b*: slope; *C.I.*: Confidence interval; r^2: determination coefficient; *d.f.*: degree of freedom). *Significant difference at the level of 0.01.

Mugil curema	Equation parameters				*t-test (d.f.)*	Growth
	a	*b*	r^2	*S.E.* of *b* (95%*C.I.* of *b*)		
Males	0.00005	2.7061	0.9581	0.0534 (2.6565 - 2.8671)	t = 4.52* (234)	- Allometry
Females	0.00004	2.7591	0.9201	0.036 (2.6354 - 2.7775)	t = -8.19* (247)	- Allometry

In general, it was sampled a total of 248 males and 235 females *M. curema* specimens. The overall sex ratio was 1:1.04 and chi-square analysis did not show significant difference from the expected ratio 1:1 (χ^2 = 0.072, df = 1). A monthly analysis showed high amount of females in January (66.7 %) and September (61.5 %), whilst males predominated in November (63.4 %), December (62.2 %) and February (63.8 %) (Fig. 4A). Males predominated at lower length classes. Intermediate length classes were equally represented by males and females, except for class ranged from 170 to 190 mm. Females were more numerous at larger length classes (Fig. 4B).

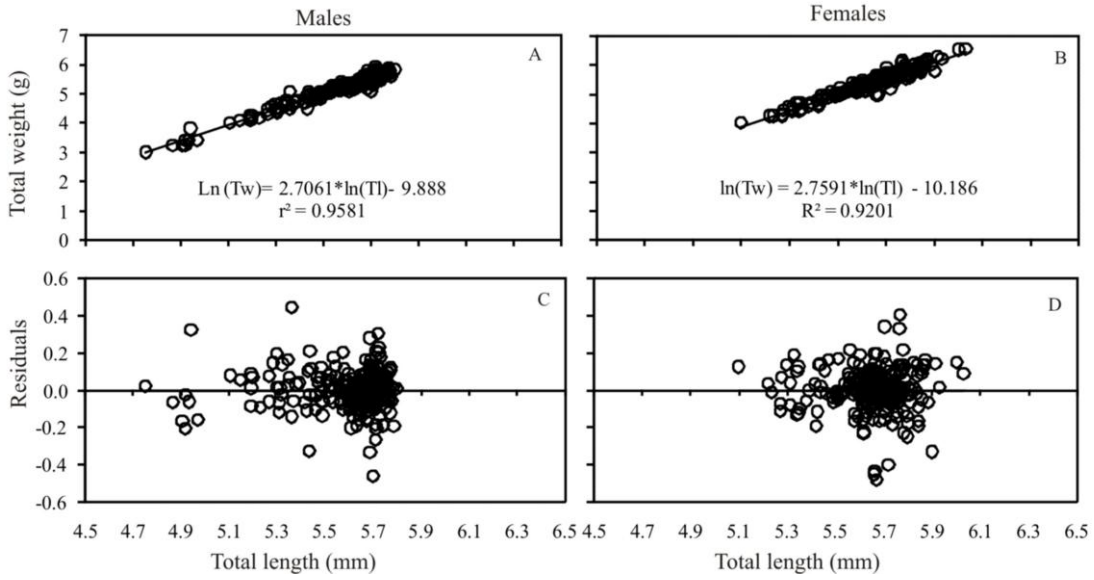

Figure 3. Relationship between the total weight (Tw) and total length (Tl) of white mullet, *Mugil curema* (data was ln transformed). Graphs A-B show linear equation and coefficient of determination (r^2) for males and females, graphs C-D show residues from the linear equation of males and females, respectively.

The analysis of gonad maturity for both sexes showed that 25.4 % of fishes were immature (I), 60.4 % were maturing (II) fish, 8.12 % were ripe (II) and 6.1 % were spent (IV) fish. However, 81.4 % of males and 90.6 % of females were registered as immature and maturing stages; 18.5 % of males and 9.3 % of females were at ripe and spent stages, respectively. The maturity stages for both sexes varied monthly throughout the studied period. Stage II was recorded throughout the whole year, with

higher abundance (73.3 %) in April. Stages III and IV were more representative from November to March. Macroscopic ovarian maturity variation in relation to pluviosity is shown in figure 5. Length at first maturity (L_{50}) was estimate as 264 mm for males and 240 mm for females (Fig. 6).

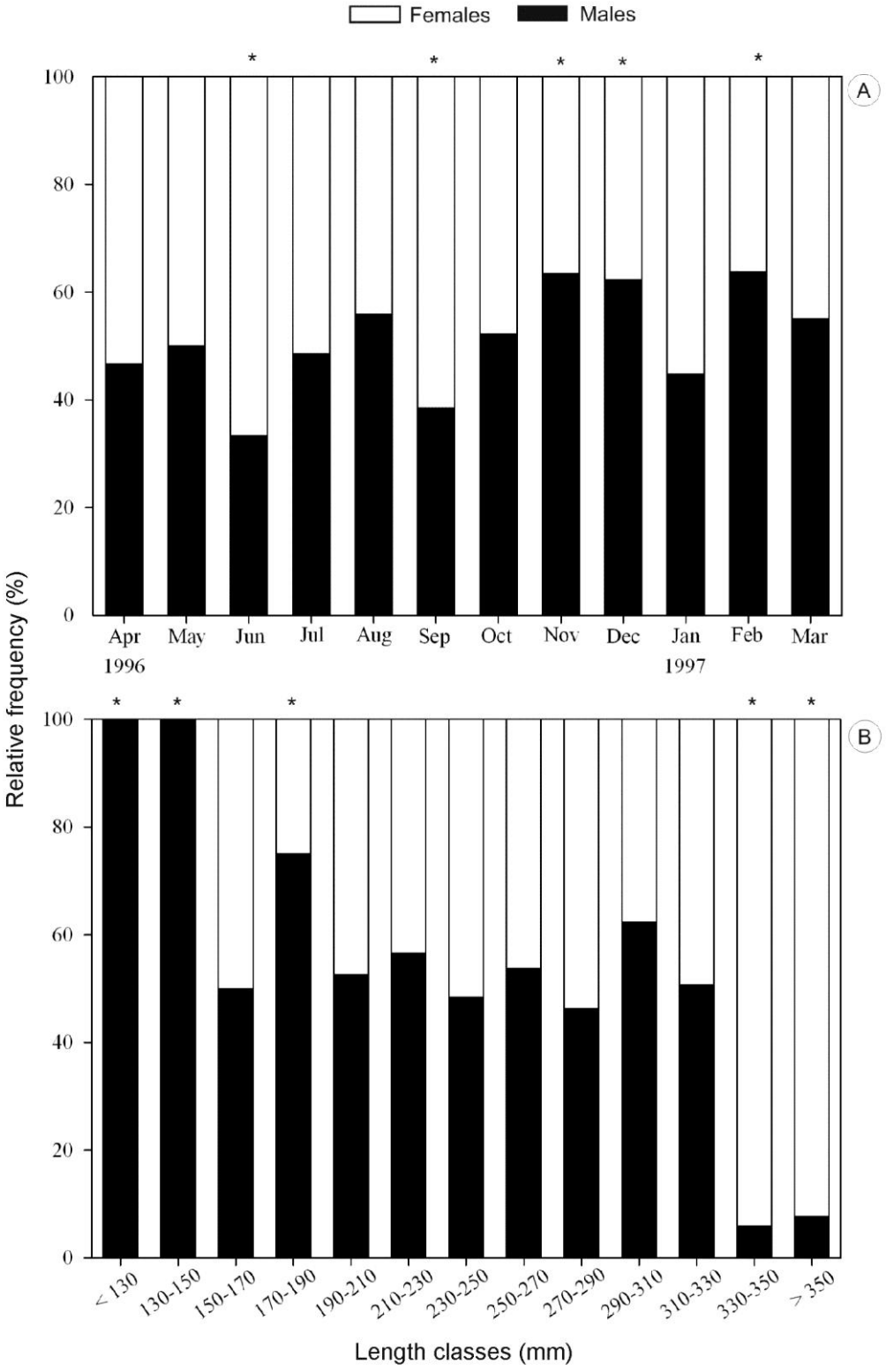

Figure 4. White mullet, *Mugil curema*, sex ratio. A - Monthly variation, and B - Length classes variation between males and females sampled at Potengi river estuary, Brazil. Statistical differences in gender proportion from the expected ratio 1:1 are indicated by *.

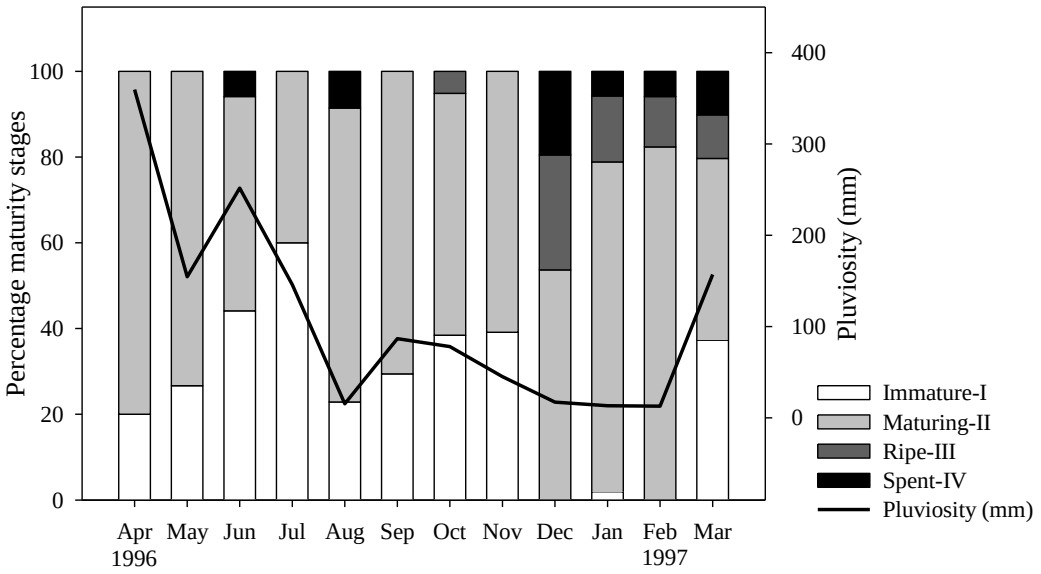

Figure 5. White mullet, *Mugil curema*, maturation distribution indicated by macroscopic gonad stage for both sexes. The *x*-axes are months of collection and *y*-axes are percentage of the gonads at different maturity stages.

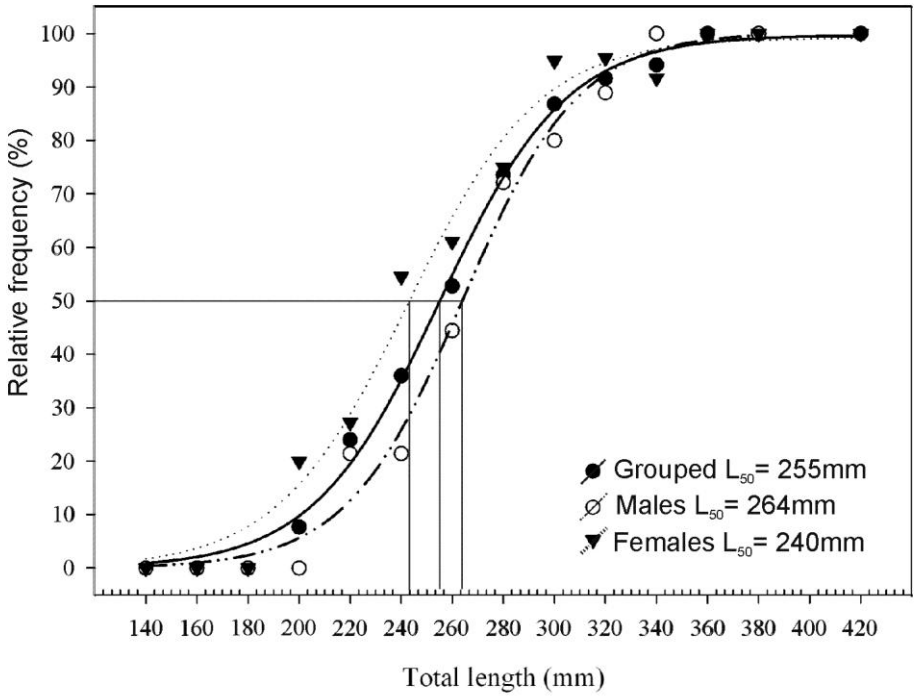

Figure 6. White mullet, *Mugil curema*, length at first sexual maturity (L_{50}) for grouped fish (Δ), only males (○) and only females (●) sampled at Potengi river estuary, Rio Grande do Norte State, Brazil.

Discussion

Knowledge of fish weight, length and gender to establish population structure are essential to management of fish stocks. In the present study, developed at Potengi river estuary, Rio Grande do Norte - Brazil, female specimens of *M. curema* were larger and heavier than males. This result is in agreement with the study realized in the Southern Caribbean by Solomon & Ramnarine (2007), which showed *M. curema* females from 260 to 405 mm in length and 260 to 800 g in weight. Changes in female's body most probably reflect the reproductive cycle, since ovaries maturity well correlates with fish weight. This is a typical pattern found for many mugilid species and gonochoristic teleosts (Brusle 1981, Chan & Chua 1980, Ilkyaz *et al*. 2006)

When information about fish weight is required, it can be estimated from length if the weight-length relationship is known for the population under concern (Jobling 2002). The *b* exponent (b = 2.7252) from the length-weight relationship function was estimated as a value lower than 3, which indicates that *M. curema* growth performance shows negative allometric pattern, indicating that fish becomes "slimmer" as it increases body length (Jobling 2002). Similar result was observed by Giarrizzo *et al*. (2006) in a study carried out at Curuçá Estuary in NE Pará, Brazil, which registered a negative allometric growth for both sexes of *M. curema* (b = 2.80).

The sexual proportion provides important information to the portrayal fish population structure. Overall, it's expected that the sexual proportion of 1:1 for a population in which the prediction birth number of females and male are the same (Vazzoler 1996). For *M. curema*, the sexual proportion was 1 male for 1 female, as expected, but, however, variation in the sexual proportion was found when considering length classes and the amount of fish collected each month. It may have occurred due to various factors such as mortality, growth and spawning migration that act differently on each sex during the fish life cycle, as stated by Vazzoler (1996) and Souza *et al*. (2007). Nevertheless, it is evident that the sexual proportion of *M. curema* varied in relation to size and month at Potengi river estuary probably due to its reproductive strategy.

Spawning migrations of mugilids is usually related to the movement of ripe fish from their feeding area (generally estuaries) to the open sea. Some authors report that the white mullet spawning occurs in the ocean and shoals forms in preparation for leaving in the coastal lagoons (Jacot 1920, Anderson 1957, Ditty & Shaw 1996, Ibañez-aguire & Gallardo-Cabello 2004, Ibañez-aguire & Benítez 2004). In accordance with Marin *et al*. (2003), the spawning of *M. curema* in lagoon is not indicated by any increase in the frequency of fish in advanced stages, but rather is associated to the disappearance of maturing and mature fish from coastal areas. In this study, ripe and spent stage fish were recorded more frequently during the period ranged from November/1996 to March/1997.

Solomon & Ramnarine (2007) reported *M. curema* in the Southern Caribbean as a multiple batch spawner with a protracted spawning season ranged from November to July, in which the gonadal development was annual and each female appears to spawn at least twice a year. On the contrary, Ibañez-Aguire & Gallardo-Cabello (2004) registered *M. curema* spawning period between February and May, with a peak in April, at a Mexican coastal lagoon. Hence, it seems that white mullet reproductive periodicity varies over its geographic distribution (Marin *et al*. 2003). Our data is in accordance with several studies that have reported mugilids protracted reproduction in tropical waters, and also showing two spawning peaks per year (Anderson 1957, Angel 1973, Alvarez-Lajonchere 1976, Garcia & Bustamente 1981, Ibañez-Aguire 1993, Rheman *et al*. 2002, El-Halfawy 2004, Chelemal *et al*. 2009). Thus, the monthly variation in the proportion of *M. curema* ripe males and females indicated an extended reproduction period normally occurs from November to March, showing two peaks of spawning, one in November and other in March.

Information of the mean size at which individuals reach sexual maturity is valuable for the control of exploitation. In this study, the size at first sexual maturity of males and females of *M. curema* were 264 mm and 240 mm, respectively. This result indicates that males reach sexual maturity larger than females at Potengi river estuary, in Brazil. Even though it's not commonly found mugilid males greater than females at first maturity (Anderson 1957, Edimar 1973, El-Halfawy 2004, Kendall & Gray 2008), our results are similar to those observed by Ibañez-aguire & Gallardo-Cabello (2004) for *M. curema* in a coastal lagoon in the Gulf of Mexico. According to Araújo & Chellappa (2002), differences in males and females body conditions may provide mechanisms for adaptive phenotypic response to tropical coastal environment changes.

Fish size at first sexual maturity is affected by genetic, physiological and environmental factors (Nikolskii 1969).

Therefore, we could conclude that *Mugil curema* from Potengi river estuary present population structure pattern similar to those found for this species in other regions. Concerning the reproductive period, it could be suggested that it is linked to seasonal rain variation, which occurred at the beginning of the summer time at the northeast region in Brazil, but, however, more studies are needed to confirm this hypothesis

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References

Alvarez-Lajonchere, L. 1976. Contribución al estudio del ciclo de vida de *Mugil curema* Valenciennes in Cuvier et Valenciennes, 1836 (Pisces: Mugilidae). **Revista Investigaciones Marinas**, 28: 3-130.

Alvarez-Lajonchere, L. 1982. The fecundity of mullet (Pisces, Mugilidae) from Cuban waters. **Journal of Fish Biology**, 21: 607–613.

Anderson, W. W. 1957. Early development, spawning, growth and occurrence of the white mullet (*Mugil curema*) along the south Atlantic Coast of the United States. **Fishery Bulletin of the Fish and Wildlife Service**, 57(119): 415-425.

Angell, C. 1973. Algunos aspectos de la biologia de la lisa, *Mugil curema* Valenciennes, en aguas hipersalinas del nororiente de Venezuela. **Fundación La Salle** de **Ciencias Naturales**, 51: 223-238.

Araújo, A. S. & Chellappa, S. 2002. Estratégia reprodutiva do peixe voador, *Hirundichthys affinis* Günther (Osteichthyes, Exocoetidae). **Revista Brasileira de Zoolgia,** 19: 691-703.

Brusle, J. 1981. Sexuality and biology of grey mullets. Pp. 94-154. *In*: Oren, O. H. (Ed.). **Aquaculture of Grey Mullets**. Cambridge University Press, Cambridge, 507 p.

Chelemal, M., Jamili, S. & Sharifpour, I. 2009. Reproductive biology and histological studies in Abu mullet, *Liza abu* in the water of the Khozestan Province. **Journal of Fisheries and Aquatic Science**, 4: 1-11.

Collins, M. R. 1985. **Species profile: life histories and environmental requirements of coastal fishes and invertebrates (South Florida)- White mullet**. Fish and Wildlife Service, United States of America, 17 p.

Chan, E. H. & Chua, T. E. 1980. Reproduction in the greenback grey mullet, *Liza subviridis* (Valenciennes, 1986). **Journal of Fish Biology**, 16: 1-10.

Ditty, J. G. & Shaw, R. F. 1996. Spatial and temporal distribution of larval striped mullet (*Mugil cephalus*) and white mullet (*Mugil curema*, family: Mugilidae) in the northern Gulf of Mexico, with notes on mountain mullet, *Agonostomus monticola*. **Bulletin of Marine Science**, 59: 271-288.

Edmar, C. L. A.1973. Algunos aspectos de la biologia de la lisa *Mugil curema* en aguas hipersalinas de Nororiente de Venezuela. **Memoria Sociedad de Ciencias Naturales**, 51: 223-238.

El-Halfawy, M. M. 2004. Reproductive biology of *Mugil seheli* (family Mugilidae) reared in fish farm. **Egyptian Journal of Aquatic Research**, 30: 234-240.

Erkoyuncu, I. 1995. **Fisheries and population dynamics.** Mayis University Press, Samsun, 265 p.

FAO. 2005. **Fishery statistics** – World Wide Web electronic publication, accessible at http:/www.fao.org./fi/statist. (Acessed 14/ 10/ 1998)**.**

Finucane, J. H. & Collins, L. A. 1886. Reproduction of Spanish mackerel *Scomberomorus maculates* from the southeastern United States. **Northeast Gulf Science**, 8: 97- 106.

Garcia, A. & Bustamante, G. 1981. Resultados preliminares del desove induzido de lisa (*Mugil curema* Valenciennes) em Cuba. **Academia de Ciencias de Cuba**, 158:7-26.

Giarrizzo, T., Silva De Jesus, A. J., Lameira, E. C., Araújo De Almeida, J. B., Isaac, V. & Saint-Paul, U. 2006. Weight-length relationship for intertidal fish fauna in a mangrove stuary in Northern Brazil. **Journal of Applied Ichthyology**, 22: 325-327.

.Gómez, A. & Cervigón, F. 1987. Perspectivas del cultivo de peces marinos en el Caribe Sur y noreste de Suramérica. **Revista Latinoamericana de Acuicultura**, 34: 40–50.

Ilkyaz, A. T., Firat, K., Saka, S. & Kinacigilh.T. 2006. Age, growth, and sex ratio of Golden Grey Mullet, *Liza aurata* (Risso, 1810) in Homa Lagoon (Izmir Bay, Aegean Sea). **Turkish Journal of Zoology**, 30: 279-284.

Ibañez-Aguire, A. L. 1993. Coexistence de *Mugila cephalus* and *M. curema* in a coastal lagoon in

the Gulf of Mexico**. Marine Biology**, 42: 959-961.

Ibañez-Aguire, A. L. 1994. Coexistence of *Mugil cephalus* and *M. curema* in a coastal lagoon to the northwest of the Gulf of Mexico. **Revista de Investestigaciones Marinas**, 15: 39-44.

Ibañez-Aguire, A. L, Gallardo-Cabello, M. & Carrara, X. C. 1999. Growth analysis of stripped mullet, *Mugil caphalus*, and white mullet, *M. curema* (Pisces: Mugilidae), in the Gulf of Mexico. **Fishery Bulletin**, 97: 861-872.

Ibañez-Aguire, A. L; Gallardo-Cabello, M. 2004. Reproduction of *Mugil cephalus* and *M. curema* (Pisces: Mugilidae) from a coastal lagoon in the Gulf of Mexico. **Bulletin of Marine Science**, 75: 37-49.

Ibañez-Aguire, A. L. & Benítez, O. G. 2004. Climatic parameters and spawning migrations of *Mugil cephalus* and *M. curema* in the Northwestern area of the Gulf of Mexico. **Journal of Fish Biology,** 65: 822-831.

Ibañez-Aguire, A. L., Cabral-Solis, M., Gallardo-Cabello, M. & Espino-Barr, E. 2006. Comparative morphometrics of two populations of *Mugil curema* in the Atlantic and Pacific coasts. **Scientia Marina**, 70: 139–145.

Ivo, C. T. C. & Fonteles-Filho, A. A. 1997. **Estatística pesqueira: Aplicação em engenharia de pesca**. TOM gráfica e editora, Fortaleza, 193 p.

Jacot, A. P. 1920. Age, growth and scale characters of mullets, *Mugil cephalus* and *Mugil curema*. **Transactions of the American Microscopial Society**, 39: 199-229.

Jobling, M. 2002. Environmental factors and rates of development and growth. Pp.97-117. *In*: Hart, P. J .B. & Reynolds, J. D. (Eds.). **Handbook of fish biology and fisheries United Kingdom** . Blackwell publishing, Oxford, 432p.

Katsuragawa, M., Muelbert, J. H. & Dias, J. F. 2006. O ictioplâncto na região entre o cabo de São Tomé (RJ) e o Chuí (RS). Pp.359-446. *In*: Rossi-Wongtschowski, C. L. D. B.; Madureira, L. S. P. (Orgs.) **O ambiente oceanográfico da plataforma continental e do talude na região Sudeste-Sul do Brasil.** EDUSP, São Paulo, 466 p.

Kendall, B. W. & Gray, C. A. 2008. Reproductive biology of two co-occurring mugilids, *Liza argentea* and *Myxus elongates*, in south-eastern Australia. **Journal of Fish Biology**, 73: 963-979.

Luckhurst, B. E., Dean, J. M. & Reichert, M. 2000. Age, growth and reproductive reproduction of the lane snapper *Lutjanus synagris* (Pisces: Lutjanidae) at Bermuda. **Marine Ecology Progress Series**, 203: 255- 261.

Marin, B. J. & Dodson, J. J. 2000. Age, growth and fecundity of the silver mullet, *Mugil curema* (Pisces: Mugilidae), in coastal areas of Northeastern Venezuela. **Revista de Biologia Tropical**, 48: 389-398.

Marin, B. J., Quintero, A., Bussière, D. & Dodson, J. J. 2003. Reproduction and recruitments of white mullet (*Mugil curema*) to a tropical lagoon (Margarita Island, Venezuela) as revealed by otolith microstructure. **Fishery Bulletin**, 10: 809-821.

Menezes, M. A. 1983. Guia prático para conhecimento e identificação das tainhas e paratis (Pisces, Mugilidae) do litoral brasileiro. **Revista Brasileira de Zoologia**, 2: 1-12.

Munro, J. L. (Ed). 1983. Caribbean coral reef fishery resources. **ICLARM Studies and Reviews,** 7: 15-25.

Nelson, J. S. 1994. **Fishes of the world.** John Wiley & Sons, Inc., New York, 600 p.

Nikolskii, G. V. 1969. **Theory of fish population dynamics**. Oliver and Boyd, Edinburgh, 323p.

Ramanathan, S., Araùjo, R. A. & Chellappa, N. T. 1980. Food and feeding habitats of adult *Mugil curema* (Valenciennes) in the brackish water ponds and the Potengi estuary- in Rio Grande do Norte- Brazil. **Ciencia e Cultura**, 32(5): 578-580.

Rheman, S., Islam, M. L., Shah, M. M. R., Mondal, S. & Alam, M. J. 2002. Observation on the fecundity and Gonadossomatic index (GSI) of Grey Mullet Liza parsia (Ham.). **Online Journal of Biological Sciences.** 2(10): 690-693.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. **Bulletin of the Fisheries Research Board of Canada,** 191: 203-233.

Sokal, R. R. & Rohlf, F. J. 1987. **Introduction to Biostatistics**. 2nd Edition, Freeman, New York, 363 p.

Solomon, F. N. & Ramnarine., I. W. 2007. Reproductive biology of white mullet, *Mugil curema* (Valenciennes) in the Southern Caribbean. **Fisheries Research**, 88: 133–138.

Souza, L. L. G., Chellappa, S. & Gurgel, H. C. B. 2007. Biologia reprodutiva do peixe-donzela, *Stegastes fuscus* Cuvier, em arrecifes rochosos no nordeste do Brasil. **Revista Brasileira Zoologia**, 24: 419-425.

Thomson, J. M. The family Mugilidae. 1978. *In*: Fisher, W. (Ed.), **FAO Species Identification Sheets for Fishery Purposes: Western Central Atlantic (Fishing Area 31)** FAO, Rome.

Thomson, J. M. 1997. The Mugilidae of the world. **Memoirs of the Queensland Museum**, 41: 457-562.

Vazzoler, A. E. A. M. 1981. **Manual de métodos para estudos biológicos de populações de peixes: reprodução e crescimento**. CNPq, Brasília, 108 p.

Vazzoler, A. E. A. M. 1996. **Biologia reprodutiva de peixes teleósteos: teoria e prática**. EDUEM, Maringá, 169 p.

Vegas-Cendejas, M. E., Mexicano-Cíntora, G. & Arce, A. M. 1997. Biology of the thread herring *Opistonema oglinum* (Pisces: Clupeidae) from a beach seine fishery of the Campeche Bank, Mexico. **Fisheries Research**, 30: 117-126.

Zar, J. H. 1999. **Biostatistical analysis**. Prentice Hall, New Jersey, 663 p.

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