PLANKTONIC COPEPOD COMMUNITY IN THE NERITIC AREA OF THE SOUTH WESTERN PART OF TUNIS BAY INFLUENCED BY MELIANE RIVER SUPPLIES (SOUTH WESTERN MEDITERRANEAN SEA)

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ملخّــــص

وصف تكوين و توزيع مجذفيات الأرجل في خليج تونس الصغير : يقع خليج تونس الصغير على الساحل الشمالي الشرقي لتونس و يخضع لمداخلات مستمرّة من وادي مليان. تهدف هذه الدراسة لوصف تكوين و توزيع مجذفيات الأرجل في هذا الجزء من الخليج الصغير للكشف عن تأثير مداخلات الوادي . لقد تمّ أخذ عيّنات بــ 19 محطّة من جويليا 2004 إلى ديسمبر 2004 بإستخدام شبكة (160µm) حسب سحب مائل أسفل – سطح . تألف مجتمع مجذافيات الأرجل من 21 صنف Calanoïdes و 4 أصناف Cyclopoïdes و 3 أصناف Poïcilostonatoïdes و صنف واحد Harpacticoïdes . وجود مؤشرات مياه الملوحة مثل *Arctodiaptomus salinus* و *Microcylops sp* و *Thermocyclops sp* تؤكد على تدفق مياه النهر. ساهمت مجذافيات الأرجل بـ 94% من كل العوالق و سيطرت *Euterpina acutifrons* و*Oithona nana*و هما صنفان يعكسان تغيير في بنية العوالق فهي تشجع ظهور مجذفيات أرجل صغيرة الحجم حاملة لحويصلات البيض و هذا نتيجة لتلوث هذه الجهة عبر وادي مليان.
<u>الكلمات المفاتيح</u> : مجذفيات الأرجل، خليج تونس الصغير، تكوين، توزيع.

RÉSUMÉ

Distribution spatiotemporelle des copépodes planctoniques dans La baie de Tunis influencée par les apports de l'oued Meliane : La baie de Tunis se situe au niveau des côtes Nord Est de la Tunisie et est sujette à des apports d'eau continuels par le biais de l'Oued Meliane. Cette étude vise à décrire la composition et la distribution spatiotemporelle des copépodes planctoniques dans cette partie de la baie afin de déceler l'effet des apports de l'oued. Dix neuf stations ont été prospectées mensuellement de juillet 2004 à décembre 2004, le mésozooplancton a été prélevé à l'aide d'un filet de 160 µm de vide de maille selon des traits obliques fond-surface.
La communauté des copépodes planctoniques était formée de 21 taxa de Calanoides, 4 taxa de Cyclopoides, 3 taxa de Poecilostomatoides et une espèce d'Harpacticoides. La présence de taxa indicateurs d'eau saumâtre tels que *Arctodiaptomus salinus*, *Microcyclops sp* and *Thermocyclops sp* confirme les apports de l'oued. Les copépodes ont contribué à 94% au mésozooplancton total. Deux espèces (*Oithona nana*et*Euterpina acutifrons*) ont dominé la communauté, elles témoignent d'un changement de la structure de la communauté à cause de la pression anthropiqueque subit cette partie de la baie, favorisant les copépodes de petite taille portant des sacs ovigères.
Mots clés : copépodes, baie de Tunis, composition, distribution.

ABSTRACT

The Tunis bay is located in the North Estern coast of Tunisia and receives in its Western part flows from Meliane River. Our study aims to describe the composition and the spatiotemporal distribution of planktonic copepods in the bay in order to identify the effect of the Meliane River supplies on the community. A grid of 19 stations was investigated monthly from July 2004 to December 2004 using a 160 µm mesh size plankton net, towed obliquely from the bottom to the surface.
The planktonic copepod community was represented by 21 taxa of Calanoida, 4 taxa of Cyclopoida, 3 taxa of Poicilostomatoida and one species of Harpacticoida. The presence of freshwater taxa like *Arctodiaptomus salinus*, *Microcyclops sp* and *Thermocyclops sp* in the coastal stations indicated the meliane River flows. The copepod community dominated the mesozooplankton, they constituted 94% of total abundance. Two species (*Oithona nana* and *Euterpina acutifrons*) dominated the community showing a shift of the planktonic copepod community structure to smaller-sized copepods carrying egg sacs due to anthropogenic supply increase.
<u>Key words</u>: copepods, Tunis bay, composition, distribution.

INTRODUCTION

Planktonic copepods hold a key position in marine food webs as the major secondary producers of the world ocean (Huys and Boxshall, 1991). They may constitute up to 80% of mesozooplankton biomass and represent the link between primary producers and planktivorous fishes. Recent study have shown that copepod activity contribute to microbial food webs through the production of particulate and dissolved organic carbon from superflous feeding, sloppy feeding, excretion and fecal pellets production (Moller *et al*., 2003; Moller, 2005). Copepods are considered as good bioindicators of climatic trends, anomalies or water masses (Formentin and Planque, 1996; Beaugrand *et al*., 2002; Bonnet and Frid, 2004) but also of increase in phytoplankton biomass and changes in zooplankton community structure (Beaugrand, 2004). In temperate Mediterranean waters, copepods community structure fluctuates depending on seasonal events and on natural or anthropogenic supplies. Many studies described coastal zone systems as sites of increase degradation because of human activities (Marcus, 2004; Turner 2004; Siokou-Frangou *et al*, 1998). This is of the utmost importance because those regions play ecological and economic roles. As a result of water enrichment due to anthropogenic supplies, (1) copepods tend to dominate the mesozooplankton population (Mouny and Dauvin, 2002; Fernandez de Puelles *et al*., 2003 a; Viera *et al*., 2003; Uriate and Villate, 2004) and (2) shifts in the copepod community could be observed due to changes in the species composition of the primary producers (Marcus, 2004).According to Souissi *et al*. (2000) and Daly Yahia *et al*. (2004), the South Western part of the Tunis bay, where is conducted this study, is characterized, since 1994, by a high turbidity and nutrient concentration compared to the Eastern part that could be explained by Meliane River flows.

The aim of this study is to show the possible impact of this freshwater supply on the composition and distribution of the copepod community in the South Western neritic area of the Tunis bay.

MATERIAL AND METHODS

The Tunis bay is located in the South part of the Tunis gulf which opens up to the siculo-tunisian and tuniso-sardinian straits. The bay is located between 10°17' and 11°37' E and 36°42' and 36°53' N; its total area is around 361 km^2 and it has an average depth of 15 m (Souissi *et al*., 2000). The bay is provided in its Western part by outflows from Meliane River that receives wastewater from sewage treatment plant and discharges from factories located around it (Ben Lamine, 2006) (Fig 1). Nineteen sampling stations were investigated monthly from July 2004 to December 2004 (Fig 1; Tab I), using a 160 µm mesh size plankton net towed obliquely from the bottom to the surface. The mesozooplankton samples were preserved in 3% buffered formaldehyde solution. Specimens were counted and identified using a stereomicroscope (Leica) and according to Trégouboff and Rose (1957 a and b).

At each station, temperature and salinity were measured with a multi 340i/set WTW probe. A 2 L Ruttner bottle was used to sample surface water for chemical analysis according to FAO (1975) and Aminot and Chaussepied (1983).

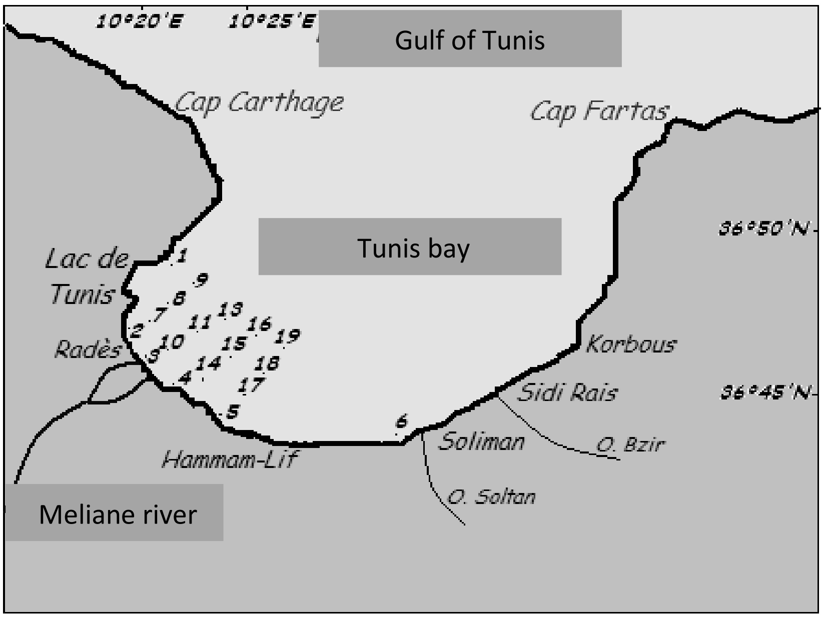

Fig. 1:Location of the sampling stations (C_1 to C_{19}) in the south western part of the Tunis bay.

Table I. Geographical positions and depth of each sampling station in the Tunis bay.

Stations	Latitude N	Longitude E	Depth (m)
C_1	36°49’45’’	10°18’90’’	1
C_2	36°47’22’’	10°17’12’’	1
C_3	36°45’36’’	10°18’39’’	1
C_4	36°44’63’’	10°19’20’’	1
C_5	36°44’10’’	10°20’9’’	1
C_6	36°43’23’’	10°26’13’’	1
C_7	36°47’28’’	10°18’11’’	5
C_8	36°47'30"	10°19'26"	7,3
C_9	36°47'33"	10°20'31"	9
C_{10}	36°46'15"	10°18'10"	1,5
C_{11}	36°46'12"	10°18'31"	5
C_{12}	36°46'50"	10°19'05"	7,8
C_{13}	36°47'14"	10°20'58"	9,7
C_{14}	36°45'10"	10°19'12"	5
C_{15}	36°45'49"	10°20'30"	9,8
C_{16}	36°46'29"	10°21'32"	10
C_{17}	36°45'08"	10°20'20'	3,4
C_{18}	36°44'54"	10°21'30"	9,7
C_{19}	36°45'42"	10°22'39"	11

RESULTS

Spatio-temporal variation of hydrobiological parameters

The seasonal variation of surface water temperature showed a mean value of 24,9°C with a maximum of 28,1°C in August 2004 and a minimum of 17,4°C in December 2004. The surface salinity reached a maximum of 38,8 psu in July 2004 and a minimum of 35,5 psu in October 2004. High nutrient concentration was observed throughout the study period, with average values about 4,4 µM of nitrates and 2,43 µM of phosphates (Fig 2). Spatial distribution of salinity ranged from 22,9 psu in the Meliane River mouth due to freshwater supply and 37,8 psu in the deepest station. The nutrient spatial distribution showed maximum values in the River mouth (Fig 3) (maximal registered values were about 10,16 µM nitrates in October 2004 and 4,49 µM phosphatesin July 2004).

Spatio-temporal distribution of planktonic copepods

Planktonic copepods were the most abundant group and represented 94% of total mesozooplankton. Thirty copepod taxa were recorded in the South Western part of the Tunis bay from July 2004 to December 2004: 21 Calanoida, 4 Cyclopoida, 3 Poicilostomatoida and 1 Harpacticoida (Tab. II). The temporal dynamic of the copepod community was characterized by differences in density according the

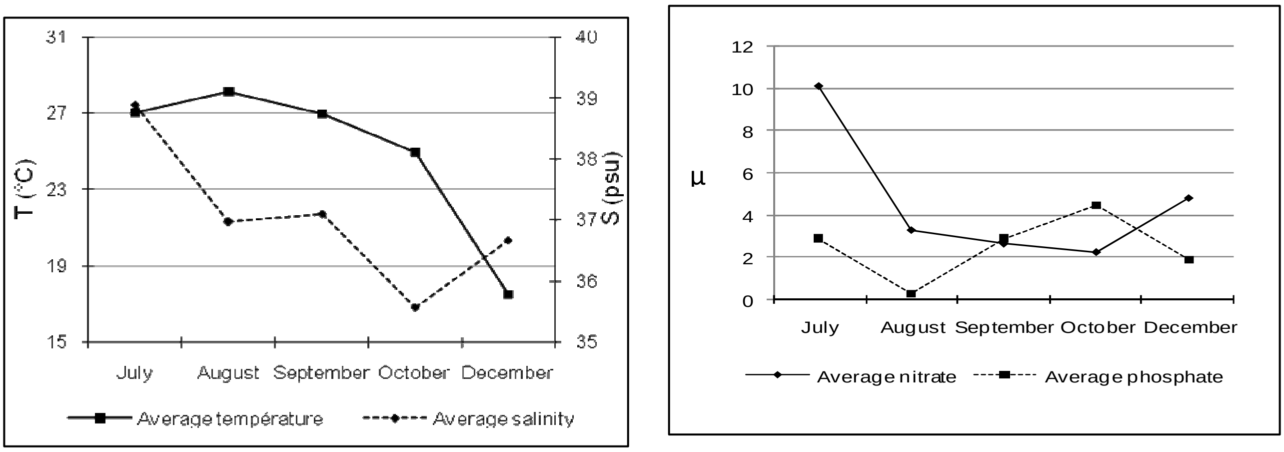

Fig. 2: Temporal variation of surface water temperature, salinity, nitrate and phosphate in the south western part of the Tunis bay from July 2004 to December 2004.

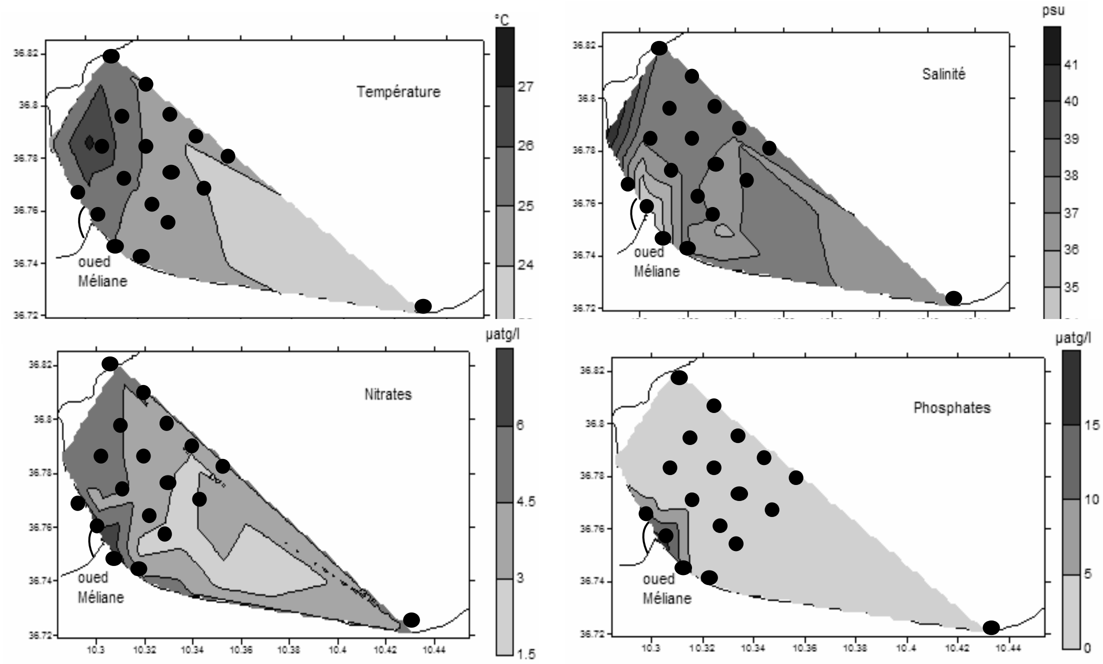

Fig. 3: Spatial variation of average temperature (A), salinity (B), nitrate (C) and phosphate (D) in the south western part of the Tunis bay from July 2004 to December 2004.

season. A first peak was registered in August 2004 with 2741 ind/m^3 and a second one in December 2004 with 2878 ind/m^3 (Fig 4).

Oithona nana was the most abundant copepod (25% of total copepods) followed by *Euterpina acutifrons* (23%), *Centropages kroyeri* (12%), *Acartia grani* (6%), *Paracalanus parvus* (3%), *Acartia discaudata* (2%), *Acartia latisetosa* (2%) and *Oithona plumifera* (1%).

O. nana occurred with low densities during the first period and reached the maximum of mean abundance in December 2004 (160,51 ind/m^3); the maximal density of 647,05 ind/m^3 was registered in C2. *E. acutifrons*was abundant during the first period of the study bat decreased in December 2004; the peak of abundance was observed in September 2004 (52,94 ind/m^3), the highest density was about 382,35 ind/m^3 and was recorded in October 2004 (station 6).*C. kroyeri* was abundant in August 2004 with a mean density of 54,18 ind/m^3. During this month, the station 3 (in front of the River) showed a high concentration of *C. kroyeri* that reached 464,70 ind/m^3.*A. grani* was abundant in September 2004 (38,77 ind/m^3) and *P. parvus* showed a highest density in December 2004 (12,13 ind/m^3).

Figure 4 showed an important spatial heterogeneity. However, the spatial distribution of total planktonic copepods during the study period was characterized by a gradient of increasing densities from the South

Table II. Copepod taxa inventory in the south western part of Tunis bay and their total densities (ind/m^3) from July 2004 to December 2004 (- means not recorded).

Copepod taxa	July	August	September	October	December
Acartia clausi Giesbrecht, 1889	-	34	55	8	33
Acartia discaudata Steuer, 1934	59	39	52	32	54
Acartia grani Sars, 1904	29	134	737	50	2
Acartia latisetosa Krichagin, 1873	47	144	35	65	2
Arctodiaptomus salinus Dana 1885	6	-	-	-	-
Nannocalanus minor Claus, 1863	-	-	-	-	2
Nannocalanus sp	-	6	1	-	-
Centropages kroyeri Giesbrecht, 1892	190	1029	526	190	10
Clausocalanus arcuicornis Dana, 1849	6	-	-	-	-
Clausocalanus furcatus Brady, 1883	11	-	-	-	-
Clausocalanus spp	17	9	15	14	4
Coryceus clausi F.Dahl, 1894	-	1	-	-	-
Coryceus latus Dana, 1849	-	-	6	-	-
Ctenocalanus vanus Giesbrecht, 1888	-	1	-	-	-
Euterpina acutifrons Dana, 1847	581	52	1006	731	95
Isias clavipes Boeck, 1865	-	-	-	-	6
Labidocera brunescens Czerniavsky, 1868	-	609	7	6	-
Labidocera wollastoni Lubbock, 1857	-	1	-	-	-
Labidocera sp	-	11	-	-	-
Metacalanus sp	6	-	-	-	-
Microcyclops sp	-	-	6	-	-
Oithona linearis Giesbrecht, 1891	-	-	6	-	6
Oithona nana Giesbrecht, 1892	19	332	237	1289	2889
Oithona plumifera Baird, 1843	-	-	-	206	60
Onceae sp	11	-	1	-	-
Paracalanus aculeatus Sewell, 1929	-	1	3	12	24
Paracalanus parvus Claus, 1863	24	71	79	96	218
Temora stylifera Dana, 1849	-	17	9	2	31
Thermocyclops sp	-	-	6	-	-
Copepodites	180	1170	546	859	300
Harpacticoids (benthics)	89	224	32	338	15
Total (ind/m^3)	1275	3885	3365	3898	3751

Est to the South West, a minimum value of copepod density in the mouth of the Meliane River and a maximum one in the coastal station 4. The freshwater taxa (*Arctodiaptomus salinus*, *Microcyclops sp* and *Thermocyclops sp*) were observed in station 3 and 5 where are located respectively the Meliane River and a small channel that contain rainwater at a low speed flow (Fig 1).

Copepod community structure

In the South Western part of the Tunis bay, the copepod community was dominated by small-sized genera such as *Oithona*, *Euterpina*, *Acartia*, *Centropages*, *Paracalanus* and *Clausocalanus*. The Shannon-Wiener diversity index was low and varied between 1,08 bits in July 2004 and 2,37 bits in September 2004. H’ showed a maximum value of about 3,31 bits at the station 19 (farthest station from the Meliane River); in the mouth of the river, it was of about 1,89 bits.

DISCUSSION

The abiotic parameters in the South Western part of the Tunis bay showed that this region tend to became eutrophic due to high nitrates and phosphates concentration that depend on the Meliane River inflow (Ben lamine, 2006). Copepods dominated the mesozooplankton population and the majority of the recorded taxa are good indicators of the hydrological regine in estuarine ecosystems (Mouny and Dauvin, 2002; Fernandez de Puelles *et al*., 2003; Uriate and Villate, 2004). Those species are small sized; this situation was observed in other Mediterranean ecosystems and could vary according the seasons and

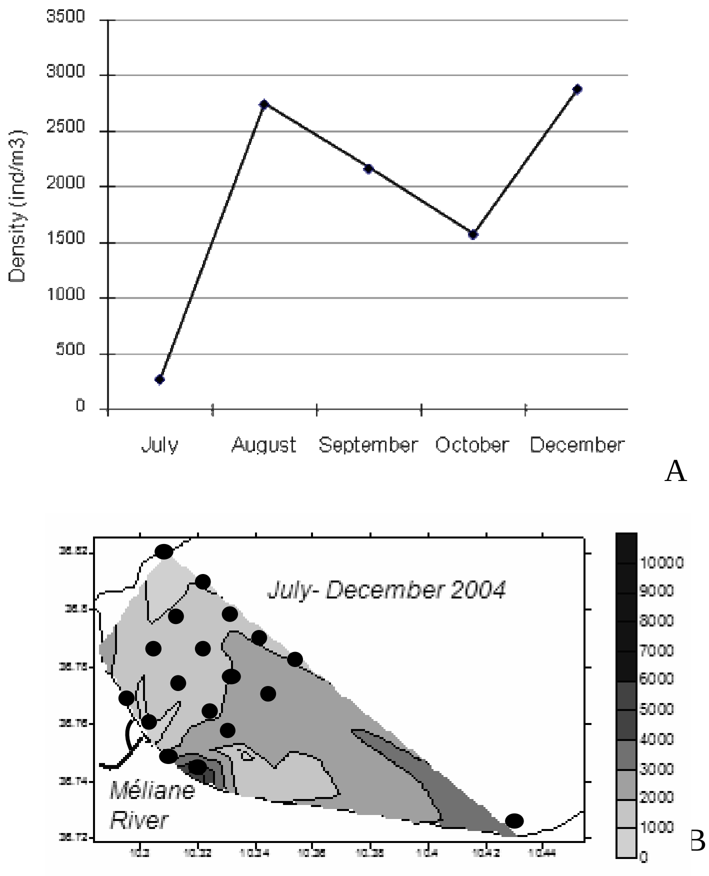

Fig. 4:Average temporal (A) and spatial (B) variation of copepod density (ind/m^3) in the south western part of the Tunis bay from July 2004 to December 2004.

Table III: Total density of copepods (ind/m^3) with and without egg sacs in the in-shore (stations 1, 2, 3, 4, 5 and 6) and off-shore stations (stations 7 to 19) of the south western part of the bay of Tunis from July 2004 to December 2004.

Period	July		August		September		October		December	
Station	with	without	with	without	with	without	with	without	with	without
In-shore	1250	100	520	930	800	1000	220	180	118	130
Off-shore	50	300	450	530	410	500	25	135	60	48

the years (Fernandez de Puelles *et al*., 2004 a and b). According to Uye (1994), a general shift to small-sized copepods could be due toeutrophication that leads to bottom hypoxia and muddy sediment conditions due to primary production increase. The shift could be attributed to changes in the food particles composition (replacement of Diatoms by small ones as a result of nutrient increase) accompanied with copepods carrying egg sacs density increase.

During this study, we suggest that copepods with egg sacs, more adapted to shallow and eutrophic waters should be more concentrated in the less deep stations of the South Western part of the Tunis bay, near the mouth of the Meliane River. Among the most abundant taxa constituting the copepod community, two groups were formed: the first group composed by taxa carrying egg sacs (*Oithona spp*, *Euterpina acutifrons*, *Clausocalanus spp*) and the second group represented taxa without egg sacs (*Acartia spp*, *Centropages kroyeri* and *Paracalanus spp*). The most of the time, copepods with egg sacs showed high densities in the more shallow stations; except in December 2004, probably due to turbulence and precipitation (Tab. III). The life cycle strategy performed by egg carrying copepods may offer several advantages in this eutrophic ecosystem characterized by the low depth of the water column which could engender the sinking of free spawned eggs to the muddy bottom sediment rich in organic matter with a very low oxygen level where the hatching success after sinking could be very low according to Marcus (2004).

CONCLUSION

The evolution of the copepod community in the South Western part of the Tunis bay is related to environmental factors. Actually, the supplies of the Meliane River play an important role in the composition, distribution and structure of the copepod community that was dominated by a low number of small-sized copepod species. The dominant species could face intense predation by zooplanktivorous consumers due to their small size. To increase their reproductive success, they developed r-strategy characterized by high productivity, egg production rate and rapid per-stage growth rate contrary to k-strategy (Hirche, 1992). However, the decrease of size had important consequences on the food chain functioning: small copepods are grazers of small particles and operate more on microbial loop by preying upon bacterioplankton and heterotrophic protists; they are prey for carnivorous invertebrates that could replace the planktivorous (fish larvae) and make an important decline in the marine resources (Turner, 2004).

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