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Temporal variability and production of the planktonic copepods in the Cananéia Lagoon estuarine system, São Paulo, Brazil. II. *Acartia lilljeborgi*

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Abstract: Diel and seasonal variations in abundance, stage and sex composition, biomass and production rate of the planktonic calanoid copepod *Acartia lilljeborgi* were studied in Mar de Cananéia, the Cananéia Lagoon estuarine system, São Paulo, Brazil. A series of plankton sample collections were carried out at intervals of 4 h over multiple 24-h periods between February 1995 and January 1996. *Acartia lilljeborgi* was present throughout the year (temperature, 18.6–29.4°C; salinity, 4.5–30.0‰; chlorophyll-*a* concentration, 1.32–20.42 μg l^{-1}). It also showed considerable diel variations in abundance, but they were usually inconsistent in pattern. Abundance of *A. lilljeborgi* was low in February when salinity was lower than 17‰. In the other months, however, no environmental parameters were correlated with the seasonal variation of *A. lilljeborgi*. Seasonal variation in prosome length was linked to temperature variations. The biomass varied from 0.579±0.656 (daily mean±SD) to 7.915±4.585 mgC m^{-3}. The estimated production rates, using the Ikeda–Motoda, Huntley–Lopez and Hirtst–Sheader models, were 0.357–5.354, 0.464–7.401 and 0.176–2.31 mgC $m^{-3} d^{-1}$, respectively. These results showed that *A. lilljeborgi* was the second largest contributor to the total copepod biomass and the third largest contributor to total copepod productivity, constituting 25 and 20% of the annual copepod community biomass and production rate, respectively.

Key words: *Acartia lilljeborgi*, temporal variation, production, Cananéia Lagoon estuarine system, Brazil

Introduction

Planktonic copepods of the family Acartiidae are widely distributed in estuarine, lagoonal and neritic waters throughout the world. In these waters, they are often one of the most quantitatively important components, in terms of abundance and biomass, of the mesozooplankton communities (Day et al. 1987).

Along the coast of Brazil, 6 species of the genus *Acartia* (*A. danae*, *A. giesbrechti*, *A. lilljeborgi*, *A. longiremis*, *A. neligens* and *A. tonsa*) have been recorded (Björnberg 1981). Among these, *A. lilljeborgi* Giesbrecht is widely distributed in many tropical and subtropical estuarine waters of Brazil, from the Tocantins River estuary, Pará (Cipólli & Carvalho 1973) in the north to Paranaguá Bay, Paraná (Montú & Cordeiro 1988) in the south, and is predominant in the zooplankton communities in various estuarine waters, e.g. in the Itamaracá region, Pernambuco (Nascimento 1981; Paranaguá & Nascimento-Vieira 1984; Nascimento-Vieira & Eskinazi Sant'Anna 1987/1989), Espírito Santo Bay, Espírito Santo (Dias 1999), Guanabara Bay, Rio de Janeiro (Wandeness et al. 1997), São Sebastião Channel, São Paulo (Gaeta et al. 1990), Una do Prelado River estuary, São Paulo (Lansac-Tôha 1985), and the Cananéia Lagoon estuarine system, São Paulo (Matsumura-Tundisi 1972; Tundisi et al. 1973; Ara 1998).

The biology and ecology of *A. lilljeborgi* have been studied, e.g. on growth and development (Björnberg 1972; Hopcroft & Roff, 1998; Gómez-Gutiérrez et al. 1999), morphological abnormalities (Dias 1999), seasonal variation in

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abundance (Matsumura-Tundisi 1972; Montú & Cordeiro 1988; Lopes 1994), salinity tolerance (Tundisi & Matsumura-Tundisi 1968), temperature and/or salinity ranges for occurrences (Teixeira et al. 1965; Björnberg 1972; Matsumura-Tundisi 1972; Nascimento 1981; Lira et al. 1996) and egg production rate (Hopcroft & Roff 1998; Gómez-Gutiérrez et al. 1999; Ara, unpublished data). However, for *A. lilljeborgi*, there have been no studies on the population production rate.

The objective of the present study was to obtain quantitative information on *A. lilljeborgi*, analyzing the diel and seasonal variations in abundance and population structure in relation to the environmental variables and to evaluate the biomass and production rate of this species in the Cananéia Lagoon estuarine system, a mangrove-surrounded estuary situated near the southern border of São Paulo State.

Materials and Methods

Field investigations were carried out at a fixed station (25°01′11″S, 47°55′43″W, 10–12 m in depth depending on the tidal phase) situated in Mar de Cananéia (Fig. 1), at 4-h intervals during multiple 24-h periods, from February 1995 to January 1996. Plankton samples were collected by vertical hauls from the bottom to the surface, using a plankton net (50 cm in mouth diameter, 150 μm in mesh size) equipped with a flowmeter. Net samples were immediately preserved in 5–10% formalin–seawater solution.

Water samples were collected at 2-m intervals from the surface to the bottom, using a 3-liter Van Dorn bottle. Water temperature was recorded with an electronic thermometer. Salinity was determined using an optical refractometer. Water aliquots of 200 to 500 ml, collected from 0, 2, 6 and 10-m depth, was filtered through a glass-fiber filter (Whatman GF/F) for spectrophotometric determination of chlorophyll-*a* concentration (Lorenzen 1967). Tidal height was cited from the tide tables given by Mesquita & Harari (1993) and Harari & Mesquita (1995).

Acartia lilljeborgi from split samples (1.25 to 40% of the original samples) were sexed and the developmental stages determined (C1–6), and counted under a microscope. Prosome length was measured using an ocular micrometer.

For statistical comparison between daytime and nighttime abundances of *A. lilljeborgi*, one-way ANOVA was applied: a p value of 0.05 was considered significant (Sokal & Rohlf 1981). Correlations between abundances of *A. lilljeborgi* and the environmental variables (temperature, salinity, chlorophyll-*a* concentration and tidal height) were examined by the Spearman rank correlation analysis. The correlation between prosome length of *A. lilljeborgi* and the environmental variables was analyzed by multiple linear regression.

Biomass was estimated by the multiplication of abundances and individual dry weights (DW, μg), calculated from prosome lengths (L in μm), using a length–weight regression equation for the stages C1–6, given as:

$$\mathrm{DW}=6.177\times10^{-9}L^{3.029}\ (r=0.952, p<0.0001).$$

Carbon content was assumed to be 45.3% of dry weight (Ara 1998; Ara, unpublished data).

Production rate (Pc, mgC m^{-3} d^{-1}) was estimated by the following equation:

$$\mathrm{Pc}=\sum N\times \mathrm{Wc}\times G$$

where N is abundance (indiv. m^{-3}), Wc is individual weight (μgC) and G is individual weight-specific growth rate (d^{-1}). Here, G was estimated using the three models proposed by Ikeda & Motoda (1978), Huntley & Lopez (1992) and Hirst & Sheader (1997). In the Ikeda–Motoda model, the growth rate is estimated from respiration rate (R, μgO$_2$ animal^{-1} h^{-1}), which can be determined from habitat temperature (T, °C) and individual animal dry weight (W, mg) (Ikeda 1974):

$$R=10^{0.02538T-0.1259}\times W^{-0.01089T+0.8918}.$$

Oxygen respired is converted to carbon using a respiratory quotient of 0.8, and to daily rates by multiplying by 24 (hours). Assuming an assimilation efficiency of 0.7 and a gross growth efficiency of 0.3, individual weight-specific growth is given as:

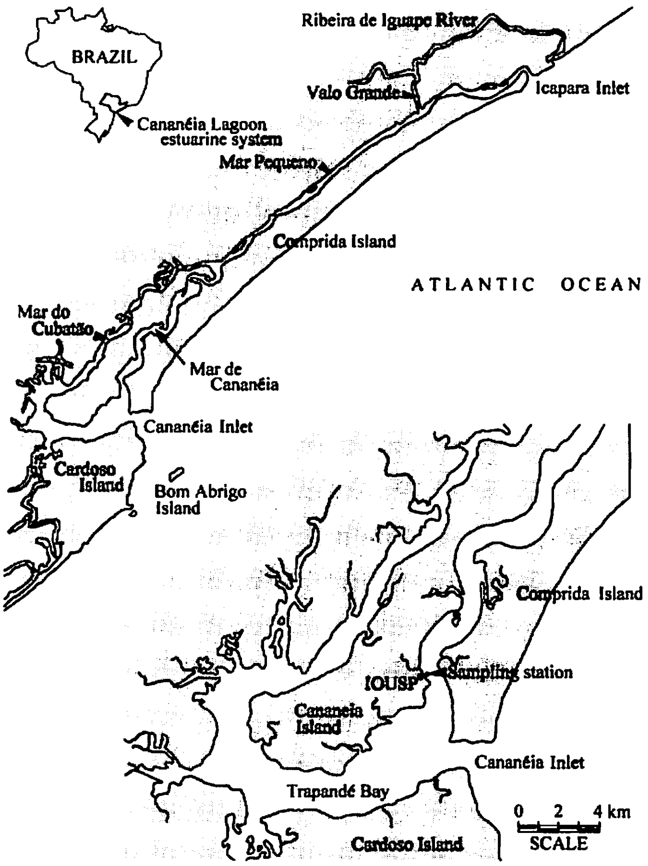

Fig. 1. Map showing the sampling station in the Cananéia Lagoon estuarine system.

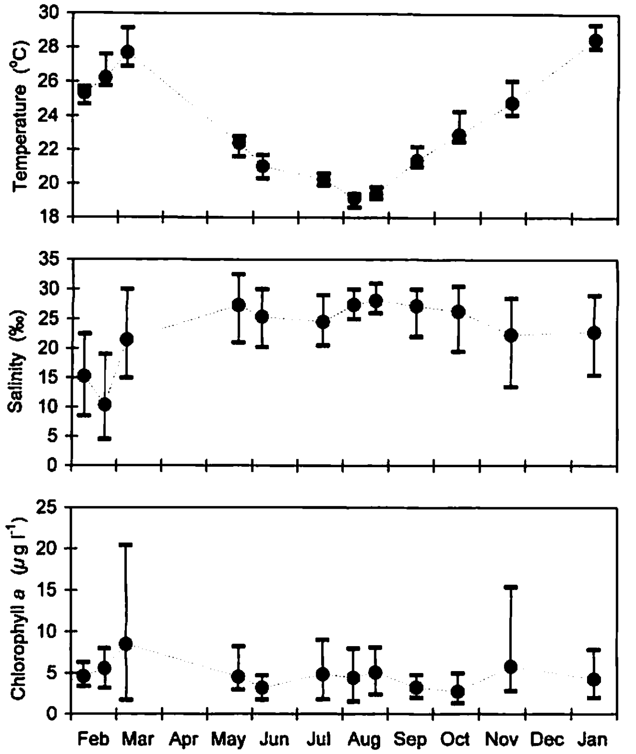

Fig. 2. Seasonal variations in water temperature, salinity and chlorophyll-*a* concentration in the Cananéia Lagoon estuarine system, from February 1995 to January 1996. Closed symbols and vertical bars denote mean values in the water column and their ranges, respectively.

$$G=(7.714\times10^{0.02538T-0.1259}\times W^{-0.01089T+0.8918})/\mathrm{Wc}\,.$$

In the Huntley–Lopez model, the growth rate is dependent on only temperature, given as:

$$G=0.0445\,e^{0.111T}.$$

In the Hirst–Sheader model, the growth rate is dependent on carbon weight (Wc, μg) and temperature, expressed as:

$$G=1.0583^{T}\times\mathrm{Wc}^{-0.2962}\times13.6616^{-1}.$$

Results

Environmental variables

Water temperature ranged from 18.6°C on 8 August to 29.4°C on 15 January (Fig. 2). No thermocline was found at any time during the year: the difference between the surface and bottom waters was 0.7–2.2°C. Salinity varied from 4.5 to 33.0‰, and was much lower in February (Fig. 2), due to the local heavy rain. Chlorophyll-*a* concentration fluctuated from 1.32 to 20.42 μg l^{-1} (Fig. 2). Salinity and chlorophyll-*a* concentration varied markedly with depth, depending on the tidal cycle.

Abundance

Diel variations in abundance of *Acartia lilljeborgi*, tidal height and salinity are shown in Fig. 3. *Acartia lilljeborgi* was present throughout the study period. On each sampling date, the abundance of *A. lilljeborgi* varied considerably with time: coefficients of variation (SD) were 21.2–71.4% (mean 49.0%) of daily mean abundance. On most sampling dates, there was no consistent trend of diel variation in abundance; peak abundance was random with respect to time and the tidal cycle. There was no statistically significant difference between daytime and nighttime abundances (ANOVA, $p>0.05$). The night:day abundance ratio varied from 0.49 in August to 1.76 in February, with an overall mean of 1.04. However, in February and March, higher abundances were recorded at times when salinity was higher.

Daily mean abundance of *A. lilljeborgi* varied from $6.7\times10^2\pm4.4\times10^2$ (mean±SD) to $6.9\times10^3\pm1.5\times10^3$ indiv. m^{-3} (Fig. 4). The population density was higher in May, June and January, but lower in February and September.

Stage and sex composition

All of the copepodite (C1–5) and adult (C6) stages were present in the plankton throughout the study period, except in February. These stages showed similar seasonal variations in abundance (Fig. 5). The annual mean numerical proportion of the stages C1–6 was 15.8, 16.6, 19.2, 16.6, 14.1 and17.8%, respectively.

Sex composition in C4–6 showed slight seasonal variations (Fig. 6). The mean percentage of females in C4–6 was 50.2, 45.0 and 59.6%, respectively.

Effect of the environmental factors

Although *A. lilljeborgi* was present in the plankton over wide ranges of the environmental variables, its higher densities were frequently found at salinities more than ca. 17‰, but not showing any preference to any particular ranges of tidal height, temperature or chlorophyll-*a* concentrations (Fig. 7).

Coefficients of correlation between the abundances of C1–6 and the environmental variables are presented in Table 1. The abundance of the stages C2–5 showed significantly positive correlations with salinity, and that of C5 was positively correlated with tidal height. Sex composition in C4–6 was not significantly correlated with any environmental factors, with the exception of a positive correlation with salinity in C6.

Prosome length

Prosome length showed seasonal fluctuations, being larger in winter and smaller in summer, particularly in the older stages (Fig. 8). The prosome length was negatively correlated to temperature and chlorophyll-*a* concentration,

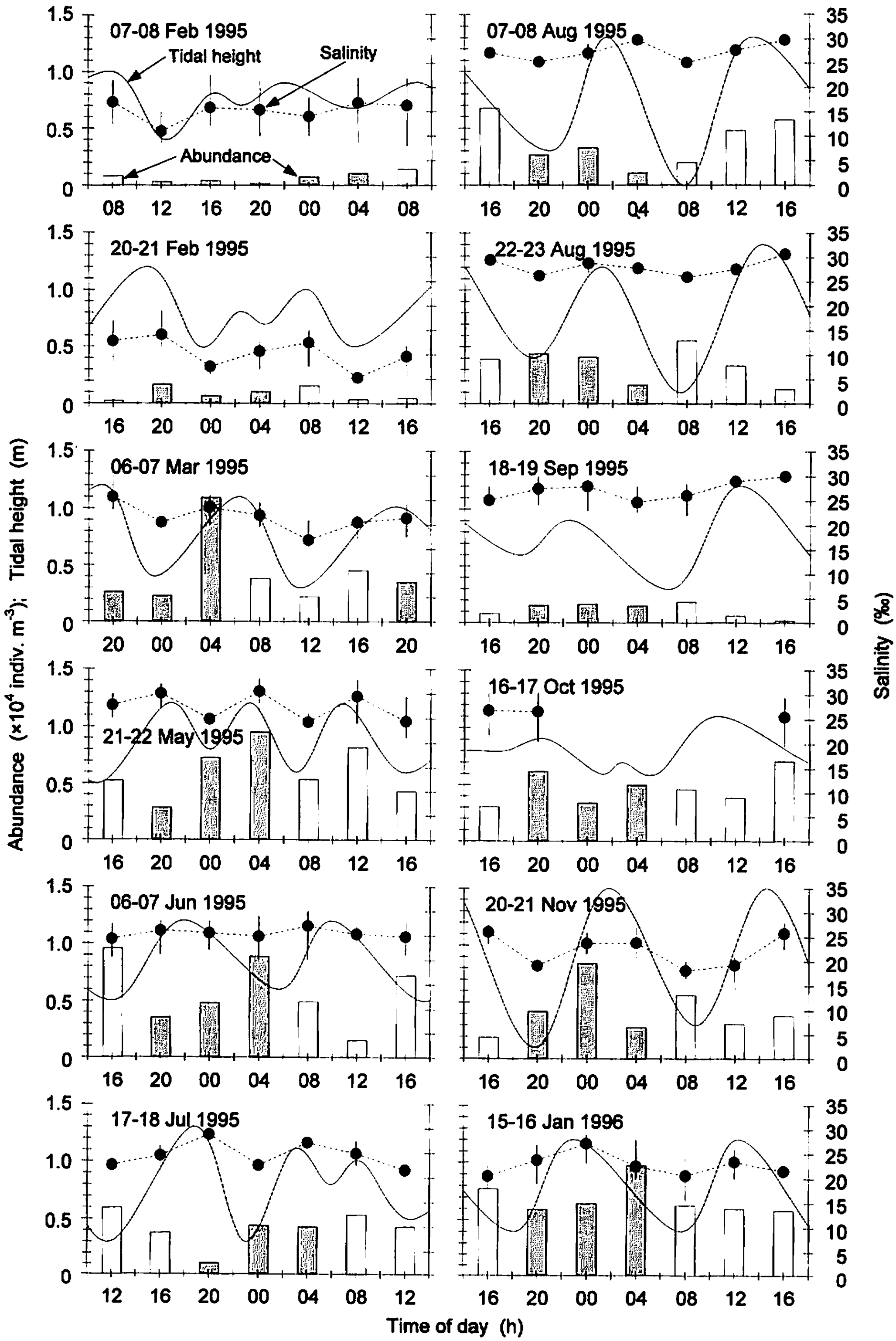

Fig. 3. Diel variations in abundance of *Acartia lilljeborgi* (C1–6), tidal height and salinity in the Cananéia Lagoon estuarine system, from February 1995 to January 1996. White and dark bars denote abundances in the daytime and nighttime, respectively. Salinity is expressed as mean value in the water column (●) and its range (vertical bars).

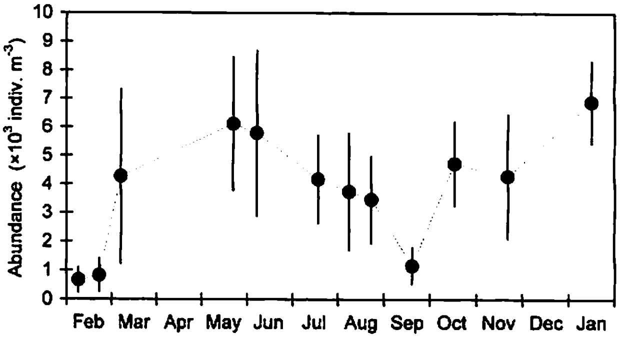

Fig. 4. Monthly variation in abundance of *Acartia lilljeborgi* (C1–6) in the Cananéia Lagoon estuarine system, from February 1995 to January 1996. Abundance is expressed as daily mean (●) ±SD (vertical bars).

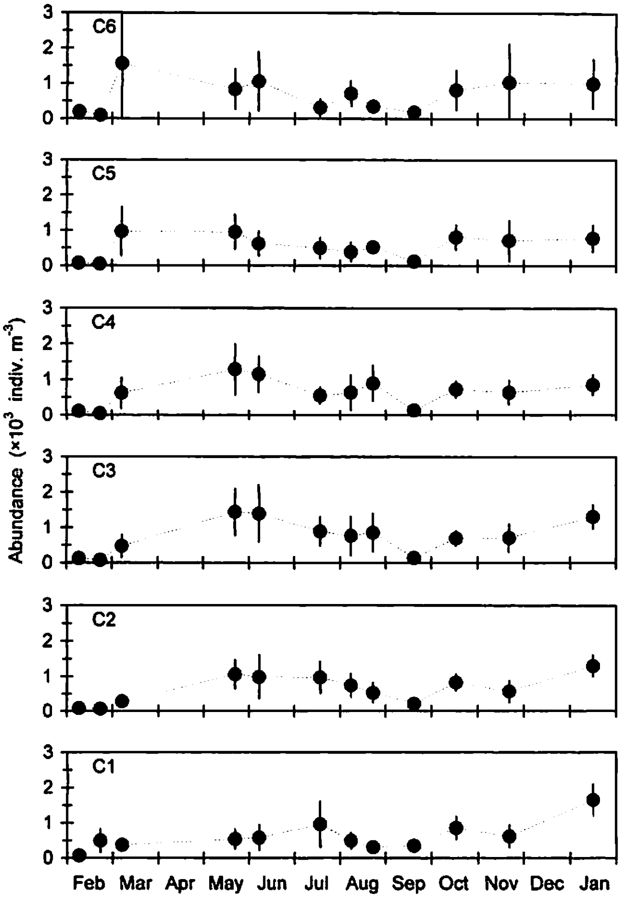

Fig. 5. Monthly variation in abundance of the stages C1–6 of *Acartia lilljeborgi* in the Cananéia Lagoon estuarine system, from February 1995 to January 1996. Abundance is expressed as daily mean (●) ±SD (vertical bars).

and was positively correlated to salinity. Among these environmental factors, temperature was the main factor to explain the variation in body length of *A. lilljeborgi* (Table 2).

Biomass and production rate

Daily mean biomass varied from 1.277±1.466 to 17.462±10.114 mgDW m^{-3}, or from 0.579±0.656 to 7.915 ±4.585 mgC m^{-3}. The biomass was high from March to June and from October to January, and was low in February and September (Fig. 9).

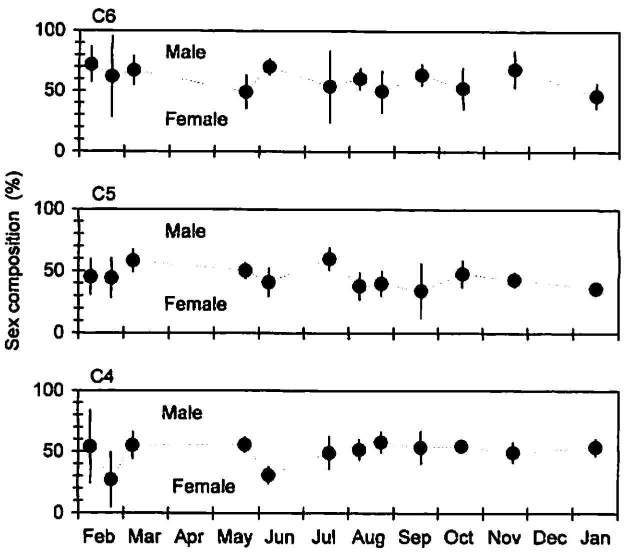

Fig. 6. Monthly variation in sex composition of the stages C4–6 of *Acartia lilljeborgi* in the Cananéia Lagoon estuarine system, from February 1995 to January 1996. Sex composition is expressed as daily mean (●) ±SD (vertical bars).

Although the pattern of temporal variations in production rate was almost similar to that of biomass, the production rate differed depending on the method of estimating growth rate; daily mean production rates calculated using the Ikeda–Motoda, Huntley–Lopez and Hirtst–Sheader models were 0.357±0.341–5.354±1.885, 0.464±0.52–7.401±3.38 and 0.176±0.178–2.31±0.905 mgC m^{-3}d^{-1}, respectively (Fig. 9). The mean ratio of daily production rate to biomass (daily *P*/*B* ratio) estimated using these models were 0.23–0.76, 0.37–1.05 and 0.18–0.33 d^{-1}, respectively.

Discussion

Although the seasonal variation in abundance of *Acartia lilljeborgi* has been studied in some estuarine waters in Brazil (e.g. Matsumura-Tundisi 1972; Lopes 1994), there is no study on the diel variation in this area. In the present study, on each sampling date, 7 plankton samples were collected at intervals of 4 h to analyze the occurrence of *A. lilljeborgi* in relation to time of day, tidal cycle and salinity variations. As demonstrated in previous studies (Sameoto 1975; Lee & McAlice 1979; Gagnon & Lacroix 1981; Ferrari et al. 1985; Zagami et al. 1996; Dauvin et al. 1998), the abundance of *A. lilljeborgi* varied considerably during the 24-h period, not showing significant differences between daytime and nighttime abundances. During the study period, *A. lilljeborgi* was present in the plankton over wide ranges of temperature and salinity (Fig. 7), as similarly found in various estuarine waters of Brazil (e.g. Mat-

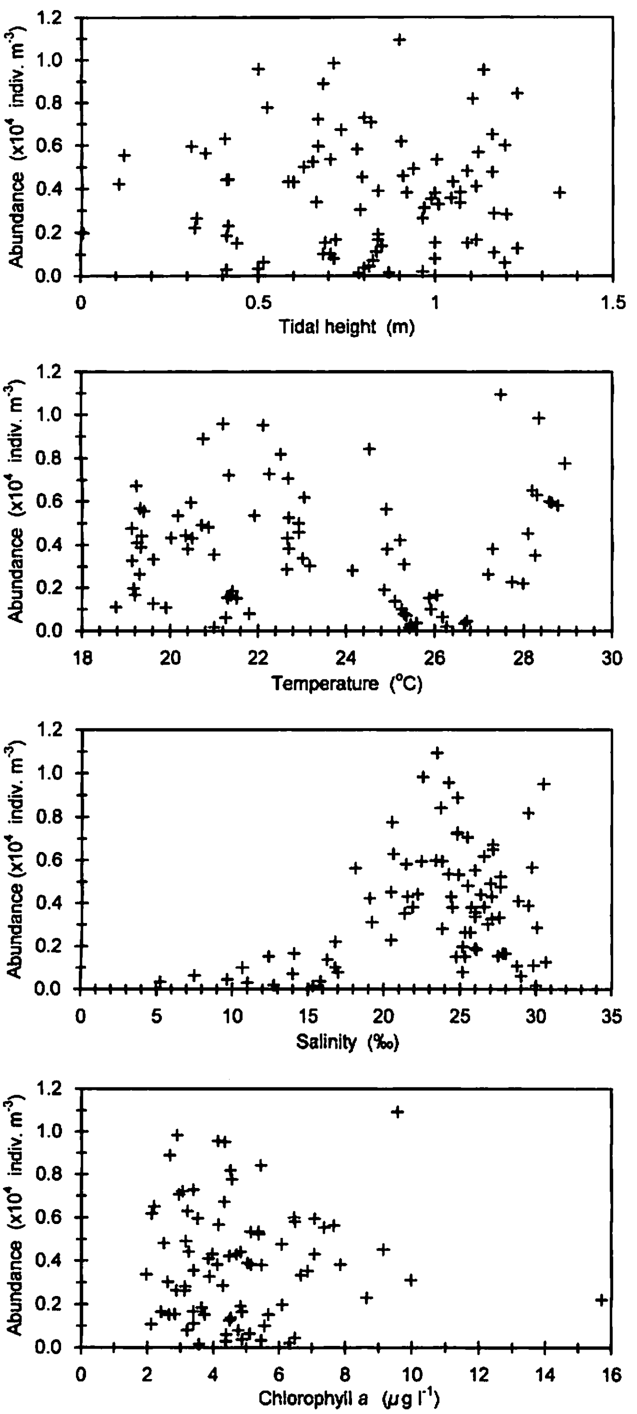

Fig. 7. Relationships between abundance of *Acartia lilljeborgi* (C1–6) and the environmental variables (tidal height and mean temperature, salinity and chlorophyll-*a* concentration in the water column) in the Cananéia Lagoon estuarine system, from February 1995 to January 1996.

Table 1. Spearman rank correlation analysis between abundance of *Acartia lilljeborgi* and the environmental variables (tidal height and mean temperature, salinity and chlorophyll-*a* concentration in the water column) in the Cananéia Lagoon estuarine system, from February 1995 to January 1996. *T*: temperature (°C); *S*: salinity (‰); Chl: chlorophyll-*a* concentration (μg l^{-1}); TH: tidal height (m). Significant correlation: *0.01<p<0.05; **0.001<p<0.01; ***p<0.001.

Stage/sex	*T*	*S*	Chl	TH
Total	−0.0319	0.214	−0.0324	−0.0049
C1	0.121	−0.0221	0.0299	−0.180
C2	−0.180	0.263*	−0.108	−0.0914
C3	−0.166	0.264*	−0.0105	−0.0319
C4 Females	−0.158	0.403***	0.0033	0.115
C4 Males	−0.208	0.327**	-0.0321	0.0785
C5 Females	0.0293	0.266*	−0.0650	0.224*
C5 Males	−0.0063	0.331**	−0.114	0.217*
C6 Females	0.0618	0.0963	−0.106	0.0483
C6 Males	0.0676	0.173	−0.155	0.118
F/F+M (C4)	0.0282	0.197	−0.0410	0.0765
F/F+M (C5)	0.0655	−0.0986	0.108	0.0241
F/F+M (C6)	0.0555	−0.234*	0.111	−0.109

sumura-Tundisi 1972; Nascimento 1981; Lira et al. 1996). Tundisi & Matsumura-Tundisi (1968) found a high degree of tolerance of *A. lilljeborgi* adult females over a wide range of salinities (8.8–30.0‰). However, *A. lilljeborgi* showed a preference for salinities higher than ca. 17‰ (Fig. 7). Additionally, during the low-salinity period of February and March, *A. lilljeborgi* was more abundant when salinity was higher (Fig. 3). Therefore, in Mar de Cananéia, the *A. lilljeborgi* population was persistent, but the location of its population center might shift depending on seasonal variation in the inflow of freshwater from rivers and seawater from the Atlantic Ocean. However, during most of the year, i.e. from May to January, when salinity was usually higher than 17‰, the abundance of *A. lilljeborgi* was not correlated with any environmental factor (Figs 3, 7). Judging from the lack of diel variations, on each sampling date the mean abundance and variation coefficient of the 7 samples were regarded as representative values to analyze the seasonal variation (Fig. 4). Although in September salinity was high, the densities of *A. lilljeborgi* were low (Figs 3, 4). The cause of these low abundances may be due to biological factors (i.e. competition) rather than environmental variables. In September, *A. lilljeborgi* may not have been able to maintain its population density because two calanoid copepods *Temora turbinata* and *Paracalanus crassirostris* were much more abundant in addition to increased abundance of the cyclopoid *Oithona hebes*, which was the most dominant copepod throughout the study period.

The annual mean proportions of females and males were similar in C4 and C5, whereas in C6 females outnumbered males (ANOVA, p<0.05). The sex composition variation observed in C6 could result from the greater sensitivity of males to hydrographic instability (i.e. low salinity): when the total population (C1–6) density decreased, males diminished proportionally (r=0.242, p<0.05) more rapidly than females. However, this does not seem to be related to a particular sensitivity of adult males to low salinity because no significant correlation was found between their abundance

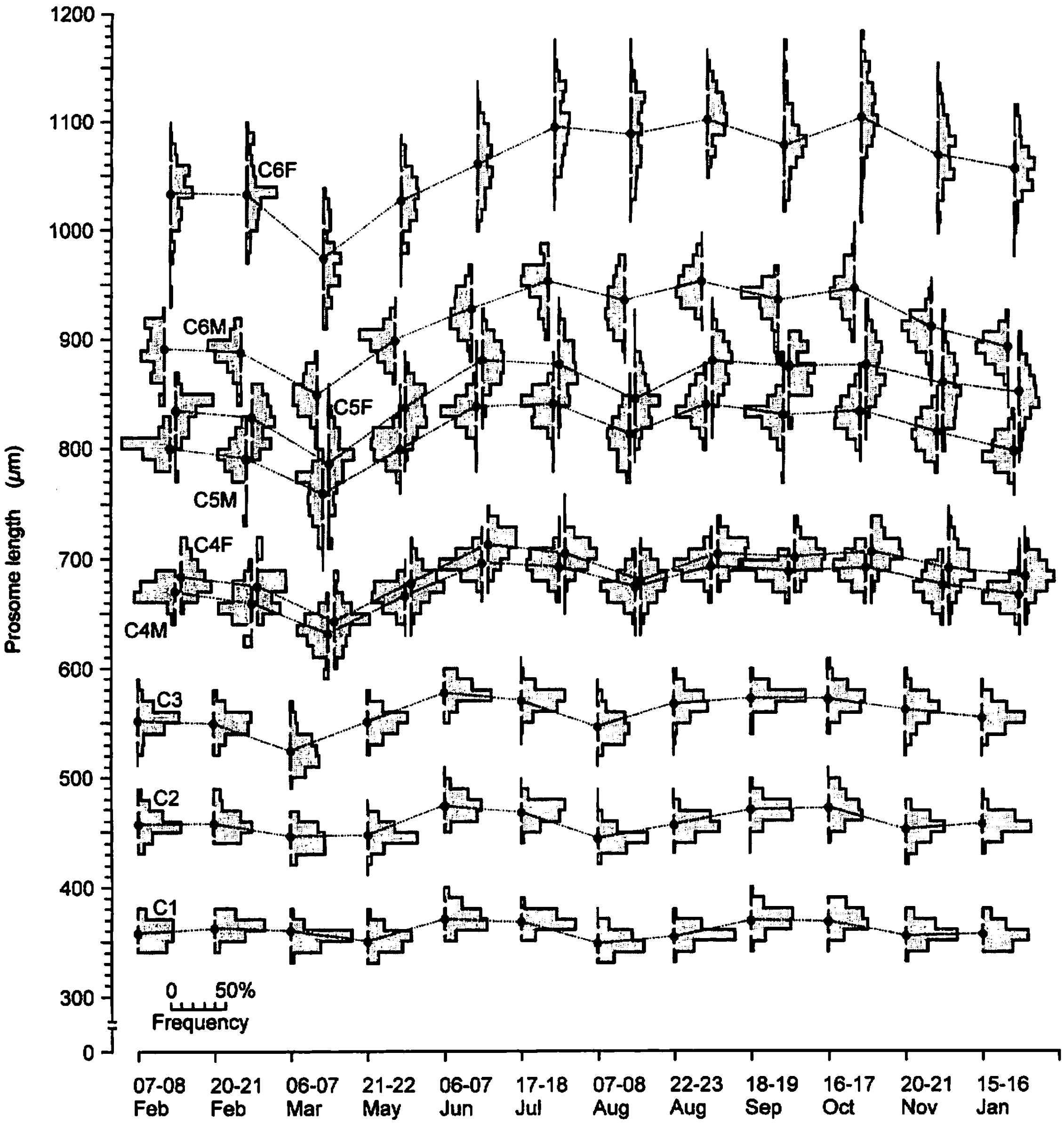

Fig. 8. Monthly variation in prosome length of the stages C1–6 of *Acartia lilljeborgi* in the Cananéia Lagoon estuarine system, from February 1995 to January 1996. Prosome length is expressed as size-frequency distribution and mean prosome length (●) ±SD (vertical bars). F: female; M: male.

and salinity, similarly as for adult females, although the proportion of adult males was positively correlated with salinity (Table 1). During periods of low population density, a higher proportion of females to males should increase egg production. This can be interpreted as compensatory and homeostatic mechanisms for the regulation of the population (Heinle 1970; Sabatini 1990; Zaballa & Gaudy 1996). However, Ara (unpublished data) found that the egg production rate of *A. lilljeborgi* decreased markedly with decreasing salinity. Thus, during the periods of low abundance associated with low salinity, *A. lilljeborgi* is unable to recover its population level rapidly by increasing egg production.

Biomass determinations have been done for several *Acartia* species in various estuarine, lagoonal and neritic waters around the world. Although in the present study the biomass of *A. lilljeborgi* was determined only for C1–6, not including the eggs and naupliar stages, the higher biomasses were equivalent to those found for other *Acartia* species around the world (Table 3).

The copepod production rate should be estimated using the species- and stage-specific growth rates, which can be determined by incubation. However, there is no available growth data for *A. lilljeborgi*. Therefore, in the present study, the production rate was estimated by three simple models from a few easily measurable parameters (temperature, individual weight and abundance). The production rates estimated by the Ikeda–Motoda and Huntley–Lopez

Table 2. Multiple linear regression equations of the relationships between prosome length of the developmental stages C1–6 of *Acartia lilljeborgi* and the environmental variables (temperature, salinity and chlorophyll-*a* concentration) in the Cananéia Lagoon estuarine system, from February 1995 to January 1996. PL: prosome length (μm); T: mean temperature (°C) in the water column; S: mean salinity (‰) in the water column; Chl: mean chlorophyll-*a* concentration ($\mu g\,l^{-1}$) in the water column; r: coefficient of correlation; n: number of cases. Significant correlation: *$0.01<p<0.05$; **$0.001<p<0.01$; ***$p<0.001$.

Stage/sex	Multiple linear regression equation (PL vs. T, S and Chl)	r	n
C1	PL= 387.68−0.197T−0.283S −0.380Chl	0.412**	79
C2	PL= 488.29−0.194T−0.0912S−0.379Chl	0.438**	77
C3	PL= 628.00−0.422T−0.0741S−0.403Chl	0.636***	76
C4 Female	PL= 784.16−0.458T−0.0493S−0.396Chl	0.671***	75
C4 Male	PL= 786.25−0.582T−0.0807S−0.368Chl	0.741***	75
C5 Female	PL= 940.34−0.391T+0.133S −0.296Chl	0.658***	75
C5 Male	PL= 924.64−0.596T+0.0982S−0.167Chl	0.740***	77
C6 Female	PL=1191.63−0.459T+0.139S −0.249Chl	0.694***	76
C6 Male	PL=1068.87−0.661T+0.121S −0.202Chl	0.839***	73

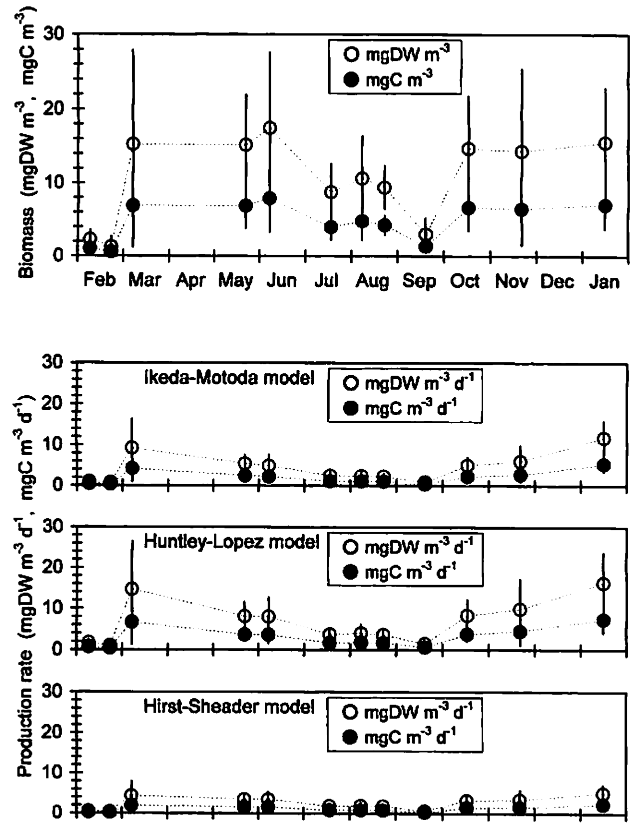

Fig. 9. Monthly variations in biomass (upper) and production rate (lower) of *Acartia lilljeborgi* (C1–6) in the Cananéia Lagoon estuarine system, from February 1995 to January 1996. Biomass and production rate are expressed as daily mean (O and ●) ±SD (vertical bars).

models were higher than those estimated by the Hirst–Sheader model, in particular during the high-temperature periods such as March, November and January (Fig. 9). There is a possibility for overestimation of the rates estimated by the two former models, as pointed out by Hirst & Sheader (1997). Although the production rates differed depending on the method for estimating growth rate, the maximum production rate of *A. lilljeborgi* obtained in the present study was equivalent to that of copepods in other estuarine, lagoonal and neritic waters (Table 3). The maximum *P/B* ratios obtained for *A. lilljeborgi* in the present study were relatively high compared to those of *Acartia* species in other estuarine, lagoonal and neritic waters (Table 3).

During the study period, *A. lilljeborgi* was one of the predominant species in the copepod community in the Cananéia Lagoon estuarine system: it was the second largest contributor to the total copepod abundance and biomass and the third largest contributor to total copepod productivity, constituting 12, 25 and 20% of the annual copepod community abundance, biomass and production rate, respectively. The present study showed that *A. lilljeborgi* was well adapted to subtropical shallow estuarine waters and played an important role as a secondary producer in the Cananéia Lagoon estuarine system, and that this estuarine system can be evaluated to be a region that has high copepod productivity compared to other estuarine, lagoonal and neritic waters. This can be attributed to the local characteristics; year-round higher temperatures and waters rich in particulate organic matter originating from mangrove litter.

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Table 3. Biomass, daily production rate and daily *P*/*B* ratio of *Acartia* species in various estuarine, lagoon and neritic waters. E: egg; N: nauplius; C: copepodite.

Species	Stage	Region	Biomass (mgC m^{-3})	Production rate (mgC m^{-3} d^{-1})	*P*/*B* ratio (d^{-1})	Temp. (°C)	Reference
Acartia bifilosa	C1–C6	Gdansk Bay, Poland	10.83–3056***	1.03–96.88***	0.03–0.12	7–18	Ciszewski & Witek 1977
Acartia bifilosa	E–C6	Gironde estuary, France	—	—	0.03–0.14	—	Irigoien & Castel 1995
Acartia clausi	N1–C6	Jakle's Lagoon, USA	—	6.3–7.7*	0.12–0.23	8–20	Landry 1978
Acartia clausi	C4–C6[b]	Ebrié Lagoon, Ivory Coast	—	—	0.21–0.74	26.0–30.2	Le Borgne & Dufour 1979
Acartia clausi	E–C6	Onagawa Bay, Japan	—	0.037–3.24	0.05–0.42	4.7–23.2	Uye 1982
Acartia clausi	E–C6	Ebrié Lagoon, Ivory Coast (1981–82)	9.7–110.9**	3.2–26.8**	0.12–0.34	26–31	Pagano & Saint-Jean 1989
Acartia clausi	E–C6	Ebrié Lagoon, Ivory Coast (1984–85)	26.1–63.7**	8.2–17.1**	0.21–0.45	26–31	Pagano & Saint-Jean 1989
Acartia hudsonica	N1–C6	Narragansett Bay, USA	10.9–255.5**	7.52–12.77	0.22–0.32*	3.0–21.8	Durbin & Durbin 1981
Acartia omorii	E–C6	Inland Sea of Japan	0–80.5	0–36.8	0.05–0.60	8.9–24.3	Liang & Uye 1996
Acartia tonsa	N1–C6	Patuxent River estuary, USA	85.89–169**	43.44–96.48**	0.46–0.57*	24.0–26.5	Heinle 1966
Acartia tonsa	N–C6	Chesapeake Bay, USA[a]	0.17–16.3**	0.08–7.47**	0.090–0.65	—	Allan et al. 1976
Acartia tonsa	N1–C6	Narragansett Bay, USA	3.3–215.8**	18.98–22.91	0.80–0.91*	17.0–23.6	Durbin & Durbin 1981
Acartia tonsa	>200 μm	Chesapeake Bay, USA	mean 7.83	mean 5.79	mean 0.74*	12.5–28.6	Purcell et al. 1994
Acartia tonsa	E–C6	Westerschelde estuary, Netherlands	0–50.0**	0–24.4**	mean 0.27*	6–22	Escaravage & Soetaert 1995
Acartia tranteri	E–C6	Westernport Bay, Australia	2.5–22.1**	0.1–3.1**	mean 0.10	11–22	Kimmerer & McKinnon 1987
Acartia spp.[c]	E–C6	Málaga Bay, Spain	<5–90**	13.9** (6.26)	—	14–25	Guerrero & Rodríguez 1994
Acartia spp.[c]	E–C6	Málaga Bay, Spain	<5–228**	29.12** (13.10)	—	—	Guerrero & Rodríguez 1997
Acartia lilljeborgi	C1–C6	Cananéia, Brazil	mean 1.28–17.46** (mean 0.58–7.92)	mean 0.36–5.35 mean 0.46–7.40 mean 0.18–2.31	mean 0.23–0.76 mean 0.37–1.05 mean 0.18–0.33	18.8–28.9	This study

* calculated from data; ** biomass (mgDW m^{-3}) and production rate (mgDW m^{-3} d^{-1}); *** biomass (mgDW m^{-2}) and production rate (mgDW m^{-2} d^{-1}); a: Rhode River sub-estuary of Chesapeake Bay, USA; b: dominant stages; c: *Acartia grani*, *A. clausi* and *A. discaudata* var. *mediterranea*.

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