Lat. Am. J. Aquat. Res., 44(4): 718-725, 2016
DOI: 10.3856/vol44-issue4-fulltext-7

Research Article

Potential of carapeba (*Eugerres brasilianus*) for aquaculture production

Emerson Carlos Soares[1], Andréa Guimarães-Paiva[1], Elton Lima-Santos[1], Simone Moreira-Pereira[1] Eduardo Santana-Santos[1], Erika Oliveira Almeida[2] & Themis Jesus Silva[1]
[1]Federal University of Alagoas, Brasil
[2]Federal Rural University of Amazon, Brasil
Corresponding author: Emerson Carlos Soares (soaemerson@gmail.com)

ABSTRACT. *Eugerres brasilianus* is an appreciated commercial species in the market of the northeastern region of Brazil**.** The purpose of this study was to analyze and determine the diet, reproductive period, and management of carapeba in recirculating aquaculture systems. The fishes were caught with a gillnet at two different places near the São Francisco River mouth. The stomach content was analyzed according to the frequency of occurrence method, using the index of relative importance, assessing the degsubjectedree of stomach repletion. The reproductive period was established by determining the gonadosomatic index and gonad maturation stages. The behavior and management of the fish were observed in captivity when subjected to artificial diets in cultivation tanks. The striped carapeba is best feed at dusk, mainly Crustacea Amphipoda, Insecta Chironomidae and Crustacea Tanaidacea. The species has parceled spawning, which occurs from February to March and from July to September. There are morphological differences between males and females, especially in the urogenital papilla, size and color. In captivity, the best fish density was between 7 and 8 fish m^{-3}, showing a good rates of centesimal composition, adapting well to the supplied diet.

Keywords: Gerreidae, feeding, behavior, sexual maturation, reproductive period, aquaculture.

Potencial de la mojarra (*Eugerres brasilianus*) para su cultivo

RESUMEN. *Eugerres brasilianus* es un pez marino comercial importante en el mercado del noreste de Brasil. El objetivo de este trabajo fue analizar y determinar la dieta, período reproductivo y manejo de la mojarra en estanques de recirculación de agua para el cultivo intensivo. Los peces fueran capturados con redes agalleras en dos sitios diferentes, cerca de la desembocadura del río São Francisco. Los contenidos estomacales fueron evaluados mediante el método de frecuencia de ocurrencia, através del índice de importancia relativa, evaluando el grado de repleción del estómago. El período reproductivo fue establecido determinando el índice gonadosomático y los estadios de maturación gonadal. Se observó el comportamiento y manejo de los peces en cautividad cuando son sometidos a dietas artificiales en estanques de cultivo. La mojarra se alimentó mejor en el crepúsculo, principalmente de Crustacea Amphipoda, Insecta Chronomidae y Crustacea Tanaidacea. La especie tiene desove parcelado, que ocurre de febrero a marzo y de julio a setiembre. Existen diferencias morfológicas entre machos y hembras, especialmente con relación a la papila urogenital, tamaño y color. En cautividad la mejor densidad de peces fue entre 7 y 8 ind m^{-3}, mostrando buenas tasas de composición centesimal, adaptándose bien a la dieta suministrada.

Palabras clave: Gerreidae, alimentación, comportamiento, madurez sexual, periodo reproductivo, acuicultura.

INTRODUCTION

The gerreids; popularly named carapeba, caratinga, carapicus or mojarras; have great importance in artisanal fishing and are greatly appreciated for human consumption. They are widely distributed from the Antilles to the south of Brazil (Bezerra *et al.*, 2001; Costa *et al.*, 2012).

The carapeba have been cited among the fish with the highest potential for marine fish farming in Brazil because it has good market value in some regions of the country, making it able to be used in polycultures and dugout ponds (Cavalli *et al.*, 2011).

Eucinostomus melanopterus, Diapterus rhombeus and *Eugerres brasilianus* are consistently captured in the vicinity of riverside towns of the lower São Francisco

Corresponding editor: Eduardo Ballester

River, northeastern Brazil. *E. brasilianus* sets as the most important among the species, being the sixth in landings as well as being the Gerreidae with the highest growth, reaching 40 cm (Bezerra *et al.*, 2001; Soares *et al*., 2011; Paiva *et al.*, 2013).

Despite the significant importance of this resource, data about its embryonic and larval development and reproductive cycle are rather scarce (Hernández *et al*., 2012). Little is known about the feeding rate and the reproductive biology of these anadromous organisms, which is considered as an obstacle to the proper managing in a farming environment (Poveda & López, 2007; Hernández *et al*., 2012).

Other factors, such as the behavior and the social relationships, are also essential to avoid the high degree of rejection of wild fish in captivity, normally related to stress and hierarchical behavior both to dominant as well as to dominated fish. They potentiate the aggression and cannibalism, contributing to changes in the growth rates and increased mortality in a confined environment (Sloman, 2007; Soares *et al*., 2007). Another important aspect to be approached refers to the studies about feeding habits, which are in extremely necessary so the ecological relations between organisms can be understood and to formulate diets capable to meet the nutritional demand in a confined environment.

Given this context, this study had as objective to understand the reproductive period, composition of the natural diet, behavior and feeding in a confined environment, from matrices of *E. brasilianus* captured from the mouth of the São Francisco River, in order to promote the viability of a cultivation form for this species.

MATERIALS AND METHODS

The fishing (authorized by SISBIO under the number 22211-1) and Animal Ethics Committee was done monthly between April 2013 and March 2014, in two areas near the Crôa Island and the Estuary/Fall (10º27'41.7"S, 36º26'13.5"W), comprising a distance between 2 and 10 km from the mouth of the São Francisco River (Fig. 1). The region is characterized by a sub-humid climate with an average annual temperature of 25°C and a varying precipitation of 500-1300 mm, concentrated between April and July.

The targeted fish of the whole study were mainly caught around dusk or at night, always in low tides in quadrature at a depth of 4 to 7 m, using gillnet (300x1.5 m; opening mesh of 45 mm between opposite knots). The time between the launching and the gathering of the fishing net was between 20 and 40 min.

Study of the feeding behavior

The fish were weighed on a scale with an accuracy of 0.01 g. Then, the digestive tract was removed and fixed in 4% formaldehyde. The biometric data of each fish (standard length-SL) were taken with the help of an analog caliper, and then weighed to get the gutted weight (GW). After 24 h, the digestive tract of each fish was removed from the formaldehyde (4%) and stored in 70% ethyl alcohol for later analysis of the stomach contents (ASC).

The ASC was conducted through qualitative and quantitative methods; the Digestion Degree (DD) analysis being the qualitative method, and the Repletion Index (RI), Frequency of Occurrence (%FO) and Numerical Frequency (%NF) corresponded to the quantitative methods. The Important Alimentary Index (IAi) proposed by Kawakami & Vazzoler (1980) was also used to identify in the lowest taxonomic category possible.

The stomach Repletion Index (RI) consists of the analysis of the amount of food in the stomach or digestive tract, being able to observe if it is full, empty or with a little amount of food, expressed in percentages, according to five categories for RI: empty, partially empty, medium, partially full, and full.

The Frequency of Occurrence (%FO) corresponded to the percentage that specific feeding item occurs in the stomach or digestive tract, being expressed by the $\text{FO\%} = (n_i \div N) \times 100$, where n_i is the number of stomachs or digestive tracts in which the item "*i*" occurred and N is the total number of stomachs or digestive tracts with content analyzed.

The Numerical Frequency (% NF) was determined by counting the number of alimentary items found in each digestive tract, divided by the total number of fish, verified by the formula: $\text{\%NF} = (n_i \div N) \times 100$ where n_i is the number of the item "*i*" and N is the total number of items shown. The alimentary items were counted, being considered only the whole organisms or parts which were possible to be identified.

The method proposed by Kawakami & Vazzoler (1980) was used for the Important Alimentary Index (IAi), given by: $\text{IAi} = (\%FO \times \%NF) \times 100 \div \sum(\%FO \times \%NF)$ where FO is the frequency of occurrence of the item shown and FN is the numerical frequency of the item shown. The categories were classified as main (IAi ≥ 50%), secondary (25% ≥ IAi <50%), and accessory (IAi <25%).

Study of the reproductive period

The specimens were labeled and conditioned in isothermal coolers (Styrofoam boxes) of 20 kg with ice, and then transported to the laboratory. After the iden-

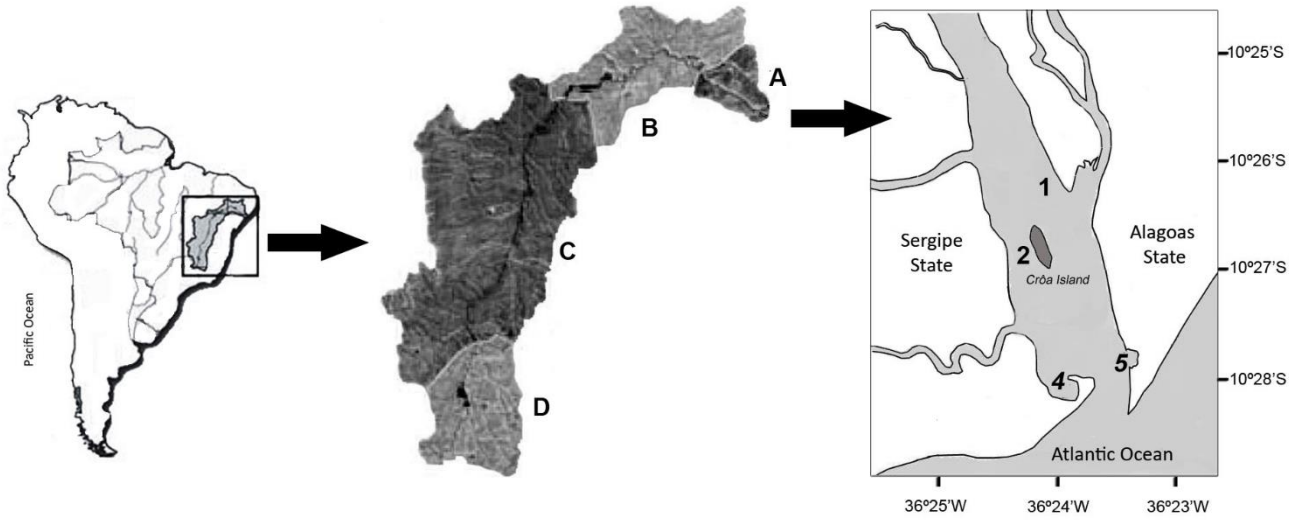

Figure 1. São Francisco River basin (A: High São Francisco, B-C: Medium São Francisco; D: Lower São Francisco) (points 4 and 5-estuary, points 1 and 2- Crôa Island (10º27'41.7''S, 36º26'13.5''W). Photo: Simone Moreira.

tification and photographic records, the animals were measured with the help of an ictiometer and a digital caliper, obtaining the following parameters: standard length (SL), head length (HL), interorbital distance (ID) and height (ALT). The fish were weighed on a digital scale with an accuracy of four decimals. The gonads were separated from the extracted material and were measured in for their length and diameter using a digital caliper, then weighed on an analytical scale, and last, conditioned in pots with 4% formalin, and after 24 h, in 70% alcohol for further macroscopic analysis.

The gonad maturation stages were made following the Vazzoler scale (Vazzoler, 1996), being classified in five stages: Stage A (immature), Stage B (in maturity), Stage C (mature) and Stage D (emptied). Additional characteristics were computed such as length and weight of the gonad in relation to the abdominal cavity, vascularization, coloration and degree of turgidity.

Calculation of the reproductive parameters

In order to determine the gonadosomatic index (GSI) of fish, the equation, $\text{IGS} = (GB \div BW) \times 100$, was applied where GW is the gonad weight, and BW the body weight.

The sexual proportion between males and females was estimated from the relation of the total number of both sexes in all the months that the fish were caught, using the nonparametric chi-square (χ^2), using the equation: $\chi^2 = (O - E)2 \div E$, where O is the frequency percentage of males and females per month, and E is the expected sexual proportion.

In addition, factors about the presence of sexual dimorphism were observed between the sexes and between mature and immature fish by observing the urogenital papilla, color and other morphological characteristics.

Maintenance of the reproducers in cultivation facilities

The fish were captured alive and then accommodated in three 50-L coolers (styrofoam boxes) each, using a volume of 30 L of water, maintaining the average temperature of 25ºC with constant and partial water exchange in order to keep the amount of oxygen above 5 mg L^{-1}.

Concluding the transportation, the fish were transferred to a reception tank with dimensions of 152x71x51 cm and 5 salinity and sandblasting constant for a period of one hour. After this stage, they were conditioned in another tank of the same size containing eugenol as an anesthetic, diluted in 1/10 alcohol at a concentration of 4 mg L^{-1}. Next, the specimens were weighed and measured (standard length), and then the urogenital papilla was observed and the presence or absence of ectoparasites. Finally, after the biometrics, the fish were chipped with ISO FDX-B transponder of 134.2 Khz and accommodated in pre-molded PVC canvas tanks with a necessary volume of 2000 L and salinity around 10.

The tanks, in a recirculation system, were arranged on a wooden platform of 30 cm high. They were set in a way that there would be a flow into treatment water

boxes of 0.50 m³ containing mechanical filters filled with bivalve shells, gravel, crushed stone, sand and cartridge filters with filtering capacity of 25 µ, and another biological filter with added bioballs increase and aerobic bacteria (biofilter) and two Canister model filters.

The water quality indicators in field and in laboratory pH, oxygen, oxide-reduction potential (ORP), dissolved solids and temperature were monitored with a multiparameter probe from Hanna Instruments, model 9828, Woonsocket, USA, to a depth of approximately 1.5 m below the water surface. The total ammonia ($NH3^+$ $NH4^+$) was measured weekly and evaluated with the help of a spectrophotometer from Hanna Instruments, model HI 83203, Belgium, using the model HI93700-01 reagents. The nitrate NO_3^- and phosphorus (P) of the emissions were analyzed with the same equipment, using the HI93705-01 reagents for nitrate and the HI93717-01 reagents for the phosphate.

The diet in captive carapebas corresponded to a proportion of 60% of crustacean and bivalve mollusks (freshwater shrimp-*Macrobrachium acanthurus*, Crustacea Amphipoda and maçunim-*Anomalocardia brasiliana*) and a pelleted diet with 40% crude protein, containing fishmeal, soybean meal, protenose, premix, soybean oil and wheat flour (Table 1).

Analysis of the centesimal composition

Ten carapeba fish were evaluated aiming to obtain the body composition, assessing proteins (Kjeldhal method), humidity, with an oven at 105°C, ashes; obtained with a muffle at 550°C and total lipids by extraction with chloroform and methanol (2:1) (AOAC, 1990).

Statistical analyzes

The analysis of morphological data, were analyzed by ANOVA (5% probability), the differences were tested with a Tukey test (5%) and the Bonferroni test for the comparison of two measurements (5%).

RESULTS

Studies of the feeding behavior

The average water temperature, dissolved oxygen, pH and salinity at the places obtained maintained an average of 25.0 ± 0.7ºC, 4.0 ± 1.0 mg L^{-1}, pH 4.5 ± 0.6 and salinity 6.0.±3.5, throughout this study period.

In studies of the feeding behavior, 141 *E. brasilianus* fish were caught with standard length (SL) ranging between 11.7 and 26.0 cm, though, 106 (75%) of these had some food in their digestive tract. The analysis of the digestional degree (DD) revealed that only 5.6% of the fish had the digested gastrointestinal contents unidentifiable and 25.6% were at the beginning of the digestion, making it was possible to identify most of the alimentary items consumed by the fish. For *E. brasilianus* fish caught near the mouth of the São Francisco River, the digested organic matter (DOM) accounted for around 49% of its gastrointestinal content. The frequency of occurrence (%FO), the numerical frequency (FN%) and the IAi of ingested items by the carapeba are described in Table 2, where it was possible to identify 13 alimentary categories.

Table 1. Chemical composition of diet for carapebas in capitivity.

Items	%
Crude protein	36.0
Ether extract	4.0
Humidity	12.0
Mineral matter	8.0
Fibrous material	2.0
Calcium	0.6
Phosphorus	0.6

Studies of the reproductive behavior

One hundred thirty-four *E. brasilianus* fish, 98 being female and 36 being male, were analyzed to determine the reproductive period, with a predominance of female fish (proportion 1M:3F) throughout the sample period, of which 75% of the captured fish were found with their gonads in development or mature.

Regarding the seasons of the year, the number of females predominated in all the periods, moreover in the summer (January) and end of spring (November) the relation between the proportion of females and males reached the highest levels (1M:4F, $\chi^2 = 12.5$ and 1M:3,4F; $\chi^2 = 9.5$) (chi-square test, χ^2; $P < 0.05$). In February and March (dry season), some fish were found with gonads in maturation and spawned; and between March and April (beginning of the rainy season), the occurrence of more than 50% (L_{50}) of the fish caught in process maturation was observed. However, in the months of July to September, the highest occurrence of mature and spawning fish was recorded (Fig. 2).

The standard length of the smallest and greatest mature female specimen was 16.3 and 25.0 cm respectively, whereas for the males this length was 14.8 and 19.2 cm (smallest and largest specimen). However, the L_{50} or length of first sexual maturity for the carapebas at the mouth of the São Francisco River was estimated at 15.0 cm for the males and 17.0 cm for the females, while the L_{100} (average standard length in which

Table 2. Alimentary items of the *E. brasilianus* with their frequency of occurrence (FO%), numerical frequency (FN%), important alimentary index (IAi%) and the category of the alimentary index (CAI).

Items alimentary	FO%	FN%	IAi%	CAI
Amphipoda Crustacea	53.77	44.75	51.00	Main
Chironomidae Insecta	45.45	35.00	35.00	Secondary
Tanaidacea Crustacea	43.40	15.30	12.26	Accessory
Isopoda Crustacea	19.81	0.75	0.25	Accessory
Ostracoda Crustacea	9.45	0.60	0.12	Accessory
Mollusca Gastropoda	17.00	0.96	0.40	Accessory
Mollusca Bivalvia	9.45	0.53	0.10	Accessory
Turbellaria	16.85	0.92	0.30	Accessory
Nematoda	11.32	0.59	0.10	Accessory
Insecta	12.26	0.60	0.12	Accessory
Macroalgae	11.23	-	-	-
Bivalve digested	32.07	-	-	-
Sediment	42.45	-	-	-
Digested organic matter	49.05	-	-	-
Others	4.00	-	-	-

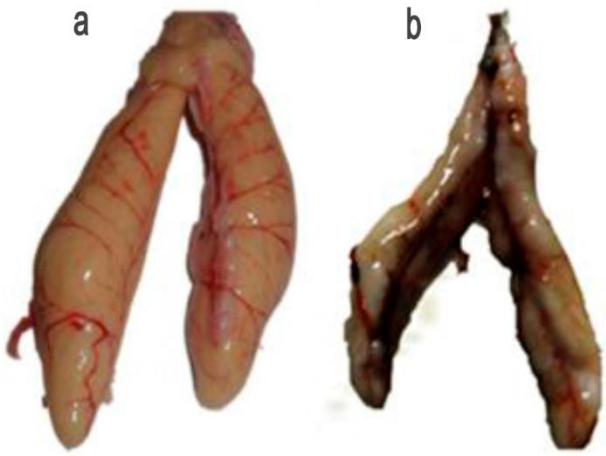

Figure 2. a) Yellowish mature female gonad, vascularized and with large oocytes full of yolk, b) mature male gonad, testicles occupying part of the coelomic cavity, flowing milky sperm. Photos: Simone Moreira.

all fish are able to reproduce) was 17 cm for the males and 20 cm for the females.

The gonadossomatic indexes (GSI average) revealed that the months from July to September showed the highest indexes for female specimens, corresponding to 5.6; 6.4 and 3.4. In male fish, the highest indexes occurred in the months of June and August, with 5.6 and 5.8. This statement suggests that the second semester reflects the best reproductive period of this species (ANOVA, $P < 0.05$; 5% Tukey test).

The average weight of female fish (230.4 ± 35.0 g) throughout the year was significantly higher than the male fish (162.3 ± 18.2 g), (Bonferroni test, $P < 0.05$), and the females being found with the highest weight values in the month of November (296 g) and males in June (230 g).

As for the morphometric data, except for the standard length (SL) data, there were no significant differences for both sex or age, between characters; interorbital distance (ID) (cm); head length (HL) (cm) and height (ALT) (cm) (ANOVA, $P > 0.05$).

The presence of the three orifices (excretion, feces and urine) and adult females is clearly visible when they show standard lengths greater than 18.0 cm, while in mature male fish, they are seen only two orifices: of excretion and releasing of the spermatozoa (Fig. 3).

Studies of capture, acclimatization, and behavior in captivity

The mortality rate between the capture and transportation was 20%, due to injuries from the capture, being common in fish with longer standard lengths (above 20 cm).

As for the behavior in captivity, 34 carapebas with an average length of 18 ± 2 cm and weight of 166.0 ± 10.8 g, and by the end of three months in farming tanks had average final weight of 200.0 ± 12.2 g, being a weight gain of 45 ± 7 g and feeding conversion of 2.0 ± 0.12.

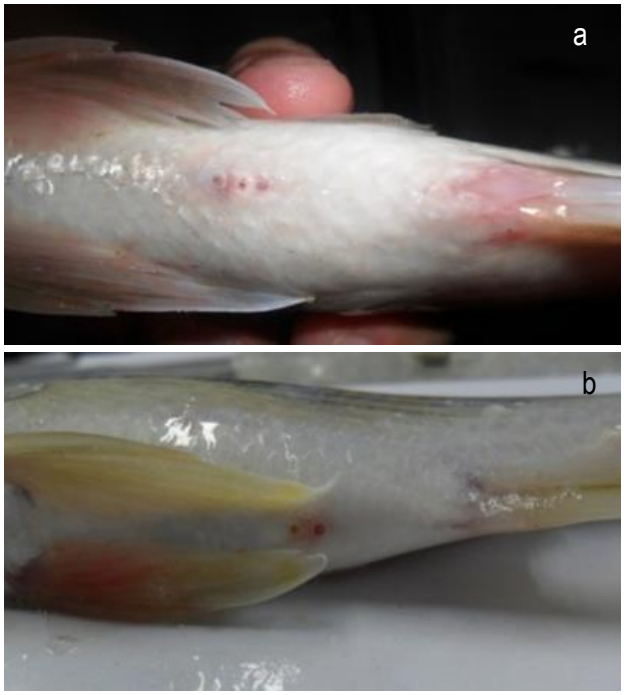

Figure 3. a) The ventral region of carapebas with vision of the papilla urogeni of females, and b) males Photos: Simone Moreira.

The physical and chemical parameters in a confined environment were as follows: 7.7 ± 0.3 mg L^{-1} oxygen-O_2, 26.9 ± 1.4 temperature (T°C), 7.7 ± 0.1 pH, 13.7 ± 2.5 salinity, 18.9 ± 0.1 µS cm^{-1} conductivity, 12.3 ± 0.1 mg L^{-1} total dissolved solids (TDS), and 70.0 ± 7.0 mg L^{-1} oxide-reduction potential (ORP) were measured during the experiment and presented satisfactory results. The ammonia (<1 mg L^{-1}) showed low values, showing no significant changes throughout this study.

During the early phases of this study, it was observed that to reduce the density of carapebas per tank (2 to 4 fish m^3), promotes the development of territorial instinct, however, as more fish are added to the system (7 to 8 fish m^3), this aggressive behavior reduces significantly. Incidents such as chasing each other with aggression (common among darker colored males) causing injuries to the scales and/or fins, besides fights and/or competition for food and territory, is the third cause of death.

At the end of the experiment, all fishes had adapted well, feeding with greater feeding rate around dusk and a smaller scale in the early hours of dim environment. As for the centesimal composition, the carapebas which were fed the artificial diet had protein, lipid, humidity and ash content of 18.2 ± 1.1%; 2.8 ± 0.6%; 76.3 ± 2.0% and 1.2 ± 0.2% on wet matter, respectively.

DISCUSSION

Results with feeding behavior suggest that the feeding time of this species is possibly nocturnal, since fishing was mainly done in the evening (at dusk). In support of this hypothesis, the digestive tracts of all carapebas captured during daytime were empty (GR).

The carapeba is a fish with nocturnal habits, well-defined pace, generalist and opportunistic, which concentrates its feeding activity during the evening, but feed itself during the day in darker places (Zavala-Camin, 1996; Ramos *et al*., 2014).

The high amounts of DOM and high rate of sediment in the digestive tract of the Gerreidae is common. This fact is due to their "poke around" substrate feeding behavior looking for their prey. According to Blaber (2000), the highly protractile mouth is a characteristic of Gerreidae family that allows them to capture small invertebrates and explore available food resources in substrate.

In this study, Crustacea Amphipoda, Insecta Chironomidea, and Crustacea Tanaidacea were the three most important items consumed. These results suggest that the *E. brasilianus* as an opportunistic species, due to the consumption of prey available in abundance in the environment and generalist by ingest a wide variety of items throughout the year. According to Zavala-Camin (1996), these fish are considered omnivores, being able to change alimentary spectrum according to the availability of food in the environment. Ekpo *et al.* (2014) showed 183 food ocurrences in estuarine fish in Qua Iboe River estuary, Nigeria, when crustaceans, detritus, nematodes, protozoans and insects were more found. According with study, the fishes feed on more than one type of food item, which reduced competition.

Crustacea Amphipoda represented the largest item in the IAi for the carapebas, being the food most eaten during the drier season in the region of the mouth of the São Francisco River. As a food source, the amphipods are fundamental to various groups, including fish, being found in considerable quantities in the stomach contents of commercially important species (Palma & Ojeda, 2002). The alimentary items consumed by *E. brasilianus* were similar to those observed in studies of Chaves & Otto (1999), except for the occurrence of polychaete, which was not seen as a feeding item of this species during this study period at the mouth of the San Francisco River.

The macroscopic analysis of the gonads allowed to confirm that the reproductive period possibly coincided with the end of the rainy season and beginning of the dry season (July to September), and the end of the summer/drier season (February-March), classifying

the carapeba as a fish that spawns at different moments. Such a fact can also be seen in the study of Silva *et al*. (2005) with fish of the same family.

This hypothesis is confirmed in the studies of Bezerra *et al*. (2001), in which states that the GSI average of *Diapterus rhombeus* showed lower amplitude in the first trimester of the year and detecting higher levels in the third and fourth trimester. It is likely that the *E. brasilianus* may migrate for reproductive purposes from fresh water to coastal environment, having sheltered and good food supply near the mouth of a river as a transitional environment/area, thus completing their reproductive cycle. Such hypothesis is consistent with the findings of Chaves & Otto (1998) with rhombeus *Diapterus* species, and also with Barbanti *et al.* (2013) analyzing the fauna fish in the Bertioga Channel in São Paulo.

As for the predominance of females in this study, Raposo & Gurgel (2001) stated that the highest incidence of females means a response of the population to the favorable conditions provided by the environment (preserved mangrove area), such as increased alimentary supply. The most docile behavior that territorial males (agonistic behavior with death because of fights and injuries) and degree of longevity reached are also factors to be considered (Shibatta, 2006).

Both male and female fish differ in the standard medium length, dark color (dominant males), the urogenital papilla shape and bulging belly (mature females). This discussion is reinforced in the studies of Ramires *et al.* (2007), in which stated that most of the fish do not have external morphological characteristics that can be observed in the distinction between the sexes.

The capture point 5 and 6 adopted as more expressive mangrove areas and of higher salinity (between 10 to 15) characterized by having a higher incidence of fish caught, very likely because of the availability of food and shelter/transitional area since the carapebas spawn in coastal regions and salinity near 30 (Ayala-Perez *et al*., 2001; Santos *et al.*, 2012).

The average of mortality is common during of capture and trasportation, Reyes *et al*. (2012) stated in their studies that the formation of a new reproducer stock takes more time due to adjustments during the capture phase and acclimatization, where the longer specimens are susceptible to the handling of the fixture due to the high stress.

The Agonistic behavior of carapeba can be atributed to territorialism. Territorialism is the behavior of defending a feeding area and factors related to the density of the fish in an area can also influence the territoriality in a population (Holbrook & Schmitt, 2002). This significantly decreased with increasing density, maintenance of homogeneous lot, increase in the number of feeders and disposal (reduction) of aggressive males (dominant). After the first two weeks of acclimation, the formation of couples was observed, even though the male normally was smaller and darker, it had a protective behavior while courting the female.

The centesimal composition of the carapebas studied, after five months in captivity, showed good parameters of humidity, ash, lipids, and especially protein content. The analysis of this study are reinforced by the information from Menezes *et al.* (2009), stating that the striped carapeba has good protein indicators, near 21%, low cholesterol content and lipid.

CONCLUSIONS

The *E. brasilianus* can be classified as a first order carnivorous species (CI) since its main food is Crustacea Amphipoda and Insecta Chironomidae. It can also be considered a generalist and opportu-nistic due to the change in their feeding spectrum according to the time of the year.

The reproductive period of the *E. brasilianus* at the mouth of the São Francisco River has two peaks: the first from February through March (drier season) and the second, which is most favorable to reproduction, from July to September, with an initial size of sexual maturity of 17 cm for females and 15 cm for males.

The carapeba adapted well to the artificial diet offered which gave them a good centesimal and organoleptic composition into its meat, being an alternative to inclusion of the species in the cultivation.

REFERENCES

Association Official of Analytical Chemist (AOAC**)**. 1990. Official methods of analysis. Association of Official Analytical Chemist, Arlington, 1298 pp.

Ayala-Perez, L.A., B.A. Gomez-Montez & J.R. Miranda. 2001. Distribución, abundancia y parámetros poblacionales de la mojarra *Diapterus rhombeus* (Pisces: Gerreidae) en la Laguna de Términos, Campeche, México. Rev. Biol. Trop., 49: 635-642.

Barbanti, B., R. Caires & A.P. Marceniuk. 2013. A ictiofauna do canal de Bertioga, São Paulo, Brasil. Biota Neotrop., 13: 276-291.

Bezerra, R.S., V.L.A. Vieira & A.J.G. Santos. 2001. Ciclo reprodutivo da carapeba prateada *Diapterus rhombeus* (Cuvier, 1829) no litoral de Pernambuco. Trop. Oceanogr., 1: 67-78.

Blaber, S.J.M. 2000. Tropical estuarine fishes: ecology, exploitation, and conservation. Blackwell Science, London, 372 pp.

Cavalli, R.O., E.C. Domínguez & S. Hamilton. 2011. Desenvolvimento da produção de peixes em mar aberto no Brasil: possibilidades e desafios. Rev. Bras. Zool., 40: 155-164.

Chaves, P.T.C. & G. Otto. 1998. Aspectos biológicos de *Diapterus rhombeus* (Cuvier) (Teleostei, Gerreidae) na baía de Guaratuba, Paraná, Brasil. Rev. Bras. Zool., 15: 289-295.

Chaves P.T.C. & G. Otto. 1999. The mangrove as a temporary habitat for fish: the *Eucinostomus* species at Guaratuba Bay, Brazil (25º52'S, 48º39'W). Braz. Arch. Biol. Technol., 42: 1-8.

Costa, M.R., R.J. Albieri, L.M. Neves, A.B.L. Santos & F.G. Araújo. 2012. Distribution size of the mojarra *Dapterus rhombeus* (Cuvier) (Actinopterygil, Gerreidae) in a southeastern Brazilian bay. Braz. J. Oceanogr., 60: 201-209.

Ekpo, I.E, M.A. Ibok-Essien & J.N. Nkwoji. 2014. Food and feeding habits and condition factor of fish species in Qua Iboe River Estuary, Akwa Ibom State, Southeastern, Nigeria. Int. J. Fish. Aquat. Stud., 2(2): 38-46.

Hernández, R.E., M.A. Pereira, A. Castillo, E. Luna, J.A. Cruz, L.M. Gómez & J.V. Zenil. 2012. Embryonic and larval development of *Eugerres mexicanus* (Perciformes: Gerreidae) in Tenosique, Tabasco, Mexico. Rev. Biol. Trop., 60: 369-379.

Holbrook, S.J. & J. Schmitt. 2002. Competition for shelter space causes density-dependent predation mortality in damselfishes. Ecology, 83: 2855-2868.

Kawakami, E. & G. Vazzoler. 1980. Método gráfico e estimativa de índice alimentar aplicado no estudo de alimentação de peixes. Bol. Inst. Oceanogr., 29: 205-207.

Menezes, M.E.S., G.M. Lira, C.M.B. Omena, J.D. Freitas & A.E.G. Sant'Ana. 2009. Valor nutritivo de peixes da costa marítima de Alagoas, Brasil. Rev. Inst. Adolfo Lutz, 68: 21-28.

Paiva, A.C.G., P.T. Chaves & M.E. Araujo. 2013. Distribution of estuarine fish fauna along coast of Brazil. Trop. Oceanogr., 41: 1-36.

Palma, A.T. & E.P. Ojeda. 2002. Abundance, distribution and feeding patterns of a temperature reef fish in subtidal environments of the Chilean coast. The importance of understory algae turf. Rev. Chil. Hist. Nat., 75: 189-200.

Received: 10 October 2015; Accepted: 6 June 2016

Poveda, O.H.A. & S.L.L. López. 2007. Saline acclimation of striped mojarra *Eugerres plumieri* (Cuvier, 1830) and optimal dosage of carpa pituitary extract (CPE) to induce spawning. Rev. Fish Biol. Fish., 17: 11-19.

Ramires, M., S.M.G. Molina & N. Hanajaki. 2007. Etnoecologia caiçara: o conhecimento dos pescadores artesanais sobre aspectos ecológicos da pesca. Biotemas, 20: 101-103.

Ramos, J.A.A., M. Barletta, D.V. Dantas, A.R.A. Lima & M.F. Costa. 2014. Trophic niche and habitat slifls of sympatric Gerreidae. J. Fish. Biol., 85: 1446-1469.

Raposo, R.M.G. & H.C.B. Gurgel. 2001. Estrutura populacional de *Serrasalmus spilopleura* Kner, 1860 (Pieces, Serrasalmidae) da lagoa de Extremoz, estado do Rio Grande do Norte, Brasil. Acta Sci., 23: 409-144.

Reyes, A., R. Kido & C.A. Moreno. 2012. Captura y mantención de *Dissostichus eleginoides* para conformar un plantel de reproductores. Lat. Am. J. Aquat. Res., 40(4): 1066-1071.

Santos, T.O., K.V.S. Andrade, H.V.S. Santos, D.A.F.G. Castaneda, M.B.S. Santana, F.S.R. Holanda & M.J.C. Santos. 2012. Caracterização estrutural de bosque de mangue: estuário do São Francisco. Sci. Plena, 8: 1-7.

Shibatta, O.A. 2006. Comportamento social do pirá-brasília, *Simpsonichthys boitonei* Carvalho (Cyprinodontiformes, Rivulidae). Rev. Bras. Zool., 23: 375-380.

Silva, J.P., N.S. Reis & R.M. Mello. 2005. Caracterização macro e microscópica dos ovários das carapebas e carapevas, durante o ciclo reprodutivo. Rev. OMNIA Saúde, 1: 55-67.

Sloman, K.A. 2007. Effects of trace metals on salmonid fish: the role of social hierarchies. Appl. Anim. Behav. Sci., 104: 326-345.

Soares, E.C.S., M. Pereira Filho, R. Roubach & R.C.S.E. Silva. 2007. Condicionamento alimentar para o tucunaré. Rev. Bras. Eng. Pesca, 2: 35-48.

Soares, E.C.S., A.M.S.S. Bruno, J.M. Lemos & R.B. Dos Santos. 2011. Ictiofauna e pesca no entorno de Penedo, Alagoas. Biotemas, 24: 61-67.

Vazzoler, A.E.A. 1996. Biologia da reprodução de peixes teleósteos. Eduem/SBI, Maringá, 169 pp.

Zavala-Camin, L.A. 1996. Introdução aos estudos sobre alimentação natural em peixes. Eduem/SBI, Maringá, 129 pp.