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# THE IDENTIFICATION OF THE PENULTIMATE LARVAL STAGE OF THE PROCESSIDAE (CRUSTACEA, DECAPODA, CARIDEA) FROM THE FRENCH COAST OF THE MEDITERRANEAN SEA (\*)

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CRUSTACEA DECAPODA  
MEDITERRANEAN PROCESSIDAE  
LARVAE  
IDENTIFICATION

**ABSTRACT.** – The penultimate larval stage of six different species or subspecies of *Processa* from plankton samples of the French coast of the Mediterranean Sea is described. The larvae of *P. modica carolii*, *P. nouveli nouveli*, and *P. edulis edulis* are identified from earlier descriptions. The larvae of three other species are described for the first time. One of these species is considered to be *P. elegantula*, the remaining could not be identified. The presence or absence of a spine on the stylocerite of the antennulae is used as a new identification character for the larvae of the Processidae. The characters used may also be applied to last stage larvae.

CRUSTACEA DECAPODA  
PROCESSIDAE MÉDITERRANÉENS  
LARVES  
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**RÉSUMÉ.** – Le pénultième stade larvaire de six espèces ou sous-espèces différentes de *Processa* provenant du plancton méditerranéen des côtes françaises est décrit. Les larves de *P. modica carolii*, *P. nouveli nouveli* et *P. edulis edulis* sont identifiées d'après des descriptions existantes. Les larves de trois autres espèces sont décrites pour la première fois. Une de ces espèces est rattachée à *P. elegantula*, les deux autres n'ont pu être identifiées. La présence ou l'absence d'une épine sur le stylocérite de l'antennule est appliquée comme nouveau caractère d'identification pour les larves des Processidae. Les caractères utilisés peuvent aussi être appliqués aux derniers stades larvaires.

## INTRODUCTION

The taxonomy of the European Processidae has been very problematic in the past. In 1957 Nouvel & Holthuis revised the adult Processidae from European waters and described eight different species for the Mediterranean Sea. Al-Adhub & Williamson revised some adult European Processidae again in 1975. Williamson & Rochanaburanon (1979) completed this revision and also reviewed the larvae of the north European species. The Mediterranean Processidae now comprise the following species and subspecies: *Processa canaliculata* Leach (Al-Adhub & Williamson, 1975), *P. edulis edulis* Risso (Nouvel & Holthuis, 1957), *P. nouveli nouveli* (Al-Adhub & Williamson, 1975), *P. modica carolii* Williamson (Williamson & Rochanaburanon, 1979), *P. robusta* Nouvel & Holthuis (Nouvel & Holthuis, 1957), *P. acutirostris* Nouvel & Holthuis (Nouvel & Holthuis, 1957), *P. macrophthalma* Nouvel & Holthuis (Nouvel & Holthuis, 1957), and *P. elegantula* Nouvel & Hol-

thuis (Nouvel & Holthuis, 1957). Besides other localities in the Mediterranean Sea, the adults of these species are all reported for the investigated French coast (Nouvel & Holthuis, 1957; Zariquiey-Alvarez, 1968).

Even though the processid larvae are very common in the Mediterranean plankton, their identification is difficult, and only few descriptions are available today.

Kurian (1956) was the first to describe the larvae of *P. canaliculata* Leach, *P. edulis edulis* Risso, and *P. modica carolii* Williamson & Rochanaburanon (as *Latreutes* sp.). Bourdillon-Casanova (1960) dealt with *P. modica carolii* Williamson & Rochanaburanon (as *P. parva* Holthuis) and the larvae and post-larvae of four different unidentified species. Williamson (1967) characterized four species (EM 4, EM 5, EM 6, EM 7) for the Eastern Mediterranean Sea. He could identify EM 7 as *P. canaliculata* Nouvel & Holthuis non Leach, which is now referred to as *P. nouveli nouveli* Al-Adhub & Williamson. Wil-

liamson & Rochanaburanon (1979) gave a detailed description of the larvae of *P. modica carolii* and *P. canaliculata* Leach.

The larvae of the remaining four species in the Mediterranean Sea, *P. robusta*, *P. acutirostris*, *P. macrophthalma*, and *P. elegantula*, are still unknown.

The main problem in identifying processid larvae is their small size. Therefore, this investigation is based on the penultimate larval stage which is common in coastal plankton and has clearly distinguishable identification characters.

In the present paper the penultimate larval stage of six different species or subspecies of the Processidae from the French Mediterranean coast are described. Three of them could be clearly identified to species, the remaining are described here for the first time.

## MATERIALS AND METHODS

Larval stages of *Processa* were collected in plankton tows at Villefranche-sur-Mer and Banyuls-sur-Mer (France) in April and September 1991, 1992, and 1993. Different oblique hauls covering a depth range of 0 to 70 m were made using nets of 300 and 500  $\mu\text{m}$  mesh-size. After relaxation in 7%  $\text{MgCl}_2$  the specimens were fixed in 3% glutaraldehyde diluted in seawater and transferred to 70% ethanol. Altogether 98 larvae in the penultimate stage were examined to establish the identification characters (*Processa edulis edulis*, 13; *P. modica carolii*, 10; *P. noveli noveli*, 53; *Processa* sp. 1, 10; *P. ? elegantula*, 8; *Processa* sp. 2, 4). The different stages and species were identified by light microscopy (LM). Scanning electron microscopy (SEM) was used to get more detailed information and to confirm the differences observed between specimens. For SEM specimens were critical-point dried using  $\text{CO}_2$ , coated with gold, and examined with a Hitachi SEM H-530. The length of the specimens was measured from the tip of the rostrum to the posterior margin of the telson (excl. setae).

### Characterization of the penultimate stage

As stated above, the morphological features used to identify the different species are only clearly distinguishable for late larval stages, i.e. the penultimate and the last larval stage. The investigated larvae were all in a comparable stage of development. They showed large biramous pleopods with appendix interna and some small setae. The second pereopods began to be chelated. The flagellum of the antenna was jointed and exceeded the length of the scale (Fig. 1). This stage is considered to be the penultimate with reference to Gurney (1923) who described the last stage having fully formed chelae on the first and the second pereopods and the flagellum of the antenna being very long. Gurney observed some specimens which moulted directly

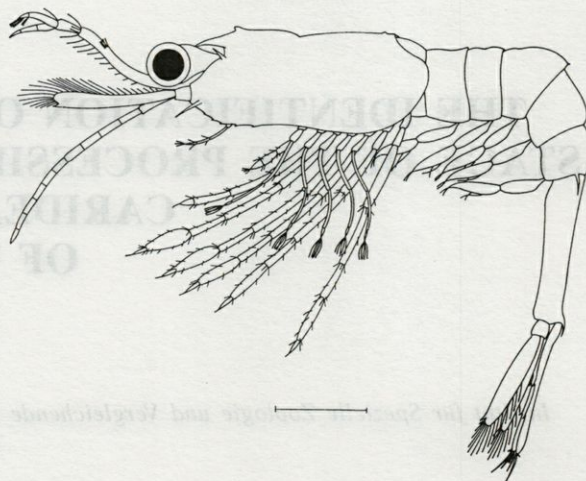


Fig. 1. – General morphology of the penultimate stage of *Processa modica carolii* (stage VIII). Bar scale = 0,5 mm.

from the penultimate stage to the post-larval and others which passed through the last stage before moulting to the post-larval. These observations were confirmed later by Lebour (1936) and Williamson & Rochanaburanon (1979). Therefore, the terms “penultimate” and “last” larval stage are used here to describe the “morphological age” of the larvae.

Unfortunately, the number of larval stages is only known for two Mediterranean species, i.e. *P. modica carolii* and *P. canaliculata* (Williamson & Rochanaburanon, 1979). Unlike *P. modica modica* from the Atlantic, which passes through seven stages, *P. modica carolii* usually has nine. *Processa canaliculata* passes through eight or nine stages.

### Characters used to separate the species

A preliminary sorting of the larvae into three groups was done with a light microscope according to the rostrum length (seen from the dorsal side): 1) rostrum not exceeding the frontal lobe (rostrum not visible in ventral view), 2) tip of rostrum exceeding the frontal lobe (only tip of rostrum visible in ventral view), 3) rostrum reaching at least to 1/2 of the first segment of the antennal flagellum (more than tip of rostrum visible in ventral view).

The dorso-median spine on abdominal somites 3 and 6 was examined by LM, but the spine on the stylocerite of the antennulae had to be examined by SEM. The spine on the stylocerite can be seen by LM only in living specimens.

Using these characters as main distinguishing features the larvae of six out of eight Mediterranean species of *Processa* were found in the samples.

Additional characters, however, as the length of the pterygostomian spine (visible in LM) and the number of denticles of the antero-ventral carapace margin (clearly distinguishable only by SEM) are necessary to compare the larvae of the species found with others described for the Mediterranean Sea.

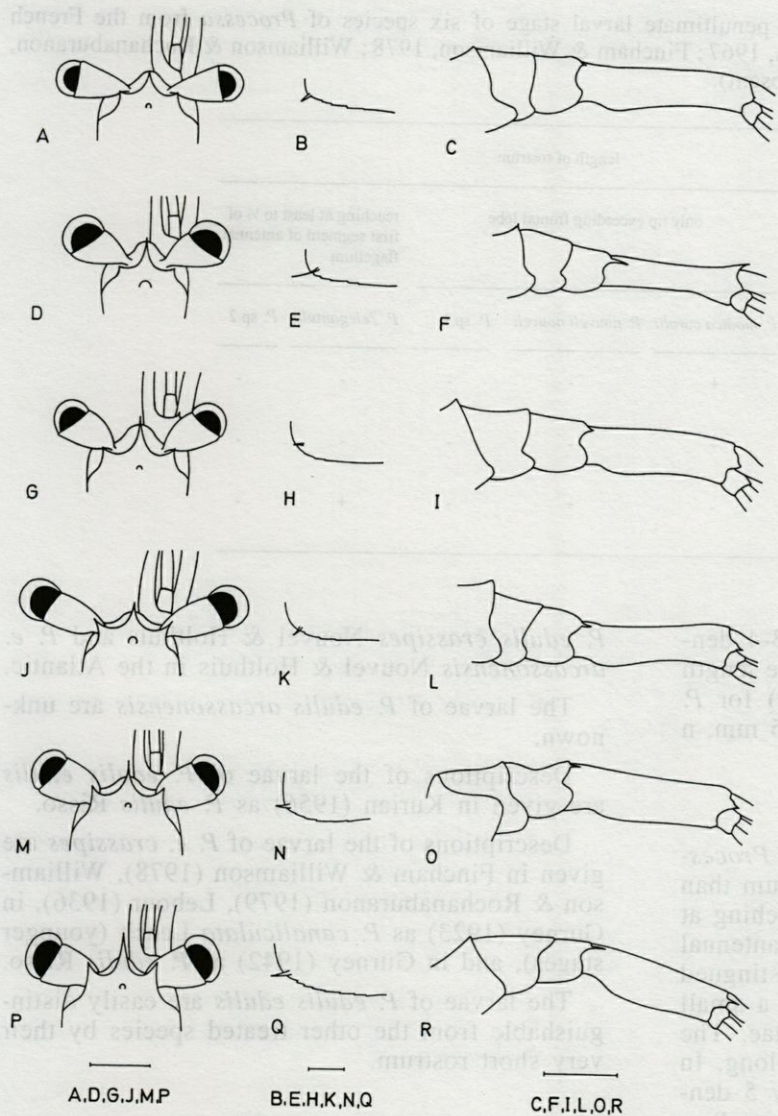


Fig. 2. - Penultimate larval stage of six species of *Processa* from the French Mediterranean coast: Head (dorsal), antero-ventral carapace margin (lateral), abdominal segments (without pleopods) (lateral). A-C, *P. edulis edulis*; D-F, *P. modica carolii*; G-I, *P. nouveli nouveli*; J-L, *Processa* sp. 1; M-O, *P. ?elegantula*; P-R, *Processa* sp. 2. Bar scales: A, D, G, J, M, P = 0,5 mm; B, E, H, K, N, Q = 0,2 mm; C, F, I, L, O, R = 0,5 mm.

**RESULTS**

**Identification characters of the six species or subspecies**

The characters are described for larvae in the penultimate stage, but may also be applied to last stage larvae.

**Group 1**

*Processa edulis edulis* (Fig. 2 A-C) is distinguished from all other species found by a very short rostrum, which is not exceeding the frontal lobe. The abdominal somites 3 and 6 of this species show no dorso-median spine and there is no spine on the stylocerite of the antennulae. *Processa edulis edulis* is further characterized by a small pterygostomial spine and 4 antero-ventral carapace denticles. Average length 4,7 mm (range: 3,6-5,6 mm, n = 10).

**Group 2**

*Processa modica carolii* (Fig. 2 D-F), *P. nouveli nouveli* (Fig. 2 G-I), and *Processa* sp. 1 (Fig. 2 J-L) have a relatively short rostrum. Only the tip of the rostrum is exceeding the frontal lobe.

*Processa modica carolii* can be distinguished from all other species found in the samples by the presence of a median spine on abdominal somites 3 and 6. The stylocerite of the antennulae shows no spine. Additionally, *P. modica carolii* is characterized by a very long pterygostomial spine and 5 denticles on the antero-ventral carapace margin. Average length 4,4 mm (range: 4,0-4,7 mm, n = 7).

In *P. nouveli nouveli* and *Processa* sp. 1 the abdominal somites 3 and 6 have no dorso-median spine. But *Processa nouveli nouveli* is separated from *Processa* sp. 1 by the presence of a spine on the stylocerite of the antennula. Both species

Table I. – Main distinguishing features of the penultimate larval stage of six species of *Processa* from the French Mediterranean coast (modified from Williamson, 1967; Fincham & Williamson, 1978; Williamson & Rochanaburanon, 1979) (+ = character present; – = character absent).

	length of rostrum					
	not exceeding frontal lobe	only tip exceeding frontal lobe			reaching at least to ½ of first segment of antennal flagellum	
	<i>P. edulis edulis</i>	<i>P. modica carolii</i>	<i>P. nouveli nouveli</i>	<i>P. sp.1</i>	<i>P. ?elegantula</i>	<i>P. sp.2</i>
spine on abd. som. 3 (dorso-median)	-	+	-	-	-	-
spine on abd. som. 6 (dorso-median)	-	+	-	-	-	-
spine on stylocerite of antennulae	-	-	+	-	+	-

have a small pterygostomian spine and 3-4 denticles on the carapace margin. The average length is 4,8 mm (range : 4,4-5,3 mm, n = 10) for *P. nouveli nouveli* and 4,8 mm (range : 4,5-5 mm, n = 8) for *Processa* sp. 1.

### Group 3

*Processa ?elegantula* (Fig. 2 M-O) and *Processa* sp. 2 (Fig. 2 P-R) have a longer rostrum than all previously described species. It is reaching at least to 1/2 of the first segment of the antennal flagellum. *Processa ?elegantula* is distinguished from *Processa* sp. 2 by the presence of a small spine on the stylocerite of the antennulae. The pterygostomian spine of both species is long. In contrast to *P. ?elegantula*, which has only 5 denticles on the antero-ventral carapace margin, *Processa* sp. 2 has 6-7. The average length is 5,0 mm (range : 4,7-5,6 mm, n = 5) for *P. ?elegantula* and 4,4 mm (range : 4,2-4,7 mm, n = 3) for *Processa* sp. 2.

Table I summarizes the main distinguishing features of the species.

### DISCUSSION

The larvae of *Processa edulis edulis*, *P. modica carolii*, *P. nouveli nouveli*, and *P. canaliculata* are known from existing descriptions, but those of *P. elegantula*, *P. robusta*, *P. acutirostris*, and *P. macrophthalma* have not yet been described.

#### *Processa edulis edulis* Risso (Tabl. I, Fig. 2, A-C)

In the revision of Nouvel & Holthuis (1957) *P. edulis* Risso is divided into three subspecies : *P. edulis edulis* Risso in the Mediterranean Sea, and

*P. edulis crassipes* Nouvel & Holthuis and *P. e. arcassonensis* Nouvel & Holthuis in the Atlantic.

The larvae of *P. edulis arcassonensis* are unknown.

Descriptions of the larvae of *P. edulis edulis* are given in Kurian (1956) as *P. edulis* Risso.

Descriptions of the larvae of *P. e. crassipes* are given in Fincham & Williamson (1978), Williamson & Rochanaburanon (1979), Lebour (1936), in Gurney (1923) as *P. canaliculata* Leach (younger stages), and in Gurney (1942) as *P. edulis* Risso.

The larvae of *P. edulis edulis* are easily distinguishable from the other treated species by their very short rostrum.

#### *Processa modica carolii* Williamson & Rochanaburanon (Tabl. I, Fig. 2, D-F)

Williamson & Rochanaburanon (1979) proposed *P. modica* as a new species with the subspecies *P. m. carolii* in the Mediterranean Sea and *P. modica modica* in the Atlantic.

The larvae of *P. modica carolii* are described by Williamson & Rochanaburanon (1979), by Caroli (1947) as *P. aequimana* (Paulson), by Kurian (1956) as *Latreutes* sp.?, and by Bourdillon-Casanova (1960) as *P. parva* Holthuis.

Those of *P. modica modica* are described by Fincham & Williamson (1978), by Williamson & Rochanaburanon (1979), and by Rees & Catley (1949) as *P. aequimana* (Paulson).

The very long pterygostomian spine and the long dorso-median spine on abdominal somite 6 are reliable characters to distinguish the larvae of *P. modica carolii* from the other examined species. Even in younger stages starting from stage III these characters are visible. Older larvae of *P. m. carolii* are also characterized by the absence of

exopods on pereopods 4 and 5. In the other species exopods are absent only on pereopod 5.

The specimens investigated here show a much smaller dorso-median spine on abdominal somite 3 than those from Naples described by Williamson & Rochanaburanon (1979). This may be due to geographical variation.

In this paper the presence of a spine on the stylocerite of the antennulae, a feature used for the identification of adults by Nouvel & Holthuis (1957), Al-Adhub & Williamson (1975), and Williamson & Rochanaburanon (1979), is applied to larvae for the first time (using SEM). However, no spine could be found in the penultimate stages of *P. modica carolii*, even though the adults of this species show this character. Maybe this spine occurs only in last stage larvae of *P. m. carolii*, which were not present in the samples. Examinations of the other described species confirm that this character is present in the penultimate stage of some species (*P. nouveli nouveli* and *P. ?elegantula*).

#### ***Processa nouveli nouveli* Al-Adhub & Williamson (Tabl. I, Fig. 2. G-I)**

Al-Adhub & Williamson (1975) revised the species described by Nouvel & Holthuis (1957) as "*P. canaliculata* Leach" and renamed it *P. nouveli*, with *P. nouveli nouveli* in the Mediterranean Sea and *P. nouveli holthuisi* in the Atlantic.

The larvae of *P. n. nouveli* are only described by Williamson (1967) as *Processa* EM 7, resp. *P. canaliculata* Nouvel & Holthuis non Leach.

Those of *P. n. holthuisi* are described by Fincham & Williamson (1978), by Williamson & Rochanaburanon (1979), and by Gurney (1923) as *P. canaliculata* Leach (later stages).

*Processa n. nouveli* is very similar to *Processa* sp. 1 (Tabl. I, Fig. 2. J-L), but the presence of a spine on the stylocerite of *P. n. nouveli* is a reliable character to separate these species. The spine on the stylocerite is also present in the adults of *P. nouveli* (Nouvel & Holthuis, 1957; Al-Adhub & Williamson, 1975).

#### ***Processa canaliculata* Leach**

This species was revised by Al-Adhub & Williamson (1975).

The larvae occurring in the Mediterranean Sea are described by Kurian (1956) and by Bourdillon-Casanova (1960) as *P. mediterranea* Parisi.

The larvae occurring in the Atlantic are described by Lebour (1936), by Fincham & Williamson

(1978), and by Williamson & Rochanaburanon (1979).

No larvae of *P. canaliculata* Leach could be found in the present collection; according to Kurian (1956) and Bourdillon-Casanova (1960) they seem to be very rare in the coastal plankton. They are characterized by the presence of dorso-lateral spines on abdominal somites 4 and 5. None of the investigated specimens showed any spines on abdominal somite 4.

#### ***Processa ?elegantula* (Tabl. I, Fig. 2. M-O)**

Nouvel & Holthuis (1957) described four adult species of *Processa* having a spine on the stylocerite: *P. parva* (i.e. *P. m. carolii*), *P. canaliculata* non Leach (i.e. *P. n. nouveli*), *P. mediterranea* (i.e. *P. canaliculata* Leach), and *P. elegantula*.

As the larvae of *P. m. carolii*, *P. n. nouveli*, and *P. canaliculata* Leach have been characterized above, the remaining larvae having a spine on the stylocerite could be those of *P. elegantula*, which have never been described before (Fig. 2. M).

*Processa ?elegantula* is very similar to *Processa* EM 6 (Williamson, 1967). Both species are characterized by a long rostrum and a strong pterygostomial spine. However *P. ?elegantula* has only 5 antero-ventral carapace denticles, while *Processa* EM 6 has 9.

#### ***Processa* sp. 1 and *Processa* sp. 2 (Tabl. I, Fig. 2. J-L, P-R)**

Among the eight Mediterranean Processidae the larvae of *P. macrophthalma*, *P. acutirostris*, and *P. robusta* are still unknown. As the adults of these species are reported for the investigated area, the French Mediterranean coast, their larvae should also occur in the examined samples.

According to the descriptions given above, there is no doubt that *Processa* sp. 1 and *Processa* sp. 2 are distinct species, but they could not yet be identified.

*Processa* EM 4 described by Williamson (1967) is very similar to *Processa* sp. 1. The only apparent difference is the lack of carapace denticulation in *Processa* EM 4, while *Processa* sp. 1 shows 3-4 distinct denticles.

The identification characters described in this paper for larvae in the penultimate stage may also be applied to last stage larvae. Unfortunately these characters are less distinct in younger larvae, which makes a separation of the species very difficult. Only the younger stages of *P. m. carolii* and *P. canaliculata* can easily be identified, as they show additional spines on abdominal somites 3 and 6, resp. on abdominal somite 4.

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