POPULATION STRUCTURE AND REPRODUCTION OF *ANABLEPS MICROLEPIS* IN AN ESTUARY FROM AMAZON

Niedja Luana da Costa Mescouto[1]
Mayra Sousa do Nascimento[2]
Luciano de Jesus Gomes Pereira[3]
Ítalo Antônio Freitas Lutz[4]
Diego Gomes Trindade[5]
Bianca Bentes[6]

ABSTRACT

Anableps microlepis is a viviparous species widespread throughout coastal regions and estuaries along the northern coast of Brazil. In order to study the population structure, fertility and morphometrics of this fish, we carried out monthly collections in the Ajuruteua Peninsula since *A. microlepis* is found at high densities at this location. A total of 368 specimens were obtained, with predominance in number, size and weight of females in relation to males for nearly the entire studied period. Males and females reached sex maturity (L50) at 11.1 cm and 11.9 cm, respectively. The number of embryos was proportional to the size of females and all analyses performed based on other measurements were negatively correlated, except for standard length x weight. These results provide ecological information about an abundant but overlooked species that contributes to the energetic dynamics of an important estuary from northern Brazil.
Keywords: Viviparity, tralhoto, North coast, Ajuruteua

ESTRUTURA POPULACIONAL E REPRODUÇÃO DE *ANABLEPS MICROLEPIS* EM UM ESTUÁRIO DA AMAZÔNIA

RESUMO

Anableps microlepis, é uma espécie vivípara com ampla distribuição em regiões costeiras e estuários ao longo da costa norte do Brasil. Com o objetivo de estudar a estrutura populacional, dieta alimentar, fertilidade e morfometria deste peixe, realizamos coletas mensais na Península de Ajuruteua, uma vez que, *A. microlepis* é encontrado em altas densidades neste local. Foram obtidos 368 exemplares, com predomínio em número, tamanho e peso de fêmeas em relação aos machos durante quase todo o período estudado, bem como maior diversidade de categorias alimentares e intensidade alimentar para as fêmeas. Machos e fêmeas atingiram a maturidade sexual (L50) com 11,1 cm e 11,9 cm, respectivamente. O número de embriões foi proporcional ao tamanho das fêmeas e todas as análises realizadas a partir das demais medidas foram negativamente correlacionadas, exceto comprimento padrão x peso. Registra-se também o hábito herbívoro da espécie com consumo secundário de organismos bentônicos como crustáceos e poliquetas mais expressivos no período chuvoso. Esses resultados fornecem informações bioecológicas sobre uma espécie abundante que contribui para a dinâmica energética de um importante estuário do norte do Brasil.
Palavras-chave: Viviparidade, tralhoto, costa Norte, Ajuruteua

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[1] Laboratório de Biologia Pesqueira e Manejo dos Recursos Aquáticos, Grupo de Ecologia e Manejo da Pesca na Amazônia, Universidade Federal do Pará. Email: niedjaluanam@gmail.com (corresponding author)
[2] RARE, Brasil. E-mail: mayra.nascimento@ymail.com
[3] Universidade Federal do Pará. E-mail: luciano_jgp@hotmail.com
[4] Laboratório de Genética Aplicada, Instituto de Estudos Costeiros, Universidade Federal do Pará, Bragança, Pará. Email: italofreitas91@hotmail.com
[5] Engenheiro de Pesca e Mestre em Ecologia Aquática e Pesca pela da Universidade Federal do Pará. E-mail: trinidadiego@gmail.com
[6] Doutorado em Ecologia Aquática e Pesca pela Universidade Federal do Pará com sanduíche no Leibniz-Zentrum für Marine Tropenforschung em Bremen, Alemanha. professor Associado da Universidade Federal do Pará e diretora acadêmica do Núcleo de Ecologia Aquática e Pesca da Amazônia (NEAP/UFPA). E-mail: bianca@ufpa.br

INTRODUCTION

Anableps microlepis (MULLER; TROSHEI, 1844) is a peculiar fish species in which the ocular structure is divided into two pairs of eyes adapted to simultaneous vision above and below the water surface (OLIVEIRA *et al.* 2006). This species is distributed from Central America to northern Brazilian coast, including the states of Pará, Maranhão, and Piauí (CERVIGÓN *et al*., 1992; RIBEIRO; CASTRO 2003).

This is specie inhabits mangrove areas, being regarded as an euryhaline and estuarine-resident species inasmuch as it completes the biological cycle within estuaries. In the Amazon delta region, *A. microlepis* usually undergoes intertidal migrations back and forward beaches according to tidal variation (BARTHEM, 1985). The finescale four-eyed fish be found in schools ranging from 10 to 50 individuals, living close to the surface or partially covered by water in mud puddles. Nonetheless, these fish might remain submerged occasionally either for mating or for defense against predators (RIBEIRO; CASTRO, 2003).

The finescale four-eyed fish is a viviparous species with sexual dimorphism (RIBEIRO; CASTRO, 2003). In males, changes in the anal fin rays form a copulatory structure named gonopodium. Females have adaptations in genital opening and ovaries that allow them nourishing the embryos through the placenta (BURNS, 1991). The embryos develop at distinct rates and the gonopore remains open until the end of the embryonic development, allowing them to leave the ovary as they reach maturity (BURNS, 1991).

Previous reports carried out in *Anableps* from coastal regions of Brazil have analyzed reproductive aspects, biometric and morphometric relationships, and fecundity, showing that the weight of females is related to continuous reproduction phase while the weight of males is related to growth and reproduction. Furthermore, there are distinct reproductive peaks between *Anableps anableps* (LINNAEUS, 1758) and *A. microlepis* (IKEDA *et al*., 2005; NASCIMENTO; ASSUNÇÃO, 2008; OLIVEIRA *et al.,* 2011).

Anablepids are commonly found in environments that suffer from anthropogenic threats. Some impacts caused by tourism, fishing, pollution from sewage discharges and inappropriate waste disposal occur on Ajuruteua beach, located in the city of Bragança, Pará (COELHO PESSOA *et al*., 2019) and which is part of an important RESEX (Reserva Marine Extractive) (ICMBIO, 2012) where specimens of tralhoto are notoriously found.

Recent and preliminary studies indicate that anablepids are important bioindicators and relevant individuals for ecophysical biomonitoring studies (GUEDES; CORREIA, 2021). In addition, A. microlepis is often caught and discarded as a bycatch in artisanal fisheries off the northern coast of Brazil (FERREIRA *et al*., 2011). This process threatens the long-term maintenance of this species which, although without regional economic importance, plays an important ecological role in the structuring of food webs throughout mangrove environments.

Therefore, the present study aims to investigate the main biological characteristics of A. microlepis in the estuarine region of Ajuruteua beach, focusing on its population structure and reproductive aspects and diet. Its main motivation is the fact that there is little information available about the characteristics of the basic ecology of this species.

MATERIAL AND METHODS

Study area

The Caeté-Taperaçu RESEX is a Federal Conservation Unit for Sustainable Use, located in the municipality of Bragança, northeastern Pará (ADBALA *et al*., 2012). The Ajuruteua beach belongs to RESEX Caeté-Taperaçu, comprising about 40 km of coastline distributed into mangrove ecosystems, estuaries, tidal channels, coastal dunes, and beaches (ICMBIO, 2012). The weather is hot-humid, with a marked dry season between August and

November and a rainy period between January and May. The average rainfall and annual temperature in this region equals 2.500 mm and 26°C, respectively, which seasonal changes in salinity and nutrients. These changes are directly related to the fish productivity in the region (MORAES *et al*., 2005). At Ajuruteua beach, the morpho-sedimentary environments are influenced by the macro-tidal regime, which can reach up to six meters in amplitude, and species inhabiting this region are adapted to such variation (SOUZA-FILHO *et al*., 2003; LUIZÃO, 2007).

Data collection

Biological samples were captured monthly from September 2018 to August 2019 at two sites (P1 and P2) (*Figure 1*). The sites were chosen based on salinity, being higher in P1 than in P2. Fieldwork was carried out during the day, at low and quadrature tides, using the "tarrafa" which is an artisanal fishing net (MESQUITA; ISAAC-NAHUM, 2015), with dimensions of 30 m/40 mm and 4 m/ 30 mm, respectively (ICMBIO, 2019). Simultaneously, environmental variables of the water were recorded including pH, salinity and temperature (°C) in a HANNA multiparameter - model HI98194. At least 20 were made per month.

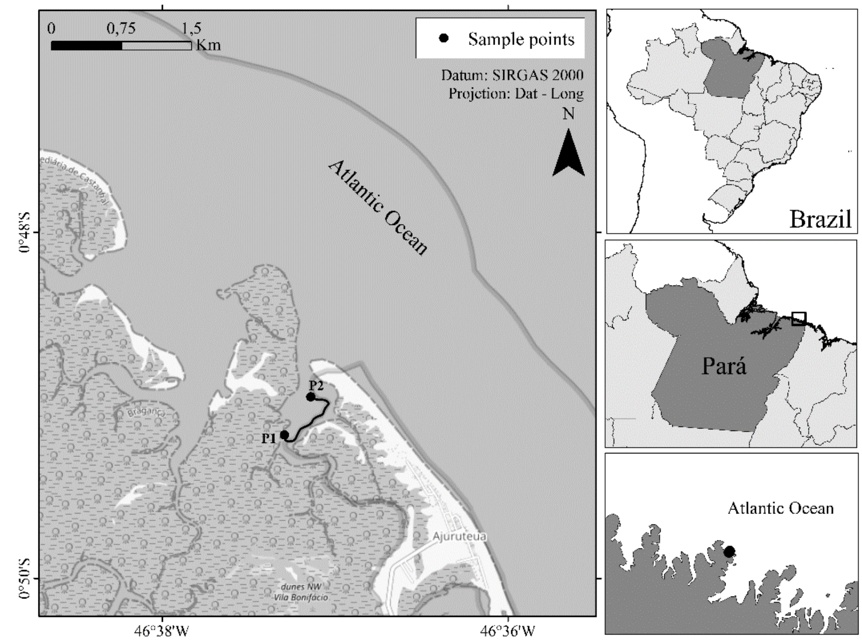

Figure 1. Geographic location of capture points (P1 and P2) for *Anableps microlepis*. Fonte: Ítalo Lutz, 2019.

The collection and transport of biological material were authorized through the permanent license for the collection of zoological material, number 47679-1, granted by the System of Authorization and Information on Biodiversity - SISBIO. The samples were stored in thermal boxes and then taken to the Laboratory of Fisheries Bioecology at the Federal University of Pará. In the laboratory, the specimens were identified according to specialized bibliography (CERVIGÓN *et al*., 1992). The sex was identified by observing the reproductive appendages and the gonadal maturation stage was defined following the methodology adapted from Oliveira *et al*. (2011) for females only. About 16 linear measurements (cm) (*Figure 2*) and mass (g) values were taken from each individual.

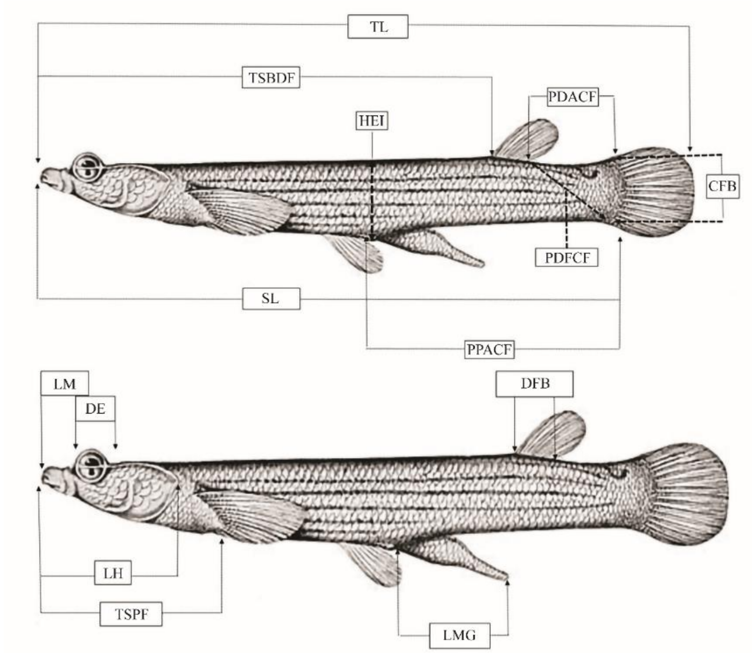

Figure 2. Schematic drawing of specimen of *Anableps microlepis*. **CT**: total length; **CP**: standard length; **CC**: Length of the head; **CFO**: muzzle length; **OD**: Eye diameter; **PC**: Base of caudal fin; **ALT**: Height; **CPDSPC**: Posterior portion of dorsal fin to anterior part of caudal-fin base; **CPNPE**: Tip of snout to end of pectoral fin; **CFDIPC**: Posterior portion of dorsal fin to base of caudal fin; **CPEIFN**: Anterior portion of pelvic fin to base of caudal fin; **CAPD**: Base of dorsal fin; **CPAPD**: Tip of snout to beginning of dorsal fin; **CGO**: Male gonopodium length.

Data analysis

The seasons were identified based on data provided by the National Institute of Meteorology (INMET) from 1999 to 2019. The rainy season (RS) encompassed the months of January to May; the transition from wet to dry season (TWD) was observed in June and July; the dry season (DS) was defined from August to November and the transition from dry to rainy season (TDW) took place in December (FREIRE *et al*., 2012).

The Kruskal Wallis test ($p<0.05$) was performed to test differences in environmental variables per site since they were not suitable for ANOVA, even after transformation. To test the variation in size (SL) and weight (W) by sex and season, analysis of variance (one-way ANOVA) considering a significance level of 5% was performed, considering normality and homoscedasticity premises. When the means differed significantly, Tukey's post hoc test ($p < 0.05$) was performed. The sex ratio was calculated in relation to month and according to SL class groups (cm), applying the chi-Square test (χ^2), with 5% of significance to test putative differences in the ratio of 1:1, according to Vazzoler (1981). The critical chi-Square values used was 3.84, taking into account a=0.05 and degree of freedom = 1.

To determine the size of the first gonadal maturity (L50) of males and females, the data set was grouped by standard length (SL) at 1-cm intervals. From the grouped dataset, a graph of cumulative frequency was built. The logistic curve of the graphics was obtained using the logistic model (KING, 2008). The coefficient of determination (R^2) was also calculated to express how both variables are related to each other. Linear regression models were applied to the morphometric relationships in order to determine the level of allometry for each comparison.

RESULTS
Environmental variables

Salinity ranged from 33.96 (November 2018) to 9.66 (August 2019). No significant differences were observed in temperature and pH values (p>0.05) between seasons (*Figure 3*).

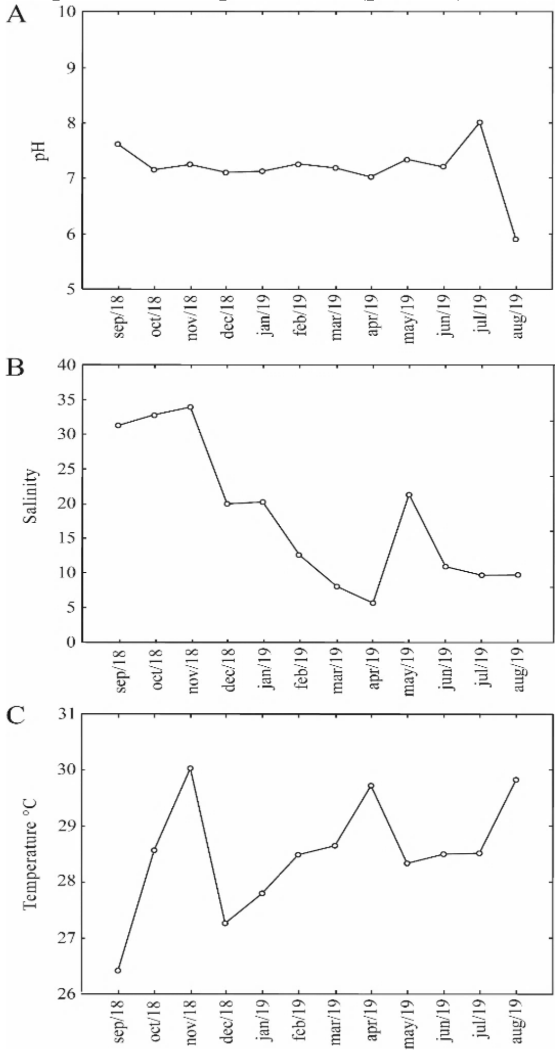

Figure 3. Fluctuation of physical and chemical water variables (**A:** pH; **B:** salinity; **C:** temperature) in relation to rainfall periods (dry= SC, dry/rainy transition= TSC, rainy= CH, rainy/dry transition= TCS) from September 2018 to August 2019 at Ajuruteua beach, Bragança – PA.

Caught samples

A total of 368 individuals were obtained, distributed into 172 females and 196 males. The largest and the smallest female specimens recorded presented 21.6 cm and 7.3 cm in standard length (cm), respectively, with a maximum weight of 98.75 g. The highest value of standard length in males was 15.8 cm while the smallest male specimens reached 2 cm; the maximum weight in males was equal to 45.95g. The average standard length, independently on sex, was 11.78 cm and the mean total weight was equal to 19.60 g (Table 1).

Females of *A. microlepis* were larger and heavier than males, besides presenting the highest values of standard length and weight in rainy season. Males also showed increased length in the rainy season, however, the highest weight values in males were recorded in the transition from dry to rainy season. Both females and males presented increased length and weight in the rainy season (*Figure 4*).

Table 1. Number of individuals (N), size and weight of females (♀) and males (♂), maximum (Max), minimum (Min), mean (Avg) and standard deviation (SD) values of standard length (SL) in centimeters (cm) and weight (W) in grams (g) of *Anableps microlepis* collected from September 2018 to August 2019 at Ajuruteua, Bragança, PA.

			SL (cm)				Weight (g)			
Month/year	**Sex**	**N**	**Max**	**Min**	**Avg**	**SD**	**Max**	**Min**	**Avg**	**SD**
Sep/18	♀	22	19.5	7.3	12.20	3.26	82.64	4.5	25.59	22.27
	♂	15	14	2	10.45	2.50	32.07	8.71	16.92	6.05
Oct/18	♀	14	16.4	11.4	13.06	1.68	98.75	16.43	32.13	21.60
	♂	22	15.8	9.9	11.71	1.28	45.95	10.43	19.06	8.09
Nov/18	♀	9	16	10.6	12.97	1.80	93.1	13.82	32.78	23.40
	♂	22	14.3	9.1	11.81	1.40	30.76	8.24	18.14	6.21
Dec/18	♀	12	14.4	10	11.74	1.36	33.22	10.93	16.91	6.12
	♂	12	13.2	9.7	10.64	0.87	20.91	8.44	13.75	2.98
Jan/19	♀	15	21.6	10.2	13.70	2.49	93.1	11.97	30.78	18.41
	♂	17	13.3	10	11.69	1.02	32.44	10.68	18.45	5.56
Feb/19	♀	16	17.4	9.5	14.04	2.07	52.94	9.19	32.84	11.80
	♂	22	13.5	9.9	11.89	1.02	26.15	11.31	19.93	4.57
Mar/19	♀	14	17.5	9.3	12.44	2.37	71.01	1.54	23.89	18.27
	♂	11	13.6	9.5	11.18	1.25	16.6	1.07	4.37	5.58
Apr/19	♀	12	18.5	10.6	13.58	2.31	71.87	14.82	30.24	17.02
	♂	19	14.2	9	12.11	1.26	28.37	8.05	18.28	5.05
May/19	♀	11	15	9	12.21	1.99	34.76	8.15	19.61	8.41
	♂	15	13.4	9.3	10.99	1.27	26.02	8.29	14.51	4.69
Jun/19	♀	15	17	9.5	11.84	2.08	51.96	9.94	19.30	11.16
	♂	10	12.5	9.9	11.05	0.62	21.72	11.31	15.16	2.80
Jul/19	♀	8	16.2	9.1	11.19	2.03	46.91	8.9	16.50	11.83
	♂	16	13	9.1	11.01	1.14	23.09	8.61	14.59	4.42
Aug/19	♀	24	12.9	9	10.06	0.85	19.45	6.88	10.07	2.56
	♂	15	11.5	9	9.92	0.64	16.72	7.46	10.21	2.30
Total		368	21.6	2	11.78	2.04	98.75	1.07	19.60	13.44

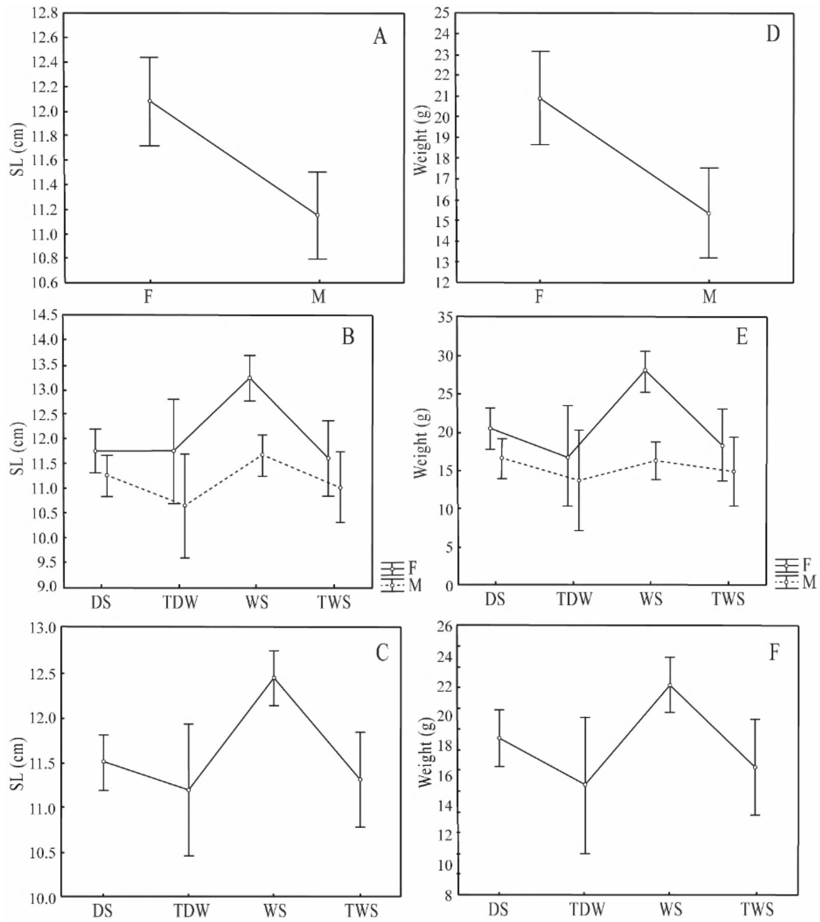

Figure 4. A: standard length ratio (SL) with the sexes (female and male); **B:** ratio of standard length (CP) with sex (female and male) and seasonal periods (dry= SC, dry/rainy transition (TSC), rainy (CH) and rainy/dry transition (TCS); **C:** standard length ratio (SL) of the total number of individuals in the seasonal periods; **D:** weight ratio (W) with the sexes (female and male); **E:** weight ratio (W) with the sexes (female and male) and with the seasonal periods (dry= SC, dry/rainy transition (TSC), rainy (CH) and rainy/dry transition (TCS); **F:** weight ratio (W) of the total number of individuals in the seasonal periods.

The females were more frequently recorded than males for most of the year, particularly in the size classes from 10 to 16 cm. The only exception was observed in November, when males were more represented than females (Tables 2 and 3).

Table 2. Proportion or sex ratio related to the standard length (SL) of *Anableps microlepis* collected from September 2018 to August 2019, at Ajuruteua, Bragança, PA. *indicates significant differences in chi-square (χ^2) test with 5% error (Critical T = 3.84).

Month	♀	♂	Total	χ^2
January	15	17	32	0.13
February	16	22	38	0.95
March	14	11	25	0.36
April	12	19	31	1.58
May	11	15	26	0.62
June	15	10	25	1.00
July	8	16	24	2.67
August	24	15	39	2.08
September	22	15	37	1.32

October	14	22	36	1.78
November	9	22	31	5.45*
December	12	12	24	-
Total	172	196	368	17.93

The L_{50} for the pooled dataset was estimated in 11.5 cm, while L_{50} for females and male, separately, was equal to 11.9 cm and 11.1 cm, respectively (*Figure 5*).

Table 3. Frequency of males and females related to the months of collection of *Anableps microlepis* from September 2018 to August 2019, at Ajuruteua, Bragança – PA. *indicates a significant difference in chi-square (χ^2) test with 5% error (Critical T = 3.84).

Standard length class (SL) cm	♀	♂	Total	χ^2
2-3		1	1	1.00
7-8	1		1	1.00
8-9	1		1	1.00
9-10	20	25	45	0.56
10-11	31	43	74	1.95
11-12	31	56	87	7.18*
12-13	27	39	66	2.18
13-14	19	21	40	0.10
14-15	12	4	16	4.00*
15-16	10	1	11	7.36*
16-17	6		6	6.00*
17-18	5		5	5.00*
18-19	2		2	2.00
19-20	2		2	2.00
21-22	1		1	1.00

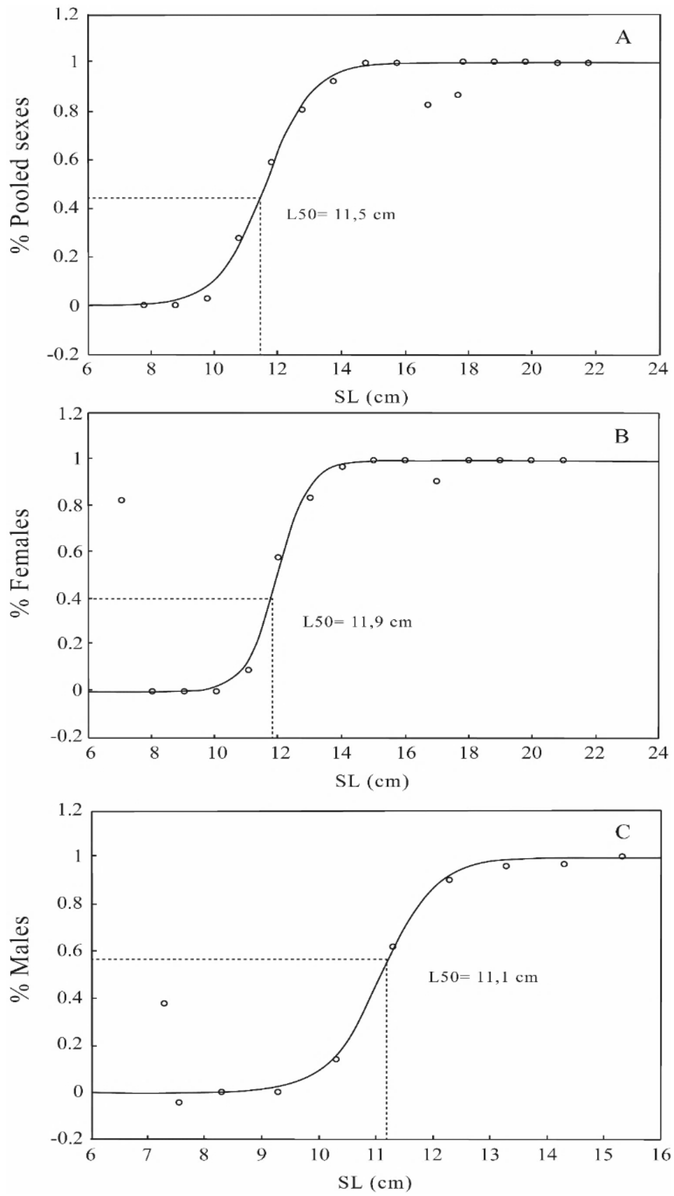

Figure 5. Distribution of cumulative frequencies for the grouped sexes, by standard length class (SL), for specimens of *Anableps microlepis*, captured from September 2018 to August 2019, on Ajuruteua beach, Bragança - PA.

Females with embryos were observed in specimens from 12 cm in standard length on. The individual with 19.5 cm presented the largest number of embryos (n=13) and the largest proportion of females with embryos was concentrated in sizes from 12 to 16 cm, with up to six embryos (*Figure 6*).

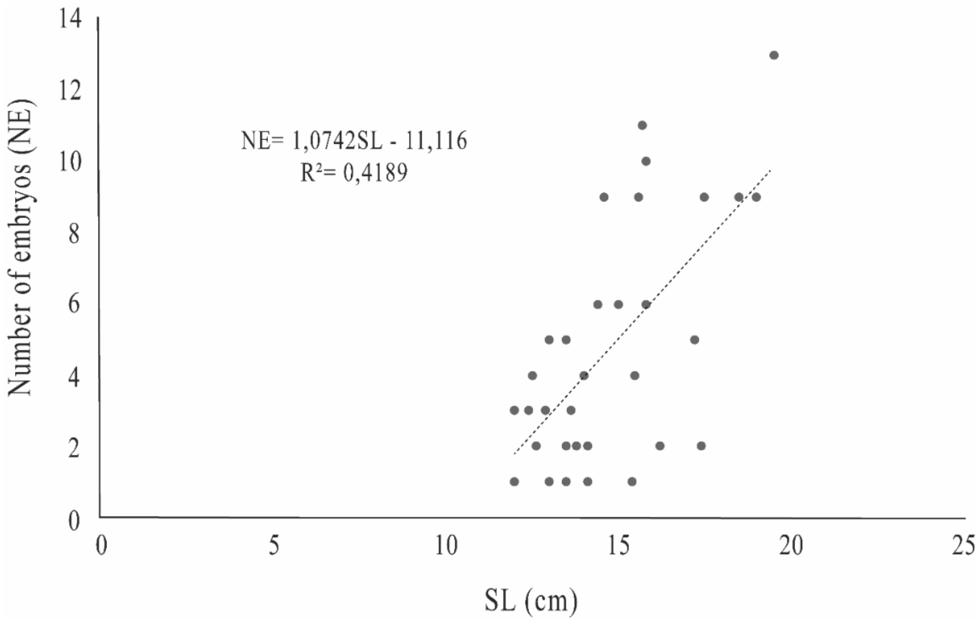

Figure 6. Linear fertility relationship as a function of the standard length (SL) of *Anableps microlepis* females, collected from September 2018 to August 2019, on Ajuruteua beach, Bragança - PA.

Morphometric and biometric relationships

Negative allometric growth was observed for all morphometric comparisons, since the standard length increased a lower rate when compared to other linear measurements (Table 4).

Table 4. Linear regression equations of the morphometric relationships of **SL** (Standard length), **LH** (Length of the head), **LM** (length of the muzzle), **DE** (Diameter of the eye), **CFB** (caudal-fin base), **HEI** (Height), **PDACF** (Posterior portion of the dorsal fin to the anterior part of caudal fin base), **TSPF** (Tip of the snout to end of pectoral fin), **PDFCF** (Posterior portion of the dorsal fin to base of caudal fin), **PPACF** (Portion of the pelvic fin anterior to the base of the caudal fin), **DFB** (Dorsal fin base), **TSBDF** (Tip of the snout to the beginning of dorsal fin), **LMG** (Length of the male gonopodium) in individuals of *Anableps microlepis* collected from September 2018 to August 2019 at the beach of Ajuruteua, Bragança, PA.

Sex	Relation	Model	R²	Allometry
Grouped	LH X SL	SL = 0.22CC+ 0.1313	0.81	-
	LM X SL	SL = 0.0706CFO - 0.1212	0.65	-
	DE X SL	SL = 0.0341DO + 0.2178	0.3	-
	CFB X SL	SL = 0.0967PC- 0.1319	0.67	-
	HEI X SL	SL = 0.1348ALT - 0.2936	0.5	-
	PDACF X SL	SL= 0.1259CPDSPC + 0.1758	0.58	-
	TSPF X SL	SL = 0.2595CPNPE + 0.1649	0.82	-
	PDFCF X SL	SL = 0.1094CFDIPC + 0.9682	0.15	-
	PPACF X SL	SL = 0.4081CPEIFN + 0.8259	0.55	-
	DFB X SL	SL = 0.0575CAPD + 0.0882	0.5	-
	TSBDF X SL	SL = 0.8314CPAPD - 0.3205	0.92	-
Females	LH X SL	SL= 0.2223CC + 0.1033	0.89	-
	LM X SL	SL= 0.0713CFO - 0.1168	0.79	-
	DE X SL	SL = 0.0341DO + 0.228	0.51	-
	CFB X SL	SL = 0.0984PC - 0.1635	0.82	-

	HEI X SL	SL= 0.1261ALT - 0.1961	0.72	-
	PDACF X SL	SL = 0.1313CPDSPC + 0.0683	0.69	-
	TSPF X SL	SL = 0.257CPNEPE + 0.2231	0.88	-
	PDFCF X SL	SL = 0.1571CFDIPC - 0.2039	0.81	-
	PPACF X SL	SL = 0.4137CPEIFN + 0.6246	0.62	-
	DFB X SL	SL = 0.0572CAPD + 0.076	0.7	-
	TSBDF X SL	SL = 0.8381CAPD - 0.3921	0.93	-
Males	LH X SL	SL = 0.2114CC + 0.2341	0.61	-
	LM X SL	SL = 0.059CFO - 0.0024	0.28	-
	DE X SL	SL = 0.0269DO + 0.2888	0.06	-
	CFB X SL	SL = 0.0924PC - 0.0768	0.39	-
	HEI X SL	SL = 0.0919ALT + 0.1734	0.34	-
	PDACF X SL	SL = 0.1389CPDSPC + 0.0729	0.42	-
	TSPF X SL	SL = 0.242CPNPE + 0.3487	0.7	-
	PDFCF X SL	SL = 0.1896CFDIPC - 0.452	0.52	-
	PPACF X SL	SL = 0.4809CPEIFN + 0.0971	0.48	-
	DFB X SL	SL = 0.0632CAPD + 0.0353	0.26	-
	TSBDF X SL	SL = 0.8016CPAPD + 0.0115	0.88	-
	LMG X SL	SL = 0.081CGO + 1.3356	0.14	-

Biometric relationships (weight-length) showed similar results to those obtained by morphometric analyses, but females showed positive allometry (Table 5).

Table 5. Potential regression equation of the biometric relationships SL (cm) (Standard length) and W (g) (Weight) of *Anableps microlepis* by sex (female and male) and grouped based on specimens collected from September 2018 to August 2019 at Ajuruteua beach, Bragança, PA.

Sex	Relation	Model	R^2	Allometry
Grouped	SL X W	$P = 0.0114CP^{2.9828}$	0.93	-
Females	SL X W	$P = 0.0103CP^{3.0175}$	0.94	+
Males	SL X W	$P = 0.0127CP^{2.9411}$	0.89	-

DISCUSSION

The seasonal effects measured in this study were typical of neotropical estuaries, corroborating several studies carried out in coastal areas (MONTEIRO *et al*., 2015; FERNANDES *et al*., 2018; MOURA; NUNES 2018). Changes in pH, salinity, and temperature are correlated with the dry, rainy, and transition seasons, following the regional rainfall cycle and freshwater flow from rivers into the ocean (BARTELLA *et al*., 2005). Salinity was the environmental variable with the greatest variation. This variable can interfere in all life stages of fish, especially growth, inasmuch as it interferes directly in metabolic processes of these organisms, being able to increase fertility rates by reducing sperm mortality (DOLOMATOV *et al*., 2012; BART *et al*., 2013). Furthermore, environmental variables play a key role in many biological phenomena such as reproduction and feeding behavior (LÒPEZ-DELGADO *et al*., 2020; VOLKOFF; RONNESTAD, 2020).

During the sampling period, both sexes were present, but females were larger and heavier than males throughout most of the year, as similarly reported by Brenner and Krumme

(2007), and Goyenola (2011). This result was expected since it is an adaptative strategy typically found in aquatic species, in which larger females have the advantages of carrying more oocytes (NASCIMENTO; ASSUNÇÃO, 2008). In addition, both size and weight of males and females were, in general, increased during the rainy season, when rainfall was higher, salinity was lower, and more nutrients were available due to river discharges (MOURA; NUNES, 2018). Therefore, the rainy season seems to be the most suitable period for reproduction and embryonic development since females prefer environments where nutrients are abundant, favoring the reproductive success of eggs, larvae, and embryos (RAPOSO; GURGEL, 2001; MONTEIRO *et al*., 2015; SANTOS *et al*. 2016).

In the case of anablepids, characterized by a high reproductive rate (MAI *et al*., 2007), their continuous breeding seem to have stimulated the development of peculiar reproductive strategies such as apparent intermittent reproduction, storage of sperm in reproductive appendages (gonopodium), in addition to the fact that these fishes are found at high densities throughout their range. Furthermore, after the first reproduction cycle of *A. microlepis*, new fertilization events might take place even during the embryonic process (NASCIMENTO; ASSUNÇÃO, 2008).

Females were predominant over males along most of the year. The same result was reported by Mai et al. (2007), Nascimento and Asunção (2008), Goyenola (2011), Nascimento et al. (2012), Cavalcante et al. (2012) and by additional studies in other Cyprinodontiformes, highlighting the female predominance in populations (OLIVEIRA *et al*., 2015; RODRIGUES *et al*., 2018). Such pattern can be related to environmental influence and viviparous reproduction, in which males need to spend more energy and time for mating, thus becoming easy targets for predators (CAVALCANTE *et al*., 2012). Similarly, environmental changes can act differently on individuals from each sex that might influence the variation in sex ratio (VAZZOLER, 1996). Furthermore, in the case of *A. microlepis*, polyandry is suggested to occur, i.e. a male copulates with several females (PANDIAN, 2011), since this is a common behavior in species with sexual reproduction (MITCHESON; LIU, 2008).

Studies that estimate the size at first sexual maturity in viviparous fish are still scarce. No females of *A. anableps* smaller than 14.9 cm were found carrying embryos by Ikeda et al. (2005). Nascimento and Assunção (2008) reported no occurrence of females smaller than 8.2 cm. According to Oliveira et al. (2011), the first gonadal maturation in females of *A. anableps* takes place when they reach 11.7 cm in standard length, while Cavalcante et al. (2012) stated that females can reproduce when they reach 13.86 cm, while the maturation of males occur when they reach 13.79 cm.

The results from the abovementioned studies differed from that obtained in the present study, since we observed sexually mature specimens with 11.5 cm in SL when both sexes were considered, reaching 11.9 cm for females and 11.1 cm for males. This difference might be related to the pressure caused by the incidental capture of the species as bycatch products or by collection of anablepids to feed traditional communities who live nearby coastal regions. To confirm the role of the *bycatch* effect in the reproduction of *A. microlepis*, it is necessary to sample populations of this species in areas not affected by fishing. This would be interesting to assert the effect of *bycatch* with greater confidence.

As a matter of fact, the finescale four-eyed fish are frequently caught in several parts along the coast of Pará by artisanal fisheries, using gillnets and by trawl nets focusing on exploitation of shrimp fisheries (FERREIRA *et al*., 2011). Usually, these fish are discarded because they are considered toxic species similar to pufferfish, *Colomesus psisitacus* and *Sphoeroides testudineus* (SANTANA NETO *et al*., 2010; BARBOZA; PEZZUTI, 2011; BARBOZA *et al*., 2014). Probably, this fishing pressure has favored the development of early maturation of specimens thus assuring the maintenance of populations, a phenomenon known as the theory of life cycles (STEARNS, 1992). Similar reproductive strategies have been reported in other coastal species, such as *Lutjanus purpureus*, C*ynoscion jamaicensis* and some crustaceans (MÁRCANO, 2002, BENTES *et al*., 2017).

High numbers of embryos were more frequently recorded in females from 12 cm to 16cm in SL, revealing that the higher the SL values, the higher the number of embryos that they could store. This positive relationship was previously reported by Burns and Flores (1981), Oliveira et al. (2011), and Cavalcante et al. (2012) suggesting that fertility is directly proportional to size, even though it is not necessarily related to increased fertility. Young specimens have reduced reproductive capacity because they are still at the beginning of the reproductive process while the oldest individuals lose their reproductive potential over time. Thereby, individuals at intermediate size classes (around 19 cm according to IKEDA *et al*., 2005) are at their best reproductive stage. Therefore, individuals found in habitats where predation is lower would present increased fecundity, production of larger embryos in both size and weight, and greater reproductive investment, traits that are directly related to their nutritional and energy intake (ZADONA *et al*., 2011).

The negative allometric growth found in all correlated linear measurements means that as the individual gets older, the growth of body parts occurs at a lower rate. Similar results were obtained by Cavalcante et al. (2012) for *A. anableps*, indicating that this a common feature for coastal fishes (MAIA *et al*., 2015; SOUZA, 2017).

The positive allometry obtained for weight in relation to the standard length in females was similar to that reported by Oliveira et al. (2011). These authors hypothesized that this pattern is related to the reproductive mode of this species, i.e., the weight increased significantly at reproduction and embryonic development stages because females need to absorb more nutrients to counterbalance the energy spent during these periods, particularly because embryos are nourished directly by the placenta (TURNER, 1938; KNIGHT *et al*., 1985). Actually, the reproductive processes have invariably evolved to optimize proper conditions to the success of offspring and, therefore, species usually converge energy to this important phase of life (OLIVEIRA *et al*., 2011).

The life history of the species, besides providing opportunities for the optimization of preservation processes is highly regulated by environmental factors. Thus, the presence of distinct dynamics in reproduction, growth, feeding, and migration are closely associated to ecosystems (ARTHINGTON *et al*., 2016; DUPONCHELLE *et al*., 2021). Accordingly, we observed that the variation of some parameters, mainly weight and size, could be related to seasonal effects. In addition, studies focusing on ecological information about coastal species, such as those inhabiting Ajuruteua, a region particularly favorable to the development of several commercially important species, are required to provide effective management and environmental conservation plans, since these ecosystems support artisanal and large-scale fisheries (BERKELEY *et al*., 2004).

Although the finescale four-eyed fish occurs at high densities and presents useful strategies to maintain their populations over time and space, this species has been continuously disregarded from approaches based on trophic models. These models are efficient tools for understanding local dynamics, besides predicting the impacts of distinct scenarios such as increased or reduced fishing pressure under some taxa (FREIRE *et al*., 2007, 2008; NASCIMENTO *et al*., 2011; MOURA). In addition, trophic models are helpful to the development of management policies, restoration plans, and assessment of impacts on ecosystems (PAULY *et al*., 2000; FULTON *et al*., 2011; DICHMONT *et al*., 2013). Therefore, the parameters used to design these models should be as reliable as possible as in order to assure accurate predictions and the elaboration of effective management strategies.

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