

Morphology of the megalopa and first crab stage of the mediolittoral crab *Pachygrapsus marmoratus* (Brachyura, Grapsidae, Grapsinae)

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ABSTRACT

Megalopae of the grapsid crab *Pachygrapsus marmoratus* were captured from a mediolittoral rocky shore in the western Mediterranean and juveniles were obtained by rearing the megalopae in the laboratory. The megalopa and the first crab stage are described and illustrated. The morphological characters of the megalopa of *P. marmoratus* are compared with those of the other known megalopae of the subfamily Grapsinae.

KEY WORDS

Megalopa,
Pachygrapsus,
Grapsidae,
larval development,
Brachyura.

RÉSUMÉ

Des mégaloques du crabe grapsidé *Pachygrapsus marmoratus* ont été capturées sur des rochers médiolittoraux en Méditerranée occidentale. Les crabes juvéniles ont été obtenus au laboratoire à partir de ces mégaloques. La mégaloque et le premier crabe sont décrits et illustrés. Les caractéristiques morphologiques de la mégaloque de *P. marmoratus* sont comparées avec celles des autres mégaloques déjà décrites d'autres crabes de la sous-famille Grapsinae.

MOTS CLÉS

Mégaloque,
Pachygrapsus,
Grapsidae,
développement larvaire,
Brachyura.

INTRODUCTION

Megalopae play an important role within the life cycle of a crab, since this is the larval stage which is going to perform, through metamorphosis, the change from a planktonic to a benthic life-style, hence the importance of knowing in detail the morphological characteristics which make this stage so adaptable to so different environments and which provide the animals with the behavioural capabilities to perform the habitat change (Forward & Rittschoff 1994; Olmi 1994; Zeng *et al.* 1997). In addition, morphological studies on crustacean larval stages, and especially on stages related to metamorphic moults, such as crab megalopae, provide important information on the evolutionary lines followed by the larval development of a species (Rice 1980, 1988).

Three species of the genus *Pachygrapsus* inhabit the northeast Atlantic and Mediterranean waters: *P. marmoratus* (Fabricius, 1787), *P. transversus* (Gibbes, 1850), and *P. maurus* (Lucas, 1846). They inhabit the mediolittoral and/or shallow sublittoral regions on rocky shores. *P. marmoratus* is distributed throughout the Mediterranean Sea, Black Sea, and eastern Atlantic waters from Brittany to Morocco and the Canary islands, including the Azores and Madeira (Zariquiy-Álvarez 1968; Ingle 1980; Manning & Holthuis 1981). It is one of the typical, and most easily seen and observed species of the mediolittoral zone of rocky shores in the western Mediterranean (Forstner 1967; Ros *et al.* 1985). However, the knowledge of its ecology is very poor and mainly based on faunistic records. Only Vernet-Cornubert (1958) devoted part of her thesis to the understanding of the life cycle of *P. marmoratus* in the Mediterranean waters of the south of France. Most other published studies dealing with the species are based on aspects of its physiology (*e.g.* Houlihan & Innes 1984; Huxi & Aravindan 1985; Warburg *et al.* 1987).

The complete larval development of any species of the genus *Pachygrapsus* is, so far, unknown. The complete zoeal development (but not the megalopal stage) of *P. crassipes* and *P. gracilis* and the early zoeal stages of *P. maurus* and *P. transver-*

sus have been described (Lebour 1944; Schlorterbeck 1976; Ingle 1987; Brossi-García & Domingues-Rodríguez 1993; Cuesta & Rodríguez 1994). Also, incomplete descriptions of larvae of *P. crassipes* and *P. transversus* are known from material obtained from the plankton (Rathbun 1923; Rossignol 1957; Villalobos 1971). Concerning *P. marmoratus*, only the first and second zoeal stages, obtained from both the plankton and laboratory rearings, are properly known (Cano 1892; Williamson 1915; Hyman 1924; Bourdillon-Casanova 1960; Paula 1985; Ingle 1987, 1992; Cuesta & Rodríguez 1994). The present paper describes the morphology of the megalopa and the first juvenile of *P. marmoratus*.

MATERIAL AND METHODS

A few large megalopae were collected by hand in October 1995 from among seaweeds on the mediolittoral zone of a rocky shore near Tarragona (41°06.4'N - 01°17.1'E) in the western Mediterranean in an area where both adult and juvenile *Pachygrapsus marmoratus* were abundant. Some megalopae were fixed in 4% buffered formalin and two of them were kept alive, immediately transported to the laboratory and kept in a constant temperature room at 18 ± 1 °C in aquaria with filtered and well aerated sea water. These two megalopae moulted during the first night in the laboratory and the juvenile crabs were subsequently reared to the fourth stage. Exuviae of megalopae and juvenile crabs were preserved in 70% ethanol.

Dissection of the appendages and measurements were performed with a binocular microscope equipped with an ocular micrometer. A phase contrast microscope was used in the observation (after mounting in polyvinyl lactophenol) of the setal structures of the appendages. All drawings were made with the aid of a *camera lucida*. Carapace width (CW) was measured as the greatest distance across the carapace, and carapace length (CL) as the distance between the frontal margin and the posterior margin of the carapace.

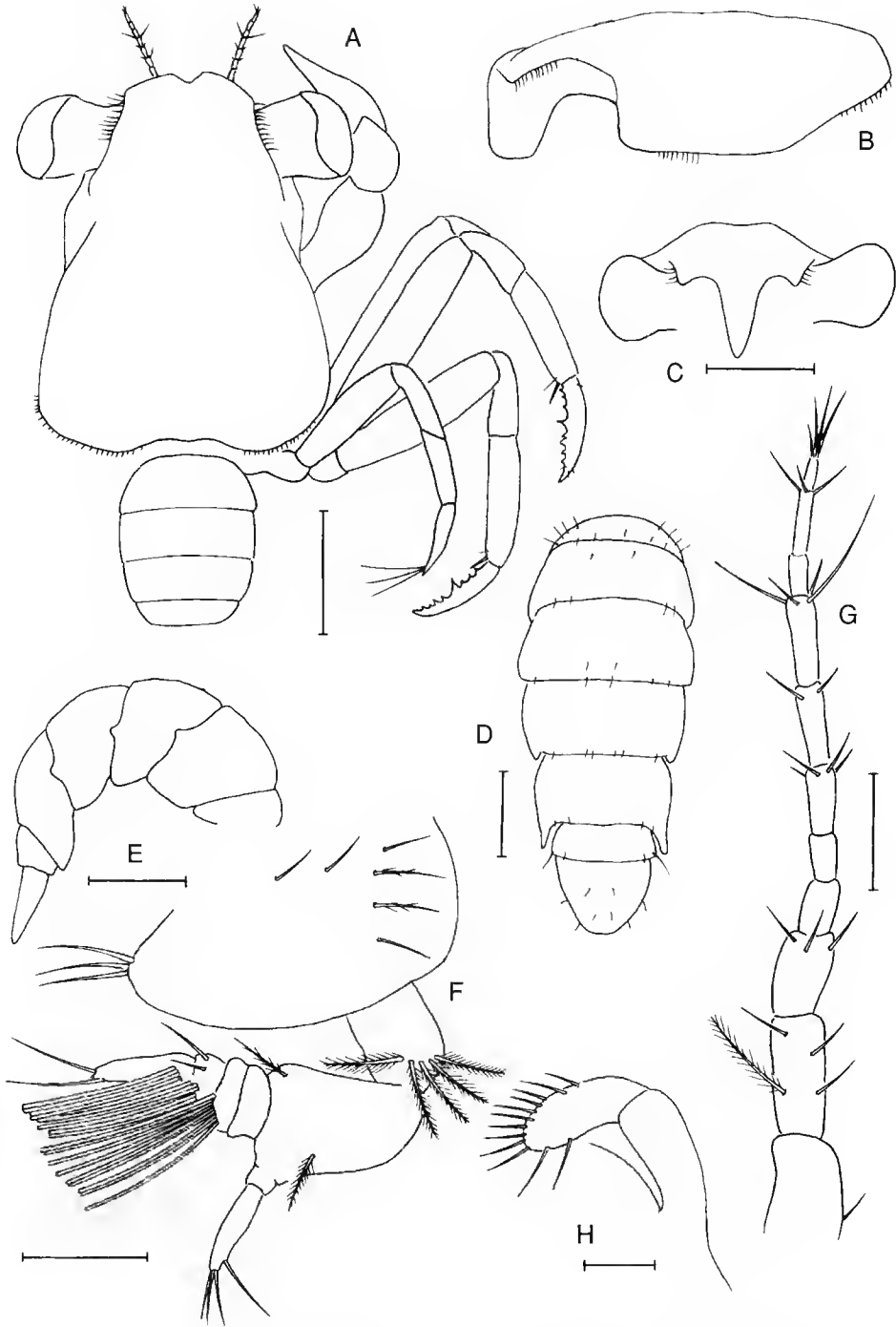


FIG. 1. — *Pachygrapsus marmoratus*, megalopa. **A**, dorsal view; **B**, carapace, lateral view; **C**, carapace, frontal view; **D**, abdomen, dorsal view; **E**, abdomen, lateral view; **F**, antennule; **G**, antenna; **H**, mandible, endopod. Scale bars: A-C, 1 mm; D, E, 0.5 mm; F, G, 0.2 mm; H, 0.1 mm.

RESULTS

MEGALOPA

Dimensions (range)

CL 3.0-3.2 mm; CW 2.1-2.3 mm.

Carapace (Fig. 1A-C)

Longer than broad, narrowing anteriorly and without spines; dorsal surface smooth; rostrum strongly deflected ventrally forming a laterally flattened keel or partition; lateral margin of the ocular, hepatic, and metabranchial regions with 10-11, 9, and about 30 simple setae, respectively.

Antennule (Fig. 1F)

Peduncle 3-segmented, with respectively 9, 5, 2 setae, basal segment bulbous; endopod 2-segmented with 0, 3 + 1 setae; exopod 4-segmented with 0, 16-18, 13, 5 aesthetascs and 0, 0, 1-2, 2 setae, respectively.

Antenna (Fig. 1G)

Protopod 3-segmented, segment 2 with 3 simple setae and one longer plumose seta, segment 3 with 3 setae; flagellum 8-segmented, with 0, 0, 4, 2, 4-5, 0, 3, 4 setae.

Mandible (Fig. 1H)

Mandibular palp 2-segmented with 0, 12 setae.

Maxillule (Fig. 2A)

Coxal endite with 18-20 setae; basal endite with 29 setae, and 4 setae on its inner lateral margin; endopod 2-segmented with 2, 3 setae.

Maxilla (Fig. 2B)

Coxal endite deeply bilobed with 5 + 15 setae; basal endite bilobed with 16-17 + 13 setae; endopod unsegmented with 4 plumose setae in its outer lateral margin; exopod (scaphognathite) with 79-82 marginal plumose setae and 4 medial setae.

First maxilliped (Fig. 2C)

Coxal endite with 20 setae; basal with 17 marginal setae; epipod with 23 long setae; endopod unsegmented with four setae; exopod 3-segmented; proximal segment with 3-5 plumose setae

placed distally, distal segment with 4 long terminal plumose setae.

Second maxilliped (Fig. 2D)

Epipod with 14 setae; endopod 4-segmented with 2, 1, 6-7, 12 setae; exopod 3-segmented, with one simple and 1-3 distally placed plumose setae on its proximal segment and 5 terminal plumose setae on its distal.

Third maxilliped (Fig. 3A)

Protopod with 6 setae; epipod with 13 setae and 31 long setae; endopod 5-segmented with 21-23, 12, 9-10, 19, 13 setae; exopod is 2-segmented, with 5-7 simple setae on the proximal segment and 5 terminal plumose setae on the distal.

Pereiopods (Figs 1A, 3B-F)

Without ischial or coxal spines; propodial segment of pereiopods 2-4 with a strong terminal spine on its inner margin, armed with two rows of spinules; inner margin of dactylus of pereiopods 2-4 armed with eight teeth, of which the first is articulated and the fourth is the largest; pereiopod 5 with 3 long subterminal setae.

Abdomen (Fig. 1D, E)

With 6 somites, broader than longer, plus telson; segments 2-4 with a small postero-lateral process; postero-lateral margin of the fifth segment slightly prolonged towards the rear.

Pleopods (Fig. 3G-I)

Present on segments 2-6; endopods with 5, 5, 5, 4 coupling hooks; exopod of segments 1-4 with 27, 30, 28, 25 long plumose natatory setae; uropods with 2 setae on the basal segment, and 17 on the distal.

Telson (Figs 1D, 3I)

Broader than long; posterior margin rounded; dorsal surface with 2 + 2 median and 4 marginal setae.

FIRST CRAB

Dimensions

CL 2.8 mm; CW 3.19-3.2 mm.

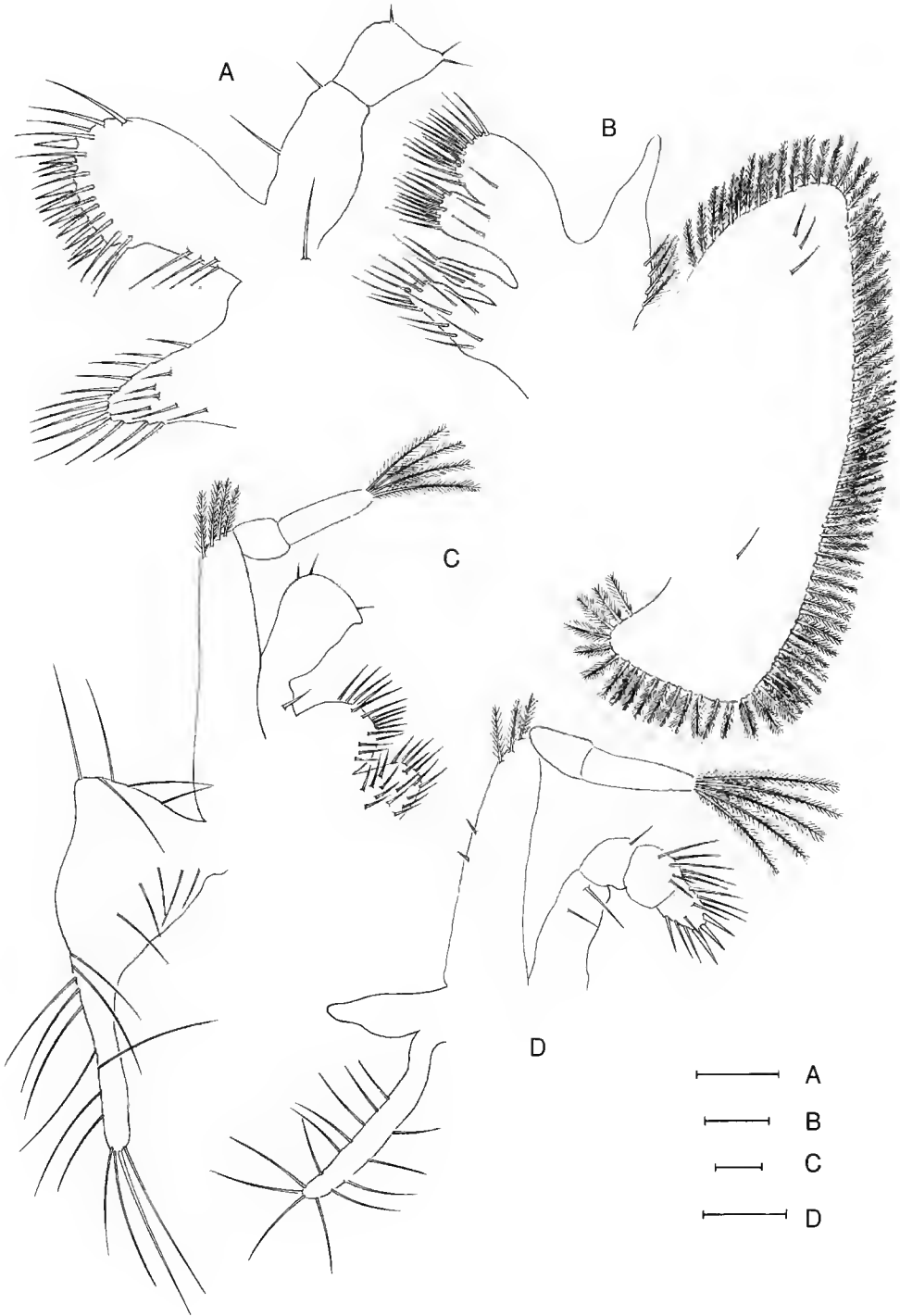


FIG. 2. — *Pachygrapsus marmoratus*, megalopa. A, maxillule; B, maxilla; C, first maxilliped; D, second maxilliped. Scale bars: A-C, 0.1 mm; D, 0.2 mm.

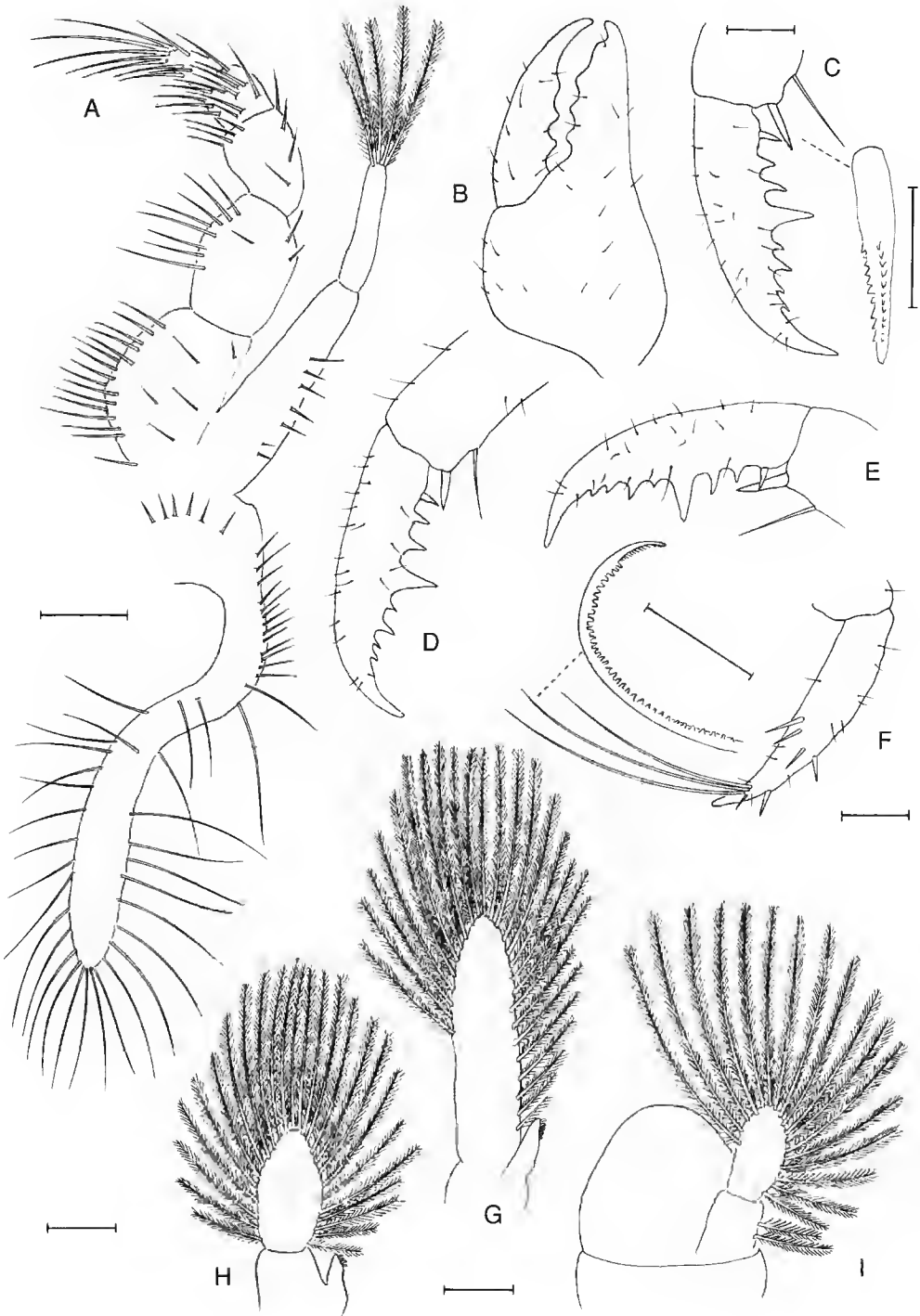


FIG. 3. — *Pachygrapsus marmoratus*, megalopa. A, third maxilliped; B, pereiopods 1, chela; C-F, dactylus of pereiopod 2-5; G, pleopod 3; H, pleopod 4; I, telson and right uropod. Scale: 0.2 mm.

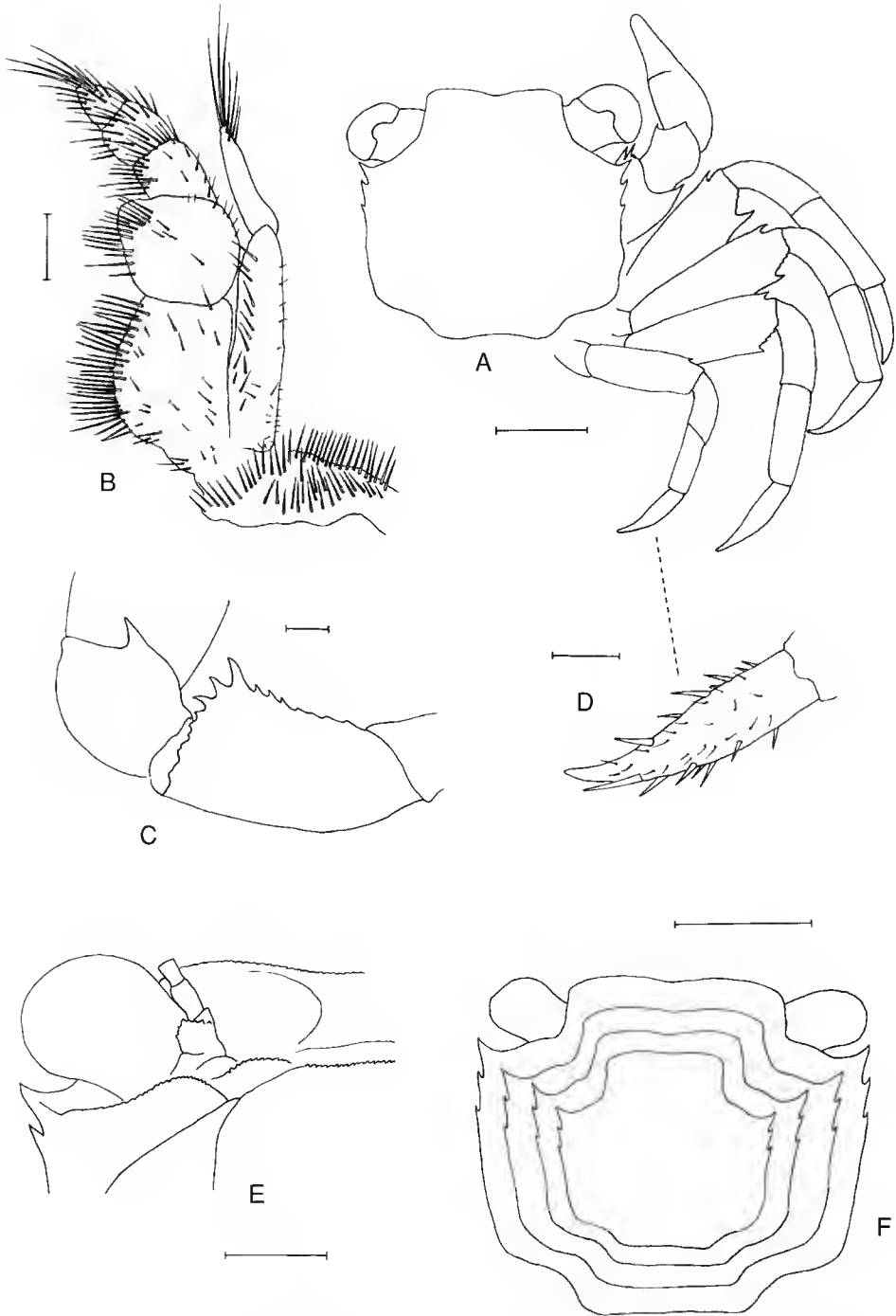


FIG. 4. — *Pachygrapsus marmoratus*, first juvenile. **A**, dorsal view; **B**, third maxilliped; **C**, merus and carpus of chelae; **D**, dactylus of pereopod 5; **E**, fronto-orbital region, ventral view; **F**, cephalotorax of juvenile 1-4. Scale bars: A, 1 mm; B, C, 0.2 mm; E, 0.5 mm; F, 2 mm.

Carapace (Fig. 4A, E)

Broader than long; frontal region broad, front measuring more than one half carapace width; orbital dorsal margin slightly angular; the V-shaped notch on the ventral outer margin of the orbit, present on the adult crab (Ingle 1980), is very poorly marked or absent in the first three juvenile crab stages (Fig. 4E); lateral regions of the carapace dorsal surface with many transverse to obliquely placed carinae; antero-lateral margins of carapace with three acute teeth, first largest and third smallest.

Third maxilliped (Fig. 4B)

Endopod 5-segmented with about 65, 35, 39, 35, and 17 setae; exopod 2-segmented with more than 41 setae on the proximal segment and 8 terminal plumose setae on the distal segment; epipodite with more than 100 setae and more than 74 non-plumose long setae.

Pereiopods (Fig. 4A, C, D)

Cheliped merus transversely striated and distal margin serrate; with acute carpal spine (Fig. 3C); pereiopods stout and compressed; merus of second to fifth pairs broad and transversely striated (except fifth); upper margins carinate, often with minute spinules; margins of dactyl of all pereiopods with prominent spines (Fig. 4D).

SECOND TO FOURTH CRAB STAGES

Specimens from second to fourth crab stages are similar in morphology to first stage, only differing in size from the stage described (Fig. 4F).

DISCUSSION

The megalopae studied herein were captured in the mediolittoral zone (Ros *et al.* 1985) at the end of the reproductive season of *Pachygrapsus marmoratus* (Vernet-Cornubert 1958; Zariquiey-Álvarez 1968; García-Raso 1984) and the reared juvenile crabs were typically grapsid in carapace shape and morphology, having three teeth on the antero-lateral margins. This character, specific to *P. marmoratus* in the Mediterranean, together with the habitat where the megalopae were captured, allowed confident specific identification

(Zariquiey-Álvarez 1968; Ingle 1980; Manning & Holthuis 1981).

Knowledge of the larval development of grapsid crabs is limited. Thus, while the family includes over 377 species, the megalopal stage is adequately described for only thirty-one species (Cuesta & Schubart, unpublished data). Within the subfamily Grapsinae, the megalopal stage is properly known for only nine species: *Pachygrapsus marmoratus* (see Cano 1892); *P. transversus* (see Rossignol 1957); *P. crassipes* (see Rathbun 1923); *Grapsus strigosus* (see Gohar & Al-Kholy 1957); *Planes minutus* (as *Nautilograpsus* in Cano 1892); *Planes cyaneus* (see Muraoka 1973); *Metopograpsus latifrons* (see Kakati 1982); *M. maculatus* (see Pasupathi & Kannupandi 1986); *M. frontalis* (see Fielder & Greenwood 1983). But the descriptions of only four of them have been based on material reared in the laboratory: *P. cyaneus*, *M. frontalis*, *M. maculatus* and *M. latifrons*. However, the megalopa described by Gohar & Al-Kholy (1957) from the plankton and attributed to *G. strigosus* is very similar in morphology to those of the genus *Metopograpsus* and, since there are no proper descriptions of megalopae of the genus *Grapsus*, it could belong to *M. messor*, a species also present in that area.

The megalopa of *Pachygrapsus marmoratus* was previously incompletely described by Cano (1892). This author described two megalopal stages for the species, but only one actually belonged to a Grapsid crab (Hyman 1924; Ingle 1987, 1992). This megalopa was very similar to the megalopa described herein, but the brief description provided by Cano does not allow a detailed comparison.

Other described megalopae of species of the genus *Pachygrapsus* are those provided by Rossignol (1957) for *P. transversus*, based on material captured by hand on the shores of central West Africa, and by Rathbun (1923) for *P. crassipes* from megalopae collected in the plankton off the west coast of Mexico. These descriptions are incomplete since there is no information on setation and detailed morphological characteristics. No appendages are described and only drawings showing the overall dorsal (and frontal in the case of *P. crassipes*) morphology of the whole animal are presented. The overall

carapace shape and that of the pereopods of both species are very similar and also similar to those of *P. marmoratus* described herein. In all species the spinulation of the dactyls of the pereopods 2-4 is particularly well developed.

Concerning other megalopae of the subfamily Grapsinae, only those of *Metopograpsus latifrons*, *M. frontalis*, *M. maculatus* and *Planes cyaneus* are sufficiently well described (Table 1) (Muraoka 1973; Kakati 1982; Fielder & Greenwood 1983; Pasupathi & Kannupandi 1986). The megalopa of *Metopograpsus* differs mainly from that of *Pachygrapsus marmoratus* in carapace shape and morphology of the frontal region, besides some additional differences in setation and shape of the fifth abdominal segment. That of *P. cyaneus* differs mainly in size (it is much bigger than that

of *P. marmoratus*) and also in setation, but not in overall shape. The most important differences in setation between the megalopae of *P. cyaneus* and *P. marmoratus* are those of the protopod of the uropod. Thus, the megalopae of *P. marmoratus* bear two plumose setae and that of *P. cyaneus* bear three. Also, the endopod of the maxilla bears four setae in *P. marmoratus* and seven in *P. cyaneus*.

Acknowledgements

We wish to thank Miss C. Simón for her help in collecting the material as well as Miss A. C. Costa (University Açores) for her bibliographical assistance.

TABLE 1. — Morphological characteristics of several described megalopae of the subfamily Grapsinae.

| Features | <i>P. marmoratus</i> (present study) | <i>M. frontalis</i> (Fielder & Greenwood 1983) | <i>M. maculatus</i> (Pasupathi & Kannupandi 1986) | <i>M. latifrons</i> (Kakati 1982) | <i>P. cyaneus</i> (Muraoka 1973) |
|--------------------------|---|--|---|--------------------------------------|-------------------------------------|
| Dimensions: | | | | | |
| CL (mm) | 3.0-3.2 | 1.56-1.64 | 1.79 | 1.85 | 3.5-4.5 |
| CW (mm) | 2.1-2.3 | 1.46-1.76 | 1.60 | 1.55 | 1.5 |
| Antennule setation: | | | | | |
| endopod | 0, 4 | 0, 4 | 0, 2 | 0, 3 | 0, 5 |
| exopod (A) | 0, 16-18, 13, 5 | 0, 6, 5, 4 | 6, 7, 9, 0 | 24 (total) | ? |
| exopod (S) | 0, 0, 1-2, 2 | 0, 1, 2, 2 | 0, 0, 0, 2 | ? | ? |
| Antenna setation: | | | | | |
| protopod | 0, 3 + 1, 3 | 3, 2 + 1, 3 | 1, 2, 2 | 1, 2, 2 | 8, 2, 2 |
| flagellum | 0, 0, 4, 2, 5, 0, 3, 4 | 0, 0, 4, 1, 5, 0, 3, 3 | 2, 0, 0, 0, 6, 1, 3, 3 | 0, 0, 3, 0, 5, 1, 2, 2 | 0, 0, 3, 2, 3, 0, 2, 3 |
| Mandible setation: | | | | | |
| palp | 0, 12 | 0, 7 | 0, 0, 9 | 0, 0, 8 | 0, 10 |
| Maxillule setation: | | | | | |
| endopod | 2, 3 | 0, 0 | 0, 3 | 0, 0 | 2, 1 |
| basial endite | 29 | 28 | 23 | 20 | 21 |
| coxal endite | 18-20 | 15 | 12 | 11-12 | 15 |
| Maxilla setation: | | | | | |
| basial endite | 16-17 + 13 | 9 + 1 | 12 + 13 | 21 | 20 |
| coxal endite | 5 + 15 | 7 + 10 | 9 + 1 | 12 | 18 |
| scaphognathite | 79-82 | 58-63 | 76 | 71 | ? |
| Maxilliped I setation: | | | | | |
| coxal endite | 20 | 14 | 12 | 10 | 13 |
| basial endite | 17 | 13-14 | 20 | 17 | 17 |
| epipod | 23 | 11 | 9 | 7 | ? |
| exopod | 3-5, 0, 4 | 3, 4 | 2, 4 | 2, 4 | 3, 0, 6 |
| Maxilliped II setation: | | | | | |
| epipod | 14 | 3 | 0 | 0? | ? |
| endopod | 2, 1, 6-7, 12 | 1, 1, 6, 9 | 0, 1, 5, 5, 7 | 0, 0, 1, 4, 10 | 2, 1, 7, 9 |
| exopod | 2-5, 0, 5 | 2, 5 | 0, 6 | 0, 5 | 3, 0, 5 |
| Maxilliped III setation: | | | | | |
| epipod | 13 + 31 | 7-9 + 22 | 12 | 14 | 36 |
| endopod | 23, 12, 10, 19, 13 | 15, 10, 8, 10, 10 | 16, 5, 2, 7, 6 | 14, 6, 1, 8, 5 | 17, 10, 5, 6, 8 |
| exopod | 5-7, 5 | 5, 5 | 0, 4 | 0, 4 | 0, 4 |
| Uropod setation: | | | | | |
| exopod | 2, 17 | 2, 13 | 1, 16 | 2, 16 | 3, 20-23 |

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*Submitted for publication on 28 March 1996;
accepted on 24 June 1996.*