FIRST LARVAL STAGE OF *SCYLLARUS POSTELI* FOREST, 1963 AND *PROCESSA MACRODACTYLA* HOLTHUIS, 1952 HATCHED IN THE LABORATORY (CRUSTACEA, DECAPODA)

J. I. González-Gordillo & A. Rodríguez

Instituto de Ciencias Marinas de Andalucía (CSIC), Campus Universitario Río San Pedro,
Apdo Oficial, E-11510 Puerto Real (Cádiz), Spain.
Fax: +34 956834701. E-mail: nacho.gonzalez@icman.csic.es

ABSTRACT

The first larval stage of *Scyllarus posteli* Forest, 1963, and *Processa macrodactyla* Holthuis, 1952, are described and illustrated from material reared in the laboratory. For both a diagnostic key for the identification of the first larval stage is provided.

For Mediterranean and adjacent Atlantic *Scyllarus* species have been described but this is the first larval stage of a *Scyllarus* to be identified with certainty. *S. posteli* belongs to the second scyllarid group larvae proposed by Sekiguchi (1987), which has four long plumose setae on the distal segment of the maxilla. *Processa macrodactyla* is characterized by presenting abdominal somite 3 without dorsal spine, four small marginal denticles behind pterygostomian spine, and antennal exopod at least $\frac{1}{4}$ the length of antennal scale.

INTRODUCTION

The correct identification of decapod larvae in plankton samples is essential for those studies related to population dynamics, spatio-temporal distributions, and other aspects. However, the identification of decapod larvae from plankton samples proves to be a complex task. In many cases it is not possible to identify the species due to the sparse available descriptions. Decapod larval are often found in large numbers in plankton samples from estuaries, salt-marsh zones and littoral waters (Paula 1987; Fuxté & Gili 1991). In most cases the parentage of these larvae is not known and they cannot be identified to specific level. The problem begins when workers group them together under headings such as "decapod larvae" or "brachyuran larvae", and discuss them in that context. These multispecific groupings bear little taxonomic or ecological significance, as they usual-

ly include taxa with diverse habitats, life histories, and ecological requirements. Estuarine decapods often display complex rhythmic patterns of larval release and larval migration in the water column (Queiroga et al. 1997). Consequently, ecological inferences drawn from this type of data analysis will be severely restricted in scope and accuracy.

For this reason, accurate identification to specific level of decapod larvae in plankton samples is required, mainly in ecological studies. In order to provide detailed descriptions of larval stages of decapod crustaceans from the Cádiz Gulf (*sensu lato*), a research programme was started in 1991 in the Instituto de Ciencias Marinas de Andalucía (Spain) to study larval taxonomy. To date larval descriptions of 26 species have been reported from the gulf.

Early zoeal stages have a high frequency in coastal plankton, mainly in estuarine waters (Drake et al. 1998). A recent planktonic study made by the authors in Cádiz Bay noted that about 85 % of the specimens collected belong to the first zoeal stage. So, descriptions of these stages is especially necessary for an accurate identification.

In this paper, morphologies of first larval stages of *Scyllarus posteli* and *Processa macrodactyla* are described. The larval morphology of these species is compared with that of congeneric species to facilitate the specific identification of individuals in plankton samples.

The genus *Scyllarus* is represented in Cádiz Gulf by three species: *S. arctus* (Linnaeus, 1758), *S. posteli* Forest, 1963 and *S. pygmaeus* (Bate, 1888). Only for *S. arctus* partial descriptions are available (Stephensen 1923; Santucci

Fig. 1. *Scyllarus posteli* (First phyllosoma). A, ventral view; B, antenna; C, antennule; D, maxilla; E, maxillule; F, dorsal view of abdomen; G, second maxilliped. Scale bars: A = 500 μ m; B-G = 100 μ m.

1925), and these are based mostly on planktonic specimens.

Within the genus *Processa* 10 species are recorded in the area: *P. acutirostris* Nouvel & Holthuis, 1957, *P. canaliculata* Leach, 1815, *P. edulis* (Risso, 1816), *P. elegantula* Nouvel & Holthuis, 1957, *P. intermedia* Holthuis, 1951, *P. macrodactyla* Holthuis, 1952, *P. macrophthalma* Nouvel & Holthuis, 1957, *P. modica* Williamson, 1979, *P. noveli* Al-Adhub & Williamson, 1975 and *P. robusta* Nouvel & Holthuis, 1957. Of these, only partial descriptions of the larval development have been made for *P. canaliculata* (Lebour 1936), *P. edulis* (Gurney 1923 – as *P. canaliculata*; Kurian 1956), *P. modica* (Williamson & Rochanaburanon 1979), and *P. noveli* (Gurney 1923; Kurian 1956 – both as *P. canaliculata*; Williamson & Rochanaburanon 1979).

RESULTS

First stage of *Scyllarus posteli* Forest, 1963

Mean dimensions (mean $\pm$ 95% confidence intervals; N=17): TL = 1.173 ± 0.05 mm; CW = 0.705 ± 0.034 mm; CL = 0.682 ± 0.028 mm; AL = 0.455 ± 0.021 mm; EL = 0.458 ± 0.015 mm.

Cephalon (Fig. 1A) rounded, extremely flattened with great dorsoventral compression, slightly wider than long, leaving the base of third maxilliped exposed. Eyes stalked, almost same length as the antennule.

Antennule (Fig. 1C) unsegmented and uniramous, with 3 aesthetascs at apex plus one small spine at inner distal angle and with one plumose seta on inner margin beyond middle of its length.

Fig. 2. *Scyllarus posteli* (First phyllosoma). A, third maxilliped; B, first pereopod; C, last segments of fourth pereopod; D, third pereopod. Scale bars 100 μ m.

Antenna (Fig. 1B) unsegmented and uniramous with one simple seta and one plumose seta at each side near distal end.

Maxillule (Fig. 1E) biramous and unsegmented without palp. Coxal endite with one stout elongated sparsely plumose seta and two shorter subterminal setae. Basal endite with two strong terminal spines and two shorter sub-

terminal setae plus one small simple seta near anterior margin.

Maxilla (Fig. 1D) consists of two segments. Basal segment elongated, bearing one small simple seta on outer margin near distal end. Distal segment small with 4 long plumose setae. First maxilliped wanting.

Second maxilliped (Fig. 1G) without exo-

Fig. 3. *Processa macrodactyla* (First zoea). A, dorsal view; B, ventral margin of carapace; C, abdomen; D, maxillule; E, mandible; F, antennule; G, antenna; H, maxilla. Scale bars: A = 250 µm; B-H = 100 µm.

pod. Endopod 5-segmented with 0, 1, 1, 6, 6 setae, respectively.

Third maxilliped (Fig. 2A) without exopod. Endopod with one strong spine plus one small simple seta on first segment; 2, 3, 7, and 7 sparsely plumose setae on segment 2-5, respectively. On fourth segment the two distal setae are hooked.

First pereopod (Fig. 2B) biramous. There is some fusion of segments, and the protopod and endopod together consist of five segments. First segment with one strong spine plus one small simple seta; second segment with one basal spine, one stout spine at base of exopod, and 4 serrate setae; third segment with one basal seta and 4 apical serrate setae; fourth seg-

ment with 30 serrate setae placed as shown; distal segment with two short simple setae, two sparsely plumose setae, and one stout terminal claw. Exopod 7-segmented with one apical simple seta on the first segment and two terminal plumose setae on the others.

Second pereopod (Fig. 2C) biramous. Setation of segments 1-3 and 5 of endopod + protopod as in first pereopod; fourth segment with 23 serrate setae placed as shown. Exopod 7-segmented with setation as in first pereopod.

Third pereopod (Fig. 2D) biramous. First segment as in first pereopod. Second segment with one basal stout spine, one stout spine at base of exopod, and 9 serrate setae; third segment as in first pereopod; fourth segment with 9 serrate setae, 4 simple setae, and 4 sparsely plumose apical setae, placed as shown; distal segment with two simple setae, one sparsely plumose seta, and 1 stout terminal claw. Exopod as a small bud near middle of its second segment.

Fourth and fifth pereopods absent.

Pleopods and uropods absent.

Abdomen (Fig. 1F) slightly longer than one third of hindbody length, narrow, slightly tapering posteriorly, with three sparsely plumose setae at each posterolateral angle.

First stage of *Processa macrodactyla* Holthuis, 1952

Mean dimensions (mean $\pm$ 95% confidence intervals; N=19). TL = 1.764 ± 0.018 mm; CL = 0.561 ± 0.011 mm.

Carapace (Fig. 3A, B) flattened, with pterygostomial spine present and 4 small teeth on anteroventral margin. Mediodorsal tubercle on anterior carapace. Rostrum absent. Eyes not stalked.

Antennule (Fig. 3F) slender with unsegmented naked peduncle. Endopod as a long ciliated seta. Exopod with one long simple seta plus 3 slender aesthetascs and a shorter plumose seta.

Antenna (Fig. 3G). Peduncle with one small spine at base of endopod. Endopod an elongated and tapering spine bearing a row of 13 minute spines. Exopod unsegmented with two plumose setae on outer side and 9 plumose setae plus a simple seta on inner side.

Mandible (Fig. 3E). Palp absent. Armature of incisor and molar processes as illustrated.

Maxillule (Fig. 3D). Coxal endite with two simple setae plus 5 plumodenticulate setae. Basal endite with 5 strong tooth-like setae. Endopod bi-segmented with 2 and 3 sparsely plu-

mose setae, respectively. Exopod present as a long plumose seta.

Maxilla (Fig. 3H). Coxal endite bilobed with 10 plumose setae on proximal lobe and one plumose plus 3 sparsely plumose setae on distal lobe. Basal endite bilobed with one plumose plus 3 sparsely plumose setae each. Endopod tetralobed with 3, 2, 2 and 2 sparsely plumose setae, respectively. Exopod small with two plumose setae on outer margin plus 3 longer plumose setae on distal margin. It is possible to distinguish a line of division running between coxal endite, basal endite, endopod and exopod.

First maxilliped (Fig. 4A). Coxa with 2 + 2 + 2 plumose setae. Basis with 3 + 3 + 3 + 3 sparsely plumose setae. Endopod 4-segmented reaching middle of exopod, with 3, 1, 2, 1 + 3 sparsely plumose setae, respectively. Exopod unsegmented with one subapical and 3 apical natatory setae.

Second maxilliped (Fig. 4B). Coxa with two setae. Basis with 1 + 2 + 3 + 3 setae. Endopod 4-segmented, extending beyond middle of exopod, with 3, 2, 2, 1 + 4 sparsely plumose setae. Exopod unsegmented with one subapical long plumose seta plus one subapical shorter simple seta and 3 terminal natatory setae.

Third maxilliped (Fig. 4C). Coxa naked. Basis with 1 + 1 + 2 sparsely plumose setae. Endopod 4-segmented as long as exopod, with 2, 0, 2, 1 + 3 sparsely plumose setae. Exopod unsegmented with two subapical and 3 apical natatory setae.

First pereopod present as biramous bud. Second to fifth pereopods absent.

Abdomen (Fig. 3A, C) 5-segmented. Somites 1 and 2 naked. Somite 3 with a small dorsal simple seta. Somite 4 bears a dorsal tuft of short setae. Somite 5 with a pair of small dorsal spines.

Pleopods and uropods absent.

Telson (Fig. 3A) broad, with a median cleft. Process formula 7 + 7, fifth and seventh process smallest. Outermost seta is inserted nearly halfway up side.

DISCUSSION

Scyllarus posteli

The family Scyllaridae is represented in the Cádiz Gulf by two genera, *Scyllarides* and *Scyllarus*. Larvae of these genera can be easily distinguished. In both, the third maxilliped is uniramous in early stages, but *Scyllarides* bears an antennal exopod whereas *Scyllarus* lacks it (San-tucci 1925; Robertson 1969).

Fig. 4. *Processa macrodactyla* (First zoea). A, first maxilliped; B, second maxilliped; C, third maxilliped. Scale bar 100 μ m.

For *Scyllarus* species, larval development is only known for *Scyllarus arctus*. The main descriptions were given by Stephensen (1923) and Santucci (1925), from Mediterranean and adjacent Atlantic planktonic material. Other workers such as Gurney (1942), Kurian (1956), & Williamson (1983) referred to these papers. However, it is possible that the descriptions proposed by Stephensen and Santucci were partially erroneous. At that time, the presence of *S. pygmaeus* and *S. posteli* in the Mediterranean and Atlantic waters was unknown; *S. pygmaeus* was recorded by Forest & Holthuis in 1960 from the Mediterranean, and *S. posteli* by Pozuelo et al. (1976) from Cádiz bay. As Stephensen (1923) and Santucci (1925) collected *Scyllarus* larvae in a zone where all three species are actually present, the descriptions of the larvae of *S. arctus* may be based on *S. pygmaeus* or *S. posteli*.

The first stage of *S. posteli* described in this paper is identical with that described and figured by Stephensen (1923). However, it is not

certain that both accounts belong to the same species. Many congeneric species of decapods have very similar larval stages, only distinguished by size (see Clark 1984). Therefore, only the description of the first stage of *S. posteli* should be considered as certain, whereas that for *S. arctus* should be confirmed with hatched larvae. Due to the absence of adequate information concerning the larval morphology of *Scyllarus* species other than *S. posteli*, we are unable to reliably assign general morphological characteristics which may separate larvae of *S. posteli* from other species of the same genus from this area.

According to Sekiguchi (1987), first larval stage of *Scyllarus* is separated into two groups by the number (three or four) of long plumose setae on the distal segment of maxilla. *S. posteli* belongs to the second group, together with *S. bicuspidatus*, *S. demani*, *S. timidus*, *S. depressus*, *S. modestus*, *S. sordidus* (as described by Saisho 1964; Ritz 1977; Robertson 1971; Johnson 1971; Prasad & Tampi 1960, respectively). First

Table 1. Morphological differences in first zoeal stage of *Processa* species from Cádiz Gulf (SW. Spain).

	<i>P. macro-</i> <i>dactyla</i>	<i>P. canali-</i> <i>culata</i>	<i>P. nouveli</i> <i>holthuisi</i>	<i>P. modica</i> <i>carolii</i>	<i>P. modica</i> <i>modica</i>	<i>P. edulis</i>	<i>P. edulis</i> <i>crassipes</i>
Author	present study	Lebour 1936	Williamson & Rochana- buranon 1979	Williamson & Rochana- buranon 1979	Williamson & Rochana- buranon 1979	Kurian 1956	Gurney 1923
Studied material	laboratory	laboratory	laboratory	plankton	plankton	plankton	plankton
Total length	1.76 mm	2 mm	1.8-2.2 mm	1.8 mm	1.4 mm	1.96 mm	1.9-2.2 mm
Abdominal spines	somite 5	somites 4, 5	somite 5	somites 3, 5	somites 3, 5	somite 5	somite 5
Setation of exopod of maxillipeds	4, 5, 5	5, 5, 5	4, 5, 5	?	4, ?, ? (2)	5, 5, 5	4, 5, 5
Carapace denticles	4	5-8 (1)	3-4	?	4	4	2 0-2 (1)
Setation of exopod of antennule	1p+1s+3a	1p+1s?+3a (2)	1p+3a	?	1p+3a (2)	?	1p+3a
Spine of antennal protopod	present	?	absent (2)	?	absent (2)	?	?
Antennal endopod/ exopod length	> ¼	> ¼ (2)	~ ¼	?	> ¼	?	~ ¼

(1): After Williamson & Rochanaburanon, 1979; (2): After drawings from authors

larval stage of species may be identified by means of the key provided below:

1. Third maxilliped partially covered by cephalon 2
- Third maxilliped not covered by cephalon 3
2. Apex of antennule with 4 aesthetascs; Coxal spines on pereopods 2 and 3.....
- Apex of antennule with 3 aesthetascs; Coxal spines on maxilliped 3 and pereopods 1-3..... *S. bicuspidatus*
- Apex of antennule with 3 aesthetascs; Coxal spines on maxilliped 3 and pereopods 1-3..... *S. depressus*
3. Exopods of pereopods 1 and 2 with 6 pairs of natatory setae 4
- Exopods of pereopods 1 and 2 with 7 pairs of natatory setae..... 5
4. Total length about 1.17 mm..... *S. posteli*
- Total length about 1.36 mm ..... *S. modestus*
- Total length about 1.45-1.50 mm... *S. timidus*
5. Fourth pereiopod present with tiny exopod bud..... *S. demani*
- Fourth pereiopod absent ..... *S. sordidus*

Processa macrodactyla

The family Processidae is only represented in this area by the genus *Processa*. A common feature of all first larval stages of *Processa* seems to be the absence of a rostrum, the presence of antennule curved and separated at base more than the width of one of them, with the endo-

pod as a simple pointed rod, antennal scale unsegmented and fifth pereiopod not developed (Dos Santos, pers. com.).

First zoeal stage descriptions are very scarce in the genus *Processa*. Gurney (1923) described the larva of *P. edulis crassipes* (as *P. canaliculata*). Later, Lebour (1936) gave a brief comment of *P. canaliculata* and *P. edulis* larvae. Kurian (1956) caught larvae of *P. edulis* and *P. nouveli* (as *P. canaliculata*) and commented on some characteristics of them. More exactly, Williamson & Rochanaburanon (1979) described and figured larval features of *P. modica modica* and *P. nouveli holthuisi* and provided a brief comparison between these and other species. Finally, Fincham & Williamson (1979) repeated the comparative table reported by Williamson & Rochanaburanon.

However, these descriptive studies (except that of *P. nouveli holthuisi*) were based on planktonic material, and therefore the identifications are questionable. In Table 1 are summarised the main resemblances and differences between first zoeal stages of processid larvae. It is evident that *P. modica* and *P. canaliculata* are easily differentiated by the presence of dorsal spines on somites 3 or 4. For other species, characteristic features are not sufficiently reliable. We think that only the relative endopod-exopod length of the antenna should be considered. The relative lengths of the antennal

endopod and exopod are included in Table 1.

Based on available data the following preliminary diagnostic key is proposed for the identification of first stages of *Processa* species:

1. Abdominal somite 3 with a median dorsal spine 2
- Abdominal somite 4 with a pair of dorsal spines. Four small marginal denticles behind pterogostomian spine .....
..... *P. canaliculata*
- These somites without spines 3
2. Small spine on somite 3 ..... *P. modica modica*
- Long spine on somite 3 ..... *P. modica carolii*
3. Antennal endopod at least $\frac{1}{2}$ the length of antennal scale. Four small marginal denticles behind pterogostomian spine ..... *P. macrodactyla*
- Antennal endopod not reaching $\frac{1}{2}$ the length of antennal scale 4
4. Carapace with at most 2 small marginal denticles behind pterogostomian spine ..... *P. edulis*
- Carapace with 3-6 small marginal denticles behind pterogostomian spine . *P. nouveli*

Williamson (in Williamson & Rochanaburanon 1979) described *P. modica* as a new species and separated it in two subspecies, *P. modica modica* (northern Europe) and *P. modica carolii* (the Mediterranean). Larvae of both subspecies are easily distinguishable by the presence of a longer mediodorsal spine on third abdominal somite in *P. modica carolii*. The adults of *P. nouveli* Al-Adhub & Williamson, 1975 were recognized by these authors as separate subspecies under the names of *P. nouveli nouveli* (the Mediterranean) and *P. nouveli holthuisi* (northern Europe). Likewise, *P. edulis* (Risso, 1816) was divided into three subspecies by Nouvel & Holt-huis (1957), *P. edulis crassipes* and *P. edulis arcasonensis* (the Atlantic), and *P. edulis edulis* (the Mediterranean). Larval differences between subspecies are not substantial in *P. nouveli* nor in *P. edulis*, and may provide unreliable distinctions in areas of overlap. For advanced larval stages, Barnich (1996) gives a table with identification characters of *Processa* species in which at least *P. edulis edulis*, *P. modica carolii* and *P. nouveli nouveli* are distinguishable.

In any case, current knowledge of the larval stages of the species of *Processa* is very poor and it has no value for comparative studies.

MATERIAL AND METHODS

In April 1997, ovigerous females of *S. posteli* were collected on a sandy bottom (depth 6 m) and *P. macrodactyla* on a muddy bottom (depth 13 m) in coastal waters of Valdelagrana and Rota, Cádiz, SW Spain. All females were maintained in 2 l glass beakers, containing filtered and well-aerated natural seawater (36‰) at a constant temperature ($22 \pm 1^\circ\text{C}$), until hatching. No food was supplied. After hatching, larvae were preserved in 4% Formalin.

Setal counts on appendages are based on the mean of 10 specimens for each species. The sequence of the zoeal description is described from the anterior to posterior somite plan, and setal armature on appendages is described from proximal to distal segments (see Clark et al. 1998).

Measurements for *Scyllarus posteli* were total length (TL), measured from the anterior margin of cephalon to the posterior end of the hindbody, cephalon length (CL), cephalon width (CW), antennule length (AL), and eye peduncle length (EL). For *Processa macrodactyla* cephalothorax length (CL) was measured from the anterior margin of eyes to the posterior lateral margin of carapace.

In this paper, we have considered Cádiz Gulf "sensu lato" the area between 30° to 40°N and 5° to 10°W .

Special thanks are due to Antonina M. dos Santos from IPIMAR (Portugal) for her valuable advice and comments on the manuscript. We also thank J.L. Palazón for improving the English. Part of this research was supported by a grant from Consejo Superior de Investigaciones Científicas (CSIC), Spain.

REFERENCES

- Al-Adhub, A.H. & D.I. Williamson 1975. Some European Processidae (Crustacea, Decapoda, Caridea). - *J. Nat. Hist.* 9: 693-703.
- Barnich, R. 1996. The larvae of the Crustacea Decapoda (excl. Brachyura) in the plankton of the French Mediterranean Coast (identification keys and systematic review). - Ph.D. Thesis, Cuvillier Verlag, Göttingen, 189 pp.
- Clark, P.F. 1984. A comparative study of zoeal morphology in the genus *Liocarcinus* (Crustacea, Brachyura, Portunidae). - *Zool. J. Linn. Soc.* 82: 273-290.
- Clark, P.F., D.K. Calazans & G.W. Pohle 1998. Accuracy and standardization of brachyuran larval descriptions. - *Inu. Repr. Dev.* 33: 127-144.
- Drake, P., A.M. Arias & A. Rodríguez 1998. Seasonal and tidal abundance patterns of decapod crustacean larvae in a shallow inlet (SW Spain). - *J. Plank. Res.* 20: 585-601.
- Fincham, A.A. & D.I. Williamson 1978. Crustacea Deca-

- poda: Larvae. VI. Caridea. – *Fich. Ident. Zooplancton* 159/160: 1-8.
- Forest, J. & L.B. Holthuis 1960. The occurrence of *Scyllarus pygmaeus* (Bate) in the Mediterranean. – *Crustaceana* 1: 156-163.
- Fusté, X. & J.M. Gili 1991. Distribution pattern of decapod larvae off the north-western Iberian Peninsula coast (NE Atlantic). – *J. Plank. Res.* 13: 217-228.
- Gurney, R. 1923. The larval stages of *Processa canaliculata* Leach. – *J. Mar. Biol. Assoc. U. K.* 13: 245-265.
- Gurney, R. 1942. *Larvae of decapod Crustacea*. – Ray Society, London. 306 pp.
- Johnson, M.W. 1971. The phyllosoma larvae of slipper lobsters from the Hawaiian islands and adjacent areas (Decapoda, Scyllaridae). – *Crustaceana* 20: 77-103.
- Kurian, C.V. 1956. Larvae of decapod Crustacea from the Adriatic Sea. – *Acta Adriatica* 6: 1-106.
- Lebour, M.V. 1936. Notes on the Plymouth *Processa* (Crustacea). – *Proc. Zool. Soc. London* 1936: 609-617.
- Nouvel, H. & L.B. Holthuis 1957. Les Processidae (Crustacea Decapoda Natantia) de eaux européennes. – *Zoologische Verhandelingen* 32: 1-53.
- Paula, J. 1987. Planktonic stages of brachyuran crabs from the south-western Iberian Coast (Crustacea, Decapoda, Brachyura). – *J. Nat. Hist.* 21: 717-756.
- Pozuelo, M., A.M. Arias, A. Rodríguez & J. Pettenghi 1976. Presencia de *Scyllarus posteli* Forest en la Bahía de Cádiz (región sudatlántica española). – *Inv. Pesq.* 40: 85-93.
- Prasad, R.R. & P.R.S. Tampi 1960. On the newly hatched phyllosoma of *Scyllarus sordidus* (Stimpson). – *J. Mar. Biol. Assoc. India* 2: 250-252.
- Queiroga, H., J.D. Costlow & M.H. Moreira 1997. Vertical migration of the crab *Carcinus maenas* first zoea in an estuary: implications for tidal stream transport. – *Mar. Ecol. Prog. Ser.* 149: 121-132.
- Ritz, D.A. 1977. The larval stages of *Scyllarus demani* Holthuis, with notes on the larvae of *S. sordidus* (Stimpson) and *S. timidus* Holthuis (Decapoda, Palinuridea). – *Crustaceana* 32: 229-240.
- Robertson, P.B. 1969. The early larval development of the scyllarid lobster *Scyllarides aequinoctialis* (Lund) in the laboratory, with a revision of the larval characters of the genus. – *Deep-Sea Res.* 16: 557-586.
- Robertson, P.B. 1971. The larvae and postlarva of the scyllarid lobster *Scyllarus depressus* (Smith). – *Bull. Mar. Sci.* 21: 841-865.
- Saisho, T. 1964. Notes on the first stage phyllosoma of scyllarid lobster, *Scyllarus bicuspidatus*. – *Mem. Fac. Fish. Kagoshima Univ.* 13: 1-4.
- Santucci, R. 1925. Contributo allo studio dello sviluppo post-embrionale degli Scyllaridea del Mediterraneo II: *Scyllarus arctus*. III: *Scyllarides latus*. – *Mem. R. Com. Talassogr. Ital.* 71: 1-16.
- Sekiguchi, H. 1987. Life histories of the scyllarid and palinurid lobsters, 12. – *Kaiyo Seibutsu (Aquabiology)* 9: 415-419.
- Stephensen, K. 1923. Decapoda – Macrura (excl. Sergestidae). – *Rep. Danish Oceanogr. Exp.* (1908-1910) 2: 1-85.
- Williamson, D.I. 1983. Crustacea Decapoda: Larvae. VIII. Nephropidea, Palinuridea, and Erynidea. – *Fich. Ident. Zooplancton* 167/168: 1-8.
- Williamson, D.I. & T. Rochanaburanon 1979. A new species of Processidae (Crustacea, Decapoda, Caridea) and the larvae of the north European species. – *J. Nat. Hist.* 13: 11-33.