

Vertical and spatial distribution of the near shore littoral meroplankton off the Bay of Blanes (NW Mediterranean sea).

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The total number of meroplanktonic larvae collected off the Bay of Blanes (NW Mediterranean) on the 12th April 1995 ranged from 113 to 203 ind. m⁻³. Bivalve veligers were the most abundant followed by polychaete larvae, among which those from hesionids, spionids and nephtyds were dominant. Larval abundances were higher in the deeper half of the water column and decreased just near the bottom, except in the shallowest confined site.

Keywords. Meroplankton; Distribution; Near shore littoral; NW Mediterranean Sea.

The division of marine life into plankton and benthos has been, and remains, very popular, but ignore that those organisms are not truly independent, particularly in coastal areas (Giangrande *et al.*, 1994; Boero *et al.*, 1996). Reciprocal connections both functional (energy fluxes) and structural (life cycle dynamics) between plankton and benthos are very strong (Boero *et al.*, 1996). Most benthic organisms spend a fraction of their life-history as larvae in the plankton, where they are referred to as meroplankton. Meroplankton represent the dispersal stages of benthic organisms but may also show significant interactions with the “typical” plankton, the holoplanktonic organisms (cf. Martin *et al.*, 1996).

The occurrence of larval phases of Mediterranean benthic organisms has been seldom documented with high taxonomic resolution (Thiriot-Quévieux, 1968 and Senz-Braconnot, 1964, 1968 for molluscs; Bhaud, 1967, 1972 for polychaetes; Pedrotti and Fenaux, 1992 and Pedrotti, 1993 for echinoderms), whereas the spatial and vertical distribution of Mediterranean shallow-water coastal meroplankton remains largely unknown. The ecology of Mediterranean meroplankton remain unexplored, with a remarkable paucity of information, particularly when compared with that available for holoplankton (e.g. Vives, 1966; Razouls and Thiriot, 1968; Fenaux and Quelart, 1977; Ferrari and Mazzocchi, 1985; Lam Hoai, 1985; Menéndez and Comín, 1986; Panayotidis *et al.*, 1994).

The Bay of Blanes is located on the Catalan coast of the Iberian Peninsula (NW Mediterranean Sea, 41° 40.12' N, 2° 47.10' E). The presence of meroplanktonic organisms off the Bay was first reported by Morales (1951), who described the occurrence of polychaete and gastropod larvae (see Table I). Additional information became available just 40 years later, when the highest meroplanktonic abundance was reported in early spring (Andreu and Duarte, 1996). The seasonal dynamics of shallow-water infaunal benthic communities of the Bay of Blanes, and the life-cycle of the most representative species have been monitored since 1992 (Pinedo *et al.*, 1996, 1997) revealing that the main recruitment period of the benthic organisms in the Bay occurs in late spring. Both planktonic and benthic studies suggested an important output of larvae to the plankton in spring, and pointed out the need to study the planktonic larval stages of benthic invertebrates to understand the dynamics of the bay ecosystem. Thus, we collected plankton samples during the recruitment peak (12th April 1995) in order to describe the vertical and spatial distribution of the meroplanktonic larvae of the main infaunal benthic organisms of the Bay of Blanes (i.e. polychaetes, bivalves, gastropods, and echinoderms).

All samples were collected at 11 am, using a series of plastic tubes (10 cm in diameter, 2 m in length) connected end to end and a short-volume plankton pump (Forner Oceanics S.A., 0.25 m³ min⁻¹ of pumping capacity, 80 μm pore size), samples were collected at different depths and at three different sites in the bay. Sites 1 and 2 (15 m in water depth), located on an intermediate zone of the Bay and in front of the opening of the Tordera river, respectively, were sampled at 1, 3, 5, 7, 9, 11, and 13 m deep intervals; site 3 (7-8 m in water depth), located at the mouth of the Blanes harbour, was sampled at 1, 3, and 5 m deep intervals. Each sample was obtained by pumping water for 2 min (about 0.5 m³). The homogeneity of the volume of water pumped in the different conditions was checked prior sampling. All samples were preserved in a buffered 10% formalin-seawater solution. Samples were examined under a stereomicroscope, where the larvae were counted and classified by groups (i.e. bivalves, gastropods, echinoderms, and polychaetes). With the exception of the scaleworms, the polychaete larvae were classified up to the family level based on Bhaud and Cazaux (1982, 1987).

The depth-averaged abundance was higher at site 3 (203 larvae m⁻³) than at sites 1 (113 larvae m⁻³) and 2 (133 larvae m⁻³). At each site, larval densities were much lower within the first few meters of the water column (Fig. 1). Larvae were most abundant between 9 and 11 m deep at site 1, between 5 and 9 m deep at site 2, and were mostly concentrated just over the bottom (i.e. 5 m deep) at site 3. Polychaete and bivalve depth-averaged larval densities were higher than those of echinoderms and gastropods (Fig. 2A). Polychaetes were most abundant at site 3, whereas bivalves dominated at sites 1 and 2. The responsible for the observed general pattern of bathymetric distribution were also these two groups, reaching maximum densities at intermediate depths at sites 1 and 2, and just over the bottom at site 3 (Fig. 3). Gastropod and echinoderm larvae, although less abundant, were also similar to the two main groups in their distributions with depth (Fig. 3).

The number of polychaete families (Fig. 2B) was lower in the mouth of the Blanes harbour (6 families, site 3) than in the remaining two sites (8 families, site 2; 9 families, site 1). The Hesionidae, Spionidae, and Nephtyidae were clearly dominant at the three sites, but specially at site 3, which showed the low polychaete larval diversity. The Hesionidae was the most abundant family at sites 1 and 2, whereas Spionidae and Nephtyidae dominated at site 3. The three most abundant polychaete families followed the observed general pattern of bathymetric distribution, reaching maximum larval densities at intermediate depths in the middle of the bay (sites 1 and 2), and just over the bottom in the mouth of the harbour (site 3) (Fig. 4). The

remaining Polychaete families showed densities always $< 10 \text{ ind. m}^{-3}$ (Fig. 2B) and their presence was scattered throughout the different sites and sampled depths.

Since often no sound quantitative information is available on larval distribution in the Mediterranean, comparing the different reported larval densities might be difficult because what causes differences in abundances would not be easily determinable (i.e., sampling methodology, period of the year, water mass dynamics). With this in mind, we have nevertheless attempted to compare our values of meroplankton abundance with those of the existing literature. The larval densities recorded in April off the Bay of Blanes were intermediate when compared with those from Mediterranean open sea areas. Nevertheless, they were much lower than those reported in Mediterranean estuarine or brackish water areas, with the exception of those from Amvrakikos Gulf (Table I).

All the highest larval abundances reported in the Mediterranean were captured by means of plankton bottles (see Table I). Ferrari *et al.* (1985) demonstrated a lower efficiency of plankton pumps when compared with plankton bottles. These authors, however, compared samples from a very rich estuarine area at the vicinity of the Po river delta, where larvae reached extraordinarily high densities that may facilitate their capture by means of bottles. Provided the low larval density in the Bay of Blanes, we believe that this device should not be reliable because of the low water volume sampled that would capture very few larvae.

In fact, the larval abundances reported in the present study were higher than those observed in individual sampling dates off the Bay of Blanes in April 1992 (Andreu and Duarte, 1996) (Table I). These samples were collected with a plankton net (Juday-Bogorov, 0.5 m in diameter, 200 μm mesh size). Meroplanktonic larvae may show different structures (e.g., natatory setae in polychaetes, spines in echinoderms) that tended to increase the possibilities of capture. However, the largest pore size in the net than in the pump may significantly contribute to the respective differences in larval capture. Moreover, the sampling performance of the plankton net seems to be density-dependent (Vives, 1966). Thus, it is likely that the lower captures reported for the plankton net may be also related with the large water volume (about 2000 m^3) filtered by this device (Andreu and Duarte, 1996) in comparison with that filtered by the pump (0.5 m^3) in an area with a relatively low larval concentration.

The different patterns of vertical distribution reported from Mediterranean localities appeared to be highly variable, with the larval densities near the bottom tending to be: (1) higher than those near the surface in the Po river region, specially for polychaetes (Ambrogi

et al., 1989); (2) lower than those near the surface in the Thau lagoon (Lam Hoai and Amanieu, 1989); (3) randomly distributed off Castellón, with the exception of the echinoderm larvae which preferred deep waters (about 60 m deep) during March in this region (Vives, 1966); (4) lower than in the lower half of the water column in the sites located in the open Bay of Blanes (present work); and (5) higher than in the lower half of the water column in the most confined and shallowest site located in the mouth of the Blanes harbour (present work) (Table I).

According to Ambrogi *et al.* (1989), the differences in zooplankton abundance and composition of the surface and the near bottom samples from the open sea in the Po river area could be an indirect evidence of the existence of an export mechanism from the coastal lagoon to the sea, linked to the existence of tidal currents. There are non-relevant tides (less than 20 cm high) in the NW Mediterranean. However, the high abundance of littoral mollusc larvae during spring suggested the presence of a surface layer of coastal waters reaching the open sea off Castellón (Vives, 1966). The submarine canyon facing the Bay of Blanes (Granata *et al.*, submitted) may have a major effect on local circulation favouring, in absence of thermocline (from September to mid-June), the presence of a recurrent, inertial, circadiurnal exchange between shelf and slope water masses, whose existence has been theoretically postulated (Masó *et al.*, 1990; Masó and Tintoré, 1991). The existence of this water mass exchange mechanism was supported by the observations of a circadiurnal cycle in surface temperature and salinity in the Bay, involving large simultaneous changes in water mass temperature (up to 2°C day⁻¹) and salinity (up to 2 psu day⁻¹) (Cebrián *et al.*, 1996): the cold, more saline, slope water mass reaches the shore line at night, whereas the warm, less saline shelf water mass is present in the Bay at day time. This pattern is at least extensible from 0 m to 15 m deep (D. Martin, unpublished data).

Although larval aggregation caused by convergences and fronts (Kingsford, 1990) may complicate sampling, the above field observations, together with the fact that the studied types of meroplanktonic larvae tend to remain in the same water mass during much or all of their development (Banse, 1986), supports that our sampling design may provide a reliable approach to the vertical and spatial distribution of meroplankton when the shelf water mass is present in the Bay of Blanes. However, further studies should be addressed to assess whether the observed bathymetric differences in meroplankton abundance and composition may result from the diel exchange of water masses, from diel vertical migration of larvae, or from an

intrinsic character of the larvae such as changes in buoyancy and swimming behaviour linked to growth.

Meroplankton densities may change depending on the studied ecosystem but, also within the same ecosystem, marked diel, seasonal, and inter-annual differences may occur. To conclude, however, the situation of the studied shallow littoral waters at noon time during spring may be summarised as follows. The lowest abundance of meroplanktonic larvae occurred both in first meters of the water column and just near the bottom in the open Bay, whereas it was higher near the bottom in the most confined and shallowest site. Larvae of bivalves (in the open Bay) and polychaetes (in the most confined site) were the dominant meroplanktonic components, in agreement with their observed dominance during the spring recruitment to the benthos (Pinedo *et al.*, 1996). Finally, the meroplanktonic polychaete larvae were dominated by a few families including the spionids, common predominant members of the meroplankton (Anger *et al.*, 1986; Lam Hoai and Amanieu, 1989), but also the hesionids and nephtyds.

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Table I. Summary of the quantitative available data on the studied meroplanktonic larvae in the Mediterranean Sea (larvae m⁻³). Date: sampling date; Data: Type of data, averages indicated between brackets; Pore: net pore size; S: near the water surface; B: near the bottom.

Authority	Date	Locality	Device		Data	Pore	Bivalves	Gastropods	Echinoderms	Polychaetes
Open sea										
Morales, 1951	1950	Bay of Blanes (NW Spain)	?		presence		--	scarce		accidental
Vives, 1966	1966	off Castellón (W Spain)	Oblique net		(March)	250 μ m	4.1	6.0	9.2	16
Ambrogi <i>et al.</i> , 1989	1986	Adriatic Sea	Patalas bottle	S			7100	200	--	6500
				B			2000	400	--	15300
Andreu and Duarte, 1996	1992	Bay of Blanes (NW Spain)	Oblique net		(April)	200 μ m	67	4.4	20	19
					April		1.4	0.7	3.6	0.6
Present work	1995	Bay of Blanes (NW Spain)	Pump	site 1		80 μ m	59	7	10	37
				site 2			60	21	11	42
				site 3			77	2	5	120
Coastal lagoons and brackish waters										
Ferrari <i>et al.</i> , 1982	1979	Canarin (Po delta)	Ruttner bottle	S	(24 h)	90 μ m		--	--	106911
				B			1879	--	--	229095
	1980	Canarin (Po delta)	Ruttner bottle	S			9562	--	--	171550
				B			4117	--	--	151475
Nicolaidou <i>et al.</i> , 1983	1980	Amvrakikos Gulf	WP 2 net	S	June	--	--	0.04 - 1.9	--	0.02 - 0.7
Ferrari <i>et al.</i> , 1985	1981	Canarin (Po delta)	Patalas bottle	S	(24 h)	90 μ m	8439	696	--	9396
				B			23920	1656	--	18952
		Canarin (Po delta)	Pump	inner		90 μ m	3920	490	--	6160
				opening			8096	644	--	7176
Menéndez and Comín 1986	1983-84	La Tancada (Ebre delta)	Niskin bottle		max.	40 μ m	300000	--	--	--
		Canal Vell (Ebre delta)	Niskin bottle				--	--	--	228000
		L'Encanyissada (Ebre delta)	Niskin bottle				80000	--	--	--
		Buda (Ebre delta)	Niskin bottle				192000	--	--	--
Ambrogi <i>et al.</i> , 1989	1986	Po River	Patalas bottle	S	(year)	50 μ m	2900	10	--	--
				B			3900	20	--	2900
		Canarin (Po delta)	Patalas bottle				20400	1700	--	33500
Lam Hoai and Amanieu, 1989	1986	Thau (South France)	Vertical net	-1 m to S	May	150 μ m	1590	318	127	784
				-3.5 m to S			1690	199	64	219
				-6 m to S			790	114	70	14

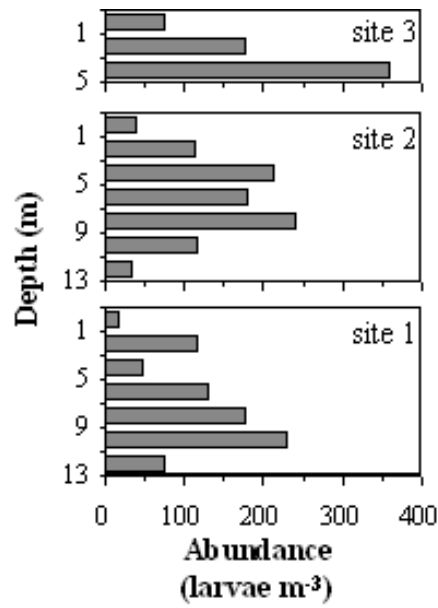


Fig. 1. Bathymetric distribution of total number of the studied larvae.

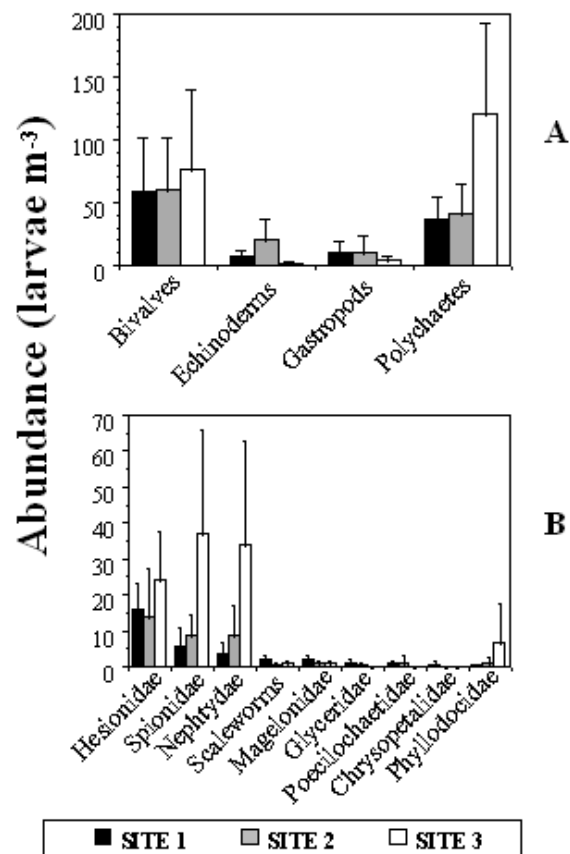


Fig. 2. Depth-averaged abundances of larvae. A. Based on the studied major taxonomical groups. B. Based on the main polychaete families.

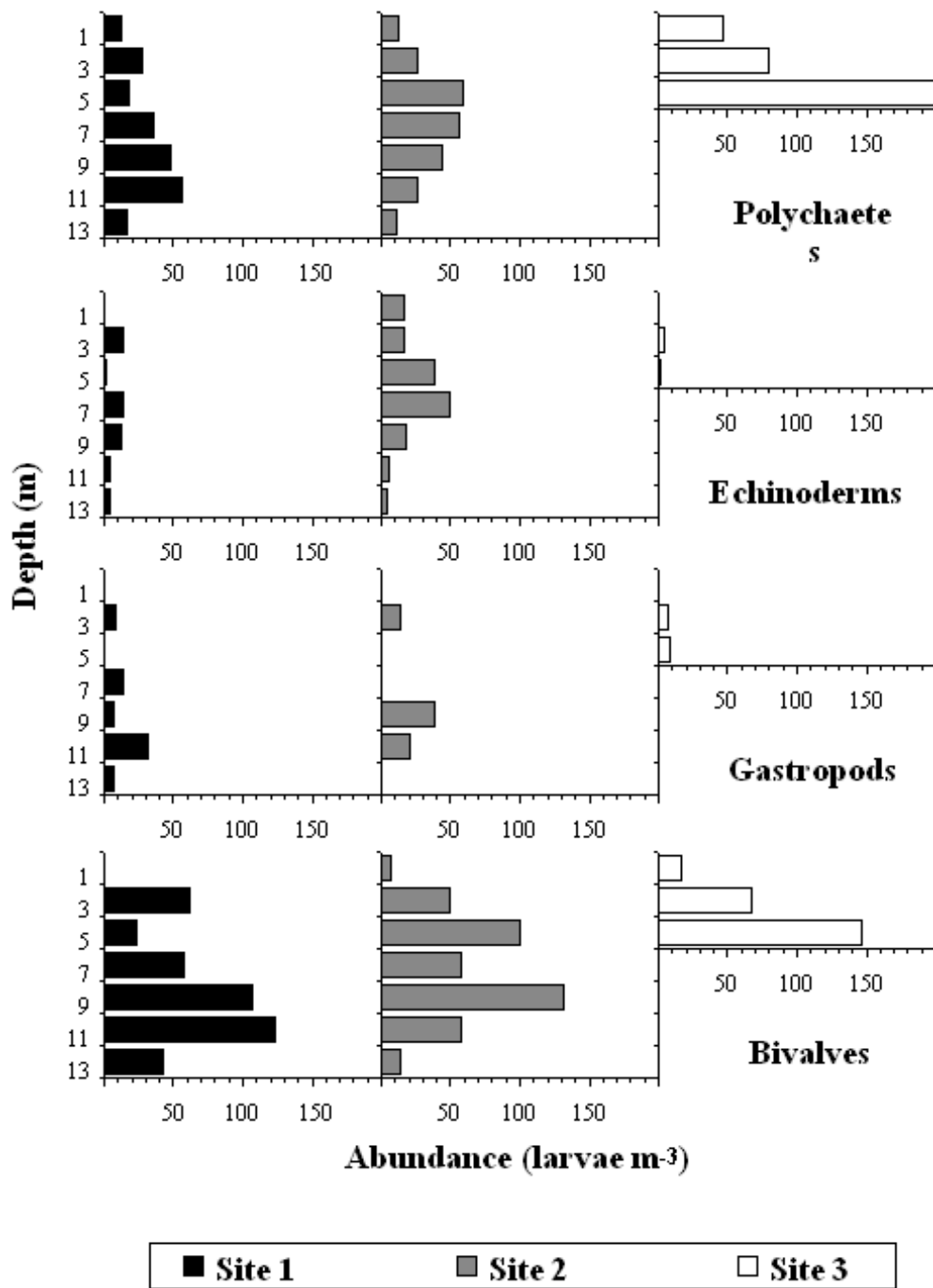


Fig. 3. Bathymetric distribution of the larvae of each studied major taxonomical group.

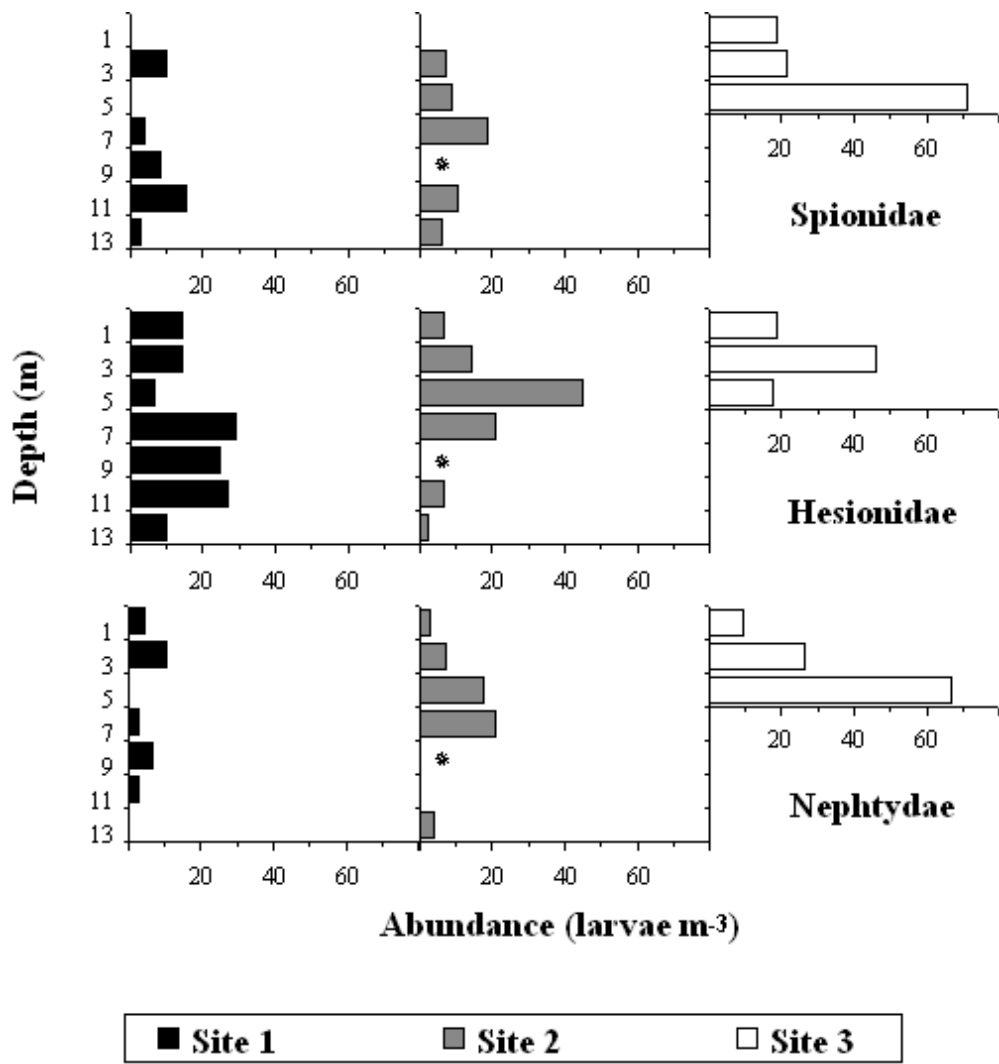


Fig. 4. Bathymetric distribution of larvae of the main polychaete families. Asterisks indicate sample loosed during handling.