

The taxonomical status of the genus *Pilumnus* Leach, 1815 (Pilumnidae, Decapoda, Crustacea) in the Mediterranean Sea, focusing on three species in the Aegean Sea

MICHALIS MAVIDIS^{1*}, MILTIADIS-SPYRIDON KITSOS¹,
MICHAEL TÜRKAY² and ATHANASIOS KOUKOURAS¹

¹ Department of Zoology, School of Biology, Aristotle University of Thessaloniki, Thessaloniki, 541 24, Greece

² Forschungsinstitut Senckenberg, Senckenberganlage 25, D-6000, Frankfurt a. M., Germany

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The review of the relevant literature and the comparative study of numerous specimens from the Aegean Sea elucidated the prevailing taxonomic confusion on the Mediterranean species of the genus *Pilumnus* and allowed the documented distinction of five species (*Pilumnus hirsutus*, *P. hirtellus*, *P. inermis*, *P. spinifer* and *P. villosissimus*). A key for the Mediterranean species of the genus is given, based on new selected constant features.

Key words: *Pilumnus*, Mediterranean, Decapoda.

INTRODUCTION

According to Türkay (2001) the following species of the genus *Pilumnus* Leach, 1815, are present in the Mediterranean Sea: *Pilumnus hirsutus* Stimpson, 1858; *Pilumnus hirtellus* (Linnaeus, 1761); *Pilumnus inermis* A. Milne-Edwards & Bouvier, 1894; *Pilumnus spinifer* H. Milne-Edwards, 1834 and *Pilumnus villosissimus* (Rafinesque, 1814).

However, the consideration of the relevant literature (Zariquiey Alvarez, 1968; d'Udekem d'Acoz, 1999) showed that the taxonomy of three Mediterranean *Pilumnus* species (*P. spinifer*, *P. hirtellus* and *P. villosissimus*) is still confused. Zariquiey Alvarez (1968) considered *P. aestuarii* Nardo, 1868 as a valid Mediterranean species which was later placed by d'Udekem d'Acoz (1999) as a junior synonym under *P. hirtellus*. The latter author also designated a new separate species, *Pilumnus* sp. 1, which corresponds to the description of *P. aestuarii* given by Zariquiey Alvarez (1968). Furthermore, d'Udekem d'Acoz (1999) considered *P. spinifer* as a form of *P. hirtellus*.

* Corresponding author: tel.: +30 2310 998363, fax: +30 2310 998269, e-mail: mmavidis@bio.auth.gr

The same author has given a detailed geographic distribution of the species of the genus in the Mediterranean.

This paper aims to elucidate the status of the species of the genus *Pilumnus* in the Mediterranean and facilitate their distinction.

MATERIALS AND METHODS

A total of 272 *Pilumnus* specimens from various localities of the Aegean Sea were examined. In all specimens, 116 morphological features and somatometric ratios were examined in order to estimate their variability.

Data were processed with the SPSS ver. 8 software package. The variability of all studied features was estimated and the variability ranges and the average values were calculated for the quantitative features. Then, the most comparable, non-overlapping morphological features were selected for *P. hirtellus*, *P. spinifer* and *P. villosissimus* and used for the distinction of these species. These features are given in Table 1 along with relevant literature data. The following abbreviations were used: CW, carapace width; P₁-P₅, pereopods 1-5.

TABLE 1. Comparison of the main morphological features of *Pilumnus hirtellus* (Linnaeus, 1761), *Pilumnus spinifer* H. Milne-Edwards, 1834 and *Pilumnus villosissimus* (Rafinesque, 1814) according to literature data and the studied material (key features in bold). For each species, percentages of the studied individuals bearing a certain feature are also given. Numbers in brackets indicate average values. In parentheses, the reference used: 1, Zariquiey Alvarez, 1968; 2, González Gurriarán & Méndez, 1985; 3, Monod, 1956; 4, Türkay et al., 1987; 5, Santaella-Alvarez, 1974

	Literature			Present study		
	<i>P. hirtellus</i>	<i>P. spinifer</i>	<i>P. villosissimus</i>	<i>P. hirtellus</i>	<i>P. spinifer</i>	<i>P. villosissimus</i>
CARAPACE						
Length to width ratio	0.67 (1)	0.76 (1)	0.7 (1)	0.64-0.83 [0.75]	0.70-0.86 [0.79]	0.67-0.85 [0.76]
Distribution pattern of plumose setae on the dorsal surface (Fig. 2)	–	–	–	in 4 distinct pairs of turfs as well as scattered ones all over the surface: 100%	in 4 distinct pairs of turfs: 100%	in 4 distinct pairs of turfs: 100%
Dentation of frontal margin (Fig. 3a'-c')	frontal margin unarmed (3)	frontal margin with spines (3)	–	small, tuberculus teeth in dense arrangement: 100%	prominent, acute teeth in sparse arrangement: 100%	prominent, acute teeth in sparse arrangement: 100%
Dentation of the dorsal margin of the orbit (Fig. 3a-3c)	–	–	–	numerous teeth, feeble and rounded: 100%	few teeth, strong and acute: 100%	few teeth, strong and acute: 100%
Presence of long, flexible simple setae (Fig. 1a'')	–	–	–	NO: 100%	NO: 100%	YES: 100%
MAXILLA						
Antero-lateral margin of endite bearing a notch (Fig. 3a''-c'')	–	–	–	NO: 100%	YES: 100%	NO: 100%
P₁ BIG CHELA						
Propodus length to width ratio	–	1.42 (1)	1.71 (1)	1.02-1.67 [1.28]	0.95-1.67 [1.21]	0.91-1.70 [1.28]
Propodus to fixed finger length ratio	–	2.90 (1)	2.21 (1)	1.90-2.91 [2.50]	1.98-3.28 [2.45]	1.78-2.80 [2.33]
Upper half of palm bears spines and/or spinules	YES (2) NO (1)	YES (1)	YES (1)	YES: 75.3% NO: 24.7%	YES: 100%	YES: 100%
Lower half of palm bears spines and/or spinules	NO (1)	NO (1)	NO (1)	YES: 2.4% NO: 97.6%	YES: 3.8% NO: 96.2%	YES: 31.3% NO: 69.7%

TABLE 1. continued

	Literature			Present study	
	<i>P. hirrellus</i>	<i>P. spinifer</i>	<i>P. villosissimus</i>	<i>P. spinifer</i>	<i>P. villosissimus</i>
P₁ SMALL CHELA					
Upper half of palm bears spines and/or spinules	YES (2)	YES (1)	YES (1)	YES: 100% NO: 1.4%	YES: 100%
Lower half of palm bears spines and/or spinules	YES (2)	YES (1)	YES (1)	YES: 74.3% NO: 25.7%	YES: 100%
P₂ (SECOND PEREIOPOD)					
Dorsal distal margin of carpus bearing a spine	NO (1, 3, 4)	YES (1, 3, 5)	YES (1)	YES: 35.5% NO: 64.5%	YES: 100%
P₃ (THIRD PEREIOPOD)					
Dorsal distal margin of carpus bearing a spine	NO (1, 3, 4)	YES (1, 3, 5)	YES (1)	YES: 2.8% NO: 97.2%	YES: 100%
Merus length to width ratio	2.31 (1)	–	–	1.7-3.3 [2.4]	2.3-3.0 [2.5]
P₄ (FOURTH PEREIOPOD)					
Dorsal distal margin of carpus bearing a spine	NO (1, 3, 4)	YES (1, 3, 5)	YES (1)	YES: 3.0% NO: 97.0%	YES: 100%
P₅ (FIFTH PEREIOPOD)					
Merus length to width ratio	1.65 (1)	–	–	2.0-2.6 [2.3]	2.2-3.3 [2.6]
Dorsal distal margin of carpus and merus bearing a spine	No spine on carpus (1, 3, 4)	Spine on carpus (1, 3, 5)	Spine on carpus (1)	NO: 100%	YES: 100%
P₁-P₅ (PEREIOPODS 1-5)					
Presence of plumose setae	YES (1, 2, 4)	YES (2)	–	YES: 100%	NO: 100%
Presence of short, stiff simple setae (Figs 1a', 1d')	–	–	–	NO: 100%	NO: 100%
Presence of brush-like setae (Fig. 1c)	–	–	–	YES: 100%	NO: 100%
Presence of long, flexible setae (Fig. 1a'')	–	–	–	NO: 100%	YES: 100%

RESULTS AND DISCUSSION

Taxonomic distinction of examined species

Until now, the distinction among *P. hirtellus*, *P. spinifer* and *P. villosissimus* has been mainly based on the morphological features given in the key of Zariquiey Alvarez (1968). However, during the present study, it was ascertained that these characters are not constant and their variability ranges widely overlap among the three species (Table 1).

The detailed comparison of the studied material revealed the presence of certain, non-overlapping, key morphological features that clearly distinguish each one of the three species from the two others (Table 1). *Pilumnus hirtellus*, *P. spinifer* and *P. villosissimus* are clearly distinguished on the basis of: a) the structure of the setae on the carapace and all pereopods (Fig. 1); b) the distribution pattern of plumose setae on the carapace (Fig. 2); c) the dentation of the dorsal margin of the orbit (Fig. 3a-c); d) the dentation of the carapace frontal margin (Fig. 3a'-c'),

and e) the shape of the endite of maxilla (Fig. 3a''-c'').

An account of the examined species of *Pilumnus* is given below along with remarks on their systematics and information on their geographical distribution.

***Pilumnus hirtellus* (Linnaeus, 1761)**

(Figs 1a-d; 2a; 3a, a', a'')

Pilumnus aestuarii, Carus, 1885: 514; Zariquiey Alvarez, 1968: 393; Türkay et al., 1987: 98, Figs 6a, b.

Pilumnus aestuarii?, Cardona Bentidito, 1965: 154, Pl. II f.

Pilumnus hirtellus, Bouvier, 1940: 255, Pl. X, Fig. 1; Băcescu, 1967: 301, Figs 56, 128b, 129a, 134a, 135c; Zariquiey Alvarez, 1968: 393; Christiansen, 1969: 75, Fig. 30.

Pilumnus hirtellus var. *villosus*?, Băcescu, 1967: 304.

Pilumnus sp. 1, d'Udekem d'Acoz, 1994: 30, Figs 2, 3c.

Pilumnus sp. 2, d'Udekem d'Acoz, 1994: 33, Fig. 3a.

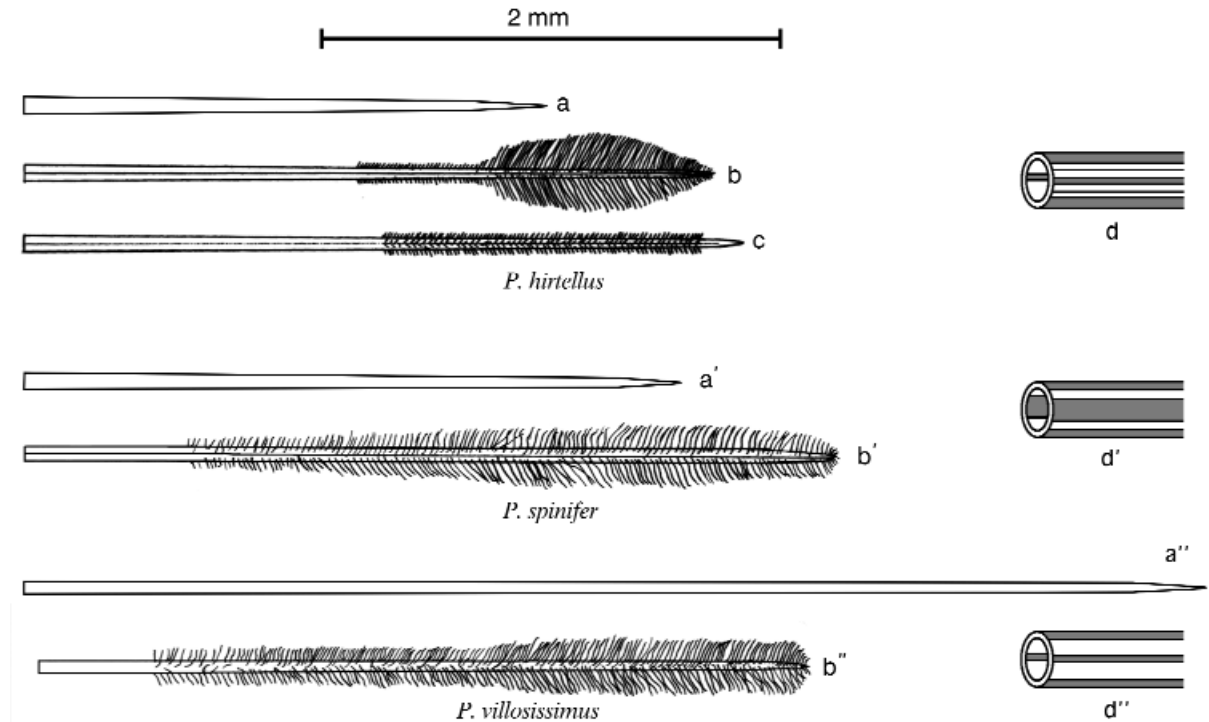


FIG. 1. *Pilumnus hirtellus* (Linnaeus, 1761): a, simple seta; b, plumose seta found both on carapace and pereopods; c, brush-like seta found only on pereopods; d, cross-section of seta: the structural axes of the cuticle (in gray) are of intermediate width. *Pilumnus spinifer* H. Milne-Edwards, 1834: a', simple seta; b', plumose seta found both on carapace and pereopods; d', cross-section of seta: the structural axes of the cuticle (in gray) are very wide. *Pilumnus villosissimus* (Rafinesque, 1814): a'', simple seta; b'', plumose seta found only on carapace; d'', cross-section of seta: the structural axes of the cuticle (in gray) are very narrow.

Material

Aegean Sea: 50 ♂♂ (CW: 0.9-2.6 cm), 31 ♀♀ (CW: 0.7-2.1 cm) from various localities.

Zariquiey Alvarez (1968) considered *P. aestuarii* Nardo, 1868 as a distinct species which, according to this author, can be separated from *P. hirtellus* by the lack of spinulation on the palm of the big chela and the slenderness of the pereopods of the former (P_3 merus length to width ratio = 3.56 in *P. aestuarii* and 2.31 in *P. hirtellus*; P_5 merus length to width ratio = 3.56 in *P. aestuarii* and 1.65 in *P. hirtellus*). However, in the studied material of *P. hirtellus* (Table 1), the two above mentioned morphological features varied considerably, indicating that the pereopods of this species may also be very slender while, at the same time the palm of the chela is spinulated. Hence, *P. aestuarii* can not be considered as a distinct species and probably corresponds to individuals of *P. hirtellus* with a specific combination of largely variable characters (e.g., slenderness of pereopods).

Distribution

- Eastern Atlantic: from Norway to Cape Verde Islands (d’Udekem d’Acoz, 1999).
- Mediterranean Sea: Western basin (Zariquiey Alvarez, 1968; d’Udekem d’Acoz, 1994 as *Pilumnus* sp. 2); Central basin (Pastore, 1976); Adriatic Sea (Carus, 1885 as *P. aestuarii*; Stevcic, 1990); Aegean Sea (Koukouras et al., 1992; d’Udekem d’Acoz, 1994); Levantine basin (Holthuis & Gottlieb, 1958).
- Black Sea (Băcescu, 1967; Türkay et al., 1987 as *P. aestuarii*).

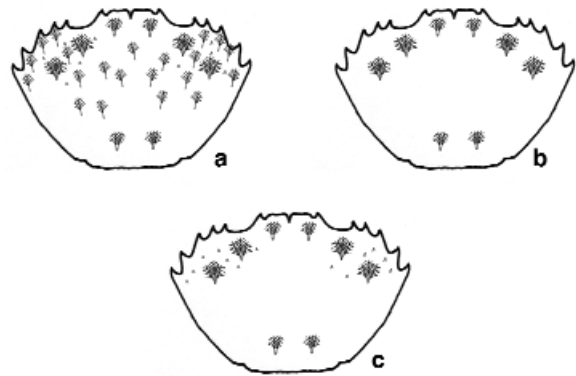


FIG. 2. Distribution pattern of plumose setae and presence of tubercles on the carapace dorsal surface of: a, *Pilumnus hirtellus*; b, *Pilumnus spinifer* and c, *Pilumnus villosissimus*.

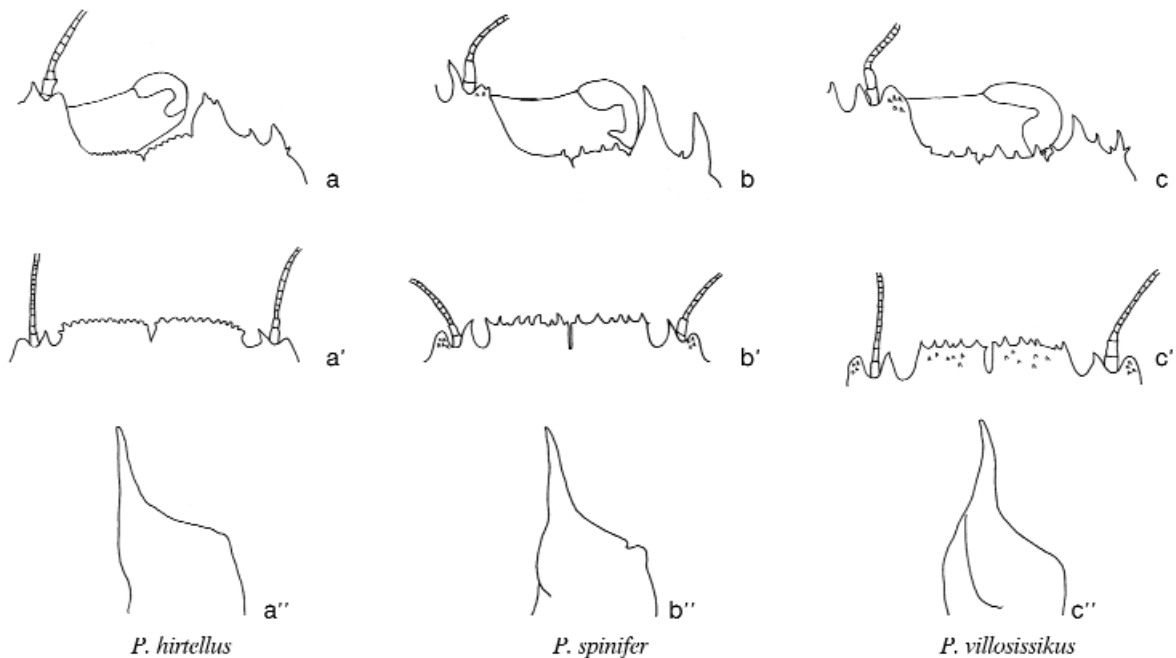


FIG. 3. Comparison of: the dentation of the orbital dorsal margin (a-c); the dentation of the carapace frontal margin (a'-c') and the shape of the maxilla endite (a''-c'') among *Pilumnus hirtellus*, *Pilumnus spinifer* and *Pilumnus villosissimus*.

***Pilumnus spinifer* H. Milne-Edwards, 1834**

(Figs 1a'-b', d'; 2b; 3b, b', b'')

Pilumnus spinifer, Monod, 1956: 251, Figs 296, 297; Zariquiey Alvarez, 1968: 391, Fig. 129 a-e; Christiansen, 1969: 77, Fig. 31, map 25; d'Udekem d'Acoz, 1994: 29, Fig. 3e.

Pilumnus hirtellus forma *spinifer*, d'Udekem d'Acoz, 1999: 239.

Material

Aegean Sea: 112 ♂♂ (CW: 0.5-2.7 cm), 47 ♀♀ (CW: 0.5-2.4 cm) from various localities.

D' Udekem d'Acoz (1999) considered *P. spinifer* as a form of *P. hirtellus* based on specimens from Greece (Lesvos island and Amvrakikos Gulf) which were intermediate between the two species. Unfortunately, he provides no information on the morphological features he studied in order to reach this conclusion. However, according to the results of this study, there are certain key morphological features (Table 1, features in bold and Figs 1-3) that clearly distinguish this species from *P. hirtellus*.

Distribution

- Eastern Atlantic: from Sweden to Canary Islands (d'Udekem d'Acoz, 1999).
- Mediterranean Sea: Western basin (Zariquiey Alvarez, 1968); Central basin (Pastore, 1976); Adriatic Sea (Stevcic, 1990); Aegean Sea (Koukouras *et al.*, 1992; d'Udekem d'Acoz, 1994); Levantine basin (Holthuis & Gottlieb, 1958; Lewinsohn & Holthuis, 1986).

***Pilumnus villosissimus* (Rafinesque, 1814)**

(Figs 1a''-b'', d''; 2c; 3c, c', c'')

Cancer villosissimus, Rafinesque, 1814: 20.

Pilumnus villosus, Risso, 1826: 10; Heller, 1863: 73; Carus, 1885: 514.

Pilumnus hirtellus var. *villosus*, Pesta, 1918: 417, Fig. 137.

Pilumnus villosissimus, Zariquiey Alvarez, 1968: 392; Türkay *et al.*, 1987: 95, Fig. 8.

Material

Aegean Sea: 22 ♂♂ (CW: 0.8-3.1 cm), 10 ♀♀ (CW: 1.0-2.2 cm) from various localities.

This species can be easily distinguished from *P. hirtellus* and *P. spinifer* by the presence of long, flexible soft setae on the pereopods and the carapace

(Table 1; Fig. 1a''). In this species, the flexibility of the simple setae seems to be related to the width of their structural axes (Fig. 1d'') which is much smaller in relation to the respective ones of *P. hirtellus* (Fig. 1d) and *P. spinifer* (Fig. 1d').

Distribution

- Eastern Atlantic: from Azores to Canary Islands (d'Udekem d'Acoz, 1999).
- Mediterranean Sea: Western basin (Zariquiey Alvarez, 1968); Central basin (Schembri & Lanfranco, 1984; d'Udekem d'Acoz, 1999); Adriatic Sea (Stevcic, 1990); Aegean Sea (Koukouras *et al.*, 1992; d'Udekem d'Acoz, 1994); Levantine basin (Ramadan & Dowidar, 1976).

Other *Pilumnus* species in the Mediterranean Sea***Pilumnus inermis*****A. Milne-Edwards & Bouvier, 1894**

Pilumnus hirtellus var. *inermis* Milne-Edwards & Bouvier, 1894, 38-40.

Pilumnus inermis Monod, 1956: 247, Figs 291-295; Giacobbe & Spanò, 2001: 659-672, Pl. 1.

Pilumnus nom. nov., d'Udekem d'Acoz, 1999: 240.

Distribution

- Eastern Atlantic: from Portugal to gulf of Guinea (d'Udekem d'Acoz, 1999).
- Mediterranean Sea: Western basin (Zariquiey Alvarez, 1968; Giacobbe & Spanò, 2001); Central basin (Falcaia, 1997).

***Pilumnus hirsutus* Stimpson, 1858**

Pilumnus hirsutus, Balss, 1936: 40, Fig. 38; Bouvier, 1940: 256, Fig. 165; Barnard, 1950: 263, Fig. 49; Galil *et al.*, 2002: 130, Fig. 1.

Distribution

- Indo-Pacific: from Red Sea to New Caledonia (d'Udekem d'Acoz, 1999).
- Mediterranean Sea: Levantine basin (Balss, 1936); Aegean Sea (Ateş *et al.*, 2004).
- Black Sea (Gönlügür-Demirci, 2006).

A Lessepsian species which had been reported in the Mediterranean only once from Egypt (Galil *et al.*, 2002). Recently, this species was recorded in the Aegean Sea (Ateş *et al.*, 2004) and the Black Sea (Gönlügür-Demirci, 2006).

Concluding remarks

To date, five species of the genus *Pilumnus* Leach, 1815 are known from the Mediterranean Sea. Among them, *P. inermis* has been described clearly and its distinction from the other species of the genus is easy, while the Mediterranean distribution of this Atlanto-Mediterranean species is limited to the western and central basin. *Pilumnus hirsutus* is an Indo-Pacific species of characteristic morphology that can be easily distinguished from the other Mediterranean species of the genus. It has migrated from the Red Sea to the Mediterranean (Lessepsian immigrant) and its presence had been recorded only from the coasts of Alexandria in 1936. Very recently this species seems to have extended its distribution to the north according to three impressive records from the gulfs of Ismir and Saros (north Aegean) and from the Black Sea (possibly carried by ships). The other three species of the genus (*P. spinifer*, *P. hirtellus* and *P. villosissimus*) have a wide distribution in the Mediterranean, including the Aegean Sea, but as they are similar species and their descriptions were few and incomplete, the distinction among them was difficult, because it was actually based on overlapping features. In this study, the variability of all the features of the three species was examined in detail and the degree of feature overlaps among the species was recorded. Furthermore, new non-overlapping features were identified that will allow the easy distinction of the three species.

Key to the Mediterranean species of Pilumnus

- 1. Carapace with 4 anterolateral spine 2
 - Carapace with 5 anterolateral spines 3
- 2. Frontal margin divided into two prominent lobes by a deep medial groove. P₂-P₄ with a medial and a distal spine on the dorsal margin of merus *P. hirsutus*
 - Frontal margin divided into two blunt, almost rectangular lobes by a shallow notch. P₂-P₄ without spines on the dorsal margin of merus *P. inermis*
- 3. Frontal margin more or less denticulated. Orbital margins dorsally denticulated. Plumose setae on the carapace dorsal surface grouped in four distinct pairs of tufts, as well as scattered. Brush-like setae present on pereopods *P. hirtellus*
 - Frontal margin with spines and/or spinules. Or-

bital margins dorsally with spines and/or spinules. Plumose setae on the carapace dorsal surface only grouped in four distinct pairs of tufts. No brush-like setae on pereopods 4

- 4. Dorsal surface of carapace more or less tuberculated. Simple setae on carapace and pereopods long and flexible. Pereiopods without plumose setae. External margin of maxilla endite without a notch *P. villosissimus*
 - Dorsal surface of carapace without tubercles. Simple setae on carapace and pereopods short and stiff. Pereiopods with plumose setae. External margin of maxilla endite with a notch *P. spinifer*

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