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Research Article

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Sex Ratio and Length-Weight Relationship for Five Marine Fish Species from Brazil

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Abstract

This study estimated the sex ratio and length-weight relationships for five marine fish species, *Mugil curema* (Valenciennes, 1836), *Chloroscombrus chrysurus* (Linnaeus, 1766), *Opisthonema oglinum* (Lesueur, 1818), *Hemiramphus brasiliensis* (Linnaeus, 1758) and *Lutjanus synagris,* (Linnaeus, 1758) from the Brazilian coastal waters. Fish were collected on monthly basis by local fishermen using diversified fishing gears, such as, beach seine net, ballyhoo fishing net, gillnets and hand lines. The population of *Mugil curema* showed the expected ratio of 1:1. However, predominance of male *C. chrysurus, O. oglinum* and *L. synagris*, and females of *H. brasiliensis* were recorded. In general, the *b* exponent ranged from 2.6243 (*C. chrysurus*) to 3.3647 (*L. synagris*). The results indicated a negative allometric growth for the species *O. oglinum* and *C. chrysurus*, and an isometric growth for *M. curema* and *H. brasiliensis*. Moreover, an isometric and a positive allometric growth were recorded for females and males of *L. synagris*.

Keywords: Length-weight relationship; Sex ratio; Marine fish; Brazilian coastal waters

Introduction

Artisanal fishing has an important impact on the economy of coastal areas of Brazil, mainly the Northeastern region which contributes 96.3% of fisheries production [1,2]. The fish species from artisanal fishing of this region, such as the white mullet, *Mugil curema*, Atlantic bumper, *Chloroscombrus chrysurus*, Atlantic thread herring, *Opisthonema oglinum*, ballyhoo, *Hemiramphus brasiliensis* and the lane snapper, *Lutjanus synagris* are important as a food source for people inhabiting the coastal region, and they also have an important role in the food chain of coastal ecosystems [3].

The sex ratio provides basic information to assess the reproductive potential and to estimates tock size of fish populations [4]. The length-weight relationship is useful in determining the weight when only the length measurements are available, and it also indicates the condition of the fish and permits comparisons of the parameters of the relationship between species from different regions [5].

Studies on the sex ratio and length-weight relationship of various marine fish species have been carried out around the world [6-12]. However, in northeastern Brazil, these studies are still scarce. Considering the importance of basic biological studies for the maintenance of natural fish stocks, the present study aimed to estimate the sex ratio and length-weight relationships of five marine fish species of northeastern Brazil.

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Materials and Methods

Study site and sample collection

The fishes were captured on monthly basis during a long-term project, in the coastal waters of Rio Grande do Norte State, Brazil (from 34° 59' to 37° 14' longitude W and from 4° 54' to 6° 34' latitude S). Samples of *H. brasiliensis* were captured from 1999 to 2001, *C. chrysurus*, *O. oglinum* and *M. curema* from 2006 to 2007 and *L. synagris* from 2010 to 2011. Fish samples were captured with the help of local fishermen. The specimens of *C. chrysurus, O. oglinun* and *M. curema* were captured using a beach seine net. The "ballyhoo fishing net" was utilized to capture *H. brasiliensis* and the specimens of *Lutjanus synagris* were sampled using gillnets and handlines with different hook sizes.

Fish collected were numbered, weighed in total body weight (to the nearest gram, g) and measured in total body length (to the nearest centimeter, cm). Detailed morphometric measurements and meristic counts were carried out to verify the taxonomical status of each fish species [13]. Since characteristics of sexual dimorphism were not exhibited by these species, each fish was dissected and sex was identified based on the macroscopic characteristics of gonads [14]. In this study maturation stages of the gonads were not estimated and consequently, juveniles and adults of each sex were grouped together as either males or as females.

Sex ratio

The sex ratio was given as males: females (M: F), calculated using the formula: total number of males/ total number of females [15]. The chi-square (χ^2) was used to verify the existence of significant differences between the sex ratio of the study species and commonly expected 1:1 sex ratio [16].

Length-weight relationship

The length-weight relationship was determined by the equation, $W = aL^b$, where W is the total weight (g), L is the total length (cm), *a* is the intercept (initial rate of growth or condition factor) and *b* is allometric coefficient (coefficient of growth or relative growth rate of fish) [17-19]. It is possible to determine the type of growth of a species through the allometric coefficient (*b*), which is isometric when $b = 3$, positive allometry when $b > 3$ and negative allometry when $b < 3$ [19,20]. Log-log plots were generated and 95% confidence limits for anti-log *a* and *b* were calculated for males, females and both sex. The *t* test was performed to confirm whether the value of *b* departed significantly from the isometric value of 3 and the differences between sexes [16].

Results and Discussion

Sex ratio

A total of 1127 fish samples were analyzed during the study period. The sex ratio for *M. curema* was 1.03:1 ($\chi^2 = 0.07$) not departing from

the expected sex ratio of 1:1. However, the sex ratio of *C. chrysurus* was 2.03:1 (χ^2=22.45), *O. oglinum* was 1.41:1 (χ^2=4.64) and *L. synagris* was 4.15:1 (χ^2=25.09), where males were significantly more numerous than the females during the study period. For *H. brasiliensis* sex ratio was 0.75:1(χ^2=6.44), showing a predominance of females in the population.

Information on sex ratio is important for understanding the relationship between individuals, the environment and the state of the population [21]. The sex ratio may vary from the expected 1:1 from species to species, or even in the same population at different times, being influenced by several factors such as adaptation of the population, reproductive behavior, food availability and environmental conditions [22-26]. For example, the reproductive success of female is normally related to access to resources and the environmental conditions, and not to the number of mating partners as in the case of males. Thus, the lifetime reproductive success of male is limited by access to females, while females are not limited by access males which lead to an unbalance in the number of individuals of each sex in the population [27]. However, none of these factors have been considered in this study. Therefore, these aspects must be considered in future studies.

Length-weight relationship

The parameters of length-weight relationship for the five marine fish species are presented in table 1. The coefficient of determination (r^2) ranged from 0.69 (*H. brasiliensis*) to 0.98 (*O. oglinum* and, *L. synagris*). The exponent *b* ranged from 2.6243 (*C. chrysurus*) to 3.3647 (*L. synagris*). The coefficient *b* ranged from 2.6243 to 3.3647 for males and 2.6935 to 3.3151 for females. In general, the value of *b* of the length-weight relationship was within the expected range of 2.5-3.5 [28]. The present study indicates a negative allometric growth for *C.chrysurus* and *O. oglinum*, a positive allometric growth for males and grouped sex of *L. synagris* and isometric growth for *M. curema*, *H. brasiliensis* and females of *L. synagris*. Thus, isometric growth indicates that the body increases in all dimensions in the same proportion during growth, whereas positive allometry indicates that the body becomes more rotund as it increases in length, and negative allometry indicates a slimmer body [19].

Negative allometric growth for grouped sex of *C. chrysurus* in southeastern coastal waters of Brazil has been reported [29]. An isometric growth was indicated for *O. oglinum* in the Mexico [30]. For grouped sex of *M. curema* isometric growth was observed in

Table 1: Descriptive statistics and parameter estimates of the length-weight relationship of five species of marine fish in coastal waters of northeastern Brazil. (M: males; F: females; B: both sex; n: simple size; Min: minimum; Max: maximum; SD: standard deviation; *a*: intercept; *b*: slope; CI: confidence interval; r^2: coefficient of determination; df: degree of freedom).

			Length (cm)		Weight (g)		Equation Parameters			
Order/family/species	**Sex**	**n**	**mean ± SD**	**min - max**	**mean ± SD min-max**	**log *a***	**CI of log *a***	***b***	**CI of b**	***r²***
Mugiliformes										
Mugilidae *Magil curema* (Valenciennes, 1836)	M	186	24.2 ± 3.3	15.6 - 32.6	141.3 ± 59.4 30 - 317.2	4.8205	5.110 to 4.530	3.0451[a]	2.954 to 3.136	0.95
	F	180	24.9 ± 4.7	15.6 - 34.5	160.5 ± 82.3 35.4 - 382	4.612	4.861 to 4.362	2.9857	2.908 to 3.063	0.97
	B	366	24.6 ± 3.7	15.6 - 34.5	150.7 ± 72.1 30 - 182	4.7216	4.910 to 4.532	3.0168	2.957 to 3.076	0.96
Perciformes										
Carangidae Chloroscombrus chrysurus (Linnaeus, 1766)	M	130	14.1 ± 3.0	8.2 - 26	31.3 ± 18 5.8 - 134.8	3.6058	3.844 to 3.367	**2.6243**	2.533 to 2.714	0.96
	F	64	14.9 ± 2.9	9.2 - 20	35.9 ± 17.9 9.5 - 75.6	3.7816	4.130 to 3.433	**2.6935**	2.563 to 2.823	0.96
	B	194	14.4 ± 3.01	8.2 - 26	32.7 ± 18.1 5.8 - 134.8	3.6656	3.859 to 3.472	**2.6481**	2.575 to 2.721	0.96
Clupeiformes										
Clupeidae *Opisthonema oglinum* (Lesueur, 1818)	M	92	13.5 ± 4.2	8.6 - 25	27.4 ± 26.2 5.7 - 136.6	3.9193	4.100 to 3.738	**2.6952**	2.624 to 2.765	0.98
	F	65	16.2 ± 5.4	8.5 - 27.2	47.6 ± 39.9 5.9 - 168.2	4.2172	4.440 to 3.993	**2.8082**[a]	2.726 to 2.889	0.98
	B	157	14.6 ± 4.9	8.5 - 27.2	35.7 ± 33.9 5.7 - 168.2	4.0671	4.203 to 3.931	**2.753**	2.701 to 2.804	0.98
Beloniformes										
Hemiramphidae *Hemiramphus brasiliensis* (Linnaeus, 1758)	M	148	23.5 ± 2.2	19.5 - 33.5	61.1 ± 23.9 24.7 - 196.1	5.1535	6.160 to 4.146	2.9213	2.602 to 3.240	0.69
	F	195	23.9 ± 2.3	15.5 -33	67.1 ± 22.3 14 - 155.7	5.4689	6.168 to 4.769	3.0334[a]	2.813 to 3.253	0.79
	B	343	23.7 ± 2.2	15.5 - 33.5	64.5 ± 23.2 14 - 196.1	5.4083	5.991 to 4.824	3.0091	2.824 to 3.193	0.75
Perciforrnes										
Lutjanidae *Lutjanus synagris* (Linnaeus, 1758)	M	54	23.6 ± 7.1	12.36	250.9 ± 214.9 17.5- 891.5	5.4309	5.729 to 5.132	**33647**[a]	3.269 to 3.460	0.98
	F	13	28.7 ± 5.08	21.5 -36.5	377.2 ± 214.1 25.5 - 743	5.3088	6.851 to 3.765	3.3151	2.854 to 3.776	0.95
	B	67	24.6 ± 7.07	12- 36.5	275.4 ± 219 17.5 -819.5	5.3828	5.666 to 5.099	**3.3467**	3.257 to 3.436	0.98

[a]Significant differences between sexes; bold: significant differences from 3 ($P < 0.05$).

the Cuyutlan lagoon of Mexico [31]. However, for the same species negative allometric growth for males and isometric growth for females was reported in the coastal lagoon of Tres Palos, Mexico [7].

The parameters of L-W relationships in fish are affected by factors such as, environmental conditions, gonad maturity stages, sex, stomach fullness, health condition, season, population and differences within species [28]. The information on the sex ratio and length-weight relationship of five marine fish species presented in this study could contribute to the management of natural stocks of these fish species which are ecologically and economically important, and possibly has suffered threats from overfishing, pollution and climate change.

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