

## A new *Psammogammarus* (Amphipoda: Melitidae) from Cabrera (Balearic Islands)

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### Abstract

Description of *Psammogammarus burri*, the third representative of the genus in the Mediterranean, from material collected in the deeper zone of an anchihaline cave lake in Cabrera (Balearic Islands). The taxon has the greatest body size recorded for the genus (up to 12 mm), crevicular habits and a high degree of morphological troglotization. Based on phenetic characters, it roughly resembles two taxa from the Philippines, but no close affinity can be inferred with the other two known Mediterranean taxa. Two hypotheses are discussed concerning its possible origin: (1) It derives from an unknown ancestor, which penetrated the Mediterranean after the Lower Pliocene transgression; or (2) it is a Tethyan marine relict. Biogeographic data favour this last assessment. The refuge offered by the crevicular marine environment is proposed as the mechanism permitting *P. burri* (or its ancestor) to survive the Messinian salinity crisis.

### Resumen

Se presenta la descripción de *Psammogammarus burri*, el tercer representante del género en el Mediterráneo, a partir de material recolectado en la zona profunda de un lago anquihalino de la Cova des Burri, en la isla de Cabrera (Islas Baleares). Se trata de una especie de hábitos creviculares, de gran talla (hasta 12 mm) y troglotización morfológica acusada. Presenta una cierta semejanza, en base a caracteres fenéticos, con dos especies de las islas Filipinas, y ninguna con las otros dos representantes conocidos del género en el Mediterráneo. Se discuten 2 hipótesis referentes a su posible origen: (1) Deriva de un ancestro desconocido, que penetró en el Mediterráneo tras la transgresión Pliocena; (2) se trata de una reliquia marina del Tety, habiendo sobrevivido in situ a la crisis de salinidad Mesiniana. Los datos biogeográficos refuerzan esta última hipótesis. Se comenta el papel que el medio crevicular marino puede haber jugado en la supervivencia de esta especie.

### Introduction

In comparison to the well known anchihaline crustacean fauna of the main Balearic Islands (see Pretus, 1991 and references therein), less is known about that of the Cabrera archipelago, a group composed by 5 main islets and 12 small reefs ranging roughly 20 km<sup>2</sup>, all calcareous and situated 7 km south of Mallorca. References on the stygofauna of this site are limited to Ginés & Ginés (1977), who cited *Salentinella* sp. from surface waters of the anchihaline lake of Cova des Burri. Our recent samplings in the archipelago have rendered two new freshwater *Pseudoniphargus* in the central plain of the main island (Jaume, 1991), *Bogidiella balearica* Dancau, 1973 and Cyclopoida, but no representative of *Salentinella* in the surface waters of Cova des Burri (Jaume, 1990). Besides, an interesting assemblage of blind and unpigmented species, viz. an amphipod, a cirrolanid isopod, a mysid and a harpacticoid was discovered in the deeper zone (ca. 15 m) of this lake. We present here the description of the amphipod found, a new representative of *Psammogammarus* S. Karaman, 1955, a genus not yet recorded from the Balearic Islands. The accompanying animals are now under study (Jaume & Garcia, in prep.) and seem also, at first sight, new taxa.

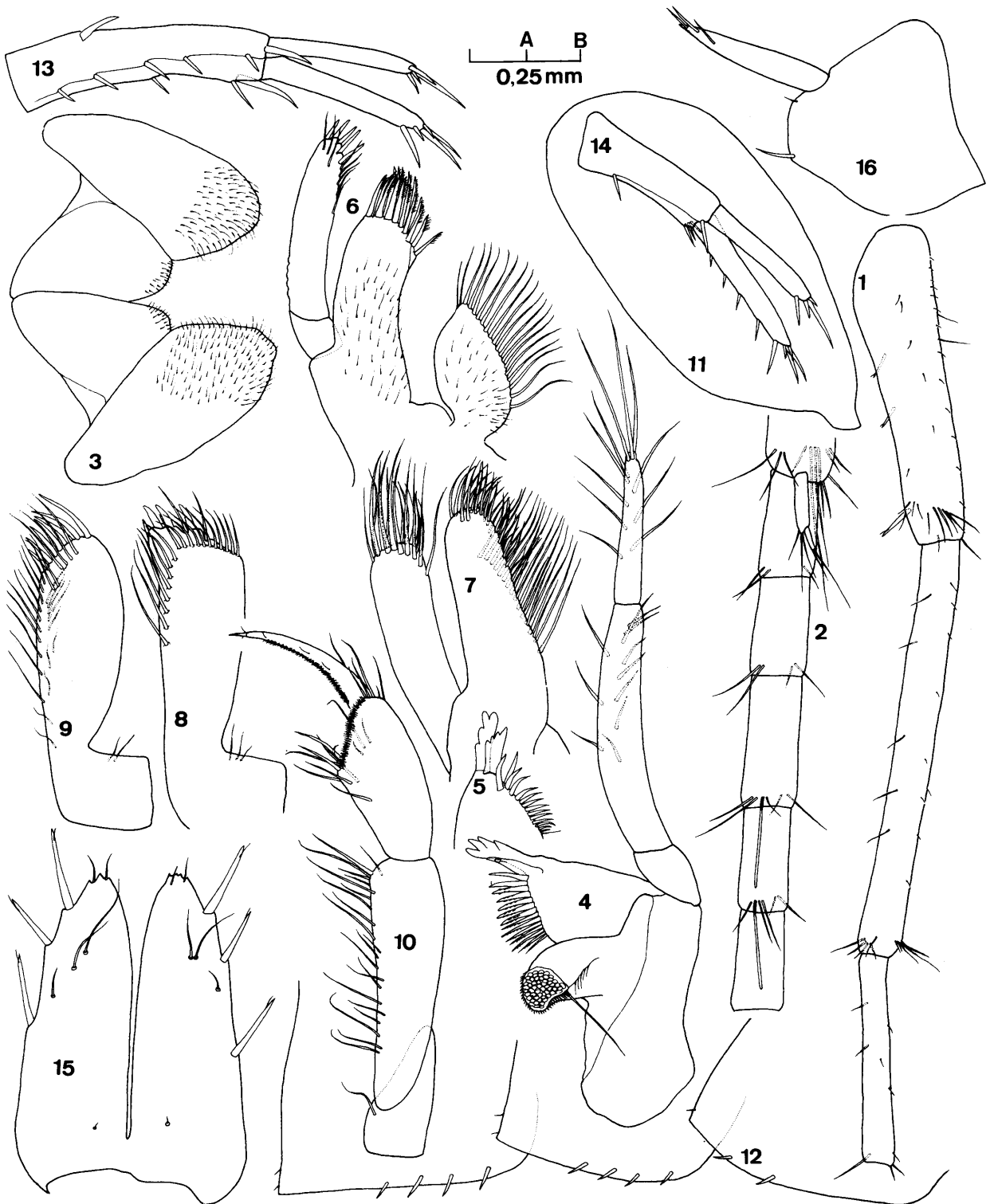


Fig. 1–16. *Psammogammarus burri* n. sp. (male holotype): 1, peduncle of antenna 1 (scale A); 2, accessory flagellum and first flagellum segments of antenna 1 (B); 3, lower lip (B); 4, right mandible (B); 5, pars incisiva of left mandible (B); 6, left first maxilla (B); 7, right second maxilla (B); 8, 9 and 10, inner and outer lobes, and palp of maxilliped, respectively (B); 11, coxal gill 3 (A); 12, epimeral plates 1–3 (A); 13, uropod 1 (A); 14, uropod 2 (A); 15, telson (B); 16, urosomite 3 and telson (A).

## Results

### *Psammogammarus burri* n. sp. (Figs. 1–36)

Material examined. – Cova des Burri (Cabrera, Balearic islands); cave entrance at 20 m a.s.l. just in front Ses Bledes islet. Anchihaline lake occupying the bottom of the cave. Damià Jaume & Lluç Garcia coll., 13 Jan. 1991. The type material is deposited in the crustacean collection of the Museu de la Naturalesa de les Illes Balears (MNCM). Holotype: Male 11.7 mm (genital processes present on inner side of coxae 7) (MNCM CR-125). Paratypes: 4 females in non-reproductive stage (presence of non-setose oostegites) measuring 12.0, 10.8, 11.1 and 11.9 mm, respectively (MNCM CM-126 to 129). 4 adults and juveniles deposited in the authors' personal collection.

Description of holotype. – Lateral head lobe rounded and antennal sinus deep; anteroventral cephalic notch absent (Fig. 18). Antenna 1 (Figs. 1, 2) very long, roughly equal to body length. Peduncle slender, 28% of the total antennal length; second segment longest. Flagellum of 31 segments, bearing aesthetascs from segment 3. Right accessory flagellum bisegmented and shorter than first flagellum segment; left one unisegmented. Antenna 2 (Fig. 17) with 9-segmented flagellum, and with peduncle slightly shorter than that of A1; gland cone reaching middle of third peduncle segment. Upper lip (Fig. 19) entire, trapezoidal, with straight distal margin. Lower lip (Fig. 3) with developed inner lobes. Right mandible (Fig. 4): Incisor process 4-dentate; stout, spine-like, 3-dentate lacinia, without notches or denticulation; pars molaris with only 1 molar seta; 14 spines between part incisiva and pars molaris; palp segment 2 with 11 marginal setae; segment 3 straight, not falcate, shorter than second one, with 3 E-setae and 8 D-setae. Left lacinia (Fig. 5) 4-dentate. Maxilla 1 (Fig. 6): Inner plate with 19 long marginal setae; outer lobe with 16 apical, denticulated spines; palp bisegmented, with 5 terminal spines. Maxilla 2 (Fig. 7): Outer lobe with 2 rows of apical setae (8 and 10 setae, respectively); inner lobe with a medial row of 15 long setae, an oblique row of 15, and 16 apical setae. Maxilliped (Figs. 8, 9, 10): Inner lobe with 4 spines and 2 apical setae, a subapical row of 11 setae and a marginal row of 8. Outer lobe with 7 apical spines, more slender than those of inner lobe, row of 6 subapical setae and marginal row of 10;

there is a medial row of 10 setae parallel to the latter. Palp segment 1 with 1 ventral seta; segment 2 with up to 21 setae along ventral margin; segment 3 roughly triangular in profile, ventral margin covered by dense spinulation; segment 4 falciform, elongate, ventral margin covered by dense spinulation as well.

Coxal gills (Fig. 11) on pereopods 2 to 6, elliptic, with a well developed stalk.

Gnathopod 1 (Figs. 20, 21) clearly smaller than G2. Coxal plate clearly wider than long, without anteroventral point. Merus with a pilose posterior swelling, and long marginal seta implanted distally of it. Carpus shorter than propodus, with 4 medial and 6 marginal rows of setae. Propodus of triangular shape; 4 rows of posterior setae; palm convex, and palmar angle with one longer and 4 shorter bifid spines.

Gnathopod 2 (Figs. 22, 23): Coxa wider than long, posterior margin shallowly excavate. Carpus with 7 marginal rows of setae. Propodus elliptic, 2.7 times as long as wide, with 5 rows of setae on posterior margin and 8 inner submarginal rows on anterior margin. Palm merging shallowly into posterior margin, with 2 long bifid spines on the transition zone; 3 stout bifid mid-palmar spines, shorter than angle spines.

Pereopods 3 and 4 (Figs. 24–27) roughly of same size and similar. Coxal plate 3 longer than wide, posterior margin shallowly excavate; ventral margin convex, with 8 setae. Coxal plate 4 similar to plate 3, but with posterior margin straight. Both bases linear.

Pereopods 5 to 7 increasingly longer. Pereopod 5 (Fig. 28, 29): Coxa bilobed, clearly longer than wide, with anterior lobe strongly developed and bearing 10 marginal setules; width of coxal plate clearly surpasses that of basis. Basis distally tapering, with well developed marginal spinulation; posteroproximal lobe developed; posterodistal lobe developed and clearly overhanging. Pereopod 6 (Figs. 30, 31): Coxa bilobed, wider than long, with anterior lobe less strongly developed than in P5,

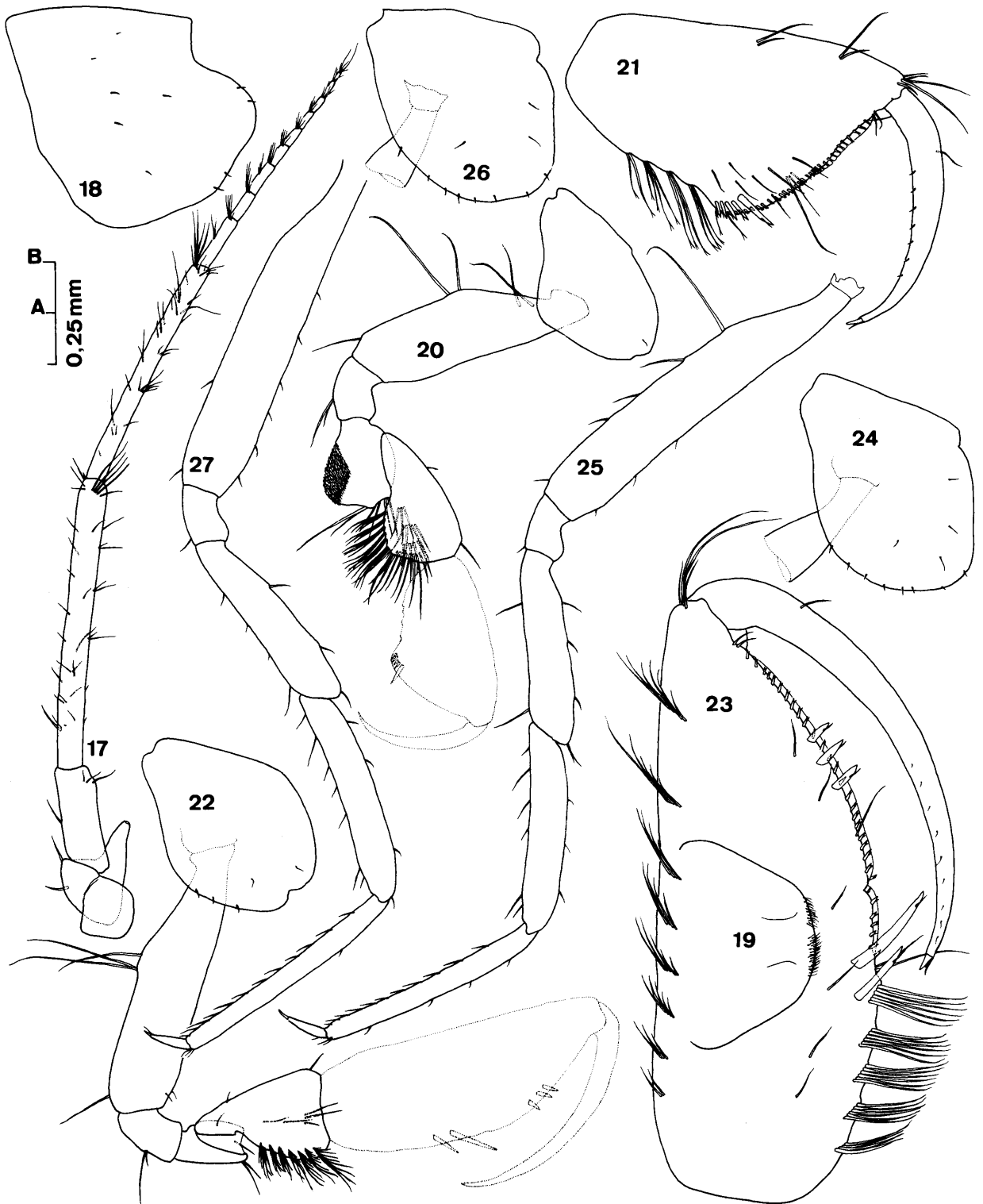


Fig. 17–27. *Psammogammarus burri* n. sp. (male holotype); 17, antenna 2 (A); 18, cephalon (A); 19, upper lip (B); 20, gnathopod 1 (A); 21, propodus-dactylus of gnathopod 1 (B); 22, gnathopod 2 (A); 23, propodus-dactylus of gnathopod 2 (A); 24, 25, pereopod 3 (A); 26, 27, pereopod 4 (A).

roughly of the same length as posterior lobe; coxa roughly of the same width as basis. Basis of rectangular profile, with well developed marginal spinulation, posteroproximal and posterodistal lobes, the latter clearly overhanging. Pereiopod 7 (Figs. 32–34) very elongate, attaining 79% of body length. Coxa of triangular profile, wider than long. Basis similar to that of P5.

Epimeral plates 1–3 (Fig. 12) subquadrate; ventral margin roughly straight. Number of spines on ventral margin: 2-4-4. Posterior margin straight, with 1-2-2 setae, respectively; angles not particularly pointed. Pleopod peduncles with 2 retinacula; exopodites 1 to 3 of 14-12-9 segments; endopodites of 11-9-9 segments.

Uropod 1 (Fig. 13): Both peduncle and rami elongate, former longer than latter. Peduncle bearing proximoventral spine plus 5 dorsal and 1 medial spines; 1 external and 2 unequal internal distal spines. Rami lacking marginal spinulation. Uropod 2 (Fig. 14): Peduncle with 1 dorsal spine and 1 external and 3 internal distal spines, latter shorter than former. Exopodite lacking marginal spinulation, while endopodite bears row of 4 dorsomarginal spines. Uropod 3 (Figs. 35, 36) very elongate, attaining roughly half of body length; peduncle not elongate, 2.5 times as long as wide; endopodite short (0.8 times as long as peduncle), scale-like, and tapering, with one apical spine and 2 spines along inner margin; exopodite very elongate, 2-segmented, segment 2 slightly longer than segment 1. Telson (Figs. 15, 16) cleft nearly to basis, longer than wide, with lobes tapering; 2 small apical setae, 3 lateral spines on outer side, and 3 medial setae on each lobe.

Variability. – Sexual dimorphism seems restricted to presence/absence of oostegites. The carpus of G1 of female is as in male, shorter than propodus. The low number of individuals studied (9) limits the known variability of the species. The lacinia of the right mandible is always 5-dentate except in the holotype, where it is 4-dentate. One gnathopod 1 observed bears 5 instead of 4 small bifid palm angle spines. Gnathopod 2 can present from 1 (in a 5.5

mm long individual) to 3 palmar medial marginal spines. The peduncle of uropod 1 can bear 2 to 5 dorsal spines and 1–2 external distal spines. The peduncle of uropod 2 of one individual lacks an external distal spine; the endopodite can bear 2 to 4 marginal spines. Variability of ventral armature of epimeral plates 1 to 3: (2)-(2 to 4)-(4 to 5).

Derivatio nominis. – The name of the species comes from Cova des Burri, its type-locality.

Diagnostic characters and affinities. – The presence of midpalmar spines on G2, and the triangular shape of propodus of G1 indicates some affinity of the taxon from Cabrera with *Eriopisa* Stebbing, 1890, but other characters indicate a closer resemblance to *Psammogammarus* S. Karman, 1955 (viz. absence of deep notch on cephalic segment, short segment 3 of mandibular palp, telson bearing lateral armature, coxal plate 1 without anteroventral point, basis of P5 to P7 of similar shape). Accepting the polarity of the character states proposed for the genus (Stock & Sánchez, 1987), we can conclude that *P. burri* is characterized by a combination of plesiomorphic (absence of sexual dimorphism in propodus of G2, inner plate of Mx1 with more than 10 setae, oblique row of setae of inner lobe of Mx2 well developed, G2 with mid-palmar spines, P3 and P4 with basis linear, P5 with lobed basis, U1 with proximoventral spine, exopodite of U2 with dorsomarginal spines) and some apomorphic character states (accessory flagellum of A1 shorter than first flagellum segment, outer lobe of Mxp with setae only, carpus of G1 shorter than propodus, exopodite of U1 without dorsomarginal spines, short endopodite of U3). *P. burri* is the largest representative of the genus up to now (10–12 mm, all the other species attain less than 6 mm). The larger number of spines between mandibular part incisiva and pars molaris, and the very elongate exopodite of third uropod are also characteristic of the Balearic species. Besides of the characters listed above *P. burri* can be distinguished from the other 11 described representatives of the genus as follows: It differs from *P. scopulorum* Stock, 1983, *P. initialis*, Stock & Sánchez, 1987, *P. longidactylus* Vonk & Stock, 1987, *P. longiramus* (Stock &

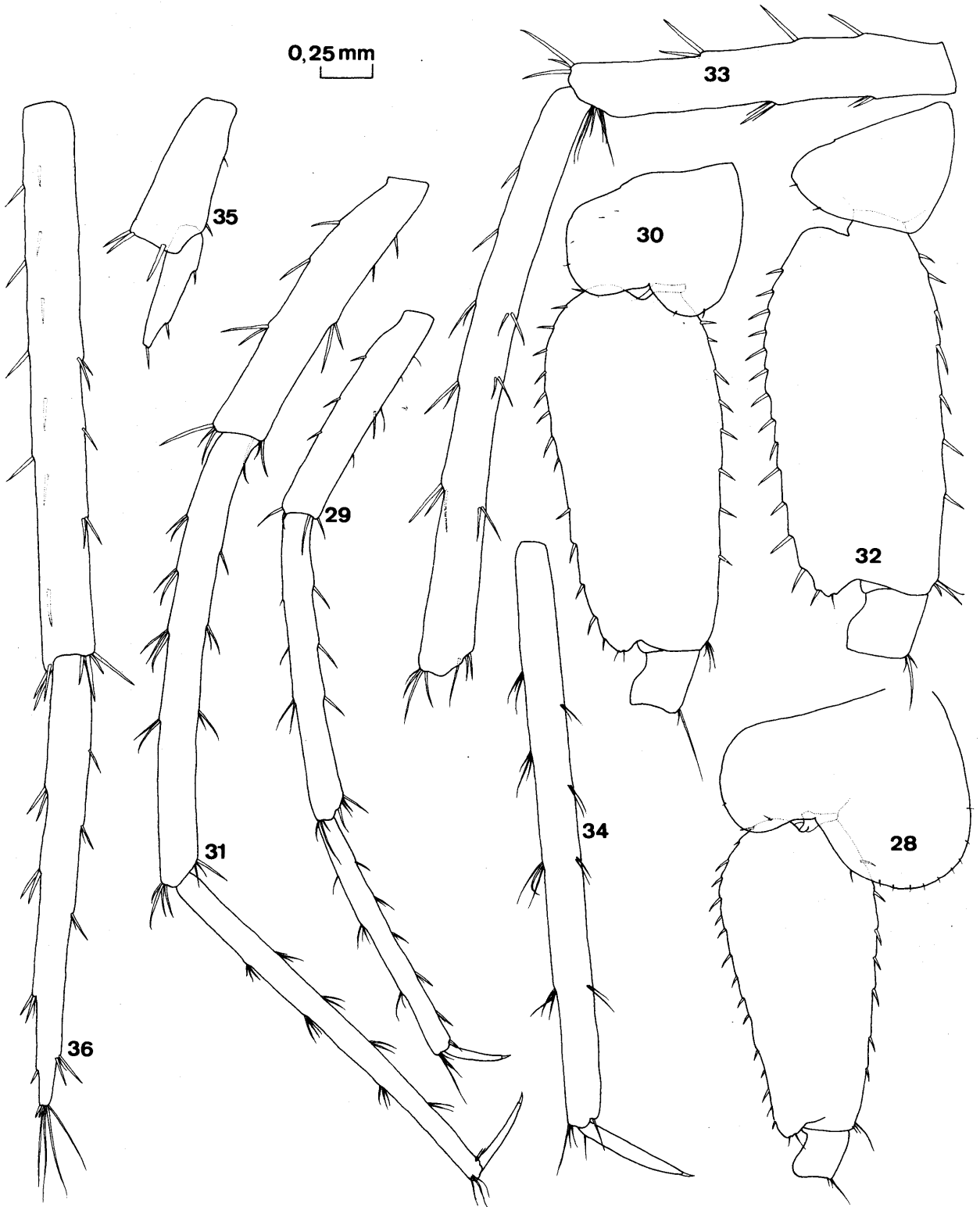


Fig. 28–36. *Psammogammarus burri* n. sp. (male holotype): 28, 29, pereopod 5; 30, 31, pereopod, 6; 32, 33 and 34, pereopod 7; 35, 36, uropod 3.

Nijssen, 1965), *P. caecus* S. Karaman, 1955 and *P. caesicolus* Stock, 1980 by, among other characters, its parviramous endopodite of uropod 3. Differences in the armature of uropods 1 and 2 are, among others, diagnostic characters for *P. burri* versus *P. garthi* (J.L. Barnard, 1952) and *P. gracilis* (Ruffo & Schieke, 1975).

Reducing the comparison between taxa to the 12 characters used by Stock & Sánchez (1987), *P. burri* shows a closer phenetic similarity to *P. philippensis* (Chilton, 1921) and *P. fluviatilis* Stock, 1991. They share the following character states: A1 accessory flagellum shorter than flagellum segment 1, inner lobe of Mx1 with more than 10 setae, oblique row of setae of inner lobe of Mx2 well developed, outer plate of maxilliped without spines, absence of sexual dimorphism in propodus of G2, G2 with mid-palmar spines, basis of P5 lobed, U1 with proximoven-tral spine, and parviramous endopodite of U3. Note nevertheless that all these states except the latter are plesiomorphic, so not indicating a real phylogenetic affinity but a shared undifferentiation. Nevertheless, *P. burri* differs from them in 3 other states, viz. carpus shorter than propodus of G1, linear profile of basis of P3-P4, and presence of dorsomarginal armature on exopodite of U2.

## Discussion

The distribution of the genus *Psammogammarus* closely coincides with the limits of the Tethys belt; it has been recorded from the West Indies, Canary Islands, the Mediterranean, the Philippines and the Cape Verde Islands (Stock & Sánchez, 1987; Stock, 1991 and in litt.; Vonk, 1990). All species (except two, *P. philippensis* (Chilton, 1921) and *P. fluviatilis* Stock, 1991) inhabit littoral marine sediments or anchihaline cave waters, which could indicate an initial phase of penetration of populations of the genus in inland groundwaters. Thus we may have here an ancient and mainly marine taxon. The question is whether the representatives of the genus in the Mediterranean existed there before the Messinian crisis, i.e., are they true Tethyan marine relicts, a category considered inadmissible elsewhere (Por &

Dimentman, 1985) or, on the contrary, have they invaded the Mediterranean waters after the re-opening of the Strait of Gibraltar at the beginning of the Pliocene.

Evidence for drastic changes in the marine abiotic conditions of the major Mediterranean basins during the Messinian are well documented (Hsü et al., 1973). There are data supporting a parallel extinction of its true marine biota as well (Benson, 1976; McCulloch & De Deckker, 1989; Esteban, 1979–1980). So, it is generally assumed that the post-Messinian repopulation of Mediterranean waters was coincident to the Pliocene transgression via Gibraltar (Pérès, 1985; Por & Dimentman, loc. cit.). Thus, the Cabrera taxon (and the other Mediterranean *Psammogammarus*) could have settled the Mediterranean very recently, in post-Messinian times, probably from an Atlantic stock. This is reinforced by the distribution of the genus, restricted to the Western Mediterranean Basin and the Adriatic Sea. As during the mid-Pleistocene Riss glaciation sea level may have stood some 100 m below its present level (Cuerda, 1975), an origin after this date may be assumed if the taxon originated in situ, but an ancient one seems more probable considering its high degree of troglobitization. The recently postulated connection of anchihaline habitats by an extended marine crevicular system (Hart et al., 1985; Manning et al., 1986) can reinforce this last statement.

An alternative hypothesis may be conceived considering the very localized and disjunct distribution of the known representatives of the genus, which advocate for its low dispersal capacity. The stygobiont nature of *P. burri* surely implies an extra-reduced dispersal potential as well (Notenboom, 1991). On the other hand, we have the clearly Tethyan pattern of distribution displayed by the genus. Thus, *P. burri* is maybe is a true Mediterranean Tethyan marine relict. Data supporting persistence of true marine conditions without interruptions during the salinity crisis in the Mediterranean basins are practically non-existent. Grecchi (1978) has described a taphocenosis of marine molluscs from the Lower Pliocene sediments covering the Messinian salt deposits, which show clear Indo-Pacific affinities. Wright (1979–1980) found the

same in reference to a benthic foraminiferan fauna from the Middle Pliocene. These faunas could have survived the salinity crisis, but they also could have penetrated in the Mediterranean in the Lower Pliocene if the water influx came also from the Indian Ocean, via Red Sea and Suez (Grecchi, loc. cit.). Of the various contradictory hypotheses (models) initially planned on the mechanism of the salinity crisis (see Riba, 1981 and references therein), only one ("deep water, deep sea basin model" of Schmalz, 1969) does not imply an important drop of sea level in the Mediterranean basin. Probably, it would not involve a parallel generalized catastrophe for the autoctonous marine fauna. Yet, it is the only hypothesis clearly rejected by geologists (Hsü et al., 1973). The nowadays prevailing, more consensus model (Malonado, 1985) supposes episode(s) of total dessication, with its inherent catastrophic consequences for marine fauna.

So, considering the prevailing theories on the paleogeography of the Mediterranean basin during the Messinian, the existence of basins with permanently normal, or nearly normal marine conditions, which could sustain marine species, appears improbable. This is reflected by the rarity (or absence) of taxa with a Tethyan pattern of distribution in Mediterranean waters. Nevertheless, due to the magnitude of the area reconstructed in paleogeographic models, it is always possible that such characteristics may have existed in zones with a continuous supply of water, as those near fresh-water inputs, which could act as refuges for marine fauna (Pérès, 1985; Notenboom, 1991). It is possible that the ancestor of *P. burri* was pushed into the marine crevicular habitat when marine conditions turned unfavourable. This would imply the existence of stygohabitats with raised salinities under the sub-aerially exposed surfaces. This hypothesis (stygohabitats as a refuge) has been advanced by Notenboom (1991), who also notes its untestability when actualistic data are lacking, and only biogeographic data are available, as is just our case.

*Psammogammarus burri* is the third representative of the genus in the Mediterranean, the other two being *P. caecus* S. Karaman, 1955, initially described from the Dalmatian coast, but later recorded also

from the Gulf of Naples, Sicily and the French Mediterranean coast, and *P. gracilis* (Ruffo & Schiecke, 1975) from the coast of Malta. Both are marine psammic elements, and have been recorded from depths of 2 to 15 m (Ruffo & Schiecke, loc. cit.). No close phenetic similarities relate these two taxa with that from Cabrera, which shows, besides, crevicular habits. So, some difficulties arise as to the ancestry of *P. burri*, a taxon with a high degree of troglolithisation and very localized distribution, from the known Mediterranean species stock.

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