Rev. Biol. Trop., 47 (Supl. 1): 157-163, 1999
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Chaetognath species composition from a coral reef lagoon in the Mexican Caribbean Sea

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Received 14-I-1999. Corrected 12-III-1999. Accepted 12-IV-1999.

Abstract. Monthly species composition and abundance of Chaetognaths from January to December 1991 at two sampling sites, from the Puerto Morelos coral reef lagoon were examined. The species were: *Ferosagitta hispida*, *Flaccisagitta enflata*, *Flaccisagitta hexaptera*, *Krohnitta pacifica*, *Pterosagitta draco*, *Sagitta bipunctata*, *Sagitta helenae*, *Sagitta tenuis* and *Serratosagitta serratodentata*, most of them being common at both survey areas. *F. hispida* (station A: 2 801 org./100m^3; station B: 11 285 org./100m^3) and *F. enflata* (station A:2 878 org./100m^3; station B: 5 470 org./100m^3) were the most abundant species, representing more than 90% of the total capture. Maximum numbers were registered in the rainy season and minimal in the "Nortes" season. The remaining species were not collected consistently and due to their sporadic caught and scarcity it was not possible to determine any abundance pattern. The coral reef lagoon presented stenohaline conditions (±1.2 psu all the year round); temperatures showed also small changes (±1.6 °C) and varied according to the season, being highest during the dry and rainy periods and slightly lower in the "Nortes".

Key words: Coral reef, chaetognath, taxonomy, abundance, Caribbean sea.

Chaetognaths are usually the second group in abundance, after copepods, in coastal, neritic, and oceanic environments (King 1979, Øresland 1990) and except for a few benthic species most chaetognaths are holoplanktonic. They are strictly carnivorous (Alvariño 1964) and are considered as one of the main via of energy transference between the abundant copepods, their main prey, (Feigenbaum and Maris 1984) and larger predators, such as planktivorous fishes; they have also been used as indicators of watermasses (Russell 1935, Øresland 1986, McLelland 1984).

The second largest coral reef barrier in the world is found in the south - eastern coast of the Yucatán Peninsula (México) down to Belize in the Caribbean Sea. In spite of its importance, studies of its flora and fauna are limited, particularly those related to the planktonic communities.

Studies on arrow-worms have been carried out in some areas from the Caribbean sea. Suárez-Caabro (1955) contributed to the knowledge on the taxonomy and ecology of the group in Cuban waters, Legaré and Zoppi (1961) off Venezuela coasts and Owre (1960) on composition and abundance in waters of the Florida stream communion. Works in the Mexican Caribbean coast are scarce (Suárez-Morales *et al.*1990, Suárez-Morales and Gasca 1994, Alvarez-Cadena *et al.* 1996a, Gasca *et al.*1996), studies directed mainly to the knowledge on the composition and abundance of the chaetognaths with the environmental conditions.

The aim of this work, is to present the monthly species richness and variations in abundance of the chaetognaths from the Puerto Morelos coral reef lagoon during an annual cycle.

MATERIAL AND METHODS

The Puerto Morelos coral reef lagoon is about 35 km south of Cancún City on the Yucatán peninsula, at 20° 51´N and 85° 55´W. There is a northward flow of watermasses, with a counter-current of less intensity near the coast (Merino and Otero 1991) , joining the Gulf of México through the Yucatán Channel. The continental shelf is narrow, sandy and varies from 2 to 7 kms from the coastline. The lagoon is 350 to 1,600 m wide (Merino and Otero 1991) with large mats of seagrasses, *Thalassia testudinum* and *Halodule* sp., on the lagoon floor intermixed with sandy areas.

The climate of the region is sub-humid, with heavier rains in summer (García 1964), annual mean temperature higher than 22°C and dominant trade winds blowing from east-southeast, except in winter when strong northern winds blow in the area. Three climatic regimes are often reported for this area, the dry season from April to June, the rainy season from July to November and the "nortes" with strong northern winds from December to March.

Zooplankton was collected monthly from January to December, 1991, at two sampling stations within the coral reef lagoon; one near to the coast (A) and the other close to the barrier coral reef (B). Samples were collected at midnight, with a conic net of 330 μ mesh size, 0.42m diameter and 1.20m length, with a digital flowmeter attached to the net mouth. The zooplankton samples were fixed with 4% buffered (lithium carbonate) formaldehyde. Temperature was measured near surface with an immersion termomether (0.1°C precision) and salinity with a Beckman Induction Salinometer (0.001 PSU maximum accuracy). Chaetognaths were sorted from aliquots made with a two-way Folsom splitter. At least 300 animals were analyzed per sample (Omori and Ikeda 1994), and abundance is given in org./100m^3. The Importance Value Index (IVI) gives an estimate of the abundance and frequency of the species, a t-test allows comparison among the abundance with the temperature and salinity and Pearson Correlation Coefficient allows to establish the relationship between the species abundance and hydrologic parameters.

RESULTS

Salinity was similar at the two sampling stations, data from January to March were 35.4-36.0 psu, increasing above 36 psu from April to August and decreasing from September until a minimum in December (35.05 psu) (Fig. 1a). There were not significant differences in salinity between stations (t-test p> 0.05).

Temperature also showed small variations, being lower in January, increasing progressively until a maximum in July and decreasing from August onwards (Fig.1b). There were not significant differences between sampled stations (t-test p> 0.05).

Composition and abundance

A total 9 species were collected, *Krohnitta*

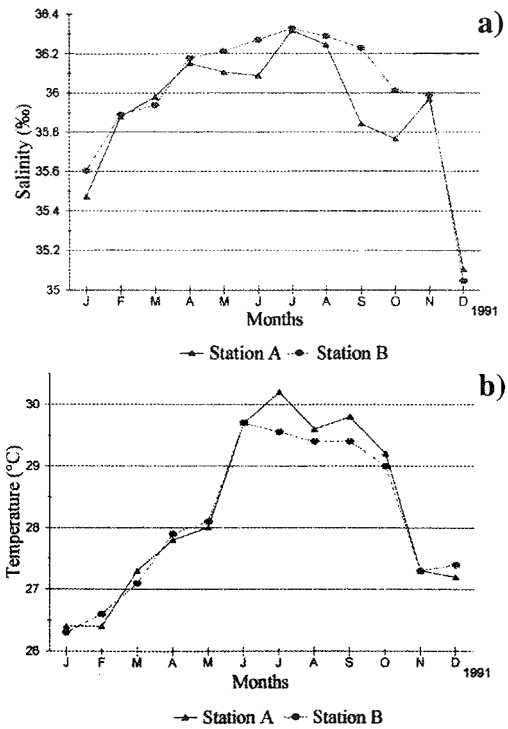

Fig. 1. Salinity (a) and temperature (b) in the Puerto Morelos coral reef lagoon during1991.

pacifica (Aida, 1897), *Pterosagitta draco* (Krohn, 1853), *Ferosagitta hispida* (Conant, 1895), *Flaccisagitta enflata* (Grassi, 1881), *F. hexaptera* (d´Orbigny, 1843) *Sagitta bipunctata* (Quoy y Gaimard, 1827), *S. helenae* (Ritter-Zahony, 1910), *S. tenuis* (Conant, 1896), *Serratosagitta serratodentata* (Krohn, 1853), all of them belonging to the Class Sagittoidea (see Bieri 1991).

Highest abundance of chaetognaths occurred from July to September (Fig. 2). At station A, abundance was maximum in July (3 886 org./100m³), whereas at station B it was in August (11 581 org./100m³). Lowest values were observed in January for station A and November for station B. Difference in abundance for both stations was not significant (t-test $p<0.05$).

Overall annual abundance showed that *Ferosagitta hispida* and *Flaccisagitta enflata* were dominant at both sampling stations (fig.3); the former presented an IVI of 65.1% at station A and 82.8% at station B. The latter had an IVI of 62.8% at station A and 49.2 % at station B. *Ferosagitta hispida* was captured at all times at both stations and its annual abundance was 2 801 org./100m³ (44.1%) at station A, and 11 285 org./100m³ (61.7%) at station B. This high difference in abundance for this species between both stations was due to a large capture in August at station B (7 924 org./100m³) (Fig. 4a).

Abundance of *Flaccisagitta enflata* was 2 878 org./100m³ (45.3%) at station A and 5 470 org./100m³ (29.9%) at station B. The maximum capture was in July (2 210 org./100m³ at station A and August (3 651 org./100m³ at station B), but it was not collected in September and October at station A and on July at station B (Fig. 4b).

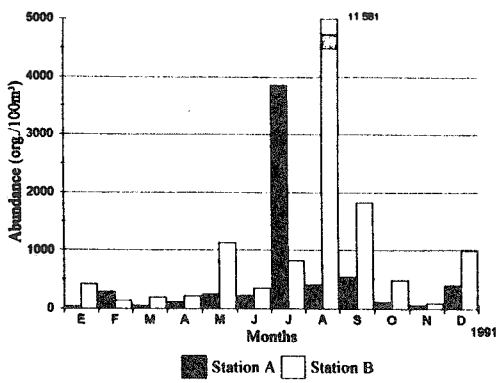

Fig. 2. Total abundance of chaetognaths in the Puerto Morelos coral reef lagoon during 1991.

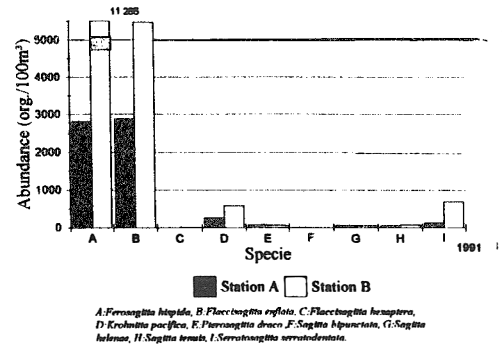

Fig. 3. Annual abundance of chaetognath species in the Puerto Morelos coral reef lagoon during 1991.

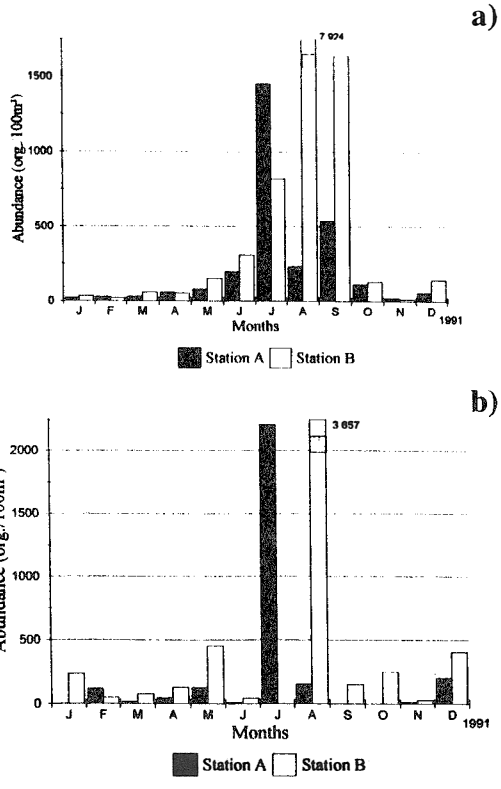

Fig. 4. Monthly abundance of (a) *Ferosagitta hispida* and (b) *Flaccisagitta enflata* in the Puerto Morelos coral reef lagoon during 1991.

TABLE 1

Monthly abundance (organisms/100m3) of chaetognath species in the Puerto Morelos coral reef lagoon, Quintana Roo, during 1991

Station A

Species	J	F	M	A	M	J	J	A	S	O	N	D	Total
Ferosagitta hispida	22	26	29	57	77	193	1448	229	533	110	21	56	2801
Flaccisagitta enflata	1	116	13	45	123	7	2210	152			11	200	2878
Krohnitta pacifica	3	51	2		10	7	114				11	69	267
Sagitta biupunctata											3	7	76
S. helenae		13				7	38						58
S. tenuis	3			3	15			19				13	53
Serratosagitta serratodentata		13	3	3	15		38				8	46	126
Sagitta sp.	4		2	6	21		38	19			3		93
Total	33	283	51	114	261	214	3886	419	533	110	57	394	6355

Station B

Species	J	F	M	A	M	J	J	A	S	O	N	D	Total
Ferosagitta hispida	33	20	58	54	151	305	819	7924	1638	128	13	142	11285
Flaccisagitta enflata	236	47	75	128	453	42		3657	152	249	26	405	5470
F. hexaptera		3			17								20
Krohnitta pacifica	138	49	35	20	151					38	8	142	581
Pterosagitta draco		10			17						11	20	58
Sagitta helenae			6	7					38				51
S. tenuis		3	6		67								76
Serratosagitta serratodentata	8	10	12	7	269					68	34	284	692
Krohnitta sp.			6		17								23
Sagitta sp.		3	6							23	3		35
Total	415	145	204	216	1142	347	819	11581	1828	506	95	993	18291

The remaining chaetognaths, *Krohnitta pacifica*, *Serratosagitta serratodentata*, *Pterosagitta draco*, *Sagitta tenuis*, *S. helene*, *S. bipunctata* y *Flaccisagitta hexaptera* were collected irregularly; their IVI was less than 20%. Abundance for these species is included in Table 1.

There was no significant correlation of abundance of most species with temperature or salinity, except for the positive correlation of *Ferosagitta hispida* with temperature at station B ($r = 0.7$, $p < 0.05$).

DISCUSSION

Salinity measurements in this work were similar to those recorded by Merino and Otero (1991), i.e. from 34.9 psu to 36.5 psu. The reef system is considered stenohaline and the minimal fluctuations were attributed to the succession of climatic regimes presented throughout the year. Salinities less than 36 psu were recorded during the rainy and "nortes" seasons, and the highest values occurred in the dry season. Temperature registered was similar to previous reports (Merino and Otero 1991) and varied between 26.3 °C to 30.2 °C.

Chaetognaths species recorded from this lagoon confirm most of those previous reports for the Caribbean Sea or adjacent waters (Suárez-Caabro 1955, Michel and Foyo 1976, Mostajo 1978, Youngbluth 1979, Michel 1984), Gulf of Mexico (Owre 1960, McLelland 1989) and the Mexican Caribbean Sea (Gasca *et al.*1996).

In this work, the highest abundance of chaetognaths was recorded during the rainy season (July to September) and seems to be

related to food availability and high temperatures. Rainfall seems to promote high productivity, whether by means of temporal changes in salinity or due to removal of nutrients from the lagoon floor promoted by wind.

There are no taxonomic studies on phytoplankton in the area. However, in a recent study, Alvarez-Cadena *et al.* (1998) reported the highest abundance of copepods (the main food of chaetognaths) in this lagoon during the wet season. In Puerto Rico Youngbluth (1979) reported that rain apparently promotes increments in nutrients with a consequent higher phytoplankton production. Youngbluth (1980) also reported that *Acartia tonsa* would produce a bloom about two weeks after the first heavy rains. It can be assumed that food supply was higher in that season and possibly is a trigger for egg production of this copepod, and the eventual reproduction of other zooplankters, particularly chaetognaths. Alvarez-Cadena *et al.* (1996b) in a study of the Nichupté Lagoon, recorded highest abundance of *Ferosagitta hispida* during the wet season, and suggested that when food is abundant the metabolic energy may be used for reproduction, as it has been reported elsewhere.

If food is not a limiting factor, the other factor to consider for the chaetognaths to reproduce is temperature. Temperature is, apparently, so important that the life cycle, and number of generations within the phylum, vary widely according to latitude. In general, fewer generations (and larger individuals) are recorded in higher latitudes (where water temperature is lower), and higher number of generations, and smaller animals, are recorded in lower latitudes where temperatures are higher. Thus, in the arctic sea, Dunbar (1962) reported that *Sagitta elegans* would produce a new generation every other year. On the other hand, Reeve and Walter (1972), reported that *Ferosagitta hispida*, under laboratory conditions, required only from 18 to 50 days to complete its life cycle, i.e. 7.3 to 20.2 generations could be produced annually.

Results from this work confirm those from previous reports and lowest abundance of chaetognaths was observed during the "nortes" season when temperature was also lowest, while highest captures were obtained when temperatures were also highest.

Sampling at midnight possibly allowed a substantial capture of *Ferosagitta hispida* and it was the most abundant species collected. This chaetognath has been reported to migrate to near bottom and it has been associated to submerged vegetation (*Thalassia testudinum*) during the day. The species is also known to respond to all-or-none upward vertical movement only when the illumination is of the order of 1016.7 photons m^2 s^{-1} (Sweatt and Forward 1985). Because of this behavior, the species has been considered as "quasi-planktonic" by Bieri (1991).

Ferosagitta hispida has been reported as one of the most abundant chaetognaths, occurring in neritic waters (Alvariño 1965). The species seems to be able to tolerate wide variations of salinity and temperature (Reeve and Walter 1972).

In the Nichupte Lagoon System Alvarez-Cadena *et al.* (1996b) reported that *F. hispida* was abundant mainly during the rainy season, in coincidence with our results. It is also possible that the species breeds continuously throughout the year in the barrier coral reef lagoon as it has been reported to occur in tropical and subtropical waters (Reeve and Walter 1972).

Flaccisagitta enflata was the second most abundant chaetognath. The species has been reported as oceanic (Alvariño 1965) but also found in neritic waters (Gasca *et al.* 1996). Its high capture within the lagoon may be explained by the very narrow continental shelf in the area, the strong water mixing processes as a result of the Yucatan Stream passing through the Yucatán channel and the coastal counter-current along the Mexican Caribbean sea (Merino 1986). The maximum abundance reported here (rainy season) coincide with previous reports of other authors as Owre (1960) for the Florida Current.

The remainder oceanic species such as *Krohnitta pacifica*, *Serratosagitta serratoden ata*, *Pterosagitta draco*, *Sagitta bipunctata* and *Flaccisagitta hexaptera* have been recorded also in neritic waters (Almeida-Prado 1968, Gasca *et al.* 1996). The neritic species, *Sagitta tenuis* and *S. helenae,* also have been recorded outside the shelf border (Gasca *et al.*1996), probably due to the hydrologic conditions and the narrowness of the continental shelf as mentioned before.

ACKNOWLEDGMENTS

We wish to thank Francisco Escobar de la Llata for his help in making tables and figures, and Uriel Ordóñez López for helping with the statistic analysis. This work was possible through a grant provided to the former author by Fundación UNAM.

RESUMEN

Se examinan los resultados de muestreos mensuales de zooplancton de enero a diciembre de 1991, en dos estaciones en la laguna arrecifal de Puerto Morelos, México. Las especies encontradas fueron: *Ferosagitta hispida*, *Flaccisagit a enflata*, *Flaccisagitta hexaptera*, *Krohnitta pacífica*, *Pterosagitta draco*, *Sagitta bipunctata*, *S. helenae*, *Sagitta tenuis* y *Serratosagitta serratodentata*, la mayoría de las cuales se registraron en ambas estaciones de muestreo. *Ferosagitta hispida* (2 801 org./100m^3, estación A; 11 285 org./100m^3, estación B) y *Flaccisagitta enflata (2 878* org./100m^3, estación A; 5 470 org./100m^3, estación B) fueron las especies más abundantes, representando más de 90% de las capturas totales. Las abundancias máximas se obtuvieron durante la temporada de lluvias y las mínimas durante la temporada de "Nortes". El resto de las especies se colectaron en forma irregular y debido a esto no fue posible determinar un patrón de abundancia. La laguna arrecifal presenta condiciones estenohalinas (±1.2 PSU durante todo el año). La temperatura también presentó cambios pequeños (± 1.6 °C) y varió de acuerdo con la época del año, siendo mas alta durante las temporadas de secas y lluvias y ligeramente más baja durante la temporada de "Nortes".

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