Population Characteristics and Fecundity Estimates of Short-spined White Sea Urchin, *Salmacis sphaeroides* (Linnaeus, 1758) from the Coastal Waters of Johor, Malaysia

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ABSTRACT

An attempt was undertaken to describe the size frequency distribution, length weight relationships and fecundity estimates of short-spined sea urchin, *Salmacis sphaeroides* from Peninsular Malaysia. In total 355 specimens of *S. sphaeroides* were collected from the inter-tidal shoal of Tanjung Kupang, Johor during the breeding season in March-August 2011. For each individual, the Total Length (TL) was measured using digital slide calipers and individual Body Weight (BW) was also taken through a digital balance. Mean length of *S. sphaeroides* was estimated as 72.85 mm and the mean weight was 143.01 g. Among the 355 specimens measured, 158 were males and 197 were females, indicating a sex ratio of 1 male to 1 female (1:1.25). The logarithmic form of length-weight relationship of *S. sphaeroides* was LogW = 2.4396×LogTL-2.3958. The exponential form of equation obtained for the length-weight relation was W = 0.004×TL^{2.4909}. The value of regression co-efficient (R²) estimated for the species was 0.77. The mean fecundity was estimated at 7,876,000 (±247773) eggs. The regression coefficient between the absolute Fecundity (F) and Total Length (TL) was 0.76 and between the fecundity and drained body weight (DW) was 0.89, revealed linear regression model with a positive and significant relationship. This study represents the first time results on the total length-body weight relationships and fecundity estimates of this sea urchin from Peninsular Malaysia. The findings would immensely be helpful towards the understanding of growth patterns and fecundity, which will ultimately facilitate to develop the breeding, larval rearing and aquaculture of sea urchins.

**Key words:** *Salmacis sphaeroides*, growth patterns, fecundity, breeding, aquaculture

INTRODUCTION

The tropical species of white sea urchin, *Salmacis sphaeroides* (Echinodermata: Temnopleuridae) occurs in the Indo-West Pacific where it can be found from China to Solomon Islands and Australia (Schoppe, 2000; Miskelly, 2002). It can also be found in the warm temperate regions including Johor Straits, between Malaysia and Singapore (Tan and Ng, 1988). This sea urchin can be occurred at depth range between 0 and 90 m, however it is generally found in
shallow waters, especially in amongst seagrass meadows and in muddy sublittoral zone or washed ashore (Tan and Ng, 1988). It has almost cloudy white test (5.0-8.0 cm diameter) with short white spines (1.0-1.5 cm). Some may have white spines with maroon bands, others with all maroon spines and yet others with green and maroon bands. This species is recognized to present in shallow seagrass bed and coral reef areas (Schoppe, 2000). *S. sphaeroides* gets their food from algae, bryozoans, seaweeds and detritus (Miskelly, 2002). It has long tube feet and is often seen carrying all kinds of things from shells to seaweeds to cover their presence from predators such as sea otters, sea gull, trigger fish and snails (helmet and bonnet snail) (Tan and Henrietta, 2010).

Sea urchins are typical objects of research in different fields of ecology, biology and evolution. Simultaneously, they are used as raw material to produce foodstuffs, particularly, the product of processing gonads known as "Sea urchin Roe or Uni" (Oshima *et al.*, 1986; Ichihiro, 1993) and are considered a prized delicacy in Asian, Mediterranean and Western Hemisphere countries (Lawrence *et al.*, 1997). People of the Asian Pacific Region have also used sea urchin gonads for many years as a remedy for improving general body condition, treatment for a number of diseases and strengthening of sexual potency of men (Yur’eva *et al.*, 2003). Gonads of sea urchins have long been a luxury food in Japan (Shimabukuro, 1991). Although, *S. sphaeroides* has not yet been used as edible species in Malaysia, it has been found to serve as a delicacy food item in the local seafood restaurants in Hong Kong (Chen *et al.*, 2010). Sea urchin gonads are also rich in valuable bioactive compounds, such as Polyunsaturated Fatty Acids (PUFAs) and β-carotene (Dincer and Cakli, 2007). PUFAs, especially eicosapentaenoic acid (EPA, C20:5 (n-3)) and docosahexaenoic acid (DHA C22:6 (n-3)), have significant preventive effects on arrhythmia, cardiovascular diseases and cancer (Pulz and Gross, 2004). On the other hand, the high levels of AA (arachidonic acid) and EPA recently detected in *S. sphaeroides*, supported the development of aquaculture of this urchin (Chen *et al.*, 2010), since PUFAs are important for human nutrition (Lawrence, 2007). Sea urchin fisheries have expanded so greatly in recent years that the population of sea urchins around the world have been overfished (Andrew *et al.*, 2002). Not surprisingly, the decrease in supply and the continued strong demand have led to a great increase in interest in aquaculture of sea urchins (Lawrence *et al.*, 1997, 2001; Robinson, 2004).

Sea urchin research is very recent in Malaysia. However, a few systematic works have been done on the distribution and feeding ecology of *S. sphaeroides* (Klumpp *et al.*, 1993; Yulin, 1998; Lane *et al.*, 2000; Tsuchiya *et al.*, 2009) but no studies on their population characteristics have yet been conducted. Due to the higher nutritional and pharmaceutical values of sea urchin gonads, it is very important to understand population characteristics and growth patterns of the highly endemic sea urchin fauna in the Malaysian coastal waters. In view of this, the present work was undertaken to determine size frequency distribution, length-weight relationships and fecundity of *S. sphaeroides* in Johor, Peninsular Malaysia.

**MATERIALS AND METHODS**

**Sample collection and maintenance:** In total 355 live specimens of matured adults of the sea urchin, *S. sphaeroides*, weighing from 90-200 g, were collected from Merambong shoal off Tanjung Kupang (01°34'N; 105°60'E), Johor at low tide during their natural breeding season from April-July, 2011. Immediately after collection, the live sea urchins (Fig. 1) were transported to the Laboratory of Marine Biotechnology, Institute of Bioscience, Universiti Putra Malaysia, where they were maintained in aerated closed aquaria before use for the experiments.
Fig. 1(a-b): Sexually matured adults of *S. sphaeroides* collected from Merambong shoal off Tanjung Kupang at Johor, Peninsular Malaysia, (a) Aboral view and (b) Oral view

**Length-weight measurement:** Each live individual of *S. sphaeroides* was measured to the nearest 0.01 mm Total Length (TL) using a digital vernier caliper and weighed to the nearest 0.01 g (total weight) using an electric balance.

**Fecundity estimation:** Mature female of various sizes of *S. sphaeroides* were categorized according to their live body weight (g) and were used for study of fecundity, following the methods described by Rahman *et al.* (2002) with slight modifications. For each individual the Total Length (TL) (mm) and drained weight (g) were measured. Eggs were collected by injecting 0.5 M KCl into the coelomic cavity until shedding of all the eggs. The collected eggs were then diluted in 500 mL FSW and a 0.1 mL aliquot of the egg suspensions were counted under a compound microscope (Nikon, Model E-400). In total, 50 sexually mature females were used and for each individual, 3 replicate counts were made to estimate total fecundity.

**Data analysis:** The length-weight relationship was calculated using the equation $W = aL^b$ (Le Cren, 1951) and logarithmically transformed into:

$$\log W = \log a + b \log L$$

where, $W$ is the weight of the urchin in g, $L$ is the total length of the urchin measured in mm, $a$ is the intercept and $b$ is the slope (growth co-efficient, i.e., relative growth rate). The parameters $a$ and $b$ of $L$-$W$ relationships were estimated by linear regression analysis (least-squares method) on log-transformed data. The coefficient of determination ($R^2$) was used as an indicator of the quality of the linear regression (Scherrer, 1984). To estimate the population structure, the length-frequency data of *S. sphaeroides* were analyzed by using the SPSS Version 15.0.
RESULTS

Size frequency distribution: A total of 355 specimens comprised of 158 males and 197 females were measured. Male:Female ratio was estimated to be 1:1.25. The mean length of the population of *S. sphaeroides* was 72.85±5.08 mm (Fig. 2) and the mean weight was 143.01±33.05 g (Fig. 3), respectively.

![Fig. 2: Length frequency distribution of *S. sphaeroides*](image)

![Fig. 3: Weight frequency distribution of *S. sphaeroides*](image)
Length weight relationships: Length weight relationship of *S. sphaeroides* was established as $\log W = 2.4396 \times \log TL - 2.3958$ ($R^2 = 0.77$), in exponential form the equation was $W = 0.004 \times TL^{2.4305}$ ($R^2 = 0.77$). The calculated growth coefficient (b) was 2.4396 and the constant (a) was 0.004. The length weight relationship curves are presented in logarithmic scale (Fig. 4) and in exponential scale (Fig. 5). The length weight relationship indicated highly negative allometric growth in *S. sphaeroides* in the study area.

Fecundity: A total of 50 female specimens were examined during their ripe stage for the fecundity estimates. The fecundity varied from 7,260,000 eggs (TL 66.88 mm and DW 53.78 g) to 8,150,000 eggs (TL 90.67 mm and DW 121.85 g). The mean fecundity was estimated at 7,676,000 ($\pm 247774$).

Models of the least square regression were used to analyze the relationship between absolute Fecundity (F) and drained body weight (DW). A linear regression provided the best-fit curve, with a positive and significant result at $p<0.05$ (Fig. 6).

![Fig. 4: Length-weight relationship of *S. sphaeroides* in logarithmic scale](image)

![Fig. 5: Length-weight relationship of *S. sphaeroides* in exponential scale](image)
Fig. 6: Linear regression between number fecundity and drained weight of *S. sphaeroides*

\[
Y = 12,445.35X + 6,582,618.58 \\
R^2 = 0.89, n = 30
\]

Fig. 7: Linear regression between number fecundity and total length of *S. sphaeroides*

\[
Y = 37,997.38X + 4,886,209.22 \\
R^2 = 0.76, n = 30
\]

Analysis of the relationship between the absolute Fecundity (F) and Total Length (TL) also revealed linear regression model with a positive and significant relationship at p<0.05 (Fig. 7).

DISCUSSION

Information on the Length-weight Relationships (LWR) of *S. sphaeroides* is presented here for the first time. Relative growth studies are widely used, especially for heavily resistant crustaceans, such as lobsters and crabs because of their hard integument and possibility of rapid changes during the ontogenesis (Ragonese et al., 1997). LWR can be useful in studies of gonad development, rate of feeding, metamorphosis, maturity and well being of the fish and shell fish population (Amin et al., 2002; Al-Barwani et al., 2007; Le Cren, 1951; Bolger and Connolly, 1989). A characteristic of the length-weight relationship in fishes and invertebrates is that the value of the exponent (b) is 3 when growth in weight is isometric (without changing shape). If b value is different from 3, weight growth is said to be allometric (body changes shape as it grows larger). Allometric growth may be negative (b<3) or positive (b>3). The present estimated exponent (b = 2.4396) is less than isometric value. Therefore, high negative allometric growth was found for *S. sphaeroides* in natural condition. Further studies including environmental parameters and feeding habits are needed to find out the reasons for negative allometric growth in *S. sphaeroides*. Until now, very limited published information is available on fecundity study on sea urchins except
Rahman et al. (2002) who recorded the mean fecundity of Indo-Pacific tropical sea urchin (Echinometra spp.) was 3,561,000 eggs. However, the present mean fecundity is 7,876,000 eggs which is much higher than Rahman et al. (2002). The reasons behind this might be due to the bigger size of S. sphaeroides (143.01±33.05 g) than Echinometra spp. (54.95±16.32 g) as well as differences in species, life-history, distribution and habitat.

CONCLUSION

The findings emerged from the designated study would immensely be helpful towards the understanding of population characteristics, relative growth patterns and fecundity, which will facilitate us to explore the possibility of aquaculture of sea urchins in captivity.

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REFERENCES


