



Study of Monstrilloida distribution (Crustacea, Copepoda) in the Southwest Atlantic

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Abstract. The Monstrilloida is one of the least known orders of planktonic Copepoda. Taxonomic and ecological work on the group has been limited by the rarity of specimens, which occur in plankton only as adults. The material examined was collected during zooplankton surveys in neritic and oceanic areas off the coast of Brazil. Sampling was carried out between April 1984 and October 1999. Data from collections made off the coast of Argentina were also analysed. Fifteen monstrilloid species: *Monstrilla brasiliensis*, *M. grandis*, *M. helgolandica*, *M. rugosa*, *M. careli*, *M. pustulata*, *M. satchmoi*, *M. bahiana*, *Cymbasoma* cf. *longispinosum*, *C. quadridens*, *C. cf. rigidum*, *C. rochai*, *C. gracilis*, *Monstrillopsis dubia* and *M. fosshageni* are reported herein for the Southwest Atlantic (5-50° S). The species groups were associated with three areas, each with different conditions of temperature and salinity. The tropical species association occurred off the northeast Brazilian coast with temperatures ranging from 20.5 to 29.1 °C and salinities from 35.6 to 37.5, indicating the presence of the Shelf and Tropical Waters in the region. The subtropical species association occurred off the central coast with temperatures between 21.0 and 29.6 °C and a salinity range of 27.5-35.8, and is related to the coastal and shelf waters. A subantarctic species association occurred off the coast of Argentina, with temperatures between 12.3 and 19 °C and a salinity range of 33.0-34.0.

Key words: Zooplankton, Species associations, Watermasses, Brazil.

Resumo. Estudo da distribuição de Monstrilloida (Crustacea, Copepoda) do Atlântico Sudoeste.

Monstrilloida é uma das ordens menos conhecidas dos Copepoda planctônicos. Estudos taxonômicos e ecológicos são limitados pela escassez dos espécimes, que ocorrem no plâncton somente como adultos. O material foi coletado durante amostragens de zooplâncton em áreas neríticas e oceânicas na costa de Brasil. As coletas foram realizadas entre abril de 1984 e outubro de 1999. Dados de materiais coletados na costa de Argentina também foram analisados. Quinze espécies de Monstrilloida: *Monstrilla brasiliensis*, *M. grandis*, *M. helgolandica*, *M. rugosa*, *M. careli*, *M. pustulata*, *M. satchmoi*, *M. bahiana*, *Cymbasoma* cf. *longispinosum*, *C. quadridens*, *C. cf. rigidum*, *C. rochai*, *C. gracilis*, *Monstrillopsis dubia* e *M. fosshageni* foram registradas para o Atlântico Sudoeste (5-50° S). As espécies estiveram associadas em três áreas, cada uma com condições diferentes da temperatura e salinidade. A associação de espécies tropicais ocorreu na costa nordeste brasileira, com temperaturas variando de 20,5 a 29,1°C e salinidades entre 35,6 e 37,5, o que indica a presença das águas de plataforma e tropical na região. A associação de espécies subtropicais ocorreu na costa central, com temperaturas entre 21,0 e 29,6°C e uma variação de salinidade entre 27,5-35,8, e foi relacionada à presença de águas costeira e de plataforma. A associação de espécies subantárticas ocorreu na costa da Argentina, com temperaturas entre 12,3 e 19,0°C e uma variação de salinidade entre 33,0-34,0.

Palavras-chave: Zooplâncton, Associação de espécies, Massas d'água, Brasil.

Introduction

The Monstrilloida are parasitic copepods associated with benthic polychaetes and molluscs during most of their lives. Only the reproductive adults and early larval stages are free-living, planktonic, and non-feeding (Huys & Boxshall 1991).

Taxonomic and ecological work on the group has been limited by the rarity of specimens, which are captured by plankton nets only as adults (Suárez-Morales & Dias 2000). Their zoogeographical distribution remains poorly understood, mainly because records have been reported from widely differing localities (Suárez-Morales & Gasca 1990) and their taxonomy is still in development. Monstrilloids occur in oceanic samples, mostly in tropical and temperate coastal waters (Suárez-Morales & Islas-Landeros 1993). Despite the rarity of monstrilloid species, the Southwest Atlantic is a region with a high number of monstrilloid taxa (Dias 2005). To date, 15 taxa of Monstrilloida have been reported from neritic and oceanic areas off the coast of Brazil and Argentina (Giesbrecht 1891, Ramírez 1971, Hoffmeyer 1983, Esteves *et al.* 1997, Johnsson 1998, Suárez-Morales & Dias 2000, Suárez-Morales & Dias 2001a, b).

In this contribution, the patterns of geographical distribution of the monstrilloid species recorded along the coasts of Brazil and Argentina in the southwestern Atlantic (5 to 50° S) are described.

Material and Methods

The specimens examined were obtained at several localities in neritic and oceanic areas off the coast of Brazil (Figure 1). The material included specimens captured during cruises carried out between April 1984 and October 1999. A variety of gear and collecting methods were used in order to sample monstrilloids, because of their rarity. Sub-superficial horizontal, vertical and oblique (until 200 m) hauls were made using zooplankton nets with 63, 150, 200, 250, 300, 330, 500 and 1000 μm mesh size. Suction pumps with a 63 μm mesh size were also used (Table I). Samples were preserved in 4% buffered formalin. When monstrilloid copepods were found, they were sorted from the whole samples, processed for identification, and counted.

We used information from different bibliographic sources from collections off the coast of Argentina (Giesbrecht 1891; Hoffmeyer 1983; Ramírez 1971; Esteves *et al.* 1997). Several colleagues kindly provided information and

unpublished data from cruises carried out in the study area (Figure 1). Temperature and salinity were measured at most stations, thus allowing a general overview of the hydrological context and oceanographic subregions (Table I).

The specimens of monstrilloids were deposited in the copepod collection of the Integrated Zooplankton and Ichthyoplankton Laboratory (LIZI) of the Federal University of Rio de Janeiro (DZUFRJ-001 to DZUFRJ-174); in the Museu Nacional/UFRJ (MNRJ-14158, MNRJ-14338, MNRJ-13646, MN-13647, MNRJ-14100, MNRJ-14157, MNRJ-14437, MNRJ-14438, MNRJ-14439, MNRJ-14440, MNRJ-14441, MNRJ-14505); and at El Colegio de la Frontera Sur (ECOSUR), Chetumal, Mexico (ECO-CHZ-00518, ECO-CHZ-00519, ECO-CHZ-00520, ECO-CHZ-00521, ECO-CHZ-01127, ECO-CHZ-01166, ECO-CHZ-01167).

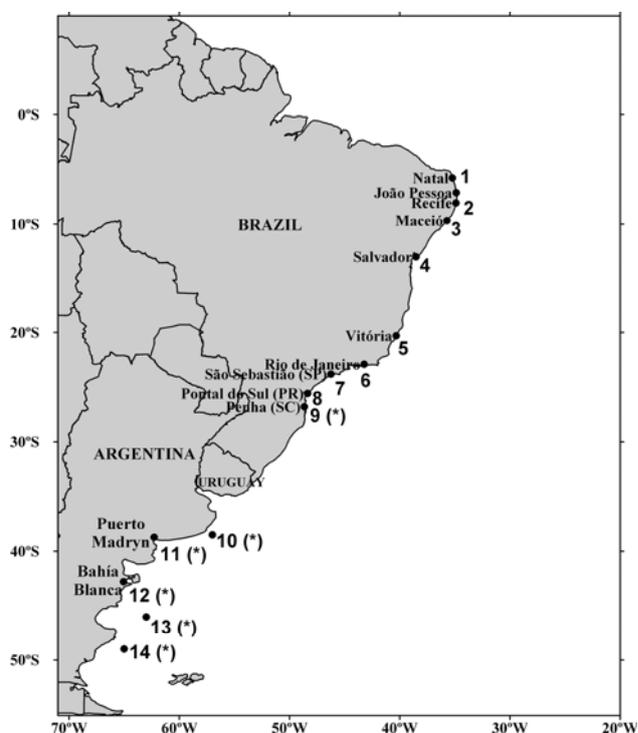


Figure 1. Map of the study area indicating the monstrilloid sampling stations, and additional localities cited in the literature (*).

Results

Four water masses were recognised: in the shelf and slope areas, the surface layer between 5 and 20°S was occupied by the Tropical Water (TW – temperatures > 18.5 °C and salinities > 36.0), which weakens between 20.01 and 30°S where the Coastal Water (CW – temperatures > 18.5 °C and salinities < 34.5) and the Shelf Water (SW – temperatures > 18.5 °C and salinities from 34.5 to 36.0) occur. Between 5 and 10.01° S the Tropical and Shelf Water is present with relatively high temperatures,

always above 27 °C and with peaks of 37 °C. The Subantarctic Water (SAW) is distinguished by temperatures below 18 °C and occupied the southern border of the study area between 30.01 and 50 °S (Figure 2).

The total of 566 monstrilloid specimens studied included 15 species. Eight belonged to the genus *Monstrilla*, five belonged to the genus *Cymbasoma* and two belonged to the genus *Monstrillopsis* (Table II).

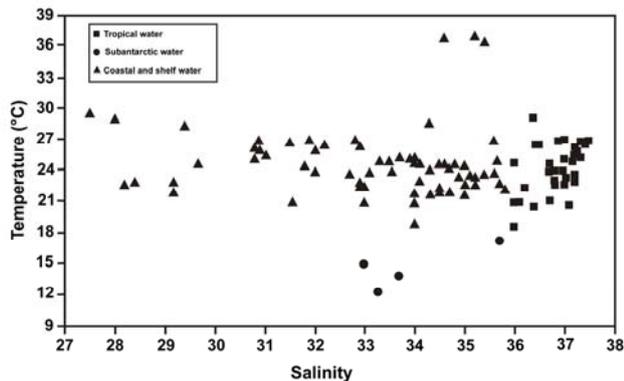


Figure 2. Temperature-salinity diagram of the watermasses found in the Southwest Atlantic.

Three monstrilloid species-groups were delimited according to the occurrence of the 15 species found and their relationship to different conditions of temperature and salinity in the region (5 to 50° S), as follows:

(A) Tropical species association. This association included *Monstrilla bahiana*, *M. brasiliensis*, *M. careli*, *M. grandis*, *M. rugosa*, *M. satchmoi*, *Cymbasoma gracilis*, *C. cf. longispinosum* and *C. cf. rigidum* (Table II). Their range off the Brazilian coast extended from Natal to Maceió, with temperatures ranging between 27.0 and 29.1 °C and salinity between 35.6 and 36.4; and the coastal zone of Bahia (Salvador), with temperatures between 20.5 and 26.9 °C and a salinity range of 36.4–37.5 (Figure 3). These values are characteristic of the SW and TW in the region (Figure 6).

(B) Subtropical species association. This association included *Monstrilla brasiliensis*, *Monstrilla grandis*, *M. pustulata*, *M. rugosa*, *Cymbasoma gracilis*, *C. cf. longispinosum*, *C. quadridens*, *C. cf. rigidum*, *C. rochai*, *Monstrillopsis dubia*, and *M. fosshageni*, which occurred in the coastal zone from Espírito Santo (Vitória) to Santa Catarina (Penha), in temperatures ranging from 21.0 to 29.6 °C and salinities from 27.5 to 35.8, mainly (Figure 4). These conditions are characteristic of the SW and CW (Figure 6). *M. bahiana* and *M. careli* were also recorded in this region (Table II).

(C) Subantarctic species association. This category included *Monstrilla helgolandica* and *M. grandis* which occurred off the coast of Argentina (Table II). Both species were associated with temperatures between 12.3 and 19 °C and a salinity range of 33.0–34.0 (Figure 5). These values are characteristic of SAW in the region (Figure 6).

Discussion

The present study recorded the occurrence of monstrilloids in the Southwest Atlantic (5 to 50° S) in neritic areas off Brazil and Argentina, and in Brazilian oceanic zones near reef-related environments. With a total of 15 species of monstrilloids, the Southwest Atlantic is a relatively rich region. Fourteen of these species were found off Brazil. Norway, with 12 species (Sars 1921), Mexico, with 17 species (Suárez-Morales unpublished), and the Pacific Ocean near the Philippines, with 17 species (Suárez-Morales 2000) were the areas with the highest numbers of monstrilloids up to now. The high number of taxa found in the present study is probably a function of sampling effort.

Most species have been recorded in different regions of both the northern and southern hemispheres. Suárez-Morales and Gasca (1990) and Suárez-Morales (2001) reported monstrilloids in reef-associated environments of the Caribbean Sea. Neritic species usually occurred in shallow surface waters, although their distribution was not determined by depth, but by the variation of the physical and chemical properties of the environment (Van der Spoel & Heyman 1983).

In the tropical species association, certain widely distributed species such as *Cymbasoma cf. longispinosum*, *C. cf. rigidum*, *C. gracilis*, and *Monstrilla grandis* occurred. These species were recorded in all the areas of the study. The largest number of individuals of *C. gracilis* occurred in the coastal zone off Maceió. The presence of *Monstrilla brasiliensis*, found previously in the coastal zone of Rio de Janeiro and Espírito Santo states (Dias 1996), and of *M. satchmoi* was observed for the first time in this region. This occurrence may represent the northern limit of their distribution. *Monstrilla bahiana* was found in this species association. This species has been collected in the oceanic region, where monstrilloids are rarely found. The species *Monstrilla bahiana* and *M. satchmoi* were found in samples collected near a reef-related environment, in the Abrolhos coral reefs (17°25'–18°10' S and 38°33'–39°37' W). The reef lagoon is the most favourable environment for monstrilloid copepod reproduction (Sale *et al.* 1976).

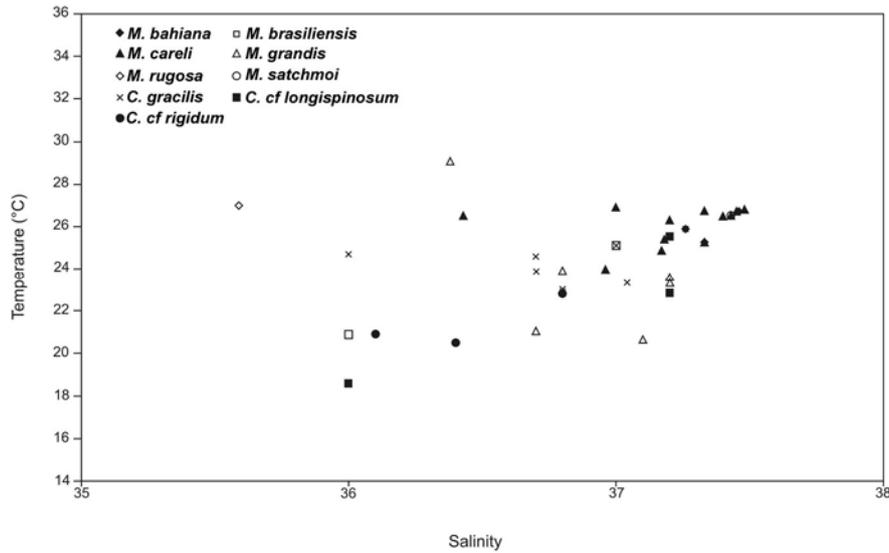


Figure 3. Temperature-salinity-species diagram of the Tropical species association found in the Southwest Atlantic.

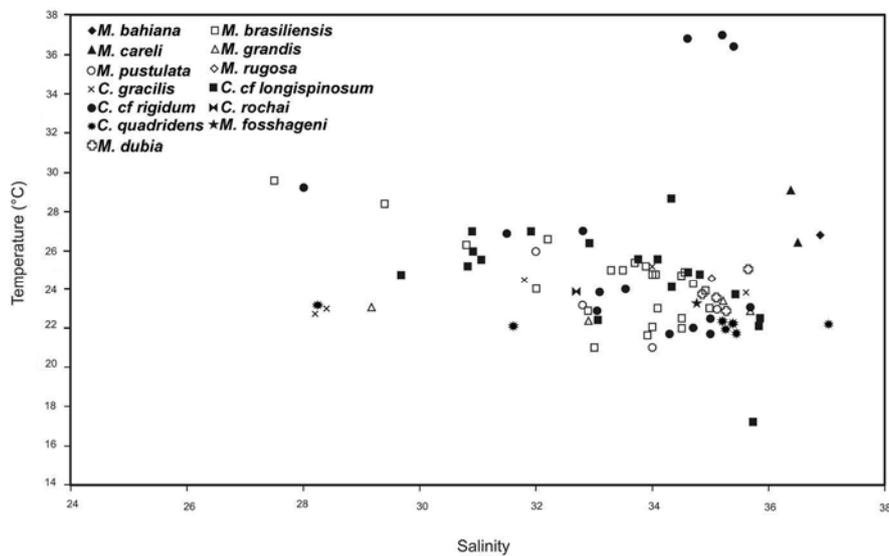


Figure 4. Temperature-salinity-species diagram of the Subtropical species association found in the Southwest Atlantic.

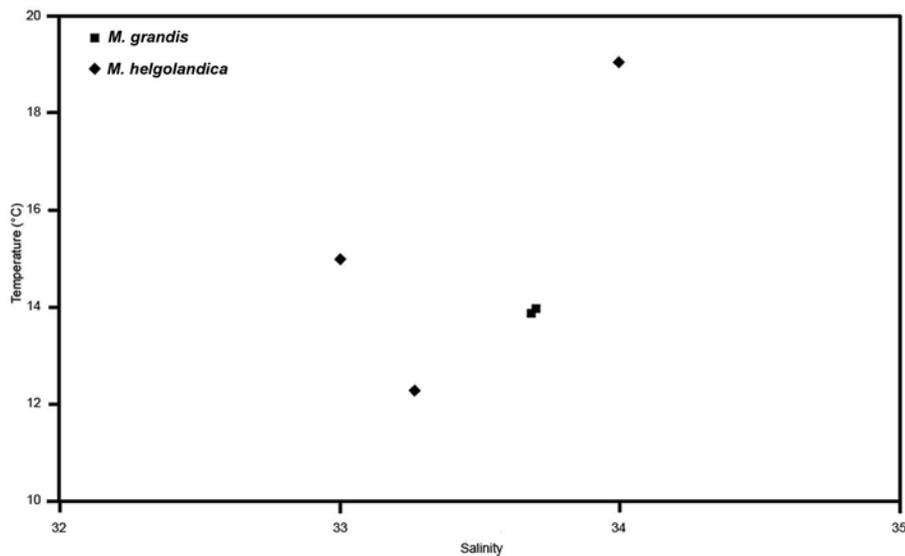


Figure 5. Temperature-salinity-species diagram of the Subantarctic species association found in the Southwest Atlantic.

Table I. Localities of sampling in the Southwest Atlantic, total samples, samples containing monstrelloids, sampling gear, type of hauls (sub-superficial horizontal, oblique, vertical), presence (X) or absence (-) of data for temperature and salinity.

Localities	Total Samples	Samples with Monstrelloida	Sampling gear	Hauls	Temperature and Salinity
BRAZIL					
Natal (6°04'00" – 6°10'60"S and 35°04'60" – 35°06'00" W)	20	4	Net (250 µm)	Hor	X
Recife (8°15' – 8°30'S and 34°55' – 35°05'W)	96	2	Net (300 µm)	Hor	X
Maceió (9°42'38"S and 35°41'89"W)	6	1	Net (200 µm)	Hor	X
Salvador (12°46'62" – 18°07'70"S and 35°52'93" – 38°54'99"W)	128	16	Net (200, 330, 500 and 1000 µm)	Obl - Hor	X
Vitória (19°52'50" – 20°35'89"S and 35°44'99" – 40°18'28"W)	639	65	Net (200, 300, 330, 500 and 1000 µm)	Obl - Hor	X
Rio de Janeiro (22°19' – 23°44'S and 41°35' – 44°22'W)	567	51	Net (200 and 500 µm) and in aquarium water with <i>Perma perna</i>	Obl - Hor - Vert	X/-
São Sebastião (23°48'07" – 23°49'86"S and 45°25'28" – 46°24'W)	17	5	Net (150 and 300 µm)	Hor	X
Pontal do Sul (25°33'41"S and 48°21'25"W)	12	5	Suction pumps and Net (63 µm)	Hor	-
Penha* (26°47'S and 48°37'W)	1	1	Net (300 µm)	Hor	X
ARGENTINA					
Coastal region *1 (38°43'31" – 42°46'37"S and 62°16'27" – 65°02'13"W)	179	5	Net (100 and 200 µm)	Hor	X/-
Oceanic region *2 (38°30' – 49°S and 57° – 63°W)	10	3	Net ("Palumbo"/ ?)	Hor - Vert	X/-

Literature: (*) Data for Penha (Brazil) were taken from Johnsson (1998); (*1) for the coastal region off Argentina from Esteves *et al.* (1996) and Hoffmeyer (1983); and (*2) for the oceanic region off Argentina from Giesbrecht (1891) and Ramirez (1971).

Table II. Numbers of specimens of each species of monstrilloid (M = male, F = female), at the sampling localities and as cited in the literature.

Species/Locality	Natal (#1)	Recife (#2)	Maceió (#3)	Salvador (#4)	Vitória (#5)	Rio de Janeiro (#6)	São Sebastião (#7)	Pontal do Sul (#8)	Penha* (#9)	Coastal Region *1 (#11/12)	Oceanic region *2 (#10/13/14)
<i>Monstrilla brasiliensis</i> Suárez-Morales and Dias 2000				1 F	8 F	66 F					
<i>Monstrilla grandis</i> Giesbrecht 1891		1 M			250 (6F/242M)	1 F					2 (1F/1M); + (#10/14)
<i>Monstrilla helgolandica</i> Claus 1893										+	1 F (#13)
<i>Monstrilla rugosa</i> Davis 1947			1 M						2 M		
<i>Monstrilla careli</i> Suárez-Morales and Dias 2000		1 F		17 F	10 F	2 F					
<i>Monstrilla pustulata</i> Suárez-Morales and Dias 2001a						3 F					
<i>Monstrilla satchmoi</i> Suárez-Morales and Dias 2001b				1 F							
<i>Monstrilla bahiana</i> Suárez-Morales and Dias 2001b				4 M	2 M						
<i>Cymbasoma</i> cf. <i>longispinosum</i> Bourne 1890	5 (3F/2M)				12 (8F/4M)	18 (12F/6M)	28 (8F/27M)		46 (7F/39M)		
<i>Cymbasoma quadridens</i> Davis 1947					13 M						
<i>Cymbasoma</i> cf. <i>rigidum</i> Thompson 1888	18 M				29 (18F/11M)	1 M		3 M			
<i>Cymbasoma rochai</i> Suárez-Morales and Dias 2001b					2 M	2 M					
<i>Cymbasoma gracilis</i> Gurney 1927	26 F			2 F	26 F	3 F		5 F			
<i>Monstrillopsis dubia</i> T. Scott 1904					2 F	1 F		1 F			
<i>Monstrillopsis fossahageni</i> Suárez-Morales and Dias 2001b					1 M						

Literature: (*) Data for Penha (Brazil) were taken from Johnsson (1998); (*1) for the coastal region off Argentina from Esteves *et al.* (1996) and Hoffmeyer (1983); and (*2) for the oceanic region off Argentina from Giesbrecht (1891) and Ramirez (1971).

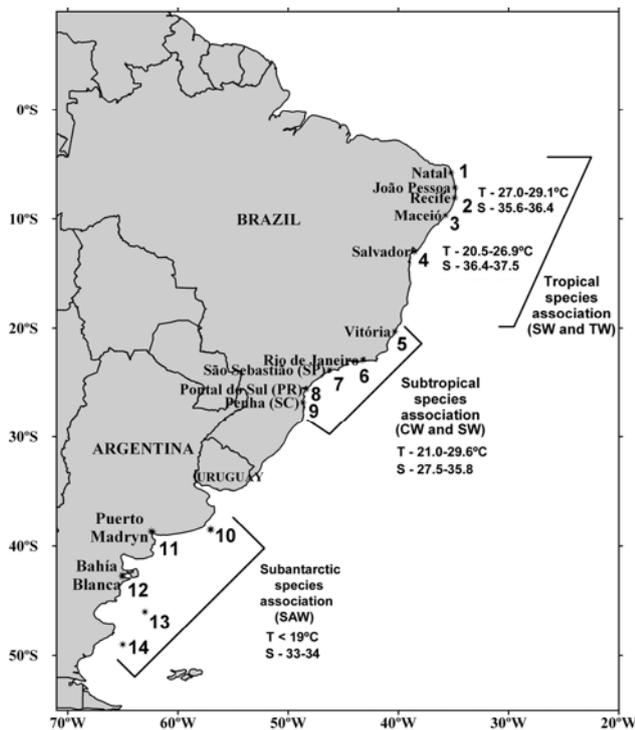


Figure 6. The three monstrolloid species associations determined by cluster analysis. The watermasses and temperature and salinity ranges within each area are indicated.

In the Subtropical species association, the highest numbers of taxa and individuals were found in the neritic zone of the central coast of Brazil, *Monstrilla grandis* and *Cymbasoma* cf. *longispinosum*, mainly. The coastal region offers a substratum for the development of potential hosts. Although the highest number of samples containing monstrolloids was related to different neritic, shallow environments, the high number of taxa and individuals of monstrolloids in a region can be attributed to other factors. According to Suárez-Morales (2001), the reasons for local aggregation in adult monstrolloid copepods (remaining near hosts or mating, but not feeding) seem to be quite different from those of other planktonic copepods (avoidance of predators, feeding, mating). Monstrolloid copepods respond to light stimuli and are lured by flashlights (Grygier 1994). They probably remain near the bottom (and near their potential hosts) during the day and swim toward the surface at dusk (Suárez-Morales 2001). Swarming enhances copepod mating encounters and success, bringing together adult males and females in high concentrations, too. This is crucial for the supposedly short-term (one day/night) reproductive life of monstrolloids.

In the Subantarctic species association (between 30-43°S) *Monstrilla grandis* and *M. helgolandica*, occurred in the coastal region of

Argentina. The presence of *M. grandis* was also recorded in the Tropical and Subtropical species associations. The occurrence of this species in the Subantarctic species association is probably a result of the intrusion of the Brazil Current waters, which flow between the main axis of the Malvinas Current and the coast and move southward along the shelf (Boltovskoy 1981, Boltovskoy *et al.* 1999, Berasategui *et al.* 2006). *Monstrilla helgolandica* was recorded only in this species association. This species was associated with low temperatures over the entire study area (Ramírez 1971, Hoffmeyer 1983, Esteves *et al.* 1997).

In the Southwest Atlantic, the number of species of Monstrolloida decreased from north to south. This latitudinal pattern differs according to each zooplankton group. Boltovskoy *et al.* (1999) made a very rough estimate of the latitudinal span of certain zooplanktonic groups, and found that few taxa are restricted to ranges below 10-20° S, or occupy areas below 50° S; instead, most zooplankters occur over moderately wide areas between 20-40° S. The same pattern was found for the Monstrolloida in this study: most species occurred in the Subtropical Zone between 20-30° S.

Very little is known about the behaviour (migrations, day-night distribution) of monstrolloids, and almost nothing is known about the seasonality of the adults emerging from their hosts. In general, not more than a few specimens of monstrolloids are caught in plankton samples. Isaac (1974) collected 40 individuals of *Monstrilla grandis*, and attributed this to a local mass liberation of adults from aggregated benthic hosts. Suárez-Morales (2001) collected a total of 2,067 individuals of different species in a reef area in the western Caribbean, which can be attributed to the aggregation and abundance of their potential hosts (polychaetes and molluscs) in reef-related environments.

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