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**Distribution characteristics of pandalid shrimps (Decapoda: Caridea: Pandalidae) along the Central Mediterranean Sea**

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**Abstract**

*The genus Plesionika is represented in the Mediterranean Sea by eight species, six of which, Plesionika acanthonotus, P. antigai, P. edwardsii, P. gigliolii, P. heterocarpus and P. martia, are very common on muddy bottoms of the continental slope. During nine experimental trawl surveys a total of 29,038 individuals of these six pandalid species, was collected off the central western coasts of Italy (central Mediterranean) in order to study population structure and spatial distribution. P. antigai inhabits the shelf break and upper slope; P. heterocarpus shows a wide bathymetric distribution, from the shelf-break to the upper slope; P. edwardsii and P. gigliolii occur in the upper slope. P. acanthonotus and P. martia occur in the deepest depths investigated. Segregation by size is revealed for the species that inhabit the same bottoms. The non-homogenous spatial distribution of Plesionika species in the study area was probably related to the spatial differences in the magnitude of primary production in the area.*

**Keywords:** Pandalidae; *Plesionika*; Distribution; Abundance; Central Mediterranean.

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**Introduction**

Within the nektobenthic decapod crustaceans, the genus *Plesionika*, is represented in the Mediterranean Sea by eight species, *Plesionika acanthonotus* (S. I. Smith, 1882), *Plesionika antigai* Zariquey Alvarez, 1955, *Plesionika edwardsii* (Brandt, 1851), *Plesionika ensis* (A. Milne Edwards, 1883), *Plesionika gigliolii* (Senna, 1903), *Plesionika heterocarpus*

(A. Costa, 1871), *Plesionika martia* (A. Milne Edwards, 1883) and *Plesionika narval* (Fabricius, 1787) (HOLTHUIS, 1987; FROGLIA, 1995; KOUKOURAS *et al.*, 1998). Six of these species, namely *P. acanthonotus*, *P. antigai*, *P. edwardsii*, *P. gigliolii*, *P. heterocarpus* and *P. martia* are very common on muddy bottoms of the continental slope of the central Tyrrhenian Sea and represent a discrete fraction of trawl fishery (FANELLI *et al.*, 2001).

*P. acanthonotus* is distributed from the Eastern to the Western Atlantic and in the Mediterranean Sea (HOLTHUIS, 1980). *P. gigliolii*, *P. heterocarpus* and *P. antigai* have a distribution restricted to the Mediterranean Sea and the Eastern Atlantic (HOLTHUIS, 1980). *P. antigai* was recently found also in the Canary Islands (GONZALEZ *et al.*, 2001). *P. martia* and *P. edwardsii* have a circumtropical distribution both in temperate and tropical waters (CROSNIER & FOREST, 1973, HOLTHUIS, 1980). For *P. edwardsii* there are no records from some areas of the Eastern Mediterranean (HOLTHUIS, 1987), it is present in the Italian and Corsican seas, but not in the Adriatic Sea (RELINI *et al.*, 1999). *P. martia* common in the Western Mediterranean and rare in the Eastern part (HOLTHUIS, 1987), is present in the Corsican and Italian seas but not in the Northern and Central Adriatic (RELINI *et al.*, 1999).

All six species have been included in the FAO Catalogue of species of interest to fisheries (HOLTHUIS, 1980), but their economic value seems to be very low with the exception of *P. edwardsii*, that is caught in some Mediterranean areas with multiple shrimps traps (Spanish coasts: GESTIN & GUENEGAN, 1989;

Corsica and Sardinia: IFREMER, 1994; SECCI *et al.*, 1994) and *P. martia* (HOLTHUIS, 1980). In general, all six species are sold in Italian fish markets, especially in the Central Tyrrhenian Sea, mixed with other shrimps.

These species have been studied in the Mediterranean by various authors both in the western (CARTES, 1993; COMPANY & SARDÀ, 1997; CARBONELL & ABELLÒ, 1998) and the eastern basin (KOUKOURAS *et al.*, 1998; POLITOU *et al.*, 2000). Concerning the Italian waters, investigations on Pandalid shrimps mostly focused on species' depth distribution and life history (MURA, 1995; CAMPISI *et al.*, 1998a, b; CUCCU *et al.*, 1998; MARSAN *et al.*, 2000; FANELLI *et al.*, 2001; COLLOCA, 2002; MAIORANO *et al.*, 2002).

This study provides information on the abundance and distribution characteristics in order to assess the future importance of these six species for fishery purposes.

## Materials and Methods

A total of 370 hauls within 7 trawl surveys was conducted in an area off the central Italian coasts between 42°30' and 41°35'N (Fig. 1),

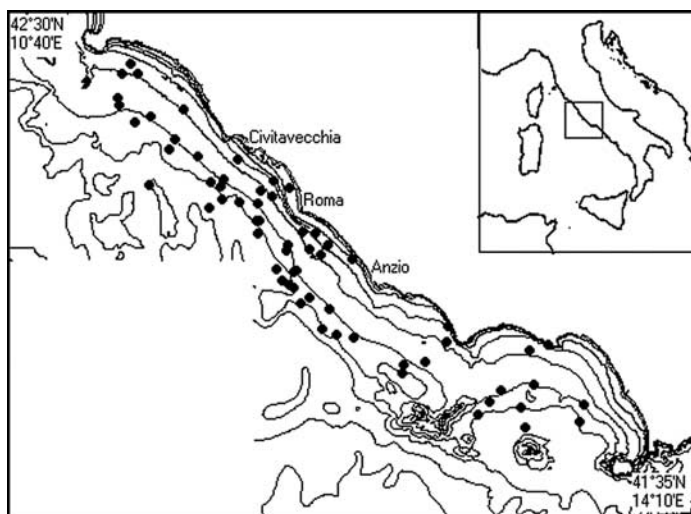


Fig. 1: Study area and sampling hauls.

from June 1997 to October 2000, at depths between 10 and 800 m, as part of two research projects: MEDITS (BERTRAND *et al.*, 2000) and GRUND (RELINI, 1998).

Both surveys used a randomized stratified sampling design based on depth (five bathymetric strata: 10-50 m, 51-100 m, 101-200 m, 201-500 m, 501-800 m depth) and area. At the beginning of the projects, location of stations was selected randomly within each stratum. The following years, the same stations were sampled (RELINI, 1998).

During the GRUND survey, a total of 62 hauls was carried out each year (1997, 1998 and 2000) in September–October during daylight (06.00–18.00). The vessel used was equipped with a hired Italian otter trawl with a head rope length of 40 m, a 40 mm thick ground chain and a 40 mm and 20 mm stretched mesh in the wing and cod-end. Each haul lasted 60 min at an average speed of 3.0 knots. During MEDITS surveys 46 hauls were repeated each year in July from 1997 to 2000 using an otter trawl net with a head rope length of 40 m, wing spread of 8 m and 10 mm mesh size at the cod-end (BERTRAND *et al.*, 2000).

A total of 29,038 specimens of *Plesionika* shrimps were collected during the study (Table 1). All sampled shrimps were identified, counted and weighed. Representative sub-samples of each species were measured (carapace length, CL, in mm with 0.1 mm accuracy) dorsally from the posterior edge of

the eye socket to the posterior edge of the cephalothorax using a vernier caliper. Information on ovigerous females was also collected (Table 1).

The *Plesionika* catch data were analyzed in order to estimate the density (N/km<sup>2</sup>) and biomass (kg/km<sup>2</sup>) along a depth gradient. The analysis was carried out separately for summer (MEDITS surveys) and autumn (GRUND surveys) samples. For the analysis of occurrence and abundance patterns, a 100 m depth interval on the slope was used. Maps of spatial distribution were derived using the ArcView Gis 3.2 software, based on the catch yield (N/km<sup>2</sup>) of *Plesionika* species from the GRUND surveys (mean values of the surveys). This choice derives from the higher number of hauls carried out each year during this survey (62 against 46 of MEDITS program for the investigated area). The size-depth relationship was investigated through the analysis of the size-frequency distributions by depth stratum obtained by pooling the data from the two surveys.

## Results

### *Bathymetric distribution*

Depth distribution pattern of species did not show marked seasonal differences; all the species showed a wide bathymetric range in both seasons (Table 2).

**Table 1**  
Size range (CL, mm) of the individuals studied and length (CL, mm) of the smallest female carrying eggs.

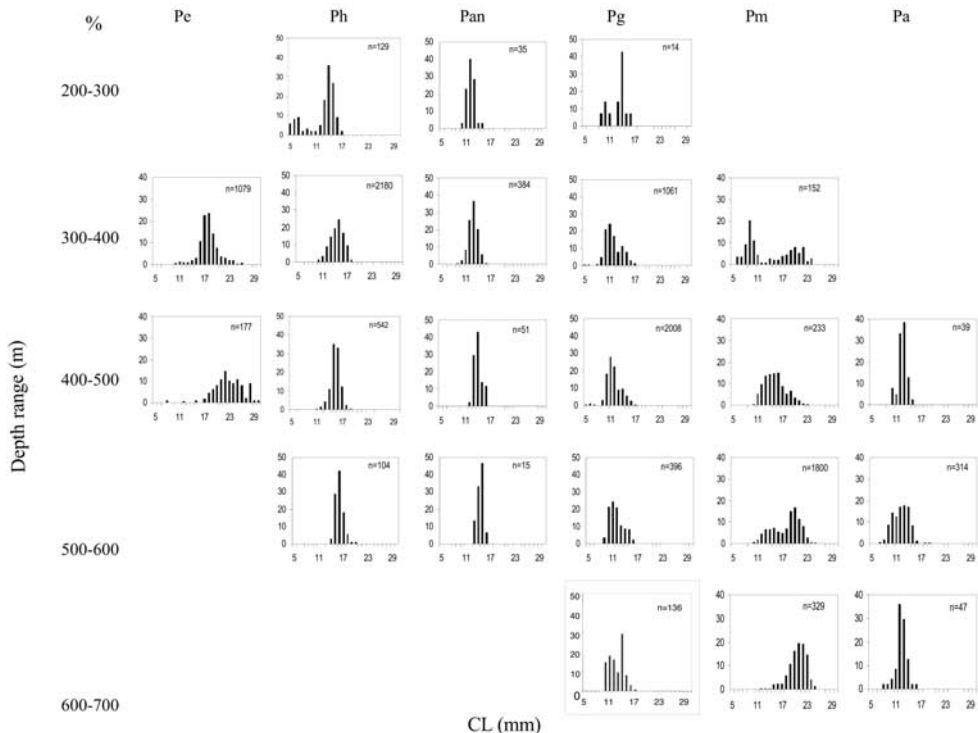
Species	No. Individuals studied	Size range of the individuals studied (CL, mm)	Ovigerous female (CL min.)
<i>Plesionika acanthonotus</i>	400	7-18	8
<i>Plesionika antigai</i>	1255	5-17	8
<i>Plesionika edwardsii</i>	1277	7-30	16
<i>Plesionika gigliolii</i>	3623	3-17	6
<i>Plesionika heterocarpus</i>	2964	3-19	10
<i>Plesionika martia</i>	2549	6-28	9

Biomass and density of the six species by depth stratum and survey are also presented in Table 3. *P. acanthonotus* occurred within a depth range of 286 to 760 m. Its frequency of occurrence was very high (over 77% of the samples) between 500 and 600 m. *P. antigai* was found at depths ranging between 184 to 585 m. The highest frequency of occurrence was found within the 300-400 m depth range. *P. edwardsii* occurred within the depth range from 187 to 622 m and its highest frequency was obtained between 300 and 400 m. *P. giglioli* was found from 286 to 615 m and was identified as one of the most common species of the middle slope (the highest densities occurred between 400 and 500 m). *P. heterocarpus* occurred from 167 to 590 m; the highest frequency of occurrence was identified between 300 and 400 m. *P. martia* was found

within a depth range of 301 to 760 m, the highest percentage of occurrence was between 500 and 600 m and was the most abundant species during the sampling period.

#### *Interspecific relationships between size distribution and depth*

Length frequency histograms by depth range and species are shown in Figure 2. The smallest individuals of *P. heterocarpus* were encountered in the upper part of the slope (200-300 m) and the largest individuals in the deepest part of its distribution range (500-600 m). The smallest individuals of *P. giglioli* occurred between 300 and 500 m, at the same depths where large individuals were also found. Size composition of *P. antigai* in all depth strata did not show differences. *P. edwardsii* showed



**Fig. 2:** Size frequency histograms by species at different depth intervals. N = number of individuals. Pa: *P. acanthonotus*, Pan: *P. antigai*, Pc: *P. edwardsii*, Pg: *P. giglioli*, Ph: *P. heterocarpus*, Pm: *P. martia*

**Table 2**  
Depth range, number of samples where a species was present (N) and frequency of occurrence within each depth stratum of  
pandalid shrimp species present in the study area during MEDITS and GRUND survey.

Species	Depth range (m)		Depth stratum (m)							
	minimum	maximum	100-200	200-300	300-400	400-500	500-600	600-700	700-800	
<b>MEDITS</b>			N	8	20	20	24	8	4	
<i>Plesionika acanthonotus</i>	286	760	36	12.5	5.0	100.0	62.5	25.0		
<i>Plesionika antigai</i>	184	500	34	62.5	85.0	55.0	0.0	0.0	0.0	
<i>Plesionika edwardsii</i>	260	501	14	0.0	30.0	30.0	0.0	0.0	0.0	
<i>Plesionika giglioli</i>	286	598	58	0.0	100.0	100.0	62.5	0.0	0.0	
<i>Plesionika heterocarpus</i>	184	550	24	5.8	65.0	10.0	4.2	0.0	0.0	
<i>Plesionika maritima</i>	306	760	45	0.0	20.0	60.0	83.3	100.0	25.0	
<b>GRUND</b>			N	9	24	21	27	6	0	
<i>Plesionika acanthonotus</i>	407	622	30	0.0	0.0	28.6	77.8	50.0	0.0	
<i>Plesionika antigai</i>	205	585	31	0.0	70.8	28.6	11.1	0.0	0.0	
<i>Plesionika edwardsii</i>	248	622	33	0.0	58.3	42.9	22.2	16.7	0.0	
<i>Plesionika giglioli</i>	316	615	60	0.0	95.8	81.0	70.4	16.7	0.0	
<i>Plesionika heterocarpus</i>	167	590	35	3.9	75.0	38.1	14.8	0.0	0.0	
<i>Plesionika maritima</i>	325	622	45	0.0	16.7	57.1	92.6	66.7	0.0	

**Table 3**  
Biomass (kg/km<sup>2</sup>) and density (n/km<sup>2</sup>)  
by depth stratum and survey for the studied  
pandalid shrimps.

Depth range	MEDITS		GRUND	
	kg/km <sup>2</sup>	n/km <sup>2</sup>	kg/km <sup>2</sup>	n/km <sup>2</sup>
<i>Plesionika acanthonotus</i>				
100-200	0	0	0	0
200-300	0.15	74.03	0	0
300-400	0.05	12.50	0	0
400-500	0.08	23.91	0.03	12.40
500-600	0.59	348.23	0.46	236.03
600-700	1.32	780.56	0.24	74.65
700-800	0.01	62.73	0	0
<i>Plesionika antigai</i>				
100-200	0	0.99	0	0
200-300	0.72	618.64	0.35	205.03
300-400	0.97	686.37	0.98	509.55
400-500	0.46	229.58	0.46	166.17
500-600	0	0	0.03	13.89
600-700	0	0	0	0
700-800	0	0	0	0
<i>Plesionika edwardsii</i>				
100-200	0	0	0	0
200-300	0.03	7.66	0.05	41.67
300-400	9.18	688.84	1.19	268.23
400-500	0.46	64.71	0.13	40.18
500-600	0	0	0.22	54.40
600-700	0	0	0.89	143.40
700-800	0	0	0	0
<i>Plesionika giglioli</i>				
100-200	0	0	0	0
200-300	0.04	39.09	0	0
300-400	0.91	533.02	1.11	575.52
400-500	2.93	1587.65	2.74	1351.69
500-600	0.26	92.24	0.62	252.78
600-700	0	0	0.02	1.74
700-800	0	0	0	0
<i>Plesionika heterocarpus</i>				
100-200	0.06	18.46	0.04	20.42
200-300	1.04	338.91	0.15	71.76
300-400	0.88	405.51	5.91	1783.85
400-500	0.04	16.72	0.80	220.68
500-600	0.01	5.21	0.02	4.24
600-700	0	0	0	0
700-800	0	0	0	0
<i>Plesionika maritima</i>				
100-200	0	0	0	0
200-300	0	0	0	0
300-400	0.05	20.05	0.03	5.64
400-500	0.60	237.62	1.21	397.87
500-600	6.76	838.04	6.02	1399.81
600-700	5.69	902.31	3.92	503.47
700-800	0.03	9.75	0	0

a higher percentage of small individuals between 300 and 400 m. In *P. martia* the smallest individuals were mainly distributed between 300 and 400 m. *P. acanthonotus* did not show a clear size-depth relationship and length frequency distributions were similar in all depth strata. Both *P. heterocarpus* and *P. martia* had a positive correlation ( $p < 0.05$ ) between mean CL and depth.

Interspecific relationships between size and depth were analysed comparing length frequency distributions and abundances by depth. *P. edwardsii* and *P. heterocarpus* on the upper slope and *P. martia* and *P. acanthonotus* on the middle slope showed a similar depth distribution but a clear size segregation. The two largest species, *P. edwardsii* and *P. martia*, differed clearly in their bathymetric distributions. On the other hand, species with similar size occurring on the upper slope, *P. heterocarpus*, *P. gigliolii* and *P. acanthonotus*,

showed a high degree of overlap in depth distributions.

#### Spatial distribution

Spatial distribution of all *Plesionika* shrimps species (Fig. 3) except *P. martia* showed a non homogeneous distribution along the Latium coast: the highest concentration area was detected between Civitavecchia and Anzio. *P. acanthonotus* and *P. antigai* showed a further area of elevated concentration along the southern coasts of the Latium region. The most abundant species, *P. martia* had a more homogeneous distribution showing a reasonable density in the whole investigated area.

#### Discussion and Conclusion

The depth range distributions of the *Plesionika* shrimps off the central-western

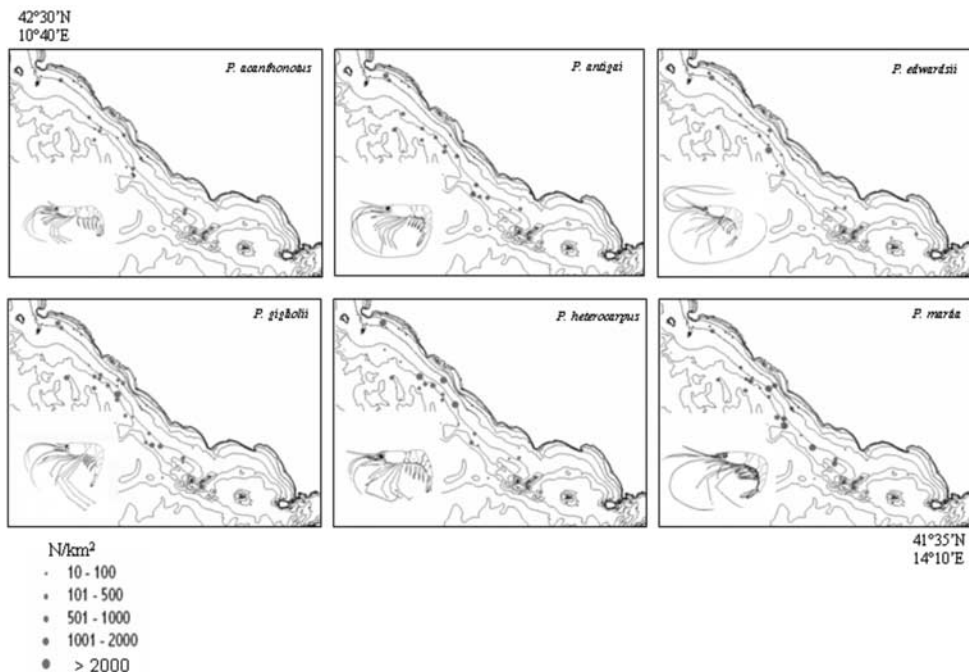


Fig. 3: Density ( $N/km^2$ ) distribution of *Plesionika* species from GRUND surveys (mean values).



coasts of Italy seem to be more restricted than those observed in other areas of the western (COMPANY & SARDÀ, 1997; CARBONELL & ABELLÒ, 1998) and eastern Mediterranean (Koukouras *et al.*, 1998; MARSAN *et al.*, 2000; POLITOU *et al.*, 2000). Along the Latium coasts, *P. antigai* was very abundant from 300 to 400 m, although, in other Mediterranean areas, it has been predominantly found at depths from 200 and 300 m (CARBONELL & ABELLÒ, 1998) or from 400 to 450 m (CAMPISI *et al.*, 1998b). *P. edwardsii* mainly occurred from 300 to 350 m, while in other areas it was more abundant over different ranges (SANTANA *et al.*, 1997; CARBONELL & ABELLÒ, 1998). *P. martia* was abundant at depths of 500 and 600 m showing a restricted abundance range with respect to other authors (MAIORANO *et al.*, 2002; CARBONELL & ABELLÒ, 1998). Some of the species studied showed intraspecific size segregation by depth, and interspecific size segregation among species was evident. This may be related to the diet composition of *P. martia* and *P. acanthonotus*, which feed on the same resources in the Catalan Sea (CARTES, 1993), segregating along a prey size gradient. This author showed that for these two species there was a different size composition at depths where they co-exist. Our results agree with this finding; in their overlapping depth distribution range, 500 to 700 m, the size composition of the two species was different. *P. martia* and *P. edwardsii*, which were found to overlap greatly in their diet composition (CARTES, 1993), did not overlap deeper than 500 m, and in the depth range where they co-existed they differed in their size composition. On the other hand, species like *P. antigai*, *P. heterocarpus* and *P. gigliolii* with a similar size in the area showed a high degree of overlap in their depth distributions. Some species of similar size like *P. gigliolii*, *P. acanthonotus* and *P. heterocarpus* showed a certain degree of overlapping but the pattern is not as clear as demonstrated by COMPANY & SARDÀ (1997) for the Catalan Sea. The low segregation among species found

in the central Tyrrhenian Sea is probably explained with the abundance of food resources due to the area's trophic condition, which is characterized by eutrophic waters.

The carapace length range found in all the species was similar with respect to other authors' observations (CARBONELL & ABELLÒ, 1998; CAMPISI *et al.*, 1998b; COLLOCA, 2002; MURA, 1995). The only exception was found in *P. heterocarpus*, the length range of which was smaller in comparison to other studies (CARBONELL & ABELLÒ, 1998; MARSAN *et al.*, 2000). The size of the smallest ovigerous female of *P. martia* was smaller than that observed by other authors (MAIORANO *et al.*, 2002; CAMPISI *et al.*, 1998b; COMPANY & SARDÀ, 1997).

In the central Tyrrhenian Sea, the pandalid shrimps of the genus *Plesionika* showed a non homogenous spatial distribution: the area of higher abundance was located from Anzio to Civitavecchia and off Giannutri Island. This can be probably explained by the higher availability of food resources in this area due to the increased primary production caused by the outflow of the Tiber River. An increase of mesopelagic fauna abundance in this eutrophic area may affect distribution and abundance of pandalid shrimps (CARTES, 1993).

The genus *Plesionika* represents an important component of the deep-sea assemblages in the Mediterranean Sea where they showed marked temporal fluctuations in abundance (FANELLI *et al.*, 2001). Further investigations in the central Mediterranean should be devoted to analyse species relationships and resource partitioning between species in order to understand better the dynamic of crustacean assemblages exposed to fishing exploitation.

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