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Population structure of fish fauna in the estuarine area of Caeté River, Bragança, Pará, Brazil

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ABSTRACT. This study describes the relative size and age structure of the sciaenids *Macrodon ancylodon*, *Stellifer rastrifer* and *Stellifer naso*, the ariid *Cathorops spixii* and the aspredinid *Aspredo aspredo* in the estuary of the Caeté River. Four bimonthly samples were collected with trawl and gill nets during August, October and December 1996 and February 1997 in three different areas: (A) main river channel, (B) bay, and (C) coastal areas. Total length and weight of 16,298 individuals of all these species were recorded. Monthly frequency distributions were plotted. Cohorts were identified by dividing the distribution into separate normal distributions; asymptotic length (L_∞) and K were estimated for these stocks by FISAT program. Biomass averages (g/m^2) were estimated using the swept area method. Average biomass of *Macrodon ancylodon* was $0.29 g/m^2$, total length ranged from 3cm to 41cm; length frequencies identified five cohorts; L_∞ = 45.50cm and K = 0.491 $year^{-1}$. For *Stellifer rastrifer,* average biomass was 0.31 g/m^2; total lengths ranged from 1 to 17cm; L_∞ = 22.5cm and K = 0.31 $year^{-1}$. For *Stellifer naso*, average biomass was 0.03 g/m^2 ; L_∞ = 26.3cm and K = 0.321 $year^{-1}$, total lengths ranged from 2 to 25cm. For *Cathorops spixii*, average biomass was 0.55 g/m^2; L_∞ = 33.3cm and K = 0,36 $year^{-1}$; density was much higher in the river habitats. *Aspredo aspredo* presented a biomass of 0.06 g/m^2; abundance was higher in the river; total lengths ranged from 2 to 36cm; L_∞ = 42.5cm and K = 0.35 $year^{-1}$. Despite the different biological strategies of each species with respect to spatial distribution and relative abundance, they all utilize the estuarine habitat as nursery grounds in the early phases of their life cycles.

Key words: average biomass, Caeté estuary, population structure, *Aspredo aspredo*, *Cathorops spixii*, *Macrodon ancylodon, Stellifer rastrifer, Stellifer naso.*

RESUMO. Estrutura populacional de peixes no estuário do rio Caeté, Bragança, Pará, Brasil. Este estudo descreve o tamanho relativo e a estrutura etária dos peixes cienídeos *Macrodon ancylodon, Stellifer rastrifer* e *Stellifer naso*, o ariídeo *Cathorops spixii* e o aspredinídeo *Aspredo aspredo* para o estuário do rio Caeté. Quatro amostragens bimensais foram feitas com malhadeira e rede de arrasto de fundo, durante os meses de agosto, outubro e dezembro de 1996, e fevereiro de 1997, em três áreas diferentes: (A) canal principal do rio, (B) baía, e (C) área costeira. O comprimento total e o peso de 16.298 exemplares dessas espécies foram avaliados. Distribuições de freqüência mensais foram plotados. As coortes foram identificadas ao dividir as distribuições de freqüência em distribuições normais isoladas. O comprimento assintótico (L_∞) e K foi estimado para esses estoques, com o uso do programa FISAT. A biomassa média (g/m^2) por espécie foi estimada utilizando-se o método de área varrida. A biomassa média de *Macrodon ancylodon* foi $0,29 g/m^2$; seu comprimento total variou de 3-41cm; as distribuições de freqüência permitiram identificar cinco coortes; L_∞ = 45,50cm e K = 0,491 ano^{-1}. *Stellifer rastrifer* apresentou uma biomassa média de $0,31 g/m^2$ e seus comprimentos totais variaram de 1-17cm, L_∞ = 22,5cm e K = 0,31 ano^{-1}. *Stellifer naso* teve biomassa média de $0,03 g/m^2$, L_∞ = 26,3cm e K = 0,321 ano^{-1}; seu comprimento total variou de 2 a 25cm. *Cathorops spixii* apresentou biomassa média $0,55 g/m^2$, estimativas de L_∞ = 33,3cm e K = 0,36 ano^{-1}; sua densidade foi a mais alta dentro dos habitats do rio. *Aspredo aspredo* apresentou biomassa de $0,06 g/m,^2$ maior abundância dentro do rio; comprimento total de 2 a 36cm; L_∞ = 42,5cm e K = 0,35ano^{-1}. Ainda que cada uma dessas espécies apresenta diferentes estratégias biológicas quanto à distribuição espacial e à abundância relativa, verificou-se que todas utilizam os habitats estuarinos como áreas de criadouro, nas primeiras fases de seu ciclo de vida.

Palavras-chave: biomassa média, estrutura de populações, estuário do rio Caeté, *Aspredo aspredo, Cathorops spixii, Macrodon ancylodon, Stellifer naso, Stellifer rastrifer*.

Estuaries are natural coastal ecosystems with high levels of fish biomass and productivity (Haedrich and Hall, 1976). The estuary of the Caeté river on the coast of the state of Pará, Brazilian Amazon, is a typical example of a tropical coastal ecosystem with a high richness of fish species (over 90) inhabiting estuarine areas during part or all of their life cycles. Latitudinal distribution gradients of estuarine species determine their respective growth parameters, age and length, which vary from stock to stock within the same species. Therefore, a particular species may have a different population structure in different parts of its geographic distribution range. Likewise, successive cohorts may grow at different rates depending on environmental conditions (Sparre and Venema, 1992). On the other hand, it is not known whether the findings of studies on stock composition, productivity, physiological and behavioral adaptations, etc. conducted in higher latitudes of the Brazilian coast (Vazzoler, 1965; 1969a; 1969b; Vazzoler, 1975; Yamaguti, 1967, 1968; Santos, 1968; Yamaguti and Santos, 1966; Giannini and Paiva Filho, 1990) are also applicable to fish populations of northern Brazil, particularly in the complex Amazonian region.

Among the most frequently caught species in the estuary of the Caeté river are the sciaenids *Macrodon ancylodon* (Bloch and Schneider, 1801), *Stellifer rastrifer* (Jordan in Jordan and Eigenmann, 1889) and *Stellifer naso* (Jordan in Jordan and Eigenmann, 1889), the ariid *Cathorops spixii* (Agassiz, 1829) and the aspredinid *Aspredo aspredo* (Linnaeus, 1758). This study describes the relative size and age structure of all these species in the region. It presents some observations on their respective occurrence in fresh, brackish, and marine water systems, and how they utilize the estuary as a habitat for nursery or growth. Previous works on *M. ancylodon* and *C. spixii* along the southeastern and northeastern coast of Brazil (Yamaguti 1979; Melo and Teixeira 1992) indicate the existence of different populations in a given system.

The area of study is located in eastern Pará, Brazilian Amazon, between 46°32'16' and 46°55'11" longitude W, and 00°43'18" and 00°04'17" latitude S. The Caeté river runs on the coastal plain of Bragança, which extends for 40km from Ponta do Maiaú to Ponta do Caeté, and 20km wide from the coastal plateau of Bragança to the ocean (Barbosa and Pinto, 1973). The estuary of the Caeté river (Figure 1) extends from the town of Bragança to the river mouth and measures about 30km in length and 10km at its widest portion near the ocean.

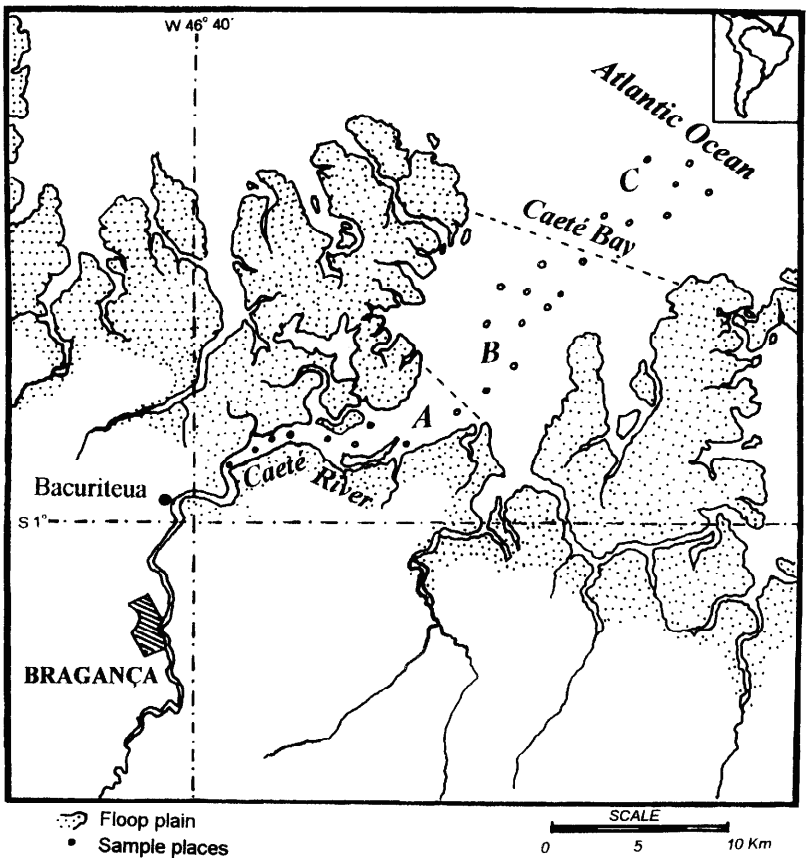

Figure 1. Estuarine area of Caeté river

The littoral region of Bragança has a type B4AW type climate (Thornthwaite, 1948, *in* Critchfield, 1968), characterized by high humidity, megathermy, and a moderate deficiency of Af and Aw (Koeppen, 1918 *in* Critchfield 1968). With a well-defined dry season from June to November, the region has mean precipitation values of 2500mm/year, which makes it one of the most rainy regions of Brazil. This seasonal pattern is a consequence of the movement of the ITCZ (Intertropical Convergence Zone) in the region (Santos *et al.,* 1992).

Methodology

Bimonthly samples were collected with trawl and gill nets during August, October and December of 1996 and February of 1997, in three different areas: (A) main river channel, (B) bay and (C) coastal area of the Caeté estuarine system (Figure 1). Ten to fifteen-minute trawls were executed in depths from 3 to 12m. Additionally gill nets with mesh sizes between 20 and 50mm, measuring 120 x 3m, were used in the three areas.

The fish caught were weighed and preserved in 10% formaldehyde. Identification at species level was based on literature (Menezes and Figueiredo, 1980; Cervigón *et al.,* 1992; Chao, 1978). Total length and weight of 1,217 individuals of *Aspredo aspredo* (Aspredinidae), 5,530 of *Cathorops spixii* (Ariidae), 7,617 of *Stellifer rastrifer*, 1,015 of *S. naso* and 919 of *Macrodon ancylodon* (Sciaenidae) were registered.

Monthly frequency distributions by area were plotted for the analysis of population structures. Cohorts were identified by dividing the distribution into separate normal distributions, according to Bhattacharya (1967) in Sparre and Venema (1992) and using the FISAT (FAO-ICLARM Stock Assessment Tools) program. Growth parameters (L_∞ and K) were obtained by fitting a von Bertallanfly growth model on length frequency histograms by ELEFAN program (Electronic Length Frequency Analysis) (Brey and Pauly, 1986). Observations on gonadal maturity were recorded in some individuals in order to estimate spawning time and length at first maturity.

Biomass averages (g/m^2) were estimated through the calculation of catch per unit area using the swept area method (Sparre and Venema, 1992). This was done only for the samples of October and December 1996, periods for which information was available.

Results

Macrodon ancylodon, Stellifer rastrifer, *Stellifer naso,* of the family Sciaenidae, *Cathorops spixii* of the family Ariidae, and *Aspredo aspredo* of the family Aspredinidae are among the most abundant species along the Caeté's estuarine system and occupy all studied habitats. The density varied for each species. Average biomass by area is shown in Table 1.

Table 1. Average biomass (g/m^2) by area for the studied species in the Caeté estuary

Species	River (g/m^2)	Bay (g/m^2)	Coast (g/m^2)	Total mean (g/m^2)
Cathorops spixii	1.12	0.39	0.28	0.55
Macrodon ancylodon	0.11	0.46	0.25	0.29
Stellifer rastrifer	0.57	0.18	0.24	0.31
Stellifer naso	0.04	0.02	0.02	0.03
Aspredo aspredo	0.07	0.03	0.01	0.06

1. Macrodon ancylodon. Average biomass of *Macrodon ancylodon* was 0.29 g/m^2, the density being higher in the bay area (Table 1). Total length ranged from 3 to 41cm, larger individuals occurred in the outer part of the estuary. Five cohorts were identified in the total length frequencies, or rather, at 7.79cm, 12.66cm, 16.68cm, 22.09cm and 27.35cm respectively (Figure 2). Monthly length frequencies indicated the growth patterns (Figure 3). Preliminary estimates of L_∞ and K were 45.50cm and 0.491 $year^{-1}$ respectively.

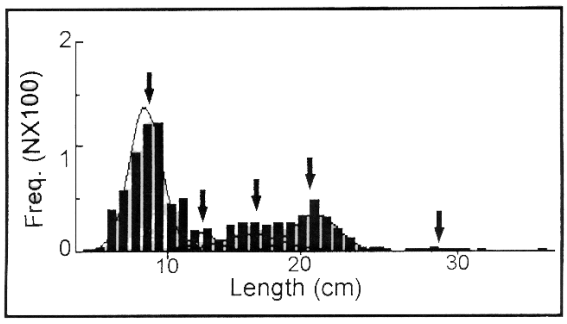

Figure 2. Total length frequency distribution for *Macrodon ancylodon*

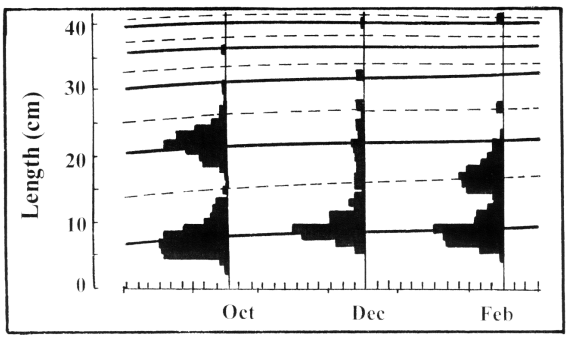

Figure 3. Monthly length frequency distributions for *Macrodon ancylodon*

Juvenile recruits were abundant. In October they occurred mostly in the bay and the coastal area, where average salinity was 31.0 ppm and 35.6 ppm respectively. The recruitment cohort was found growing in the same area in December and entering the river proper in February. The occurrence of

recruits in practically all samples may indicate a long period of reproduction for this species. Nevertheless, studied females did not appear with mature ovarian stage in either December or February.

2. Stellifer rastrifer. This is one of the most abundant species of the region. Estimated average biomass was 0.31 g/m^2 (Table 1). Total lengths ranged from 1 to 17cm. Largest individuals were caught in the three areas during the December survey, with higher densities in the river area (Table 1). From the length frequency distribution for all samples, four cohorts: 3.92cm, 6.50cm, 8.46cm and 14.07cm were differentiated (Figure 4). Estimates of L_∞ and K were 22.5cm and 0.31year^{-1} respectively.

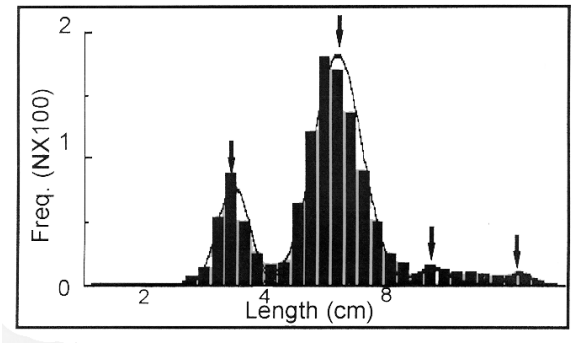

Figure 4. Total length frequency distribution for *Stellifer rastrifer*

The occurrence of juveniles with sizes between 2 and 7cm from August to December (Figure 5) indicates the existence of a wide reproduction period along the year. It seems that the river is the most adequate habitat for the development of the first juvenile phases of their life cycle.

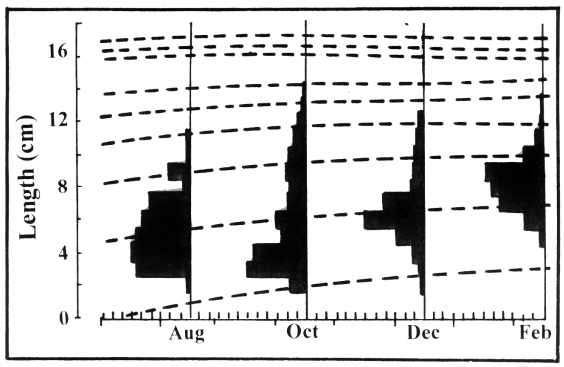

Figure 5. Monthly length frequency distributions for *Stellifer rastrifer*

3. Stellifer naso. Had an average biomass of 0.03 g/m^2, ten times lower than that of *S. rastrifer*. Higher values also occurred in the river (Table 1). Total lengths ranged from 2cm to 25cm, and four cohorts were evident: 3.83cm, 6.04cm, 9.07cm, 14.8cm; one cohort of juveniles (3-9cm) was very abundant (Figure 6). Preliminary estimates of L_∞ and K were of 26.3cm and 0.321 year^{-1} respectively.

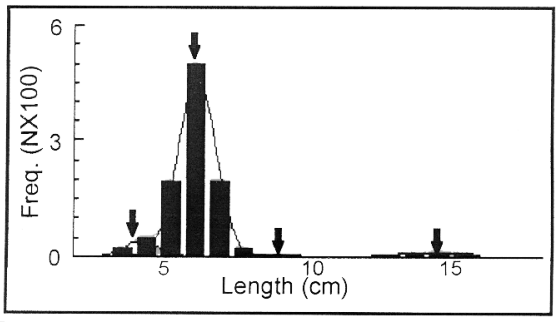

Figure 6. Total length frequency distribution for *Stellifer naso*

Two recruitment periods, in August and in December, were detected in bimonthly frequencies. Larger individuals (13 to 20cm total length), were abundant in October (Figure 7), particularly in the bay and coastal areas, where salinity was higher. In February, during the rainy season, catch of this species fell considerably.

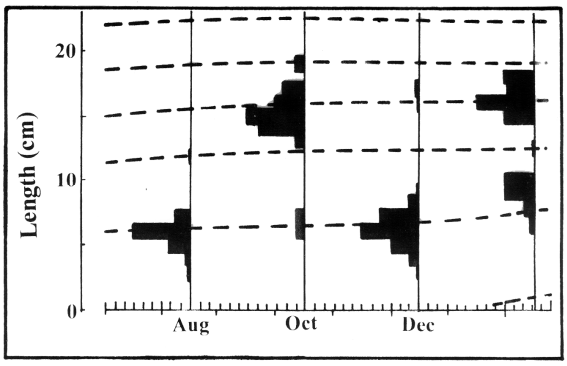

Figure 7. Monthly length frequency distributions for *Stellifer naso*

4. Cathorops spixii. Was the most abundant among the species studied. Average biomass reached 0.55 g/m^2, one of the highest of all fish species in the system. Density was much higher in the river habitats (Table 1). Total length ranged from 2 to 22cm. Four cohorts were differentiated, 4.31cm, 9.09cm, 13.23cm and 18.2cm (Figure 8). Growth rate was approximately 1cm per month in the recruit cohort, being lower in the older groups, as expected (Figure 9). Preliminary estimates of L_∞ and K were 33.3cm and 0.36 year^{-1} respectively.

Recruits were more abundant in the bay area, but spawning stocks preferred riverine habitats. Mature individuals from 6.5cm total length and over were found. During December and February many males carrying eggs in their mouths were found, indicating that the reproductive season of *Cathorops spixii* coincides with the beginning of the rainy season. Fecundity ranged from 4 to 25 eggs/female, with a

mean of 8 eggs. Average egg diameter was 6.5mm. Mouth incubation occurred preferentially in the river area. Probably this indicates that juvenile fish support low levels of salinity.

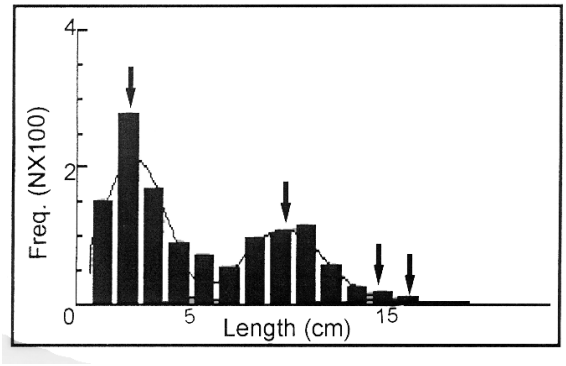

Figure 8. Total length frequency distribution for *Cathorops spixii*

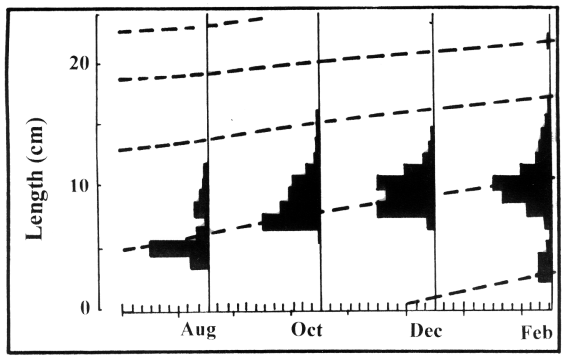

Figure 9. Monthly length frequency distributions for *Cathorops spixii*

5. Aspredo aspredo. This species presented an average catch per unit area of 0.06 g/m^2. Abundance was higher in the river (Table 1). Total lengths varied from 2 to 36cm. Four cohorts were separated: 12.02cm, 19.99cm, 27.23cm and 33.67cm (Figure 10). Preliminary estimates of L_∞ and K were 42.5cm and 0.35 year^{-1} respectively.

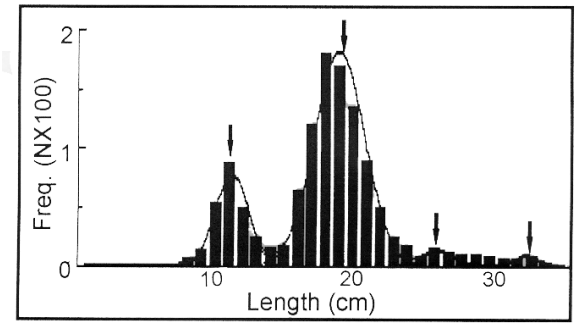

Figure 10. Total length frequency distribution for *Aspredo aspredo*

Recruits appeared in August (Figure 11). Recruiting cohorts grew at a rate of approximately 1cm per month. Older cohorts showed slower growth rates. *Aspredo aspredo* had a restricted distribution with a clear preference for low salinity. Nevertheless, in December they spread into the bay area. Females with eggs attached onto the ventral part of their thorax were caught in the river during August and February, indicating that the species utilizes this habitat for spawning. *Aspredo aspredo* may have two reproductive seasons.

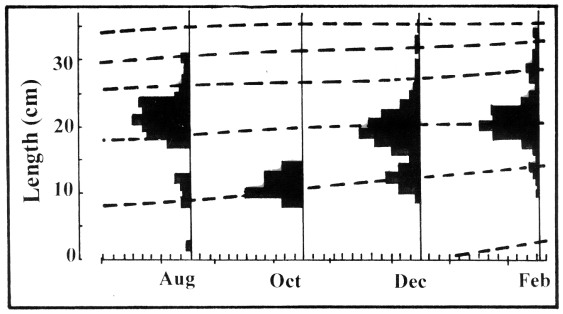

Figure 11. Monthly length frequency distributions for *Aspredo aspredo*

Discussion

Estuarine fish species differ in their strategy of ecosystem usage. Evidences of this are adaptations of their life cycles to environmental changes such as salinity, turbidity or food availability (Day *et al.,* 1989). This was confirmed in the Caeté estuary. Each species presented different distribution patterns during their respective life cycles.

If young recruits could tolerate the low salinity of the river area, larger *Macrodon ancylodon* demonstrated a marked preference for the bay and the coastal habitats. Migration patterns of adults offshore were already reported in studies made in the southeastern coast of Brazil (Menezes and Figueiredo, 1980). Larger individuals collected in the Caeté estuary are close in size range to the individuals off Venezuela, which reach up to 45cm (Cervigón, 1993).

The growth parameter estimated for the estuarine area of Caeté river did not differ significantly from that estimated by Kotas (1994) for the coastal area of Rio Grande do Sul (28°45´S and 33°45´S). However, these results indicated that southern populations of *Macrodon ancylodon* had a lower growth rate than that observed in the Caeté river population; conversely, they had a larger asymptotic length. We can conclude that populations of lower latitudes grow more quickly but attain smaller sizes than populations in areas of higher latitudes.

In the Brazilian coast south of 29°S, Vazzoler (1963) determined the beginning of the first maturity

at 28cm. Two peaks of high spawning activity (December and February) were observed by Juras and Yamaguti (1989) in population of *M. ancylodon* in the southern coast of Brazil. This result confirms the existence of partial spawning, suggested by a multimodal distribution pattern of egg diameters in pre-spawning individuals. Different periods of more intense spawning were detected in May and November by Vazzoler (1963). According to these conclusions, our growth analysis was based on the two yearly recruiting cohorts.

Since *Stellifer rastrifer* was found in the three areas (river, bay and coast), it is clear that this species has a great tolerance for different salinity levels. It occupies the entire estuarine area for nursery, recruitment, growth and spawning functions. Reproduction may occur in the estuary for a prolonged period. According to Giannini and Paiva Filho (1990), *S. rastrifer* spawns only once during the summer period. Larger individuals sampled by the authors of the present research matched ranges recorded by Menezes and Figueiredo (1980), Giannini and Paiva Filho (1990) and Cervigón (1993). However the L_∞ value estimated is lower than that reported by Giannini and Paiva Filho (1990).

In the bay-estuary complex of Santos and São Vicente (24ºL.S.), *Stellifer rastrifer,* abundantly caught by shrimp trawlers (Paiva Filho *et al.,* 1988), is distributed across a wider range of depths. In contrast to *S. rastrifer*, it also seems that juveniles of *S. brasiliensis* do not seek oligohaline habitats for their development (Giannini and Paiva-Filho, 1995).

Stellifer naso, usually caught together with *S. rastrifer*, seems to prefer less saline areas and shallower waters (Cervigón, 1993), particularly during its early life cycle. However, its spawning stock may occur in the outer part of the estuary. Individuals of this species registered by Chao (1978) measured up to 7.5cm, and those examined by Cervigón (1993) ranged from 10 to 15cm in total length. The individuals collected for this study showed a wider size distribution range, or rather, from 2 to 25cm.

Results suggest that *Cathorops spixii* also seems to use the estuary as nursery, growth and spawning habitat. Cervigón (1991) and Melo and Teixeira (1992) registered maximum lengths of over 30cm while our individuals measured only up to 22cm. While five cohorts were recorded by Etchevers (1978), we found only 4 cohorts in the Caeté system. Adults of this species seem to migrate offshore to deeper waters (Cervigón *et al.,* 1992). It is evident that even if migration occurs, mature individuals remain in the upper part of the estuary for spawning. The presence of mature individuals with eggs in their mouth confirms this conclusion. In Margarita Island, Venezuela, the smallest mature individuals reached 14cm and mean length at first maturity was estimated to be 19cm (Etchevers, 1978). Melo and Teixeira (1992) estimated the length at first maturity as 12.6cm and 11.9cm for females and males, respectively. In the Caeté river individuals up to 6.5cm were undergoing maturation. Recent unpublished research on small ariids, however, suggests *Cathorops spixii* is actually a species complex, probably with different valid species along its distribution in Central and South America (Higuchi, MPEG, personal communication).

Aspredo aspredo presented the most restricted distribution in the system. Movement into the bay occurred only at the beginning of the rainy season when habitat had a lower salinity. According to Sands (1985), this species migrates upstream, from the estuary to freshwater, although spawning takes place in brackish water. Though reproduction seems to occur in the main river channel, the absence of smaller individuals in the Caeté samples could indicate that nursery grounds are located upstream, in freshwater habitats. Maximum sizes in our samples were very close to those registered by Cervigón *et al.* (1992).

Length-based methods were demonstrated to be useful to estimate growth parameters in the fish species of the Caeté estuary. This confirms Isaac's (1990) conclusion that such methods are appropriate for tropical fish stocks with a relatively short life cycle and without great variability among individuals. Results of this paper showed that even for such species as *Macrodon ancylodon,* which have two yearly spawning periods, the formation of cohorts is evident in the length frequency histograms and that it is possible to separate normal distributions, identify each recruitment peak and follow the cohorts during all their life span.

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