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ZOOPLANKTON VARIABILITY AND COPEPOD SPECIES ASSEMBLAGES FROM A TROPICAL COASTAL LAGOON

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ABSTRACT Results of monthly zooplankton sampling, carried out from December 1990 to November 1991, are compared from three localities in the Mexican Caribbean. Two stations, Bojórquez, and Cuenca Norte, represent partially enclosed areas of the Nichupté Lagoon System in the northeastern region of the Yucatán Peninsula; a third station was located in adjacent neritic waters. At the neritic station, temperature was lower, salinity was higher, and variations in the two parameters smaller as compared to the two lagoon stations. Zooplankton abundance ranged from 3585.5 org./m^3 at the neritic station to 18,742.7 org./m^3 at Cuenca Norte. Considering all animals collected, decapod larvae (39%), copepods (28.7%) and ophiopluteus-echinopluteus larvae (22.8%) made the bulk of the catch. A total of 47 copepod species were recorded, of these, 14 were found at Bojórquez, 12 at Cuenca Norte and 42 at the neritic station. *Acartia tonsa* dominated the copepod population assemblage at Bojórquez (94.4%) and made important contributions at Cuenca Norte (34.5%) and in the neritic station (24.5%). *Paracalanus quasimodo* was most abundant at Cuenca Norte (40.3%) and contributed 20.9% at the neritic station. It is suggested that both, the high capture of *A. tonsa* in Bojórquez and the dominance of *P. quasimodo* at Cuenca Norte, is probably related with two factors: the anthropogenically nutrient-enriched condition of Bojórquez lagoon and the relatively higher breeding frequency of the chaetognath *Sagitta hispida* in Bojórquez. The highest abundance of zooplankters occurred at the stations within the lagoonal system, and the highest number of copepod species was found at the neritic station, where more stable conditions prevailed.

Introduction

Bojórquez lagoon, as part of the Nichupté Lagoon System (NLS), is a striking example of man's improper use of a coastal body of water. Jordán et al. (1978) reported oligotrophic conditions in the system, although with some symptoms of ecological deterioration. Subsequent studies by Reyes-Gómez (1988), González-López (1989), Merino et al. (1990) and Hermus (1992) showed that the NLS presented eutrophic conditions. Several factors contributed to this. The oceanic tidal range of 20 cm for this area of the Caribbean sea (instituto de Geofísica 1984) is further reduced to only 3 cm within the NLS (García-Krasovsky 1984). Water exchange in the NLS is consequently very low, and in spite of having two inlets, the system can be considered as "choked" according to Kjerfve's (1986) classification. Being located on the eastern end of the system, Bojórquez lagoon is further affected by its considerable distance from the two inlets and by a lack of continental runoff. Runoff is relatively important during the rainy period on the west side of the NLS (Merino et al. 1990), but does not reach Bojórquez. Thus, the only important freshwater input for Bojórquez is from local rainfall.

In the 1970's the construction of Cancún City, the most ambitious Mexican tourist resort in the Caribbean, brought additional stress to the lagoon. Dredging or refilling of parts of Bojórquez were carried out to permit boat navigation or provide tourist facilities. With increasing human population, domestic waste increased accordingly and the need for a sewage treatment facility became compulsory. A supposed "sewage treatment plant" was placed in the vicinity of Bojórquez and its high nutrient content discharge was released into the lagoon. Although sewage disposal has since been diverted to deep holes used as septic tanks, illegal sewage discharges or malfunctions of the treatment plant occasionally occur, such as when the amount of waste exceeds the plant capacity during the rainy period causing the overflow to enter the lagoon. Nutrient enrichment has promoted proliferation of macroalgae (Serviere 1986; Cúlhuac 1987; Hermus 1992) and although some efforts have been made to sanitize Bojórquez (harvesting the macroalgae for example), 25 years have elapsed since the initial sewage discharges and environmental conditions have not improved. At present, a project is underway for a water pumping system devised by Ruíz-Rentería et al. (1994) to bring sea water into Bojórquez.

The importance of this work, beside the fact that zooplankton community studies in this area are extremely scarce, is that we will be able to monitor the evolution in composition and abundance of the zooplankton community once the pumping system is working. We will have the information before, during and after the system has been installed.

In this paper, monthly copepod species assemblages and fluctuations in the abundance and composition of zooplankton groups are compared for three regions: (1) Bojórquez lagoon, (2) Cuenca Norte, an area at the northern end of the NLS but nearer to the tidal inlet, and (3) the neritic waters north of the NLS.

Study Area

The Nichupté Lagoon System (NLS) is located in the non-mountainous northeastern region of the Yucatán Peninsula, 21°07'N and 86°46'W (Figure 1). The climate of this area is subhumid and warm (lowest temperatures are higher than 18°C), with the main rainy season in summer and moderate rainfall in winter (type AW1 (X') (i') g of García 1964). The NLS was originally oligotrophic as are the waters of the Caribbean sea, and although the system (type IV-B of Lankford 1977) at present is surrounded by tourist facilities (hotels, scuba diving facilities, sport fishing fleets, etc.), it was originally bordered by mangrove vegetation. Particular features in the area are a highly porous and permeable soil (Butterlin 1958; López-Ramos 1974) allowing a rapid filtration of rain, and a lack of land runoff. Rivers frequently found in other lagoon systems are absent here, there being instead subterranean water and "cenotes" (karstic water deposits).

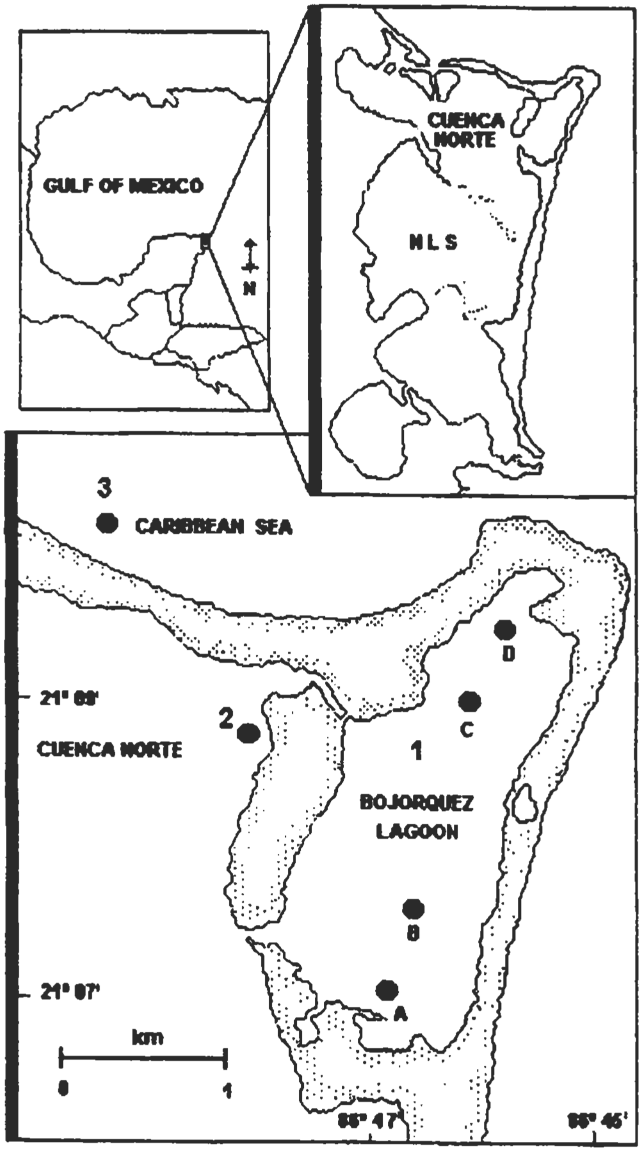


Figure 1. Study area and sampling locations in the Nichupté Lagoon System (NLS). 1 Bojórquez, 2 Cuenca Norte, and 3 neritic station. Note that Bojórquez contains four sampling sites.

Three climatological regimes, "nortes" (strong northern winds blow in the area), dry and rainy, are reported annually in this area (Merino and Otero 1991). However, year to year variations in the length of these periods are also recorded. During the present survey, the "nortes" period extended from December to March, followed by a dry period from April to July, and a rainy period from August to November.

MATERIALS AND METHODS

Zooplankton samples and hydrographic data (salinity and temperature) were collected monthly at three sampling stations from December 1990 to November 1991. Station 1 (Bojórquez Lagoon) with a 1.5 m mean depth, consisted of four sampling sites (1A-1D). Results on abundance and composition of the zooplankton at these sites were pooled and mean values were reported for this area. Station 2 (2.5 m depth) was situated in the northern part of the NLS, locally known as Cuenca Norte. Station 3 (4 m depth) was neritic, at ca. 3 km offshore from the Cancún inlet (Figure 1). Due to bad weather conditions, samples were not collected in January at this station.

Near-surface tows were made between 0900 and 1200h using a conical plankton net (0.42 m diameter and 1.30 m length) with a 330 µm mesh. This mesh size was selected after several trials conducted to determine the rapidness of clogging and the efficiency in collecting most of the fauna. A General Oceanics digital flowmeter was attached to the mouth of the net to estimate volume of water filtered (m^3). Collections were taken in a circular path at ca. 1.5 -2 knots for five minutes. Zooplankton samples were preserved in 5% buffered (lithium carbonate) formalin.

Floating vegetation and its associated fauna was accidentally collected together with the zooplankton mainly at Bojórquez. This associated fauna and zooplankton were dislodged by repeatedly rinsing and shaking the algae collected during the tows. Subsampling was performed following Russell's method (1927), and considering Omori and Ikeda's (1984) recommendations for having a representative aliquot in which at least 300 organisms per sample should be analyzed. Subsequent aliquots were taken when the previous subsamples did not yield enough animals or, instead, the whole sample was analyzed. Zooplankton was identified to major taxonomic groups, and the highly abundant copepods to species, when possible. Data were standardized to organisms per m^3 based on numbers counted and volume of water filtered.

RESULTS

Temperature and salinity

Surface temperature recorded during the present study ranged between 25.7 and 32.3°C. Greater fluctuations were recorded at Bojórquez (SD± 2.18) than at Cuenca Norte (SD± 2.06), or the neritic station (SD±1.11). Maximum values were recorded in July and August for the former two areas and in September for the latter (Figure 2a).

Salinity ranged from 28.30 to 36.49 o/oo year round. Highest values were recorded in June at the neritic station (SD± 1.44), while lowest values were observed in November at Cuenca Norte (SD± 1.85). At Bojórquez, intermediate salinity values (SD± 1.78) were recorded (Figure 2b).

Temperature and salinity values were lower from December to March (nortes) when cold, strong northern winds blew in the area. Both parameters increased progressively from April to July (dry period) until reaching a peak in August, just before the rainy period started (Figure 2a,b).

Zooplankton taxa

A mean of 9964.7 org./m^3 were collected from the three locations. The highest abundance of zooplankters was recorded at Cuenca Norte (18743 org./m^3), compared to Bojórquez (7563 org./m^3) or the neritic station (3585 org./m^3). Abundance also varied seasonally. At Bojórquez (Table 1) there was clearly a higher abundance during the rainy period (4416 org./m^3), followed by the "nortes" (2400 org./m^3), whilst during the dry period only 747 org./m^3 were caught. At Cuenca Norte (Table 2), the dry (6630 org./m^3), rainy (6497 org./m^3) and "nortes" (5617 org./m^3) periods had similar abundances. In the neritic station (Table 3) the "nortes" period was clearly more productive (2515 org./m^3), than the dry (944 org./m^3) or rainy periods (127 org./m^3).

Changes in the zooplankton composition were also recorded. Abundance of the zooplankters mainly consisted of decapod larvae, copepods and ophiopluteus-echinopluteus larvae, however not in this same order for the three locations. Copepods were, by far, the most abundant group at Bojórquez (Table 1), comprising 81.7% of the total catch, followed by decapod larvae (4.9%) and ophiopluteus-echinopluteus larvae (3.9%). Nineteen other taxa made up the remaining percentages; of them, protozoans and nematodes were the most important components of the plankton year round. At Cuenca Norte (Table 2), decapod larvae (57.2%), ophiopluteus-echinopluteus larvae (23.0%) and copepods (11.9%), comprised more than 90% of the total population. Other important groups at this area were sergestids (*Lucifer*) and chaetognaths. At the neritic station (Table 3), ophiopluteus-echinopluteus larvae (61.1%), decapod larvae (15.9%) and fish eggs (7.7%) were the main contributors. Cirripeds and copepods constituted 5.3% and 5.7% respectively.

Copepod species

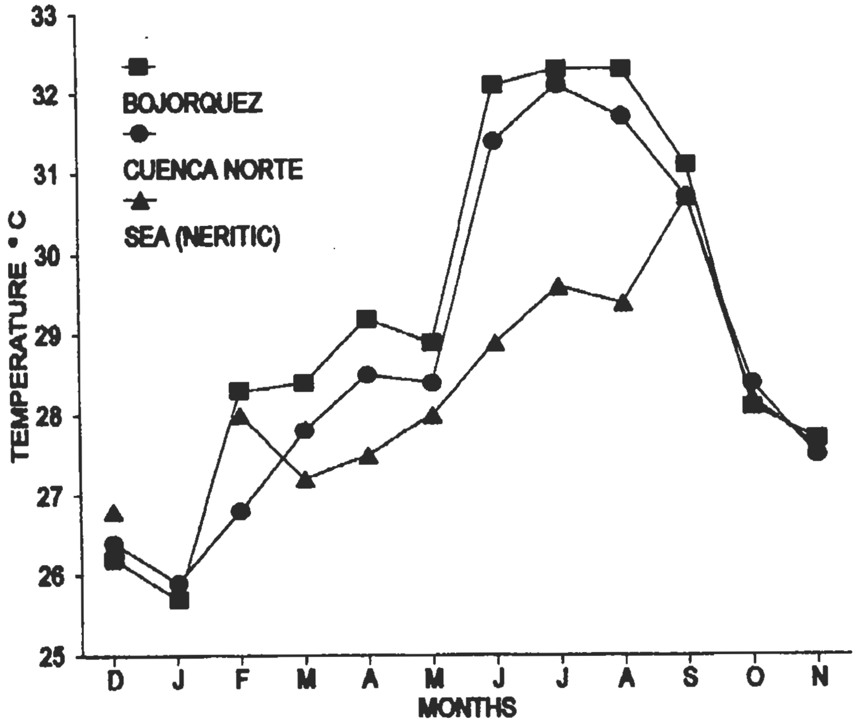
A total of 44 nominal species including representatives of Calanoida, Cyclopoida, Poecilostomatoida, Harpacticoida and Monstrilloida were recorded. Of these, 41 species were collected at the neritic station, 13 at Bojórquez, and 10 at Cuenca Norte. Six species were common at all locations, three were exclusively found at Bojórquez, and one species was restricted to Cuenca Norte (Table 4).

Acartia tonsa, *Paracalanus quasimodo*, and *Labidocera spp.* dominated the populations assemblages throughout the year. They comprised 97.2% of all copepods taken, and with the exception of *A. tonsa*, not recorded at the neritic station in June, they were caught at all times. Harpacticoids were also found at all three locations, but their abundance was notable only at Bojórquez (Table 4).

Acartia tonsa made up the bulk of the copepod assemblage, particularly at Bojórquez, where it accounted for 94.4% of the total catch (Table 4). Lowest numbers were recorded at the neritic station where the mean percentage was 24.5. At Cuenca Norte, *Paracalanus quasimodo* dominated the copepod assemblage (40.3%), while at the neritic station it accounted for 20.9%. The lowest numbers for this species occurred at Bojórquez with only 2.9%. *Labidocera* spp. were more abundant at Cuenca Norte (22.2%) and at the neritic station (10.9%) than at Bojórquez (1.4%; Table 4). The remaining copepod species were recorded in low numbers, except for the harpacticoid, *Miracia efferata* (21.2%) and the poecilostomatoid, *Farranula gracilis* (7.1%) at the neritic site (Table 4).

DISCUSSION

Temperature differences among sampling sites are probably related to the particular hydrological characteristics at the three locations. Thus, the highest (rainy period) and a)



b)

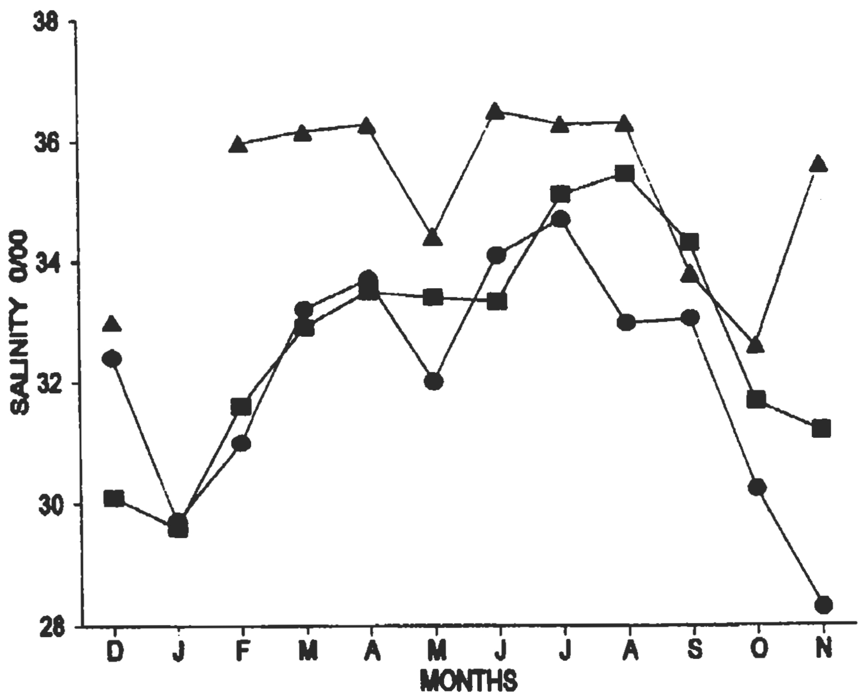


Figure 2 Annual variation of a) temperature and b) salinity at two stations in the NLS and at the adjacent neritic station. Mean values (n=4) are given for Bojórquez.

TABLE 1

Mean monthly standardized abundance (org./m^3) of zooplankton by taxa collected at the four sampling sites (1a-1d) in Bojórquez. Values listed under taxa are annual mean totals. % = percent of total mean values.

TAXA	D	J	F	M	A	M	J	J	A	S	O	N	Taxa totals	%
PROTOZOA	1.00	0.37	1.00	3.80	0.00	1.30	4.80	2.80	4.80	72.20	18.50	48.20	158.77	2.09
MEDUSAE	1.60	1.10	23.40	1.00	0.50	0.28	2.10	0.87	2.80	7.00	16.60	7.60	64.85	0.85
NEMATODA	0.50	0.37	0.19	17.50	0.00	0.04	3.10	0.06	1.60	0.67	0.00	0.60	24.63	0.32
POLYCHAETA	0.25	0.74	0.00	4.00	0.00	0.70	1.90	0.66	0.25	3.40	2.70	6.00	20.60	0.27
GASTROPODA	23.50	9.80	9.20	8.70	0.95	8.30	4.20	5.80	8.90	4.60	5.50	33.00	122.45	1.61
NUDIBRANCHIA	0.00	0.00	0.00	0.00	0.00	0.00	49.00	0.00	0.00	0.00	0.00	0.30	49.30	0.65
PELECYPODA	0.15	0.00	0.00	0.00	0.00	0.08	0.35	0.02	0.00	0.00	0.00	0.00	0.60	0.01
OSTRACODA	0.12	0.92	0.00	11.40	0.00	1.70	1.00	3.50	0.47	7.20	7.00	1.00	34.31	0.45
COPEPODA	489.50	367.50	563.75	675.75	46.50	9.30	84.90	199.00	810.70	1257.70	1053.80	619.25	6177.65	81.68
CIRRIPEDIA	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.72	2.10	0.00	4.00	1.40	8.57	0.11
CUMACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.30	1.40	0.01
TANAIDACEA	0.27	0.00	0.75	6.70	0.00	2.70	3.10	0.27	0.12	0.00	4.20	1.20	19.31	0.25
ISOPODA	0.07	0.00	0.38	0.00	0.24	0.03	0.73	0.08	0.12	0.00	0.00	0.24	1.89	0.02
AMPHIPODA	0.55	0.67	0.00	3.00	0.12	0.71	3.90	0.83	0.62	0.56	0.55	0.00	11.51	0.15
DECAPODA (LARVAE)	18.50	9.70	9.30	21.90	1.80	18.20	39.30	3.30	101.50	18.40	109.65	21.00	372.55	4.92
SERGESTIDAE	0.82	0.00	0.00	2.10	0.12	5.40	0.00	0.00	0.00	0.00	2.00	0.87	11.31	0.14
SIPUNCULIDA	0.00	0.00	0.00	0.00	0.00	0.00	3.40	2.00	1.20	0.00	1.00	0.00	7.60	0.10
CHAETOGNATHA	6.30	11.00	5.90	3.10	2.10	4.10	15.30	5.10	39.50	19.00	13.50	13.00	137.90	1.82
ECHINODERMATA	20.50	11.70	29.20	1.10	15.50	0.92	143.50	33.80	0.00	12.90	4.00	23.50	296.62	3.92
UROCHORDATA	2.42	1.54	6.81	0.55	0.36	0.69	0.94	1.26	0.70	0.00	0.00	9.25	24.52	0.32
FISH EGGS	1.90	0.86	3.50	1.10	0.00	2.40	0.00	0.06	1.50	0.00	3.20	1.20	15.72	0.20
FISH LARVAE	0.26	0.00	0.26	0.15	0.00	0.02	0.08	0.03	0.06	0.09	0.11	0.03	1.09	0.01
Monthly totals	568.21	416.62	653.64	761.85	68.19	56.87	361.60	260.16	976.94	1404.82	1246.31	787.94	7563.15	
	NORTES				DRY				RAINY					
	2400.322				746.82				4416.01					

TABLE 2

Total standardized abundance (org./m^3) of zooplankton taxa collected at Cuenca Norte. % = percent of taxa totals.

TAXA	D	J	F	M	A	M	J	J	A	S	O	N	Taxa totals	%
PROTOZOA	3.00	0.00	0.00	0.00	1.70	0.00	0.00	1.20	0.00	0.00	2.50	1.20	9.60	0.05
MEDUSAE	4.00	1.00	5.50	5.12	0.30	0.00	2.10	0.00	5.10	8.23	4.00	4.20	39.55	0.21
POLYCHAETA	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	1.20	3.70	0.02
GASTROPODA	0.00	3.00	0.00	0.00	1.70	0.00	20.00	2.40	0.00	0.00	1.70	3.00	31.80	0.17
CLADOCERA	0.00	0.00	0.00	0.00	0.00	0.00	2.50	4.20	4.40	0.00	0.00	0.00	11.10	0.06
OSTRACODA	0.00	0.00	0.00	0.00	0.00	1.60	7.50	0.00	0.00	0.00	0.00	0.00	9.10	0.04
COPEPODA	274.00	160.00	91.00	298.00	453.00	242.00	295.00	92.00	74.00	58.00	125.00	74.00	2236.00	11.93
CIRRIPEDIA	3.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	2.30	0.00	2.00	5.40	16.70	0.09
DECAPODA (LARVAE)	69.00	48.40	34.80	362.00	510.50	347.56	3487.50	63.60	4848.90	602.50	325.00	28.00	10727.76	57.23
SERGESTIDAE	54.00	0.00	0.00	117.00	295.00	333.00	22.50	8.30	0.00	0.00	3.30	6.50	839.60	4.48
SIPUNCULIDA	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.60	0.00	0.00	0.00	1.20	6.80	0.03
CHAETOGNATHA	49.00	5.00	9.60	12.50	15.80	44.30	82.50	49.40	133.30	17.90	0.30	31.00	450.60	2.40
ECHINODERMATA	36.31	136.00	219.00	5.00	154.00	9.80	45.00	11.30	0.00	0.00	52.50	49.00	4312.60	23.00
UROCHORDATA	0.00	0.00	4.20	0.00	0.00	1.60	5.00	0.00	0.00	0.00	0.00	0.00	10.80	0.05
FISH EGGS	0.00	0.00	5.50	2.50	3.60	3.30	0.00	0.60	20.00	0.00	0.80	0.00	36.30	0.19
FISH LARVAE	0.06	0.00	0.00	0.07	0.30	0.00	0.01	0.20	0.07	0.05	0.02	0.00	0.70	0.00
Monthly totals	4087.06	357.40	369.60	802.19	1435.90	983.16	3977.11	233.80	5088.07	686.68	517.12	204.70	18742.71	
	NORTES				DRY				RAINY					
	5616.25				6629.97				6496.57					

TABLE 3

Total standarized abundance (org./m^3) of zooplankton taxa collected at the neritic station. % = percent of taxa totals.

TAXA	D	F	M	A	M	J	J	A	S	O	N	Taxa totals	%
PROTOZOA	13.20	21.80	0.45	7.80	0.00	0.50	7.40	0.60	1.30	0.70	1.00	54.75	1.52
MEDUSAE	1.30	3.50	0.30	0.02	0.10	0.02	0.80	0.10	0.06	0.40	0.30	6.9	0.19
NEMATODA	0.00	2.30	0.10	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	2.8	0.08
POLYCHAETA	0.00	0.00	0.07	0.00	0.00	0.20	0.80	0.10	0.00	0.02	0.00	1.19	0.02
GASTROPODA	0.00	3.40	0.30	0.06	0.00	0.10	0.80	0.20	0.10	0.10	0.80	5.86	0.16
CLADOCERA	0.00	0.00	0.00	0.10	0.00	0.10	0.00	0.20	0.00	0.02	0.00	0.42	0.01
OSTRACODA	0.00	4.60	0.14	0.00	0.00	0.03	0.00	0.00	0.04	0.06	0.05	4.92	0.13
COPEPODA	74.90	63.40	0.70	1.00	23.30	1.50	4.40	8.12	5.30	19.00	1.00	202.62	5.65
CIRRIPEDIA	2.60	0.00	0.00	1.22	0.00	0.00	181.00	0.04	0.06	4.80	0.00	189.72	5.29
CUMACEA	38.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38	1.05
TANAIDACEA	0.00	3.40	0.04	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	3.47	0.09
AMPHIPODA	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.14	0
DECAPODA (LARVAE)	22.40	6.90	2.40	1.16	495.90	0.90	16.40	7.30	6.95	8.30	0.20	568.81	15.86
SERGESTIDAE	5.30	2.30	0.10	0.04	6.50	0.00	0.00	0.00	0.00	0.30	0.00	14.54	0.4
CHAETOGNATHA	10.50	3.40	0.02	0.30	1.10	0.00	0.50	0.50	0.50	0.10	0.00	16.92	0.47
ECHINODERMATA	1689.00	486.00	0.02	0.02	0.00	0.00	3.30	0.00	0.00	11.10	1.90	2191.34	61.11
UROCHORDATA	0.00	3.45	0.05	0.04	1.13	0.23	0.00	0.00	0.00	0.04	0.20	5.14	0.14
FISH EGGS	38.20	0.00	9.50	1.20	10.90	0.40	172.10	12.30	13.10	18.80	0.30	276.8	7.72
FISH LARVAE	0.10	0.07	0.50	0.00	0.00	0.03	0.40	0.00	0.00	0.04	0.00	1.14	0.03
Monthly totals	1895.50	604.52	14.71	12.98	538.93	4.44	387.90	29.46	27.41	63.78	5.85	3585.48	
	NORTES			DRY				RAINY					
	2514.73			944.25				126.5					

TABLE 4

Mean annual standardized abundance (org./m^3) of copepod species collected at the three stations. Values given for Bojórquez represent means from four sites. * = mean percentage for two species of *Labidocera* and associated copepodid stages.

	Bojorquez Org./ m^3	%	C . Norte Org./ m^3	%	Sea (Neritic) Org./ m^3	%	
Calanoida							
Acartia tonsa	6724.60	94.4	775.00	34.50	49.73	24.50	
A. spinata					6.42		
Pacalanus quasimodo	204.30	2.9	883.00	40.3	42.35	20.9	
Acrocalanus longicornis					2.27		
Nannocalanus minor					0.02		
Neocalanus gracilis						0.02	
Undinula vulgaris					0.56		
Clausocalanus arcuicornis					0.02		
C.furcatus					2.01		
Calocalanus pavo					0.48		
C.pavoninus					0.24		
Subeucalanus crassus					0.02		
S.pileatus					0.07		
Mecynocera clausi					0.02		
Candancia bipinnata					0.02		
Calanopia americana	9.40		29.00		4.90		
Labidocera mirabilis	46.10		34.00		0.16		
L.scotti	7.60	1.4*	124.00	22.2*	2.38	10.9*	
L.spp (copepodids)	34.50		299.00		19.63		
Pontellina plumata						0.02	
Temora stylifera					0.41		
T.turbinata			1.60		0.27		
Scolecithrix bradyi						0.02	
Pseudodiaptomus cockeri			0.60				
Cyclopoida							
Oithona nana	10.90	5.3	1.00		0.02		
O. plumifera					1.06		
O. setigera					0.02		
O. oculata	0.40						
O. simplex	0.40						
O. sp	1.70		3.00				
Poecilostomatoida							
Ratania sp	0.40						
Corycaeus amazonicus	0.90		53.00	2.4	4.73	2.3	
C.flaccus						0.02	
C.latus					0.06		
C.subulatus	0.70				0.23		
C.speciosus					0.85		
C.sp					0.06		
Farranula gracilis				1.00		14.49	7.1
Oncaea media					0.02		
O.mediterranea					0.02		
O.venusta					3.05		
Sapphirina nigromaculata					0.02		
Harpacticoida							
Harpacticoids	82.00	1.1	4.00		1.21		
Clytemnestra scutellata					0.02		
Microsetella rosea						0.62	
Miracia efferata					43.04	21.2	
Monstrilloida							
Thaumaleus sp	0.20				0.58		

lowest ("nortes") temperature values, i.e. widest variations, were observed at the shallow Bojórquez Lagoon, whereas the other, deeper areas presented accordingly more stable temperature values.

Salinity was usually lower at Cuenca Norte, especially from the beginning to the end of the rainy period (August-November), possibly due to runoff or the presence of water springs in the area (Merino et al. 1990). In contrast, the highest salinity values and lowest variations were recorded at the neritic station, indicating a more stable environment.

In comparing zooplankton abundances from the three sampling sites, seasonal differences were noted usually because of the high capture of a single taxon. At Bojórquez, the highest abundance was recorded during the rainy period due primarily to large numbers of copepods. At the neritic station, a single catch of mainly entangled masses of ophiopluteus-echinopluteus larvae made the "nortes" the most abundant period. Cuenca Norte showed similar abundances during the three climatic periods, with slightly higher captures during the dry period due to the combined catch of decapods, copepods and sergestids (*Lucifer*). It should be noted that, while copepods were regularly caught at the three sampling sites throughout the year, in the case of the other taxa, sporadic large captures of one group influenced the overall abundance at periods other than the rainy period.

The scarcity of previous zooplankton studies in the area makes it difficult to discuss in a comparative sense, the results found in this work. A preliminary report on the plankton population in the Nichupté Lagoon System during the dry and rainy seasons by Alvarez-Cadena et al. (1996a) revealed a major catch of zooplankton during the rainy season. Similarities were also encountered when comparing studies carried out in adjacent waters. Gasca and Castellanos (1993) found a higher zooplankton biomass in October (rainy period) for the Bahía de Chetumal. Segura-Puertas and Ordóñez-López (1994), studying the medusan fauna from the Campeche Bank and the Mexican Caribbean, also recorded higher values of abundance and species composition during the rainy season.

Copepods, decapod larvae and echinoderms were the most numerous and frequently recorded groups in this study. Copepods strongly dominated at Bojórquez while decapod larvae dominated at Cuenca Norte and were second in abundance at the neritic and Bojórquez stations, with lowest catches occurring at the latter. Due to a single massive catch in December, echinoderms dominated at the neritic station (1689 org./m^3). Results of the present study agree with a previous report by Suárez and Gasca (1990), who found decapod larvae (45-55%) and copepods (30-35%) to be the dominant groups in Bahía de Ascensión, a region to the south of the study area.

The number of copepod species at Bojórquez was similar to Cuenca Norte (12 and 11 respectively) and increased substantially to 41 at the neritic station, even though our sampling effort at Bojórquez was four times that at the other two locations. This confirms the generality, as reported by Margalef (1969) and Reeve (1975), that tropical lagoons have lower species diversity as compared to adjacent oceanic environments.

Acartia tonsa was the major component of the copepod assemblage in Bojórquez and the neritic sites as has been reported in other estuarine environments such as San Diego Bay (Esterly 1905), Cape Hateras, North Carolina, and southern Texas (Turner 1981). The species is well adapted to these habitats, despite eutrophication or pollution from human activities as in Mazatlán, Sinaloa, México (Alvarez-Cadena and Cortés-Altamirano 1990) or Guayanilla, Bay, Puerto Rico (Youngbluth 1976).

Acartia tonsa has been reported as euryhaline and eurythermic, and usually the dominant form in other Mexican estuarine environments such as Agiabampo, Sonora (Zamora-Sánchez 1974), Mar Muerto, Oaxaca (Escudero-Díaz 1975) and El Verde, Sinaloa (Hendrickx and Sánchez-Osuna 1983). According to Tester and Turner (1991), the success of the species may be due to the naupliar stages' tolerance to a wide salinity range. They proposed that the dominance of *A. tonsa* was a function of the physiology of the nauplii rather than of the adult.

In comparing the abundances of *Acartia tonsa* in Bojórquez and *Paracalanus quasimodo* in Cuenca Norte, it is possible to detect factors at these two sites that may account for the differences. As mentioned before, the waters of Bojórquez have a high nutrient content due to human influence. Fulton (1984), in experimental conditions, reported that an increase in nutrient concentration was associated with both an incremental increase in numbers of *A. tonsa* and a steady decline in the abundance of *Paracalanus crassirostris*, a sibling species of *P. quasimodo* reported here. Another possible reason might be predation pressure from chaetognaths, which are known to be important copepod predators (Feigenbaum and Maris 1984; Ohman 1986; Alvarez-Cadena 1993). In studying the chaetognaths of the NLS, Alvarez-Cadena et al. (1996b) found a single species, *Sagitta hispida* Conant, at Cuenca Norte and Bojórquez. Apparently this species reproduces more frequently at Bojórquez because of higher temperatures; this correlation with temperature has been found elsewhere for other species (ϕresland 1983, 1985; Sameoto 1971, 1973; Tande 1983). A rapid generation time implies either a higher frequency of small, young immature animals or that adults mature at a smaller size.

Both of these population characteristics were evident for the chaetognaths at Bojórquez, where the dominant maturation stage, gonadic stage I, was smaller there (2.96 mm annual mean size) than at Cuenca norte (4.18 mm). Prey size is known to be correlated with head width in chaetognaths (Pearre 1980), thus it is likely that smaller prey will be more readily removed from the population at Bojórquez. Thus, the smaller *P. quasimodo* is susceptible to predation at all stages, while *A. tonsa* is more at risk only during the younger stages.

To enhance the value of this work, more studies are needed for a better understanding of planktonic associations and assemblages in tropical environments. Bojórquez lagoon is an excellent natural laboratory where these associations could be monitored and, at the same time, it serves as an example of how easy an oligotrophic system can be damaged.

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