Arquivos de Ciências do Mar

REPRODUCTIVE BIOLOGY OF LANE SNAPPER, *Lutjanus synagris* (PERCIFORMES: LUTJANIDAE), OFF NORTHERN PERNAMBUCO STATE, BRAZIL

Biologia reprodutiva do ariacó, *Lutjanus synagris* (Perciformes: Lutjanidae), capturado na costa norte de Pernambuco, Brasil

Daniel F. Viana.[1]*, Fábio Hissa Vieira Hazin[1], P. G. Oliveira[1]

ABSTRACT

A total of 704 specimens of lane snapper, Lutjanus synagris*, caught off Pernambuco State, Northeast Brazil, by small-scale artisanal fishing boats, were analyzed with regard to gonad maturation, gonadosomatic index, size at first sexual maturity, fecundity, and type and time of spawning. Of the sampled specimens, 364 were males and 340 females, resulting in a sex-ratio of 1.1 M : 1.0 F. Size at first sexual maturity was estimated at 16.4 cm TL for males and 17.1 cm TL for females. The monthly mean gonadosomatic index and the frequency of mature gonads suggest that the spawning season of the species in the studied region spans period from September to April. Absolute fecundity ranged from 30,870 to 59,280 oocytes.*

Keywords: Lutjanus synagris*, fecundity, size at first sexual maturity, gonadosomatic index, spawning season.*

RESUMO

Um total de 704 espécimes do ariacó, Lutjanus synagris*, capturados por embarcações da frota artesanal do norte do Estado de Pernambuco foram analisados quanto a sua maturação gonadal, índice gonadossomático, comprimento na primeira maturidade sexual, fecundidade, e tipo e época de desova. Dos exemplares amostrados, 364 eram machos e 340 fêmeas, resultando em uma proporção sexual de 1,1 M : 1,0 F. O comprimento na primeira maturidade sexual foi estimado em 16,4 cm CT para os machos e 17,1 cm CT para as fêmeas. As médias mensais do índice gonadossomático juntamente com a frequência de gônadas maduras indicam que a época de desova do ariocó na região amostrada se estende de setembro a abril. A fecundidade absoluta variou de 30.870 a 59.280 ovócitos.*

Palavras-chaves: Lutjanus synagris*, fecundidade, tamanho de primeira maturação, índice gonadossomático, desova.*

[1] Bren School of Environmental Science and Management, 4410 Bren Hall, University of California, Santa Barbara, CA 93106. *Corresponding author. E-mail:danielf.vi@hotmail.com

[2] Departamento de Pesca e Aquicultura, Universidade Federal Rural de Pernambuco, Av. Dom Manoel de Medeiros, s/n, Recife, Brasil.

INTRODUCTION

The lane snapper, *Lutjanus synagris,* is one of the highest priced reef fishes caught by artisanal fisheries in northeastern Brazil (Rezende *et al.*, 2003). As so, it is one of the main target species, accounting for a large proportion of the landed catch in that region (Ferreira *et al.*, 2004).The intense fishing pressure coupled with a lack of management has threatened the sustainability of lane snapper's fishery, with the stocks already showing signs of overexploitation (Frédou *et al.*, 2009). Studies on the reproductive biology can provide crucial information for management of the species. Regulations that are widely used in Brazil, such as size limits and fishing season closure, depend directly on reproductive information. In addition to providing important information for future stock assessment, studies on reproduction dynamics should also help to make the lane snapper amenable to marine fish farming all over Northeast Brazil.

Distributed along the western Atlantic Ocean, from North Carolina (USA) to São Paulo (Brazil), the lane snapper commonly inhabits rocky grounds and reefs, from close to shore to about 400m depth. It is, however, more common in shallow waters, being one of the most costal species of Lutjanidae. More active during the night, it feeds mainly on small fish, crabs, and shrimps. It has planktonic eggs and larvae, with juveniles forming schools, mostly in mangroves, while adults tend to live isolated and in deeper waters (Allen, 1985), away from the shore.

Several studies have been conducted on the biology of lane snapper elsewhere in the world, including reproductive aspects (Manickch & Dass 1987; Luckhurst *et al.*, 2000; Claro & Lindeman, 2004), and age and growth (Acosta & Appeldorn, 1992; Johnson *et al.*, 1995; Aiken, 2001). In Brazil, studies have been published on the biology of the species for different regions, such as Alegria & Menezes (1970), on age and growth; Gesteira & Rocha (1976), on fecundity; Souza-Junior *et al.* (2008), on sexual maturity and spawning; Cavalcante *et al.* (2012), on reproductive aspects; and Freitas *et al.* (2011) on spawning patterns.

The objective of the present work, therefore, is to provide information on sex structure, spawning season, gonad development, size at first sexual maturity and fecundity of the lane snapper from the northern coast of Pernambuco State, Brazil. We expect that the information provided may be useful to improve management of the species in order to ensure its conservation and fishery sustainability.

MATERIAL AND METHODS

A total of 704 specimens, 364 males and 340 females, were collected in all months from March, 2004 to November, 2010. All the samples examined were obtained from a fishing community located at Itamaracá Island, off northern Pernambuco State. The specimens were caught with bottom traps, usually set during the night and collected in the following morning. Box-like traps are set by small boats, with the number of traps varying according to the size of the boat. Traps are thrown manually in the water, baited with fish and connected with a longline.

Once in the laboratory, total length, fork length and total weight were measured. All specimens were then eviscerated for collection of gonads, which were also weighed and measured. The gutted weight was also recorded, following evisceration. All gonads were initially immersed in 10% formaldehyde solution for fixation, and transferred after 24 hours to a 70% ethanol solution.

For an accurate determination of maturation stages histological analysis of the gonads of 231 females and 250 males were conducted. Cross-sectional cuts were taken from the middle part of the gonads and then submitted to a dehydration process in ethanol, at concentrations of 80%, 90% and 100%, followed by clarification in xylene, and impregnation with paraffin, at 60°C. The paraffin blocks were then sectioned at 6μm, and stained with haematoxylin and eosin (Behmer *et al.*, 1976). Cuts were then examined under optical microscope (100x). The following maturation stages were considered, adapted from Vazzoler (1996) with small modifications according to Hunter (1985), West (1990) and Brown-Peterson (2011):

Females

Immature: small and translucent ovaries, with no visible vascularization, with a thin wall and oocytes distinguishable only with a microscope.

Maturing: larger ovaries, with noticeable vascularization, and oocytes visible to the naked eye. Microscopically they could be differentiated in early and late maturation. Gonads in early maturation showed most of oocytes in the cortical alveolar (CA) stage, while in late maturation most oocytes were already in the yolked or vitellogenic stage.

Mature: ovaries with an even larger volume, well vascularized, and with a great number of clearly visible oocytes. In most oocytes the vitellogenesis process was complete.

Spent: flaccid and well vascularized ovaries. Microscopically, this stage was recognizable by the presence of post-ovulatory follicles (POF).

Resting: ovaries with reduced size and little vascularization. Microscopic aspects were similar to immature gonads, but with a thicker ovarian wall.

Males

Immature: without spermatozoa in the seminiferous tubules.

Mature: with spermatozoa in the seminiferous tubules.

In order to evaluate the seasonal changes of the gonadosomatic index (GSI) immature specimens were excluded from the analysis. The monthly mean GSI was estimated by the equation:

$$GSI = GoW / GW*100$$

where: GSI is the gonadosomatic index, GoW is the gonad weight (grams) and GW is the gutted weight (grams).

The Analysis of Variance (ANOVA) was applied to determine whether there was a difference between mean monthly GSI. When any difference was found, Tukey's complementary test was used to identify which months differed significantly.

Fecundity was estimated from 12 females with gonads in the mature stage. The gravimetric method was used, according to which, the number of hydrated oocytes from a gonad section of a known weight were counted and extrapolated to the whole weight of the gonad (Vazzoler, 1996). An aliquot of 0.03 to 0.05 was removed from gonads in the mature stage and placed in a modified Gilson solution to release the oocytes and so allow their counting.

A logistic model, based on the relative frequency of adult individuals (not in immature stage) in the different size classes, was used to determine the size at first sexual maturity (L_{50}). The logistic curve was fitted to the observed data according to the least squares method (Motulky & Christopoulos, 2004) with the following model:

$$Mf = \frac{1}{[1+\exp^{(a+b*TL)}]} \quad (2)$$

where, *Mf* is fraction of mature individuals, *TL* is the total length, and *a* and *b* are parameters of the model.

In order to determine the spawning season, the variation of male and female monthly mean gonadosomatic indices was analyzed along with the frequency distribution of different maturation stages (Vazzoler, 1996). Weight-length relationship was adjusted using the least sum of squares method for regression analysis.

RESULTS

From specimens collected, the sex ratio was 1.06 males for each female, with no significant difference ($\chi^2 = 0.82$; df = 1; $p < 0.05$). However, the monthly sex-ratio differed significantly in July, when females predominated, and in September and October, when males were more frequent (Table I). Female total length (TL) ranged from 14.5 cm to 44.0 cm, with most of the specimens lying between 21.1 cm and 22.0 cm. Males ranged from 7.8 cm to 32.0 cm, with a mode of 21.0 cm (Figure 1). Weight-length relationship was also estimated with no significant difference between males and females (a = 0.021866, b = 2.825465).

Table I - Monthly numbers of males and females, and sex-ratio of lane snapper, *Lutjanus synagris*, caught at Itamaracá Island, off northern Pernambuco State, Brazil, from March, 2004 to November, 2010.

Month	Males (n)	Females (n)	Total	Males (%)	Females (%)	χ^2
Jan	29	23	52	55.7	44.3	0.69
Feb	21	26	47	44.6	55.4	0.53
Mar	31	28	59	52.5	47.5	0.15
Apr	28	34	62	45.2	54.8	0.58
May	52	50	102	50.9	49.1	0.04
Jun	23	26	49	46.9	53.1	0.18
Jul	8	23	31	25.8	74.2	7.26*
Aug	26	32	58	44.8	55.2	0.62
Sep	46	20	66	69.7	30.3	10.24*
Oct	33	17	50	66.0	34.0	5.12*
Nov	30	24	54	55.5	45.5	0.66
Dec	37	37	74	50.0	50.0	0
Total	364	340	704	51.7	48.3	0.82

*Significant at a 5% statistical level.

Of the examined females, 14% were immature, 18% were in early maturation, 19% in late maturation, 22% mature, 7% spent and 18% were resting. From May to August most of the gonads were resting, while during the rest of the year females showed a much higher reproductive activity, with many gonads in maturation, mature and spent. Mature specimens were particularly frequent in December and January (Figure 2). From the 364 males collected 18% were immature and 82% were mature.

Monthly mean gonadosomatic index (GSI) showed statistically significant differences for males and females (Table II). Monthly mean GIS for females presented highest values from October to December and in March, with a statistically significant difference ($p < 0.05$) to the remaining months (Figure 3).

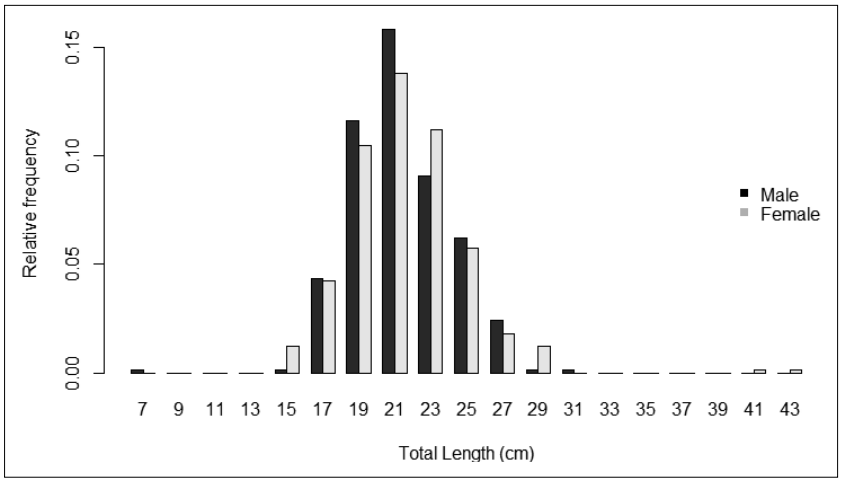

Figure 1 - Length frequency distribution of male and female lane snapper, *Lutjanus synagris*, caught off Itamaracá Island, Pernambuco State, Brazil.

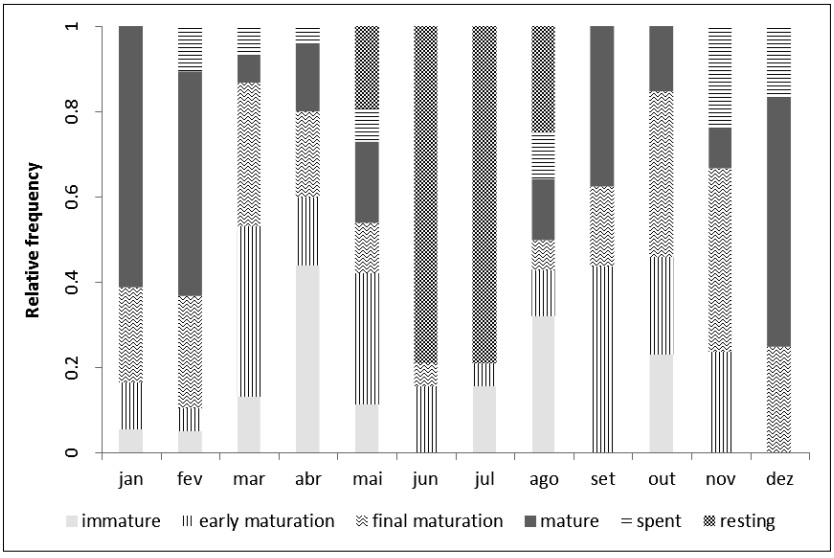

Figure 2 - Monthly distribution female lane snapper, *Lutjanus synagris*, by gonad stages, caught off Itamaracá Island, Pernambuco State, Brazil.

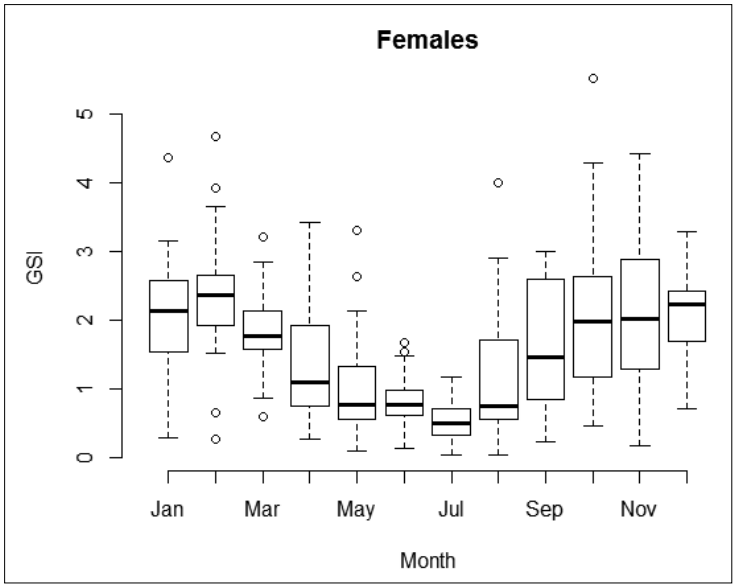

Figure 3 - Monthly mean values of the gonadossomatic index (GSI) of female lane snapper, *Lutjanus synagris*, caught off Itamaracá Island, Pernambuco State, Brazil.

Table II - ANOVA table for monthly mean males and females gonadosomatic index (GSI) of lane snapper caught off Itamaracá, northeastern Brazil, from March, 2004 to November,w 2010.

Source of Variation	df	Sum of Squares	Variance	F	p
Females	11	0.6809	0.06190	6.864	6.15e-10
Males	11	0.1216	0.01105	8.134	1.79e-12

Monthly mean GSI for males was highest from September to December with significant differences observed when compared to lower GSI months, such as February, April and May (Figure 4).

The mean size of first maturity (L_{50}) was estimated at 17.1 cm TL for females (a=10.25, b=-0.59 and R^2=0.95) and 16.4 cm TL for males (a= 5.92, b= -0.36 and R^2= 0.91) (Figure 5). Fecundity ranged from 30,870 to 59,280 oocytes, with a mean of 39,790 oocytes per ripe gonad observed in fish with TL varying from 20.5 to 23.5 cm.

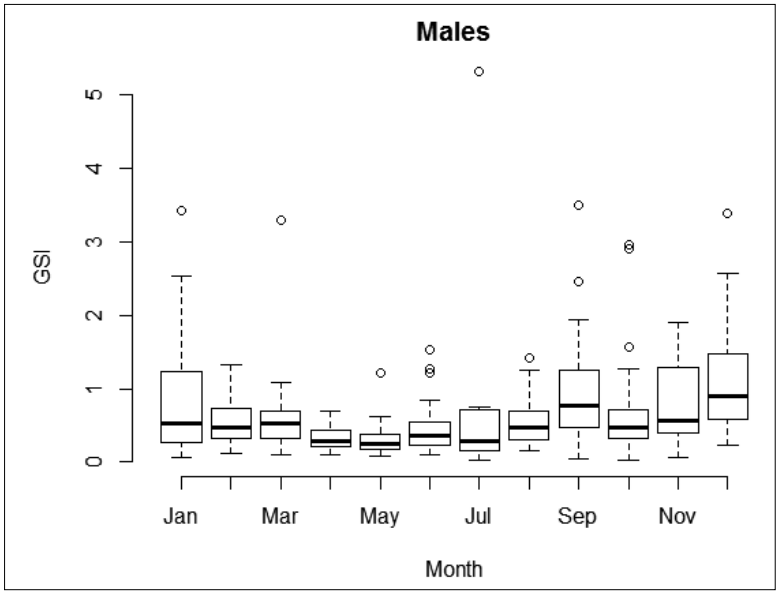

Figure 4 - Monthly mean values of the gonadossomatic index (GSI) of male lane snapper, *Lutjanus synagris*, caught off Itamaracá Island, Pernambuco State, Brazil.

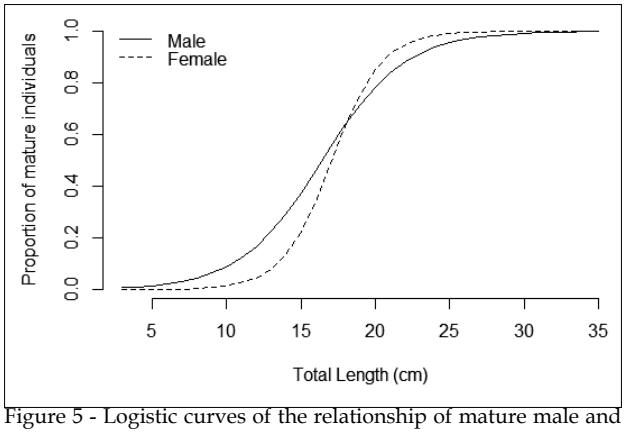

Figure 5 - Logistic curves of the relationship of mature male and female proportions on total length for lane snapper, *Lutjanus synagris*, caught off Itamaracá Island, Pernambuco State, Brazil.

DISCUSSION

Lane snapper populations usually present a great variability on sex ratio throughout its occurrence range. In many places females were more abundant than males including Jamaica (Aiken, 2001) and Cuba (Claro, 2004), while in Bermudas (Luckhurst *et al.*, 2000), Mexico (Torres-Lara *et al.*, 1990) and Jamaica (Thompson & Munro, 1983), like in the present work, the sex ratio was closer to 1:1.The size distribution of the sampled specimens is certainly related to the selectivity of the fishing gear (bottom traps). It clearly shows, however, that most of sampled fish had already attained sexual maturity, which is a positive aspect for the sustainability of the fishery.

The variation of the monthly mean GSI for both females and males, together with the distribution of female sexual stages by month, gives strong evidence that this species spawns mainly from October to March. Souza-Junior *et al.* (2008), working with the same species in the coast of Ceará, northeastern Brazil, found a more intense reproductive activity between January and April, with the specimens being less active between August and November. This seasonality pattern is close to the one found in the present study, with a small temporal displacement, which may be related to the higher latitude of Ceará State in relation to Pernambuco, or due to different oceanographic conditions. In Caribbean waters many authors found that the spawning season coincided with summer, when the water temperature was higher, between May and September, with a peak between July and August, also corroborating with the present study (Luckhurst *et al.*, 2000, in Bermuda; Aiken, 2001, in Jamaica; Claro, 2004, in Cuba; Figueroa *et al.*, 1998, in Puerto Rico).

Mean size at first maturity for females (17.1 cm TL) was slightly larger than for males (16.4 cm TL), coinciding with the findings of previous studies (Claro,1982; Figueroa *et al.*, 1998). Although all these results indicate a larger size at maturity for females, there seems to be a large variation between regions, with a range from 18.5 to 26.8 cm FL, or up to 31 cm TL, for females, and from 14.7 to 23.5 cm FL, or 25 cm

TL, for males (Luckhurst *et al.*, 2000; Aiken, 2001; Manickchand-Dass, 1987). The sizes at first maturity found in the present study, equal to 17.1 and 16.4cm, for females and males respectively, are among the smallest of all, except for 14.7 cm for males from Figueroa *et al.* (1998). In Brazil, Souza-Junior *et al.* (2008) and Cavalcante *et al.* (2012) also found a size at first maturity for females (23.4 cm and 25.7 cm TL, respectively) much larger than the value found in the present study. Although the reasons for these discrepancies are not clear, they might be related to differences in habitat, prey availability, selectivity of fishing gears, fishing pressure or genetic differences. The small number of individuals with length classes lower than the estimated L_{50} prevents a more assertive conclusion and can also be another reason for such differences.

The total fecundity estimated by the present work (from 30,870 to 59,280) was much lower than those found in Caribbean waters and surrounding areas, but still lower to the one found in Northeastern Brazil. In Caribbean waters the total fecundity varied from 28,700 to 1,191,000 oocytes from studies made in Trinidad (Manickchand-Dass, 1987), Cuba (Claro, 1972) and Colombia (Erhardt, 1977). In northeastern Brazil, Gesteira *et al.* (1976) also found a greater value for the total fecundity, with an average of 89,500 oocytes. This difference is probably related to the smaller size of the individuals evaluated in the present work, since smaller specimens will naturally have also smaller gonads.

Presently, most reef fishes, including the lane snapper, have very little fishing regulations and a deficient control of the landings by the Brazilian authorities. The results of the present study can be used for setting adequate management policies for the lane snapper such as size limits and season closures. Catch and fishing effort data, combined with biological information, are crucial for an adequate assessment of the stock and consequent implementation of conservation and management measures needed to guarantee the sustainability of the fisheries and conservation of the species.

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