Inventory of benthic amphipods from fine sand community of the Iberian Peninsula east coast (Spain), western Mediterranean, with new records

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Recent sampling surveys (2004–2008) of the shallow (12–20 m) soft-bottom homogeneous fine-sand community have allowed the collection of 55 marine amphipod species (53 Gammaridea and 2 Caprellidea) along the 250 km of Iberian Peninsula east coast (Spain, Mediterranean Sea). Among the species recorded, one recently described is new to science, five were collected for the first time in the Spanish Mediterranean and 14 were recorded for a second time confirming their presence. Of these 20 species; six are considered to be endemic to the Mediterranean Sea, seven are also north-eastern Atlantic species, and the last seven have a wide geographical distribution in the Indo-Pacific or Arctic and the Atlantic Oceans. Finally, multivariate analyses of species distribution showed changes among locations according to the north–south axis and depth, parameters that highly influence the benthic communities.

Keywords: amphipods, Mediterranean, Spain, fine-sand

Submitted 29 June 2010; accepted 1 October 2010

INTRODUCTION

The Mediterranean Amphipoda fauna has a high richness, with more than 452 recorded species (Bellan-Santini et al., 1998), and has been widely studied; however, the knowledge of this order is not uniform throughout the entire Mediterranean. In this way, knowledge of the ecology and taxonomy of amphipod species on the Mediterranean coast of the Iberian Peninsula is still fragmentary (Jimeno & Turón, 1995; Bellan-Santini et al., 1998) and the central east coast has been studied relatively infrequently (Marti, 1989).

According to Jimeno (1993), there are 368 known species along the coast of the Iberian Peninsula, of which only 146 are reported from the Mediterranean side. Works on amphipods from this area have been mainly carried out on the Catalan coast (Castany et al., 1982; Bibiloni, 1983; Carbonell, 1984; Jimeno, 1993; San Vicente & Sorbe, 1999; Munilla & San Vicente, 2005; Cartes et al., 2007, 2009; Delgado et al., 2009) and the Andalucia coast (Conradi et al., 1995; Conradi & López-González, 1999; Sánchez-Moyano et al., 2007; Gonzalez et al., 2008; Guerra-García et al., 2009a, b; Izquierdo & Guerra-García, 2010; Guerra-García & Izquierdo, 2010). Other studies have been produced in the Balearic Islands (Cartes et al., 2003; Ortiz & Jimeno, 2003) and indeed, on the Iberian Peninsula east coast (Marti, 1989; Sánchez-Jerez et al., 1999; Vázquez-Luis et al., 2008, 2009), where this study was carried out (Figure 1); however, more studies on the distribution of amphipods are still required in order to increase the knowledge of species distribution and amphipod diversity of this area.

One of the communities more frequent in shallow soft-bottom non-vegetated areas from the western Mediterranean is the medium-to-fine sand community of Spisula subtruncata (Cardell et al., 1999). This community tends to colonize exposed or semi-exposed sublittoral habitats, from the beach environment to 30 m depth (Sardà et al., 1996, 2000; Cardell et al., 1999). Although this community generally contains low numbers of individuals and low values of biomass, a high abundance and diversity of amphipods had been reported (Bakalem et al., 2009).

The main objective of this paper was to report the status of the knowledge of the amphipod species inhabiting this widely distributed community on the eastern Spanish Mediterranean coast and to analyse changes in species composition among sampled locations.

MATERIALS AND METHODS

A total of 40 stations from ten different locations along approximatley 250 km of south-west coast of the Balearic Islands...
Basin (Comunidad Valenciana, Iberian Peninsula east coast) were sampled (Figure 1). All locations were characterized by homogeneous fine-sand sediment (median sediment included between 0.125 mm and 0.25 mm) with a depth-range from 12.4 to 20 m (Table 1). For each location, four sites were sampled, keeping a constant depth in each location. All samples were collected in July during five consecutive years (2004 to 2008). Four Van Veen grab samples (400 cm²) were obtained at each site. Three samples were sieved through a 0.5-mm screen, fixed in 10% formalin and preserved in 70% ethanol for the study of the amphipod assemblage. The other sample was used to characterize the sediment (granulometric analysis and organic content). Grain size analysis was assessed by standard sieve fractionation (Holme & McIntyre, 1984). Organic content of dry sediment was estimated as the loss of weight after ashing.

### Table 1. Locations, geographical coordinates, depth (m) and physical characteristics of sediment of the stations of each location.

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Depth</th>
<th>% Mud</th>
<th>% Fine sand</th>
<th>% Medium sand</th>
<th>% Coarse sand</th>
<th>% Gravel</th>
<th>% Organic matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vinaroz</td>
<td>40°28.15'N</td>
<td>0°30.44'E</td>
<td>15.0</td>
<td>4.25</td>
<td>78.85</td>
<td>5.14</td>
<td>9.27</td>
<td>2.50</td>
<td>2.47</td>
</tr>
<tr>
<td>2. Benicarlo</td>
<td>40°24.35'N</td>
<td>0°27.70'E</td>
<td>14.0</td>
<td>7.56</td>
<td>73.55</td>
<td>5.68</td>
<td>6.79</td>
<td>6.43</td>
<td>1.61</td>
</tr>
<tr>
<td>3. Peñiscola</td>
<td>40°20.79'N</td>
<td>0°24.99'E</td>
<td>14.8</td>
<td>1.49</td>
<td>83.56</td>
<td>4.27</td>
<td>5.62</td>
<td>5.07</td>
<td>2.02</td>
</tr>
<tr>
<td>4. Alcossebre</td>
<td>40°14.45'N</td>
<td>0°18.55'E</td>
<td>12.4</td>
<td>1.03</td>
<td>74.34</td>
<td>14.01</td>
<td>5.64</td>
<td>4.98</td>
<td>1.56</td>
</tr>
<tr>
<td>5. Torreblanca</td>
<td>40°11.85'N</td>
<td>0°14.59'E</td>
<td>13.9</td>
<td>1.23</td>
<td>86.82</td>
<td>5.63</td>
<td>3.96</td>
<td>2.36</td>
<td>1.47</td>
</tr>
<tr>
<td>6. Canet d’en Berenguier</td>
<td>39°40.96'N</td>
<td>0°10.77'W</td>
<td>15.6</td>
<td>0.72</td>
<td>83.36</td>
<td>5.87</td>
<td>9.16</td>
<td>0.88</td>
<td>1.62</td>
</tr>
<tr>
<td>7. Puebla de Farnals</td>
<td>39°31.97'N</td>
<td>0°15.44'W</td>
<td>18.9</td>
<td>9.18</td>
<td>69.05</td>
<td>8.36</td>
<td>9.32</td>
<td>4.09</td>
<td>2.61</td>
</tr>
<tr>
<td>8. Gandia</td>
<td>39°0.15'N</td>
<td>0°8.31'W</td>
<td>16.5</td>
<td>1.76</td>
<td>88.91</td>
<td>4.50</td>
<td>3.32</td>
<td>1.50</td>
<td>2.02</td>
</tr>
<tr>
<td>9. Oliva</td>
<td>38°56.92'N</td>
<td>0°5.55'W</td>
<td>15.6</td>
<td>1.79</td>
<td>91.94</td>
<td>3.33</td>
<td>1.54</td>
<td>1.39</td>
<td>2.46</td>
</tr>
<tr>
<td>10. Javea</td>
<td>38°46.83'N</td>
<td>0°12.60'E</td>
<td>20.0</td>
<td>7.77</td>
<td>75.71</td>
<td>12.55</td>
<td>3.09</td>
<td>0.88</td>
<td>1.61</td>
</tr>
</tbody>
</table>
Amphipods were identified using the key of Mediterranean amphipod fauna established by Bellan-Santini et al. (1982, 1989, 1993, 1998), except for the genus Bathyporeia, which was identified using d’Udekem d’Acoz & Vade (2005). The taxonomy was validated using the ERMS referential for amphipod introduced by Bellan-Santini & Costello (2001) (http://www.marbef.org/data/erms.php, consulted on 25 May 2010). New records for the Mediterranean Spanish coast were checked using published available literature (Figure 1).

Non-parametric multivariate techniques were used to compare species composition among locations. All multivariate analyses were performed using the PRIMER v. 6 statistical package (Clarke & Warwick, 1994). Triangular similarity matrices were calculated through the Bray–Curtis similarity coefficient using abundance values that were previously square root transformed. Locations were classified into groups according to the cluster analysis of Bray–Curtis similarity coefficients. Similarities percentage analyses (SIMPER) of abundances were used to determine the species with higher percentage contribution in dissimilarity between groups.

The BEST procedure was used to determine the parameter (granulometry, organic matter %, depth and latitude) most correlated with species composition changes between sampled stations. Spearman correlation between similarity matrices of samples based on the abundances of benthic community and parameters was determined. Canonical correspondence analysis (CCA) was used to identify the relationships among the spatial distribution patterns of amphipods and environmental gradients. The CCA was conducted using the software CANOCO. The output is displayed as biplot, in which the plotted points for stations can be related to environmental gradients that are represented as arrows. The strength of the correlation of an environmental variable is reflected in the length of the arrow, and its association is reflected in the acuteness of the angle with the axis. Thus, the relationships among stations and environmental variables can be displayed on one plot.

RESULTS AND DISCUSSION

Taxonomic composition

A total of 55 species, belonging to 38 genera and 22 families, were identified. Among them, five species were first reported from the Mediterranean Spanish coast, 14 species were recorded for the second time and this study confirms their presence along the Spanish Mediterranean coast. A new species of Medicorophium, M. longisetosum sp. nov. (Myers et al., 2010) was also described from this collection. The species list is reported in Table 2, indicating when each species was previously cited and the bottom type where it was found. Some details on the new and second species records are given.

Order AMPHIPODA Latreille, 1816
Suborder GAMMARIDEA Latreille, 1803
Family AMPHILSIDAE Costa, 1957
Amphelisca sarsi Chevreux, 1888

This species is common on fine-sand shallow water (10–108 m depth) of the eastern Atlantic Ocean from the western part of the Channel, where it can form abundant populations, to the African coast of Senegal, and in the Mediterranean Sea where it was present in the Marseilles Gulf and in the Adriatic Sea (Bellan-Santini et al., 1982; Bellan-Santini & Dauvin, 1988). It was also present along the Algerian coast in the Bou Ismail and Algiers Bays and the Bejaia Gulf from 13 to 120 m on diverse types of sediment from mud to coarse sand (Bakalem & Dauvin, 1995). Amphelisca sarsi was also recorded at 383 m from the Portuguese coast (Marques & Bellan Santini, 1993). From the Spanish Mediterranean coast, A. sarsi was previously reported as a first record by Conradi & López-Gonzalez (1999) among Bugula neritina and Mesophillum in Algeciras Bay (Andalucian coast). This species has been recorded from Vinaroz to Puebla de Farnals and always in low abundances. A total of 64 individuals have been collected from 12.4 to 15.6 m.

Amphelisca spinifer Reid, 1951

It was observed in the eastern Atlantic Ocean from Ireland to the Libera coast, and in the Mediterranean in the Marseilles Gulf, the Tyrrhenian Sea and the coast of Israel (Bellan-Santini et al., 1982; Bellan-Santini & Dauvin, 1988). It was also recorded in Bou Ismail Bay in mud and muddy gravel between 25 and 100 m depth (Bakalem & Dauvin, 1995). Amphelisca spinifer was not previously reported from the Spanish Mediterranean coast. A total of 37 specimens have been recorded in Vinaroz, Benicarlo, Peniscola, Puebla de Farnals, Oliva and Javea, from 14 to 20 m in fine-sand bottom. Its ecology was previously established between 15 to 182 m depth on several types of sediment, from muddy to coarse sand but always in sediments with a large amount of mud (Bellan-Santini et al., 1982; Bellan-Santini & Dauvin, 1988; Marques & Bellan Santini, 1993).

Amphelisca tenuicornis Liljeborg, 1855

It was observed in the eastern Atlantic Ocean from northern Norway to the Senegal coast, from 0 to 510 m depth; where it can form abundant populations in shallow muddy fine sand community (Bellan-Santini & Dauvin, 1988). Ampelisca tenuicornis was previously reported from the Mediterranean Spanish coast at the continental shelf of Ebro Delta (western Mediterranean) by Cartes et al. (2007, 2009). We have found a total of 1084 individuals from all studied locations (from 12.4 to 20 m), obtaining the highest abundances (956 ind/m²) in Gandia during the year 2004. This species was found in sandy and muddy bottom in shallow waters in the eastern and western part of the Mediterranean Sea including the Algerian coast (Bellan-Santini et al., 1982; Bakalem & Dauvin, 1995).

Family ANIDAE Stebbing, 1899
Autonoe spiniventris Della Valle, 1893

Despite being previously established as Mediterranean endemic (Bellan-Santini et al., 1982), Autonoe spiniventris has since been observed by Martinez & Adefraga (2001) on the Atlantic coast (San Sebastian, Spain). This species is common in the Bou Ismail and Algiers Bays between 15 and 100 m depth from sand to muddy coarse sand (Bakalem & Dauvin, 1995). It was reported from the Spanish
Table 2. Amphipods species identified during present study. Asterisks indicate new records (*) and second records (**) for Spanish Mediterranean Coast. Literature and substratum where each species was found are indicated.

<table>
<thead>
<tr>
<th>Families</th>
<th>Species</th>
<th>Recorded by</th>
<th>Substratum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ampeliscidae</strong></td>
<td>Ampelisca brevicornis (Costa, 1853)</td>
<td>III, V, XII</td>
<td>A, M, D</td>
</tr>
<tr>
<td></td>
<td>Ampelisca diadema (Costa, 1853)</td>
<td>VI, XI, XII</td>
<td>A, D, V</td>
</tr>
<tr>
<td></td>
<td>Ampelisca sarsi (Cheveux, 1888)**</td>
<td>VI</td>
<td>V, B</td>
</tr>
<tr>
<td></td>
<td>Ampelisca spinifer (Reid, 1951)**</td>
<td>This study</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Ampelisca tenuicornis (Liljeborg, 1853)**</td>
<td>XV</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Ampelisca typica (Bate, 1856)</td>
<td>VI, VIII</td>
<td>A, M, D, V</td>
</tr>
<tr>
<td><strong>Amphilochoidea</strong></td>
<td>Amphilocho bruneus (Della Valle, 1893)</td>
<td>VI, XV</td>
<td>A</td>
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<tr>
<td><strong>Amphithoeidae</strong></td>
<td>Amphithoe ramondi (Audouin, 1826)</td>
<td>I, IV, VI, VII, VIII, XII, XIV, XVII</td>
<td>A, V, D, C</td>
</tr>
<tr>
<td><strong>Aoridae</strong></td>
<td>Aoria spinicornis (Afonso, 1976)</td>
<td>I, IV, V, IX, XVI</td>
<td>A, V</td>
</tr>
<tr>
<td></td>
<td>Autone spini ventris (Della Valle, 1893)**</td>
<td>XII</td>
<td>A</td>
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<tr>
<td></td>
<td>Microdentopus versiculatus (Bate, 1856)</td>
<td>VI, IX, XII</td>
<td>A, M, D, V</td>
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<td></td>
<td>Tethrylembus viguieri (Cheveux, 1911)</td>
<td>I, VI</td>
<td>A, M, D, V</td>
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<td><strong>Argissidae</strong></td>
<td>Argissa stebbingi (de Rouville, 1894)*</td>
<td>This study</td>
<td>A</td>
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<tr>
<td><strong>Atylidae</strong></td>
<td>Atylus guttatus (Costa, 1851)</td>
<td>I, IV, V, XII, XVI</td>
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<td>Atylus massiliensis (Bellan-Santini, 1975)</td>
<td>III, XII</td>
<td>A</td>
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<tr>
<td><strong>Bathyoreidae</strong></td>
<td>Bathyoreia lineastra (Stebbing, 1906)*</td>
<td>This study</td>
<td>A</td>
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<tr>
<td></td>
<td>Bathyoreia guiliemontiana (Bate, 1857)</td>
<td>V, VI, VIII, XII</td>
<td>A, V</td>
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<td></td>
<td>Bathyoreia borgi (d’Udèkem d’Acoz &amp; Vader, 2005)*</td>
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<td>A</td>
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<td><strong>Caprellidae</strong></td>
<td>Paraimbis typicus (Kroyer, 1844)</td>
<td>III, IX, XIV</td>
<td>A, V</td>
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<td>Phitsica marina (Slabber, 1769)</td>
<td>I, IV, VI, VII, X, XIV, XVI</td>
<td>A, V</td>
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<tr>
<td><strong>Cheirocratidae</strong></td>
<td>Cheirocrata sudevaldi (Liljeborg, 1861)**</td>
<td>VI</td>
<td>A, M, D, V</td>
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<tr>
<td><strong>Corophiidae</strong></td>
<td>Leptocherius hirsutimanus (Bate, 1863)**</td>
<td>VI</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Leptocherius pecinatus (Norman, 1869)</td>
<td>VI, XIV</td>
<td>M, D, C</td>
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<td></td>
<td>Medicorophium longisetosum (Myers, de-la-Ossa-Carretero &amp; Dauvin, 2010)</td>
<td>This study</td>
<td>A</td>
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<tr>
<td></td>
<td>Medicorophium runcicorne (Della Valle, 1893)**</td>
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<td>M, D</td>
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<td>Monocorophium sextoae (Crawford, 1937)</td>
<td>IV, VI, VII, XVI</td>
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<td>Siphonocetes sabateri (de Rouville, 1864)</td>
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<td>A, V</td>
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<td><strong>Dexaminidae</strong></td>
<td>Dexamene spinosa (Montagu, 1813)</td>
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<td>V, H</td>
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<td><strong>Eusiridae</strong></td>
<td>Eusirida alacris (Krapp-Schickel, 1969)**</td>
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<td><strong>Isaeidae</strong></td>
<td>Isaeopsis alata (Kroyer, 1846)</td>
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<td><strong>Ischyroceridae</strong></td>
<td>Ischyrocerus wallacei (Norman, 1867)</td>
<td>II, III, VIII</td>
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<td><strong>Leucothoidae</strong></td>
<td>Leucothoe inicia (Robertson, 1892)</td>
<td>II, VIII</td>
<td>A</td>
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<tr>
<td></td>
<td>Leucothoe obo (Karaman, 1971)**</td>
<td>VI</td>
<td>A, D, H</td>
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<td><strong>Lysianassidae</strong></td>
<td>Hippomedon massiliensis (Bellan-Santini, 1965)**</td>
<td>VI</td>
<td>A, M, D, B</td>
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<td>Lepidepecreum longicorne (Bate &amp; Westwood, 1861)**</td>
<td>V</td>
<td>V</td>
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<td>Lysianassa costae (Milne-Edwards, 1830)</td>
<td>VI, XII, XIV</td>
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<td>Orchomenella nana (Kroyer, 1846)</td>
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<td>A</td>
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<td></td>
<td>Tryphosites longipes (Bate &amp; Westwood, 1861)</td>
<td>VI, XI, XV</td>
<td>A, M</td>
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<td><strong>Megaluropidae</strong></td>
<td>Megaluropus massiliensis (Ledoyer, 1976)</td>
<td>V, VI, XII, VIII, XII</td>
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<td>Melaena grossiman (Montagu, 1808)</td>
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<td>A, D, V</td>
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<td>Maera knudseni (Reid, 1951)**</td>
<td>V</td>
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<td>Elasmosus pocillamum (Bate, 1862)</td>
<td>I, IV, VII, X, XII, XIV, XVII</td>
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<td><strong>Oedicerotidae</strong></td>
<td>Monoculodes gibbosus (Cheveux, 1888)**</td>
<td>XI</td>
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<td></td>
<td>Periculodes longimanus (Bate &amp; Westwood, 1868)</td>
<td>III, V, VI, VIII, XI, XV</td>
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<td>Synchelidium haplocala (Grube, 1864)**</td>
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<td>Synchelidium macrogrid (Stebbing, 1906)</td>
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<td>Megamphopus cornutus (Norman, 1869)</td>
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<td>Photis longicaudata (Bate &amp; Westwood, 1862)*</td>
<td>This study</td>
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<td>Phoxocephalus longipes (Della Valle, 1893)</td>
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<td>Harpinia cremulata (Boeck, 1887)</td>
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<td>Harpinia pecinata (Sars, 1861)</td>
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<td>A</td>
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<td>Metaphoxus fultoni (Scott, 1890)</td>
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<td><strong>Urothoidae</strong></td>
<td>Urothoe pulchella (Costa, 1853)</td>
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<td></td>
<td>Urothoe elegans (Costa, 1853)**</td>
<td>XI</td>
<td>M</td>
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</table>

Mediterranean coast among *Posidonia oceanica*, and *Cymodocea nodosa* from the Alicante coast (Vazquez-Luis *et al.*, 2009). Its depth-range was established (Bellan-Santini *et al.*, 1998) from 2 to 100 m in well-sorted sand bottoms and among photophilic algae. We have collected 5825 specimens from 12.4 to 20.0 m. It has been found in all locations, being especially abundant in northern locations (from Vinaroz to Torreblanca) and Canet d’en Berenguer, with a maximum density of 2125 ind/m² at Vinaroz in 2006.

**Family CORYPHIDAE** Leach, 1814

*Leptocheirus hirsutimanus* Bate, 1862

It was observed along the north-eastern Atlantic Ocean and Mediterranean Sea from 7 to 350 m (Bakalem & Dauvin, 1995; Bellan-Santini *et al.*, 1998). Its ecology was established as detritic and mud coastal bottoms and bathyal muds (Bellan-Santini *et al.*, 1982, 1998) as well as gravelly and coarse sand (Marques & Bellan-Santini, 1993). *Leptocheirus hirsutimanus* was first recorded from the Mediterranean Spanish coast by Conradi & López-Gonzalez (1999) in medium sand, biodetrital and hard bottoms from the Andalucian coast. We have found 26 individuals in Puebla de Farnals at 18.9 m water depth.

**Medicorophium runcinerve** Della Valle, 1893

This species has only been reported from the Mediterranean and Black Seas in mud and mobile substrates and among algae from 15 to 105 m (Bellan-Santini *et al.*, 1982, 1998; Bakalem & Dauvin, 1995). *Medicorophium runcinerve* was recorded for the first time from the Spanish coast by Conradi & López-Gonzalez (1999) in biodetrital, mud and clayey bottoms from the Andalucian coast. A total of 1304 individuals have been collected. It has been reported in all locations from 12.4 to 20 m water depth, obtaining the highest abundances in the locations of Gandia and Oliva (325 ind/m²).

**Medicorophium longisetosum** Myers, de-la-Ossa-Carretero & Dauvin, 2010

A total of 365 specimens were collected from all locations with a depth-range of 12.4 to 20 m. Numbers of specimens collected in the ten sampling sites varied from 211 individuals at Vinaroz to one specimen at Javea. The presence of this new species, which is habitual and relatively abundant, is the best example of the necessity for more taxonomic studies in this area. It was fully described in Myers *et al.* (2010).

**Family EUSTRIDEAE** Stebbing, 1888

*Apherusa alacris* Krapp-Schickel, 1969

This Mediterranean endemic species was established inhabiting among seagrasses (*Zostera*) and fine and coarse sand bottoms from 3 to 25 m (Bellan-Santini *et al.*, 1982, 1998). It was recorded for the first time in the Spanish Mediterranean coast by Conradi & López-Gonzalez (1999) among *Haloperis escoraria*. We have found 12 individuals in the locations of Alcossebre, Torreblanca and Oliva from 12.4 to 15.6 m in fine-sand bottoms.

**Family LEUCOTHOIDEAE** Dana, 1852

*Leucothoe oboa* Karaman, 1971

This species was previously established as a Mediterranean endemic and its ecology was established in muddy bottoms from 14 to 400 m (Bellan-Santini *et al.*, 1989, 1998), however, it was also reported from the Portuguese coast (Marques & Bellan-Santini, 1993) on gravelly and coarse sand bottoms from 52 to 97 m water depth. It was recorded...
in the Oran Gulf at a depth of 80 m on sandy mud and in the Oran Harbour on mud with shells (Grimes et al., 2009). *Leucothoe oboa* was first recorded from the Spanish Mediterranean coast by Conradi & López-Gonzalez (1999) in hard and sand biodetrital bottoms. We have found it in sandy bottoms with specimens of *Leucothoe incisa*. We have collected a total of 213 individuals from 12.4 to 20 m water depth. It has been found in all locations though always in low abundances (40 ind/m²).

Family **LYSIANASSIDAE** Dana, 1849

*Hippomedon massiliensis* Bellan-Santini, 1965

This Mediterranean endemic species was distributed on sandy and muddy bottoms from 4 to 350 m (Bellan-Santini et al., 1989, 1998). It was also recorded from Bou Ismail Bay (10–88 m) from sand to muddy gravel (Bakalem & Dauvin, 1995). *Hippomedon massiliensis* was only recorded from the Spanish coast by Conradi & López-Gonzalez (1999) in sand, mud and detrital bottoms as well as among Bugula neritina. We have collected 228 individuals from 12.4 to 20 m depth, distributed in all locations but always in low densities (up to 40 ind/m²).

**Lepidepecreum longicorne** Bate & Westwood, 1861

This species was observed in the north-eastern Atlantic Ocean and Mediterranean Sea at depths ranging from 0 to 360 m (Bellan-Santini et al., 1989, 1998; Bakalem & Dauvin, 1995). Its ecology is established in gravels and sand bottoms as well as abyssal and bathyal muds. *Lepidepecreum longicorne* was observed on the Spanish Mediterranean coast among *Posidonia oceanica* meadows along the Alicante coast and the Iberian coast, it was also previously recorded in Portugal (Marques & Bellan-Santini, 1993). We have found 46 specimens in northern locations (Vinaroz to Alcossebre), from 12.5 to 15 m water depth.

Family **MELITIDAE** Bousfield, 1973

*Maera knudseni* Reid, 1951

It is distributed in the Atlantic Ocean (West Africa) and the Mediterranean Sea (Bellan-Santini et al., 1982). It was common in Bou Ismail Bay on mud and sandy-muddy gravel between 45 to 100 m depth (Bakalem & Dauvin, 1995). Its ecology was established in mud, muddy sands, coarse sands, fine gravel and detritic bottoms with a depth range from 10 to 68 m (Bellan-Santini et al., 1982, 1998). *Maera knudseni* was previously observed in *Posidonia oceanica* meadows along the Alicante coast (Sanchez-Jerez et al., 2000). We have found 18 individuals only in Puebla de Farnals at 18.9 m water depth.

Family **ODYCEROTIDAE** Liljeborg, 1865

*Monoculodes gibbosus* Chevreux, 1888

This species was previously observed in the north-eastern Atlantic Ocean and Mediterranean Sea in soft bottoms from 10 to 360 m water depth (Bellan-Santini et al., 1993, 1998). It was reported in the Bejaia Gulf and Bou Ismail Bay on various sediment types ranging from mud to coarse sand and at depths from 24 to 86 m (Grimes et al., 2009). *Monoculodes gibbosus* was previously reported on the muddy bottoms of the deep slope in front of Barcelona (western Mediterranean) from 593 to 598 m water depth (Cartes & Sorbe, 1999). We have found 14 individuals from Vinaroz, Benicalo, Peñiscola, Puebla de Farnals and Oliva in 14 to 15.6 m.

**Synchelidium haplocheles** Grube, 1864

It is known from the Mediterranean Sea, Atlantic Ocean and Indo-Pacific Ocean (Bellan-Santini et al., 1993, 1998; Bakalem & Dauvin, 1995), living from 3 to 100 m water depth on well sorted sand and coastal terrigenous mud bottoms. *Synchelidium haplocheles* was previously recorded on beaches from the Catalonian coast (Munilla & San Vicente 2005). We have found 90 specimens at depths from 12.4 to 15.6 m in northern locations, Puebla de Farnals and Gandia.

Family **PHOTIDAE** Boeck, 1871

*Photis longicaudata* Bate & Westwood, 1862

This cosmopolitan species was observed in the Atlantic Ocean (from Norway to West Africa), the Indian Ocean and the Mediterranean Sea. Its ecology was established from infralitoral, among algae and *Posidonia* meadows, to bathyal (400 m), among mud and detritic bottoms (Bellan-Santini et al., 1989, 1998; Bakalem & Dauvin, 1995). Although it was previously recorded from the Atlantic Iberian coast (Marques & Bellan-Santini, 1993; Matinez & Adarraga, 2001), *Photis longicaudata* was not previously reported from the Spanish Mediterranean coast. Two specimens have been collected in Torreblanca at a depth of 13.9 m.

Family **UROTHOIDEAE** Bousfield, 1979

*Urothoe elegans* Costa, 1853

This species was observed in the Atlantic Ocean, Indian Ocean and Mediterranean Sea (western, Tyrrhenian, Adriatic, Israel and North Africa) associated with fine sediments distributed from 2 to 644 m (Bellan-Santini et al., 1989, 1998; Bakalem & Dauvin, 1995). *Urothoe elegans* was previously reported on the muddy bottoms of the deep slope in front of Barcelona (western Mediterranean) (Cartes & Sorbe, 1993, 1999). We have found 143 individuals, in locations at Canet d'en Berenguer, Puebla de Farnals and Javea, from 15.6 to 20 m water depth.

**Species distribution among locations**

Cluster analyses based on species composition showed a segregation of stations according to the north–south axis (Figure 2). In this way, locations from north of the studied area (Groups A and B) obtained similarities among them higher than 60% and location 10 (Group F), which is sited south of studied area, showed more dissimilarity than other locations.

Changes among these locations were due to a decrease in abundance of species such as *Autonoe spiniventris*, *Periculodes longimanus* or *Siphonocetes sabatieri* from north to south. Whereas, other species abundance increased in locations 8 and 9, such as *Amphelisa typica*, *Amphelisa tenuicornis* or *Medicorophium runcicorne*, or from locations 6 to 9 *Urothoe pulchella*, or from locations 7 to 9 *Photis longipes* (Table 3).

The influence of geographical situations of each location in amphipod assemblage was reflected in BEST and CCA results.
Latitude together with depth obtained the highest Spearman correlation (Rho: 0.609 and 0.606) with changes in species composition. The CCA showed that both parameters were related since the southern locations are slightly deeper than northern ones (Figure 3; Table 1). Both latitude and depth highly influence benthic communities and were related to other abiotic parameters such as hydrodynamic conditions, temperature, dissolved oxygen, granulometry and organic content. For instance, temperature, influenced by latitude and depth, affect most biological processes and act on growth rates, maturation or reproduction cycle. Despite the fact that species contributing to differences among locations displayed a wide bathymetric distribution, some of them could be less adapted to hydrodynamic processes than others (Bellan-Santini et al., 1998). The fine sand communities, such as the study area, are always influenced by high hydrodynamism which can remove the surface layer (Cardell et al., 1999), in such a way that local changes could change species abundances according to their capacity to shelter.

Other parameters such as mud percentage or organic matter showed a weak correlation (Rho: 0.291 and 0.208), whereas percentages of other granulometric sizes showed the lowest correlations (Rho < 0.2) with amphipod species composition. Changes in these parameters were related to species differences among close locations. Despite the fact that sediments in the area were homogeneous and low changes in granulometry among locations were registered, grain size and organic content are factors that may be related to food availability and the ability to burrow (Oakden, 1984; Marques & Bellan-Santini, 1993); as a result light changes in sediment from close areas could produce changes in species composition.

**BIogeographical Considerations**

The present study recorded a total of 55 total species, but for a limited length of Spanish coast (250 km) and only for sandy bottoms. Among these species, 30 have a north-eastern Atlantic distribution and 17 have a wide distribution in Atlantic and Indo-Pacific or Arctic Oceans (Bakalem & Dauvin, 1995; Bellan-Santini et al., 1998; Grimes et al., 2009). Meanwhile, only eight species were considered Mediterranean endemics. Among these endemics, six are reported as first or second records on the Spanish Mediterranean coast; and among the north-eastern Atlantic species Autonoe spiniventris and Leucothoe oboa are known only along the Iberian coast (Marques & Bellan-Santini, 1993; Martinez & Aderraga, 2001). Among the 20 species recorded for the first or second time on the Mediterranean coast, only two species Apherusa alacris and the new species Medicorophium longisetosum were absent along the Algerian coast (Bakalem & Dauvin, 1995; Grimes et al., 2009), and four species, namely the two same species for Algeria, plus the two Bathyporeia species, B. borgi and B. lindstromi, were absent from the French Mediterranean coast. This shows a good resemblance of the continental shelf amphipod fauna at the scale of the western part of the Mediterranean Sea.

A total of six species (>10% of the recorded species) was new for the Spanish coast, and among them a new species was described (Myers et al., 2010). This proves the need to significantly increase the prospection of the amphipods from the Mediterranean Spanish coast. To give some comparative numbers, the French Mediterranean continental shelf accounts for 250 Gammaridea (Dauvin & Bellan-Santini, 2002). Nevertheless records depended on the sampling efforts among the regions, respectively 240 in the 'Provence-Alpes Côte d’Azur' region which included the Marseilles Gulf where numerous studies were made mainly through the expertise of Denise Bellan-Santini, 100 for the 'Languedoc–Roussillon' region at the frontiers with Spain, and only 78 species around Corsica (Dauvin & Bellan-Santini, 2002). Recent works on Algerian amphipods, including three orders, i.e. Caprellidea, Gammaridea and Hyperidea (Bakalem & Dauvin, 1995; Grimes et al., 2005), revealed that the fauna accounts for 298 species of the 451 species recorded in the mid-1990s for the whole Mediterranean fauna. Using these records, we expected that the total amphipod marine fauna (Caprellidea, Gammaridea and Hyperidea) of the Mediterranean coast of Spain should include between 250 and 300 species. A first inventory of all

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**Table 3. Mean abundance of species contributing more in dissimilarities among groups established in CLUSTER analysis.**

<table>
<thead>
<tr>
<th>Species</th>
<th><strong>Average abundance (ind m⁻²)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
</tr>
<tr>
<td><em>Amphelica tenuicornis</em></td>
<td>20.45</td>
</tr>
<tr>
<td><em>Amphelica typica</em></td>
<td>140.15</td>
</tr>
<tr>
<td><em>Autone spiniventris</em></td>
<td>778.79</td>
</tr>
<tr>
<td><em>Medicorophium runcicorne</em></td>
<td>100.76</td>
</tr>
<tr>
<td><em>Perioculodes longimanus</em></td>
<td>220.45</td>
</tr>
<tr>
<td><em>Photis longipes</em></td>
<td>96.21</td>
</tr>
<tr>
<td><em>Siphonoecetes sabatieri</em></td>
<td>180.3</td>
</tr>
<tr>
<td><em>Urothoe pulchella</em></td>
<td>25.76</td>
</tr>
</tbody>
</table>
species collected in this area should be completed from published works particularly those of J.M. Guerra-Garcia on caprellids (Guerra-Garcia et al., 2000, 2001a,b, 2002, 2009a,b). Moreover, the higher percentage of endemics among first or second records indicates the need for more sampling studies in order to increase distribution knowledge of Amphipoda species from the Spanish Mediterranean coast.

ACKNOWLEDGEMENTS

This research would not have been possible without help from many people. We gratefully acknowledge the staff of the Department of Marine Sciences and Applied Biology and of the Station Marine de Wimereux. We also thank Dr Alan Myers for his inestimable collaboration with the species M. longisetosum sp. nov. I would like to especially thank Angel Climent Ballester’s for her invaluable help. We also acknowledge the contributions of the two anonymous referees on the first version of the manuscript. We gratefully acknowledge CONSORMAR S.A. and Entitat de Sanejament d’Aigües for the financial contribution. We are also grateful to the University of Alicante for awarding a predoctorate grant to J.A.O.C. for a stay in Station Marine de Wimereux (France) and to this host institution for the admission.

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