CHARACTERIZATION OF SOME BIOLOGICAL ASPECTS OF *Atherinella brasiliensis* CAUGHT DURING SPORT FISHING TOURNAMENTS: A CASE STUDY FROM NORTHEASTERN BRAZIL*

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ABSTRACT

Fishing tournaments represent good opportunities to gather biological information for some species, such as *Atherinella brasiliensis*. Samples of *A. brasiliensis* were obtained from fishing tournaments promoted in the states of Bahia and Rio Grande do Norte (northeastern Brazil) from 2006 to 2009 (N = 1,124 specimens). For each specimen, total length (TL; cm), fork length (FL; cm), standard length (SL; cm), and total weight (TW; g) were measured. Sex and maturity stage were macroscopically identified. The maximum observed size was 14.9 cm TL. At sizes of 8-13 cm TL, 60-90% of the specimens were mature. The length-weight relationships estimated indicated positive allometry: $TW = 0.005\ TL^{3.113}$ (Bahia) and $TW = 0.004\ TL^{3.236}$ (Rio Grande do Norte). Length-length relationships were estimated to allow for comparison of the maximum total length with results from the literature for other regions: TL = 1.0615 FL + 0.2179 and TL = 1.1890 SL + 0.2855. Females were more abundant than males in three out of the four samples in which sex was identified.

Key words: Brazilian silversides; population dynamics; sport fishery; recreational fishery

CARACTERIZAÇÃO DE ALGUNS ASPECTOS BIOLÓGICOS DE *Atherinella brasiliensis* CAPTURADA DURANTE TORNEIOS DE PESCA ESPORTIVA: UM ESTUDO DE CASO NO NORDESTE DO BRASIL

RESUMO

Torneios de pesca são vistos como boas oportunidades para obter informações biológicas para algumas espécies, tais como *Atherinella brasiliensis*. Amostras de *A. brasiliensis* foram obtidas em torneios promovidos nos estados da Bahia e Rio Grande do Norte (nordeste do Brasil), em 2006-2009 (N = 1.124). Para cada espécime foram medidos o comprimento total (TL; cm), comprimento zoológico (FL; cm), comprimento padrão (SL; cm) e peso total (TW; g). O sexo e o estágio de maturação foram identificados macroscopicamente. O tamanho máximo observado foi de 14,9 cm TL. Aos 8-13 cm TL, 60-90% dos espécimes já estavam maturos. As relações peso-comprimento estimadas indicaram uma alometria positiva: $TW = 0{,}005\ TL^{3{,}113}$ (Bahia) and $TW = 0{,}004\ TL^{3{,}236}$ (Rio Grande do Norte). Relações comprimento-comprimento foram estimadas para permitir a comparação do comprimento total máximo com resultados da literatura para outras regiões: TL = 1,0615 FL + 0,2179 e TL = 1,1890 SL + 0,2855. As fêmeas foram mais abundantes do que os machos em três das quatro amostras em que o sexo dos espécimes foi identificado.

Palavras chave: Pisquila; mamarrei; dinâmica populacional; pesca esportiva; pesca amadora

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INTRODUCTION

Recreational fisheries in Brazil have been increasing in importance since the 1990s (FREIRE, 2005). However, the scientific community has not yet invested much effort into the analysis of this sector, with the exception of some isolated initiatives (e.g., LEWIS *et al.*, 1999; IPAAM, 2001; BASAGLIA and VIEIRA, 2005; CATELLA, 2006; FRÉDOU *et al.*, 2008; PEREIRA *et al.*, 2008). The same was true for the agency responsible for managing recreational fisheries up to 2009 (IBAMA – Brazilian Institute of Environment and Renewable Natural Resources). The Ministry of Fisheries and Aquaculture (MPA) has been in charge of the management of recreational fisheries since mid 2009. Although some control measures are in place, the level of enforcement is rather poor. Some scientists have found that recreational fisheries and associated activities may have deleterious effects on fish populations in some regions (COLEMAN *et al.*, 2004; LEWIN *et al.*, 2006).

In countries such as the United States of America (USA), competitive fishing events are important components of recreational fisheries. A total of 32,321 fishing events were promoted in fresh water in the USA in 2005 (SCHRAMM and HUNT, 2007). In 2000, a total of 25,000 events were estimated for fresh water in both USA and Canada (KERR and KAMKE, 2003). Saltwater events are much less common. There is some controversy about fishing competitions in Germany, as the primary objective of competitive fishing is considered illegal. In Australia, the number of events is not that impressive: 500-1,000 per year (SCHRAMM Jr. and HARRISON, 2008). There is no such a national estimate in Brazil, but FREIRE (2010) has estimated that more than 100 fishing events are annually organized in northeastern Brazil alone (oceanic and freshwater events excluded). These events present unique opportunities of obtaining biological data for some target or by-catch species (SCHRAMM Jr. *et al.*, 1991).

There are at least 32 fishing clubs or associations in northeastern Brazil, six of them in the State of Bahia (FREIRE, 2010). Clube de Pesca de Ilhéus (CLUPESIL) is the second oldest fishing club in Bahia, being launched in 1975. In the state of Rio Grande do Norte, there are eight clubs or associations engaged in sport fisheries. Pâmpano Esporte Clube was established in 1954 and is the oldest club in the state and third in the northeastern region (FREIRE, 2010). Both clubs are very active. Each one promotes an average of two official events a month during a calendar year. *Atherinella brasiliensis* is one of the species (among several others) caught by anglers in specific locations in Ilhéus - Bahia and in the state of Rio Grande do Norte. In the latter, there are two events that target only this species. Studies focusing on the biology of *Atherinella brasiliensis* are mainly concentrated on southern-southeastern Brazil (see, e.g., BEMVENUTI, 1987; HOSTIM-SILVA *et al.*, 1995; FÁVARO *et al.*, 2007). For northeastern Brazil, no study on the biology of this species was found.

The objective of this study was to determine some biological aspects of the portion of the *A. brasiliensis* population that is vulnerable to capture by sport fisheries off northeastern Brazil. It is important to understand the biology of this species targeted by both commercial and recreational fisheries, even though there is no statistical record of its catch.

MATERIAL AND METHODS

The total number and weight of *A. brasiliensis* was determined in all 30 events promoted by Clube de Pesca de Ilhéus (state of Bahia) from November 2006 to November 2008 and in all 16 fishing events promoted by Pâmpano Esporte Clube from March to November 2009 (state of Rio Grande do Norte). No event took place in January, February and December. Anglers used rod and reel in 44 of these events and only rod in two events that occurred in Rio Grande do Norte. For all specimens caught, total length (TL; cm), fork length (FL; cm), standard length (SL; cm), and total weight (TW; g) were measured. Length and weight were measured *in situ* with an aluminum measuring board and digital scales, respectively. Subsamples were taken to the laboratory and kept frozen. Gonads were later taken out for macroscopic definition of sex and maturity stage, according to VAZZOLER (1996): immature, mature, spawning, and spent.

A non-linear relationship between TW and TL was estimated ($TW = a \cdot TL^b$), after applying logarithm to both variables. Le Cren's relative condition factor was calculated to measure the deviation of an individual from the average weight for length in a sample:

$$K_{rel} = TW / a \cdot TL^b,$$

where TW and TL are as previously defined, and 'a' and 'b' are the parameters of the weight-length relationship (FROESE, 2006). Linear relationships were established between TL and FL, and between TL and SL. All three relationships were presented for mixed specimens as many could not be sexed (due to time restrictions imposed by anglers). The hypothesis of equal sex ratio (females:males) was tested using the chi-square test (ZAR, 2010). All tests were performed in SPSS 17.0 using a 5% significance level.

RESULTS AND DISCUSSION

Atherinella brasiliensis, locally known in Ilhéus as 'pisquila', was caught in only seven out of the 30 fishing events that took place from November 2006 to December 2008 in Ilhéus. Two of these events occurred in the Estuary of the Cachoeira River (Ilhéus; 14º48.4'S) and five outside the estuary. In the state of Rio Grande do Norte, this species is known as 'mamarrei' and was caught in four out of the 16 fishing events that were promoted by the Pâmpano Esporte Clube in 2009. Three of these events took place in the Estuary of the Potengi River (Natal; 05º46.4'S) and the fourth one had some anglers fishing inside the Estuary of Cunhaú – children and women (southern part of the state of Rio Grande do Norte; 06º18.1'S). In Ilhéus, the maximum observed total length and total weight were 13.4 cm and 16.9 g, respectively (Table 1). In Rio Grande do Norte, they were 14.9 cm and 16.5 g, respectively.

According to BERVIAN and FONTOURA (2007), one would expect specimens in lower latitudes to have smaller sizes. The maximum size observed in the northeastern region was indeed slightly smaller than that observed in the Estuary of Tramandaí – RS (16.0 cm; BERVIAN and FONTOURA, 2007) and Rio de Janeiro (16.0 cm; NEVES *et al.*, 2006), but within the range of maximum size for the southern-southeastern region (13.2-16.0 cm; see, e.g., CARVALHO, 1954; PAIVA FILHO and GIANNINI, 1990; HOSTIM-SILVA *et al.*, 1995; FÁVARO *et al.*, 2007) (Table 2). TRIVÉRIO-CARDOSO (2007) found a maximum size of 14.2 cm TL (estimated from standard length) for the state of Rio de Janeiro, smaller than the maximum observed for the state of Rio Grande do Norte (this study; 14.9 cm), even using a very selective gear such as small hooks. It is interesting to observe that only one mode was observed in the frequency distribution of total length of *A. brasiliensis* in the state of Rio Grande do Norte (Figure 1), as in the southeastern region, with an average size of 10.9 cm. Those specimens could be two years old if the same growth pattern is observed as in southern Brazil (BERVIAN and FONTOURA, 2007). In Ilhéus, two modes were observed: 8.0 and 11.0 cm (Figure 1).

The length-weight relationships estimated for Ilhéus (BA) and Rio Grande do Norte were $TW = 0.005\ TL^{3.113}$ (n = 526) and $TW = 0.004\ TL^{3.236}$ (n = 592), respectively (Figure 2). Relationships for males and females were not estimated separately as the sample size was very small for males in Ilhéus (n = 10). Both relationships indicated a positive allometry: IC (b; 0.95) = [3.069; 3.157] for Bahia and IC (b; 0.95) = [3.121; 3.351] for Rio Grande do Norte. Similar pattern was observed by other authors (Table 2), except by MACIEIRA and JOYEUX (2008). However, the size range sampled in that study was much smaller than in any other study. Le Cren's relative condition factor indicated that the weight of sampled specimens was in average very similar to the expected value of the mean weight at that length derived from the weight–length relationship (K_{rel} = 1.014 and 1.001 for Bahia and Rio Grande do Norte, respectively).

Length-length relationships were estimated for both states together (unsexed), as no statistical difference was observed: TL = 1.0615 FL + 0.2179 and TL = 1.1890 SL + 0.2855 (Figure 3). No length-length relationship was available in FishBase (FROESE and PAULY, 2011). The latter relationship was used to convert maximum standard to total length available in CARVALHO (1954) for the state of São Paulo and in TRIVÉRIO-CARDOSO (2007) for Macaé, in the state of Rio de Janeiro.

Table 1. Total number (N), total weight (Wt), minimum, maximum, mean, and standard deviation (SD) of total length and total weight of the specimens of *Atherinella brasiliensis* caught by anglers using rod and reel in each fishing event promoted by Clube de Pesca de Ilhéus (CLUPESIL-Bahia) and Pâmpano Esporte Clube (Rio Grande do Norte) in 2006-2009. 1. Special event for children only; 2. Rod only.

DATE	LOCAL	LAT	LONG	N	W(g)	TOTAL LENGTH (cm)				TOTAL WEIGHT (g)			
						Min	Max	Mean	SD	Min	Max	Mean	SD
25/11/2006	Estuary of Cachoeira River (outer part)	14°48.4′	39°01.90′	243	1206	5.0	12.8	8.7	1.7	0.8	15.2	5.0	3.1
12/05/2007	Estuary of Cachoeira River (outer part)	14°48.4′	39°01.90′	85	401	5.1	12.9	8.7	2.1	0.7	14.0	4.8	3.7
3-4/11/2007	Avenida Soares Lopes Beach	14°47.9′	39°01.77′	9	65	8.7	12.4	10.4	1.1	3.9	11.4	7.2	2.3
29/03/2008	Avenida Soares Lopes Beach	14°47.9′	39°01.77′	42	399	8.0	13.4	11.0	0.9	3.6	16.9	9.5	2.3
27/04/2008	Falafino Beach	14°44.5′	39°03.75′	4	33	6.7	11.5	10.2	2.3	1.9	10.7	8.3	4.3
19/10/2008	Avenida Soares Lopes Beach	14°47.9′	39°01.77′	30	193	8.6	12.9	10.0	0.9	3.8	12.8	6.4	1.9
1-2/11/2008	Avenida Soares Lopes Beach	14°47.9′	39°01.77′	114	712	6.1	12.5	9.8	1.2	1.2	10.9	6.2	2.1
	TOTAL – BAHIA	—	—	**527**	**3009**	**5.0**	**13.4**	**9.2**	**1.7**	**0.7**	**16.9**	**5.7**	**3.2**
05/04/2009	Estuary of Potengi River (outer part)	5°45.4′	35°11.8′	5	24	8.6	9.8	9.0	0.5	4.0	6.0	4.4	0.9
07/06/2009	Barra de Cunhaú	6°18.1′	35°01.9′	10	119	9.9	14.9	11.9	1.4	8.0	15.0	11.9	2.3
11/10/2009	Estuary of Potengi River (inner part)[1,2]	5°45.6′	35°12.4′	345	3252	6.5	12.8	10.9	0.9	1.0	16.5	10.0	3.4
25/10/2009	Estuary of Potengi River (inner part)[2]	5°45.6′	35°12.4′	237	1787	6.7	12.7	10.3	1.0	1.0	15.0	7.5	2.4
	TOTAL – RIO GRANDE DO NORTE	—	—	**597**	**5180**	**6.5**	**14.9**	**10.6**	**1.0**	**1.0**	**16.5**	**8.7**	**2.5**

Table 2. Comparison between biological data obtained in this study and from other studies carried out in Brazilian waters. Lmin and Lmax = minimum and maximum length; a and b are parameters of the weight-length relationship; F:M corresponds to the sex ratio (females:males); L_{50} = length at first maturity. "Picaré" = beach seine (name used as in the original reference). SL = standard length, TL = total length.

Year	Locality	Gear	Lmin (cm)	Lmax (cm)	Length type	a	b	F:M	L_{50}	Source
1954-1955	Cananéia (SP)	–	–	12.3	SL	–	–	–	–	CARVALHO (1954)
1980s-1990s	Southern Brazil	Bottom and mid-water trawl	2.7	15.5	TL	0.0033	3.332	–	–	HAIMOVICI and VELASCO (2000)
1993-1994	Tramandaí Lagoon (RS)	Beach seine (research)	–	16.0	TL	0.0049	3.200	–	–	BERVIAN and FONTOURA (2007)
1996-1998	Sepetiba Bay (RJ)	"Picaré" net (research)	1.3	13.8	TL	–	–	–	–	PESSANHA and ARAÚJO (2001)
1998-1999	Sepetiba Bay (RJ)	Beach seine (research)	1.8	12.9	TL	–	–	–	–	PESSANHA and ARAÚJO (2003)
1998-1999	Paranaguá Bay (PR)	"Picaré" net (research)	–	15.1	TL	–	–	0.93	7.6 ♀ 6.9 ♂	FAVARO *et al.* (2003)
1999-2000	Guaratuba Bay (PR)	Beach seine (research)	5.9	15.1	TL	–	–	–	–	CHAVES and VENDEL (2008)
2000-2001	Paranaguá Bay (PR)	Beach seine (research)	1.9	15.8	TL	–	–	1.39	–	FAVARO *et al.* (2007)
2001-2002	Imboassica (RJ)	Beach seine (research)	0.9	11.1	SL	0.0121	3.062	1.14	6.2 ♀ 7.7 ♂	TRIVÉRIO-CARDOSO (2007)
2002-2003	Baía de Todos os Santos (BA)	Beach seine (research)	1.6	4.4	TL	–	–	–	–	OLIVEIRA-SILVA *et al.* (2008)
2002-2003	Sepetiba Bay (RJ)	"Picaré" net (research)	1.0	16.0	TL	–	–	–	–	NEVES *et al.* (2006)
2003-2004	Curuçá Estuary (PA)	Fyke/hoop net (research)	6.1	11.4		0.0036	3.310	–	–	GIARRIZZO *et al.* (2006)
2003-2005	Ubatuba (SP)	"Picaré" net (research)	2.0	14.5	TL	–	–		8.7 ♀♂	FERNANDEZ (2007)
2004-2005	Vitória Bay (ES)	"Picaré" net (research)	4.6	14.1	TL	–	–	–	–	ARAÚJO *et al.* (2008)
2005-2006	Guaraguaçu River (PR)	Beach seine (research)	1.9	11.9	SL	–	–	–	–	CONTENTE *et al.* (2011)
2005-2007	Castelhanos Beach (ES)	Rotenone/hand net (research)	2.4	7.1	TL	0.0073	2.910	–	–	MACIEIRA and. JOYEUX (2008)
2008	Ilhéus (BA)	Rod/reel (recreational)	5.0	13.4	TL	0.0050	3.113	1.32	–	This study
2009	Rio Grande do Norte (RN)	Rod/reel (recreational)	6.5	14.9	TL	0.0040	3.236	1.75	–	This study
2008-2009	Piraquê-açú and Piraquê-mirim Rivers (ES)	Beach seine (research)	2.8	12.4	TL	0.0061	3.010	–	–	MAZZEI *et al.* (2011)

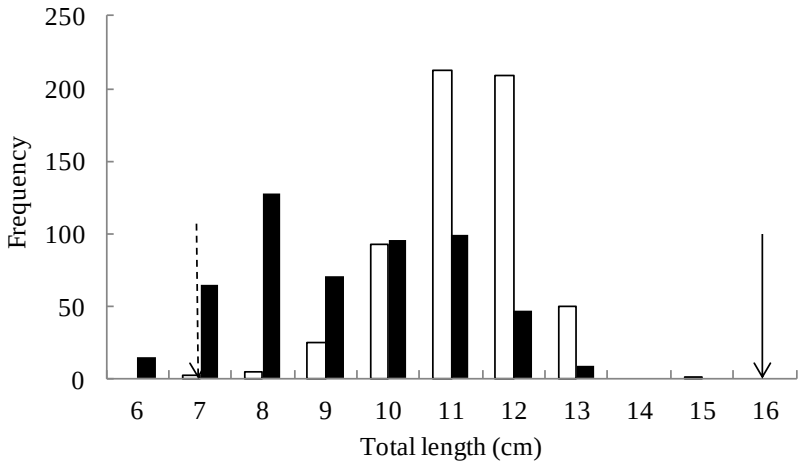

Figure 1. Frequency distribution of total length for *Atherinella brasiliensis* caught by anglers in the states of Bahia (black columns) and Rio Grande do Norte (white columns) in 2006-2008 and 2009, respectively. The solid arrow represents the maximum recorded size (FROESE and PAULY, 2011) and the dashed arrow indicates the size at first maturity for females (TRIVÉRIO-CARDOSO, 2007).

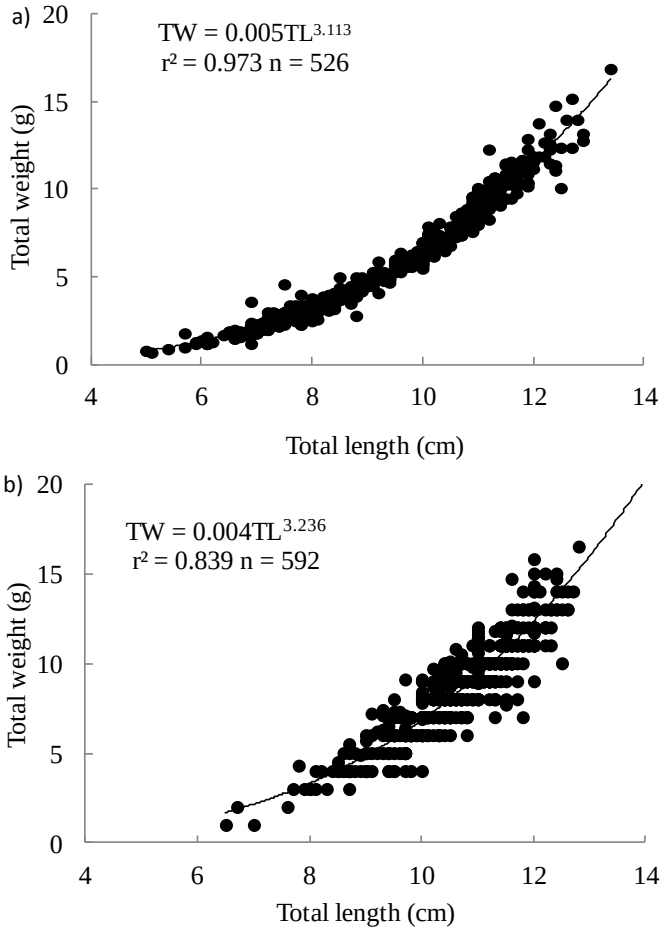

Figure 2. Length-weight relationship for *Atherinella brasiliensis* caught by anglers in the states of Bahia (a) and Rio Grande do Norte (b) in 2006-2008 and 2009, respectively.

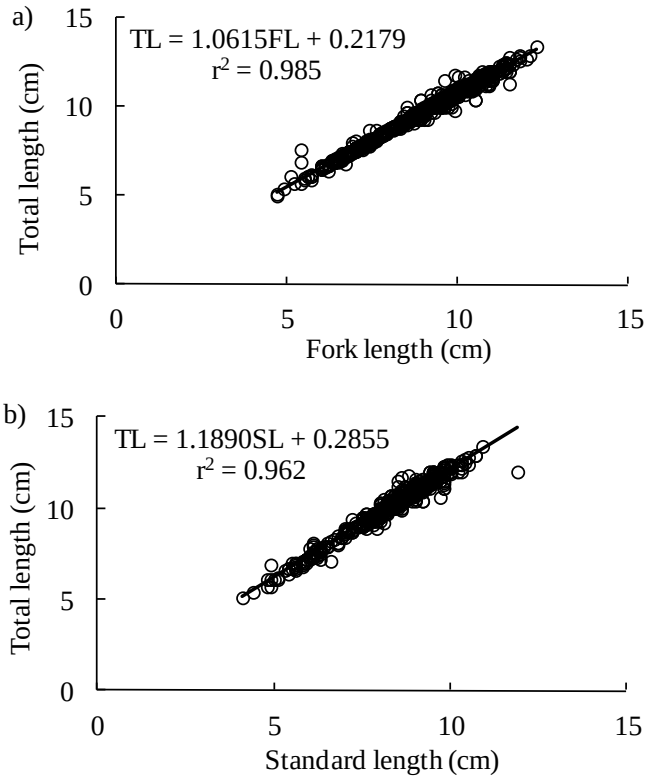

Figure 3. Length-length relationships for *Atherinella brasiliensis* caught by anglers in the states of Bahia and Rio Grande do Norte in 2006-2009.

A predominance of females was observed in Ilhéus - Bahia and in Rio Grande do Norte (Table 3). However, for the second sample from Rio Grande do Norte, two weeks apart from the first, the sex ratio was not significantly different from one. This difference may be associated to a change in the fishing ground, slightly inwards the estuary in the latter, and/or selectivity of the fishing gear. FÁVARO *et al.* (2003) also found such variability in the sex ratio for the state of Paraná.

The analysis of the maturity stage did not allow the estimation of the size at first maturity (L_{50}), but it demonstrated that at a size of 8-13 cm, 60-90% of the females were mature. It indicates that the L_{50} is smaller than eight. That was expected as L_{50} for females was equal to 7.0 cm in Rio de Janeiro (TRIVÉRIO-CARDOSO, 2007), 7.6 cm in Paraná (FÁVARO *et al.*, 2003), and 10.0 cm in Patos Lagoon - RS (BEMVENUTI, 1987) (see also Table 2). If we consider that size at first maturity is expected to be lower in lower latitudes, thus most of the specimens caught by anglers in Ilhéus and Rio Grande do Norte are expected to be larger than L_{50}. This has to be considered when deciding on fishing grounds where fishing tournaments may take place.

Table 3. Sex ratio for *Atherinella brasiliensis* caught by anglers in Ilhéus and Rio Grande do Norte in 2008-2009.

Date	Locality	Females	Males	F:M	p-value
29/03/2008	Ilhéus, Bahia	38	4	9.50*	<0.0001
01/11/2008	Ilhéus, Bahia	79	6	13.17*	<0.0001
11/10/2009	Rio Grande do Norte	88	48	2.46*	<0.0001
25/10/2009	Rio Grande do Norte	19	31	0.61	0.0897

** Statistically different from one (alfa = 0.05).*

One difficulty in analyzing data from coastal fishing events is that anglers usually consume their catch. In Rio Grande do Norte, *A. brasiliensis* is a traditional delicacy and particularly appreciated when fried and sold in the market. We suggest that a year round sampling scheme is adopted, independent from the anglers' calendar, to enable detection of the presence of juveniles in the region and to define the size at first maturity for *A. brasiliensis* in the states of Bahia and Rio Grande do Norte. This is the first time *A. brasiliensis* is recorded as a target species for anglers in Brazil. Moreover, there is also a commercial interest in this species in the state of Rio Grande do Norte. Finally, one should also consider that this species is one of the most abundant fish species in some estuarine areas (see, e.g., ANDREATA *et al.*, 1997; GONDOLO *et al.*, 2011), and probably so in estuaries located in northeastern Brazil. Thus, as much as possible basic biological information related to *A. brasiliensis* in various regions should be available to make informed decisions for management of its populations when required. Using data gathered from catches provided by anglers was an effective strategy for describing some biological aspects of this species in northeastern Brazil where information is currently missing.

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