

Population Structure and Size at Maturity of the Orange Mud Crab *Scylla olivacea* in Klong Ngao Mangrove Swamp, Ranong Province, Thailand

Kanchana Jirapunpipat

ABSTRACT

Population structure and size at maturity of the orange mud crab *Scylla olivacea* in Klong Ngao mangrove swamp, Ranong Province, Thailand was investigated to derive information for its management. Sampling was carried out monthly during November 2002 to December 2003. The results showed that the large crabs with a carapace width greater than 8 cm, the weight of male is greater than that of female. The small sized mud crabs of both male and female accounted for the major catches while large crabs dominated the lower catches. The size frequency distribution of *S. olivacea* indicated that the recruitment of this species was continuous throughout the year with males being recruited in larger numbers than females. The proportion of males was significantly higher than that of females with a ratio of 1.3:1 (male: female). The sex ratio of large sized females, with a carapace width greater than 9 cm, varied depending on the spawning period. When 50% of females were mature for the first time their carapace width was 9.55 cm, as estimated from a logistic model.

Key words: population structure, size at maturity, *Scylla olivacea*, Klong Ngao mangrove swamp, Thailand

INTRODUCTION

Mud crabs of the genus *Scylla* occur throughout tropical to temperate zones of the Pacific and Indian oceans. They are commonly associated with mangrove swamps and nearby inter-tidal and sub-tidal muddy habitats (Keenan, 1999). Before 1998, all mud crab in Thailand was recognized as belonging to one species, *S. serrata*. However, four species, *Scylla serrata*, *S. paramamosain*, *S. tanquebarica* and *S. olivacea* have since been recognised (Keenan *et al.*, 1998). Allozyme and morphometric investigations of mud crabs in Klong Ngao led to the conclusion

that the mud crab identified in Klong Ngao was *Scylla olivacea* (Pradissan, 2006; Sodsuk, 2006).

Scylla olivacea is one of the most important commercial species in Thailand. This species has been found throughout coastal waters of Thailand especially in Ranong Province, on the west coast of Thailand where it is known as the orange mud crab. These crabs live in inter and sub-tidal habitats, especially in mangrove swamps where they feed predominantly on mollusks and other less mobile invertebrates (Hill, 1980). After mating, female crabs migrate offshore for spawning (Hyland *et al.*, 1984). The entire larval development period takes 3-4 weeks and during

this time the larvae have to reach a suitable nursery site for recruitment. The crab larvae have little ability for horizontal movement and are therefore dependent on favorable currents for successful recruitment into nursery areas (Macintosh *et al.*, 1999).

Populations of *Scylla olivacea* support a small scale fishery in Klong Ngao mangrove swamp, Ranong Province. They represent about 99% of the total annual catch in Ranong Province (Moser *et al.*, 2005). The crabs are mostly caught by collapsible trap and crab lift net. Since the reduction in mangrove swamp area and the increase in demand of small size crabs for soft shell mud crab culture, the annual catch has fallen from 109 tons in 1989 to 65 tons in 1995 (Jirapunipat and Pradissan, 2005).

Ecological conditions have an influence on the sexual maturity of mud crab through the amount of available food and the environmental temperature. Reduction in mangrove swamp area may perturb the food chain in the mangrove swamp

affecting crab sizes at sexual maturity while the spawning period may vary from year to year (Blaxter, 1989). The size at sexual maturity is often used as a benchmark to establish minimum catch size. Therefore this study will provide information on the population structure, carapace width-weight relationship, sex ratio and mean size at 50% first maturity of *Scylla olivacea* in Klong Ngao mangrove swamp.

MATERIALS AND METHODS

Mud crab sampling was carried out monthly at two villages, Banlang and Hat Sai Khao at Klong Ngao mangrove forest, Ranong province from November 2002 to December 2003 (Figure 1). The samples were sexed, and the external carapace width (ECW) (nearest 1 mm), and body weight (W) (nearest 1 g) were measured.

The analysis of covariance was applied to identify the relationship of sex on weight which will result in the estimation of carapace width-

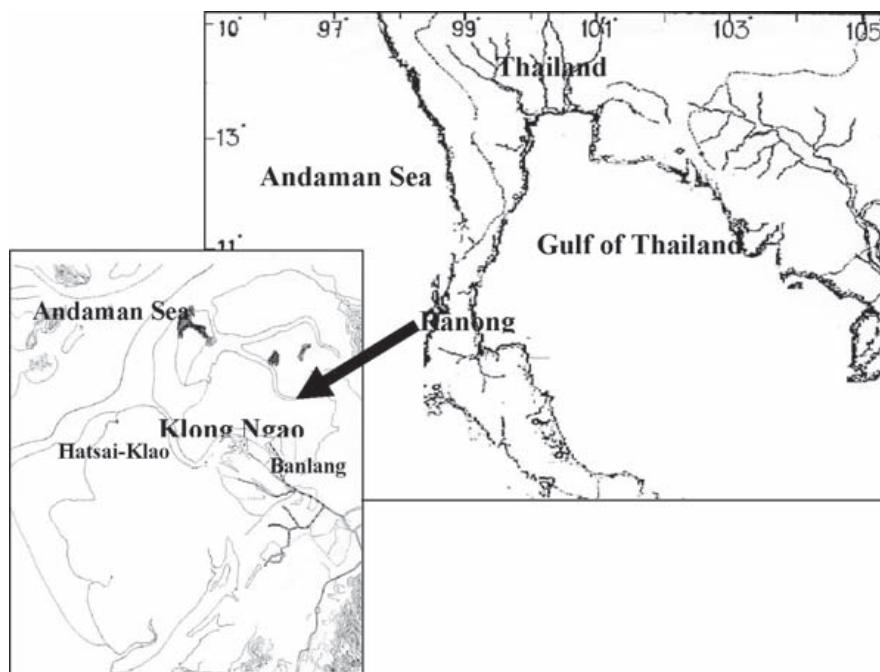


Figure 1 Study area of mud crab in Klong Ngao mangrove swamp, Ranong Province, Thailand.

weight relationship whether it should be estimated separately by sex or whether both sexes should be combined. Then carapace width relationship was subsequently calculated using the equation:

$$W_{(i)} = q \times ECW_{(i)}^b \quad (\text{Sparre and Venema, 1992})$$

The analysis was done in the computer software SPSS Version 10 (Statistical Package for the Social Science). Statistical difference were considered significant when $p < 0.05$.

Sex ratio was estimated per sampling date and per size class. A chi-square test was used to determine if the proportion of males and females were significantly different from 1:1. The probability level was set at 0.05.

The condition factor of the crab (K_a) was calculated by the equation $K_a = W/aCW^b$, where a and b are the coefficients of the allometric equation (Le Cren, 1951).

The mean size at 50% first sexual maturity for females was estimated by fitting the logistic function, $P_{ECW} = 1/(1+e^{c-dECW})$, where P_{ECW} is the proportion of mature individuals by carapace width and c and d are the parameters determining the maturity curve. The mean size at 50% first maturity (ECW_{50}) was taken as that at which 50% of individuals ($P_{ECW} = 0.5$) were mature.

RESULTS

Carapace width-weight relationship

The relationships between weight and carapace width for both sexes were significantly different (ANCOVA, $p < 0.05$, Figure 2). Small sized male and female crabs with a carapace width below 8 cm have the same weight at the same carapace width size. However, in larger crabs with a carapace width greater than 8 cm, the weight of males is greater than that of females at the same carapace width size (Figure 3).

Size frequency distribution

The size distribution of male mud crab ranged from 4.0 to 15.5 cm with the average size caught being 7.7 cm. For female crabs sizes ranged from 4.0 to 14.0 cm with an average size of 7.9 cm. Most of the individuals caught by collapsible trap in each month were small sized mud crabs. The size distribution of both sexes was similar throughout the study period and the size most frequently caught was 7.5 cm for both males and females. However more male mud crabs were captured than females each month (Figure 3 and 4).

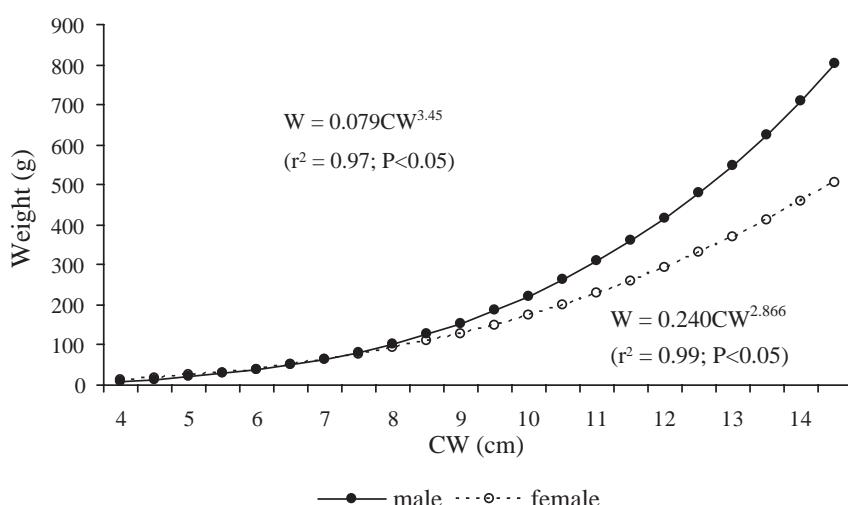


Figure 2 Carapace width-weight relationship of male and female of *Scylla olivacea*.

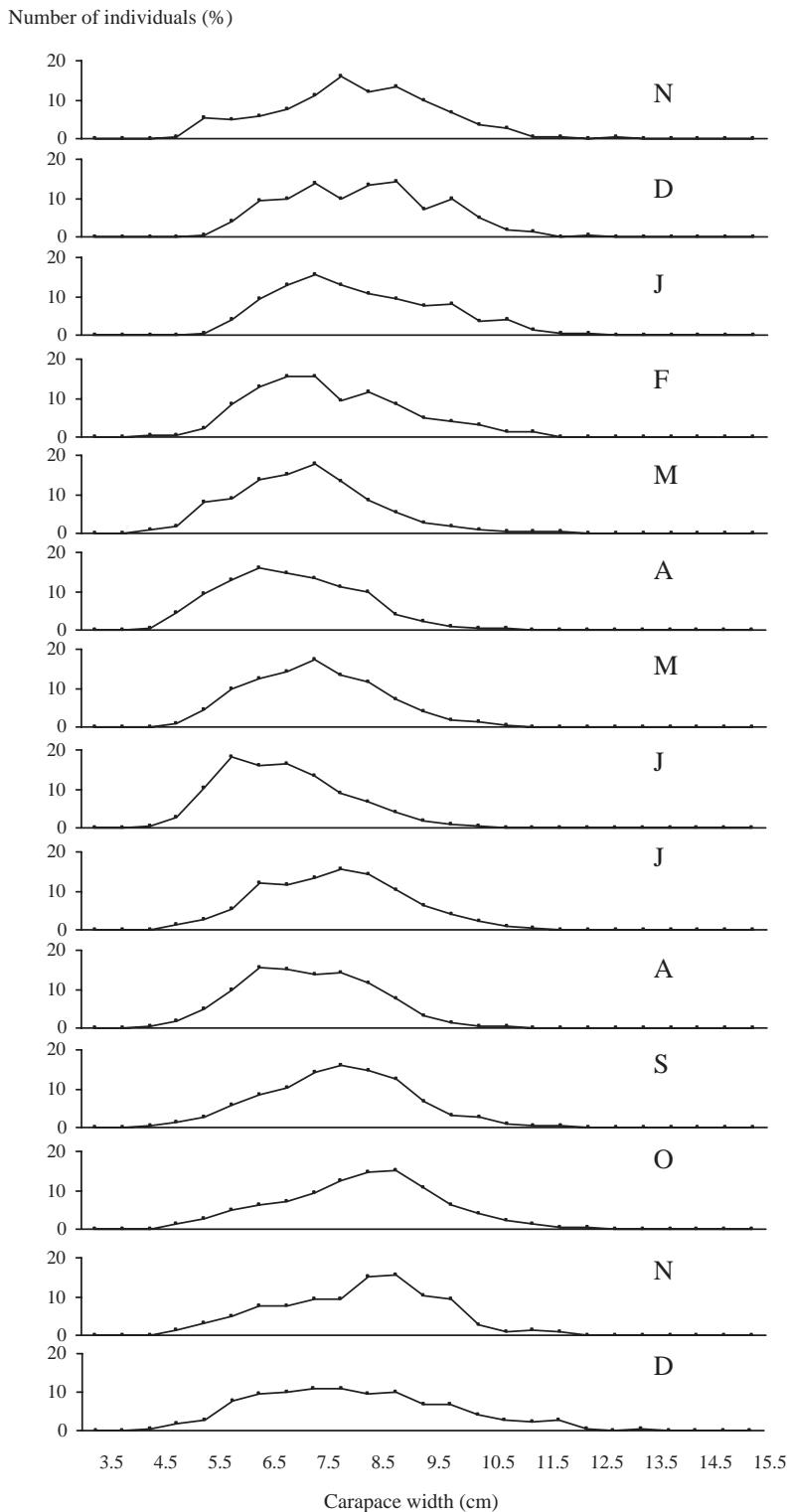


Figure 3 The percentage size frequency of male *Scylla olivacea* from November 2002-December 2003.

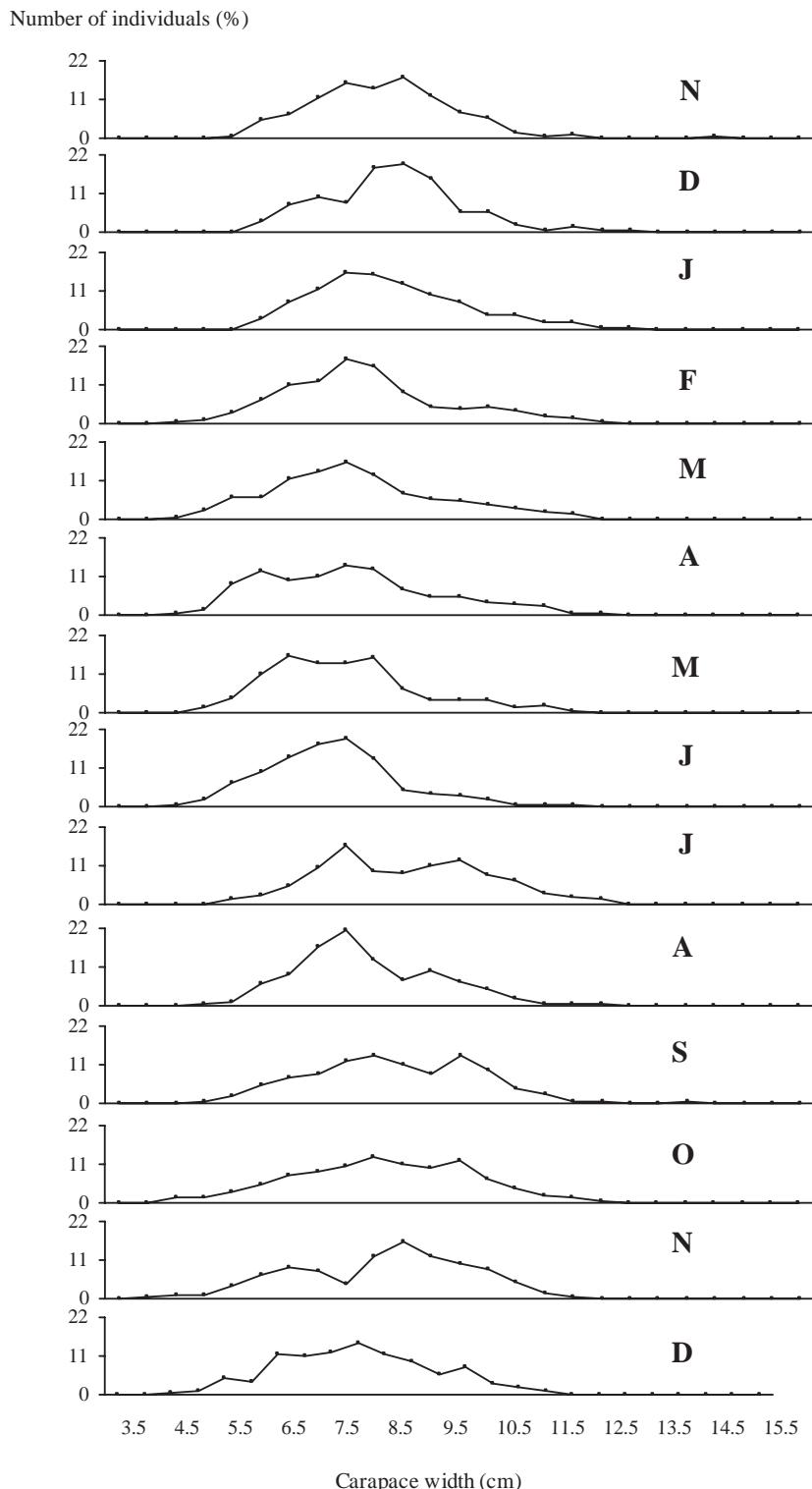


Figure 4 The percentage size frequency of female *Scylla olivacea* from November 2002-December 2003.

Sex ratio

The total numbers of mud crabs sampled were 9,257 males and 7,131 females. The largest sizes of male and female were 15.5 and 14.0 cm for external carapace width, respectively. The overall sex ratio (male/female) was 1.3:1, which significantly deviates from the hypothetical distribution of sex ratio 1:1 (χ^2 test: $p<0.05$). The distribution of sexes by size class showed a significant predominance of male mud crabs with a size less than 8 cm (χ^2 test: $p<0.05$), except in June. Males were also dominant in the size class between 8-9 cm (χ^2 test: $p<0.05$) except in

December and June. For females, size classes larger than 9 cm were predominant in March to April and June to September. During October to February males outnumbered females (Table 1).

Condition factor

Monthly evaluation of the condition factor followed the same pattern for both males and females and showed maximum values of 0.3904 in July for females and 0.1421 in September for males. The lowest values occurred in December for females and January for males (Figure 5).

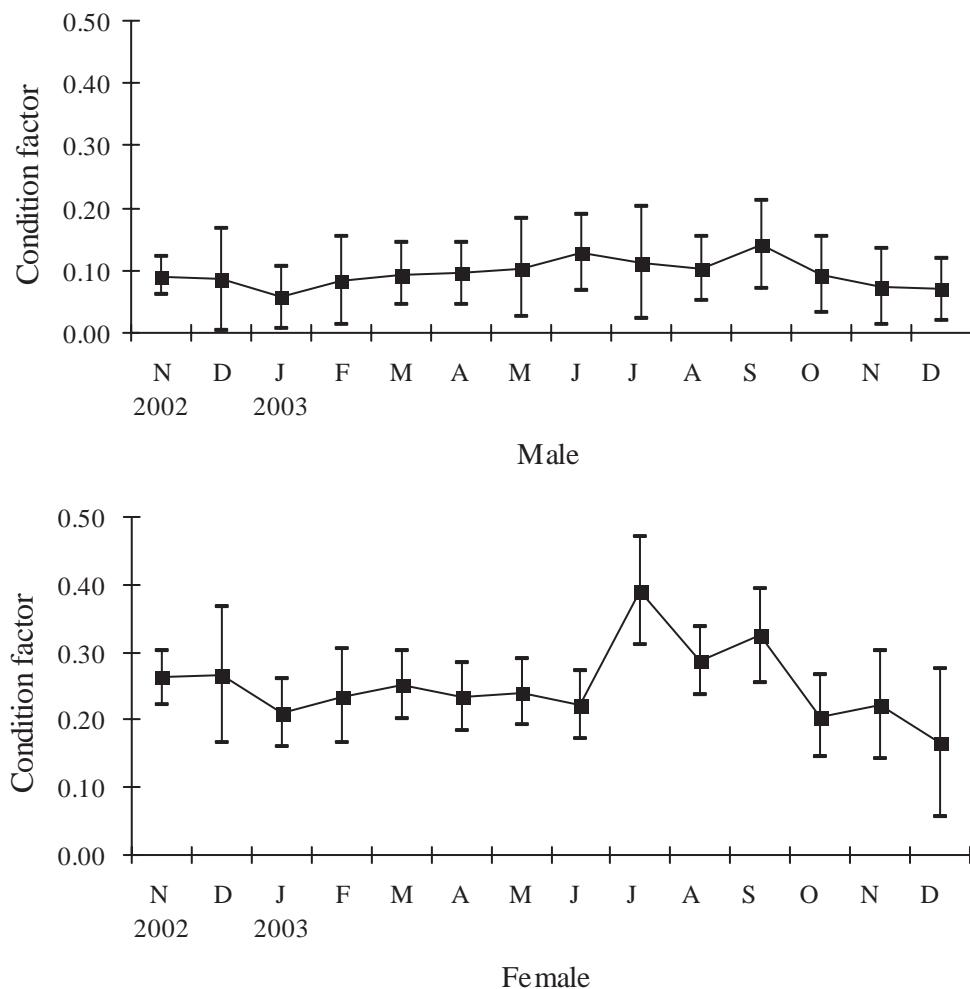


Figure 5 Monthly change of condition factor (mean \pm S.D.) of male and female *Scylla olivacea*.

Mean size at first maturity

A total of 7,130 of female mud crab were used for estimating the mean size at first maturity (ECW). The estimated values of parameter c and d are 27.65 and 2.897, respectively. The size at maturity, estimated through logistic regression (CW_{50}) for the entire sampling period, was 9.55 cm ECW (Figure 6).

DISCUSSION

Most of *S. olivacea* caught at Klong Ngao were composed of small sized crabs. The largest male *S. olivacea* was 15.5 cm ECW. Only one crab of this size was caught during the study period and it is probably close to the upper size limit of this species. The maximum size of all

Table 1 Monthly sample size and sex ratio of *Scylla olivacea*.

Month	Number of individuals			Sex ratio (male/female)			
	Total	Males (%)	Females (%)	Small (<8cm)	Medium (8-9cm)	Large (>9cm)	All size
Nov.	551	61.34	38.66	1.40*	1.42*	2.03*	1.59*
Dec.	376	59.84	40.16	1.87*	0.91	1.82*	1.49*
Jan.03	1566	56.64	43.36	1.40*	1.06	1.42*	1.31*
Feb.	1327	57.27	42.73	1.41*	1.09	1.45*	1.34*
Mar.	1814	56.39	43.61	1.50*	1.37*	0.68*	1.29*
Apr.	1739	53.77	46.23	1.41*	1.17	0.46*	1.16
May	901	55.49	44.51	1.22*	1.36*	1.19*	1.25*
Jun.	1766	47.90	52.10	1.00	0.78	0.63*	0.92
Jul.	1042	51.34	48.66	1.36*	1.71*	0.55*	1.06
Aug.	1510	55.43	44.57	1.40*	1.55*	0.65*	1.24*
Sep.	1487	54.74	45.26	1.48*	1.51*	0.78*	1.21*
Oct.	1059	60.91	39.09	1.29*	1.76*	1.71*	1.56*
Nov.	664	72.74	27.26	2.71*	2.29*	2.91*	2.67*
Dec.	586	73.21	26.79	2.64*	2.12*	3.41*	2.73*
Total	16,388	56.49	43.51	1.38*	1.33*	1.16*	1.30*

* significant at $p<0.05$

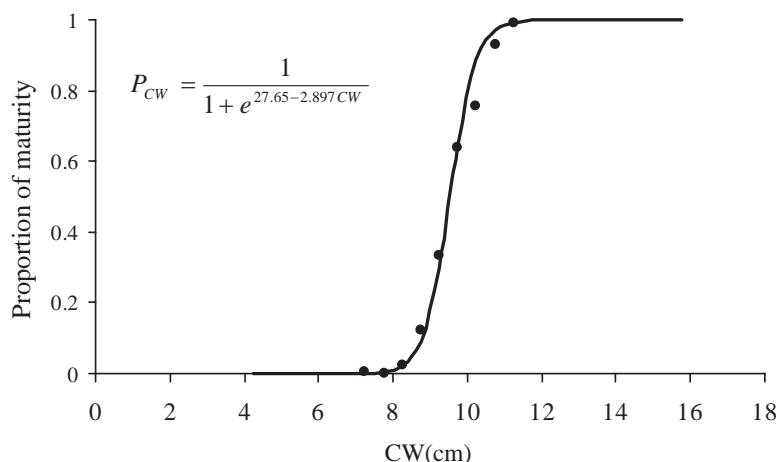


Figure 6 Relationship between carapace width and proportion of mature females.

female crabs measured was 14.0 cm, which was comparable to records of the same species caught in Buswan, in the Philippines (Walton *et al.*, 2006). The smallest mud crab caught was 4.0 cm for both male and female indicating first recruitment to the trap fishing started at this size. The size frequency distribution of *S. olivacea* indicated that the recruitment of this species was continuous throughout the year with males being recruited in larger numbers than females. Similar results, based on the size distribution, were obtained by Poovachiranon (1987) who found that the recruitment of *S. olivacea* occurred all year round. Moser *et al.* (2005) also found the recruitment of mud crabs was continuous throughout the year and that male and female mud crabs recruited in similar numbers.

The numbers of male crab in all sizes were larger than female except in June (Table 1). The value of the sex ratio in small sized mud crab was similar to that of medium sized category while the sex ratio in larger size was variable. The large females outnumbered males in the summer except in May while large males outnumbered females in the winter. The seasonal trends in sex ratio may be linked with migration patterns; in particular, the offshore migration of mature females for spawning.

Krajangdara *et al.* (2001) reported that the condition factor value is greatly influenced by the development of the reproductive organs and decline during the spawning period and increase thereafter. Based on the results of condition factor and maturity stage, Koolkalya *et al.* (2006) indicated that the spawning period of *Scylla olivacea* occurred all year round with dominant peak occurred over the period of July to December. The spawning period corresponded to the change in sex ratio in larger size female, with the number of mature females with a carapace width greater than 9 cm being lower during the major spawning period.

The mean size at first maturity of female

S. olivacea in Ranong (Andaman Sea) was 9.55 cm ECW with minimum size at first maturity being 8.3 cm. The mean size at first maturity in this study was a little smaller than that of *S. paramamosain* in Bandon Bay in the Gulf of Thailand but similar to the same species caught in Bandon Bay (Macintosh and Overton, 2002). The size frequency distributions of both male and female mud crabs showed a unimodal distribution but during the period July to October some female mud crabs with a carapace width between 8.0 to 9.5 cm were not caught by baited collapsible traps. At this time they probably migrate offshore for spawning. Heasman *et al.* (1985) reported that the berried females are less susceptible to conventional fishing methods, e.g., baited trap, as they stop feeding when they migrate offshore. In general, the mean size at first maturity is frequently used as a minimum legal size for the retention of the decapods species. However, the mean size of female crabs in Klong Ngao was 7.92 cm which is much below the mean size at first maturity (9.55 cm CW). This result suggests that a size restriction for mud crabs caught by trapping should be proposed during the spawning period.

CONCLUSIONS

The smallest mud crab caught was 4.0 cm. for both male and female sexes, indicating first recruitment to the trap fishing started at this size. The size frequency distribution of *S. olivacea* indicated that the recruitment of this species occur throughout the year with males being recruited in larger numbers than females. The number of male crabs in all sizes was larger than females except in June. The crabs with a carapace width greater than 8 cm, the weight of males is greater than that of females at the same carapace width size. The sex ratio in small sized mud crabs were similar to those of medium sized categories while the sex ratio in larger sized crab was variable. The large females outnumbered males in the summer except

in May while large males outnumbered females in the winter. The seasonal trends in sex ratio may be linked with migration patterns; in particular, the offshore migration of mature females for spawning. The mean size at first maturity of *S. olivacea* in Ranong (Andaman Sea) was 9.55 cm with minimum size at first maturity being 8.3 cm.

ACKNOWLEDGEMENTS

The author wish to thank Professor Barbara Brown, School of Biology, and University of Newcastle upon Tyne, United Kingdom for helpful comment and reading through the manuscript and also my thanks go to the fishermen from Klong Ngao mangrove swamp, Ranong Province, which made this study possible through their support and friendship. This study was funded by Thailand Research Fund (TRF) under the crab project (grant no. RDG4620002).

LITERATURE CITED

Blaxter, J.H.S., J. C. Gamble and H.V. Westernhagen. 1989. **The early life history of fish.** The third ICES symposium, Bergen, 3-5 October 1988. 497p.

Heasman, M.P., D.R. Fielder and R.K. Shepherd. 1985. Mating and spawning in the mud crab *Scylla serrata* (Decapoda:Portunidae), in Morton Bay, Queensland (Australia). **Aust. J. Mar. Freshw. Res.** 36: 773-783.

Hill, B.J. 1980. Effects of temperature on feeding and activity in mud crab *Scylla serrata*. **Mar. Biol.** 59: 189-192.

Hyland, S.J., B.J. Hill and C.P. Lee. 1984. Movement within and between different habitats by the portunid crab *Scylla serrata*. **Mar. Biol.** 80: 57-61.

Jirapunipat, K. and N. Pradissan. 2005. **Identification and stock assessment of mud crab in Klong Ngao mangrove forest, Ranong province.** Final report of mud crab project. Thailand Research Fund, Thailand. 108 p.

Keenan, C.P., Peter J.F. Davie and D.L. Mann. 1998. A revision of the genus *Scylla* De Haan 1883 (Crustacea: Decapoda: Brachiyura: Portunidae). **Raffles Bull. Zool.** 46: 217-245.

Keenan, C.P. 1999. Aquaculture of mud crab, genus *Scylla* past, present and future, pp.9-13. *In* C.P. Keenan and A. Blackshaw, (eds.). **Mud crab aquaculture and biology.** Proceedings of an international scientific forum held in Darwin, Australia, 21-24 April 1997. ACAIR Proceeding No.78. Canberra, Australian Center for International Agricultural Research.

Kookalya, S., T. Thapanand, S. Tunkijanujj, V. Havanont and T. Jutagate. 2006. Aspects in spawning biology and migration of the mud crab *Scylla olivacea* in the Andaman Sea, Thailand. **Fish. Manage. Ecol.** 13: 391-397.

Krajangdara, T., B. Taruthamsophon and S. Keawkaew. 2001. Biology and fishery of the red frog crab, *Ranina ranina* (Linnaeus, 1758), on the Andaman Sea Coast of Thailand. **Thai Fisheries Gazette** 52: 30-36.

Le Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and conditions in the perch *Perca fluviatilis*. **J. Animal Ecol.** 20: 201-219.

Macintosh, D.J., F. Goncalves, A. Soares, S. Moser and N. Paphavasit. 1999. Transport mechanisms of crab megalopae in mangrove ecosystem, with special reference to a mangrove estuary in Ranong, Thailand, pp. 178-186. *In* C.P. Keenan and A. Blackshaw, (eds.). **Mud crab aquaculture and biology.** Proceedings of an international scientific forum held in Darwin, Australia, 21-24 April 1997. ACAIR Proceeding No.78. Canberra, Australian Center for International Agricultural Research.

Moser, S., D. Macintosh, S. Laoprasert and N. Tongdee. 2005. Population ecology of the mud

crab *Scylla olivacea*: a study in the Ranong mangrove ecosystem, Thailand, with emphasis on juvenile recruitment and mortality. **Fish. Res.** 71: 27-41.

Overton, J. L. and D.J. Macintosh. 2002. Estimated size at sexual maturity for female mud crabs (Genus *Scylla*) from two sympatric species within Ban Don Bay, Thailand. **J. Crust. Biol.** 22: 790-797.

Poovachiranon, S. 1987. Mud crab *Scylla serrata* (Forskal) fishery at Bangla mangrove area, Phuket and some biological studies, pp. 234-242. *In Proceeding the Seminar on Fisheries* 1987. Department of Fisheries. September 15-17, Bangkok, Thailand. 1987:

Pradissan, N. 2006. An Identification and Stock assessment of mud crab in Klong Ngao mangrove forest, Ranong Province. **Newsletter Aquatic Animals** 8: 30-31.

Sodsuk, P. 2006. Genetic diversity study of the blue swimming crab (*Portunus pelagicus*) and mud crabs (*Scylla* spp.) populations of Thailand. **Newsletter Aquatic Animals** 8: 24-25.

Sparre, P. and S.C., Venema. 1992. Introduction to tropical fish stock assessment. Part I:Manual. FAO Fish. Tech. Pap. No. 306/1 Rev.1. Rome, FAO. 376 pp.

Walton, M.E., L.L. Lewis, J.H. Lebata and J.M. Primavera. 2006. Seasonal abundance, distribution and recruitment of mud crabs, (*Scylla* sp.) in replanted mangroves. **Estua. Coast. Shelf. Sci.** 66: 493-500.