Dynamic of Decapod Crustacean Larvae on the Entrance of Guanabara Bay

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ABSTRACT

In the present study, we observed seasonal variations in the density of decapod larvae as well as changes in density related to diurnal and tidal cycles. Among the decapod larvae collected, portunids and grapsids were the most abundant, especially during nocturnal ebb tides and near the surface. The same results were obtained in late winter (September) and late summer (March). These results demonstrated a flow of decapod larvae from Guanabara Bay to adjacent coastal waters. Luciferid (Lucifer faxoni) was the only group with high densities during flood tides and we suggest this is an evidence of L. faxoni larvae entering Guanabara Bay in late winter. Probably these changes in distribution of Lucifer faxoni among winter and summer were related to reproductive cycle in the bay. For the portunids, grapsids and ocypodids, a similar dispersion strategy was observed towards adjacent coastal waters in the surface during nocturnal ebb tides.

Key words: Crustacea Decapoda larvae, Zooplankton, Vertical Distribution, Vertical Migration, Dynamic, Guanabara Bay

INTRODUCTION

Most estuarine decapod (McConaugha, 1988) and non-decapod larvae (Stancyk and Feller, 1986; Wolanski and Sarsenski, 1997) tend to be dispersed under local hydrodynamic patterns toward oceanic areas. Some of them can survive in oceanic oligotrophic waters, such as the Cancridae and Portunidae, but most species display special strategies to keep themselves inside estuaries, or to come back soon, such as the Xanthidae and Ocypodidae (McConaugha, 1988).

Staying in eutrophic estuarine waters can be an advantage considering the availability of food resources, however, this is countered by higher pollution levels and higher predation rates in estuarine waters. The way in which planktonic decapod larvae stay in estuaries or reach oceanic waters is mainly by regulating their depth within the water column. Staying near the surface during ebb tides, as observed for portunid larvae (Sandifer, 1975), may result in fast dispersion towards the ocean. In the same way, staying near the bottom may result in low dispersion. There are other strategies affecting the retention and the dispersion of larvae from estuaries, which include fast development, ontogenetic vertical migration,

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and epibenthic behaviour (Epifanio, 1988; Schwamborn, 1993).

Guanabara Bay has been the focus of attention for a ten-year multidisciplinary study carried out by the Federal University of Rio de Janeiro. There are many reasons for this effort, all of them related to the environmental changes observed in Guanabara Bay both before and during the study. Examples of environmental changes include: increased silting rates (Amador, 1997), changes in seasonal patterns of salinity and temperature (Paranhos and Mayr, 1993), decreased water quality (Kjerfve et al., 1997) and changes in the composition and distribution of the zooplankton community (Nogueira et al., 1989). These changes are likely to impact on fisheries and the large number of people who depend on them. For example, according to Almeida (1993), more than 6,000 people removed about 10 tons of shrimp per month from the bay.

The only specific study about decapod larvae in this bay was done by Oliveira (1962), in which some larval stages of Chasmagnathus granulata were described. Nogueira et al. (1989) investigated total zooplankton community in Guanabara Bay. They found distinctive communities within the bay and at the entrance to the bay and implied that a gradient existed from the bay to continental shelf waters. Their study did not focus on decapod larvae. Recently, Valentin et al. (1999) published a review on the planktonic system in Guanabara Bay.

The aim of this paper was to describe the dynamics of decapod larvae at the entrance of the Guanabara Bay.

MATERIALS AND METHODS

Considering the influence of depth regulation behaviour upon the dynamics of the larvae, to follow the distribution of decapod larvae in the water column during several tidal cycles was chosen and proved to be an interesting method to estimate the larval flux between Guanabara Bay and the adjacent coastal area.

This study was carried out at a fixed point (043°09.0 W, 22°54.4 S) near the entrance of Guanabara Bay (Fig. 1). The point was located in the main channel, at approximately 30 meters depth and high current speeds.
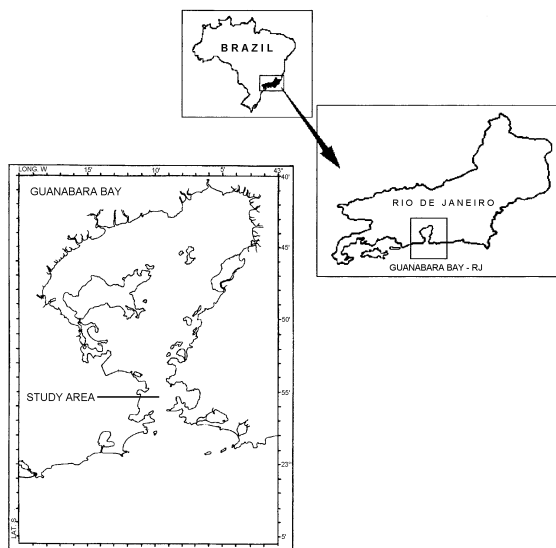

Figure 1 - Study area (black line in detail) inside Guanabara Bay, Rio de Janeiro State.

Zooplankton was collected over six days, three days in late winter (September 13 to 15, 1995) and three days in late summer (March 13 to 15, 1996). In each period, 20 samples were collected in horizontal hauls, ten at the surface and ten near the bottom (± 25 m). The hauls occurred during the night and the day with intervals of 6 hours between each catch. A cylindrical-conical net with a mesh size of 200μm and equipped with a calibrated flowmeter was used. Samples were taken during ebb and flood tides and stored immediately in 4% formaldehyde solution, buffered with borax. Water temperature and salinity data, from surface to near the bottom were registered at one-meter intervals by means of a conductivitythermosalinometer (LabComp). Wind direction was also recorded during sampling.

Decapod crustacean larvae were sorted, identified and grouped as following: 1) Luciferidae; 2) Ocypodidae; 3) Xanthidae; 4) Portunidae/ Grapsidae; and 5) others Brachyura (including Gecarcinidae, Pinnotheridae and Majidae). Other observed decapods included non-brachyuran and non-luciferid decapods, mainly Caridea and Anomura larvae, and was called simply 6) other decapods. Portunids and grapsids were grouped together because of the similarities between them. Differences in the densities among surface and bottom, ebb and flood, and day and night samples in winter and in summer were compared separately by non-parametric Kruskal-Wallis ANOVA

(Siegel, 1975). Three winter samples were excluded from the ANOVA test because they were made during a non-typical tidal flux. The interaction of tide and light factor was excluded from the analysis of variance because of the low number of samples. Before ANOVA, data were homogenised according to Ibanez (1976) by log $(x+1)$.

RESULTS

Water temperature in winter varied from 24.5°C at the surface to 22.5°C at depth. The range of water temperature was larger in summer than in winter. Surface water temperature was about 26.5°C and near the bottom about 22°C. The termocline was at 12 meters depth.

Salinity data followed the same pattern of variation as water temperature, with a larger range in summer than in winter. Salinity ranged from 32‰ at the surface to 34.5‰ near the bottom in winter and from 26‰ to 36‰ in summer. The lower values indicated the influence of river inputs to Guanabara Bay.

Densities of decapod larvae ranged from 0.4 to 788 ind.m^{-3} in winter and from 1.3 to 612 ind.m^{-3} in summer. In winter, the average density at the surface and near the bottom was 281 ind.m^{-3} ($\pm$248 ind.m^{-3}) and 24.3 ind.m^{-3} ($\pm$24.5 ind.m^{-3}), respectively. In summer, the average density at the surface and near the bottom was 169 ind.m^{-3} ($\pm$216 ind.m^{-3}) and 11 ind.m^{-3} ($\pm$7.7 ind.m^{-3}), respectively. In both periods, highest densities were found at the surface during nocturnal ebb tides, while the lowest values occurred during the diurnal flood tides (Figs. 2 and 3).

Depth and season influenced significantly the density of total decapod crustaceans recorded ($p<0.01$ and $p<0.05$, respectively), as well as the brachyuran density (Tables 1, 2 and 3). Depth / tide and depth / light interactions were shown to significantly affect brachyuran density in the winter (Table 1). So, the highest brachyuran densities observed near the surface during the nocturnal ebb tide were significantly different from that recorded during the day in both the surface and near the bottom, and during the night near the bottom.

Among the decapod larvae collected in winter, brachyuran zoeae were the most abundant group, frequently representing more than 90% of total decapod density. Highest densities, 400 to 700

ind.m^{-3}, were found at the surface during nocturnal ebb tides (Fig. 2). Although this group was dominant near the bottom too, their population density never reached more than 73 ind.m^{-3}. In summer, brachyuran zoeae were also the most abundant group, mainly during the ebb tide and at the surface. During the day, brachyuran densities were lower than 60 ind.m^{-3}, and near the bottom, lower than 14 ind.m^{-3}. In both summer and winter, high densities were coincident with high tides. These high values occurred before midnight in winter and after midnight in summer.

Among the brachyuran zoeae collected, portunids and grapsids were the most abundant, representing more than 90% of total brachyuran zoeae. Xanthids, ocypodids, and other brachyuran such as pinnotherids, majids, and gecarcinids, occurred in low density.

Portunid and grapsid density ranged between 0 and 651 ind.m^{-3} with highest densities at the surface in both winter and summer. Significant differences ($p<0.05$) in density values between nocturnal and diurnal samples were only found in the summer (Table 2). No significant differences were found in densities between ebb and flood tides, neither in the winter nor in the summer sampling periods (Table 3). Ocypodid density varied from 0 to 132 ind.m^{-3}. During both winter and summer, highest densities occurred at the surface in nocturnal samples (Tabs. 1 and 2). As for Portunid and Grapsid larvae, no significant association with tide or season was found (Tables 1, 2 and 3). The density of Xanthids was lower than portunids, grapsids and ocypodids, ranging between 0.1 and 115 ind.m^{-3}. No significant differences in sample density between summer and winter were found (Table 3). In summer, the highest xanthid densities occurred at the surface during nocturnal ebb tides (Fig. 3). Some xanthid megalopae were also collected from near the bottom, mainly during flood tides.

Others Brachyura (mainly pinnotherids, majids and gecarcinids) occurred in low densities. It's density varied from 0 to 87 ind.m^{-3}. As with the xanthid larvae, no significant correlation between depth and tide were found in the winter samples (Table 1). In summer, the population densities were associated with depth and tidal factors (Table 2). Among the non-brachyuran, Luciferidae (*Lucifer faxoni*), Sergestidae (*Acetes americanus*), Alpheidae, Palaemonidae, Pasiphaeidae (*Leptochaela* sp.), Porcellanidae

(*Megalobrachyum* sp.), Paguridae, Diogenidae, and Callianassidae were also collected.

Population densities for the Luciferidae (*L. faxoni*) ranged from 0.003 to 30 ind.m^{-3} in winter and from 0.2 to 93 ind.m^{-3} in summer. High values in winter were found twice at the surface during flood tides (Fig. 4). Although population densities were low near the bottom in winter (3.0 ± 3.6

ind.m^{-3}), the density of *L. faxoni* increased to 12.3 ind.m^{-3} with the onset of southerly winds (Fig. 3, Station 6). The highest density values for *L. faxoni* were found in the summer and again twice at the surface during the night, but now during ebb tides not flood tides. Initial low values found near the bottom increased during nocturnal flood tides.
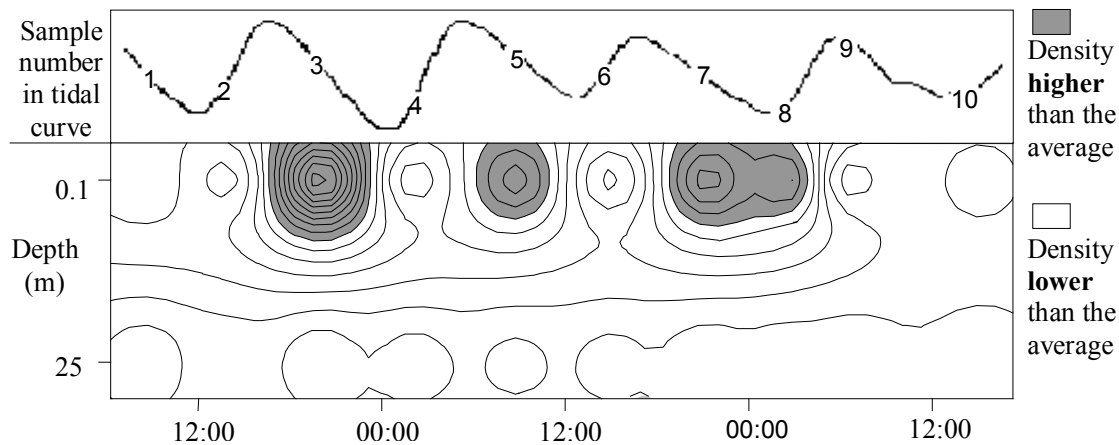

Figure 2 - Vertical distribution of brachyuran zoea during the days of sampling in winter in Guanabara Bay - an example of vertical distribution indicating the flux toward the shelf waters associated with both the nocturnal and diurnal ebb tide. The station numbers and the tidal curve were showed on the top.
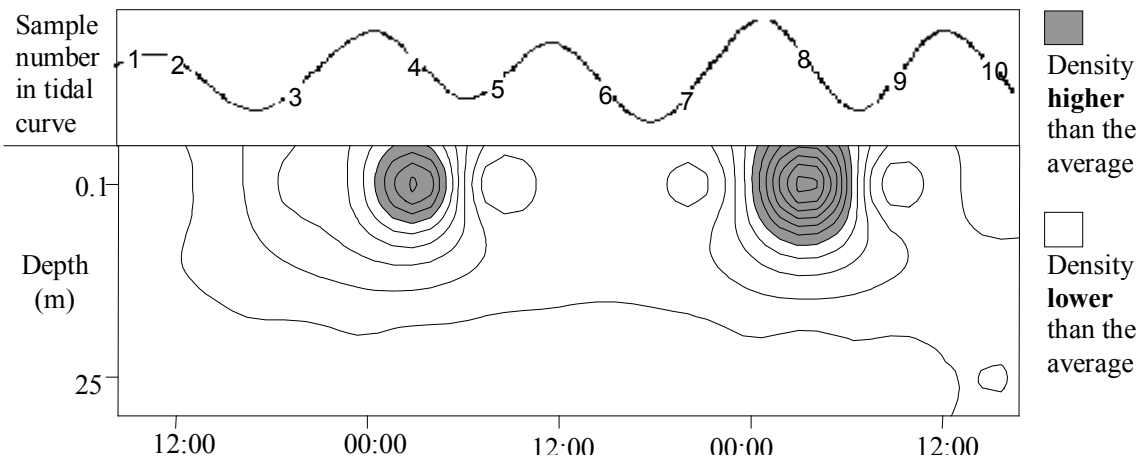

Figure 3 - Vertical distribution of xanthid zoea during the days of sampling in summer in Guanabara Bay - an example of vertical distribution indicating the flux toward the shelf waters associated with nocturnal ebb tide. The station numbers and the tidal curve were showed on the top.
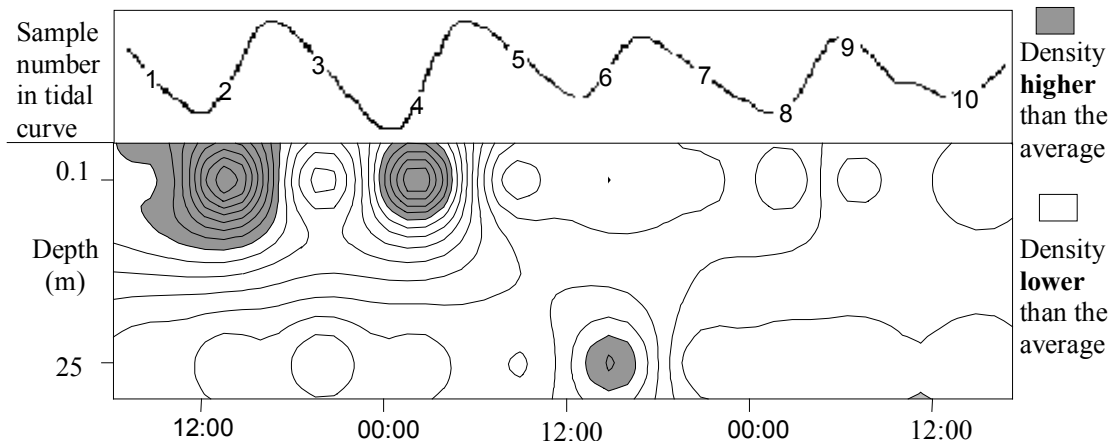
Figure 4 - Vertical distribution of luciferid during the days of sampling in winter in Guanabara Bay - an example of vertical distribution indicating retention inside the bay associated with <u>flood</u> tide. The station numbers and the tidal curve were showed on the top.

Table 1 - Analysis of variance (Anova) of density (ind.m-3) in response to depth, diurnal and tidal cycles, and their interactions in winter samples. Significant relations are marked with p level.

	Depth	Light	Tide	Depth/Light	Depth/Tide
Total decapod	**p<0.01**	Ns	Ns	**p<0.05**	**p<0.05**
Total brachyuran	**p<0.01**	Ns	Ns	**p<0.05**	**p<0.01**
Total other	**p<0.01**	Ns	Ns	**p<0.05**	Ns
Luciferid	Ns	Ns	Ns	Ns	Ns
Portunid/grapsid	**p<0.05**	Ns	Ns	Ns	Ns
Ocypodid	**p<0.05**	Ns	Ns	**p<0.05**	Ns
Xanthid	Ns	Ns	Ns	Ns	Ns
Non-identified brachyuran	Ns	Ns	Ns	Ns	Ns

Ns = Not significant

Table 2 - Analysis of variance (Anova) of density (ind.m^{-3}) in response to depth, diurnal and tidal cycles, and their interactions in summer samples. Significant relations are marked with p level.

	Depth	Light	Tide	Depth/Light	Depth/Tide
Total decapod	**p<0.01**	**p<0.05**	Ns	Ns	Ns
Total brachyuran	**p<0.01**	Ns	Ns	**p<0.05**	Ns
Total other	Ns	**p<0.05**	Ns	**p<0.05**	Ns
Luciferid	Ns	**p<0.05**	Ns	Ns	Ns
Portunid/grapsid	**p<0.01**	**p<0.05**	Ns	**p<0.05**	Ns
Ocypodid	**p<0.01**	**p<0.05**	Ns	**p<0.05**	Ns
Xanthid	**p<0.01**	Ns	**p<0.05**	**p<0.05**	Ns
Non-identified brachyuran	**p<0.01**	Ns	**p<0.05**	Ns	**p<0.05**

Ns = Not significant

Table 3 - Analysis of variance (Anova) of density (ind.m^{-3}) in response to seasonal cycle (Season) and the interaction with depth (S/D - Season/Depth), tide (S/T - Season/Tide) and light (S/L - Season/Light).

	Season	S/D	S/T	S/L
Total decapod	p<0.05	Ns	Ns	p<0.05
Total brachyuran	p<0.05	Ns	Ns	Ns
Total other	Ns	Ns	Ns	p<0.05
Luciferid	Ns	Ns	p<0.05	p<0.05
Portunid/grapsid	Ns	Ns	Ns	Ns
Ocypodid	Ns	Ns	Ns	Ns
Xanthid	Ns	Ns	Ns	Ns
Non-identified brachyuran	Ns	Ns	Ns	Ns

Among the *L. faxoni* sampled, the following stages were identified: protozoeae, juveniles, adult females (few ovigerous), and adult males (Cardoso, 2000). All the other non-brachyuran and non-luciferid decapod larvae found constituted a low-density group called "other decapod". The total density of the "other decapod" group was similar to that for *L. faxoni*, in that high densities occurred during the night at the surface and during the day near the bottom in winter. The same result was not found during the summer. Two high densities occurred during nocturnal ebb tides.

Densities of *L. faxoni* and "other decapod" were associated with depth and with season / light interaction. *L. faxoni* was the only group that showed significant changes in population density in response to season and tide (Tab. 3).

DISCUSSION

Decapods by staying high in the water column during flood tides have found an efficient way to reach the shelf quickly (Saigusa, 1981). High densities of decapod crustacean larvae in surface waters during ebb tides support a hypothesis of larval transport from Guanabara Bay to the shelf coastal areas. Portunid (e.g. *Callinectes*), ocypodid (e.g. *Uca*) and cancrid (e.g. *Cancer*) larvae are commonly exported from estuaries to adjacent coastal areas (Epifanio *et al.*, 1989; Epifanio, 1996). High densities of portunid / grapsid zoeae found in this study at the surface during ebb tides, when the velocities of transport should be fast (see McConaugha, 1988), suggest the same pattern of dispersion toward oceanic waters. Portunid and cancrid zoeae have a high-salinity requirement for complete larval development (Epifanio and Dittel, 1984). As such, being exported to oceanic water is an ecological strategy to find optimal conditions

for development. In addition, this strategy avoids high predation rates common in estuaries (Morgan and Christy, 1997).

Ocypodids are believed to follow the same strategy because they were abundant at the same time as the portunids / grapsids. These results support the hypothesis of a dispersion strategy to the coastal adjacent waters. In Paranaguá Bay (Brazil), Freire (1998) found a similar dispersion strategy for *Ucides cordatus* to adjacent coastal waters. However, Sandifer (1975) suggested that retention in estuarine waters may be due to species specific behaviour.

In this study, unlike the portunids / grapsids and ocypodids, xanthids and luciferds did not show the same pattern of distribution in winter and summer. In the summer, xanthids and luciferids were exported from Guanabara Bay during nighttime ebb tides, as were the portunids / grapsids and ocypodids. In contrast, in the winter, xanthids were homogeneously distributed throughout the water mass, while luciferids were retained in the bay or imported from adjacent coastal waters. It is not clear yet if these distribution patterns represent family group strategies, because they may be related to occasional or to seasonal disturbances. In the first case, changes in vertical distribution are unpredictable. In Guanabara Bay, cold weather fronts cause occasional disturbances in vertical distribution and account for the high density of *Lucifer faxoni* near the bottom during the winter. In the second case, a seasonal pattern of distribution can be explained by the seasonal changes in salinity and temperature in Guanabara Bay (Paranhos *et al.*, 1993). In contrast, Lochmann *et al.* (1995) didn't find evidence to support links between tidal and diurnal changes and the vertical distribution of crab larvae (*Callinectes sapidus*). In our study, we found significant differences in the seasonal distribution of *Lucifer faxoni*.

Whether this difference was related to the marked seasonal variation in salinity and temperature is yet unclear. However, we could suggest a seasonal distribution pattern for *L. faxoni* as follows: in the winter, larval stages are imported into Guanabara Bay to complete their development inside estuary, and in the summer non-reproductive adults are exported to the shelf waters. In Guanabara Bay, the vertical distribution of decapod larvae are related to environmental conditions, as light and tide. Portunids / grapsids and ocypodids follow the same predictable pattern of dispersion toward the adjacent coastal waters, while for the luciferids and xanthids larvae, that pattern of distribution still remains unclear.

RESUMO

Larvas de crustáceos decápodes são organismos planctônicos comuns tanto em regiões costeiras rasas como em estuários. Nesse trabalho, foi acompanhada a variação da densidade das larvas de decápodes num ponto estratégico entre a porção interior da baía de Guanabara e a região costeira adjacente. A coleta de grandes quantidades de zoés de braquiúros, principalmente das famílias Portunidae e Grapsidae, na superfície durante as marés de vazante noturnas sugere uma tendência de exportação para a região costeira adjacente. A repetição desse padrão no inverno e no verão demonstrou que as respostas dos organismos às variações de luz e maré não foram alteradas de modo significativo entre as duas estações do ano, exceto para os luciferídeos. O fluxo observado para a única espécie de luciferídeo capturada (*Lucifer faxoni*) foi significativamente diferente entre os dois períodos do ano analisados. É provável que essas diferenças na distribuição de *Lucifer faxoni* seja relacionada ao ciclo reprodutivo da espécie. Foi observado um padrão de dispersão similar para as larvas zoé dos portunídeos, grapsídeos e ocypodídeos; transporte para a região costeira adjacente pela superfície durante as marés de vazante noturnas.

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