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Research Article

New records of the genus *Pachygrapsus* (Crustacea: Decapoda) from the central Mediterranean Sea with a review of its Mediterranean zoogeography

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Abstract

The occurrence of *Pachygrapsus maurus* and *Pachygrapsus transversus* is reported from the Maltese Islands for the first time on the basis of one specimen of *P. maurus* collected in 1990 and numerous recent specimens, and the distribution of the two species is mapped. The controversial presence of *P. maurus* in Italy is confirmed and two new sites for this species are reported, including the first for the mainland of Italy. The examination of the historical specimen of *P. maurus* from the Genova area revealed a misidentification of *P. transversus*; this record could be a result of ship-mediated transport. First notes on the habitat of *P. maurus* in the central Mediterranean Sea are given. Updated maps of the distribution of *P. maurus* and *P. transversus* in the Mediterranean are provided and the zoogeography of these species is revisited.

Keywords: *Pachygrapsus marmoratus*; *Pachygrapsus maurus*; *Pachygrapsus transversus*; Zoogeography; Mediterranean Sea.

Introduction

The grapsid genus *Pachygrapsus* Randall, 1840 has been recently revised by Poupin *et al.* (2005) who recognized at least 12 valid species. Subsequently, Schubart *et al.* (2005), on the basis of morphological and genetic differences between populations of *Pachygrapsus transversus* sensu Rathbun (1918) and subsequent authors up to 2005, reinstituted the taxon *P. socius* Stimpson, 1871 for Eastern Pacific populations, raising to 13 the number of valid species in the genus.

Three species included in *Pachygrapsus* occur in the Mediterranean Sea: *P. marmoratus* (Fabricius, 1787), *P. maurus* (Lucas, 1846) and *P. transversus* (Gibbes, 1850); although these species can be readily distinguished on the basis of morphological features (Zariquiey Alvarez, 1968) (Fig. 1),

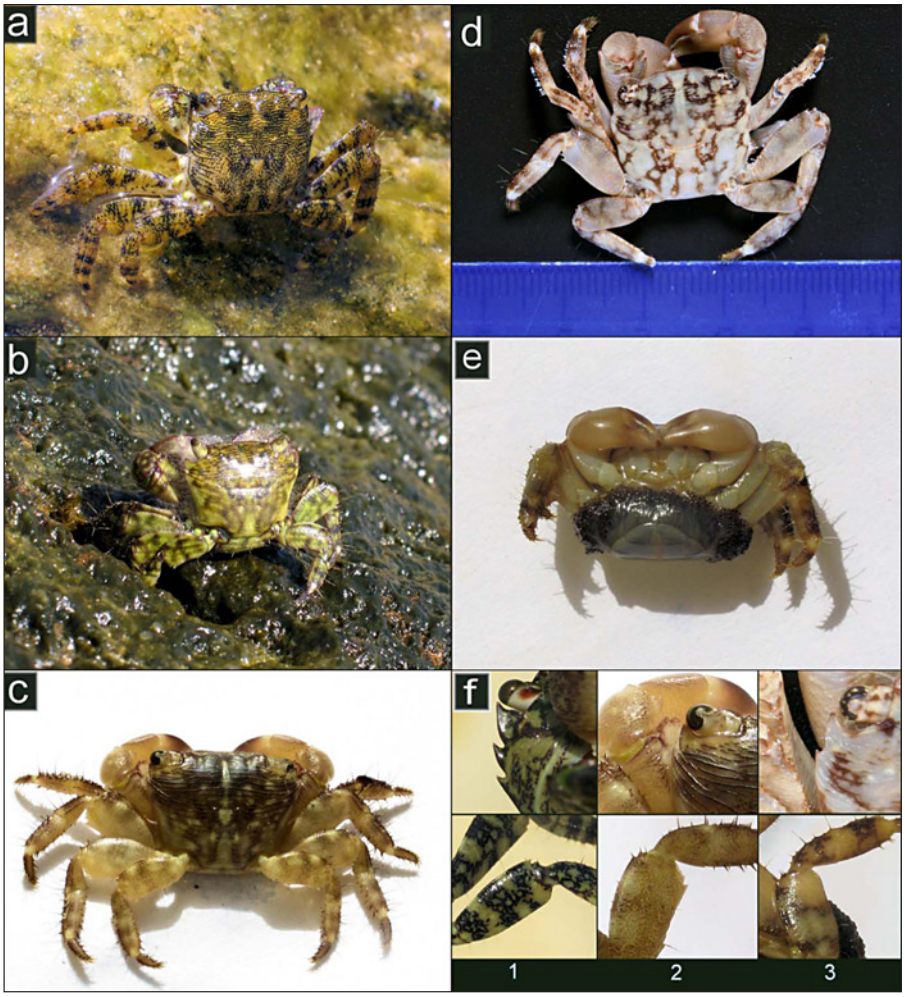

Fig. 1 a: *Pachygrapsus marmoratus* from Malta. f1. Diagnostic characters. ***b-c:*** *Pachygrapsus transversus* from Malta. f2. Diagnostic characters. ***d-e:*** *Pachygrapsus maurus* from Malta. f3. Diagnostic characters. Diagnostic characters are the number of post-orbital spines and the presence or absence of apical spines on the posterior border of the meropodite of the fifth pereiopod.

the zoogeography of the latter two species in the Mediterranean is not at all clear.

The present contribution reports for the first time the presence of *P. maurus* and *P. transversus* in the Maltese Islands and reviews their occurrence in Italy. Previous reports of these species from the Mediterranean are collated and reviewed and updated distribution maps are given together with a discussion of zoogeography.

Material and Methods

The occurrence of *Pachygrapsus maurus* and *Pachygrapsus transversus* in the Maltese Islands was noted more or less simul-

taneously in Gozo by two of us (JP and SM, respectively). Subsequently, systematic searches for both species were made by the same person (JP), with an approximately equal searching effort, in 33 rocky sites on the three main islands of the Maltese archipelago during the period VI-IX 2009 to map their local distribution (Table 1; Fig. 2). Searches were made from 08.00h to 11.00h with the exception of Dwejra, where searches were also made at other times during the day. Particular attention was paid to crevices, holes, rock pools and any other topographical features where crabs could seek shelter. A limited number of individuals were preserved in 70% ethanol for subsequent studies in the laboratory. Private collections of decapods were examined for possible specimens of *P. maurus* and *P. transversus* that may have gone undetected amongst material of *P. marmoratus,* or have been misidentified as such.

The occurrence of *P. maurus* in the Tuscan Archipelago was noted by one of us (PP) during field studies on the local polyplacophoran fauna. The species was recorded during two visits in August 2008 to Cala Buia near Baratti, on the north side of the Piombino promontory (Tuscany, northern Tyrrhenian Sea). Specimens were collected, identified in the laboratory and dry-preserved. A record of *Pachygrapsus maurus* from Lampedusa Island (Italy), based on photographs examined by one of us (FC), is also included here. The historical specimen of *'P. maurus'* from Genova (Colosi, 1923) was traced to the Museo Regionale di Scienze Naturali di Torino (Cr.1143-MRSN ex 191-MZUT) and examined.

The carapace width (CW) and carapace length (CL) of all preserved specimens were measured to the nearest 0.05 mm using vernier callipers. Sizes reported in 'Material examined' are in millimetres and given as CL x CW. Unless otherwise specified, *legit* of all Maltese specimens is Joseph Piscopo. Abbreviations used: leg., *legit;* AM, Adrian Mallia; JC, John Camilleri;

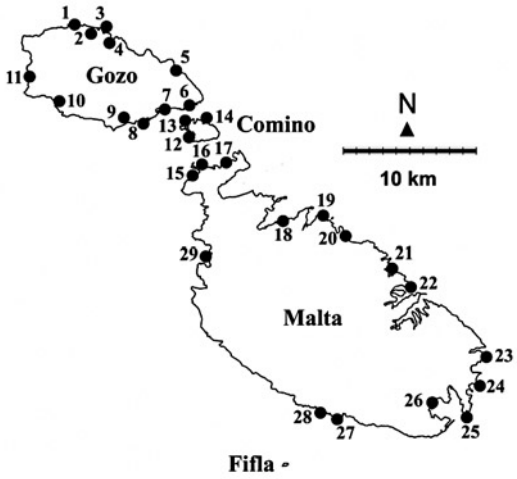

Fig. 2: Map of the Maltese Islands showing localities where species of *Pachygrapsus* were sampled.

LC, Luca Corradi; PJS, Patrick J Schembri; PP, Paolo Paolini; RG, Ramon Grech; SM, Stephen Mifsud.

Results

Taxonomic account

Pachygrapsus maurus (Lucas, 1846)

Grapsus maurus Lucas, 1846: 20, vol. 4, pl. 2, fig. 5 [type locality: Oran, Algeria]

? Pachygrapsus maurus (Heller), Magrì, 1911: 17. [see Table 2, notes]

? Pachygrapssus maurus (Theller) (sic!), Misuri, 1914: 264. [see Table 2, notes]

Not *Pachygrapsus maurus sensu* Colosi, 1923: 10; Steinitz, 1933: 152; Bodenheimer, 1935: 468; 1937: 281; Gottlieb, 1953: 441.

Pachygrapsus maurus, Zariquiey Alvarez, 1948: 291; Zariquiey Alvarez, 1952: 46; Zariquiey Alvarez, 1962: 34; Zariquiey Alvarez, 1963: 154; Zariquiey Alvarez, 1956: 405; Zariquiey Alvarez, 1968: 424; García Raso & Jiménez Millán, 1981: 22; Kocataş, 1981: 162; García Raso, 1984: 108; García Socias & Gracia, 1988: 54; d'Udekem d'Acoz, 1994: 36; d'Udekem d'Acoz, 1999: 255; Poupin *et al.,* 2005: 28; Vaccaro & Pipitone, 2005: 679; Doğan *et al.,* 2008: 1360.

Material examined

Maltese Islands. Gozo: Hondoq ir-Rummien, 21 II 2009, 1 ♂ (15,1x16,85), 1 ♀ (11,75x12,9); 27 II 2009, 1 ♀ (13,3x15,5), PJS, JC & RG leg.; Xatt l-Ahmar, 31 V 2009, 1 ovigerous ♀ observed, SM leg.; Dwejra, Il-Qasir, 10 VI 2009, 12 ♂♂ (10,9x12; 8,3x9,4; 10,9x11,9; 8,4x9,3; 11,4x12,5; 11,4x12,6; 12,9x13,8; 10,5x11,85; 13,35x14,2; 11,7x12,9; 10,85x11,9; 9,2x10,4), 3 ♀♀ (10,8x12,1; 12,5x13,95; 9,7x11), 5 ovigerous ♀♀ (10,3x11,5; 11,1x12; 11,5x13; 11,1x12,4; 10,8x12,1); Dwejra, Il-Port, 10 VI 2009, 1 ♂ (10,85x11,9), 1 ♀ (12,2x13,6), 2 ovigerous ♀♀ (8,9x10,15; 10,6x12); Marsalforn, 15 VI 2009, 1 ♂ (12,7x13,9), 1 ovigerous ♀ (11,85x13); Dahlet Qorrot, 20 VI 2009, 1 ♂ (13,35x14,4), 1 ovigerous ♀ (9,7x11,1); Hondoq ir-Rummien, 20 VI 2009, 1 ♂ (14,4x15,4), 1 ♀ (10,8x12); Zewwieqa, 26 VII 2009, 1 ♂ (15,1x16,1); Xlendi, 29 VII 2009, 1 ♂ (14,6x15,9), 1 ovigerous ♀ (13,15x14,4). Comino: Crystal Lagoon, 8 VIII 2009, 1 ♀ (13,5x14,7). Malta: Xghajra, Summer 1990, 1 ♂ (10,2x11,9), AM leg.; Wied iz-Zurrieq, 27 VI 2009, 2 ♂♂ (14,8x16; 16,7x17,8); Ghar Lapsi, 27 VI 2009, 1 ♂ (5,85x7,1), 2 ovigerous ♀♀ (7,8x9,1; 11,2x12,6); Delimara, 03 VII 2009, 3 ♂♂ (14,25x15,5; 16,55x17,5; 8,3x9,1), 1 ovigerous ♀ (15,5x16,9); St. Thomas bay, 03 VII 2009, 1 ovigerous ♀ (10,1x11,4); Sliema, 16 VII 2009, 3 ♂♂ (11,1x12,05; 15,1x16,2; 12,9x14), 1 ♀ (13,2x14,6); St. Julians, 16 VII 2009, 1 ♂ (8,6x9,95), 1 ♀ (14,35x16,3); Armier Bay, 21 VII 2009, 1 ♀ (13x14,3). Italy. Sicily: Lampedusa, Guitcia, 14 VIII 2007, photo of one specimen, LC leg. Tuscany: Piombino, Cala Buia, 1 VIII 2008, 1 ♀ (9,2x10,1), PP leg.; 26 VIII 2008, 1 ♂ (11x12,2), 1 ♀ (11,1x11,9), 5 juveniles (CL about 4-5 mm) observed, PP leg.

Mediterranean distribution and relevant notes

The Mediterranean distribution of *P. maurus* is summarized in Table 2 and mapped in Figure 3. The occurrence or otherwise of *P. maurus* in Italian waters is a complicated question. At least three old works reported its presence in Sicily (Magrì, 1911; Misuri, 1914) and along the northern Tyrrhenian shores (Colosi, 1923), but have been overlooked by subsequent authors (Zariquey Alvarez, 1968; Pastore, 1972; Ševčić & Galil, 1994; D'Udekem d'Acoz, 1999; Pipitone & Arculeo, 2003), who did not men-

Table 1
Localities for *Pachygrapsus* spp. in the three main islands of the Maltese archipelago with an estimate of abundance and notes on habitat. Sites correspond to sampling locations mapped in Figure 2. Key: +++ = abundant (> 2 individuals/m²); ++ = common (1 - 2 individuals/m²); + rare (<1 individual/m²).

Site	Locality	Species and abundances			Shore type
		P. marmoratus	*P. maurus*	*P. transversus*	
	GOZO				
1	Wied il-Ghasri	+++	-	-	Cliff shore
2	Xwejni Bay	+++	-	-	Cobble shore
3	Qbajjar	+++	-	-	Lowland rocky shore
4	Marsalforn	+++	+	-	Lowland rocky shore
5	Dahlet Qorrot	++	+	-	Lowland rocky shore and boulder shore
6	Hondoq ir-Rummien	+++	+	-	Boulder and cobble shore
7	Zewwieqa	++	+	-	Lowland rocky shore
8	Xatt l-Ahmar	++	+	+	Lowland rocky shore
9	Mgarr ix-Xini	++	-	-	Cobble shore
10	Xlendi	++	+	-	Lowland rocky shore
11a	Dwejra-Cliffs	+	-	-	Cliff shore
11b	Qawra Inland Sea	+++	-	-	Cobble shore
11c	Dwejra-Iz-Zerka	+++	-	-	Lowland rocky shore
11d	Dwejra-Il-Qasir	+	+++	-	Lowland rocky shore
11e	Dwejra-Il-Port	+	++	+	Lowland rocky shore
COMINO					
12	Crystal Lagoon	+	+	-	Cliff shore
13	Blue Lagoon	+	-	+	Lowland rocky shore
14	Santa Marija Caves	+	-	-	Lowland rocky shore
MALTA					
15	Paradise Bay	+++	-	-	Boulder and cobble shore
16	Cirkewwa	+++	-	-	Lowland rocky shore
17	Armier Bay	++	+	-	Lowland rocky shore
18	St. Paul's Bay	++	-	-	Concrete piers
19	Ghallis	++	-	-	Lowland rocky shore
20	Bahar ic-Caghaq	+++	-	-	Lowland rocky shore
21	St. Julians	++	+	-	Lowland rocky shore
22	Sliema	+	++	-	Lowland rocky shore
23	St. Thomas Bay	++	+	-	Lowland rocky shore
24	Xrobb l-Ghagin	++	-	-	Lowland rocky shore
25	Delimara	+++	+	-	Lowland rocky shore
26	Marsaxlokk Bay	+++	-	-	Lowland rocky shore
27	Wied iz-Zurrieq	+++	+	-	Lowland rocky shore
28	Ghar Lapsi	+	+	-	Lowland rocky shore
29	Golden Bay	+	-	-	Boulder shore

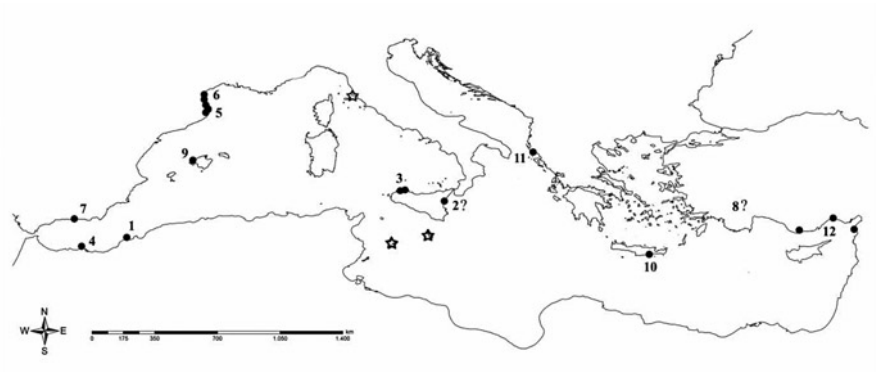

Fig. 3: The known Mediterranean distribution of *Pachygrapsus maurus* (Lucas, 1846). Stars are new sites reported in the present paper.

tion *P. maurus* as a species occurring along the Sicilian or Italian shores. The sole partial exception was Froglia (1995), who mentioned its presence in Ionian and Tyrrhenian Sicily following Magrì (1991) and Misuri (1914) (Carlo Froglia, pers. comm.). A recent work by Vaccaro & Pipitone (2005) reports *P. maurus* as a common species co-occurring with *P. transversus* in Sicily, without providing any details. Distributional data listed in Froglia (1995) will be amplified in the new checklist of the Decapoda of Italy and neighbouring countries, in the light of recent records by d'Udekem d'Acoz (1999) from Ionian Greece and by Vaccaro & Pipitone (2005) from Tyrrhenian Sicily (Carlo Froglia, pers. comm.). However, we note that both Magrì (1911) and Misuri (1914) based their identifications on Heller (1863). Since the latter work does not include *P. transversus* and this species would key out as *'P. maurus'* using Heller's (1863) key, without examining Magrì's and Misuri's specimens, it is not possible to be certain of the exact species these authors collected, and thus we have decided to consider their records as unconfirmed. Moreover, the Misuri collection appears to no longer be extant, at least where it was originally deposited (M. Sarà, pers. comm.). Finally, the record of *P. maurus* by Colosi (1923) has been shown to be erroneous and to actually refer to *P. transversus*: in the absence of any evidence that this species is indigenous to the area, we speculate on a possible introduction through ship-mediated transport.

Pachygrapsus transversus (Gibbes, 1850)
Grapsus transversus Gibbes, 1850: 181 [type locality: Key West, Florida]
Pachygrapsus advena Catta, 1876: 7, pl. 1.
Pachygrapsus maurus sensu Colosi, 1923: 10; Steinitz, 1933: 152; Bodenheimer, 1935: 468; 1937: 281; Gottlieb, 1953: 441.
? Pachygrapsus transversus, Menioui, 1992a: 90; 1992b: 97. [see Table 2, notes]
Pachygrapsus transversus, Calman, 1927: 216; Balss, 1936: 45; Bouvier, 1940: 290; Carmin, 1955: 2; Forest & Guinot, 1958: 13; Holthuis & Gottlieb, 1958: 101; Holthuis, 1961: 59; Kinzelbach, 1964: 266; Boschma, 1968: 108; Christiansen, 1969: 92; Lipkin & Safriel, 1971: 7; Ramadan & Dowidar, 1976: 133; Shiber, 1977: 185; Shiber, 1981: 871; Manning & Holthuis, 1981:

234; García Raso & Jiménez Millán, 1981: 22; García Raso, 1984: 108; Lewinsohn & Holthuis, 1986: 51; Warburg *et al.,* 1987: 761; Warburg & Schwartz, 1993: 33; d'Udekem d'Acoz, 1999: 256; Garcia, 1994: 59; Fishelson, 2000: 413; Kocataş *et al.,* 2001: 154; Poupin *et al.,* 2005: 44; Schubart *et al.,* 2005: 103; Vaccaro & Pipitone, 2005: 677; Zaouali *et al.,* 2007: 2; Warburg *et al.,* 2007: 71; Hasan *et al.,* 2008: 530.

Material examined

Maltese Islands. Gozo: Xatt L-Ahmar, 30 VI 2007, photo of one specimen, SM leg.; Xatt l-Ahmar, 31 V 2009, 1 ♂ (11,5x14,1), SM leg., 2 VI 2009, 1 ♂ (6,8x8,2), SM leg; Dwejra, Il-Port, 6 X 2009, 1 ovigerous ♀ (13,6x17). Comino: Blue Lagoon, 30 VII 2009, one specimen observed. Italy. Liguria: Genova, 1 ♂ (15x18), MRSN - Cr. 1143.

Mediterranean distribution and relevant notes

In compiling records of this species, we have noted that the record from the Sea of Marmara by Christiansen (1969) is based on a misinterpretation by Holthuis (1961) of a locality on the southern coast of Turkey near Antalya, and we correct this here. The Mediterranean distribution of *P. transversus* is summarized in Table 2 and mapped in Figure 4. The record from the Aegean Sea by Vaccaro & Pipitone (2005) is not included here since it is based on a misunderstanding of Koukouras (1972), who only refers to the original record of this species from the Aegean by Kinzebach (1964) and not to a second record. Records from the Mediterranean coast of Morocco (Menioui, 1992a; 1992b) are considered doubtful due to the implied absence of the otherwise ubiquitous *P. marmoratus,* and need to be confirmed to eliminate the possibility of misidentification.

Observations

Table 1 gives the results of the surveys for *Pachygrapsus* spp. made on Maltese shores. In the Maltese Islands, both *P. maurus* and *P. transversus* only occurred on Coralline Limestone shores and were never found on Globigerina Limestone ones, nor on artificial (concrete) shores and vermetid platforms. Ovigerous females of both species were found. In general, *P. maurus* seemed to prefer exposed shores and in embayments it was only found along the headlands at the mouth of the bay. The highest population densities of *P. maurus* were recorded at Il-Qasir in Dwejra (Gozo), one of the most exposed shores in the Maltese Islands. The crabs sheltered in holes in the rock where they fitted snugly and were only occasionally found in crevices. Moreover, where *P. maurus* co-occurred with *P. marmoratus,* the first occurred mainly in the upper mediolittoral/supralittoral zone and rarely at sea level, while the latter was found closer to sea level in the lower mediolittoral. *P. marmoratus* also commonly occurred in rock pools, where *P. maurus* was never found. The few specimens of *P. transversus* found in the Maltese Islands only occurred close to sea level either on algal turf or amongst algae.

At Cala Buia individuals of *P. maurus* occurred on the seaward margin of a *Lithophyllum byssoides* and vermetid cornice rich in encrusting Rhodophyta and exposed to strong wave action under N and NW winds. Crabs were noted to move rapidly among the small vermetid gastropods and rocky crevices at sea level. Five juvenile specimens were observed in the field but were not caught. Adults and juveniles of *P. marmoratus* were also recorded at the same site.

Table 2

Literature records of *Pachygrapsus maurus* (M) and *P. transversus* (T) from the Mediterranean Sea with localities of occurrence, date of record, material examined (where given; NS = not stated; † = dead specimen; sps = specimen/s; juv = juvenile/s) and notes on the record (# = our notes). Abbreviations used: MRSN (Museo Regionale di Scienze Naturali di Torino).

Locality and date	Species	Reference	Material	Notes
Algeria				
Oran Bay - 1840-42	M - 1	Lucas, 1846	2♂♂	During summertime. # Type locality.
Cyprus				
Almost all the Island – see notes	T - 7	Lewinson & Holthuis, 1986; Kocataş *et al.,* 2001.	2♀♀, 4juv NS	X-1968-69 (1♀, 4juv). V-1984 (1♀). V-1997 (NS) + VII-1998 (NS).
Egypt				
From Abu Qir area to Port Said area	T - 3	#1 Holthuis & Gottlieb, 1958;	NS	#1 - VI-1922 or
Port Said - 1922		#2 Poupin *et al.*, 2005.	1♂, 1♀	#2 - VII-1922?
Port Said - 1924		Calman, 1927.	NS	
Abu Qir		Balss, 1936.	1♀	
W of Abu Qir to Port Said - 1961-71		Ramadan & Dowidar, 1976.	NS	
France				
Marseille - 1873	T - 1	#Catta, 1876; Bouvier, 1940.	2sps	Described as a new species, *P. advena.* # First Mediterranean record, but found on a ship. There is no evidence that the species has survived in the area.
Argel, Banyuls sur Mer	M - 6	Zariquiey Alvarez, 1968; d'Udekem d'Acoz, 1999; Poupin *et al.*, 2005.	NS, 1♀	
Greece				
Pigadia Bay (Karpathos Island) - 1963	T - 6	Kinzelbach, 1964; Boschma, 1968.	2♂♂, 1NS 1†	IV. One specimen with *Sacculina carcini.* IX (1†).
Koutsounari (Crete) - 1983-87	M - 10	d'Udekem d'Acoz, 1994.	14♂♂,	One ♂ with *Sacculina carcini.* Five 8♀♀ ovigerous ♀♀ with blackish eggs.

(continued)

Table 2 (Continued)

Locality and date	Species	Reference	Material	Notes
Saraciniko (NW of Parga) - 1993	M - 11	d'Udekem d'Acoz, 1999; d'Udekem	1 sps	
		d'Acoz, pers. comm.		
Israel				
From Haifa area to Bat Yam area	T - 4			*P. transversus* commoner than *P. marmoratus.* Usually from V-VI to XII.
Haifa area - 1925-1984-99		Steinitz, 1933; Warburg *et al.*, 1987; Warburg & Schwartz, 1993; Warburg *et al.*, 2007.	NS, 352sps	From III. Catch and release.
Athlit area - 1929-1950		Carmin, 1955; Holthuis & Gottlieb, 1958; Forest & Guinot, 1958.	NS 1♂, 5♀♀	VI-1929. Legit Carmin. 1950: VI (1♂, 4♀♀). VII (1♀).
Caesarea area - 1951-54		Gottlieb, 1953; Holthuis & Gottlieb, 1958; Forest & Guinot, 1958.	NS 11♂♂, 11♀♀, 2juv	1951-54. From III to VI. 1951-52: IX (1juv). XII (6♂♂, 3♀♀, 1juv). III (1♀). V (3♂♂, 4♀♀). VI (2♂♂, 3♀♀).
Mikmoret area - 1960-64		Lipkin & Safriel, 1971.	NS	
Tel Aviv area 1929-32 - 1966		Carmin, 1955; Holthuis & Gottlieb, 1958;	NS	Legit Carmin. 1929: V, VI. 1930: I. 1931: XII. 1932: VI.
Bat Yam area - 1929		Schubart *et al.,* 2005. Carmin, 1955; Holthuis & Gottlieb, 1958.	1♂, 1♀ NS	 VI-1929. Legit Carmin.
Not stated		Bodenheimer, 1935; 1937; Fishelson, 2000.	NS	

(continued)

Table 2 (Continued)

Locality and date	Species	Reference	Material	Notes
Italy				
Aci Trezza (Catania)	M - 2	#Magrì, 1911.	NS	Rare, fished with "tartarone" from XII to IV. # see Mediterranean distribution and relevant notes.
NW Sicily	M - 3			
Off Palermo Harbour		#Misuri, 1914.	1sps	Already present in the area. # see Mediterranean distribution and relevant notes.
Ustica-Addaura-Isola delle Femmine Mongerbino - 2002-2004		Vaccaro & Pipitone, 2005.	NS	V-VIII. Always co-occurring with *Pachygrapsus marmoratus* and *P. transversus.*
Genova	T - 2	#Colosi, 1923.	1sps	Specimen deposited in MRSN. # see Mediterranean distribution and relevant notes (of *P. maurus*).
Ustica-Addaura-Isola delle Femmine-Mongerbino (NW Sicily) - 2002-2004	T - 12	Vaccaro & Pipitone, 2005.	8♂♂, 5♀♀, other sps	Ustica (VII, 1♂); Addaura (V, 1♂, 1♀); Isola delle Femmine (VI, 2♂♂); Mongerbino (VIII, 6♂♂, 3 ovigerous ♀♀). See also notes in M - 3.
Lebanon				
Ras Beirut area - 1975-77	T - 8	Shiber, 1977; Shiber, 1981.	23sps 7 sp, 1♀	Four sites. Common from early spring and into the fall months. One ovigerous ♀.
Morocco				
Melilla - 1946	M - 4	Zariquiey Alvarez, 1948; 1952.	1♂	VI.
Cap de l'Eau area	T - 10	#Menioui, 1992a; #Menioui, 1992b.	21sps, 4sps	IX. I. # see Mediterranean distribution and relevant notes.

(continued)

Table 2 (Continued)

Locality and date	Species	Reference	Material	Notes
Spain				
Cadaqués area-Girona littoral - 1946-60's	M - 5	Zariquiey Alvarez, 1948; 1956; 1962; 1963; 1968; Poupin *et al.,* 2005.	NS, 4♂♂, 1♀	Many specimens (adults and juveniles). Ovigerous ♀♀ in VII, VIII, IX. One ovigerous ♀ in VII.
Malaga area - 1978-1981	M 7	Garca Raso & Jiménez Millán, 1981;	2sps (M)	
Balearic Islands	T 9	García Raso, 1984; García Raso *et al.,* 1987.	3sps (T)	
Sóller (Palma de Mallorca) - 1984-1986	M 9	García Socias & Gracia, 1988.	1♂, 1♀	VIII-1984 (♂). XI-1986 (♀) on floating material. One specimen with a Sacculinidae.
Portixol (Palma de Mallorca) - 1993	T 11	Garcia, 1994.	1♂	VII. Co-occurring with *P. marmoratus.*
Cala Vedella, St. Vincent (Ibiza) - 2001	T 11	Schubart *et al.,* 2005.	1♀, 3juv	
Syria				
Lattakia area - 2006	T - 13	Hasan *et al.,* 2008.	6♂♂, 5♀♀	IV, VIII, IX. Several sites. 1 ovigerous ♀ in VIII.
Tunisia				
Zarzis Harbour - 2006	T - 14	Zaouali *et al.,* 2007.	1♀	Harbour area. IX - ovigerous.
Turkey				
Antalya, Selimiye, Mersin - 1959	T - 5	Holthuis, 1961.	1♂, 2♀♀	Antalya (IV, 1♀); Selimiye (V, 1♂); Mersin (V, 1♂).
Mediterranean Turkey	M - 8	#Kocataş, 1981; #Kocataş & Katagan, 2003.	NS	# No exact localities.
Eastern Mediterranean Turkey - 2005	M - 12	Doğan *et al.,* 2008.	4 sps	IX. Three different sites.

Discussion

Pachygrapsus marmoratus is clearly a Northwest Atlantic-Mediterranean species that occurs throughout both basins of the Mediterranean, in the Sea of Marmara and in the Black Sea, in most islands of the Macaronesian archipelagos, and on the mainland Atlantic coast from Morocco to the French coast at the western entrance of the English Channel (D'Udekem d'Acoz, 1999; Ingle & Clark, 2008; Dauvin, 2009).

Pachygrapsus maurus seems to be a predominantly Macaronesian-West Mediterranean species, with stable populations in all the Macaronesian archipelagos, except for the Cape Verde Islands, and patchily distributed Mediterranean populations along the Spanish coast, including the Balearic Islands, France and the Tyrrhenian shores of Italy. Its presence in the eastern basin seems to be more sporadic, with a few records from the Ionian coast of Sicily, Greece close to the Strait of Otranto, Crete in the Aegean, and from the southern coast of Turkey. Altogether, only three specimens are known from the Mediterranean shores of Africa (two from 1840-42 and one from 1946), all from the Algerian and Moroccan coasts in the western basin, while there are no records of this species from Corsica and Sardinia, the Adriatic, and the entire southern and eastern shores of the Mediterranean from western Algeria to the Turkish-Syrian border (Table 2; Fig. 3). Were it not for the records of this species from Crete (D'Udekem d'Acoz, 1994) and the present records from Lampedusa and Malta, this crab would have a typical northern Mediterranean distribution characteristic of less thermophilic species. No information is available on the thermal biology of this species, which is unfortunate in view of the current interest in possible biogeographical shifts in the distribution of temperature-sensitive species powered by the warming of the Mediterranean (e.g. Bianchi, 2007). According to Poupin *et al.* (2005), the patchy Mediterranean distribution is due to the rarity of suitable habitats. However, our observations on Malta show that here at least, *P. maurus* is neither limited to coralline algal trottoirs, as some authors have suggested (e.g. Zariquiey Alvarez, 1948; 1968), nor to *Brachidontes pharaonis* beds as in Turkey (Doğan *et al.,* 2008) or to vermetid platforms (Chemello, 2009), but seems to prefer a narrow ecological niche constituted by topographically complex rocky shores exposed to intense wave hydrodynamism, as supposed by d'Udekem d'Acoz (1994). Moreover, no specimens were found in *Brachidontes* facies during this or previous studies in the Maltese Islands (Mifsud & Cilia, 2009) and along the Calabrian shores of the Messina Strait area (Crocetta *et al.,* 2009; Crocetta, pers. obs.). *P. maurus* may well occupy a rather specific microhabitat on exposed rocky shores but there is no reason to believe that such microhabitats are not more widespread in the Mediterranean than suggested by the known distribution of this species. Observations made in the Maltese Islands suggest a spatial partitioning with respect to the other two *Pachygrapsus* species, but this was not confirmed by field observations from Cala Buia, where both *P. maurus* and *P. marmoratus* occurred at sea level. Further studies are therefore needed to understand how the crabs reduce interspecific competition when sympatric.

Pachygrapsus transversus has a wide distribution on both coasts of the tropical and subtropical Atlantic, including many island groups, and in the Mediterranean, where it has a more or less tripartite distribution with records from the western part of the West Basin (Spain), records from the Cen-

tral Mediterranean (Tunisia, Sicily and Malta, where it is a rare species in all three localities), and established populations in the eastern part of the East Basin (Egypt, Israel, Lebanon, Syria, Cyprus, with a few records from southern Turkey and the Aegean Sea) (Table 2; Fig. 4). The origin of the entire eastern Mediterranean population of *P. transversus* has been hypothesized to be due to an initial accidental introduction to the Levantine coasts (Holthuis & Gottlieb, 1958), although Manning & Holthuis (1981) have subsequently suggested a natural range for this species from Angola to the eastern Mediterranean Sea, and therefore along the entire north coast of Africa. However, this hypothesis is not supported by records of *P. transversus* from the Mediterranean African coast, apart from those listed in Table 2. The distance tree based on mtDNA sequences in Schubart *et al.* (2005) suggests that the West and East Basin populations of this species are genetically close and much closer to Eastern Atlantic populations than to Western Atlantic ones. It suggests an Eastern Atlantic source population for the Mediterranean populations of *P. transversus* whether these originated through a natural range extension into the Mediterranean from West Africa or through human transport, or a combination of both processes. Several workers have hypothesized a relict Mediterranean distribution of this essentially Atlantic species (Por, 1978; Almaca, 1985; Zibrowius, 1991), but the lack of studies of upper-shore crabs by taxonomists, especially along the African Mediterranean shores, makes such a suggestion premature. The ecological niche of *P. transversus* is somewhat puzzling. *P. transversus* occupies a wide array of habitats along its Mediterranean distributional range. It has been reported from rock pools and holes in the mediolittoral (Shiber, 1981; Lewinsohn & Holthuis, 1986; Fishelson, 2000) as well as in the upper infralittoral (Holthuis, 1961; Kinzelbach, 1964; Garcì a Raso & Jiménez Millá n, 1981), and it has been found in the mediolittoral on cobble (Warburg *et al.,* 2007) and rocky (Lipkin & Safriel, 1971) shores, on infralittoral rocky bottoms (Garcì a Raso & Jiménez Millá n, 1981; Hasan *et al.,* 2008), among algae (Holthuis, 1961; Hasan *et al.,* 2008), on sandy bottoms with stones, or with stones and *Posi-*

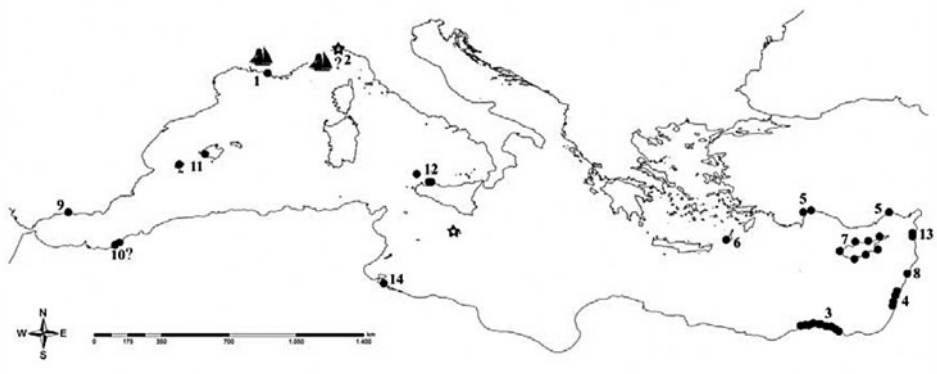

Fig. 4: The known Mediterranean distribution of *Pachygrapsus transversus* (Gibbes, 1850). Stars are new sites reported in the present paper. The ship symbols represent occurrences probably as a result of ship-mediated transport.

donia (Holthuis, 1961), and associated with vermetid platforms (Vaccaro & Pipitone, 2005; Chemello, 2009). In the Maltese Islands it was only found close to sea level, either on algal turf or amongst algae, suggesting that the species could occupy the same ecological niche as *P. marmoratus* and further studies are therefore needed to understand niche partitioning in these species. The wide ecological valency of *P. transversus* is not consistent with its patchy Mediterranean distribution. As for *P. maurus,* the paucity of records of *P. transversus* may well be an artefact of lack of studies along the African Mediterranean coasts and possibly also due to misidentification of the species as *P. marmoratus.*

The new records reported here immediately raise the question of the origin of these crabs. The decapod fauna of the Maltese Islands was last reviewed by Schembri & Lanfranco (1984), who, on the basis of literature records and examination of collections, only listed *Pachygrapsus marmoratus.* The past presence of the other two species seems to be excluded since examination of old collections and of photographs did not reveal any specimens attributable to any species other than the ubiquitous *P. marmoratus* prior to 1990. Moreover, while only very few individuals of *P. transversus* have been found, *P. maurus* occurs as considerable populations on all the three main islands of the Maltese archipelago and on shores that are much frequented, including by naturalists and by others collecting shore crabs for scientific research or use in student practicals. Human-mediated transport also seems to be excluded. The ease with which shore and shallow water grapsids are transported by vessels or with floating objects has been commented on by many (e.g. Wolff, 1954; Garcia, 1994) and the documented transport of *P. transversus* by ships to localities, usually ports, outside its natural distributional range (e.g. Catta, 1876; Christiansen, 1969), led Zaouali *et al.* (2007) to suggest that their recent record of this species from Tunisia was the result of ship-mediated transport. However, in Malta, neither *P. maurus* nor *P. transversus* have been found within or close to the commercial port areas (the Valletta harbours and Marsaxlokk Bay), and while *P. maurus* was found at Zewwieqa, just outside the only port on Gozo (Mgarr Harbour), this is not an international port but serves mainly for inter-island transport and has a small yacht marina. Had either species been introduced through commercial shipping, populations would have been expected also in the port areas and not predominantly in localities well away from any port activities. The most feasible explanation for the occurrence of both *P. maurus* and *P. transversus* in the Maltese Islands and Lampedusa seems to be that these new records are a result of a natural range expansion. There does not seem to be any published information on the duration of the planktonic larval stages of either species, however. As presently known, *P. maurus* occurs on the northeastern and eastern coasts of Sicily, while *P. transversus* is found on the northeastern Sicilian coast only; however, there is a strong possibility that either or both species may live along the southern coast in as yet undiscovered populations. Natural range extension would involve larval transport from established Sicilian populations since ones further to the west and to the east of the Maltese and Pelagian Islands are likely to be too far away for this mechanism to operate.

In the case of Italy, a *Pachygrapsus* sp. (not *P. marmoratus*) is known to have occurred in Sicily for at least 100 years (Misuri 1914). That it was only recently re-discovered along the shores of the Palermo area (Vaccaro & Pipitone, 2005) may be attrib-

utable to the lack of studies on shore decapods and/or on misidentifications by non-specialists. The Tyrrhenian record of *P. maurus* reported here may be due to natural dispersal since the locality where the species was found is quite far from harbours; moreover, it can be only be accessed by boat during calm seas, so there is also the possibility that the population had existed undiscovered for many years. The recently discovered population of *P. transversus* in northern Sicily (Vaccaro & Pipitone, 2005) does not seem to be connected with the first, probably ship-mediated record of this species from Italy (Colosi, 1923 - misidentified as *P. maurus*).

In conclusion, we note that the Mediterranean zoogeography of both *P. maurus* and *P. transversus* is still uncertain given that large areas of shore have not been systematically explored for these species, and that in some localities, two, and occasionally all three, species may occur sympatrically, suggesting that presently unknown mechanisms for resource portioning may be operating.

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