ECOLOGICAL DISTRIBUTION OF THE SHRIMP "CAMARÃO SERRINHA" *Artemesia longinaris* (DECAPODA, PENAEIDAE) IN FORTALEZA BAY, UBATUBA, BRAZIL, IN RELATION TO ABIOTIC FACTORS

by

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RESUMEN

Distribución ecológica del camarón "serrinha" *Artemesia longinaris* (Decapoda, Penaeidae) en la Ensenada de Fortaleza, Ubatuba, Brasil, en relación con factores abióticos. En el presente trabajo se realiza un estudio de la distribución espacial y temporal de la especie *Artemesia longinaris* en la Ensenada de Fortaleza, litoral norte del Estado de São Paulo, Brasil, en relación con algunos factores abióticos. Las capturas se realizaron mensualmente, desde noviembre de 1988 a octubre de 1989, en siete secciones predeterminadas a bordo de un barco pesquero preparado con redes de tipo "double otter trawl". La profundidad se registró en el punto medio de cada sección con obtención de muestras de agua y sedimento para medir salinidad, temperatura, textura y contenido de materia orgánica del sedimento. Los camarones capturados fueron clasificados e identificados y se separó una submuestra de 100 g de cada sección para realizar la medición de longitud del caparazón. Se obtuvieron un total de 3.083 individuos. La mayor abundancia se registró entre noviembre y febrero (62% del total de individuos capturados) y entre junio y agosto (37%). En lo que respecta a la distribución espacial, el mayor número de individuos se capturaron en las áreas más profundas y con mayor salinidad (secciones I y VII, boca de la ensenada) (Pearson, $p>0,05$). Sin embargo, no se capturaron camarones en las secciones II y V con sedimentos de fracciones granulométricas con diámetros mayores y escasa profundidad. La presencia de Aguas Continentales del Atlántico Sur (temperatura < 20 °C y salinidad < 36‰) a fines de la primavera y en verano y las bajas temperaturas del invierno serían las causantes de una mayor abundancia de *A. longinaris* en el área de estudio. La ausencia de la especie en las áreas internas de la ensenada se relacionó con las condiciones de menor salinidad.

SUMMARY

The aim of this study is to analyze the spatial and temporal distribution of the shrimp *Artemesia longinaris* in Fortaleza Bay, northern coast of São Paulo State, Brazil, in relation to abiotic factors. Shrimp samples were obtained on a monthly basis from November 1988 through October 1989 at seven pre-delimited transects on board of a fishing vessel supplied with double otter trawl nets. Depth was recorded at the midpoint of each transect; water and sediment samples were taken to measure salinity, temperature, texture and organic matter content of sediment.

The shrimps obtained in the trawls were sorted, identified and 100 g subsample at each transect was separated for measurements (carapace length). A total of 3,083 individuals were obtained. Shrimps were more abundant from November through February (62% of all individuals captured) and from June through August (37%). Regarding their spatial distribution, the largest number of individuals was captured in deeper areas with higher salinity (transects I and VII – mouth of the Bay). No shrimps were obtained at transects II and V (sediment with very coarse sand and shallow waters). The presence of the South Atlantic Continental Waters (temperature < 20 °C and salinity < 36 ‰) at the end of spring and during summer and the decrease of water temperature in winter seem to favour the presence of *A. longinaris* in the study area. The absence of the species in the inshore areas of the Bay was related to the low salinity of the habitat.

Key words: Ecological distribution, abiotic factors, *Artemesia longinaris*, Penaeidae, Brazil.
Palabras clave: Distribución ecológica, factores abióticos, *Artemesia longinaris*, Penaeidae, Brasil.

INTRODUCTION

The shrimp fishery in Southeast Brazil targets the most profitable species such as the pink (*Farfantepenaeus brasiliensis, F. paulensis*), the white (*Litopenaeus schmitti*) and the "sete barbas" schrimp (*Xiphopenaeus kroyeri*). According to Iwai (1973), the increase of the fishing fleets and the decrease of landings of commonly exploited species contributed to the expansion of the *Artemesia longinaris* (Bates 1888) fishery. This monotypic species is restricted to the Western Atlantic, from Atafona (Rio de Janeiro, Brazil) to the Province of Chubut, Argentina (D'Incao, 1995). In general, the "serrinha" shrimp lives exclusively in the marine environment throughout its life cycle (Boschi, 1963).

According to Boschi (1969 a), adults of *A. longinaris* migrate into offshore areas where spawning takes place. Then, the planktonic stages migrate into inshore waters, usually to sheltered places with high salinity, where they grow and develop to juvenile and adult shrimps. According to Dall *et al.* (1990), this pattern of the life cycle is considered as type III.

Of the available information on *A. longinaris*, most data were taken from populations in Argentinean waters where the species is heavily exploited and thus, of great economic importance (Boschi, 1963, 1969a, b). Our knowledge of the biology of the species along the Brazilian coast is restricted to information on its taxonomy, and bathymetric distribution and fauna survey (Coelho and Ramos, 1972; Iwai, 1973; Pires, 1992; D´Incao, 1995; Costa *et al.,* 2000). However, contributions to the biology and ecology of this species are scanty. Nascimento (1981) and Ruffino (1991) examined the population structure and Nakagaki *et al*. (1995), Costa (2002) and Fransozo *et al.* (2002) studied the variation of abundance throughout the year. Nevertheless, the ecological distribution of *A. longinaris* along the Brazilian coast is still unknown.

Sediment type and depth were emphasized as major variables affecting the distribution of penaeid shrimps (Boschi, 1963; Dall *et al.*, 1990; Somers, 1994 and Costa and Fransozo, 2004). The objective of this study is to analyze the spatial and temporal distribution of *A. longinaris* in Fortaleza Bay, Ubatuba (São Paulo State, Brazil), a region close to the northern limit of the species distribution along the Western Atlantic. The correlation between individuals and abiotic factors (temperature, salinity, depth, texture and organic matter content of sediment) was checked to identify the variables that influence the temporal-spatial distribution of *A. longinaris*.

MATERIALS AND METHODS

Fortaleza Bay is located in the northern coast of São Paulo State (23º29'30''S and 45º06'30''W). According to Castro-Filho *et al.* (1987), the region is influenced by three different water masses, with different distribution patterns in summer and winter: South Atlantic Central Waters (SACW – temperature < 20 ºC and salinity < 36‰), Tropical Waters (TW – T > 20 ºC and S > 36‰) and Coastal Waters (CW - T > 20 ºC and S < 36‰).

Samples were taken on a monthly basis from November 1988 through October 1989, using a fishing vessel equipped with two double otter trawl nets (3,5 m mouth width, 10 mm codend mesh size). Preliminary samples were taken during six months to establish a sampling design for this study. Specimens were collected in seven subareas of the Bay. Biological and environmental data were collected in daylight along transects of 1 km length in each of the seven subareas (Figure 1). Trawling was performed at 1,5 knots for 20 min, sufficient to prevent significant escape from the nets. Abiotic factors and depth were quantified at the midpoint of each transect. Samples of water and sediment were collected to obtain records of temperature, salinity, texture and organic matter content of sediment (Phi = mean diameter of sediment). Details of the methods used to measure those parameters are described by Negreiros-Fransozo *et al*. (1991).

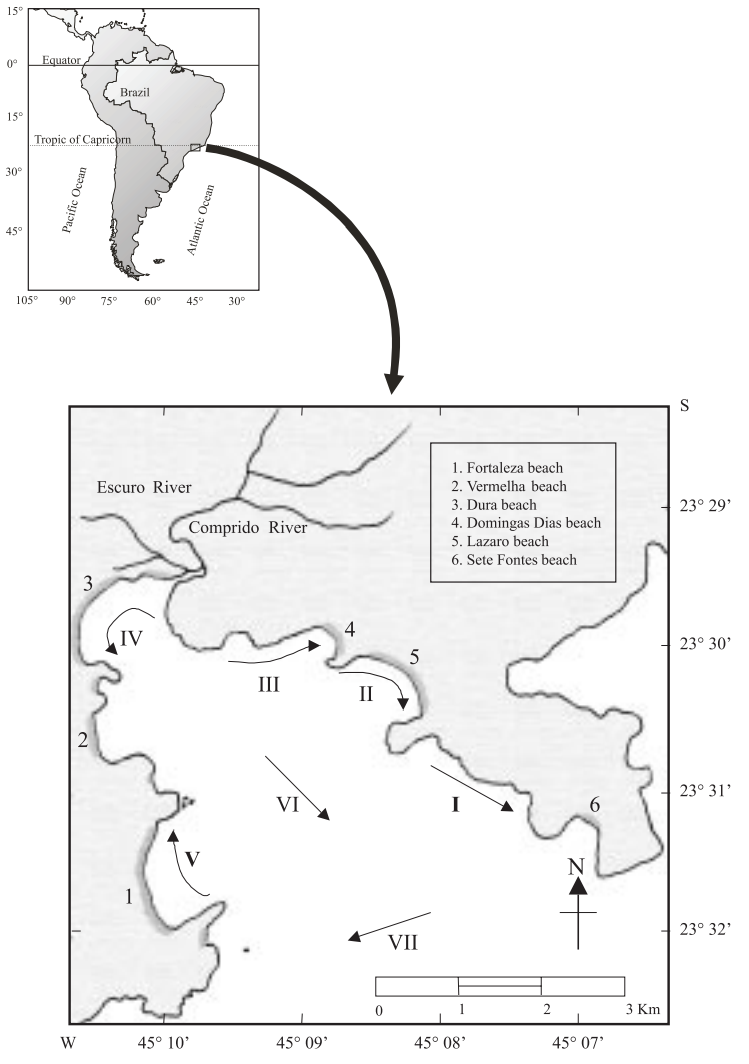

Figure 1. Map of Fortaleza Bay with indication of the transects area.
Figura 1. Mapa de Bahía Fortaleza con indicación del área de las secciones.

Shrimps captured were sorted, identified and preserved in 70% ethanol. A 100 g subsample was separated at random for measurements. The carapace length (CL = measured from the tip of rostrum to the rear of the carapace in the mid dorsal line) was chosen as the measure of size.

On the basis of the number of shrimps recorded per month at each collecting transect, absolute abundance was calculated. For a better interpretation of results, the months were grouped into seasons: spring (October, November and December), summer (January, February and March), autumn (April, May and June) and winter (July, August and September). Pearson's linear correlation ($p<0.05$) was calculated to determine the existence of a correlation between the absolute abundance of shrimps and each environmental factor (depth, temperature, salinity, organic matter and grain size of the sediment). The variation range of abiotic factors was divided in classes to which the number of collected shrimps was attributed over the 84 trawls.

RESULTS

Depth, texture and organic matter content of sediment for each transect are listed in Table 1. In general, salinity at transect IV was lower than that of the other deeper transects in the Bay. In Fortaleza Bay, predominance of fine and very fine sand ($3.0 < phi < 4.0$) was detected. On the whole, the highest values of organic matter content were obtained at transects I, VI, VII, mainly II, and the lowest at transects III, IV and V. As shown in Figure 2, when compared to other seasons, a clear raise of temperature values during fall was observed.

A total of 3,083 shrimps were caught. Shrimp monthly abundance is shown in Figure 2. The largest number of individuals was obtained in winter (July - August), and specially during late spring (December) and early summer (January) when mean temperature was lower. During late summer, and particularly in autumn, when temperature was higher, the species was found to have low abundance in Fortaleza Bay. The mean number of individuals collected under different environmental conditions is presented in Figure 3.

The largest number of individuals was recorded at deeper transects I and VII, and proved absent at transects II and V where the sediment was composed of medium size grain sand (Table 1). The smallest number of individuals of *A. longinaris* was recorded at shallow transects III and IV, mainly at IV.

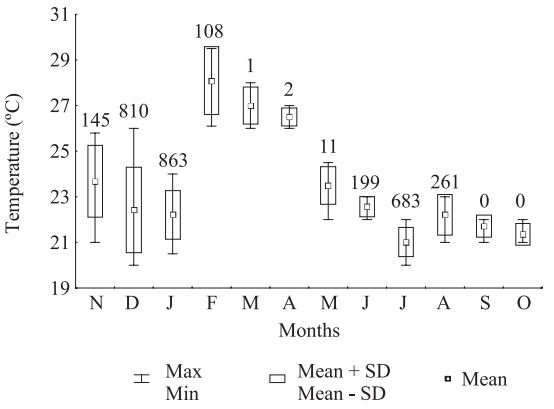

Figure 2. Range and mean monthly values of temperature (°C) and number of captured individuals in Fortaleza Bay from November 1988 through October 1989.

Figura 2. Rango y media de valores mensuales de temperatura (°C) y número de individuos capturados en Bahía Fortaleza desde noviembre de 1988 a octubre de 1989.

The number of individuals captured was directly proportional to salinity and inversely proportional to temperature values (Figures 3 A and 3 B). In terms of seasonality, a larger number of shrimps was observed during spring and summer, recorded mainly in the depth range between 10 and 15 m. Only during winter was this shrimp species collected at all depths (Figure 4).

Pearson's correlation analyses indicate a significant ($p<0.05$) correlation between number of individuals and temperature (Pearson, $r = -0.30$; $p = 0.006$), depth (Pearson, $r = -0.32$; $p = 0.004$) and salinity (Pearson, $r = -0.32$; $p = 0.003$).

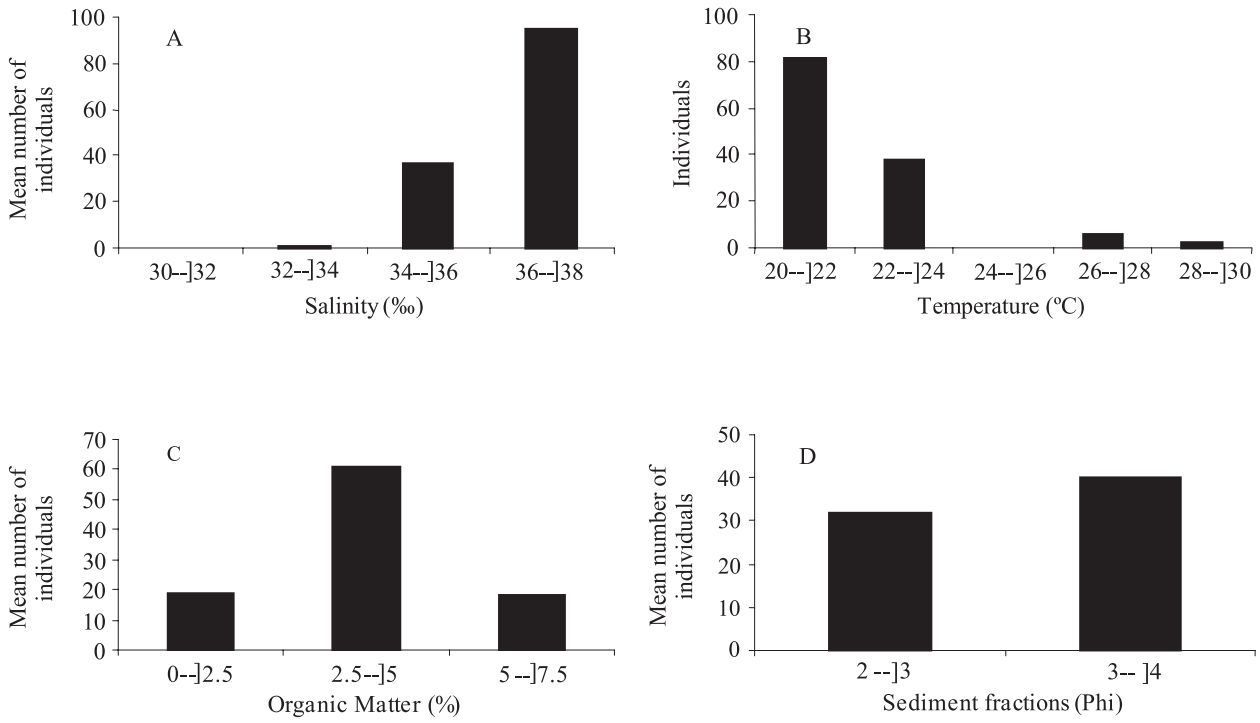

Figure 3. Shrimp occurrence under the different environmental conditions found during the study period (A: salinity, B: temperature, C: organic matter and D: sediment fractions).

Figura 3. Presencia de camarones en distintas condiciones ambientales durante el período de estudio (A: salinidad, B: temperatura, C: materia orgánica y D: fracciones de sedimento).

Table 1. Mean values of abiotic factors and number of trawled individuals at each surveyed transect from November 1988 through October 1989.

Tabla 1. Media de valores de factores abióticos y número de individuos capturados en cada sección estudiada desde noviembre de 1988 a octubre de 1989.

Transect	Depth (m)	Phi	Salinity (‰)	Organic matter (%)	Number of individuals
I	11.2 ± 0.9	2.9	34.8 ± 0.8	4.4 ± 2.5	1,151
II	7.0 ± 0.9	2.5	34.3 ± 1.3	6.7 ± 2.4	0
III	8.5 ± 0.9	3.8	34.4 ± 1.1	2.3 ± 1.3	276
IV	4.4 ± 0.6	3.3	33.3 ± 1.5	1.8 ± 1.3	172
V	7.1 ± 0.8	2.7	34.4 ± 1.1	3.5 ± 1.4	0
VI	11.1 ± 1.2	3.4	34.4 ± 1.1	5.1 ± 1.8	435
VII	13.3 ± 1.6	3.5	34.9 ± 1.7	4.6 ± 3.6	1,049

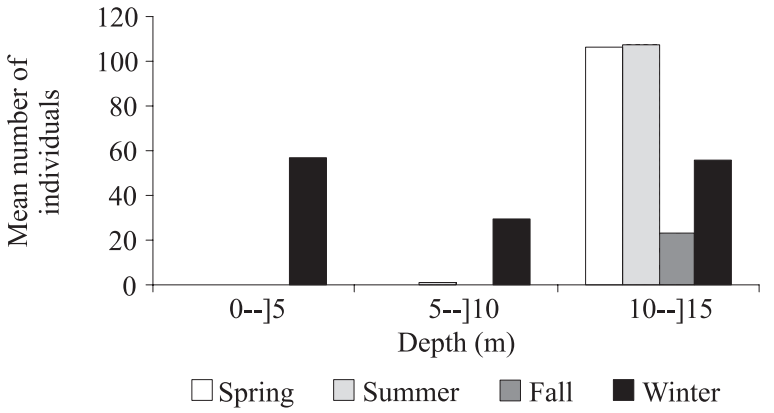

Figure 4. Number of individuals captured in each season and strata depth.
Figura 4. Número de individuos capturados en cada estación y estrato de profundidad.

DISCUSSION

According to Boschi (1963) and Dall *et al.* (1990) the distribution of penaeid shrimps is influenced by the action of various abiotic factors. In this study, temperature, depth and salinity can be considered as key variables responsible for the distribution of *A. longinaris* in Fortaleza Bay, Brazil. Most shrimps were collected in deeper areas of the Bay with higher salinity and lower temperature where sediments are mostly composed of very fine sand with low content of organic matter. This spatial pattern suggests that the life cycle of the species corresponds to the type III proposed by Dall *et al.* (1990). Species under this category are those restricted to true marine environments, with shrimps usually migrating from inshore to offshore areas over their ontogeny. Supporting this hypothesis, Nakagaki *et al.* (1995) and Costa (2002) found a similar pattern of distribution for *A. longinaris* in Ubatuba Bay which is close to the area sampled during this study.

Nascimento (1981), Ruffino (1991) and Boschi (1969 a and b) also stated that this is a species typical of colder regions, occurring at a temperature ranging 15-21°C and salinity higher than 33‰. According to Santos *et al.* (1994), even in limited areas as Fortaleza Bay, there are salinity variations from one site to another, specially near river mouths (transect IV). The low frequency of this shrimp at the transects sampled at depths lower than 10 m suggests that the species does not invade the estuaries.

According to Castro-Filho *et al.* (1987) and Pires (1992), Coastal Waters (CW) have a relevant influence on shallow waters of up to 25 m depth. In this water mass, salinity is always below 36‰ and temperature higher than 20 °C. Besides, the influence of the South Atlantic Central Waters (SACW) is more pronounced during summer when a decrease of temperature occurs in deeper areas, occasionally reaching more coastal grounds. According to Negreiros-Fransozo *et al.* (1991) the effect of the SACW may be observed in Fortaleza Bay from the end of spring to the beginning of summer in shallow areas above the 10 m isobaths covering transects I, VI and VII.

Decrease of temperature in winter, observed at all transects, and the dynamics of SACW during the end of spring may account for the most important factors that affect the seasonal distribution of *A. longinaris* and favour migration and retention in shallower areas. When intruding into the

embayment, the SACW cause a decrease of temperature and the confinement of the shrimp population in shallower areas (<10 m). It may be inferred that the raise of temperature at the end of summer and in autumn is responsible for the migration of shrimps to the outer areas of the bays. Similar results for the shrimp *Pleoticus muelleri* were reported by Costa (2002) and Fransozo *et al.* (2002), the shrimp *Rimapenaeus constrictus* by Costa and Fransozo (2004) and the crab *Callinectes danae* by Chacur and Negreiros-Fransozo (2001).

The organic matter content of sediments does not seem to affect the distribution of *A. longinaris* in the area. Branford (1981) found similar results for *Penaeus monodon* and *P. indicus* and Ruello (1973) concluded that the distribution of *Metapenaeus macleayi* is more affected by grain size than by the availability of food.

The very fine sand of Fortaleza Bay probably influences the presence of this species in the area under study. Similar results for the species in Argentinean waters were reported by Boschi (1969 a and b). The species was absent at transects II and V all year round. Other shrimp species, *i.e. Xiphopenaeus kroyeri* and *Pleoticus muelleri*, were also absent in said sites (Fransozo *et al.*, 2002). Most probably, coarse sediments would prevent *A. longinaris* from moving to these areas of the Bay.

We cannot discard the influence of other abiotic factors on the distribution of *A. longinaris*. However, salinity and the effect of the SACW on the bottom temperature seem to be particularly important, accounting for a significant part of the spatial and seasonal distribution of the species.

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