Bolm Inst. oceanogr., S Paulo, 28(2):1-15, 1979

# COPEPODS OF THE GENUS *OITHONA* FROM CANANÉIA REGION (LAT. 25°07' S, LONG. 47°56' W)

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Synopsis

*Some ecological aspects of two congeneric species of Cyclopoid copepods, Oithona ovalis and O. oligohalina, have been studied for the first time in the estuarine region of Cananéia. The spatial distribution and seasonal variation of both species of Oithona are studied in relation to salinity, temperature and dissolved oxygen. The results obtained are compared to previous work done in the area and to similar studies undertaken elsewhere.*

## Introduction

The genus *Oithona* is widely distributed and occurs in all kinds of marine environments (estuarine, coastal and oceanic waters). It is not usually recorded in zooplankton samples due to its small size in relation to the mesh aperture of the gause commonly used in zooplankton nets. The species of *Oithona* are very similar and often misidentified (Grice, 1960).

The purpose of this paper is the study of the spatial and temporal distribution of *Oithona oligohalina* and *O. ovalis* in the estuarine region of Cananéia, South littoral of the State of São Paulo, Brazil (Lat. 25°07'S - Long. 47°56'W).

Copepods are the dominant animals of the plankton in the Cananéia region and among them the genus *Oithona* is one of the most abundant (Teixeira, Tundisi & Kutner, 1965).

The two species of *Oithona* found in Cananéia waters are morphologically almost alike (Fonseca & Björnberg, 1976; Fonseca, 1976) but have different patterns of distribution in relation to salinity.

Temperature, salinity and dissolved oxygen were considered the main environmental factors in the study of the distribution of the species along the estuary.

The salinity of estuarine waters suffers wide fluctuations (Kinne, 1967). The seasonal variation of salinity is remarkable in estuaries especially in Summer. Besides this, it has a semidiurnal salinity variation due to tidal movements (Fraga, 1972).

The area delimited for this study is very narrow but suffers a very strong influence of tidal movements.

Many papers have been published on plankton from the Cananéia region (Teixeira, Tundisi & Kutner, 1965; Teixeira, Tundisi & Santoro Ycaza, 1969; Tundisi, 1970; Prado, 1972; Kutner, 1972; Tundisi, 1972) but this is the first on congeneric species of copepods living there. It is also the first time that zooplankton samples were collected in a river of this complex estuarine region.

## Material and methods

Plankton samples were taken monthly (June, 1973 - May, 1974) at three fixed stations as follows: the first station was located in the upper waters of Taquari river, the second at its mouth and the third in Trapandé Bay (Fig. 1). The depths of the stations I, II and III were respectively 1.70, 3.80 and 4.00 m. The influence of coastal water is greater at St. III and smaller at St. I. Surface plankton samples were taken by means of a zooplankton net type WP3 (Fraser, 1968) with its size reduced to half and mesh aperture 75 µm. All hauls were taken with the ship running at slow speed, against the tide, during 3 minutes.

The first and second stages of *O. oligohalina* and *O. ovalis* were obtained from ovigerous females in the laboratory (Fonseca & Prado, in preparation).

Salinity determinations were made by the Harvey Method and dissolved oxygen by the Winkler Method. The temperature was recorded with a reversing-thermometer adapted to a Nansen water-bottle.

*Publ. nº 444 do Inst. oceanogr. da Usp.*

An aliquot of 5 ml of each haul was obtained by means of a Stempel pipette and all the nauplii stages and the adults of both sexes were counted up. Copepodites were disregarded due to the difficulties of quick identification.

The number of nauplii and adults was plotted against salinity and temperature of each haul (T. S. P.).

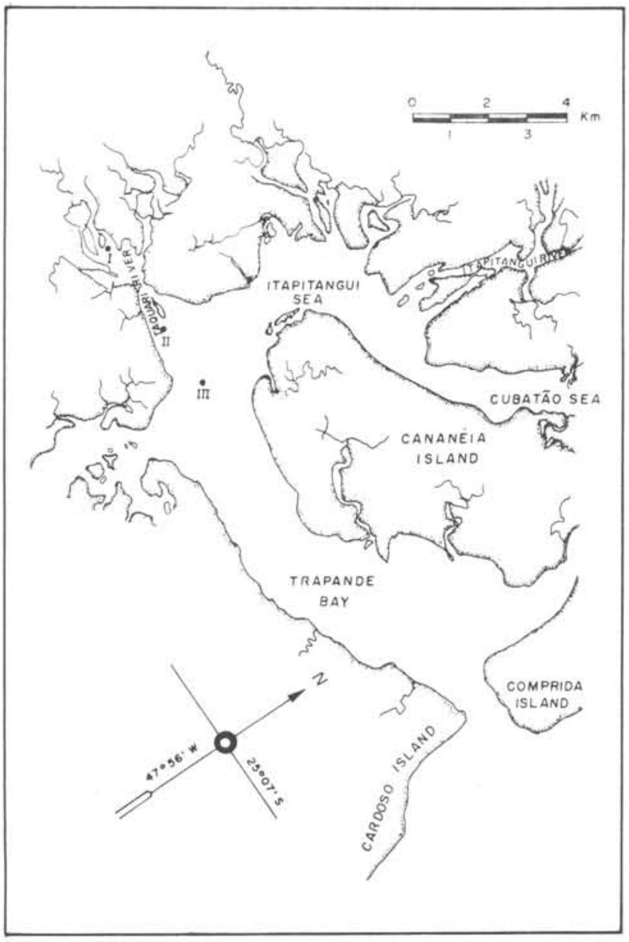


Fig. 1. Sampling location. Cananéia region.

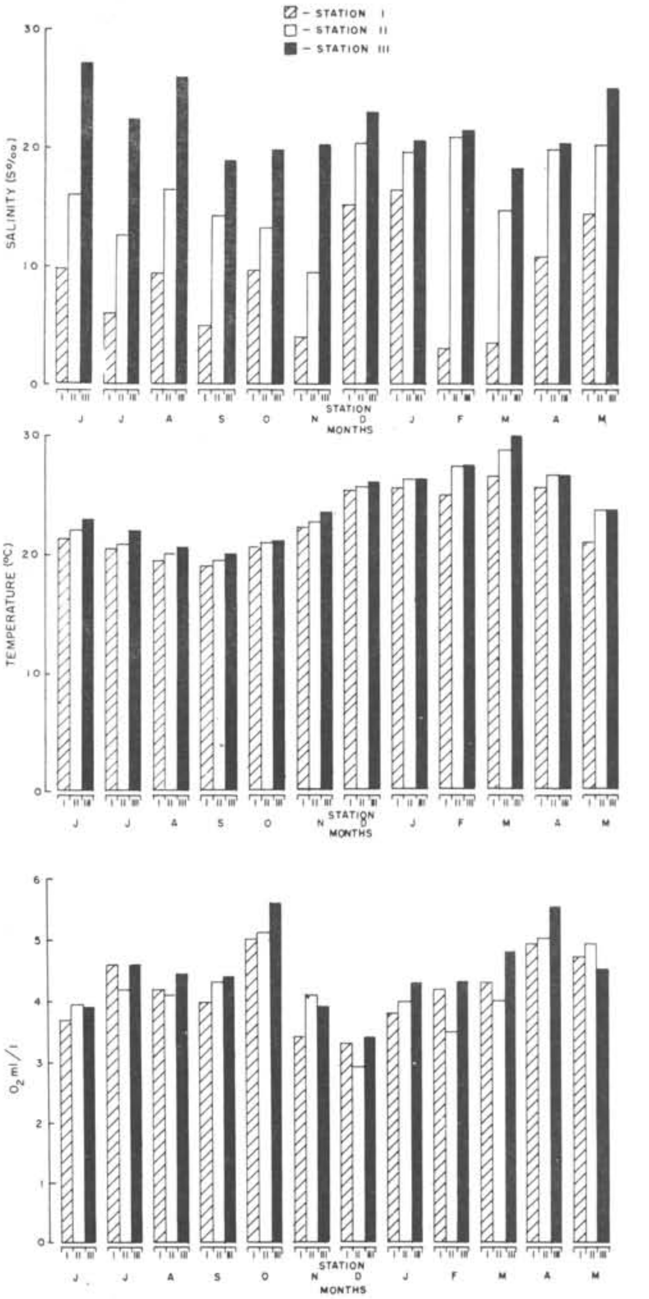


Fig. 2. Salinity (°/oo), temperature (°C) and dissolved oxygen (ml/l) at St. I, II and III (June 1973 to May 1974).

Results

*1. Hydrographical data*

Figure 2 shows the data of temperature, salinity and dissolved oxygen of St. I, II and III, from June 1973 to May 1974.

A small increasing gradient of temperature from St. I to St. III was observed. These differences can be explained by the sampling time and the position of the stations. Samples were always taken earlier in the morning at the St. I and later on at the St. II and III. The Station I is also more sheltered by coastal vegetation than St. II and III.

A strong increasing gradient of salinity was registered from St. I to II and III, due to tidal movements and to the influence of the river discharge.

The dissolved oxygen in the same day does not show significative differences at the three stations.

The samples were always taken in the morning at any tidal level. Figure 3 shows the tidal level in each haul.

*2. Distribution and seasonal variation of Oithona ovalis and O. oligohalina*

*2.1. Oithona ovalis*

*Abundance*: *O. ovalis* was more a-

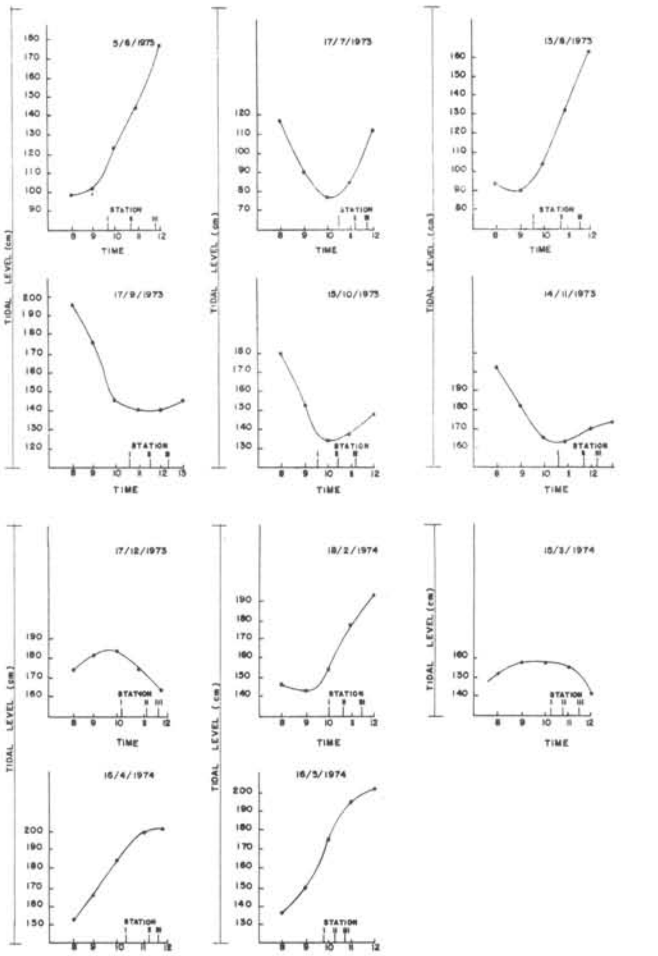


Fig. 3. Tidal level at Cananéia (data furnished by the Physics Section - Instituto Oceanográfico - Universidade de São Paulo.

bundant. A total of 1,921,000 adults and 796,800 nauplii was found in all the samples (Tab. I).

*Horizontal distribution:* this species was more abundant at the St. II and III than at the St. I, excepting in January when it was more numerous at the St. I. At this time a higher salinity was registered at all stations. The presence of *O. ovalis* at the St. I coincided always with higher salinity. *O. ovalis* occurred in a range of salinities from 12.67 to 27.16°/oo. It was most frequent in waters of salinity about 20.00°/oo (Fig. 4). The nauplii of *O. ovalis* occurred in a narrower range of salinity than the adults, from 14.30 to 27.16°/oo (Fig. 5).

*Seasonal variation*: the seasonal distribution on nauplii and adults of *O. ovalis* is shown in Figures 6 and 7.

*St. I* - the greater number of adult specimens was registered in January (80,600 specimens per sample) when the salinity was 16.48°/oo and the nauplii were more abundant in December (68,400 specimens per sample) in water of salinity 15.23°/oo. The occurrence of *O. ovalis* at the St. I, only during the months of December, January and May, is associated with the high tide (Fig. 3). Although the station time was not registered in January, the samples were taken during high tide based on the salinity data.

*St. II* - the maximum number of adults and nauplii per sample was 675,000 and 296,800 respectively in February when the salinity registered was 20.82°/oo.

*St. III* - nauplii and adults were most abundant in January. A number of 45,600 adults and 39,000 nauplii per sample was recorded in waters of salinity 20.52°/oo.

This species was more numerous during the Summer months which is characteristic of the holoplankton of the Cananéia region. The higher number of *O. ovalis*, at the three stations, occurred in February, one of the warmest months (27.30°C). Excepting August, adults and juveniles occurred all the year round.

Ovigerous females were recorded during the whole period of study, but the higher numbers occurred during the summertime (Fig. 12). This finding suggests that there is a greater intensity of breeding in the warmer season. The greater occurrence of nauplii, in February, just follows the maximum of ovigerous females. It was not possible to establish the number of generations, nor the span of life of the species in this region, as all stages of development occurred continuously throughout the period of study.

*Sex ratio:* Table II records the number

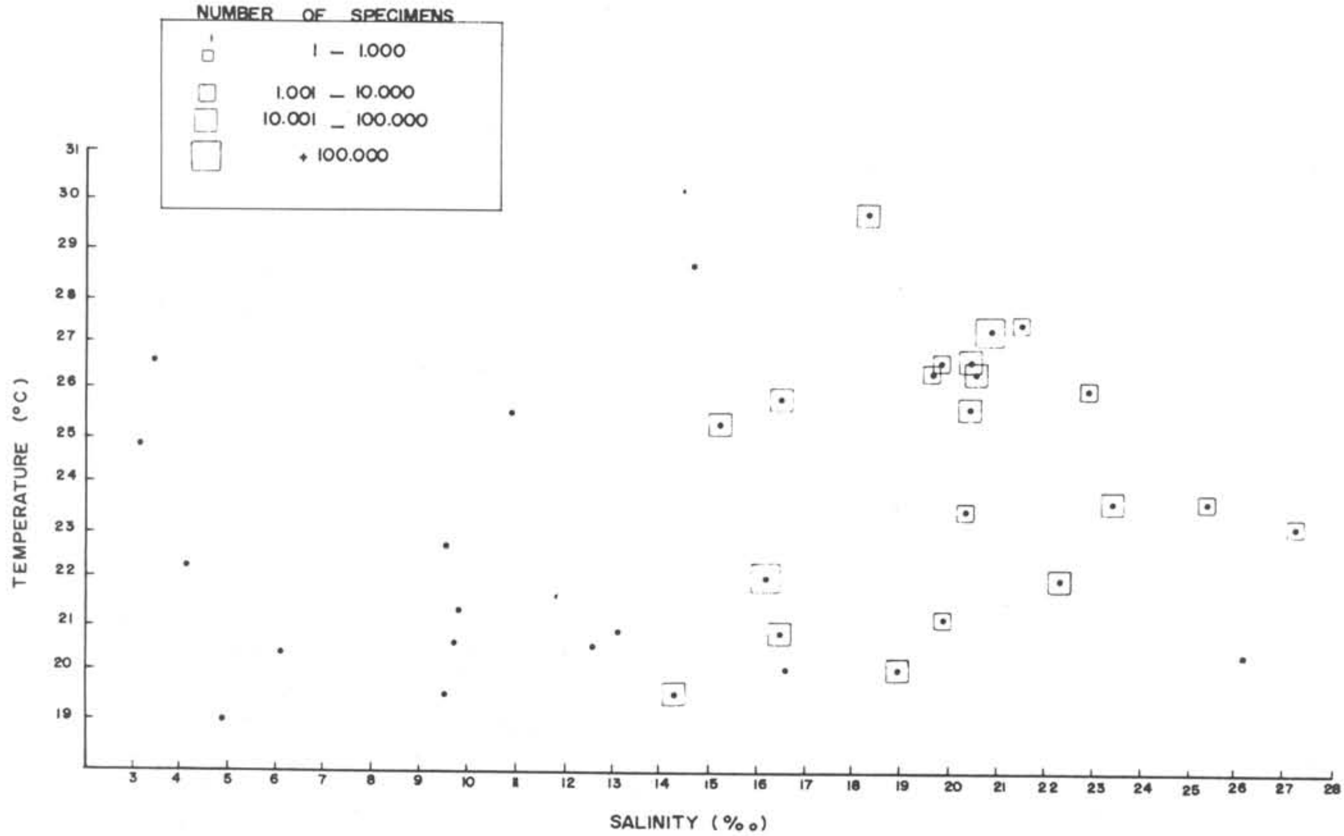


Fig. 4. T. S. P. diagram - adult specimens of *Oithona ovalis*.

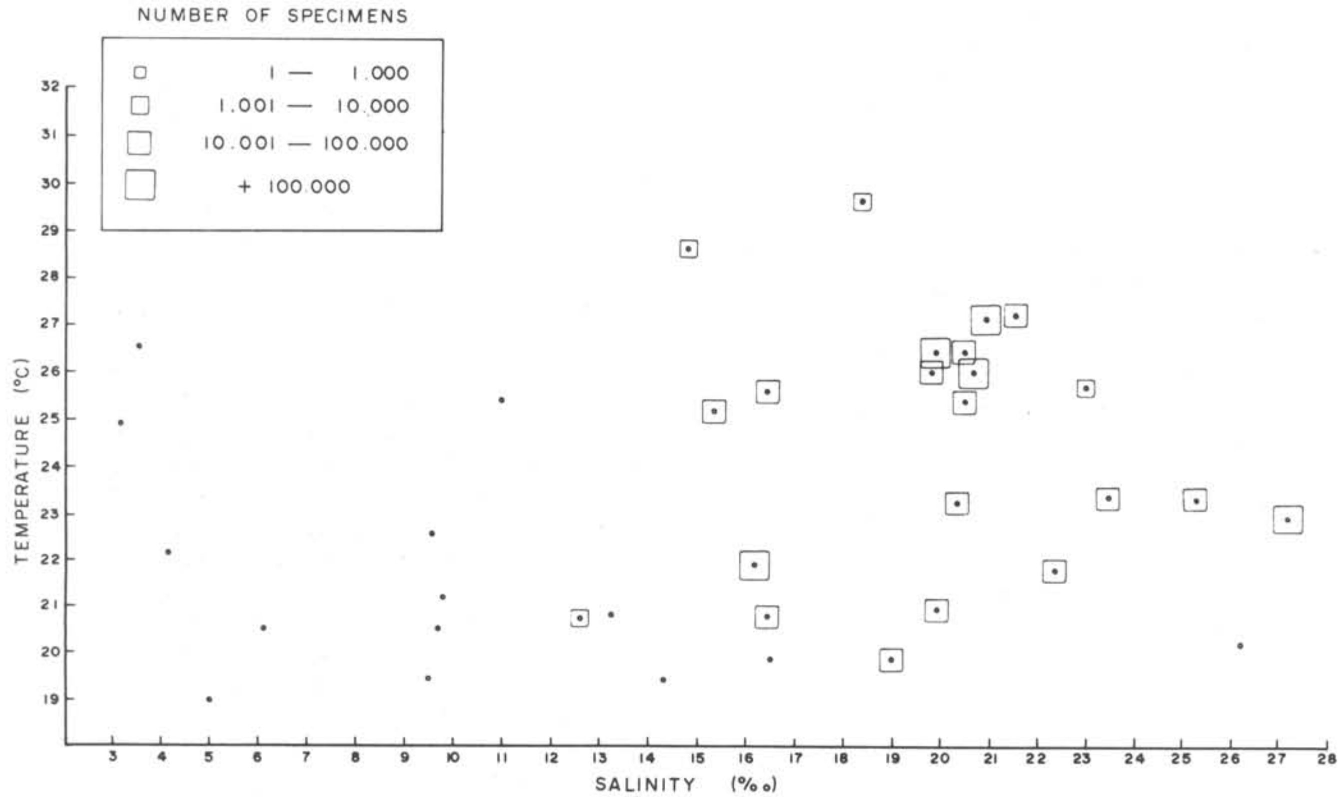


Fig. 5. T. S. P. diagram - nauplii of *Oithona ovalis*.

of males and females of *O. ovalis*. Females were always more numerous.

2.2. *Oithona oligohalina*

*Abundance:* it was less abundant than

*O. ovalis* (Tab. I). A total of 633,600 adults and 669,000 nauplii were recorded in all samples.

*Horizontal distribution:* the species was recorded in a range of salinity from 3.15 to 22.32°/oo. The higher number (more than 1,000 specimens/sample) was found in water with salinity from 3.15

Table I - Number of specimens of *Oithona oligohalina* and *O. ovalis* collected in each station (June 1973 to May 1974)

| Species | Data → | June | | | July | | | August | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Station / Developmental stage | I | II | III | I | II | III | I | II | III |
| *Oithona oligohalina* | Male | 3.400 | - | - | - | 41.200 | - | - | - | - |
| | Female | 20.000 | 2.800 | 400 | - | 141.200 (4.600) | 800 | - | - | - |
| | Nauplius I | - | - | - | 200 | 600 | - | - | - | - |
| | Nauplius II | 200 | - | - | 400 | 1.000 | - | - | - | - |
| | Nauplius III | 200 | - | - | 200 | 5.400 | - | - | - | - |
| | Nauplius IV | 4.600 | - | - | - | 44.200 | - | - | - | - |
| | Nauplius V | 7.200 | - | - | 600 | 103.000 | - | - | - | - |
| | Nauplius VI | 8.600 | - | - | - | 115.600 | - | - | - | - |
| *Oithona ovalis* | Male | - | 26.400 | 15.000 | - | - | 9.200 | - | - | - |
| | Female | - | 101.400 (1.800) | 87.400 (400) | - | 4.200 | 55.600 (1.000) | - | - | - |
| | Nauplius I | - | - | - | - | - | 200 | - | - | - |
| | Nauplius II | - | - | - | - | - | 400 | - | - | - |
| | Nauplius III | - | 2.400 | 800 | - | - | 400 | - | - | - |
| | Nauplius IV | - | 24.600 | 1.800 | - | - | 1.800 | - | - | - |
| | Nauplius V | - | 41.200 | 4.800 | - | - | 2.200 | - | - | - |
| | Nauplius VI | - | 32.800 | 4.000 | - | - | 7.600 | - | - | - |
| | Copepodites* | 18.400 | 88.800 | 89.000 | - | 315.600 | 49.600 | - | - | - |

| Species | Data → | September | | | October | | | November | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Station / Developmental stage | I | II | III | I | II | III | I | II | III |
| *Oithona oligohalina* | Male | - | 200 | - | 2.200 | 6.200 | - | 600 | 37.400 | - |
| | Female | - | 4.600 | 200 | 2.600 | 19.400 (600) | 200 | 3.000 (800) | 114.000 (11.400) | - |
| | Nauplius I | - | - | - | - | - | - | - | 200 | - |
| | Nauplius II | - | 400 | - | - | 200 | - | - | 1.200 | - |
| | Nauplius III | - | 1.000 | - | 200 | 200 | - | - | 6.600 | - |
| | Nauplius IV | - | 2.400 | - | 600 | 1.800 | - | - | 9.600 | - |
| | Nauplius V | - | 2.600 | - | 400 | 2.600 | - | 200 | 13.600 | - |
| | Nauplius VI | - | 4.800 | - | 800 | 4.000 | - | 200 | 6.200 | - |
| *Oithona ovalis* | Male | - | - | 2.400 | - | - | 2.200 | - | - | 14.000 |
| | Female | - | 1.000 | 21.800 (600) | - | 2.000 | 12.400 | - | - | 70.600 (4.400) |
| | Nauplius I | - | - | 600 | - | - | - | - | - | - |
| | Nauplius II | - | - | 600 | - | - | - | - | - | - |
| | Nauplius III | - | - | 1.400 | - | - | - | - | - | - |
| | Nauplius IV | - | - | 2.800 | - | - | 600 | - | - | 800 |
| | Nauplius V | - | - | 5.800 | - | - | 1.600 | - | - | 3.000 |
| | Nauplius VI | - | - | 6.000 | - | - | 1.600 | - | - | 3.400 |
| | Copepodites* | - | 17.200 | 36.600 | 3.400 | 35.400 | 28.000 | 2.200 | 58.600 | 86.400 |

cont.

| Species | Data / Station / Developmental stage | December I | December II | December III | January I | January II | January III | February I | February II | February III |
|---|---|---|---|---|---|---|---|---|---|---|
| *Oithona oligohalina* | Male | - | - | - | 400 | - | - | - | - | - |
| | Female | 4.000 | 200 | - | 4.800 (1.000) | - | - | - (400) | 1.000 | - |
| | Nauplius I | - | - | - | - | - | - | - | - | - |
| | Nauplius II | - | - | - | - | - | - | - | - | - |
| | Nauplius III | - | - | - | - | - | - | 800 | - | - |
| | Nauplius IV | 1.000 | - | - | - | - | - | 2.400 | - | - |
| | Nauplius V | 1.800 | - | - | 400 | - | - | 3.600 | - | - |
| | Nauplius VI | 3.000 | - | - | 1.000 | - | - | 1.400 | - | - |
| *Oithona ovalis* | Male | 800 | 10.600 | 600 | 20.800 | 9.800 | 13.600 | - | 205.400 | 10.000 |
| | Female | 15.000 | 67.800 (5.400) | 6.200 (400) | 58.400 (1.400) | 33.400 (2.400) | 152.600 (8.400) | - | 467.000 (2.600) | 24.800 (1.400) |
| | Nauplius I | - | - | - | - | - | - | - | - | - |
| | Nauplius II | - | - | - | - | - | - | - | - | - |
| | Nauplius III | 1.600 | 2.000 | - | 3.000 | - | 1.200 | - | 3.000 | 200 |
| | Nauplius IV | 10.800 | 10.600 | 200 | 6.600 | 800 | 7.000 | - | 55.000 | 400 |
| | Nauplius V | 26.000 | 19.000 | 400 | 13.200 | 1.800 | 15.200 | - | 127.800 | 1.400 |
| | Nauplius VI | 30.000 | 26.600 | 800 | 9.400 | 1.200 | 15.600 | - | 111.000 | 800 |
| | Copepodites* | 126.000 | 204.000 | 10.400 | 130.400 | 53.800 | 205.400 | - | 2.107.200 | 57.800 |

| Species | Data / Station / Developmental stage | March I | March II | March III | April I | April II | April III | May I | May II | May III |
|---|---|---|---|---|---|---|---|---|---|---|
| *Oithona oligohalina* | Male | 200 | 19.800 | - | 2.200 | - | - | - | - | - |
| | Female | 1.200 | 134.800 (6.000) | - | 36.800 (1.400) | - | - | 1.600 | - | - |
| | Nauplius I | - | - | - | - | - | - | - | - | - |
| | Nauplius II | - | - | - | - | - | - | - | - | - |
| | Nauplius III | 2.000 | 7.000 | - | 6.000 | - | - | - | - | - |
| | Nauplius IV | 5.600 | 59.000 | - | 11.600 | - | - | - | - | - |
| | Nauplius V | 5.800 | 90.000 | - | 12.000 | - | - | - | - | - |
| | Nauplius VI | 4.600 | 94.600 | - | 3.600 | - | - | - | - | - |
| *Oithona ovalis* | Male | - | - | 600 | - | 17.400 | 9.000 | 400 | 35.400 | 8.600 |
| | Female | - | 4.200 | 5.600 | - | 82.400 (7.600) | 81.800 (1.400) | 18.000 | 60.400 (200) | 35.400 |
| | Nauplius I | - | - | - | - | - | - | - | - | - |
| | Nauplius II | - | - | - | - | - | - | - | - | - |
| | Nauplius III | - | - | 800 | - | 200 | 4.000 | 3.200 | - | - |
| | Nauplius IV | - | - | 4.400 | - | 1.400 | 7.800 | 9.000 | 9.000 | 1.000 |
| | Nauplius V | - | - | 16.800 | - | 2.000 | 11.000 | 11.600 | 19.400 | 4.200 |
| | Nauplius VI | - | - | 11.800 | - | 600 | 9.000 | 4.600 | 17.200 | 1.000 |
| | Copepodites* | 19.400 | 705.200 | 24.400 | 42.600 | 41.600 | 215.000 | 75.000 | 72.600 | 53.400 |

( ) - Ovigerous females
* - Copepodites were not counted separately by stage of development because of difficulties in rapid identification

to 16.48°/oo (Fig. 8). The nauplii of *O. oligohalina* occurred in salinities from 3.15 to 16.48°/oo (Fig. 9). The greater abundance occurred in salinities around 11.00°/oo.

*Seasonal variation:* Figures 10 and 11 show respectively the seasonal variation of adults and nauplii of *O. oligohalina*.

*St. I* - the higher number of *O. oligohalina* was registered in April (40,400 adult specimens and 33,200 nauplii per sample) in water of salinity 10.96°/oo.

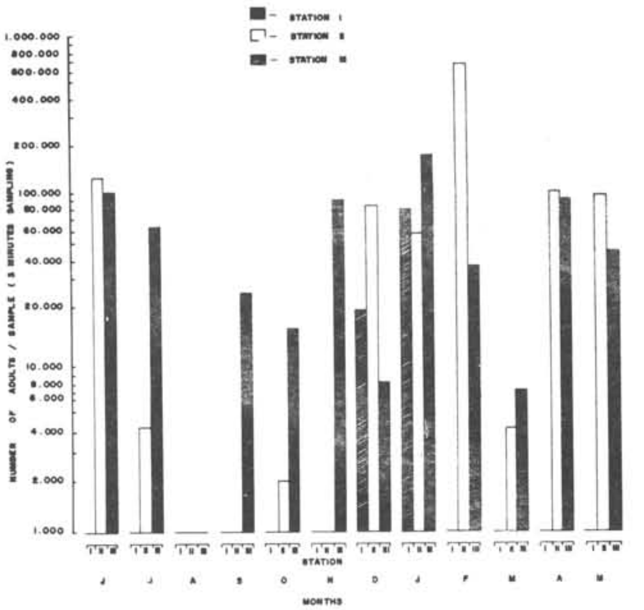

Fig. 6. Relative abundance and seasonal of the adult specimens of *Oithona ovalis* at the St. I, II and III (June 1973 to May 1974).

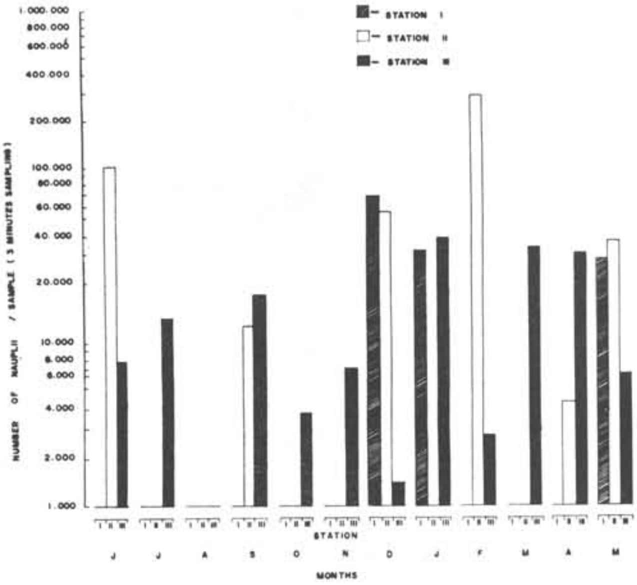

Fig. 7. Relative abundance and seasonal variation of the nauplii - *Oithona ovalis* .

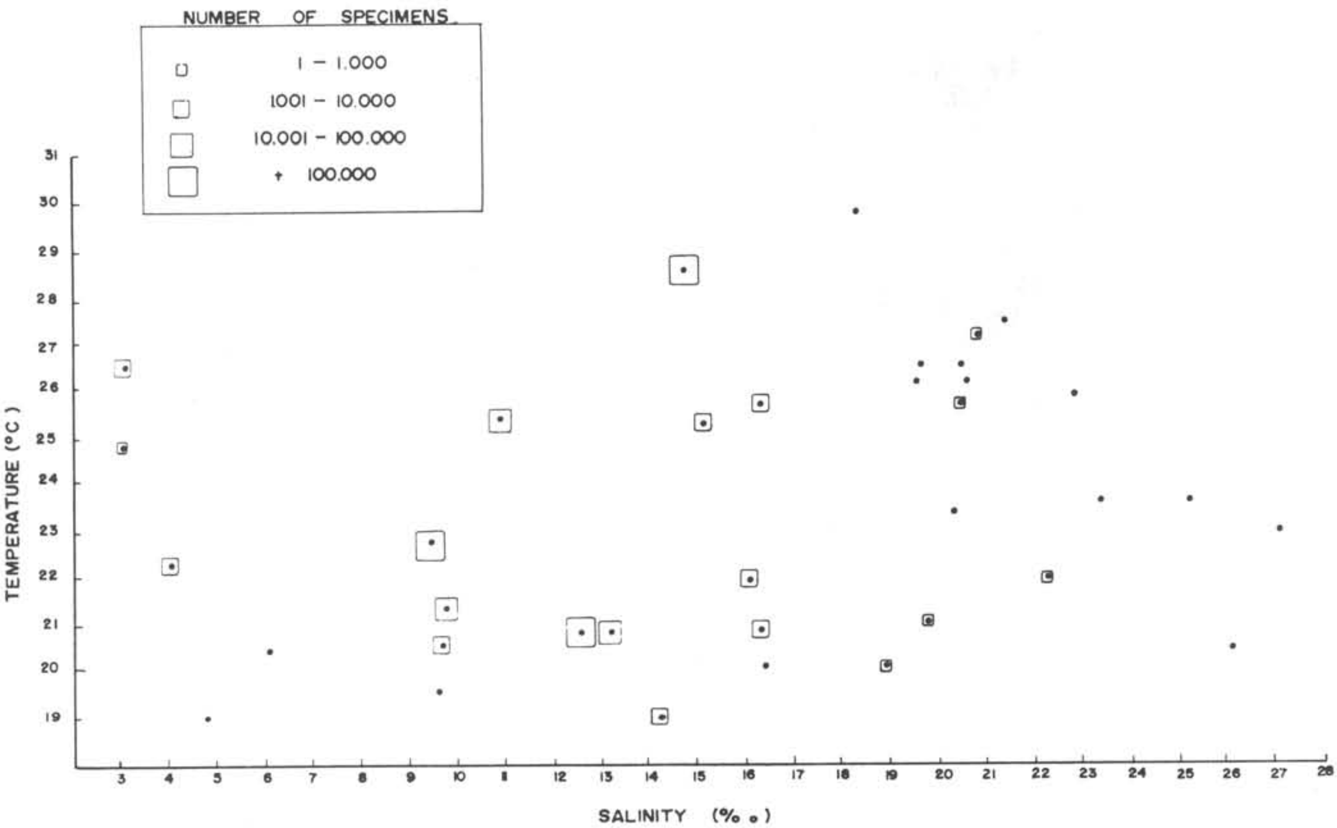


Fig. 8. T. S. P. diagram - *Oithona oligohalina*.

*St. II* - the species was more abundant in July (187,000 adults and 267,800 nauplii/sample) in water of salinity 12.67°/oo.

*St. III* - the species was hardly represented at this station and more than 1,000 specimens per sample never occurred. The salinities registered at this station varied from 18.39 to 27.16°/oo. Only 400 specimens of *O. oligohalina* were found in June when the highest salinity occurred. No nauplii of *O. oligohalina* was found at

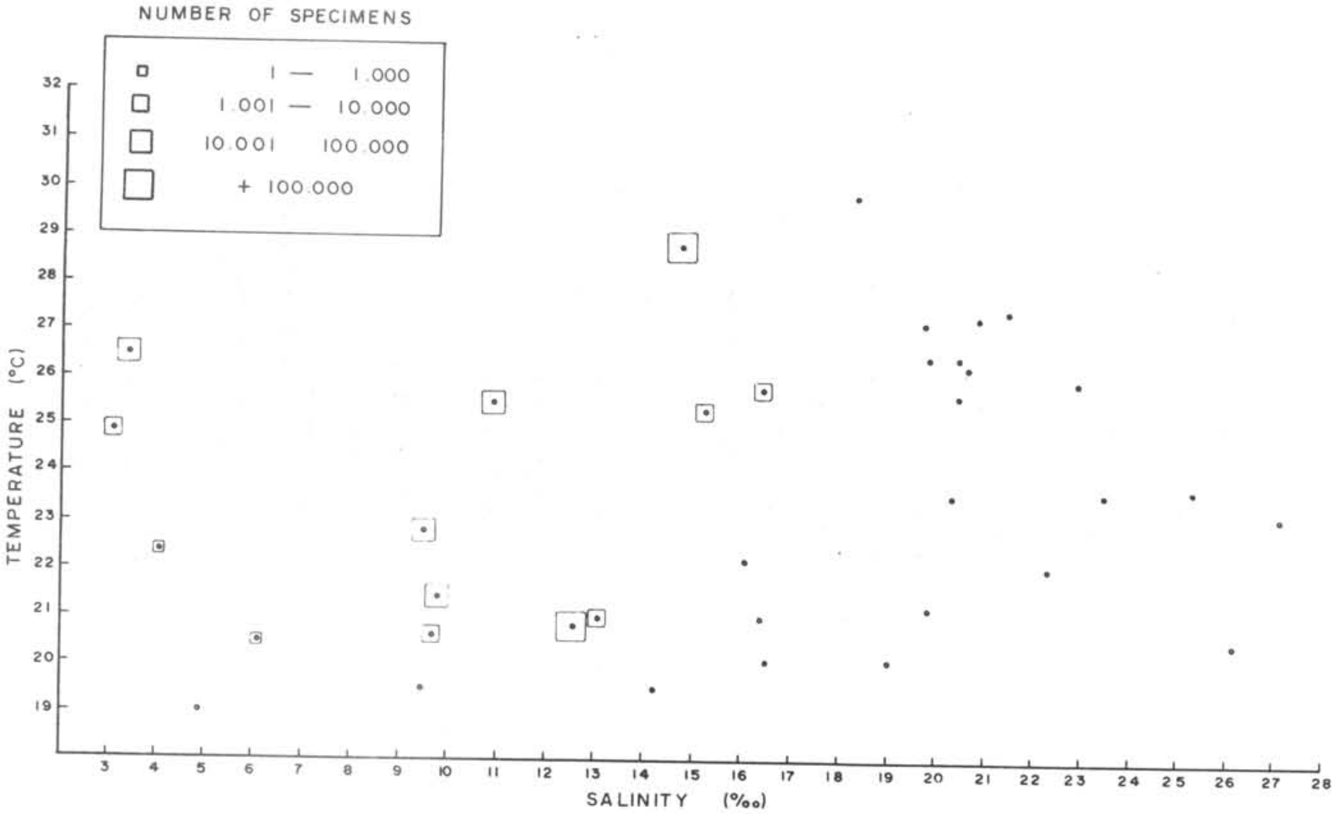


Fig. 9. T. S. P. diagram - nauplii of *Oithona oligohalina*.

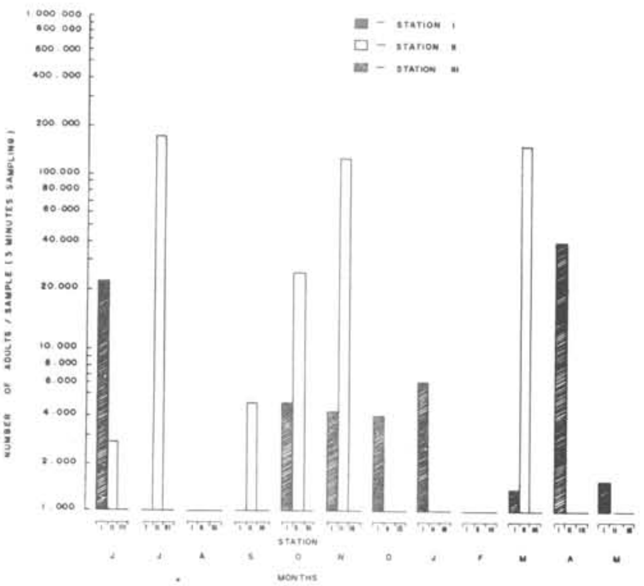


Fig. 10. Relative abundance and seasonal variation of *Oithona oligohalina* at the St. I, II and III (June 1973 to May 1974).

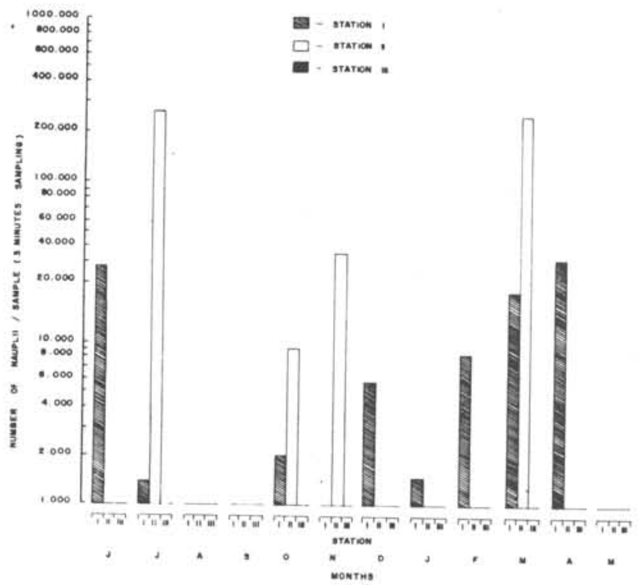


Fig. 11. Relative abundance and seasonal variation of the nauplii of *Oithona oligohalina* (June 1973 to May 1974).

this time.

The characteristic pattern of seasonal fluctuation for *O. oligohalina* was not established. The higher abundances are observed to be in July, November and March. The greatest number occurred in July, with a total of 142,000 specimens for all three stations when the water temperature was 20.80°C.

Ovigerous females were best represented in December (Fig. 12) and nauplii in July and March.

As with *O. ovalis*, it was not possible to establish the number of generations, nor the span of life of *O. oligohalina* because all the developmental stages, also adults, occurred throughout the year.

*Sex ratio* (Table II): females specimens were always more abundant than males.

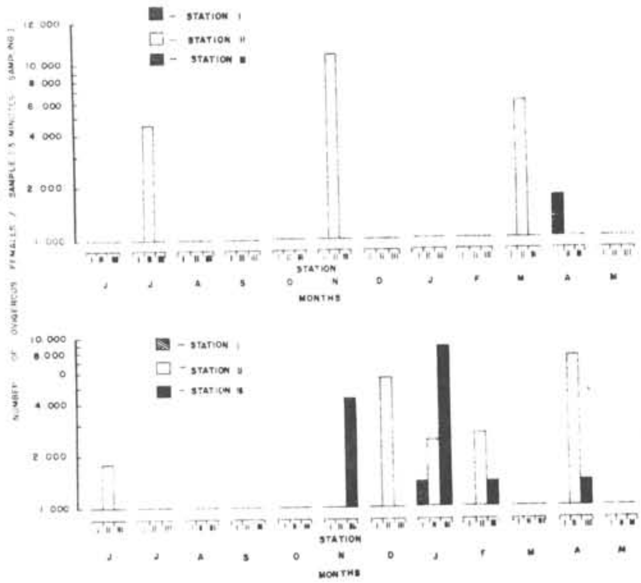


Fig. 12. Relative abundance and seasonal variation of the ovigerous females of *Oithona ovalis* and of *O. oligohalina* at the St. I, II and III (June 1973 to May 1974).

Table II - Sex-ratio of *Oithona ovalis* and of *O. oligohalina*

| Month | Percentage | | | | | |
|---|---|---|---|---|---|---|
| | Station I | | Station II | | Station III | |
| | *O. ovalis* | *O. oligohalina* | *O. ovalis* | *O. oligohalina* | *O. ovalis* | *O. oligohalina* |
| June | - | 14.52 | - | 0 | 14.59 | 0 |
| July | - | - | 0 | 22.00 | 13.98 | 0 |
| August | - | - | - | - | - | - |
| September | - | - | 0 | 4.16 | 9.67 | 0 |
| October | - | 45.82 | 0 | 23.66 | 15.06 | 0 |
| November | - | 13.63 | - | 22.97 | - | - |
| December | 5.06 | 0 | 12.64 | 0 | 8.33 | - |
| January | 25.80 | 6.45 | 21.46 | - | 7.78 | - |
| February | - | 0 | 30.42 | 0 | 27.62 | - |
| March | - | 14.28 | 0 | 12.32 | 9.67 | - |
| April | - | 5.44 | 16.20 | - | 9.76 | - |
| May | 2.17 | 0 | 36.87 | - | 19.54 | - |

## Discussion and Conclusion

Many papers have been published on systematics and ecology of *Oithona ovalis* collected in Brazilian coastal and brackish waters. Herbst (1955) described the female of this species from the Cananéia region. Björnberg (1963) mentions the presence of *O. ovalis* as occasional visitors in coastal waters off South Brazil. The developmental stages of *O. ovalis* were described by Björnberg (1972) from specimens collected in Santos, Ubatuba and Cananéia (State of São Paulo). Tundisi & Tundisi (1968) studied the tolerance to salinity of *O. ovalis* in laboratory conditions. Tundisi (1972) studied the distribution and annual variation of this species in the estuarine region of Cananéia. The male of *O. ovalis* was described by Santos (1970) from Itapagipe Bay (Bahia State). The author found a second species of *Oithona* in Cananéia waters and based on González & Bowman (1965) identified it as *O. hebes* Giesbrecht, 1891. Tundisi (1972) also mentioned the presence of a second species in Cananéia waters but did not identify it. Fanta (1976) studied the internal anatomy of all the naupliar stages of *O. ovalis* correlating organs and functions. Fonseca & Björnberg (1976) verified that *O. hebes* identified by Santos (1970) was new to science and described it as *Oithona oligohalina*.

For the first time the presence of *O. ovalis* and *O. oligohalina* in a river of this region is registered.

*Horizontal distribution of Oithona ovalis and O. oligohalina*

Salinity is an important factor controlling the distribution of organisms in estuaries (Kilby, 1955; Gunter, 1956; Kinne, 1971; Vernberg & Vernberg, 1972). Many papers on laboratory studies of the salinity tolerance by marine copepods are available in the literature (Marshall *et all.*, 1935; Barnes, 1953; Ranade, 1957; Hooper, 1960; Lance, 1962, 1963, 1964; Battaglia & Bryan, 1964; Tundisi & Tundisi, 1968; Moreira & Yamashita, 1973). The distribution of *Eurytemora affinis* in relation to salinity was studied by Vaupel-Klein & Weber (1975) based on field and laboratory observations.

Figures 4 and 5 show that *O. ovalis* prefers higher salinities than *O. oligohalina* and that both species can coexist in a small range of salinity (12.67 to 16.48°/oo). The coexistence of both species beyond these limits was only occasionally registered. Intermediate forms between the two species were not recorded. Bayly (1965) found that two closely related species of *Pseudodiaptomus* are able to coexist in Brisbane River but one of the species is always dominant. *Oithona brevicornis* and *O. nana* occur together in Alligator Harbor but the first is dominant (Grice, 1956). The dominance of one of the two species was also verified in the range of salinity in which they occur together in Cananéia.

Tundisi (1972) established the limits of salinity for adults and copepodits of *O. ovalis* as 1.00 - 34.06°/oo but higher abundances (+ 10,000 specimens) were more frequent from 9.05 to 30.68°/oo. Tundisi & Tundisi (1968) found that under laboratory conditions the superior and inferior lethal salinities are respectively 6.30°/oo and 26.00 to 30.00°/oo. The first value corresponds to the low salinity in which *O. oligohalina* can be found and 34.06°/oo to the higher salinity, thus Tundisi & Tundisi (1968) and Tundisi (1972) probably worked with a mixed population of the two species instead of experimenting on *O. ovalis* only, and their data therefore can not be compared to ours.

Santos (1970) analized various plankton samples collected in coastal water from the Brazilian coast and found *O. ovalis* from Ponta do Seixas (PA) in the North to Paranaguá (PR) in the South in salinities varying from 11.91 to 35.89°/oo.

The limits of salinities registered for *O. ovalis* by Santos (*op. cit.*) in Cananéia agree with the present data. On the other hand, the data recorded for *O. hebes* (= *oligohalina*) in Todos os Santos Bay by Santos (*op. cit.*) are opposite to those found in Cananéia. Possibly the *Oithona* collected at Todos os Santos Bay is not *O. oligohalina*.

The presence of *O. ovalis* at Station I is associated with the incomming tide. *O. oligohalina* was only occasionally found at St. III, and in small number, suggesting that St. III is an expatriation area for the species (Yashnov, 1966).

The inferior limit of salinity in which nauplii of *O. ovalis* occurred is higher than that registered for adults of the same species. The limits of salinity for nauplii of *O. ovalis* registered by Tundisi (1972) are much wider than the present records and must be based on experiments with mixed specimens of *O. ovalis* and *O. oligohalina*.

*O. oligohalina* nauplii were most abundant in water of salinity varying from 3.15 to 16.48°/oo. The salinity limit for nauplii and adults are coincident.

The results obtained show that the sampling method was not good for the nauplii because the first stages suffered more selection than the older stages by escapement through the net meshes. Stage I, II and III were scarcely represented in the samples. Obviously a natural population presents higher densities of younger than older stages due to mortality.

The number of adults of *O. ovalis* was twice the number of nauplii and the adults of *O. oligohalina* were slightly less abundant than their nauplii. These records suggest that there is a migration of adult specimens from coastal waters into the estuary since the number of samples in the three Stations were the same. *O. oligohalina* is an endemic species of the estuary.

The present paper deals with the distribution of the *Oithona* according to the salinity gradient of an estuary as in Cronin *et al.* (1962) who noted that the species composition changed along the Delaware River characterizing the inner reaches, a medium portion and the entrance of the estuary.

It is important to remark that the species considered in this paper are congeneric and very closely related. The occurrence of congeneric and competitor species is very often found in estuaries. Lance (1963) showed experimentally that closely related planktonic species can have different abilities to survive in low salinity waters. *Acartia tonsa* has a higher tolerance to diluted water than *A. bifilosa* and this species is more tolerant than *A. discaudata*.

Jeffries (1967) records congeneric associations of some species of Copepoda and Cladocera in a region between New England and Virginia. He registers the coexistence of *Oithona brevicornis* and *O. similis* and classified them as estuarine-marine and euryhaline-marine species respectively. According to Jeffries' classification, *O. oligohalina* is a true estuarine species and *O. ovalis* is an estuarine-marine species.

Jeffries (*op. cit.*) made some references on the speciation of the genus *Eurytemora* which appears to have penetrated the osmo-regulatory barrier independently, forming a chain of species with overlapping distribution along the salt gradient. Each member of the chain probably had a better ability to tolerate lower salinity. A continuous chain of species extending from salty to fresh water can be the result of an intrageneric competition.

The presence of two very closely related species of *Oithona*, with different limits of salinity tolerance, in a narrow section of the estuary, can be explained by the mechanisms described by Jeffries (*op. cit.*) and indicates that the genus *Oithona* has suffered speciation into the estuary.

The intraspecific conflict plays an important role in the distribution of certain species. Hodgkin & Rippingale (1971) examined this problem in Swan River (Australia). The great abundance of copepods that prey upon nauplii can restrict the distribution of other euryhaline species of the same group, to an inner part of the estuary where the environmental conditions are adverse to the predator species. The relation between *O. ovalis* and *Acartia lilljeborgi* in Cananéia seems to be analogous to that described by Hodgkin & Rippingale (*op. cit.*). Great numbers of nauplii, copepodites and adults of *A. lilljeborgi* were registered in Sts. II and III in September, while *O. ovalis* was less numerous. *A. lilljeborgi* was still abundant and the quantity of *O. ovalis* strongly decreased in October. This inverse relation of *A. lilljeborgi* and *O. ovalis* can probably be ascribed to predation effects since the environmental conditions were good to the occurrence of *O. ovalis*.

*Oxygen:* the values of dissolved oxygen found in the Taquari River are higher than those recorded by Prado (1972) in depth, by Tundisi (1972) at the surface and by Kutner (1972) at the surface in a tidal creek of the Cananéia region. According to Kato (1966) the remarkably low quantity of oxygen in the tidal creek water is caused by a characteristic state of reduction in the upper reaches of the "river" and indicates a correlation with the quantity of reduced matter in the water. Taquari River has a different condition from that found in the tidal creek because low values of dissolved oxygen were never found. Thus dissolved oxygen is not a controlling factor of the distribution of *Oithona* in this section of the Cananéia estuarine region.

*Temperature:* a slight increasing gradient of temperature was recorded from St. I to St. III throughout the period of sampling. However this small difference of temperature was not sufficient to affect the horizontal distribution of the genus *Oithona* in this area. The gradient of temperature never goes beyond the limit of tolerance of both species.

### *Seasonal variation*

Estuaries have a marked seasonal variation (Riley, 1967). The Summer and Winter are well characterized in Cananéia by the quantitative composition of plankton (Tundisi, 1972).

Jeffries (1962*a,b*) showed that one species can seasonally take the place of another closely related to it in an estuary of the east coast of America. He supposed that these congeneric species were in competition and that environmental conditions (salinity and temperature combinations) favor one of the two species as in the case of the two *Oithona* from Cananéia, but these do not show the pattern of seasonal substitution.

*O. ovalis* and *O. oligohalina* were registered throughout the period of study excepting in August when only animal skeletons and diatoms valves were present. The higher occurrence of *O. oligohalina* was recorded in July when temperature was only a little higher than August and salinity was within the limit of tolerance of both species. This lack of plankton must be due to some other factor than temperature and salinity.

Three peaks in the abundance of *O. oligohalina* were registered throughout the year (July, November and March) all at St. II. Ovigerous females and nauplii were most abundant in these same samples. Possibly the salinities found at St. II during these months are close to the optimum for *O. oligohalina*.

A more regular annual distribution was observed in *O. ovalis*. A higher number of ovigerous females and nauplii occurred during the summertime. It seems that the reproductive activity is more intense in this period. A significative number of ovigerous females (more than 1,000 specimens/sample) begins in November and reaches its maximum in January.

No data exists on seasonal variation of *O. ovalis* and *O. oligohalina* in other areas.

*O. ovalis* showed an analogous pattern of seasonal variation to that of the *O. brevicornis* found by Grice (1956) in Aligator Harbor. *O. nana* also has one annual maximum (Grice, 1956; Esterly, 1928; Woodmansee, 1958; Hirota, 1962) although it occurred in different periods of the year according to the place considered. *O. similis* has one annual maximum in the Norwegian fjords (Lie, 1967).

*O. oligohalina* has several discrete maxima throughout the year as *O. spinirostris* (Gundersen, 1953) and *O. similis* (Frolander *et al.*, 1973). A peak in reproductive activity was not observed throughout the seasons.

Tundisi (1972) established two patterns of seasonal cycles for copepods from Cananéia region. The first includes *O. ovalis*, *Acartia lilljeborgi* and *Paracalanus crassirostris* which have a period of more intense reproduction. This is typical of tropical estuarine species of planktonic copepods. The second includes *Pseudodiaptomus acutus*, *Euterpina acutifrons* and *Labidocera fluviatilis* which have several discrete maxima. The present findings confirm the position of *O. ovalis* and add *O. oligohalina* to the second group.

There are very few records on seasonal variation of *Oithona* nauplii. According to Raymont & Miller (1962), Deevey (1948) found a main period of reproduction of *O. brevicornis* in Tisbury Great Pond besides smaller broods. Faber (1966) registered a great number of *O. brevicornis* in Narraganset Bay in the Summer. According to Sazhina (1971) *O. nana* has seven annual maxima and possibly an eighth depending on the temperature. In lower temperatures the development takes a longer time. It is difficult to establish the number of generations of *Oithona* in Cananéia because the reproduction is continuous throughout the year.

Cananéia region shows the small annual variation of temperature typical of a tropical region. This variation is not wide enough to control the distribution of planktonic animals or to determine a marked life cycle as it does in colder regions. Here, the salinity and predation seem to play a more important role on the occurrence and distribution of planktonic animals.

*Sex-ratio*

The present records confirm previous ones from this area (Teixeira *et al.*, 1965; Tundisi, 1972). Adult females of both *Oithona* are always more numerous than adult males (Tab. II). It must be pointed out that Teixeira *et al.* (*op. cit.*) and Tundisi (*op. cit.*) refer to a mixed population of *Oithona ovalis* plus *O. oligohalina*.

The literature contains many data on sex-ratio of copepods (Campbell, 1934; Mednikov, 1962). The males of many species have a shorter span of life than the females. The sex-ratio of one species can vary depending on the place where they live (Bogorov, 1939 after Mednikov, 1962). Mednikov (1962) studied the sex-ratio of three pelagic groups: estuarine, superficial oceanic and bathypelagic. He came to the conclusion that the percentage of males increases from bathypelagic to the estuarine. He obtained 50% of males in epiplanktonic species such as *Acartia tumida* Willey and *Centropages mcmurrichi* Willey. The populations of *Oithona* studied in Cananéia never showed such a high percentage of males.

Conclusions

1 - *O. ovalis* occurs in a range of salinity from 12.67°/₀₀ to 27.16°/₀₀ and *O. oligohalina* from 3.45°/₀₀ to 16.48°/₀₀.

2 - According to Jeffries' classification (1967), *O.ovalis* is estuarine-marine and *O. oligohalina* is true-estuarine.

3 - The presence of two closely related congeneric species, the distribution of which partially overlaps in a narrow range of salinity suggests that the genus *Oithona* has suffered speciation within the estuary.

4 - *O. ovalis* was more abundant than *O. oligohalina*. Both species occurred throughout the year.

5 - *O. ovalis* has an intense reproductive period in the Summer and others less intense throughout the year. *O.oligohalina* showed only three discrete maxima all year round.

6 - The co-existence, throughout the year of a population composed by nauplii and adults indicates continuous breeding of these species in the area with periods of greater reproductive activity.

7 - It was not possible to determine the number of generations.

8 - The salinity plays an important role in the occurrence and distributions of both species since the temperature never reached limiting values for both species.

9 - The percentage of adult females of both species was always higher than adult males.

## Resumo

Alguns aspectos ecológicos de duas espécies congenéricas de copépodos ciclopóides, *Oithona ovalis* e *O. oligohalina* são estudados pela primeira vez na região estuarina de Cananéia. A distribuição espacial e variação sazonal destas espécies são estudadas em relação à salinidade, temperatura e oxigênio dissolvido. Os resultados obtidos são comparados com trabalhos preliminares feitos nesta área e estudos similares em outras regiões. As principais conclusões obtidas são as seguintes:

1 - *O. ovalis* ocorre em uma faixa de salinidade de 12,67 a 27,16°/oo e *O. oligohalina* em 3,45 a 16,48°/oo.

2 - A presença de duas espécies congenéricas estreitamente relacionadas cuja distribuição se recobre parcialmente em uma estreita faixa de salinidade sugere que o gênero *Oithona* sofreu especiação dentro do estuário.

3 - A salinidade tem um papel importante na ocorrência e distribuição destas espécies desde que a temperatura nunca alcançou valores limitantes para estas espécies.

## Acknowledgements

We wish to express our thanks to Dra. Tagea K. S. Björnberg for her critical reading of the manuscript and valuable remarks.

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(Recebido em 27/dezembro/1977)