

Pycnogonid ecology in the Mar Menor (Murcia, SW Mediterranean).*

ANGEL PÉREZ-RUZAFA¹ and TOMAS MUNILLA²

¹Dpto. de Biología Animal y Ecología. Facultad de Biología. Universidad de Murcia. 30100 Murcia. Spain.

²Laboratorio de Zoología. Universidad Autónoma de Barcelona. 08193 Bellaterra. Barcelona. Spain.

SUMMARY: The Mar Menor is a hypersaline coastal lagoon in the SW Mediterranean. A study of pycnogonids was based on 52 samples from the different benthic communities found in the lagoon, using 1001 individuals belonging to 5 species (*Tanystylum conirostre*, *Achelia echinata*, *Ammothella longipes*, *A. appendiculata* and *Anoplodactylus pygmaeus*), from infralittoral rock communities. Neither the meadows of *Cymodocea nodosa*, *Caulerpa prolifera* and *Ruppia cirrhosa*, nor the soft substrates revealed the presence of pycnogonids. All 5 species were found in the proximity of El Estacio channel (the main communication with the Mediterranean), while at sites within the lagoon only the first and last species were found. These were also the species with the highest population densities. Data about the abundance and development stages of the species, the diversity of samples and their affinity are reported. A study of the intermediary development between larva and juvenile is presented for *Tanystylum conirostre*.

RESUMEN: ECOLOGÍA DE LOS PICNOGÓNIDOS EN EL MAR MENOR (MURCIA, MEDITERRÁNEO SUROCCIDENTAL). — El Mar Menor es una laguna costera hipersalina. El estudio de la fauna de picnogónidos se ha efectuado a partir de 52 muestras tomadas en las distintas comunidades bentónicas lagunares. Se han hallado 1001 ejemplares, pertenecientes a 5 especies (*Tanystylum conirostre*, *Achelia echinata*, *Ammothella longipes*, *A. appendiculata* y *Anoplodactylus pygmaeus*), típicas de comunidades infralitorales sobre roca. Las praderas de *Cymodocea nodosa*, *Caulerpa prolifera* y *Ruppia cirrhosa*, así como los sustratos blandos no poseen picnogónidos. Las 5 especies se localizan en las proximidades de El Estacio (principal canal de comunicación con el Mediterráneo), mientras que en las estaciones internas de la laguna sólo se encuentran la primera y la última, que, a su vez, son las especies con densidades más altas en las poblaciones estudiadas. Se describe un estadio de desarrollo intermedio entre la larva y el juvenil en *Tanystylum conirostre*. Asimismo, se aportan datos de abundancia y estados de desarrollo en las distintas especies, así como la diversidad y afinidades entre estaciones.

INTRODUCTION

The Mar Menor is a hyperhaline coastal lagoon of 135 Km² with an average depth of between 3 and 4 m, the maximum being 7 m. It is separated from the Mediterranean Sea by a sand bar with 5 entrance channels (*golas*), all functional to a greater or lesser degree, which join it to the Mediterranean Sea. Of these, El Estacio is the most important since it has been dredged and artificially widened. Water salinity in the lagoon varies with the time of year, rainfall and proximity to the canals, varying between 42 and 47 % throughout the year, although differences between

localities are less than 2 % at any time. Water temperature is relatively uniform throughout the lagoon, varying between 11°C in January-February and 30-31 °C in August-September (see PÉREZ-RUZAFA, 1989 for details).

The bottom of the lagoon is principally composed of muddy substrate over which a mixed meadow of *Cymodocea nodosa*-*Caulerpa prolifera* grows. Around the edges there are sandy bottoms with no vegetation or with isolated growths of *Cymodocea nodosa*. Rocky substrates are only found around the islands, some outcrops of limestone crusts of the internal shore and man-made structures (pillars of piers, breakwaters and jetties of pleasure harbours).

Literature on lagoon pycnogonids is scarce. We

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have found only two previous studies on the pycnogonids of Mediterranean coastal lagoons and some isolated reports from more than a hundred works reviewed on both subjects, including a revision of the pycnogonid fauna from the Mediterranean Sea (ARNAUD, 1987). STOCK (1952) cites 7 species (*Callipallene phantoma*, *C. producta*, *Achelia simplex*, *Ammothella longipes*, *Tanystylum orbiculare*, *Anoplodactylus angulatus* and *Endeis spinosa*) on photophilic algae and *Zostera minor* in Venice lagoon; the first (23 exs.) and the last (19 exs.) are the most abundant species of the 81 individuals reported. CANDELA *et al.* (1985) also report 4 individuals of *Ammothea hilgendorfi* in this lagoon. In the Bay of Alfaques, Tarragona, MUNILLA (1988) cites *Endeis spinosa* on the beach of Aluet at 0 m, swimming on the shoreline over sand. DIAPOULIS and BOGDANOS (1983) report 2 individuals of *Nymphon* sp. at the entrance of the channel of communication with the sea of Geras Bay in Lesvos Island (Greece).

On the European Atlantic coasts, WOLFF (1976) reports 7 species (*Nymphon rubrum*, *Achelia echinata*, *Phoxichilidium femoratum*, *Anoplodactylus petiolatus*, *A. pygmaeus*, *Pycnogonum littorale* and *Callipallene brevirostris*) in the estuarine areas of the rivers Rhine, Meuse and Scheldt. The present study forms part of a wider one on the benthic assemblages of the Mar Menor (see PÉREZ-RUZAFA, 1989 for a detailed description of the communities).

MATERIAL AND METHODS

The 52 samples were collected by diving along transects perpendicular to the coast and at random sampling points. Table 1 shows the samples studied and their characteristics. Samples were taken from rocky substrates by total scraping of the surfaces (BELLAN-SANTINI, 1970; CASTRIC-FEY, 1984). The samples from the soft substrates were also collected by diving, using a small spade; a Van Veen type grab was used in the center of the lagoon (ELEFTHERIOU AND HOLME, 1984).

Different sampling areas were used, according to the heterogeneity and density of the assemblages (see PÉREZ-RUZAFA, 1989 for a discussion). For the supralittoral assemblages, 100 cm² (10 × 10 cm quadrates) were used, in the rocky infralittoral substrates 400 cm² (20 × 20 cm) and 1600 cm² (40 × 40 cm), and for the communities found in the compact red clays and sands, including the meadows of *Cymodocea nodosa*, 1600 cm². 400 cm² was used for the *Rup-*

pia and of *Caulerpa prolifera-Cymodocea nodosa* meadows both by diving and by van Veen grab. These areas are usually used in sampling Mediterranean benthic communities to include the assemblage minimum area (GILI and ROS, 1985).

Once collected, the samples were sieved through a 500 µm mesh, labelled and preserved in 4 % formaldehyde in water from the lagoon for further study. The pycnogonids were separated from the other faunistic groups by means of a binocular microscope (from 8 to 40 enlargements) and preserved in 70 % alcohol for subsequent identification and counting.

The reproductive state of the individuals of each species was calculated on the basis of egg-bearing males and pregnant females.

The frequency of occurrence of a species was given by the percentage of sampling points in which it appeared and the mean density by the number of individuals of each species collected per unit of sampling area and extrapolated to 1 m²; mean dominance was expressed as the number of individuals of a taxon collected in relation to the total number of individuals of all the species collected in all the samplings carried out in a particular community (BELLAN-SANTINI, 1970).

Diversity was measured by the Shannon-Weaver index (MARGALEF, 1974).

Sample affinities were expressed by means of Czekanowski's coefficient for quantitative data (DAY *et al.*, 1971). The data were transformed so that $y = \ln(x + 1)$, where y is the transformed datum and x is the number of individuals/m².

RESULTS AND DISCUSSION

Of the 52 samples studied, pycnogonids were found in 13 (23 % occurrence), corresponding to 5 of the 20 sampling sites (Fig. 1). 1001 individuals were collected, belonging to 5 species, all typical of the infralittoral photophilic algae communities. Table 1 shows the characteristics of samples studied. Tables 2 and 3 show the developmental stage of the individuals, the abundance of different species and the mean dominance of pycnogonids in each sample as well as the frequency of occurrence and mean dominance of the pycnogonid species in different assemblages.

Taxonomy and ecology of the species

The general ecological characteristics of the 5 species found in the Mar Menor refer to the characteristics of these species in the Mediterranean Sea.

TABLE 1. — List and characteristics of the samples collected along the transects and in the stations distributed throughout the Mar Menor. Samples that contain pycnogonids are marked with*. The samples are referred to as follows T (transect), the number of the transect, followed by the distance from the coast in metres. The season is denoted by letter (A - summer, B - autumn, C - winter and D - spring). The random sampling points are referred to as P, followed by the number of the particular location.

Sample	Date	Depth (m)	Distance to the shoreline (m)	Sampled area (cm ²)	Kind of substrate community
*T2A5F	26.07.84	0.75	5	1600	Rock. Photophilic algae.
*T2B5F	14.11.84	0.7	5	400	Rock. Photophilic algae.
*T2B5E	14.11.84	0.7	5	400	Rock. Sciaphilic assemblage.
*T2C5F	13.02.85	0.5	5	1600	Rock. Photophilic algae.
*T2C5E	13.02.85	0.5	5	1600	Rock. Sciaphilic assemblage.
*T2D5F	24.05.85	0.7	5	1600	Rock. Photophilic algae.
*T2D5E	24.05.85	0.7	5	1600	Rock. Sciaphilic assemblage.
T2D30	24.05.85	2.50	30	4 × 400	Mud. <i>Cymodocea</i> - <i>Caulerpa</i> .
T3A39	28.07.84	0.75	39	1600	Sand.
T3A132	28.07.84	1.10	132	1600	Sand. <i>Cymodocea</i> meadow.
T3A148	28.07.84	1.27	148	1600	Compact red clay.
T3C132	06.02.85	0.95	132	1600	Sand. <i>Cymodocea</i> meadow.
T3C148	06.02.85	1.12	148	4 × 400	Compact red clay.
T3D2	19.06.85	0.45	2	1600	Sand and gravel.
T3D132	19.06.85	1.30	132	4 × 400	<i>Cymodocea</i> meadow.
T3D148	19.06.85	1.47	148	4 × 400	Compact red clay.
T4A0	20.08.84	0	0	100	Midlittoral rock.
T5-20	14.04.87	1	40	400	Rock. Photophilic algae with <i>Cystoseira</i> sp.
T9A1F	30.08.84	0.10	0	400	Rock. Photophilic algae.
T9A25	30.08.84	5	24.5	4 × 400	Mud. <i>Cymodocea</i> - <i>Caulerpa</i> .
T9B6F	07.11.84	2.5	5.5	400	Rock. Photophilic algae.
*T9B6E	07.11.84	2.5	5.5	400	Rock. Sciaphilic assemblage.
T9C6F	27.05.85	2.4	5.5	1600	Rock. Photophilic algae.
T9C6E	27.05.85	2.4	5.5	1600	Rock. Sciaphilic assemblage.
T9C25	27.05.85	5	24.5	4 × 400	Mud. <i>Cymodocea</i> - <i>Caulerpa</i> .
T9D0	18.06.85	0	0	400	Midlittoral rock.
T9D1F	18.06.85	0.20	0	1600	Rock. Photophilic algae.
*T9D1E	18.06.85	0.20	0	1600	Rock. Sciaphilic assemblage.
T9D6F	18.06.85	2.50	5.5	1600	Rock. Photophilic algae.
*T9D6E	18.06.85	2.50	5.5	1600	Rock. Sciaphilic assemblage.
T9D25	18.06.85	5.10	24.5	4 × 400	Mud. <i>Cymodocea</i> - <i>Caulerpa</i> .
T11-6	15.05.87	0.20	6	400	Mud. <i>Ruppia cirrhosa</i> .
T13A73	21.11.84	1.30	73	400	<i>Cymodocea</i> - <i>Caulerpa</i> on mud and limestone crust.
T13C0	09.05.85	0.10	0	1600	Nitrophilic assemblage on rock.
T13C2	09.05.85	0.3	2	400	Nitrophilic assemblage on rock.
T13C8	09.05.85	0.34	8	400	Sand. <i>Cymodocea</i> meadow.
T13C25	09.05.85	1.10	25	1600	Limestone crust.
T13C73	09.05.85	1.34	73	4 × 400	<i>Cymodocea</i> - <i>Caulerpa</i> on mud and limestone crust.
T31-5	23.04.87	1	5	400	Rock. Photophilic algae with <i>Cystoseira</i> sp.
P4C	09.05.85	0.1	0	1600	Rock. Nitrophilic assemblage.
P5A	24.11.84	0.15	8	1600	Rock. Sciaphilic assemblage under jetties.
*P5B	06.03.85	0.20	8	1600	Rock. Sciaphilic assemblage under jetties.
P7	07.04.87	0.5	100	400	Sand. Sponge and foronids.
*P8	14.04.88	2.5	1000	400	Floating masses of <i>Chaetomorpha linum</i> .
*P9	14.04.88	3	100	400	Floating masses of <i>Chaetomorpha linum</i> .
2, A, B, CH, F, K, N	12.04.87	5-6	1000-3000	400	Mud. <i>Cymodocea</i> - <i>Caulerpa</i> .

Family Ammotheidae

Achelia echinata (Hodge, 1864)

Achelia echinata STOCK, 1968: 17; CHIMENZ *et al.*, 1979: 482; MUNILLA and DE HARO, 1984; ARNAUD, 1987; 38.

Ecology: Infralittoral and circalittoral species, very abundant in all superficial algal communities and in *Posidonia oceanica*, although it can also be found as deep as 100 m (180 m in the Canary islands area). Ubiquitous. It can tolerate harbour environments and thermal pollution. It appears in the colonizing phases of virgin substrates. In the Mar Menor it is confined to the uppermost sciaphilic community of blocks forming the El

Estacio breakwater and only in spring, when it constitutes 10 % of pycnogonid population.

Geographical distribution: North Atlantic, Pacific (Japan), Mediterranean.

Ammothella appendiculata (Dohrn, 1881)

Ammothella appendiculata STOCK, 1968: 15, fig. 8; CHIMENZ *et al.*, 1979: 484, fig. 5; ARNAUD, 1987: 39.

Ammothea appendiculata DOHRN, 1881.

Ecology: Infralittoral. Characteristic of polluted waters in rhizomes of *Posidonia oceanica*, and on sandy bottoms. Also found in fouling. As with the previous species, it is confined to sciaphilic communities of the

TABLE 2. — Specimens of pycnogonids found in the different samples of the Mar Menor and their development stage. OM: ovigerous males; WM: males without eggs; PF: pregnant females; WF: females without eggs; J: juveniles.

Sample	SPECIES	OM	WM	PF	WF	J	Nº	% of the sample	% from TOTAL
T9D1E	<i>Tanystylum conirostre</i>	12	31	45	8	5	101	37.45	
	<i>Anoplodactylus pygmaeus</i>	6	60	28	12	8	114	42.70	
	<i>Achelia echinata</i>	1	16	3	7	1	28	10.48	
	<i>Ammothella appendiculata</i>	2	4	2	1	15	24	8.99	
	<i>Ammothella longipes</i>			1			1	0.37	
T9D6E	<i>Anoplodactylus pygmaeus</i>	1	1				2	40	
	<i>Ammothella appendiculata</i>					3	3	60	
T9B6E	<i>Ammothella appendiculata</i>					1	1	50	
	<i>Anoplodactylus pygmaeus</i>		1				1	50	
T9 Subtotal Ex.		22	113	79	28	33	275		27.50
P5B	<i>Tanystylum conirostre</i>	180	110	236	11	48	585		58.59
T2A5F	<i>Tanystylum conirostre</i>	4		1	1	2	8		100
T2B5F	<i>Tanystylum conirostre</i>	1	7	2	1	3	14		100
T2C5F	<i>Tanystylum conirostre</i>	2		2		1	5		100
T2C5E	<i>Tanystylum conirostre</i>		13	18	11	1	43	89.85	
	<i>Anoplodactylus pygmaeus</i>	2	3				5	10.42	
T2D5F	<i>Tanystylum conirostre</i>	5	3	9		23	40	97.56	
	<i>Anoplodactylus pygmaeus</i>		1				1	2.44	
T2D5E	<i>Tanystylum conirostre</i>	4	2	5	2	3	16	76.19	
	<i>Anoplodactylus pygmaeus</i>	1		2	1		4	19.05	
	undifferentiated juvenile					1	1	4.76	
T2 Subtotal Ex.		19	29	39	16	34	137		13.70
P8	<i>Tanystylum conirostre</i>	1		1			2	100	
P9	<i>Tanystylum conirostre</i>		2			2	100		
P Subtotal Ex.		1		3			4		0.40
TOTAL Ex. 1001	<i>Tanystylum conirostre</i>	816	81.6 %						
	<i>Achelia echinata</i>	28	2.8 %						
	<i>Ammothella appendiculata</i>	28	2.8 %						
	<i>Ammothella longipes</i>	1	0.1 %			Total Ammotheidae	873	87.3 %	
	<i>Anoplodactylus pygmaeus</i>	127	12.7 %			Total Phoxichilididae	127	12.7 %	
	undifferentiated juvenile	1	0.1 %						

El Estacio breakwater. It appears in spring and autumn samples.

Geographical distribution: Amphi-Atlantic, Mediterranean, Red Sea.

Ammothella longipes (Hodge, 1864)

Ammothella longipes STOCK, 1968: 15, fig. 7; MUNILLA and DE HARO, 1984; MUNILLA, 1986; ARNAUD, 1987.

Ammothella hispida: CHIMENZ *et al.*, 1979: 486, fig. 6.

Ecology: Infralittoral and circalittoral. Lives in photophilic algae and in *Posidonia oceanica* rhizomes; it has been reported in fouling samples from Nice at 87 m depth. In the Mar Menor only one individual has been collected in the uppermost sciaphilic community of the breakwater of El Estacio, in spring. Cited by STOCK (1952) in the Venice lagoon.

Geographical distribution: Northeastern Atlantic, Mediterranean.

TABLE 3. — A) Abundance (specimens/m²) of the different species for each sample and diversity of the samples; B) Mean dominance of pycnogonids in relation to the other faunistic groups in the samples; C) Frequency of occurrence and mean dominance of pycnogonid species in different assemblages in the Mar Menor (IPhR: Infralittoral photophilic rock; IScR: infralittoral sciaphilic rock; FMCh: floating masses of *Chaetomorpha*).

A Samples Number of indiv./m ²	T2A5F	T2B5F	T2C5F	T2C5E	T2D5F	T2D5E	T9B6E	T9D1F	T9D6E	P5B	P8	P9
<i>Tanystylum conirostre</i>	200	350	31	269	250	94	0	631	0	3656	50	50
<i>Anoplodactylus pygmaeus</i>	0	0	0	31	6	25	25	713	13	0	0	0
<i>Achelia echinata</i>	0	0	0	0	0	0	0	175	0	0	0	0
<i>Ammothella appendiculata</i>	0	0	0	0	0	0	25	150	19	0	0	0
<i>Ammothella longipes</i>	0	0	0	0	0	0	0	6	0	0	0	0
Diversity (bits/indiv.)	0	0	0	0.48	0.17	0.74	1	1.74	0.97	0	0	0

B Samples Total number of individuals / m ² % number of individuals	T2A5F	T2B5F	T2C5F	T2D5F	T2C5E	T2D5E	T9D1F	T9B6E	P5B	P8	P9
	178 669	17 550	31 744	27 306	13 500	18 113	61 206	10 075	38 756	2150	4525
NEMATODA	0.02	0.57	0.10	0.18	0.23	0.14	0.26	0.00	1.98	0.00	0.00
POLYCHAETA	3.54	41.03	6.71	7.69	0.00	32.06	1.57	45.41	14.63	5.81	10.50
OSTRACODA	0.04	0.00	0.00	0.53	0.00	0.07	0.00	0.00	0.00	0.00	0.00
CIRRIPEDIA	0.00	0.00	0.02	0.21	0.00	0.03	0.03	0.00	0.55	0.00	0.00
TANAIDACEA	60.99	28.49	16.11	23.12	58.15	58.52	88.78	33.00	1.53	1.16	0.00
ANFIPODA	26.54	0.00	71.33	56.17	28.29	0.00	0.35	0.50	41.48	0.00	37.02
ISOPODA	2.38	3.70	2.15	2.20	3.80	2.28	0.39	0.00	29.75	36.05	16.57
PYCGONOIDA	0.11	1.99	0.10	0.94	2.22	0.66	2.74	0.50	9.43	2.33	1.10
CHIRONOMIDAE	0.59	0.85	0.02	2.75	0.19	0.86	0.28	0.00	0.00	0.00	0.00
MOLLUSCA	5.55	23.08	3.33	5.56	6.99	4.90	5.62	20.60	0.65	50.00	34.25
ECHINODERMATA	0.22	0.28	0.14	0.66	0.14	0.49	0.00	0.00	0.00	4.65	0.55

Frequency of occurrence (%)	IPhR	IScR	FMCh
<i>Tanystylum conirostre</i>	44.4	44.4	100
<i>Anoplodactylus pygmaeus</i>	11.1	55.6	0
<i>Achelia echinata</i>	0	11.1	0
<i>Ammothella appendiculata</i>	0	33.3	0
<i>Ammothella longipes</i>	0	11.1	0
Total Pycnogonida	44.4	66.7	100

Mean dominance (%)	IPhR	IScR	FMCh
<i>Tanystylum conirostre</i>	0.358	4.179	1.527
<i>Anoplodactylus pygmaeus</i>	0.176	0.084	0.000
<i>Achelia echinata</i>	0.043	0.000	0.000
<i>Ammothella appendiculata</i>	0.037	0.026	0.000
<i>Ammothella longipes</i>	0.002	0.000	0.000
Total Pycnogonida	0.614	4.289	1.527

Tanystylum conirostre (Dohrn, 1881)

Tanystylum conirostre KRAPP, 1973: 73, fig. 3; CHIMENZ *et al.*, 1979: 492, fig. 8; ARNAUD, 1987: 43.

Clotenia conirostris DOHRN, 1881: 161, lam. VIII, IX.

Ecology: Infralittoral. It lives in photophilic algae on rocky substrates. Also found in coralligenous communities and in harbour fouling. It is the most abundant species in the Mar Menor and is widely distributed, both in photophilic and sciaphilic communities. Egg-bearing males are found throughout the year.

Geographical distribution: Amphi-Atlantic. Mediterranean.

Family Phoxichilididae

Anoplodactylus pygmaeus (Hodge, 1864)

Anoplodactylus pygmaeus STOCK, 1968: 26, fig. 20; CHIMENZ *et al.*, 1979: 479, fig. 3; MUNILLA, 1981: 81; ARNAUD, 1987: 46.

Ecology: Infralittoral, although it can reach a depth of 587 m. It generally lives in photophilic algae, in *Posidonia* and in nitrophilic communities. It has also been found in the hollows of sponges and hydroids and in harbour fouling. Distributed through the Mar Menor, where it is mainly found in sciaphilic communities, all year round. In spring some egg-bearing males were caught.

Geographical distribution: Amphi-Atlantic. Mediterranean.

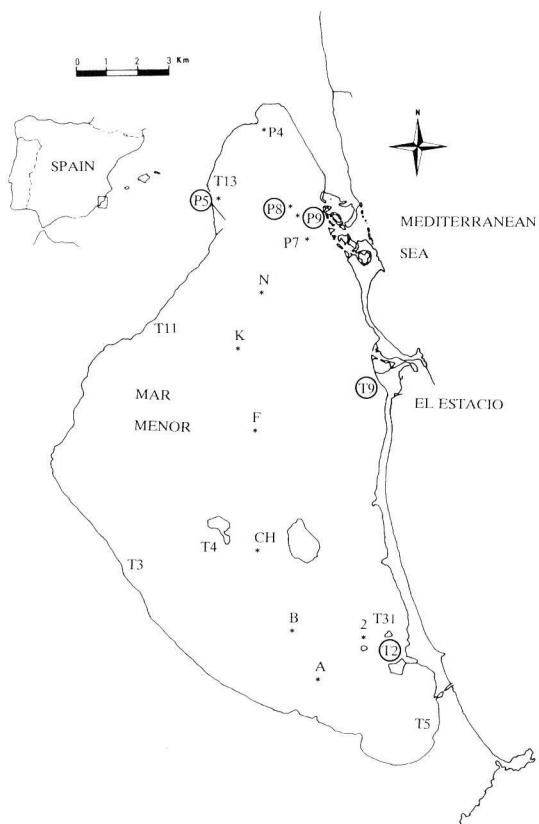


FIG. 1. — Location of transects and sampling sites in the Mar Menor. Localities with pycnogonids are marked with a circle.

Bionomic distribution and communities ecology

The pycnogonid fauna of the Mar Menor is absent from midlittoral assemblages and from soft bottoms (mixed meadows of *Caulerpa prolifera*-*Cymodocea nodosa*, meadows of *Ruppia cirrhosa* over mud, *Cymodocea nodosa* meadows on sand and sandy bottoms without vegetation), is confined to infralittoral communities of hard substrates and calm environments (Table 1), and is more abundant in sciaphilic communities.

Table 3b shows the percentage of pycnogonids compared to other groups of invertebrates in samples that include pycnogonids. In the photophilic community of infralittoral rocks in calm water with no fucoid dominance, characterized by the presence of *Acetabularia calyculus*, *A. acetabulum*, *Jania rubens*, *Gelidium pusillum*, *Padina pavonica*, *Siphonocladus pusillus*, *Valonia aegagropila* and *Laurencia obtusa* (PÉREZ-RUZAFA *et al.*, 1988; PÉREZ-RUZAFA, I., 1989), the mean dominance is only 0.6 %, reaching 2 % in T2B5F and 2.7 % in T9D1F. In photophilic communities on floating masses of *Chaetomorpha linum* they form 1.5 % of the total invertebrate fauna.

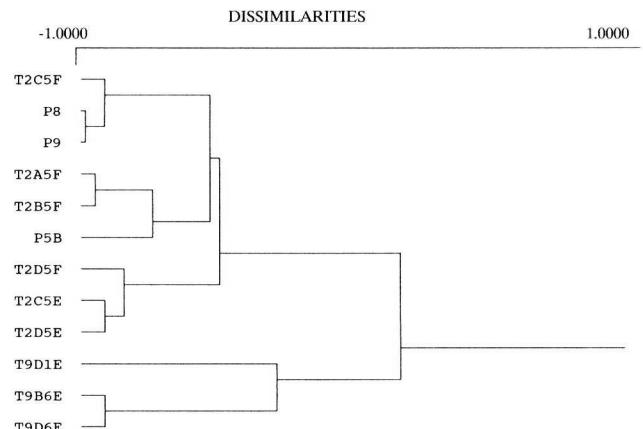


FIG. 2. — Dendrogram of dissimilarities (farthest neighbor method) between samples including pycnogonids. Matrix of similarity made using the Czekanowsky index for regularized data.

In the infralittoral sciaphilic assemblages on rock, pycnogonids constitute 4.3 %. Under jetties, they reach 9.4 % (sample P5B). This community is dominated by faunistic assemblages of sponges (*Suberites massa*, *Haliclona mediterranea*, *Pleraplysilla spinifera*, *Reniera arenata*, etc.), cnidaria (*Kirchenpaueria echinulata*, *Ventromma halecioides*, *Telmactis forskaillii*), bryozoans (*Scrupocellaria bertholleti* and *Schizoporella errata*), ascidians (*Styela canopus*), etc. The vegetation consists of *Phymatolithon lenormandii*, *Valonia aegagrophila* and *Cladophora coelothrix*.

Although some of the species captured also belong to nitrophilous communities and harbour environments (*Achelia echinata*, *Ammothella appendiculata* and *Anoplodactylus pygmaeus*), none of them is represented in the nitrophilous assemblages sampled (T13C0, T13C2, P4C) nor in those zones of high sedimentation (T13C25).

The resulting cluster after use of the affinity index (Fig. 2) differentiates two distinct groups of samples. The first consists of the sites furthest from the entrance channel, with *Tanystylum conirostre* as the predominant species, followed by *Anoplodactylus pygmaeus*. The second group consists of sites near the channel which communicates with the Mediterranean (T9), in which all the species appear, three of them not present in the rest of the lagoon, and which have the highest diversity.

This cannot be merely explained by differences in salinity or temperature between locations (maximum difference between T2 and T9 salinities were 0.9 during the sampling period, PÉREZ-RUZAFA, 1989) but may be interpreted according to models proposed to explain the horizontal zoning in lagoons based on the confinement concept (GUELORGET *et al.*, 1983; GUE-

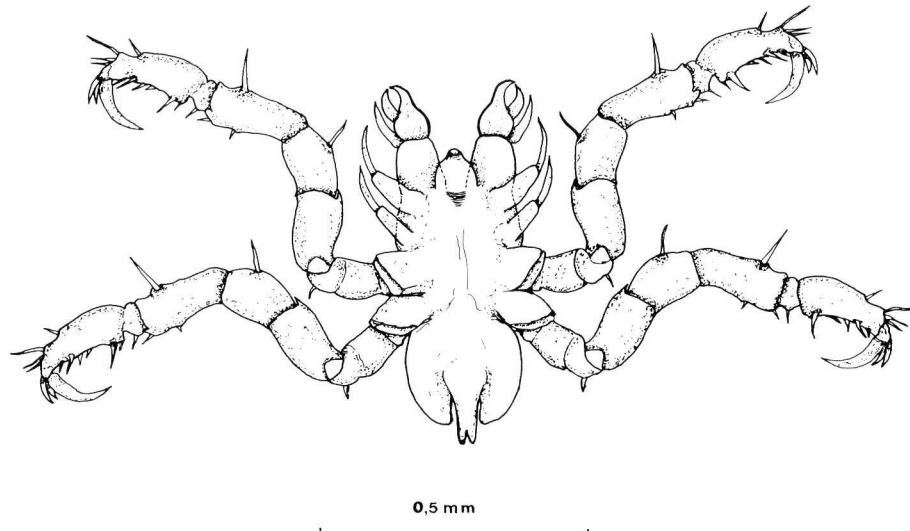


FIG. 3. — Intermediate stage of development between larvae and juvenile of *Tanystylum conirostre* (ventral view).

LORGET AND PERTHUISOT, 1983; PÉREZ-RUZAFA, 1989). In this way, in the proximity of the channels communicating with the open sea, the possibility of colonization by larvae or adults permits a relatively structured stable population with a high number of species.

In this sense, the fact that the 5 pycnogonid species found have benthic larvae may involve higher difficulties in the colonization of the lagoon than for groups such as molluscs or polychaeta with planktonic larvae. In fact, these groups show higher diversities in the lagoon (v.g. 1.78 and 2.73 respectively at T2D5E) and have shown a progressive increase in the specific richness since the enlargement of the El Estacio Channel and the related increase of the interchange rates of water (PÉREZ-RUZAFA, 1989).

The depth distribution of the species in the different sites varies but, in general, there is a concentration of the populations in depths of less than 1 m. Although the analyses made show no differences between the photophilic and sciaphilic assemblages and *T. conirostre* shows the same frequency of occurrence in both, it shows higher mean densities in sciaphilic communities. *A. pygmaeus* shows clear preferences also for sciaphilic assemblages, both in frequency of occurrence and mean density. *A. echinata*, *A. appendiculata* and *A. longipes* appear only in shady environments under stones.

Ecology and biology of *Tanystylum conirostre*

This species is the most abundant in the lagoon

(82 % of the collected individuals). It coincides with observations in the Alfaques lagoon in the Ebro Delta, where it reaches the 68 % of the total pycnogonid fauna (MUNILLA, unpublished data). In the Mar Menor it constitutes dense populations (see Table 3a). These concentrations of pycnogonids are the highest encountered to date; DAHL *et al.* (1976) have reported 3959 ex./ha in benthic communities from the Norwegian Sea at 3000 m (see ARNAUD AND BAMBER, 1987 for some data of other populations). The densities observed in the Mar Menor could be explained by the availability of food, especially at site P5B where, as described before, sponges, cnidarians and bryozoans abound, and reach biomass values of 10, 4.8 and 9 (ashfree dry weight) g/m², respectively. It is to be noted that the colour exhibited by pycnogonids in this locality coincides with the red and orange colour of some of these species.

Another possible cause of these densities at P5B is the coupling of reproductive individuals which in total (egg-bearing males and pregnant females) constitute 71.1 % of the population (62 % of the males and 95.5 % of the females). This is not due to the recruitment of juveniles, which in this sample constitute only 8.2 % of the population.

Although *T. conirostre* is common in both photophilic and sciaphilic assemblages, at T2 (Table 3a) a movement of the population from photophilic to sciaphilic assemblages occurs from autumn to winter when the lower temperature of the water and the lower sea level coincide with an important reduction in algal biomass and cover in the upper surface of sto-

nes. At T2-5 algal cover were 141 % to 61 % from spring to summer and 19 % to 31 % from autumn to winter (PÉREZ-RUZAFÁ, I., 1989).

Some other aspects of the *T. conirostre* population should be mentioned. We have found, at T2D5, two individuals which show a form of postembryonic development (Fig. 3) which is intermediate between the larva and the juvenile with two pairs of larval appendages and two of a juvenile-adult. Until now, the literature has only cited larvae or juveniles with 3 pairs of legs; therefore, this intermediate stage partly confirms that the larva-juvenile stage of this species is spent in the same substrate as inhabited by adults. BEHRENS (1984) shows a similar pattern in *Pycnogonum littorale* raised in the laboratory and MAUCHLINE (1984) does the same for an indeterminate planktonic juvenile on the umbrella of the scyphomedusa *Periphylla periphylla*, but already with 4 pairs of juvenile legs and 2 pairs of larval legs.

On the other hand, the adult males of *T. conirostre* with empty egg sacs (180) have no attached larvae, as occurs normally in Ammotheidae; that is, there are no larvigerous males in this population (P5B). This absence suggests that the larvae do not spend any development time with their parents, but live freely after eclosion.

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BIBLIOGRAPHY

- ARNAUD, F. — 1987. Les pycnogonides (Chelicerata) de Méditerranée: Distribution écologique, bathymétrique et biogéographie. *Mesogee*, 47: 37-58.
- ARNAUD, F. and R. N. BAMBER. — 1987. The Biology of Pycnogonida. *Adv. Mar. Biol.* 24: 1-96.
- BEHRENS, W. — 1984. Larvenentwicklung und Metamorphose von *Pycnogonum littorale* (Chelicerata, Pantopoda). *Zoomorphology*, 104: 266-279.
- BELLAN-SANTINI, D. — 1970. Méthodologie pour l'étude qualitative et quantitative des peuplements de substrat dur. *Thalassia Jugoslavica*, 6: 129-137.
- CANDELA, A., R. SCONFIENTI and A. R. TORELLI. — 1985. Ricerche sperimentali sulla dinamica stagionale delle zoocenosi intermareali della laguna di Venezia. *Boll. Mus. civ. St. nat. Venezia*, 34: 7-28.
- CASTRIC-FEY, C. — 1984. Revue des méthodes actuelles d'étude des substrats durs infralittoraux. *Oceanis*, 10(3): 207-235.
- CHIMENZ, C., P. M. BRIGNOLI, and G. BASCIANO. — 1979. Pantopodi del porto di Civitavecchia e Dintorni (Italia centrale). *Cahiers de Biologie Marine*, 20: 471-497.
- DAHL, E. et. al. — 1976. Some quantitative results on benthic communities of the deep Norwegian Sea. *Astarte*, 9: 61-79.
- DAY, J. H., J. G. FIELD and M. P. MONTGOMERY. — 1971. The Use of Numerical Methods to Determine the Distribution of the Benthic Fauna Across the Continental Shelf of North Carolina. *J. Anim. Ecol.*, 40: 93-125.
- DIAPOULIS, A. and C. BOGDANOS. — 1983. Preliminary study of soft substrate macrozoobenthos and marine flora in the bay of Gera (Lesbos island, Greece). *Thalassographica*, 6: 127-139.
- DOHRN, A. — 1881. Die Pantopoden des Golfs von Neapel und der angrenzenden Meeresabschritte. *Monographie der Fauna und Flora des Golfs von Neapel*, 3: 1-252.
- ELEFTHERIOU, A. and N. A. HOLME. — 1984. Macrofauna Techniques. En: HOLME, N. A. & MCINTYRE, A. D. (Eds.). *Methods for the Study of Marine Benthos*. Blackwell. Oxford: 140-216.
- GILI, J. M. and J. D. ROS. — 1985. Study and cartography of the benthic communities of Medes islands (NE Spain). *P.S.Z.N.I.: Marine Ecology*, 6 (3): 219-238.
- GUELORGET, O., G. F. FRISONI, and J. P. PERTHUISOT. — 1983. La zonation biologique des milieux lagunaires: définition d'une échelle de confinement dans le domaine paralique méditerranéen. *Journal de recherche océanographique*, 8 (1): 15-35.
- GUELORGET, O. and J. P. PERTHUISOT. — 1983. Le domaine paralique. Expressions géologiques, biologiques et économiques du confinement. *Travaux du laboratoire de géologie*, 16: 1-136.
- KRAPP, F. — 1973. Pycnogonida from Pantelleria and Catania, Sicily. *Beaufortia*, 21(277): 55-73.
- MARGALEF, R. — 1974. *Ecología*. Omega. Barcelona.
- MAUCHLINE, J. — 1984. Pycnogonida caught in bathypelagic samples from the Rockall Throught, northeastern Atlantic Ocean. *Jour. Nat. Hist.*, 18: 315-322.
- MUNILLA, T. — 1981. Contribució al coneixement de la distribució ecològica dels Pycnogonids catalans de la Costa Brava. *But. Inst. Cat. Hist. Nat.*, 47: 77-86.
- 1986. Biometría de una población de *Ammothella longipes* (Hodge, 1864) (Pycnogonida). *Orsis*, 2: 103-114.
- 1988. Prémiers pycnogonides de détroit de Gibraltar (coté ibérique). *Bull. Inst. Cat. Hist. Nat.*, 55: 59-65.
- MUNILLA, T. and A. DE HARO. — 1984. Pycnogonids de les Illes medes. En: ROS, J., OLIVELLA, I. & GILI, J. M. (Eds.). *Els sistemes naturals de les Illes Medes*, 531-536.
- PÉREZ-RUZAFÁ, A. — 1989. *Estudio ecológico y bionómico de los poblamientos bentónicos del Mar Menor (Murcia, SE de España)*. Tesis Doctoral. Universidad de Murcia, 751 pp.
- PÉREZ-RUZAFÁ, A., I. M. PÉREZ-RUZAFÁ, C. MARCOS and J. D. ROS. — 1988. Cartografía bionómica del poblamiento bentónico de las islas del Mar Menor. I. Islas Perdiguera y del Barón. *Oecol. Acuat.*, 26-40.
- PÉREZ-RUZAFÁ, I. M. — 1989. *Fitobentos de una laguna costera. El Mar Menor*. Tesis Doctoral. Universidad de Murcia, 356 pp.
- STOCK, J. H. — 1952. The pycnogonids of the lagoon of Venice. *Bollettino Soc. Venez. Historia Nat.*, 6 (2): 179-186.
- STOCK, J. H. — 1968. Faune marine des Pyrénées orientales. 6. Pycnogonides. *Vie et Milieu*, 19 (1A): 1-36.
- WOLFF, W. J. — 1976. Distribution of pantopoda in the estuarine area in the southwestern part of the Netherlands. *Netherlands Journal of Sea Research*, 10(4): 472-478.

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