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Abstract

Based on larval literature, an identification key has been constructed for the megalopae of 55 species of Mediterranean Brachyura. This key is based mainly on external morphological characteristics visible, by using a microscope, limiting the necessity for dissection of specimens. Characteristics used include presence/absence of ornamentation on the carapace, number of abdominal somites, number and position of setae and/or spines on antennula, antenna, pereiopods and structure of uropods, etc. Partial dissection is only required to count the setae on the scaphognathite margin. Using the above characters, it is also possible to gather almost all the families into groups. However, the megalopae of Portunidae as well as those of the three species of Brachynotus genus are similar to each other and their identification at a specific level requires the use of features somehow variable and difficult to count. In the Majidae, the megalopae of 14 species are already known. The complexity of morphological characters typical of this family makes it difficult to define characters common to all spider crab megalopae. Nevertheless, the key may be an aid for carcinology studies, especially those including sorting and identification of megalopae from plankton samples.

Keywords: Larval development; Larval morphology; Key; Decapoda; Brachyura; Mediterranean Sea.

Introduction

The larval development of Brachyura (Crustacea, Decapoda) includes two or more planktonic stages of zoea and the planktobenthonic stage of megalopa. The identification of megalopae is difficult because:

- there is a lack of adequate descriptions and their usual scarce presence in plankton samples prevents their assignment to known zoeal series;
- during laboratory larval rearing experiments, obtaining this phase usually results in a high zoeal mortality.

Of the 138 species of Brachyura totally present in the Mediterranean (d'Udekem d'Acoz, 1999), one or more zoeal stages are known for 78 species (PESSANI *et al.*, 1998; GONZALES-GORDILLO *et al.*, 2001), while the complete larval development (zoeal stages plus megalopa) has been described for 65 species. For a few species only the megalopa is known.

A key for the identification of the Mediterranean crab zoeae exists already

(PESSANI *et al.*, 1998); a key for the identification of the zoeae and megalopae of the Northeastern Atlantic crabs was provided by INGLE (1992) while a key for the identification of the zoeae from the Atlantic coast of Europe was provided by PAULA (1996). The aim of the present work is to create a dichotomic key fit for the identification of the megalopa stage of the Mediterranean Brachyura species.

Materials and Methods

To create the key, the literature regarding crabs' larval stages has been taken into account, selecting the works which had provided the complete description and the most accurate illustrations.

The key is based mainly on external morphological characters that are visible, by using an optical microscope, without the necessity of dissecting specimens. Though for some species first antenna requires removal for an adequate observation, the only included character requiring dissection is the number of setae on the scaphognathite (Fig. 1).

Results

The key includes all the 55 Mediterranean crab species, whose megalopa had been previously described in detail (Table 1).

The key has been constructed by subdividing the species into groups, based first of all on the most evident characters (presence of spines on the carapace, number of abdominal somites, structure of the uropods, etc.), then on characters gradually less easily identifiable or countable. For a correct identification, all the characters indicated in each point must be present in the specimen under examination.

Considerations

Although the used features are almost all simple and visible, however, they are numerous and, in some cases, detailed. As a consequence, the incomplete description existing for 12 species does not allow them to be inserted in the key: Medorippe lanata (Linnaeus, 1767) by GILET (1952); Ethusa mascarone (Herbst, 1785) and Ilia nucleus (Linnaeus, 1758) by CANO (1892); Ebalia cranchii Leach 1817 and Xaiva biguttata (Risso, 1816) by LEBOUR (1928); Herbstia condyliata (J. C. Fabricius,1787), Lissa chiragra (J. C. Fabricius,1775) and Maja crispata Risso, 1827 by CANO (1893); Sirpus zariquieyi Gordon 1953 by BOURDILLON-CASANOVA (1960); Asthenognathus atlanticus Monod, 1933 by BOCQUET (1965); Planes minutus (Linnaeus, 1758) by LEBOUR (1944); Pachygrapsus transversus (Gibbes, 1850) by ROSSIGNOL (1957). Generally, the use of the key enables an easy identification of the megalopae; but for most of the Portunidae species, as well as for the megalopae of the three species of Brachynotus genus, it has been necessary to use characters in some way variable and often difficult to count.

The features used in this key do not reflect any systematic arrangement of the Brachyura families; nevertheless, with the aid of few characters, it is possible to separate different families or to gather the families into groups (Table 2). For the families not reported in the table, a combination of many different features is necessary. The megalopae of 14 Majidae species are already known: the complexity of morphological characters typical of this family – already pointed out by PESSANI & SALTON (1998) as regards planktonic zoeae – prevents us from finding characteristics common to the megalopae of the whole family.

Though the number of Mediterranean species, whose megalopa is actually known, is still small (about 50%), this key may be a useful aid for carcinology studies, especially those including sorting and identification of megalopae in plankton samplings.

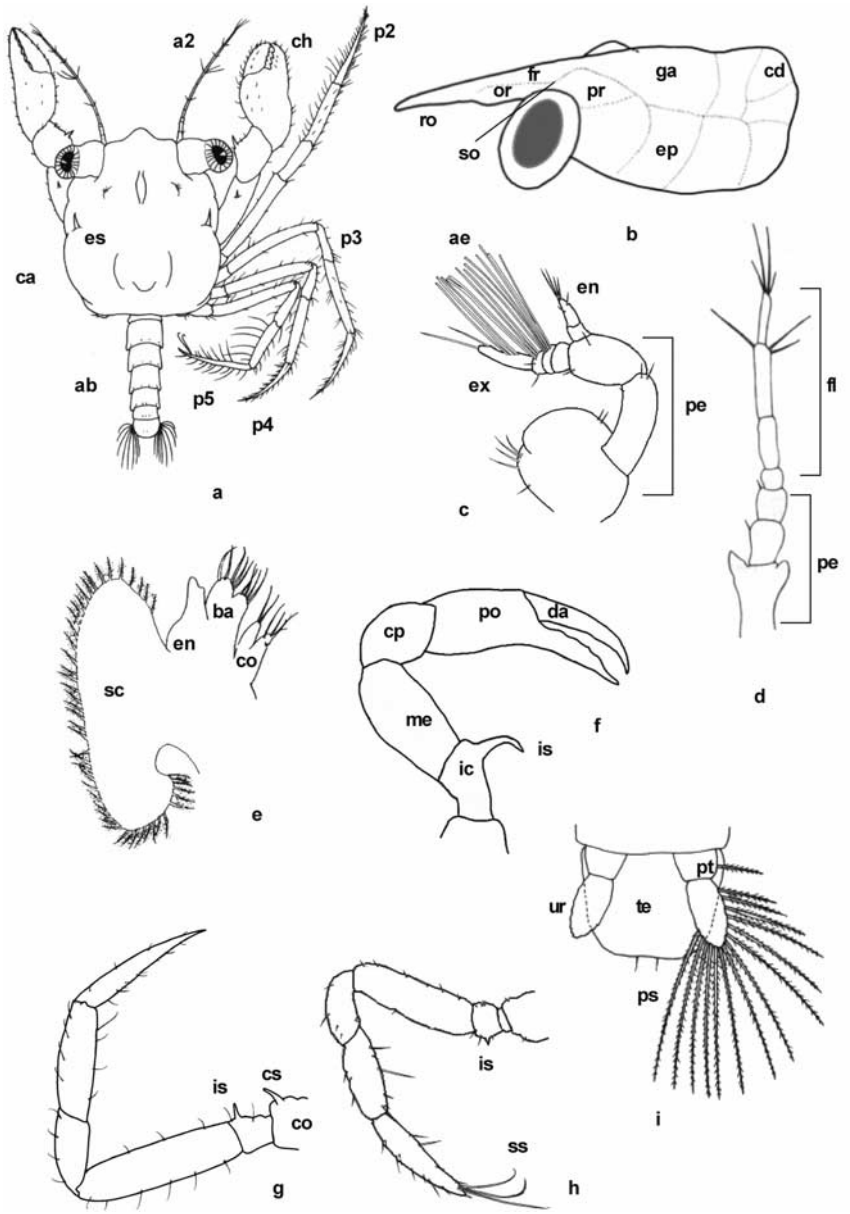

Fig. 1: *Schematic representation of the characters used in the key. a = megalopa, dorsal view (from KURATA & MATSUDA, 1980, modified); b = carapace, left lateral view (from INGLE, 1992, modified); c = antennula; d = antenna; e = maxilla; f = cheliped; g = pereiopod 2; h = pereiopod 5; i = telson and uropods, ventral view (c–i = from various authors, modified). Abbreviations: a2 = antenna; p2-p5 = pereiopod 2-5; ab = abdomen (6 abdominal somites, telson and uropods; pleopods not visible); ae = aesthetascs; ba = basis; ca = carapace; cd = cardiac region; ch = cheliped; co = coxa; cp = carpus; cs = coxal spine; da = dactyl; en = endopod; ep = epibranchial region; es = epibranchial spine; ex = exopod; fl = flagellum; fr = frontal region; ga = gastric region; ic = ischium; is = ischial spine; me = merus; or = orbital region; pe = peduncle; po = propodus; pr = protogastric region; ps = posterior setae; pt = protopod; ro = rostrum; sc = scaphognathite; so = supraorbital region; ss = subterminal setae; te = telson; ur = uropod.*

Table 1
List of the known Mediterranean species of brachyuran megalopae.

Family	Species	Author
Dromiidae	*Dromia personata*	RICE *et al.*, 1970
Homolidae	*Homola barbata*	WEAR & FIELDER, 1985
Latreillidae	*Latreillia elegans*	RICE, 1982
Calappidae	*Calappa granulata*	GUERAO *et al.*, 1998
Leucosiidae	*Ebalia tuberosa*	SALMAN, 1982a; INGLE, 1992
Majidae	*Acanthonyx lunulatus*	GUERAO & ABELLÓ, 1996
	Achaeus cranchii	BOCQUET, 1954; INGLE, 1992
	Dorhynchus thomsoni	WILLIAMSON, 1982; INGLE, 1992
	Eurynome aspera	SALMAN, 1982b; INGLE, 1992
	Eurynome spinosa	INGLE, 1992
	Inachus dorsettensis	CLARK, 1983; INGLE, 1977; INGLE, 1992
	Inachus leptochirus	CLARK, 1983; INGLE, 1992
	Inachus phalangium	CLARK, 1983; INGLE, 1992
	Macropodia rostrata	INGLE, 1982
	Macropodia tenuirostris	SALMAN, 1981; INGLE, 1992
	Maja goltziana	PAULA, 1988A
	Maja squinado	CLARK, 1986
	Pisa armata	INGLE & CLARK, 1980
	Pisa tetraodon	RODRÍGUEZ, 1997
	Rochinia carpenteri	INGLE, 1979
Parthenopidae	*Parthenope massena*	THIRIOT, 1973
Atelecyclidae	*Atelecyclus rotundatus*	HONG & INGLE, 1987
	Atelecyclus undecimdentatus (?)	PAULA, 1987; INGLE, 1992
Cancridae	*Cancer pagurus*	INGLE, 1981
Corystidae	*Corystes cassivelaunus*	INGLE & RICE, 1971
Pirimelidae	*Pirimela denticulata*	PAULA, 1987; FLORES & PAULA, 2000
Thiidae	*Thia scutellata*	INGLE, 1984
Geryonidae	*Geryon longipes*	GUERAO *et al.*, 1996
Portunidae	*Bathynectes longipes*	INGLE, 1985
	Callinectes sapidus	ROFF *et al.*, 1984; Ingle, 1992
	Carcinus aestuarii	RICE & INGLE, 1975
	Carcinus maenas	RICE & INGLE, 1975
	Liocarcinus arcuatus	INGLE, 1992
	Liocarcinus corrugatus	KIM & HONG, 1999
	Liocarcinus depurator	INGLE, 1992
	Liocarcinus marmoreus	INGLE, 1992
	Liocarcinus pusillus	INGLE, 1992
	Necora puber	INGLE, 1992
	Polybius henslowi	INGLE, 1992
	Portumnus latipes	PAULA, 1988B
	Portunus pelagicus	YATSUKA & SAKAI, 1980
Goneplacidae	*Goneplax rhomboides*	INGLE & CLARK, 1983
Xanthidae	*Eriphia verrucosa*	LUMARE & GOZZO, 1972
	Monodaeus couchi	INGLE, 1983
	Pilumnus hirtellus	INGLE, 1983
	Rhithropanopeus harrisii	ROFF *et al.*, 1984
	Xantho incisus	INGLE, 1983
	Xantho poressa	RODRIGUEZ & MARTIN, 1997
Grapsidae	*Brachynotus atlanticus*	RODRIGUEZ *et al.*, 1992
	Brachynotus gemellari	GUERAO *et al.*, 1995
	Brachynotus sexdentatus	CUESTA *et al.*, 2000
	Pachygrapsus marmoratus	GUERAO *et al.*, 1997
Pinnotheridae	*Nepinnotheres pinnotheres*	INGLE, 1992
	Pinnotheres pisum	INGLE, 1992
Euryplacidae	*Eucrate crenata*	KURATA & MATSUDA, 1980

Table 2
Characters which enable separation or grouping of some brachyuran families.

Main character	Secondary character	Family
Many long spines on carapace		Latreillidae Majidae (partly)
5 abdominal somites		Majidae (partly) Pinnotheridae
6 abdominal somites	biramous uropod	Dromiidae Homolidae
	long cardiac region spine	Atelecyclidae Cancridae Majidae (partly) Parthenopidae
	7-segmented antenna	Majidae (partly)
	20-segmented antenna	Corystidae
	setae on telson posterior margin	Calappidae Majidae (partly) Geryonidae Portunidae (partly) Xanthidae (partly)
	no coxal or ischial spine on cheliped and pereiopod 2-5	Grapsidae
	pereiopod 5 dactyl with 2 subterminal setae	Thiidae

Key for the identification of Mediterranenan brachyuran megalopae

(The couplet in brackets indicates the previous point of the key)

1a. – 2 pairs of long spines on frontal region; 1 pair of long spines on protogastric region; cheliped and pereiopod 2-5 with long and prominent spines ..... *Dorhynchus thomsoni*
1b. – not as above 2

2a. (1b) – 1 pair of very long and diverging spines on the supraorbital region; a prominent spine, with a small anterior spine, on the gastric region; 1 pair of hook-shaped spines on the epibranchial region ..... *Latreillia elegans*
2b. (1b) – not as above 3

3a. (2b) – 5 abdominal somites; 4 pairs of pleopods 4
3b. (2b) – 6 abdominal somites; 5 pairs of pleopods 11

4a. (3a) – 1 pair of long spines on the protogastric region; 1 long spine on the cardiac region ..... (*Macropodia* spp.) 5
4b. (3a) – not as above 6

5a. (4a) – antennula exopod 4-segmented, with resp. 0, 0, 2, 3 aesthetascs; 23-26 setae on scaphognathite margin ..... *Macropodia tenuirostris*

5b. (4a) – antennula exopod 2-segmented, with resp. 2, 4 aesthetascs; 19 setae on scaphognathite margin ..... *Macropodia rostrata*

6a. (4b) – 1 pair of spines on the frontal region; spines on abdominal somites 7
6b. (4b) – absence of spines on the carapace and abdominal somites 10

7a. (6a) – abdominal somites 2-5 resp. with 1, 2, 3, 4 pairs of posterio-dorsal spines, some of them very small ..... *Achaeus cranchii*
7b. (6a) – abdominal somites 2-5 with 1 pair of small posterio-dorsal spines ..... (*Inachus* spp.) 8

8a. (7b) – 4 spines on cheliped merus; 16 setae on pereiopod 5 propodus ..... *Inachus leptochirus*
8b. (7b) – 3 spines on cheliped merus; 15 setae on pereiopod 5 propodus 9

9a. (8b) – pereiopod 2-4 propodus resp. with 16, 16, 17 setae ..... *Inachus dorsettensis*
9b. (8b) – pereiopod 2-4 propodus resp. with 17, 17, 16 setae ..... *Inachus phalangium*

10a. (6b) – tubercle on the cardiac region; 2 setae on antennula terminal flagellum segment ..... *Nepinnotheres pinnotheres*
10b. (6b) – no tubercle on the cardiac region; 4 setae on antennula terminal flagellum segment ..... *Pinnotheres pisum*

11a. (3b) – uropod endopod present and setose 12
11b (3b) – uropod endopod absent 13

12a. (11a)– carapace dorsal surface with numerous conical spines; antenna 15-segmented ..... *Dromia personata*
12b. (11a)– carapace dorsal surface without conical spines; antenna 30-segmented ..... *Homola barbata*

13a. (11b)– rostrum and cardiac region spine long and acute 14
13b. (11b)– not as above 18

14a. (13a)– cardiac region spine dorsally directed; antenna 7-segmented ..... *Rochinia carpenteri*
14b. (13a)– cardiac region spine posteriorly directed; antenna 8-9-11-segmented 15

15a. (14b)– antenna 8-9-segmented; pereiopod 5 dactyl without terminal or subterminal setae ..... *Parthenope massena*
15b. (14b)– antenna 11-segmented; pereiopod 5 dactyl with 3 terminal or subterminal setae 16

16a. (15b)– cheliped with ischial spine; uropod exopod with 8 setae ..... *Cancer pagurus*
16b. (15b)– cheliped without ischial spine; uropod exopod with 10 setae ..... (*Atelecyclus* spp.) 17

17a. (16b)– antennula exopod 4-segmented with resp. 0, 5-8, 6-8, 6-7 aesthetascs ..... *Atelecyclus rotundatus*
17b. (16b)– antennula exopod 4-segmented with resp. 0, 12, 9, 7 aesthetascs ..... *Atelecyclus undecimdentatus* (?)

18a. (13b)– antenna 20-segmented ..... *Corystes cassivelaunus*
18b. (13b) – antenna max. 11-segmented 19

19a. (18b)– spines on the protogastric or epibranchial region 20
19b. (18b)– not as above 21

20a. (19a)– protogastric region with a spine; antennula exopod 4-segmented; antenna 10-segmented ..... *Goneplax rhomboides*
20b. (19a)– epibranchial region with a spine; antennula exopod 5-segmented; antenna 11-segmented ..... *Eucrate crenata*

21a. (19b)– antenna max. 7-segmented; pereiopod 5 dactyl without terminal or subterminal setae 22
21b. (19b)– antenna at least 7-segmented; pereiopod 5 dactyl with terminal or subterminal setae 29

22a. (21a)– cheliped with a prominent ischio-meral process; 42-44 marginal setae on scaphognathite ..... *Ebalia tuberosa*
22b. (21a)– cheliped without ischial process or spine ..... (*Majidae* spp.) 23

23a. (22b)– uropod exopod with 3 setae ..... (*Eurynome* spp.) 24
23b. (22b)– uropod exopod with 5 setae 25

24a. (23a)– antennula exopod indistinctly segmented; pereiopod 3 with an obtuse coxal process ..... *Eurynome aspera*
24b. (23a)– antennula exopod 3-segmented with resp. 5, 3, 1 aesthetascs; pereiopod 2-4 with a minute coxal process ..... *Eurynome spinosa*

25a. (23b)– antennula exopod 4-segmented; telson posterior margin with 2 setae ..... *Acanthonyx lunulatus*
25b. (23b)– antennula exopod 3-segmented; telson posterior margin without setae 26

26a. (25b)– an ischial spine only on pereiopod 2 ..... (*Pisa* spp.) 27
26b. (25b)– an ischial spine on pereiopod 2-5 ..... (*Maja* spp.) 28

27a. (26a)– telson posterior margin concave; pleopod 1-4 exopod each with 10 setae ..... *Pisa armata*
27b. (26a)– telson posterior margin straight; pleopod 1-4 exopod resp. with 12, 12, 11, 9 setae ..... *Pisa tetraodon*

28a. (26b)– 48 setae on scaphognathite margin; pereiopod 2-4 with a coxal spine ..... *Maja goltziana*

28b. (26b)– 34-36 setae on scaphognathite margin; pereiopod 2-4 without a coxal spine ..... *Maja squinado*

29a. (21b)– uropod exopod with 3 setae ..... *Rhithropanopeus harrisii*
29b. (21b)– uropod exopod with more than 3 setae 30

30a. (29b)– pereiopod 5 dactyl with 5 terminal or subterminal setae; uropod exopod with 10-11 setae 31
30b. (29b)– pereiopod 5 dactyl with 2, 3, or 4 terminal or subterminal setae 32

31a. (30a)– antennula exopod 3-segmented; pereiopod 4 with a very long coxal spine; no setae on telson posterior margin ..... *Portunus pelagicus*
31b. (30a)– antennula exopod 4-segmented; pereiopod 4 without coxal spine; telson posterior margin with 6-8 setae ..... *Callinectes sapidus*

32a. (30b)– pereiopod 5 dactyl with 4 long terminal setae; uropod exopod with 16 setae; telson posterior margin with 3 setae ..... *Eriphia verrucosa*
32b. (30b) – pereiopod 5 dactyl with 2, or 3 terminal or subterminal setae; other characters not combined 33

33a. (32b)– pereiopod 5 dactyl with 2 subterminal setae; antennula exopod 3-segmented; no setae on telson posterior margin; uropod protopod without setae ..... *Thia scutellata*
33b. (32b)– pereiopod 5 dactyl with 3 terminal or subterminal setae; other characters not combined 34

34a. (33b)– telson posterior margin with setae 35
34b. (33b)– telson posterior margin without setae 39

35a. (34a)– telson posterior margin with 6 setae; 126 setae on scaphognathite margin ..... *Calappa granulata*
35b. (34a)– not as above 36

36a. (35b)– telson posterior margin with 4 setae; 90 setae on scaphognathite margin ..... *Monodaeus couchii*
36b. (35b)– telson posterior margin with 2, or 3 setae; 30 – 80 setae on scaphognathite margin 37

37a. (36b)– telson posterior margin with 2-3 setae; 76-80 setae on scaphognathite margin; uropod exopod with 13-15 setae ..... *Geryon longipes*
37b. (36b)– telson posterior margin with 3 setae; 34-58 setae on scaphognathite margin; uropod exopod with 9-12 setae ..... (*Xantho* spp.) 38

38a. (37b)– 57-58 setae on scaphognathite margin; uropod exopod with 12 setae ..... *Xantho incisus*
38b. (37b)– 34-36 setae on scaphognathite margin; uropod exopod with 9 setae ..... *Xantho poressa*

39a. (34b)– antennula exopod 3-4-segmented; cheliped and pereiopod 2-5 without ischial or coxal spines ..... (Grapsidae) 40
39b. (34b)– antennula exopod 4-segmented; at least cheliped ischial spine, or pereiopod 2 coxal spine, or both 43

40a. (39a)– antennula exopod 4-segmented; uropod protopod with 2 setae; uropod exopod with 17 setae ..... *Pachygrapsus marmoratus*
40b. (39a)– antennula exopod 3-segmented; uropod protopod with 1 seta; uropod exopod with 9 setae ..... (*Brachynotus* spp.) 41

41a. (40b)– inner margin of pereiopod 2-4 dactyl with resp. 5, 3, 2 small teeth ..... *Brachynotus gemmellari*
41b. (40b)– inner margin of each pereiopod 2-4 dactyl with 3 teeth (or spines) 42

42a. (41b)– 46 setae on scaphognathite margin; abdominal somite 1 with 9 mid-dorsal setae; telson margin almost straight ..... *Brachynotus sexdentatus*
42b. (41b)– 42 setae on scaphognathite margin; abdominal somite 1 with 1 mid-dorsal seta; telson margin convex ..... *Brachynotus atlanticus*

43a. (39b)– cheliped with an ischial spine; pereiopod 2-4 without ischial or coxal spines . 44
43b. (39b)– cheliped with or without ischial spine; pereiopod 2 with coxal spine 46
44a. (43a)– antennula exopod 4-segmented with resp. 0, 6, 5-7, 3-7 aesthetascs; scaphognathite margin with more than 45 setae ..... *Portumnus latipes*
44b. (43a)– antennula exopod 4-segmented with resp. 0, 3-4, 3-4, 3-4 aesthetascs; scaphognathite margin with less than 45 setae ..... (*Carcinus* spp.) 45

45a. (44b)– telson posterior margin straight or convex ..... *Carcinus aestuarii*
45b. (44b)– telson posterior margin concave ..... *Carcinus maenas*

46a. (43b)– cheliped with ischial spine; pereiopod 3-4 without coxal spine ..... *Pirimela denticulata*
46b. (43b)– cheliped with or without ischial spine; pereiopod 3-4 with coxal spine 47

47a. (46b)– cheliped with ischial spine; pereiopod 2-3 with ischial spine ..... *Pilumnus hirtellus*
47b. (46b)– cheliped with or without ischial spine; pereiopod 2-3 with ischial spine 48

48a. (47b)– cheliped without ischial spine; uropod protopod with 2 setae ..... *Liocarcinus corrugatus*
48b. (47b)– cheliped with ischial spine; uropod protopod with 0, 1, or 2 setae 49

49a. (48b)– antenna 9 (apparently 8) -segmented; scaphognathite margin with 64-68 setae; uropod protopod with 2 setae ..... *Polybius henslowii*
49b. (48b)– scaphognathite margin with 40-55 setae; uropod protopod with 0, or 1 seta . 50

50a. (49b)– antennula exopod with resp. 0, 11, 10, 7 aesthetascs; uropod exopod without seta ..... *Liocarcinus depurator*
50b. (49b)– antennula exopod not as above; uropod exopod with a seta 51

51a. (50b) .– antennula exopod with resp. 0, 8, 9, 6 aesthetascs; scaphognathite margin with 44-46 setae ..... *Liocarcinus arcuatus*
51b. (50b)– antennula exopod not as above; scaphognathite margin with 49-55 setae ... 52

52a. (51b)– antennula exopod with resp. 0, 10, 7, 5 aesthetascs; antenna peduncle with resp. 3, 2, 2 setae; uropod exopod with 8 – 11 setae ..... *Necora puber*
52b. (51b)– antennula exopod and antenna peduncle not as above 53

53a. (52b) – antennula exopod with resp. 0, 11, 8, 6 aesthetascs; antenna peduncle with resp. 0(?), 2, 1 setae; uropod exopod with 8-9 setae ..... *Liocarcinus pusillus*
53b. (52b)– antennula exopod not as above; antenna peduncle with resp. 4, 2, 2 setae ... 54

54a. (53b) – antennula exopod with resp. 0, 7, 7, 7 aesthetascs; uropod exopod with 9 setae . ..... *Liocarcinus marmoreus*
54b. (53b)– antennula exopod with resp. 0, 10, 8, 6 aesthetascs; uropod exopod with 11 setae ..... *Bathynectes longipes*

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