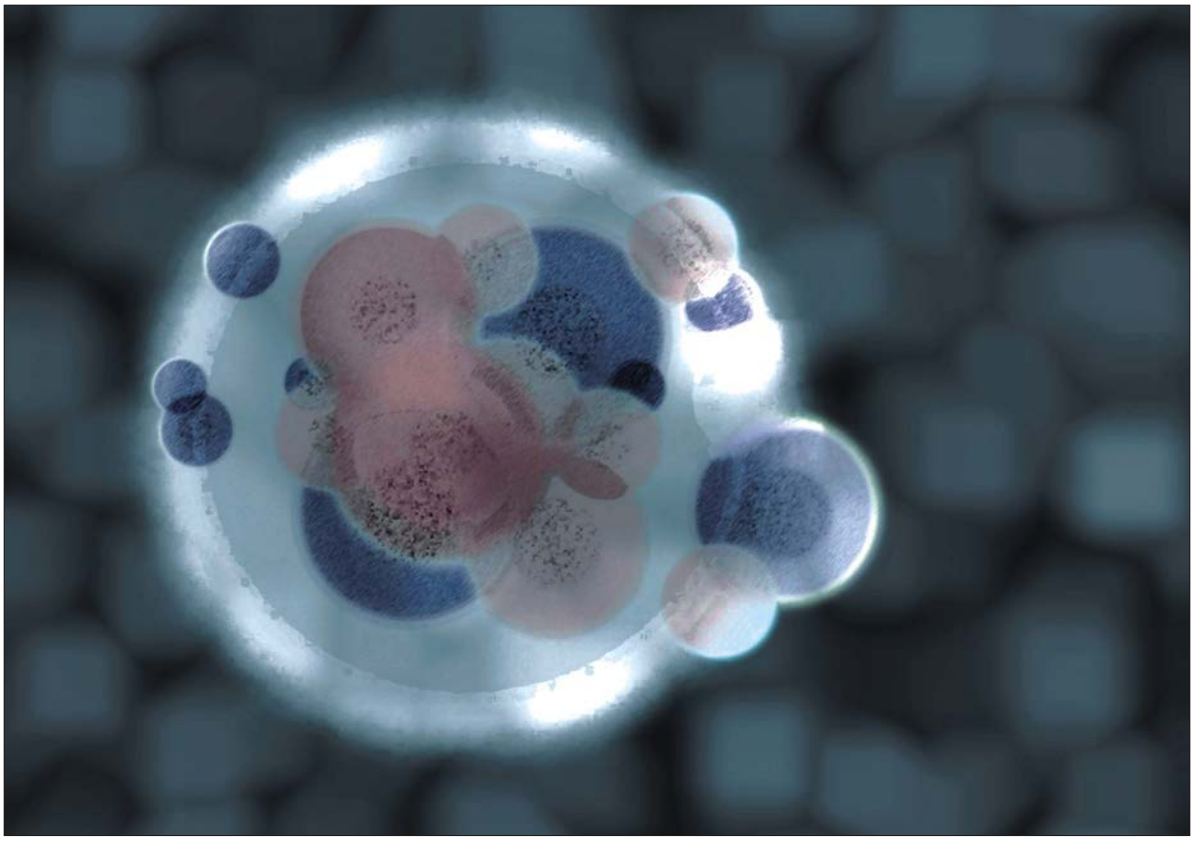

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New Distribution Record of Two Pen Shells (Bivalvia: Pinnidae) from the Seagrass Beds of Sungai Pulai, Johore, Malaysia

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Abstract: Studies on taxonomy of pen shells were conducted at Merambong Shoal (N1° 19' 55.62" E103° 35' 57.75"), Tanjung Adang Shoal (N1° 19' 48.03" E103° 33' 59.44") and Merambong Island (N1° 18' 54.83" E103° 36' 33.37") off South Western Johor coast, Peninsular Malaysia from August 2005 to June 2006. One hundred and seven individuals of pen shells were collected from the study areas for taxonomy identification. Pen shells were grouped based on the internal and external surface of the valves. Seven species were clearly identified where *Atrina* and *Pinna* are dominant. Among these seven species, "*Pinna deltodes* (Menke, 1843) and *Pinna incurva* (Gmelin, 1791)" are the new distribution record from the seagrasses bed of Sungai Pulai.

Key words: Pinnidae, pen shells taxonomy, shell morphology

INTRODUCTION

The Pinnidae or razor, wing or Pen shells are a family of large wedge-shaped bivalves that live in mud and sand or amongst rocks or corals. They are widely distributed in the Indo-Pacific from southeastern Africa to Melanesia and New Zealand, north to Japan and to New South Wales and New Zealand. Pen shells are also found in Mediterranean and American waters (Rosewater, 1961; Butler, 1987; Scheltema, 1983; Zavodnik *et al*., 1991; Munguia, 2004).

Atrina and *Pinna* species exist as metapopulations, comprised of small groups or patches of individuals. Pen shells are generally large bivalves (30-48 cm long), triangular in shape, thin with shell tapering to a point and light yellow-brown to dark brown in color. Pen shells live with their pointed end embedded in sediment, attached by fine byssal threads (Keen, 1958; Tyler-Walters, 2004; FAO, 1998, 2002). Pen shells are relatively common at the sandy substrate of the seagrass beds (*Posidonia oceanica* and *Cymodocea nodosa*), lagoons and coral rubble areas (Anonymous, 2003; Luc-Solandt, 1999).

Pinna and *Atrina* are used for different purposes by many different cultures around the world (Velasco, 1998). The fine golden-brown byssal fibers of the Mediterranean *Pinna* were used to weave the legendary Cloth-of-Gold, a fabric that must have rivalled our finest synthetics, for a woman's scarf of this material was said to be so flexible it could be rolled into a ball the size of a walnut (Turk, 1982). So much work are involved to harvest enough of the Pinnas and to process the fiber for weaving, however, that the cloth could be afforded only by royalty (Wang, 1964).

Marine shells of the family Pinnidae are a popular food source and high commercial value in a number of Asia-Pacific countries. Pinnidae has a noticeable economic importance in the western Pacific. They are actively collected for food in Japan and surrounding areas, as well as in Polynesia and several other Indo-Pacific island groups (Yu *et al*., 2004). According to Velasco (1998), their posterior abductor mussel is widely marketed domestically and sometimes the much smaller anterior abductor muscle and even the mantle are also consumed. At this time, pen shell meat may reach a price as high as 150 Mexican pesos/kg (US9. 40/pound).

Most publications on the taxonomy of pen shells come from the researchers in Indo-Pacific, Mediterranean and American regions (Rosewater, 1961; Butler, 1987; Perry and Larsen, 2004). Monographs on the Pinnidae by Rosewater (1961) and Scheltema (1983) were much needed for taxonomic order to recent members of the family and have a wide geographical distribution.

Pinna bicolor Gmelin is a common Indo-Pacific species. Rosewater (1961) synonymized 31 species under *P. bicolor*, including the fossil *P. inermis* Tate, *P. menkei*

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Hanley Reeve, *P. madida* Reeve, *P. attenuate* Reeve, *P. fumata* Reeve, *P. dolobrata* Lamarck, *P. moluccensis* Clessin, *P. isosceles* Hedley and *P. atropurpurea* Sowerby (Scheltema, 1983). Also included four specific names were referred as 'short and wide form of *bicolor* (Rosewater, 1961); the earliest name for this form is *Pinna deltodes* Menke.

Little is known on the pen shells population in Malaysian waters. Pen shell is one of the important fisheries resources in the country and can easily be established as important commercial bivalves. The aim of this study is to generate specific information on the taxonomic distribution of the pen shells in Sungai Pulai seagrass beds. These areas were chosen because of the natural presence of the shells that live in great abundant in association with the seagrass. Previous study by Rosewater (1961) lacked specific information on the species, where most of the listed species were restricted to the species occurred in Malaya. Statements given are non-specific and not directed to certain geographical area. Also Purchon and Purchon (1981) reported the existing of pen shells only from the northern part and east coast of Peninsular Malaysia especially in Kuala Kedah, Penang, Lumut and Pulau [= Island] Perhentian.

MATERIALS AND METHODS

Study areas: A study was conducted at Merambong Shoal (1° 19' 55.62" N 103° 35' 57.75"E), Tanjung Adang Shoal (1° 19' 48.03"N 103° 33' 59.44"E) and Merambong Island (1° 18' 54.83"N 103° 36' 33.37"E) off South Western Johore coast, Malaysia (Fig. 1). The areas chosen provide ample diversity of pen shells associated with the seagrass habitat.

Specimens collection: Specimens of pen shells were manually collected by using hand scope from the study areas during the low tide from August 2005 to June 2006. One hundred and seven specimens were collected from the study areas and were transferred to the laboratory for taxonomic identification. Labeled specimens were stored in 10% formalin and images were taken and important body color attributes were recorded.

Taxonomic identification: Shells were measured using digital vernier caliper (MITUTOYO) for total length and other shell morphometric characters. Measurement was emphasized on the following parameters:- length of anterior to posterior adductor (1), posterior adductor to

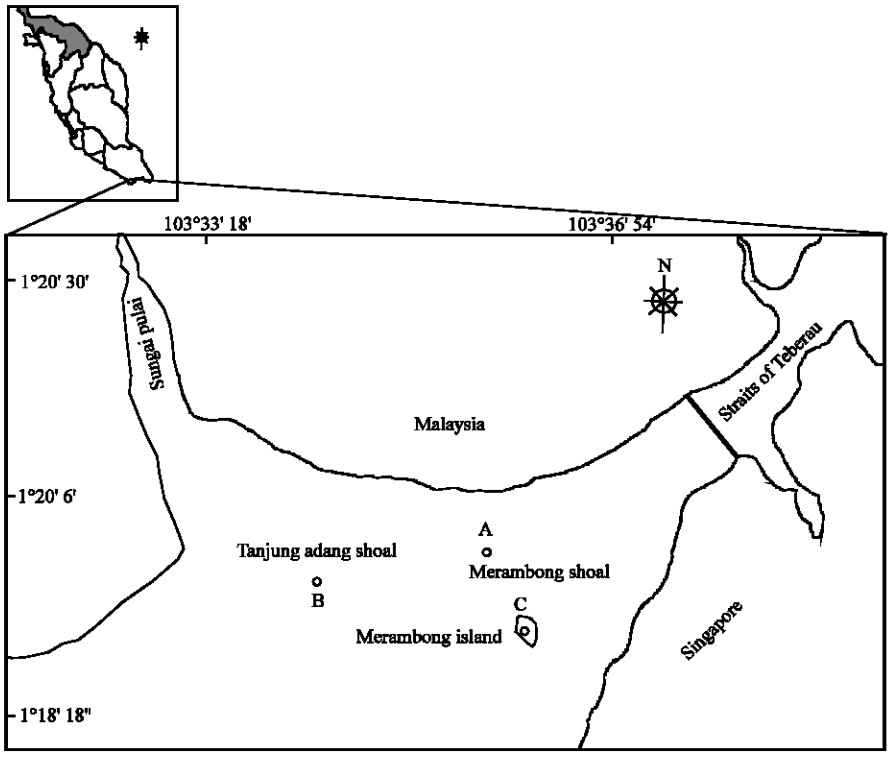

Fig. 1: Map showed the sampling areas. (A) Merambong Shoal, (B) Tanjung Adang Shoal and (C) Merambong Island off South Western Johore coast, Malaysia

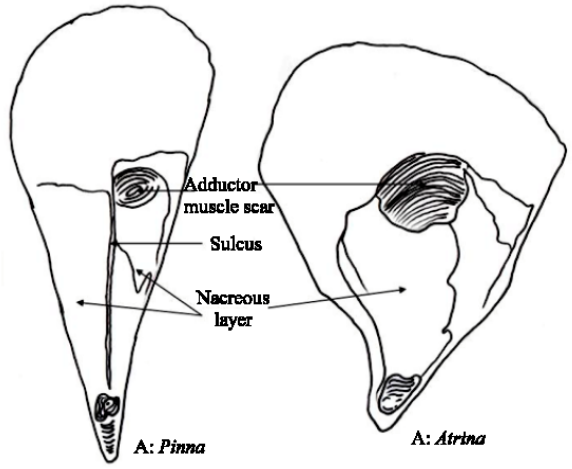

Fig. 2: The genus taxonomic difference between *Pinna* and *Atrina*

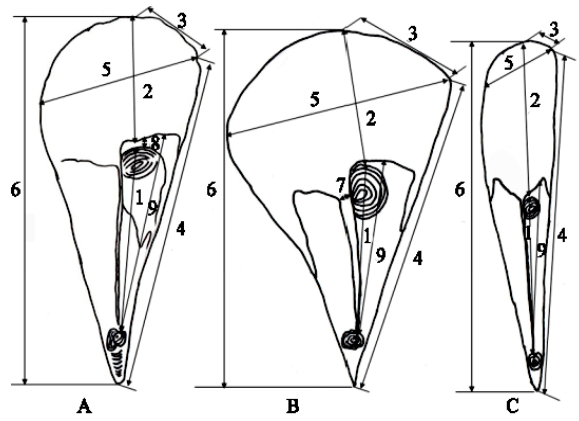

Fig. 3: Inside left valves of *Pinna bicolor* (A), *Pinna deltodes* (B) and *Pinna incurva* (C) showing the position of nacreous lobes and posterior adductor muscle scar. (1) anterior to posterior adductor (2) posterior adductor to posterior shell margin (3) dorsal posterior margin (4) dorsal margin (5) width (6) length (7) width of sulcus (8) posterior adductor margin to posterior nacreous margin and (9) nacreous length

posterior shell margin (2), dorsal posterior margin (3), dorsal margin (4), width (5), length (6), width of sulcus (7) posterior adductor to posterior nacreous lobe (8) and dorsal nacreous length (9) (Fig. 3). For the identification of the different morphological structures, the study of Winckworth (1929), Rosewater (1961, 1982), Butler and Keough (1981), Scheltema (1983), FAO (1998, 2002) and Perry and Larsen (2004) were followed.

RESULTS AND DISCUSSION

A total of seven species of pen shells were recorded from the study areas (Table 1). The identification of the species was based on the nine characteristics of internal and external characteristics of the valves (Fig. 2, 3). From these seven species, five species belonged to the genus *Pinna* and two species were *Atrina*. *Pinna bicolor* and *Pinna atropurpurea* were the two dominant species found in these study areas. In addition, *Pinna deltodes* Menke (Fig. 4) and *Pinna incurva* Gmelin (Fig. 5) are two new distribution records of pen shells from Sungai Pulai seagrass beds.

***Pinna deltodes* (Menke, 1843):** *Synonymy*-1843. *Pinna deltodes* Menke, Molluscorum Novae Hollandiae Specimen, p. 37 (prope Victoria River). [Type figure Reeve, 1858, Conchologia Iconica, XI, *Pinna*, P1. 21, Fig. 40, by subsequent designation, Rosewater, 1961; figured specimen Brit. Mus. (NH).]

1924. *Pinna scapula* Hedley, Rec. Australia Mus. 14:148, pl. 19, Fig. 6, 7 (Northern Territory: Darwin). [Holotype Australian Museum.] 1939. *Exitopinna deltodes ultra* Idedale, Gr. Barrier Reef Exp. Sci. Repts. 5:315 (Low Isles, Qld.). [Holotype Australian Museum; figured in Rosewater, 1961, pl.150.]

Description: The average shell length and width were found 228.57 (±52.77) mm and 116.68 (±22.16) mm. Maximum shell length and width were 276.81 mm and 128.11 mm, respectively (Table 2, Fig. 3B, No. 5, 6 and Fig. 4). According to Scheltema (1983) maximum shell length and width for *P. deltodes* are 370 and 210 mm. Shell widths about three-quarters shell total length. Shell extremely flared posteriorly so that width nearly equals the length. Attenuately triangular in shape, posterior margin rounded. Valves usually fan shaped, dorsal and ventral margins nearly equal in length and about three-quarters greater than shell length. Shell width about three-quarters shell length. The colour of shell was translucent, light horn to dark brownish purple. From the examination of all specimens, showed reddish to dark brown and also brown to purplish black coloration. According to Scheltema (1983) shell horn in colour, internally smoky horn. About 10 to 12 radiating ribs present which are preserved at anterior end of larger shells.

Posterior shell margin rose in high, symmetrical arch, with highest point and greatest shell length midway between dorsal and ventral margins. Dorsal and ventral posterior margin were almost same in length. Posterior shell margin raises in high, symmetrical arch, with highest

Table 1: List of pen shells species found in the study areas for taxonomy identification

Species	Merambong Shoal St 1	Merambong Shoal St 2	Tanjung Adang Shoal St 3	Merambong Island St 4
Pinna bicolor	19	12	5	3
Pinna muricata	5	1	0	2
Pinna deltodes	7	4	2	6
Pinna atropurpurea	9	4	3	5
Pinna incurva	3	1	1	0
Atrina vexillum	3	1	0	0
Atrina pectinata	6	1	4	0
Total	52	24	15	16

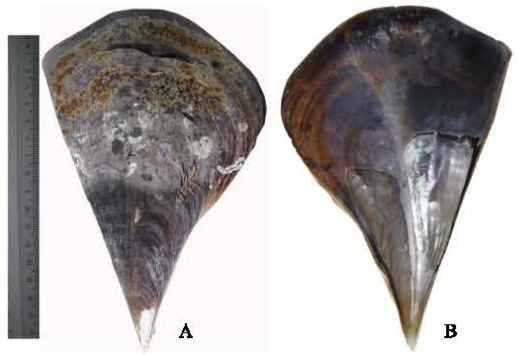

Fig. 4: Exterior of right valve of *Pinna deltodes* showing outer and inner surface (A), internal view of left valve (B) showing the posterior adductor muscle protruded on posterior margin of dorsal lobe and the wide of sulcus between dorsal and ventral lobe of nacreous layer

Fig. 5: Exterior of right valve of *Pinna incurva* Showing outer and inner surface (A), internal view of left valve (B) showing the deep V shape on dorsal and ventral lobes of nacreous layer

Table 2: Mean and standard deviation (±SD) of shell measurements of *P. deltodes*, *P. incurva* and *P. bicolor* from Sungai Pulai Seagrass Beds, Johor

Morphometric characteristics (mm)	Species	N	Mean	Standard Deviation (±SD)
TL	*P. bicolor*	39	225.11	(±22.82)
	P. deltodes	19	228.57	(±52.77)
	P. incurva	5	232.08	(±16.62)
WL	*P. bicolor*	39	93.64	(±18.23)
	P. deltodes	19	116.68	(±22.16)
	P. incurva	5	66.56	(±16.55)
DML	*P. bicolor*	39	202.86	(±21.17)
	P. deltodes	19	200.97	(±43.86)
	P. incurva	5	190.34	(±48.72)
DPML	*P. bicolor*	39	47.43	(±12.56)
	P. deltodes	19	71.86	(±16.69)
	P. incurva	5	27.12	(±8.84)
PAMPSM	*P. bicolor*	39	84.57	(±11.97)
	P. deltodes	19	89.74	(±19.79)
	P. incurva	5	91.11	(±12.33)
APAML	*P. bicolor*	39	125.71	(±14.90)
	P. deltodes	19	120.39	(±30.39)
	P. incurva	5	121.49	(±13.93)
DNL	*P. bicolor*	39	133.27	(±13.79)
	P. deltodes	19	129.13	(±29.14)
	P. incurva	5	144.43	(±21.16)
PAMPDNL	*P. bicolor*	39	6.78	(±2.34)
	P. deltodes	19	3.09	(±2.23)
	P. incurva	5	6.94	(±2.83)
WS	*P. bicolor*	39	1.59	(±0.60)
	P. deltodes	19	4.60	(±1.34)
	P. incurva	5	1.72	(±0.98)

TL = Total Length; WL = Width Length; DML = Dorsal Margin Length; DPML = Dorsal Posterior Margin Length; PAMPSM = Posterior Adductor Muscle to Posterior Shell Margin; APAML = Anterior to Posterior Adductor Muscle Length; DNL = Dorsal Nacreous Length; PAMPDNL = Posterior Adductor Muscle to Posterior Dorsal Nacreous Layer; WS = Width of Sulcus

point and thus greatest length, midway between dorsal and ventral margins (Scheltema, 1983). Ventral margin was posteriorly convex and concave anteriorly. Dorsal margin was usually longer than ventral margin. Usually straight, but may be only slightly convex to moderately concave. Means length for dorsal margin was 200.97 (±43.86) mm (Fig. 3B, No. 4). Nacreous area iridescent, roughly the anterior half of the shell and divided along most of its length by a longitudinal sulcus.

Dorsal and ventral lobes of nacreous area moderately well separated. The wide range between dorsal and ventral lobes were almost 2.16 to 6.07 mm and the mean was 4.60 (± 1.34) mm (Fig. 3B, No. 7). Scheltema (1983) reported, sulcus separating dorsal and ventral nacreous lobe wide, 3 mm to 10 mm at its greatest lobe. Dorsal lobe was higher and bigger than ventral lobe with the mean length of 129.13 (±29.14) mm (Fig. 3B, No. 9). Extend farther posteriorly than ventral lobe. Posterior margin for dorsal lobe of nacreous layer was truncate. Ventral lobe was shorter and smaller than dorsal lobe. Posteriorly margin truncate to slightly oblique. Moderately large, subterminal on ventral half of dorsal lobe. The posterior

adductor muscle was medium in size with 19.50 mm in diameter. Posterior adductor muscle located near or touching onto posterior edge of dorsal lobe with mean of 3.09 (±2.33) mm (Fig. 3B, No. 8). Never extending onto ventral lobe. Anterior adductor muscle was small to moderately size, located just anterior to end of longitudinal sulcus.

Distribution: *Pinna deltodes* is originally an Indo-Pacific species but reportedly ranging from east Africa to eastern Australia and Lord Howe Island and northward to Pakistan, southern India and the Indo-Malay Archipelago (Rosewater, 1961; Scheltema, 1983). In the study area, this species was found at intertidal zone in the western side of Merambong Island and amongst seagrass vegetation of Merambong Shoal.

Habitat: Most of *P. deltodes* was collected from soft and hard substratum. In Merambong Shoal, most of the individuals were buried upright of soft sediment and live associated with seagrasses. Scheltema (1983) reported that most of *P. deltodes* in Australia are from hard substratum, either rock-strewn reef and flats or coral blocks and heads. Meanwhile, in Merambong Island, most of the *P. deltodes* buried in hard substratum and live associated with living zoanthids and soft coral. In both areas *P. deltodes* was exposed to the direct sunlight during the low tide for one to two hour.

***Pinna incurva* (Gmelin, 1791)**

Synonymy: 1791. *Pinna incurva* Gmelin, Systema Naturae, ed. 13, p. 3366 (in Oceano indico); refers to Chemnitz, vol. 8, pl. 90, Fig. 778 and others; 1818, Wood, Index Testaceologicus, London, p. 60 (Amboyna); 1825, Wood, ibid., pl.13, Fig. 15.

1825. *Pinna incurva* Sowerby, A Catalogue of Shells of Earle of Tankerville, p. 23 (no locality given); 1858, Reeve, Conchologia Iconica, vol. 11, *Pinna*, pl. 5, Fig. 8 (Moluccas); both refer to Chemnitz, vol. 8, pl. 90, Fig. 778; neither are *Pinna incurvata* Born, 1778 [= *P. nobilis* Linne']. [Holotype Australian Museum; figured in Rosewater, 1961, pl.154-155.]

Description: Mean shell length and width found in the study areas were 232.08 (±16.62) mm and 66.56 (±16.55) mm, respectively (Table 2, Fig. 3C, No. 5, 6 and Fig. 5). Rosewater (1961) reported that shell length and width are 290 and 78 mm. Narrowly attenuated and wedge-shaped in outline. Shell translucent to nearly transparent. Sometime, light reddish brown to yellowish-horn colour. Examination on shell found 90% was translucent to nearly transparent and 10% was yellowish-horn in colour. Radial sculpture hardly observable and consists of about six ribs limited to the posterior slope.

Posterior margin extremely arcuate in shape or rounded, subinflated, with a relatively weak longitudinal keel on the anterior half of the shell. Ventral margin was posteriorly convex and straight anteriorly. Dorsal margin straight from anterior to posterior. Mean length for dorsal margin was 190.34 (±48.72) mm (Fig. 3C, No. 4). Nacreous layer iridescent, occupying most of the anterior half of the shell and divided along most of its length into two lobes by a narrow longitudinal sulcus with a mean of 1.72 (±0.98) mm (Fig. 3C, No. 7).

Dorsal and ventral lobes with the posterior margins obliquely truncate, sloping from sulcus toward dorsal and ventral shell margins, forming with this equal posterior extension a wide and deep V (Fig. 3C and 5) (Rosewater, 1961). Dorsal and ventral lobes were obliquely truncated and sloping from sulcus. The mean length of dorsal nacreous layer was 144.43 (±21.16) mm (Fig. 3C, No. 9). Posterior adductor muscle was medium in size, subterminal on ventral portion of dorsal nacreous lobe with size 16.17 mm in diameter. The adductor muscle scar was not touching the posterior margin of dorsal nacreous lobe with mean 6.94 (±2.83) mm (Fig. 3C, No. 8). Anterior adductor muscle was moderately small in size, subapical, the sulcus nearly reaching it.

Distribution: *Pinna incurva* was found in the East coast of India, Burma and the East Indies (Winckworth, 1929); Nicobar Islands (Chemnitz); the Philippines and northern Australia (Rosewater, 1961). In southwestern Johore, the species were distributed within the soft substratum of the seagrass bed of Merambong and Tanjung Adang Shoals. The individuals were found patchy in distribution at the study areas.

Habitat: Most of *P. incurva* was found from soft substratum. In Merambong and Tanjung Adang Shoals, most of the individuals were buried upright of soft sediment and live associated with seagrasses. The valve buried with two third of their total shell length into the soft sediment. Rosewater (1961) reported that *P. incurva* found embedded deep in sandy-muddy bottom, below the low tide mark of 9-12 fathoms in Port Curtis, Queensland, Australia.

Comparison between *Pinna bicolor*, *P. deltodes* and *P. incurva*: A total of 19 specimens of *Pinna deltodes*, 5 specimens of *Pinna incurva* and 39 specimens of *Pinna bicolor* (Fig. 6) were examined for non-overlapping character states. The specimens of *P. bicolor* and *P. deltodes* were collected from three localities

Table 3: Means and ranges of shell measurements and their ratios in selected *Pinna deltodes*, *P. incurva* and *P. bicolor* shells

Measurement or ratio*		*P. deltodes*	*P. incurva*	*P. bicolor*
Dorsal post. margin (3): length (6)	Means	0.32	0.12	0.21
	Range	0.22-0.43	0.07-0.15	0.14-0.31
Width (5): length (6)	Means	0.52	0.29	0.42
	Range	0.40-0.60	0.22-0.36	0.30-0.56
Dorsal margin (3): length (6)	Means	0.88	0.82	0.90
	Range	0.75-0.95	0.81-1.02	0.76-1.02
Ant. to post. adductor (1): post. adductor to post. shell margin (2)	Means	1.34	1.36	1.51
	Range	0.92-1.74	1.05-1.73	1.17-2.06
Width of sulcus in mm (7)	Means	4.60	1.72	1.47
	Range	2.16-7.46	0.63-2.93	0.94-2.17
Nacreous length (9): total length (6)	Means	0.57	0.62	0.95
	Range	0.52-0.64	0.56 - 0.72	0.53-0.69
Posterior adductor muscle to posterior dorsal nacreous layer (8)	Means	2.68	6.94	6.79
	Range	0.07-5.67	3.92 - 11.03	3.47-12.87

*Refer to Fig. 3 for key to measurement number

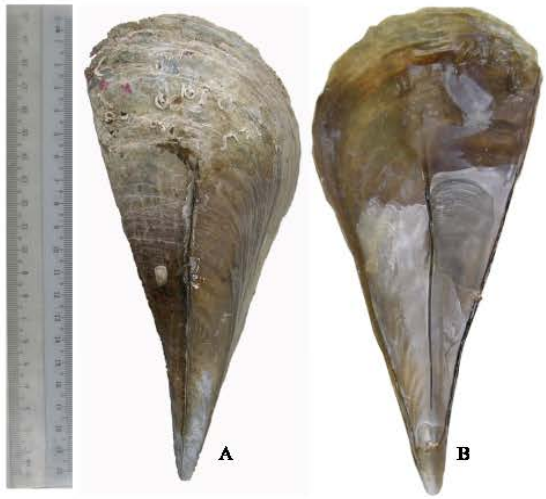

Fig. 6: Exterior of right valve of *Pinna bicolor* showing outer and inner surface (A), internal view of left valve (B)

(Merambong Island, Merambong and Tanjung Adang Shoals) and collected from four stations (Table 1). *Pinna incurva* came from two localities (Merambong and Tanjung Adang Shoals) and represented by three stations. Differences in the distribution of width length, dorsal posterior margin and width of sulcus distinguish *Pinna deltodes*, *Pinna incurva* and *Pinna bicolor* with one another (Fig. 3) and correlate with differences in position of the posterior adductor muscle scar in relation to the dorsal nacreous lobe (Fig. 3A-C, No. 8).

The pattern of the nacreous layer and the position of the posterior adductor muscle scar determine generic and species membership in family Pinnidae (Rosewater, 1961). Unique to the genus *Pinna* is the sulcus which divides the nacreous area into dorsal and ventral lobe (Fig. 2). In all specimens of *P. deltodes* examined (Table 1), the posterior adductor muscle scar was found to touch the posterior edge of the dorsal nacreous lobe (Fig. 3B, No. 8) whereas in *P. bicolor* and *P. incurva* shells, the posterior adductor muscle was always found to lie within the dorsal nacreous lobe (Fig. 3A, 3C). An examination of all *P. bicolor* and *P. deltodes* shells in several museums showed no overlap of these two character states in specimens from Australia (Scheltema, 1983).

The shape of the dorsal and ventral nacreous lobes was the obvious part of these three specimens (Fig. 3-6). Nacreous area iridescent, roughly occupying the anterior half of the shell and is divided along most of its length by a longitudinal sulcus. Dorsal and ventral lobes of nacreous area moderately well separated. *Pinna bicolor* (Fig. 3A), dorsal lobe of nacreous area usually extends farther posteriorly than ventral lobe near the sulcus. Its posterior margin truncate to slightly oblique. Ventral lobe may extend obliquely farther posteriorly near the ventral margin or is sometimes unevenly truncate and shorter than the dorsal lobe. The width of sulcus for *P. bicolor* was 1.03-2.17 mm (Fig. 3A, No .7) and (Table 3).

Pinna deltodes nacreous lobe occupied two-third of the shell (Fig. 3B), Nacreous area extended farther posteriorly than ventral lobe and posterior margin truncate. Ventral lobe extend obliquely farther posterior but quite far from the ventral margin or sometime rounded and shorter than the dorsal lobe. The width of sulcus for *P. deltodes* was 2.57-6.07 mm (Fig. 3B, No. 7) and (Table 3). *P. incurva* nacreous lobe usually occupying half of the shell length (Fig. 3C). Dorsal and ventral lobes with the posterior margins obliquely truncate, sloping from sulcus toward dorsal and ventral shell margins, forming with the equal posterior extension a wide and deep V shape. The width of sulcus for *P. incurva* was 0.63-2.93 mm (Table 2).

CONCLUSIONS

From this study it can be concluded that Merambong Shoal, Tanjung Adang Shoals and Merambong Island

provided natural habitat for pen shells where, *Pinna bicolor* and *Pinna atropurpurea* were found to be dominant in these three study areas. A total of seven species of pen shell were found at the three study areas and they were patchy in distribution. Among these seven species *Pinna deltodes* (Menke, 1843) and *Pinna incurva* (Gmelin, 1791) are new distributions records at Sungai Pulai seagrass bed off South Western Johore coast, Malaysia. Most of the *P. deltodes* were found at soft substratum covered with seagrasses at Merambong and Tanjung Adang Shoals and hard substratum either rock strew reefs and coral block at Merambong Island. Meanwhile, *P. incurva* were found at soft substratum at Merambong and Tanjung Adang Shoals.

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