

Morphological Study in Zoeal Stages of Mud Crabs: *Scylla olivacea* (Herbst, 1796)

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ABSTRACT

The larva of mud crab, *Scylla olivacea* consisted of five zoeal stages. These zoeal stages were illustrated on the basis of laboratory culture from three ovigerous females. The appendage such as mandible, maxillule, maxilla including antennule, antenna, maxilliped and telson were described showing the difference among the zoeal stages. In the first zoeae, the presence of the sessile eyes and 3 pairs of setae at the telson were used to distinguish from the other zoeal stages. From the second through the fifth zoeal stages, the number of setation on maxillule, maxilla, first and second maxilliped were used to discriminate among these zoeal stages. The more advanced zoeal stages, the more number of setation on these appendages. From the second through the fifth zoeae, the setae on basal endite of maxillule and maxilla were 8, 9, 12, 14 and 9, 10, 12, 16 setae, respectively. The setae on the exopod of the first and second maxilliped were 6, 8, 10, 12-15 and 6, 9, 11-12, 14-16 setae, respectively. For the fifth zoeae, the presence of biramous pleopod on the second to the fifth segment was the key character to distinguish from the other zoeal stages. The zoeal morphology of *Scylla olivacea* from this study were compared with those of *Scylla serrata*.

Key words: *Scylla olivacea*, zoea, mud crab, morphology, identification

INTRODUCTION

The mud crabs, *Scylla* spp. (Family Portunidae) are very important economic crab. They inhabit in the brackish waters, such as mangrove areas and estuaries of Australia, Indonesia, Malaysia, Singapore, Vietnam, Philippines and Thailand (Hill, 1979; Fushimi and Watanabe, 1999; Keenan, 1999). In Thailand, four species of mud crabs: *Scylla serrata*, *S. tranquebarica*, *S. paramamosian* and *S. olivacea* are found along the coast of the Gulf of Thailand

and Andamans Sea (Quinitio, 2003). However, *S. olivacea* is the dominant species in Thailand contributed to 80% of the total mud crabs. In recent years, mud crab capture and culture in Thailand have been expanding because of the most widely consumed in domestic and the large export. In 1997, the export value for mud crabs is approximately 180 million bahts and estimated the total value of 3,867 tons (Anonymous, 1999). The principle constraint in the expansion of aquaculture is lack of seed and an attempt at seed production of *Scylla* is performed without consideration in

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species identification. Therefore, the purpose of this study was to provide a description and features in the zoeal stages of *Scylla olivacea*. The knowledge of the zoeal morphology of this species was to ensure the sustainability of crab farming and for identify the zoeal species of this crabs in plankton samples.

MATERIALS AND METHODS

The zoeal samples were collected from three ovigerous or berried females of *Scylla olivacea*. The zoeae were transferred into the culturing cement pond containing eighteen tons sea water of 30 to 33 ppt salinity and were fed with rotifer and newly hatched artemia daily. The zoeae were observed daily for successive developmental stages (moulting zoeae). Each zoeal stage was randomly collected and preserved in 70% ethanol. The preserved zoeae were then measured and dissected for morphological observation. Twenty samples of each zoeal stage were measured by using a calibrated ocular micrometer under stereomicroscope. Methods for measurement followed that of Ingle (1997). Measurements taken were: (a) the body length (BL) the distance between the tip of dorsal spine to the tip of the rostral spine; (b) the rostral spine length (RS) from the anterior part of eye to the tip of rostral spine; (c) the dorsal spine length (DS) from the base to the tip of dorsal spine; (d) the body width (BW) from the tip side of lateral spine to another tip side and; (e) the lateral spine length (LS) from the basal margin of lateral spine to the tip. For the morphological description, at least ten samples of each zoeal stage were examined by dissecting off the appendage using entomological needles under an Olympus stereomicroscope. The key characteristic identification were eyes, antennule, antenna, mandible, maxillule, maxilla, maxilliped, abdomen including the number of appendage setae. After observation, the appendages were photographed and used as template for drawing.

RESULTS

The larval development of *Scylla olivacea* consisted of five zoeal stages (Figure 1). Total development from zoeae I to zoeae V was approximately 18-19 days. The measurements for the five zoeal stages of *S. olivacea* were given in Table 1. The major characteristics of each zoeal stage were described.

Description of zoeal stages

(a) **The compound eyes:** in the first zoeae were sessile while in the second to the fifth zoeae, they were stalked.

(b) **Carapace:** was a global shape, had long rostral and dorsal spine, and short lateral spine (Figure 1). In the fourth and fifth zoeae, a row of sparsely setae appeared at the posterior margin.

(c) **The antennule** (Figure 2) was conical, non-segmented and terminated in a group of aesthetascs and setae. The first zoeae had 3 terminal aesthetascs and 1 short seta, the second zoeae possessed 4 terminal aesthetascs and 2 short setae, the third zoeae was unchanged but increased in size. The fourth zoeae possessed 4 long aesthetascs and 1 short seta terminal while the subterminal comprised 2 long aesthetascs and 2 short setae. The fifth zoeae, the aesthetascs of the antennule were arranged in three tiers of 3, 8 and 7, respectively, and developed an endopod bud.

(d) **The antenna** (Figure 3): the first and the second zoeae consisted of a protopodite which tapered gradually to a point and had 2 long rows of small sharp spines, the exopodite terminated in two unequal setae. The third zoeae, the exopodite was elongated and the endopod developed as a minute bud. In the fourth zoeae, the endopod was approximately the size of the exopod. For the fifth zoeae, the endopod was elongated and larger than exopodite, it was approximately the half of the protopodite in length.

(e) **The mandible** (Figure 4): in the first zoeae, asymmetrically dentate, incisor processed each of few small teeth. From the second to the

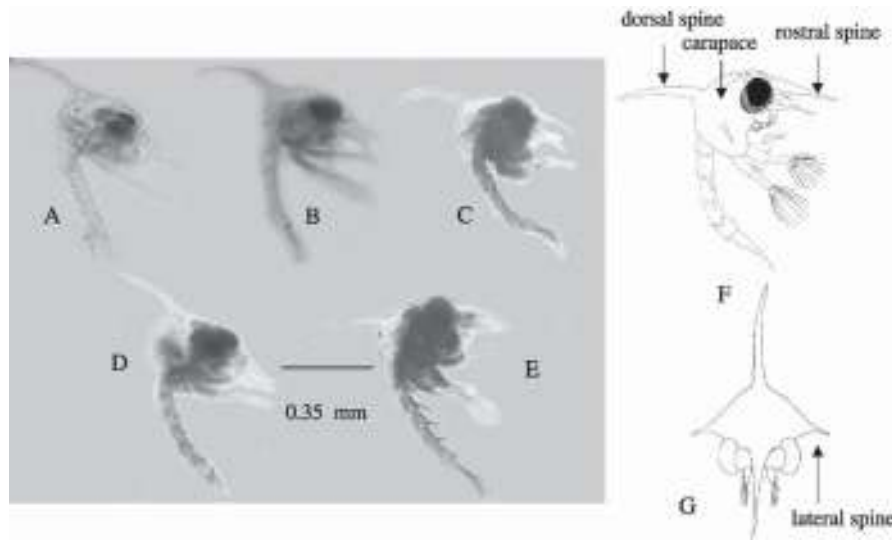


Figure 1 Photograph of *S. olivacea* larvae at different zoeal stages; A. first zoea B. second zoea C. third zoea D. fourth zoea E. fifth zoea.
Drawing of *S. olivacea* larva showing F. lateral view G. anterior view.

Table 1 Mean \pm SE of dorsal spine length (DS), rostral spine length (RS), lateral spine length (LS), body width (BW), body length (BL) and the range of body length of the five zoeal stages of *Scylla olivacea*.

Zoeal stage	DS (mm)	RS (mm)	LS (mm)	BW (mm)	BL (mm)	Range of body length (mm)
I	0.48 \pm 0.006	0.30 \pm 0.004	0.17 \pm 0.001	0.59 \pm 0.007	1.20 \pm 0.009	1.12-1.25
II	0.58 \pm 0.007	0.44 \pm 0.010	0.20 \pm 0.002	0.79 \pm 0.008	1.55 \pm 0.013	1.47-1.65
III	0.82 \pm 0.009	0.62 \pm 0.008	0.29 \pm 0.003	1.05 \pm 0.009	2.06 \pm 0.018	1.90-2.17
IV	1.11 \pm 0.034	0.84 \pm 0.018	0.35 \pm 0.003	1.38 \pm 0.024	2.63 \pm 0.036	2.35-2.80
V	1.45 \pm 0.039	1.14 \pm 0.033	0.39 \pm 0.003	1.66 \pm 0.020	3.54 \pm 0.032	3.35-3.80

Sample size are 20 samples.

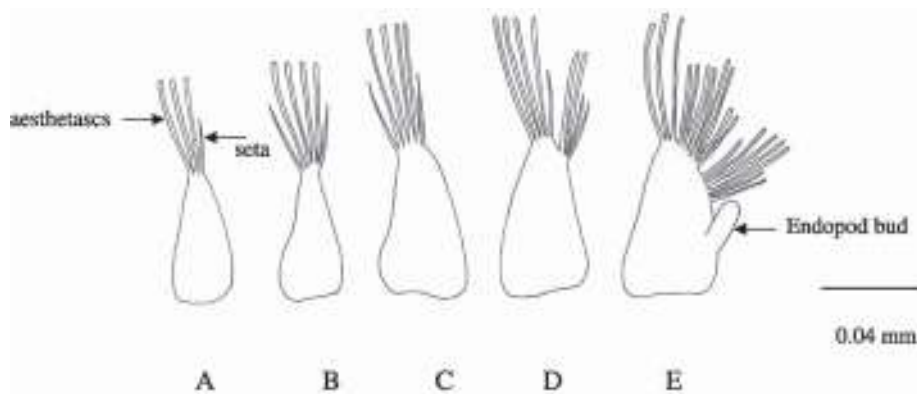


Figure 2 Drawing of antennule of *S. olivacea*. A. first zoea B. second zoea C. third zoea D. fourth zoea E. fifth zoea.

fifth zoeae, the mandible was larger with additional teeth and more fine serrate.

(f) The maxillule (Figure 5): consisted of two segmented endopodite (distal and the proximal segment), unsegmented basal and coxal endites. In all zoeal stages, the distal segment of endopodite had 4 terminal setae and 2 subterminal setae while the proximal segment had 1 seta. From the second to the fifth zoeae, the base of the maxillule on its outside margin had 1 large seta.

The number of setae on the coxal and basal endite in each zoeal stage are given in Table 2.

(g) The maxilla (Figure 6): consisted of bilobed coxal and bilobed basal endite, endopod and a scaphognathite. The number and position of setae on coxal, basal endites and scaphognathite of the maxilla in each zoeal stage are given in Table 3. All segments had plumose setae. Endopod of all zoeal stages had 4 terminal setae and 2 subterminal setae.

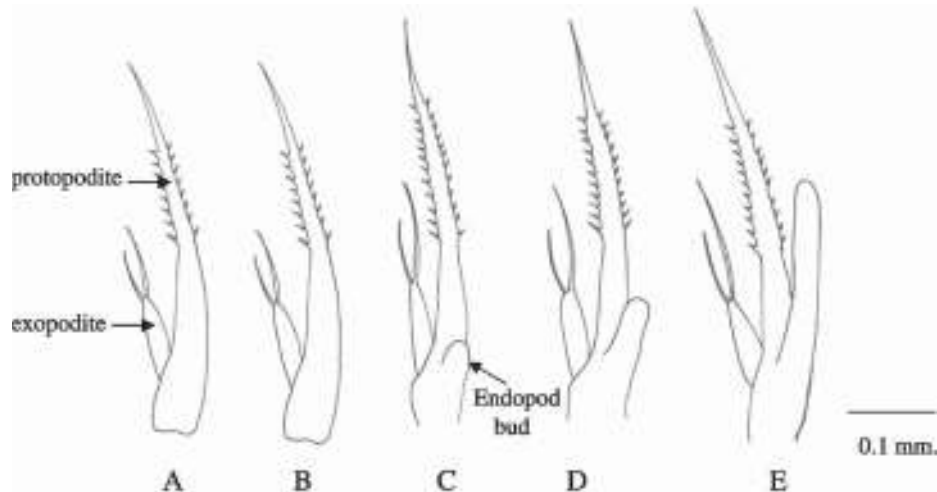


Figure 3 Drawing of antenna of *S. olivacea*. A. first zoea; B. second zoea; C. third zoea D. fourth zoea E. fifth zoea.

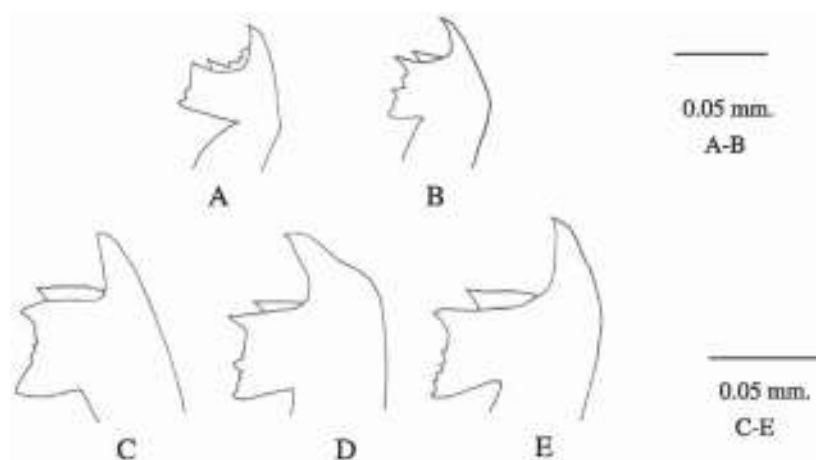


Figure 4 Drawing of mandible of *S. olivacea*. A. first zoea B. second zoea C. third zoea D. fourth zoea E. fifth zoea.

(h) **The first maxilliped** (Figure 7): consisted of basal endite, 2 incompletely segmented exopodite and a 5 segmented endopodite. In the first and the second zoeae, the endopodite segments from base to tip were 2,2,0,2,5 setae. In the third, fourth and fifth zoeae, the setation of the endopodite were 2,2,1,2,6. The exopodite had 4, 6, 8, 10 and 12-15 plumose natatory setae in the first, second, third, fourth and fifth zoeae.

(i) **The second maxilliped** (Figure 8):

Table 2 The number of setae on coxal and basal endites of maxillule of *S. olivacea* from the first zoea to the fifth zoea (ZI–ZV).

Zoeal stage	Coxal endite	Basal endite
I	6	5
II	7	8
III	8	9
IV	10	12
V	10	14

consisted of basal, 3 segmented endopodite and unsegmented exopodite. The endopodite of all zoeal stages consisted of 1, 1 and 5 setae from the proximal to the distal segment. The exopodite had 4, 6, 9, 11-12 and 14-16 plumose natatory setae in the first, second, third, fourth and fifth zoeae.

(j) **The third maxilliped**: began to develop as an externally visible bud in the fourth zoeae and became larger with biramous in the fifth zoeae.

(k) **The abdomen** (Figure 9): consisted of five segments plus telson in the first and second zoeal stage. The third, fourth and fifth zoeae possessed 6 segments plus telson. In the first and second zoeae, a pair of lateral knobs or spines were present on the second and the third segment. In the fourth zoeae, the pleopod buds appeared at the ventral posterior end on the second to the sixth abdominal segment. In the fifth zoeae, the pleopod buds increased in size and presented as biramous.

The telson was typically forked and gradually curved distally. In the first zoeae, there were three pairs of setae presented on the inner

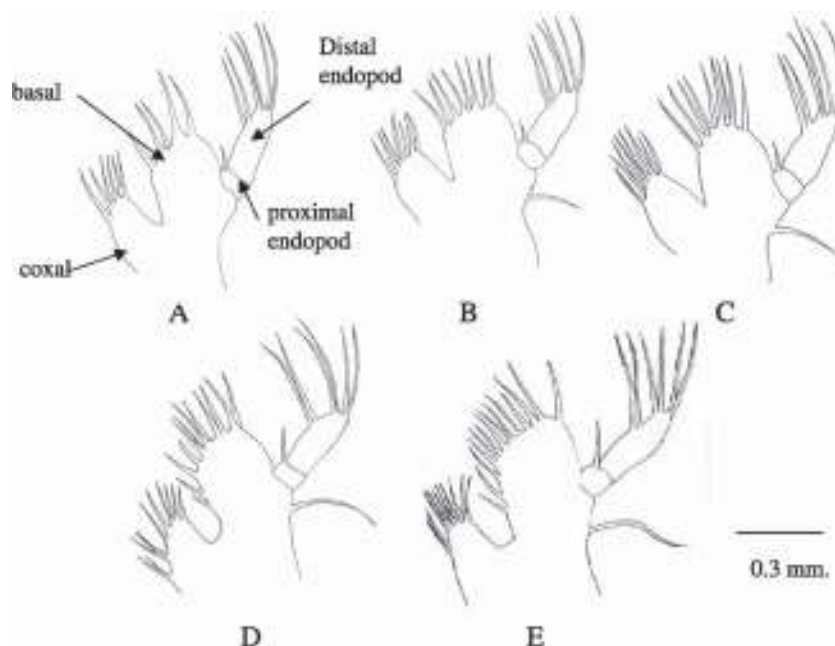


Figure 5 Drawing of maxillule of *S. olivacea*. A. first zoea B. second zoea C. third zoea D. fourth zoea E. fifth zoea.

surface of the telson. The second and third zoeae had 4 pairs of setae while in the fourth and the fifth zoeae, a small median seta was added on the posterior margin.

DISCUSSION

The zoeae of *Scylla olivacea* was segmented and made up of appendages as the other arthropod (McLaughlin, 1982). They had one of rostral spine, long dorsal spine and the short lateral spines on each side of carapace. During their development, the length of the body, lateral spine,

rostral spine and dorsal spine increased in size as well as the body width. The zoeal metamorphosis were induced by hormone for growth and extended the skeleton (Warner, 1977). In this study, *Scylla olivacea* had five zoeal stages which was the most common in many crab species such as *Scylla serrata* (Ong, 1964), *Cancer anthonyi* (Trask, 1974), *Neosarmatium indicum* (Islam *et al.*, 2002), *Parasesarma plicatum* (Selvakumar, 1999) and *Cyclograpsus punctatus* (Fagetti and Campodonica, 1971).

The first zoeae of *S. olivacea* could be separated from the other stages as seen from the

Table 3 The number and position of setae on coxal, basal endites and scaphognathite of the maxilla of *S. olivacea* from zoea I to zoea V (ZI-ZV).

Endite	Lobe	Z I	Z II	Z III	Z IV	ZV
Coxal	Proximal	3	3	3	5	5
	Distal	3	4	4	4	5
Basal	Proximal	4	5	5	6	8
	Distal	4	4	5	6	8
Scaphognathite		4	8	15	25-27	35-38

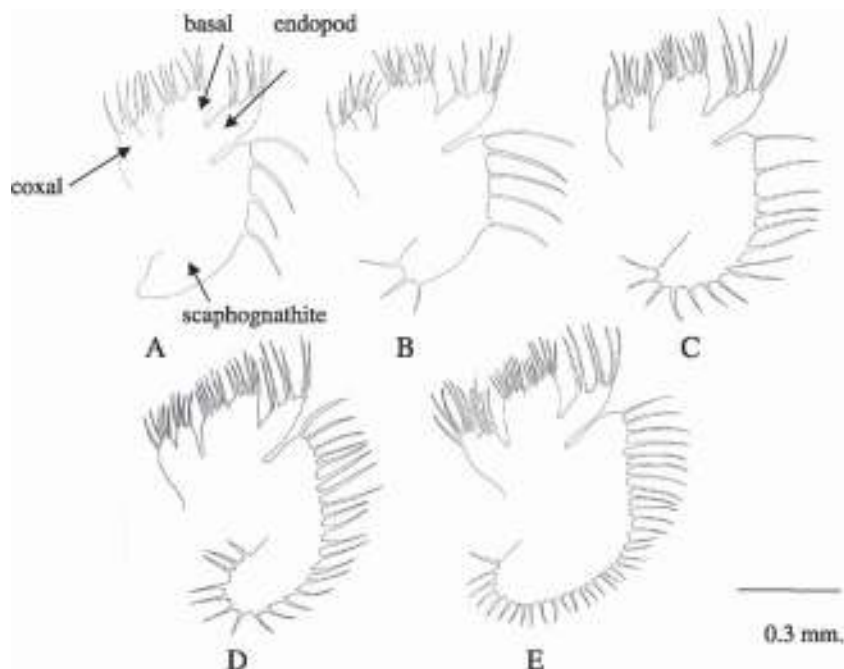


Figure 6 Drawing of maxilla of *S. olivacea*. A. first zoea B. second zoea C. third zoea D. fourth zoea E. fifth zoea.

sessile eyes and 3 pairs of setae at the telson . This character was similar to that of *S .serrata* as described by Ong (1964). The zoeae of *S. olivacea* had no gastric mill (Jantrarotai *et al.*, 2005), but using the mouthparts such as maxillule, maxilla

and mandible to break down their prey. In this study, the maxillule and maxilla of *S. olivacea* showed the greatest density of setae of all appendages. The difference in number of setation on mouthpart was used to discriminate among the

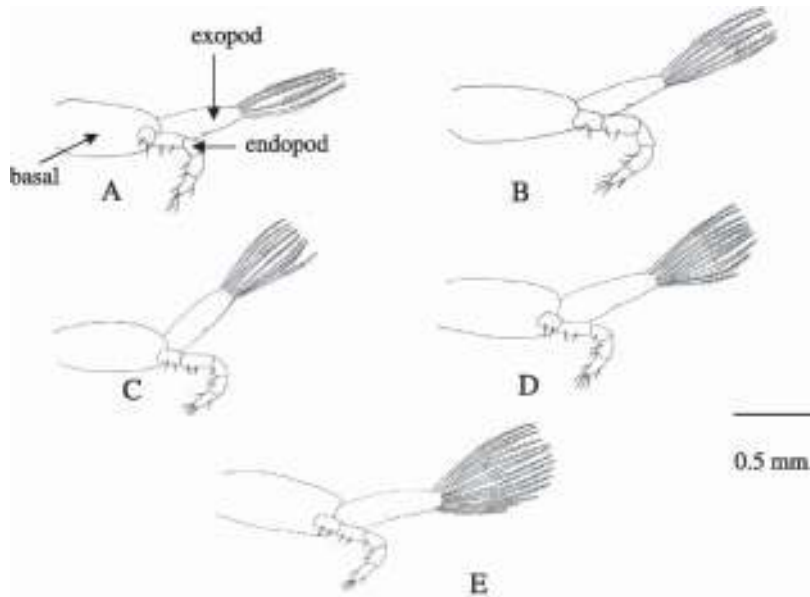


Figure 7 Drawing of the first maxilliped of *S. olivacea*. A. first zoea B. second zoea C. third zoea D. fourth zoea E. fifth zoea.

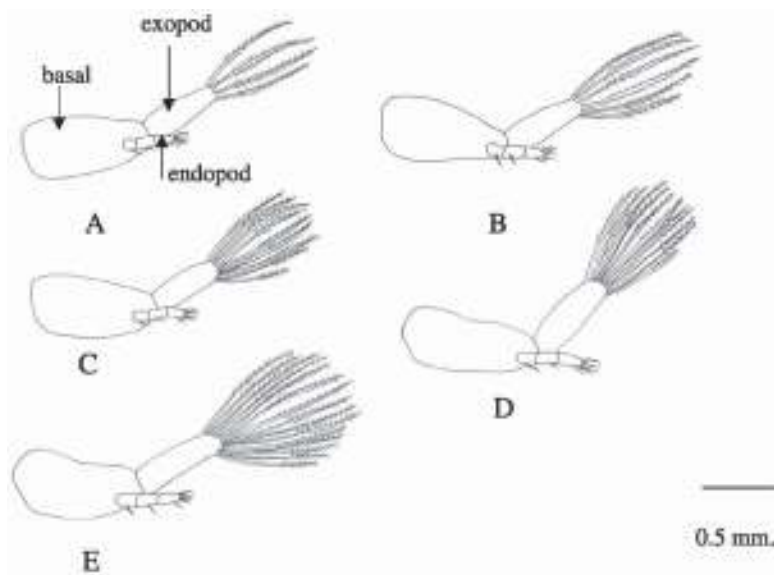


Figure 8 Drawing of the second maxilliped of *S. olivacea*. A. first zoea B. second zoea C. third zoea D. fourth zoea E. fifth zoea.

zoal stages such as the number of setation on the basal of maxillule and on the basal of maxilla. From the first through the fifth zoal stage, the numbers of setae on the basal endite of maxillule were 5, 8, 9, 12, 14 setae while on the basal endite of maxilla were 8, 9, 10, 12, 16, respectively. This was commonly adapted for feeding especially the larvae in the planktotrophic form (McLaughlin, 1982).

The maxilliped was a thoracic appendages which aided in catching food particle and movement. The first and second maxilliped had the distinctive appendages to be observed or removed. Therefore, these appendages were used for identifying the stages and species of zoeae by counting the number of setation arranged along the exopod of the first and second maxilliped . The more advanced zoal stage, the more difference in number of setation along the exopod were presented. From the first through the fifth zoal stage, the setae on the exopod of the first and second maxilliped were 4, 6, 8, 10, 12-15 and 4, 6, 9, 11-12 and 14-16 setae, respectively. These characters were also found in brachyuran zoeae such as *S.serrata* (Ong ,1964) and it could be used

to determine the stage of zoeae (Warner, 1977). In the fifth zoeae, it was easily distinguishable from the other zoal stages by having the biramous pleopod on the second to the fifth segment.

The zoal morphology of *S. olivacea* from this study were compared to those of *S. serrata* which was described by Ong (1964). In the first zoeae, the difference in number of setation on basal and coxal endite of maxilla was used to discriminate between these two species due to *S. olivacea* had 5 and 6 setae while *S.serrata* had 5 and 7 setae, respectively. In the second zoeae, the zoeae of *S. olivacea* were closely resemble to those of *S. serrata*. However, in the third zoeae, the number of setation arranged on the endopod of the first maxilliped was used to identify these species. For *S. olivacea*, the endopod had 2, 2, 1, 2, 6 setae while *S.serrata* had 2, 2, 0, 2, 5 setae. In the fourth and fifth zoeae, the setation on basal and coxal endite of maxillule and the number of setae on the scaphognathite of maxilla were used to distinguish between these two species. In the fourth zoeae, *S. olivacea* was characterized by 12 and 10 setae on the basal and coxal endite of maxillule with 22-24 setae on scaphognathite

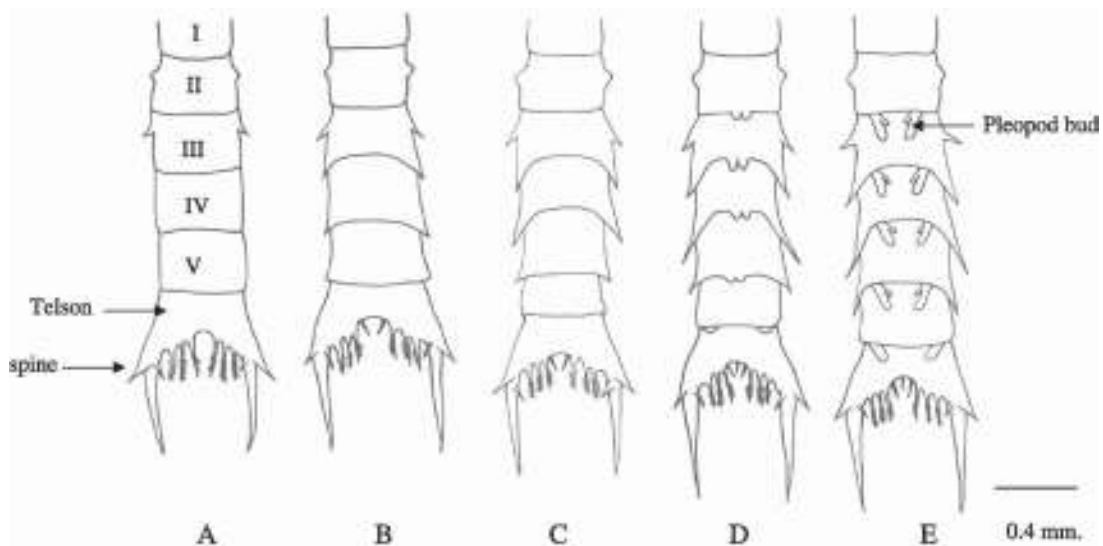


Figure 9 Drawing of abdomen of *S. olivacea*. A. first zoea B. second zoea C. third zoea D. fourth zoea E. fifth zoea.

while *S. serrata* had 14 and 12 setae on maxillule with 25-27 setae on the scaphognathite. The fifth zoeae, *S. olivacea* had 15 and 12 setae on the basal and coxal endite of maxillule with 33-37 setae on the scaphognathite while *S. serrata* had 20 and 15 setae on maxillule with 45-50 setae on the scaphognathite. These characters were also used to discriminate *Cyclograpsus cinereus* from *C. punctatus* (Diaz and Ewald, 1968) as well as *Hemigrapsus sexdentatus* from *H. crenulatus* (Cuesta *et al.*, 2001). Browne and Patel (2000) stated that the variable numbers of setae in these appendages were often found within genera; the more advanced zoeal stage, the more difference in the appendage pattern that could be used to discriminate the species of crustacean.

This study was useful to distinguish *S. olivacea* among the zoeal stage and allowed them to be easily identified from *S. serrata*. However, the identification of the zoeal stages of other species within genus *Scylla* is necessary for further study.

CONCLUSION

The morphological characteristic of mud crab zoeae (*S. olivacea*) at different stages were described. For the first zoea, the presence of the sessile eyes and 3 pairs of setae at the telson were used as the identification key to distinguish from the other zoeal stages. From the second through the fifth zoeae, the setation on basal and coxal endite of maxillule, the setation on basal endite and scaphognathite of the maxilla, the setation on the exopod of the first maxilliped were used to discriminate these zoeal stages. For the fourth and the fifth zoeal stage, the presence of the third maxilliped, the pleopod bud in the abdominal segment and 4 pairs and 1 seta at the telson were used to discriminate from the previous stage. For the fifth zoeae, it was distinguish from the fourth zoeae by having the biramous pleopod.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Graduate School, Kasetsart University for research fund.

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