

Larval development of the red crab *Pleuroncodes monodon* (Decapoda Anomura: Galatheidae) under laboratory conditions*

E. FAGETTI and I. CAMPODONICO

Departamento de Oceanología, Universidad de Chile; Viña del Mar, Chile

Abstract

Larvae of *Pleuroncodes monodon* (MILNE-EDWARDS, 1837), a red crab of commercial importance in South America, were reared in the laboratory at 2 different temperatures (15° and 20 °C), from hatching up to the last larval stage. The 5 typical stages, with their corresponding functional appendages, are described and figured. The main characteristics useful in differentiating larvae of *P. monodon* from those of the other Chilean species of Galatheidae and its northern congener *P. planipes* are discussed. Data on duration of each larval stage, length of moulting intervals and mortality at the 2 test temperatures are also given.

Introduction

Pleuroncodes monodon (MILNE-EDWARDS, 1837) ranges in distribution from the Island "Lobo de Afuera", Perú, to Ancud, Chile (HAIG, 1955); it is a pelagic species of great economical importance in both countries. In Chile, according to observations of MISTAKIDIS and HENRÍQUEZ (1966), this species makes up approximately 40% of the commercial catch of "langostino", which includes 2 galatheid species: the yellow or blue crab ("langostino amarillo o azul") *Cerimunida johni* PORTER and the red or carrot crab ("langostino zanahoria") *Pleuroncodes monodon* (MILNE-EDWARDS). The latter species has been found on several occasions in the stomach contents of the commercial species of Chilean conger eels (DELFIN, 1903; PORTER, 1916; BAHAMONDE, 1965 and CHOCAIR et al., 1969). HENRÍQUEZ and BAHAMONDE (1964) demonstrated through a year-study, that *P. monodon* constitutes the main diet of the Chilean South American conger eel *Genypterus maculatus*, in whose stomach it was found with a 75% frequency, representing 94% of the total number of specimens found in the stomach content.

The two specimens used for this study were found in the mouth of the fish *Merluccius gayi gayi* (GUICHENOT), which could indicate that *Pleuroncodes monodon* constitutes a food item also for this other commercial species of our coast. RAYNER (1935) states that specimens of *M. gayi* from the Falkland Islands

and Argentinian Patagonian Coast "were frequently found to be subsisting entirely on" the free-swimming post-larval forms of *Munida gregaria* and *M. subrugosa*. Nevertheless, the studies so far available on the stomach content of the Chilean hake (BAHAMONDE, 1953, 1958; BAHAMONDE and CÁRCAMO, 1959) do not mention the Galatheidae as diet of this fish.

Its northern congener *Pleuroncodes planipes* also represents a significant food item of the tuna species, when they migrate into the California Current (LONGHURST, 1967).

While HAIG (1955) and LONGHURST et al. (1969) doubted the validity of the two Pacific species of Galatheidae, comparative studies of the adults of both species are still unavailable. One of the objectives of our study, therefore, was to furnish more biological information that could help towards a critical revision of the genus. Our primary objective, however, has been to provide a description of the larval development of this species, which is of such great economical importance to our fisheries, and to study the effects of temperature on survival and duration of its larval stages.

Material and methods

On April 22, 1970, two ovigerous females of *Pleuroncodes monodon* (MILNE-EDWARDS) were found in the mouth of *Merluccius gayi gayi* (GUICHENOT), a fish of commercial importance caught by a fisherman in Valparaiso Bay. We maintained the ovigerous females in a circulating sea-water aquarium (water temperature approximately 15 °C) until the larvae hatched, on April 29, 1970. The larvae were reared in water of normal salinity for the region (34.4 to 34.6‰) under two different constant temperature conditions (15° and 20 °C), and fed *Artemia* nauplii as well as *Phaeodactylum tricorutum* phase oval. Details on the original number of larvae, diet and temperatures for each experiment, are given in Table 1.

The rearing technique was the same as that previously employed for the brachyuran larvae (COSTLOW and FAGETTI, 1967), consisting basically in daily change of freshly filtered seawater, control of exuviae

* This study was financially supported by the Chilean Ministry of Agriculture and by the National Commission for Scientific and Technological Research (CONICYT).

and dead larvae, and controlled photoperiod of light and darkness. All the larval stages as well as the corresponding functional appendages were drawn at the microscope with the aid of a camera lucida; the chromatophore pattern was determined from living specimens.

Results

Larval stages

Stage I (Fig. 1: 1). The carapace has a long and strongly serrated rostral spine and is produced behind into 2 posterior spines, which reach the distal border of the 4th abdominal segment; the posterior borders of the carapace are serrated. The abdomen has 5 segments plus the telson; the posterior corners of the 4th and 5th abdominal segments terminate in a spine; the posterior border of the 1st segment is slightly denticulate; the posterior margins of segments 2 to 5 show a spinulation made up by 4 longer spines plus 1 shorter spine on each side. On the dorsal surfaces of segments 2 to 5, there are 2 hair-like setae; the telson formula is of 6 + 6 setae, the outermost is reduced and hair-like; the furcal rami are strongly denticulate. The posterior margin of the telson has several small thorns, distributed in numbers of 1 to 3 between each setae; a fine denticulation is visible on the dorsal surface of the telson. The base of the antennule (Fig. 1: 5) is unsegmented and bears a long sub-apical plumose spine on its inner border and 6 terminal aesthetascs. The antenna (Fig. 1: 9) shows 2 short spines on its base and an aciculate flagellum almost as long as the antennal scale; this bears 8 plumose setae and terminates as a strongly denticulate spine; a fine denticulation is visible on the surface of the antennal scale. The mandibula (Fig. 1: 13) has the molar and incisive processes denticulated. The unsegmented endopodite of the maxillula (Fig. 2: 19) bears 3 plumose setae plus 2 short smooth setae; the basipodite bears 5 spines and the coxopodite 7 apical plumose setae. The scaphognatite of the maxilla (Fig. 2: 23) terminates as a plumose distal spine and bears 4 plumose setae on its outer border; endo-basi and coxopodite are bilobulate and have respectively 4—3, 4—4 and 4—6 spinose setae. The coxopodite of the 1st maxilliped (Fig. 2: 27) bears one seta on its inner margin and the protopodite 2—3—3—2 setae; the 5 segmented endopodite bears 2 spinose setae in the 1st, 2nd and 4th segments, one spinose seta in the 3rd segment, and 3 spinose setae plus 2 smooth setae on the terminal segment; the exopodite with two undistinguished segments, bears 4 plumosae swimming setae. The protopodite of the second maxilliped (Fig. 2: 31) with 3 spinose setae, the 4-segmented endopodite with 2 spinose setae in each of segments 1 to 3 and 3 spinose setae plus 2 others, smooth, on the apical segment; the partially bisegmented exopodite with 4 plumose swimming setae. The

third maxilliped (Fig. 2: 35) is still rudimentary and without setae.

The larvae are quite transparent with a few orange chromatophores distributed as follows: first and second stage, in the mouth region, and two dorsal eritrophores in the middle line of 1st and 2nd abdominal segments and 2 at the basis of the telson. In the 3rd, 4th and 5th stages an additional small eritrophore is present in the lateral anterior region of the carapace; other eritrophores are also visible at the basis of the 2nd and 3rd maxilliped.

Stage II (Fig. 1: 2). At this stage, the proximal portion of the rostral spine is denticulated; the telson formula is now 7 + 7 setae, the outermost being always the more reduced; 2 short hairs are now present on the posterior dorsal surface of the telson.

Changes in the appendages are as follows: 3 sub-apical short hairs are added on the outer border of the basis of the antennule (Fig. 1: 6); 10 plumose setae are now present in the antennal scale (Fig. 1: 10); the basipodite of the maxillula (Fig. 2: 20) has now 6 setae and spines; the scaphognatite of the maxilla (Fig. 2: 24) is fringed by 6 plumose setae on its outer margin; the exopodite of the first and second maxillipeds (Fig. 2: 28, 32) bears now 7 swimming setae; the third maxilliped (Fig. 2: 36), now functional, carries 6 terminal plumose setae.

Stage III (Fig. 1: 3). The sixth abdominal segment is added and shows a middle spine in its posterior dorsal margin. The uropods are now present, the inner rami are reduced and without setae; the outer ones carry 8 plumose setae in the inner border and 2 shorter and non-plumose, hair-like setae on the distal surface; the tip is produced into an expanded spine.

The telson has now 9 projections on each side. Besides the furcal rami there are: 5 plumose setae interior to the furcal rami, 1 short plumose seta and 1 hair-like seta plus a spine externally; 2 pairs of hairs are now present on the dorsal posterior surface of the telson, where the fine denticulation is no longer visible.

Changes in the appendages are as follows: the antennule (Fig. 1: 7) is now segmented and 2 short plumose setae are present on the inner margin of the basipodite; the antennal scale (Fig. 1: 11) has usually 12 setae, the aciculate spine is more reduced in size; the inner spine has increased in length and now has a terminal hair; the basipodite of the maxillula (Fig. 2: 21) now has 8 terminal spines and setae; the setae of the outer border of the scaphognatite of the maxilla (Fig. 2: 25) have increased to 11, and 1 seta is added in the inner border; the lobes of the basipodite now bear 6 and 5 setae and the lobes of the coxopodite have 4 and 7 setae; the exopodite of 1st and 2nd maxillipeds (Fig. 2: 29, 33) with 8 plumose setae; the third maxilliped (Fig. 2: 37) has usually 7 setae, but specimens with 6 setae in one of these appendages were also observed.

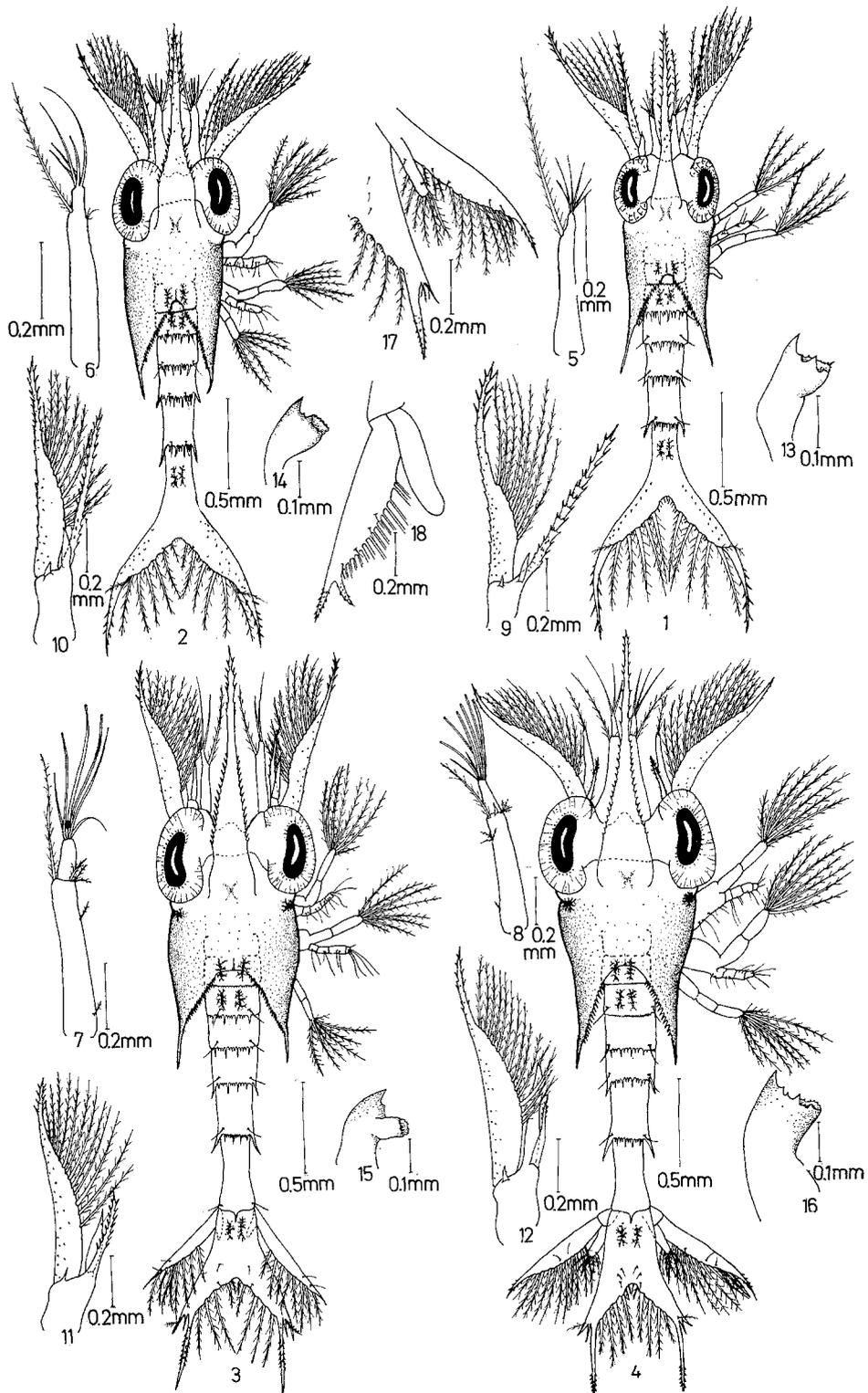


Fig. 1. *Pleuroncodes monodon* (MILNE-EDWARDS). 1, 2, 3, 4: Stages I—IV a, dorsal view; 5, 6, 7, 8: antennule, stages I—IV a; 9, 10, 11, 12: antenna, stages I—IV a; 13, 14, 15, 16: mandibula, stages I—IV a; 17: telson and uropods, stage IV a; 18: abnormal uropods, stage IV a

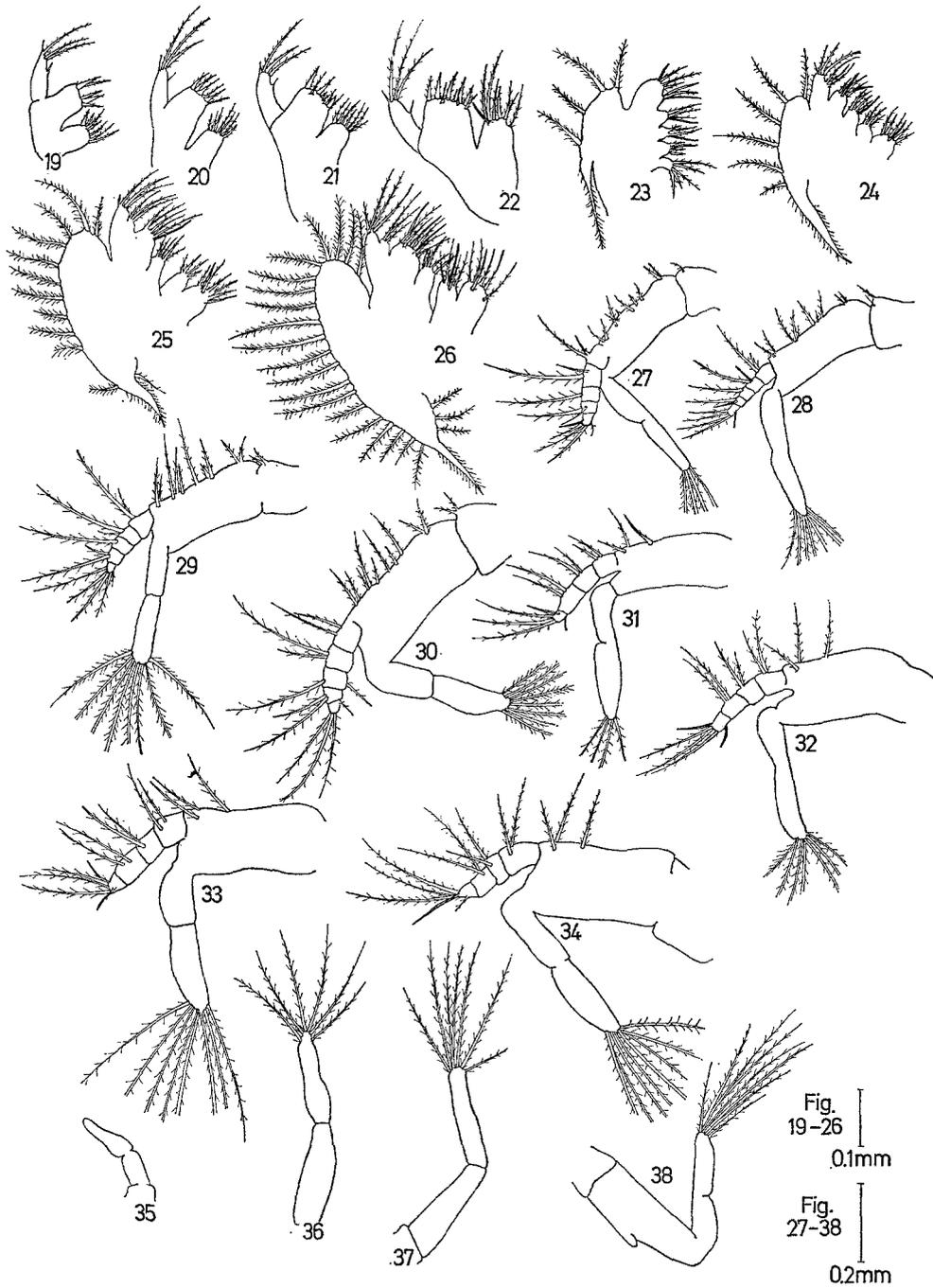


Fig. 2. *Pleuroncodes monodon* (MILNE-EDWARDS). 19, 20, 21, 22: Maxillula, stages I—IVa; 23, 24, 25, 26: maxilla, stages I—IVa; 27, 28, 29, 30: first maxilliped, stages I—IVa; 31, 32, 33, 34: second maxilliped, stages I—IVa; 35, 36, 37, 38: third maxilliped, stages I—IVa

Stage IVa (Fig. 1: 4). In the telson (Fig. 1: 17), a small inner seta is added at each side of the median line, and 3 pairs of hair-like setae are now present on its dorsal surface. The number of setae on the inner branch of the uropods varies from 5 to 7, but usually 6

setae are present, on their surface are 2 hair-like setae; on the outer branch the number of setae varies from 10 to 13, but usually 12 are found, and 4 small hair-like setae are also present; the end of the outer branch of the uropods is produced into a long denticulate spine.

Changes in the appendages are as follows: the inner margin of the basipodite of the antennule (Fig. 1: 8) carries 3 setae on its distal portion, a short protuberance (endopodite) has developed at the end of the basipodite where 4 short hairs are also present; 2 apical and 1 lateral aesthetacs are now added in the exopodite; the inner spine of the antenna (Fig. 1: 12) has increased in size being now longer than the flagellum; the antennal scale usually bears 13 setae; the basipodite and coxopodite of the maxillula (Fig. 2: 22) now bears 9 and 8 spinose setae, respectively; the scaphognatite of the maxilla (Fig. 2: 26) bears 20 plumose setae on its outer margin and 3 on the inner posterior border; the number of setae in the lobes of basi and coxopodite has increased; a seta is added on the inner margin of the 3rd segment of the endopodite of the 1st maxilliped (Fig. 2: 30); the 2nd maxilliped (Fig. 3: 34) is unchanged, and the 3rd (Fig. 2: 38) now bears 8 plumose setae and shows the endopodite bud.

Stage IVb. Changes are reduced to the setation of some appendages. There are now 4 pairs of hairs on the dorsal surface of the telson; the inner and outer branches of the uropods usually bear 9 and 14 setae, respectively; but specimens with from 7 to 9 and from 13 to 15 setae were also found; the number of setae of the telson is unchanged and there are now 4 pairs of hairs on its dorsal surface; the small spines of the posterior border of the telson are now more reduced in number.

The antennule now bears 1 pair of subapical aesthetacs; another short seta is added on the inner proximal border of the basipodite. The endopodite of the antenna has increased in size and it is now $2\frac{1}{2}$ times longer than the inner flagellum; the antennal scale now bears 14 plumose setae. The basipodite of the maxillula now has 10 apical spines and setae. The number of setae on the lobes of basi and coxopodite of the maxilla has increased; the scaphognatite now has 25 plumose setae on its outer margin and 4 on the inner posterior margin; the number of spines and setae of basi and coxopodite has also increased.

Changes in the maxillipeds are reduced to an additional apical seta on the terminal segment of the endopodite of the first maxilliped.

Stage IVc. The inner branch of the uropods usually bears 11 setae; their number varies from 10 to 12; the number of setae of the outer branch has increased to usually 16, varying from 15 to 17. There are 5 pairs of hairs on the dorsal surface of the telson and 5 pairs of rudimentary pereopods are visible under the carapace.

Changes in the setation of the appendages are as follows: 2 subterminal aesthetacs are added on the exopodite of the antennule; the antennal scale now usually bears 16 plumose setae, but 15 have also been observed; the endopodite has increased in size, being almost 4 times longer than the inner flagellum; the

basi and coxopodite of the maxillula now bears 12 and 9 spines and setae, respectively; the scaphognatite of the maxilla bears about 31 setae on its outer margin, plus 7 on the inner posterior border. The endopodite bud of the 3rd maxilliped has increased in size and the setation of the endopodite of the second maxilliped is now 2—2—3—5. An anomaly has been observed in one of the specimens, in which the outer branch of one of the uropods as well as one of the furcal rami of the telson presented a bifurcate tip (Fig. 1: 18).

Stage IVd. The number of plumose setae of the outer and inner rami of the uropods varies from 17 to 19 and from 13 to 15, respectively. Three pairs of subterminal aesthetacs are now present on the exopodite of the antennule; the number of plumose setae on the antennal scale varies from 17 to 19, 19 setae being more common; the endopodite is almost as long as the antennal scale; basi and coxopodite of the maxillula now bear 14 and 11 setae, respectively; the scaphognatite of the maxilla bears 40 plumose setae in the outer margin plus 9 in the inner posterior one: the endopodite bud of the third maxilliped has increased in size.

Stage IVe. Changes are reduced to the following: the antennal scale now has from 19 to 20 plumose setae; basi and coxopodite of the maxillula bear 15 and 13 setae and spines, respectively; the endopodite of the third maxilliped is longer than in the previous stage, it now reaches the base of the exopodite.

Stage V (Fig. 3: 39). At this stage the 5 pairs of pereopods are visible under the carapace, the first pair being chelate; 4 pairs of bifid pleopods are now present in abdominal segments 2 to 5; the outer and inner rami of the uropods have now 21 and 19 plumose setae, respectively; in the telson 2 small inner setae are added at each side of the median line. More subterminal aesthetacs are added, in groups of 2 or 3, in the exopodite of the antennule (Fig. 3: 40); the endopodite has increased in size, being half the length of the exopodite. The number of plumose setae of the antennal scale (Fig. 3: 41), whose tip is no longer spinulate, has increased to approximately 21. The basipodite of the maxillula (Fig. 3: 42) now bears 16 setae and the scaphognatite of the maxilla (Fig. 3: 43) is fringed by approximately 45 plumose setae in the outer margin, plus 10 in the inner margin. The endopodite of the third maxilliped (Fig. 3: 44) is much more developed than in the previous stage, but still unsegmented.

Larval development

Five experiments were carried out under two different temperature conditions (15° and 20 °C) with 3 kinds of diet (Table 1). The 100 original larvae, reared at 15° and 20 °C and fed on *Phaeodactylum tricornutum* died within the first 9 days of culture, without moulting into the second stage. The time of development in days and the percent survival at each

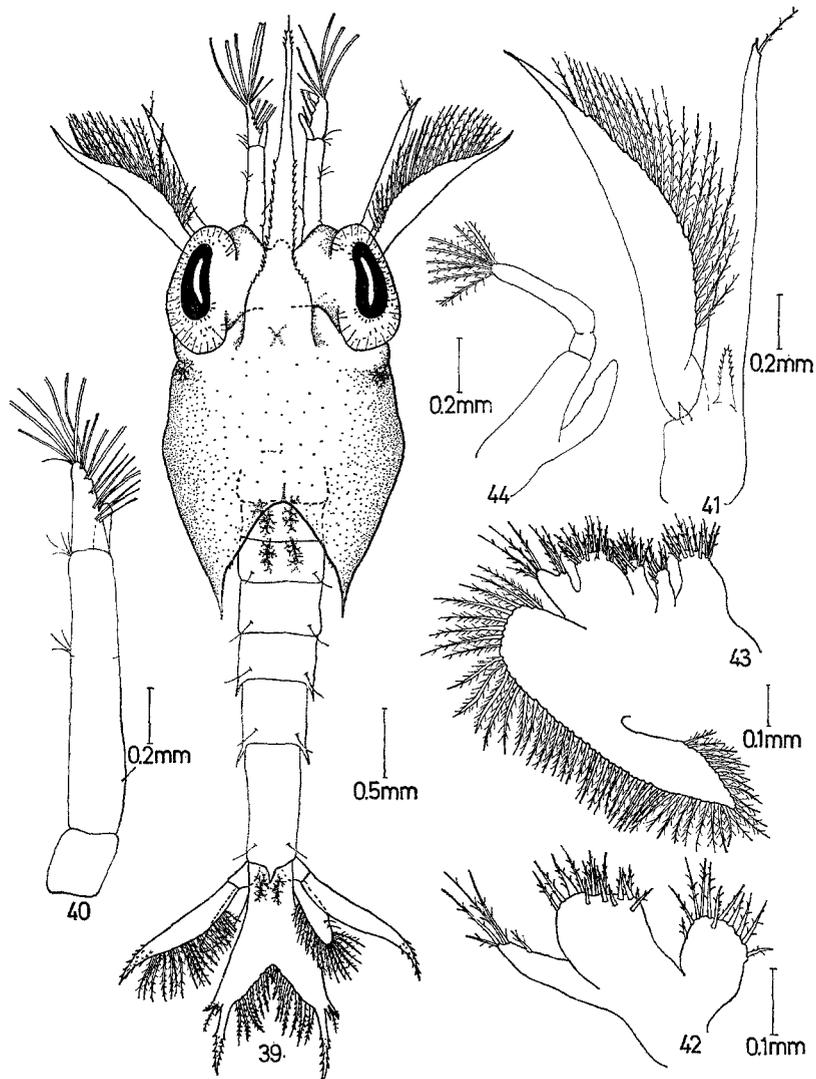


Fig. 3. *Pleuroncodes monodon* (MILNE-EDWARDS), Stage V. 39: Dorsal view of the larvae; 40: antennule; 41: antenna; 42: maxillula; 43: maxilla; 44: third maxilliped

Table 1. *Pleuroncodes monodon*. Original numbers of larvae and type of diet for each experiment at different temperatures

Temperature (°C)	Original numbers of larvae	Diet
15°	100	<i>Artemia</i> nauplii
15°	100	<i>Phaeodactylum tricornerutum</i>
15°	100	<i>Artemia</i> + <i>P. tricornerutum</i>
20°	100	<i>Artemia</i> nauplii
20°	100	<i>Phaeodactylum tricornerutum</i>

stage for larvae reared under 15° and 20 °C temperature conditions and fed *Artemia* nauplii, and those with a mixed diet of *P. tricornerutum* and *Artemia*, are given in Table 2.

The larvae reared at 20 °C reached (through 7 moults) only stage IVe, and died without moulting to the last stage. Fortyeight mean days were required by these larvae to moult to stage IVe (Fig. 4); highest mortality was registered during the first 15 days and also between the 40th and 63rd days of culture (Fig. 5).

No significative differences were found between the results obtained from larvae reared at 15 °C with 2 different diets (Table 1); the development of larvae fed a mixed diet was only slightly slower, they also

Table 3. Comparison of larvae of *Pleuroncodes monodon* and *Munida* sp.

Characteristics	Stage II		Stage III		Stage IV		Stage V	
	<i>P. monodon</i>	<i>Munida</i> sp.	<i>P. monodon</i>	<i>Munida</i> sp.	<i>P. monodon</i>	<i>Munida</i> sp.	<i>P. monodon</i>	<i>Munida</i> sp.
Spinulation of first abdominal segment	Denticulate	Smooth	Denticulate	Smooth	Smooth	Smooth	Smooth	Smooth (?)
Spinulation of abdominal segments 2-5	4 long and several small spines	4 long spines	4 long and several small spines	4 long spines	Segment 2 denticulate. Segments 3-5 with 4 long and several small spines	Segment 2 smooth. Segments 3-5 with 4 spines	Segment 2 smooth. Segments 3-5 with 4 spines	Segment 2 smooth. Segments 3-5 with 4 spines
Proximal portion of the rostrum	Strongly serrated	Smooth	Strongly serrated	Smooth	Strongly serrated	Smooth	Strongly serrated	Only partially serrated
Distal portion of the rostrum, antennal scale and furcal rami	Strongly denticulate	Slightly denticulate	Strongly denticulate	Smooth	Denticulate	Smooth	Denticulate	Smooth
Hair-like setae on dorsal surface of telson	1 pair	Absent	2 pairs	Absent	From 3 (IV a) to 5 pairs (IV d)	Absent	(?)	Absent
Outer spines of the telson	Absent	Absent	Shorter than furcal rami	As long as furcal rami	Shorter than furcal rami	Shorter than furcal rami	(?)	Absent
Tip of outer branches of uropods	—	—	Produced into spines	Ending as 1 seta	Produced in a serrated spine	Produced into a smooth spine	Produced in a serrated spine	Produced into a smooth spine

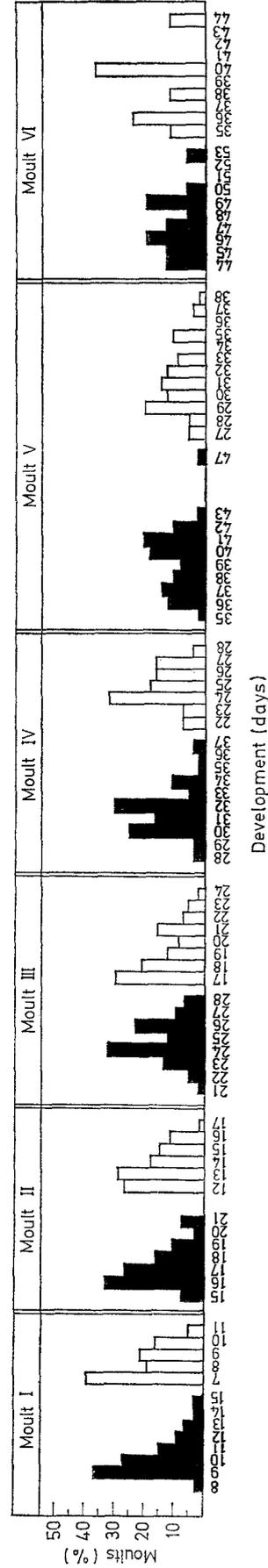


Fig. 6. *Pleuroncodes monodon* (MILNE-EDWARDS). Larval moulting intervals for each stage reared in the laboratory at 15 °C (black) and 20 °C (white)

from 5 to 12 days at 20 °C. The time required for each moult is given in Fig. 6.

Discussion

Larval stages

Among the 12 species belonging to the family Galatheididae recorded in Chilean waters (HAIG, 1955), the larvae of only 2 genera have been previously described. RAYNER (1935) described from plankton material the 5 larval stages of two southern species of the genus *Munida*: *M. gregaria* and *M. subrugosa*, but he was unable to distinguish two different larval forms that could be assigned to the 2 adult species. FAGETTI (1960) described the first larval stage of the endemic Chilean species *Cervimunida johni* from larvae hatched in the laboratory.

The first larval stage of *Pleurocodes monodon* is very similar to the first stage previously described for the other Chilean species of *Munida* and *Cervimunida*; the main distinguishing characteristic is the length of the posterior lateral spines of the carapace, which are shorter in *Munida* sp., extending only up to the 3rd abdominal segment; medium size in *P. monodon*, extending to the 4th abdominal segment; and longer in *C. johni*, extending to the 5th abdominal segment. In addition, the denticulation of the furcal rami, of the rostrum, and of the antennal scale is slightly different; it is more pronounced in the larvae of *C. johni*, intermediate in *P. monodon*, and reduced in *Munida* sp. The abdominal segments 2 to 5 of the first larval stages of *Munida* sp. and *C. johni*, lack the pair of dorsal hairs observed in *P. monodon*. Small differences between setation of the appendages can be discussed only in relation to *C. johni*, as no description and figures are available for *Munida* sp.

The larvae of *Cervimunida johni*, bear 6 instead of 5 setae on the endopodite of the maxillula, 2—3—3—3 setae on the protopodite of the first maxilliped instead of 2—3—3—2 and, finally, at the base of the antenna, there is only 1 spine.

Both larvae of *Cervimunida johni* and *Pleurocodes monodon*, at each stage, are easily differentiated from larvae of *Munida* sp. on the basis of the aciculate flagellum of the antenna, which is as long as the rostral spine in the two first-named species, but is very short reaching hardly the base of the antennule in the larvae of *Munida* sp.

The differences between later stages of *Pleurocodes monodon* and *Munida* sp. are given in Table 3, where differences in the setation of the appendages of stage IV were not taken into account because only one of the phases of stage IV was described for *Munida* sp.

BOYD (1960) described, from plankton material, larval stages of *Pleurocodes planipes*, whose larvae are very similar to those described here for its southern

congener *P. monodon*; also, the adults are very similar, HAIG (1955) says "No careful study has ever been made of the differences between *P. monodon* and its northern hemisphere congener, *P. planipes* Stimpson, but examination of the two species would seem to indicate that they may be identical. A comparative study of the two forms will be the subject of a future paper". We could establish no great difference between the larvae of the 2 species; those small differences noted are mainly confined, for all stages, to the spinulation of the rostral spine, antennal scale and spine, and to the denticulation of the telson. Details of these characters, at each developmental stage, are given in Table 4. The setation of the appendages are very similar in both larvae, at each stage, with a few exceptions found in: (a) the number of aesthetacs and setae of the antennule at stage III (6 apical aesthetacs on the exopodite and 2 setae on the inner border of the base for *P. monodon*; only 5 and 1, respectively in *P. planipes*); (b) the number of setae on the scaphognathite of the maxilla at stage III (11 plus 1 in *P. monodon* and 9 plus 1 in *P. planipes*); (c) number of setae on the exopodite of the first maxilliped at stage II (7 and 6, respectively); (d) number of setae on the third maxilliped at stage III (7 and 6, respectively); (e) segmentation of the base of the antennule at stage V (3-segmented in *P. planipes*, 2-segmented in *P. monodon*). As in the description of *P. planipes* larvae no differences were made between the phases of development within stage IV, it is not possible to make a detailed comparison of the setation of the appendages of both larvae for each one of the 4 phases described by us.

Besides these minor differences, it is necessary to mention the comparative length of the posterior lateral spines of the carapace: in stages I and II of both *Pleurocodes* species, they reach backwards to the posterior border of the 4th abdominal segment; in stages III and IV, they cover the 5th abdominal segment in the larvae of *P. planipes* and only the 4th segment in *P. monodon*; in stage V they reach over half the 4th abdominal segment in the larvae of the first named species and only up to the 3rd segment in those of *P. monodon*.

Comparing the larvae of the British species of *Galathea* described by LEBOUR (1930, 1931) and the 3 northern species of *Munida* (HUUS, 1934), GURNEY (1942) states that: "there are no important differences between either larvae or adults in these genera". We also found no great differences between the larvae of 2 genera from our waters: *Pleurocodes* and *Cervimunida*. RAYNER (1935), who was not able in his study of planktonic larvae to separate two forms corresponding to the two southern species of *Munida* (*M. subrugosa* and *M. gregaria*), makes the following comment: "Certainly the differences between the very earliest post-larvae, before the modification of the external maxilliped in *M. gregaria*, are such as to make

Table 4. Comparison between each larval stage of *Pleuroncodes monodon* and *P. planipes*

Characteristics	Stage I		Stage II		Stage III		Stage IV		Stage V	
	<i>P. monodon</i>	<i>P. planipes</i>	<i>P. monodon</i>	<i>P. planipes</i>	<i>P. monodon</i>	<i>P. planipes</i>	<i>P. monodon</i>	<i>P. planipes</i>	<i>P. monodon</i>	<i>P. planipes</i>
Spinulation of rostral spine	Along the whole spine	Only on the tip	On the distal half	Only on the tip	On the distal third	Only on the tip	On the distal third	Smooth	Only on the tip	Smooth
Spinulation of antennal scale	Along the whole scale	Only on the tip	Along the whole scale	Only on the tip	Along the whole scale	Only on the tip	Along the whole scale	Very fine only on the tip	Smooth	Smooth
Spinulation of antennal spine	Strong along the whole spine	Very fine along the whole spine	Strong along the whole spine	Very fine along the whole spine	Strong along the whole spine	Very fine along the whole spine	Only on the distal portion	Smooth	Along the whole spine	Smooth (?)
Ventral spine on the base of the antenna	Present	Absent	Present	Present	Present	Present	Present	Present	Present	Present
Denticulation of the telson	On the furcal rami and on its dorsal surface	Only on the distal portion of the furcal rami	On the furcal rami and on its dorsal surface	Only on the distal portion of the furcal rami	Only on the furcal rami	On the furcal rami	On the distal half of the furcal rami	On the furcal rami (?)	Only on the furcal rami	On the furcal rami

distinction at this stage difficult or even impossible, and considering the close resemblance and relationship of the two species, a very marked similarity or even morphological identity of the two larval forms would not be surprising". Taking into account the former remarks of these authors about the similarity of the Galatheidae larvae for species of the same genus as well as for different genera, and the differences found here between the larvae of *P. monodon* and *P. planipes*, we conclude that only a detailed comparative study of the adults will solve the taxonomical position of species belonging to the genus *Pleuroncodes*.

Larval development

The main conclusion drawn on the basis of our experiments with *Pleuroncodes monodon* is that, throughout successive moults, the larvae reach a different developmental stage according to the temperature conditions in which they are reared: at 15 °C the larvae moult from stage IVd to the last stage V, while at 20 °C they moult to a more advanced phase of stage IV (IVe). This phenomenon was previously observed for larvae of the northern congener *P. planipes* by BOYD and JOHNSON (1963) who, through a series of experiments at 5 different temperatures, found that: "at higher temperatures the larvae pass through more substages than they do at lower temperatures". The larvae of *P. planipes* passed, within stage IV, through more substages than the larvae of our species at similar temperature conditions. In fact, all our *P. monodon* larvae kept at 15 °C, moulted to stage V after having attained stage IVd, while *P. planipes* larvae passed through more successive "substages", from IVe to IVh (or some of these) in different percentages, before moulting to the last stage; none moulted (as did our larvae) from stage IVd to stage V. As very few larvae reached the last stage in our experiment, our results cannot be taken as very accurate. It must be pointed out, however, that the great numbers of "substages" attained by *P. planipes* larvae could be due to the use of antibiotics which were not employed in our cultures, and whose use could probably affect the number of instars. This could be proved also by the fact that BOYD and JOHNSON (1963) found a stage VI in the *Pleuroncodes planipes* larvae reared in the laboratory, which stage was not found in the larvae from the plankton (BOYD, 1960).

Variability in number of instars has been observed in other groups of Crustacea. COSTLOW (1965) summarized the information available on this subject, and suggested that the variability in number of instars as well as minor differences in morphological characters of the larvae may be due to the malfunction of the endocrine system, caused by "dietary deficiencies, insufficient food, or absence of certain organic or inorganic trace elements in sea water".

A comparison of the time of development between the larvae of both species of *Pleuroncodes* reared under laboratory conditions can only be performed by experiments conducted at similar or identical temperatures. The mean time of development required by both larvae to reach the common stage IVd was almost $\frac{1}{3}$ longer for *P. planipes* larvae than for *P. monodon* larvae at equal (20 °C) or similar temperatures (14°, 15°, and 16 °C).

In our experiment, at different temperatures, the rate of development is almost constant for each stage as observed also for *Pleurocondes planipes* larvae. The mortality rate was greater during stage I and during the last 3 phases of stage IV (IVb, IVc, and IVd); it was more or less constant during the intermediate phases while, in the experiment conducted by BOYD and JOHNSON (1963) in the northern species, the mortality rate stayed essentially equal in all stages after the first stage, at which the highest mortality rate was registered.

As no significant difference was observed in our experiments conducted with a diet of *Artemia* nauplii only and of *Artemia* nauplii plus *Phaeodactylum tricornerutum*, it can be concluded that the larvae of *Pleuroncodes monodon* do not require a complementary diet of diatoms, but can survive when fed exclusively *Artemia* nauplii; however, they do not survive when only diatoms are available in the culture.

Summary

1. Larvae of the red crab *Pleuroncodes monodon* (MILNE-EDWARDS, 1837) were reared in the laboratory from hatching to the last larval stage. The larvae were maintained at 2 different temperatures (15° and 20 °C) and fed different diets (*Artemia* nauplii; *Phaeodactylum tricornerutum* phase oval, and a mixed diet of both).

2. The larvae passed through 8 stages, by 7 successive moults; as the morphological characteristics did not change basically during the 3 moults following stage IVa, the larvae were classified in 5 distinctive stages and 3 phases within stage IV. Each larval stage, as well as the appendages, are described.

3. The main characteristics useful for distinguishing *P. monodon* larvae from those of species of the same family previously described for Chilean waters (*Munida* sp. and *Cervimunida johni*), as well as from larvae of its northern congener *P. planipes*, were discussed.

4. All larvae reared at 2 temperatures and fed only diatoms, died within the first 9 days of culture, without moulting to the 2nd stage. Larvae kept at 20 °C did not reach the last stage (stage V) and required a mean of 48.3 days to moult to stage IVe. At 15 °C, larvae fed *Artemia* nauplii, as well as those fed

a mixed diet, reached the last larval stage, but in a reduced number and without passing through stage IVe. They required up to a mean of 55 days for moulting to the last larval stage. In all experiments, the highest mortality was registered during the first and the last 3 stages (IVb, IVc and IVd).

5. Data on the larval development of *P. monodon* obtained in our experiments were compared and discussed in relation to data from experiments carried out with its northern congener *P. planipes*.

Literature cited

- BAHAMONDE, N.: Alimentación de la Merluza en los canales (*Merluccius australis*, HUTTON) con datos biométricos sobre los ejemplares. Investnes zool. chil. 2 (2), 23—32 (1953).
- Sobre el contenido estomacal de ejemplares de Merluza (*Merluccius gayi gayi*) capturados en Coquimbo. Boln Inf. Pesca Caza, Chile 54, 9—12 (1958).
- El langostino (*Cervimunida johni*, PORTER) en Chile (Crustacea, Decapoda, Anomura). Investnes zool. chil. 12, 93—130 (1965).
- y M. CÁRCAMO: Observaciones sobre la alimentación de la Merluza (*Merluccius gayi*) en Talcahuano. Investnes zool. chil. 5, 211—216 (1959).
- BOYD, C. M.: The larval stages of *Pleuroncodes planipes* STIMPSON (Crustacea, Decapoda, Galatheididae). Biol. Bull. mar. biol. Lab., Woods Hole 118, 17—30 (1960).
- and M. W. JOHNSON: Variations in the larval stages of a decapod crustacean, *Pleuroncodes planipes* STIMPSON (Galatheididae). Biol. Bull. mar. biol. Lab., Woods Hole 124 (3), 141—152 (1963).
- CHOCAIR, J., F. ORELLANA y J. SERRA: Estudio del género *Genypterus* (congrios) en aguas chilenas (Pisces: Ophidiidae) (1969). (In litteris).
- COSTLOW, J. D.: Variability in larval stages of the blue crab *Callinectes sapidus*. Biol. Bull. mar. biol. Lab., Woods Hole 128 (1), 58—66 (1965).
- and E. FAGETTI: The larval development of *Cyclograpsus cinereus* DANA, under laboratory conditions. Pacific. Sci. 21, 166—177 (1967).
- DELFIN, F.: Los congrios de Chile. Revta chil. Hist. nat. 7, 154—192 (1903).
- FAGETTI, E.: Huevos y el primer estadio larval del langostino (*Cervimunida johni*, PORTER 1903). Revta chil. Hist. nat. 55, 33—42 (1960).
- GURNEY, R.: Larvae of decapod Crustacea, 306 pp. London: Royal Soc. 1942.
- HAIG, J.: The crustacean anomura of Chile. Lunds Univ. Årsskr. (N.F. Avd. 2) 51 (12), 1—60 (1955).
- HENRÍQUEZ, A. G. y N. BAHAMONDE: Análisis cualitativo y cuantitativo del contenido gástrico del congrio negro (*Genypterus maculatus* TSCHUDI) en pescas realizadas entre San Antonio y Constitución (1961—1962). Rev. Univ. 49, 139—158 (1964).
- HUUS, J.: Zur morphologischen systematischen und biologischen Kenntnis der Nordischen *Munida* Larven (Crustacea, Decapoda). Bergens Mus. Årb. 8, 1—32 (1934).
- LEBOUR, M.: The larvae of the Plymouth Galatheididae I. J. mar. biol. Ass. U.K. 12, 175—186 (1930).
- The larvae of the Plymouth Galatheididae II. J. mar. biol. Ass. U.K. 12, 385—390 (1931).

- LONGHURST, A. R.: The pelagic phases of *Pleuroncodes planipes* STIMPSON (Crustacea, Galatheidae) in the California Current. Rep. Calif. coop. oceanic Fish. Invest. **11**, 142—154 (1967).
- and staff: EASTROPAC: micronekton (Special components). Prog. Rep. Scripps Instn Oceanogr. (SIO Ref. 69-23) p. 11 (1969).
- MISTAKIDIS, M. y G. HENRÍQUEZ: Informe sobre investigaciones exploratorias de langostinos y camarones en la zona de Constitución — Isla Mocha. Octubre—Noviembre 1965. Publ. Inst. Fom. pesq. **16**, 1—17 (1966).
- PORTER, C.: Materiales para la fauna carcinológica de Chile. Revta chil. Hist. nat. **20**, 111—117 (1916).
- RAYNER, J. W.: The Falkland species of the Crustacean genus *Munida*. 'Discovery' Rep. **10**, 209—245 (1935).
- First author's address: Dr. E. FAGETTI
Departamento de Oceanología
Área de Matemáticas
y Ciencias Naturales
Universidad de Chile
Casilla 13-D
Viña del Mar, Chile

Date of final manuscript acceptance: October 5, 1970. Communicated by M. VANNUCCI, Cochin