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Full Length Research Paper

Reproductive seasonality and maturation of the sergestid shrimp, *Acetes japonicus* (Decapoda: *Sergestidae*) in coastal waters of Malacca, Peninsular Malaysia

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Sex ratio, length at first maturity and spawning season of the sergestid shrimp (*Acetes japonicus*) were investigated between April 2006 and March 2007 in coastal waters of Klebang Besar, Malacca, Peninsular Malaysia. Klebang Besar waters are one of the main fishing grounds for *A. japonicus* in the Peninsular Malaysia. The overall annual sex ratio was found to be 1:1.46 (males: females). The spawning season was March to July with peak in May, however there was also some spawning in October to November. The female attained sexual maturity at a minimum size of 17.5 mm total length. The matured and near to spawn stages (II and III) occurred more than 50% in every month except in August. Therefore, it may be inferred that *A. japonicus* breeds continuously throughout the year in the coastal waters of Malacca, Peninsular Malaysia.

Key words: Spawning, sex ratio, maturity, *Acetes japonicus.*

INTRODUCTION

The shrimp of the genus *Acetes*, Family Sergestidae, is a minor planktonic crustacean group locally known as 'udang geragau' in Peninsular Malaysia and supports a considerable subsistence fishery (Tham, 1950), which is based mainly on *Acetes indicus* and *Acetes japonicus* (Omori, 1975). In addition, other four species, viz., *Acetes erythraeus, Acetes serrulatus, Acetes sibogae* and *Acetes vulgaris* also occur (Pathansali, 1966; Johnson, 1976), and are confined mainly to the western coast from Perlis to Johor, with Malacca, Perak, Selangor and Penang being the major fishing center (Mistakidis, 1973; Omori, 1975).

The ecological and economic importance has stimulated various investigations about the reproduction and ecology of *Acetes* shrimps (Xiao and Greenwood, 1993, Oh and Jeong, 2003). Reproductive biology of the genus *Acetes* such as sexual cycle, spawning, maturity and breeding pattern are very essential for the development of aquaculture industry and formation of management policy for the *Acetes* fishery. Spawning of pelagic shrimp usually occurs in open water of less than 50 m depth, often much shallower (Dall et al., 1990).

The commercial importance of *Acetes* is derived from consumption by humans and its potential use as a food for aquaculture industry (Kungvankij et al., 1986; Ung and Itoh, 1989). These combined features promote *Acetes* as an excellent candidate for the study of reproductive

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Abbreviations: GSI, Gonadosomatic index; **TL,** total length.

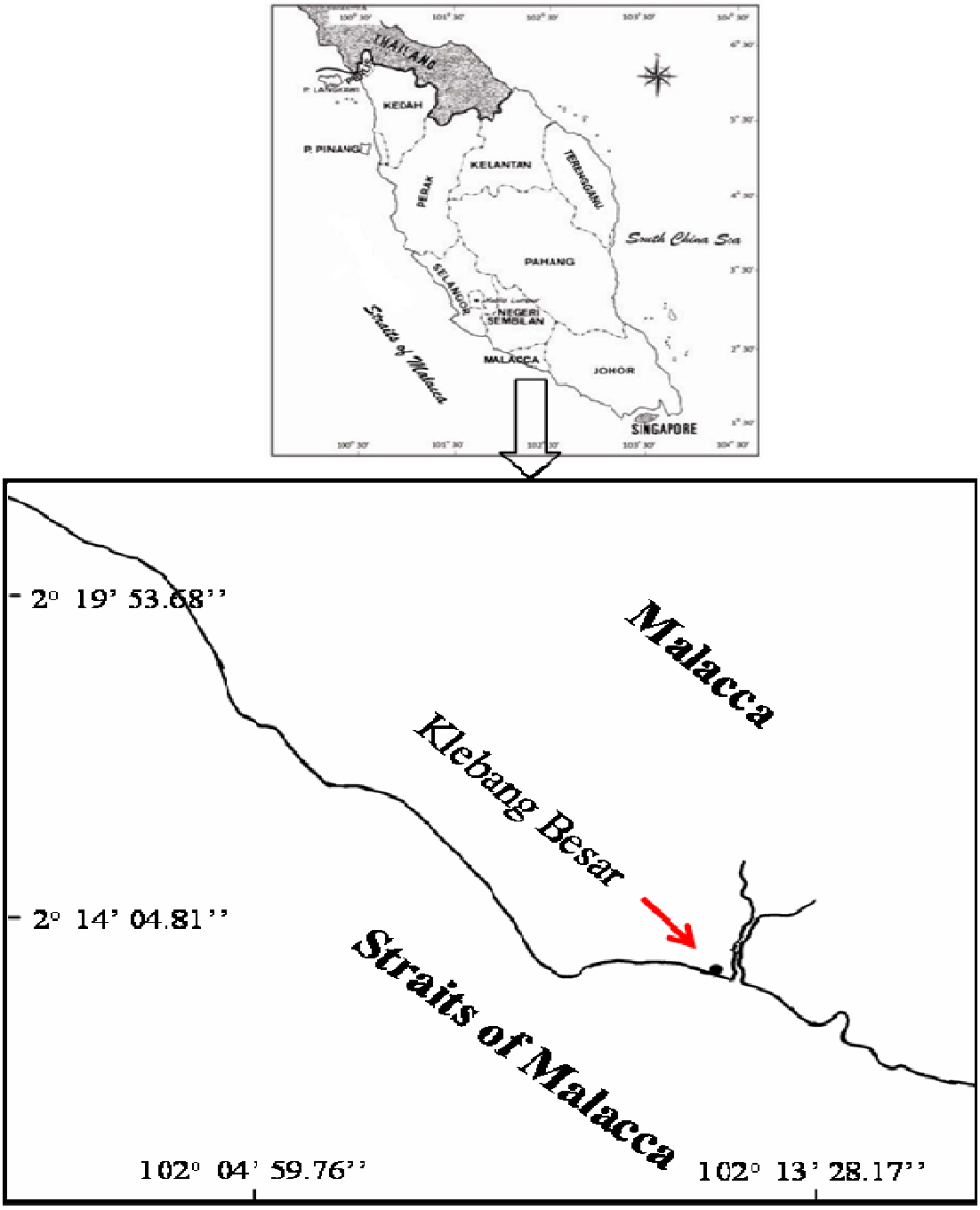

Figure 1. Sampling station (dot) and location of Klebang Besar, Malacca, Peninsular Malaysia.

biology. In spite of greater abundance and importance of the genus *Acetes* in the fishery of Asian countries, information on reproductive biology of this genus is still lacking except the studies carried out by Deshmukh (2002) and Oh and Jeong (2003) elsewhere. However, until now there has been no study on the reproductive biology of *A. japonicas* in Peninsular Malaysia. In the present study, our goal was to provide information on the reproductive biology including the breeding season, size at sexual maturity and sex ratio of *A. japonicus* in coastal waters of Malacca, Peninsular Malaysia.

MATERIALS AND METHODS

Sampling were undertaken monthly between April 2006 and March 2007 from the Klebang Besar, (N 102° 13.009' and E 102° 11.921') coastal waters of Malacca, Peninsular Malaysia (Figure 1). The estuarine push net was operated between the depth of 1 and 1.5 m

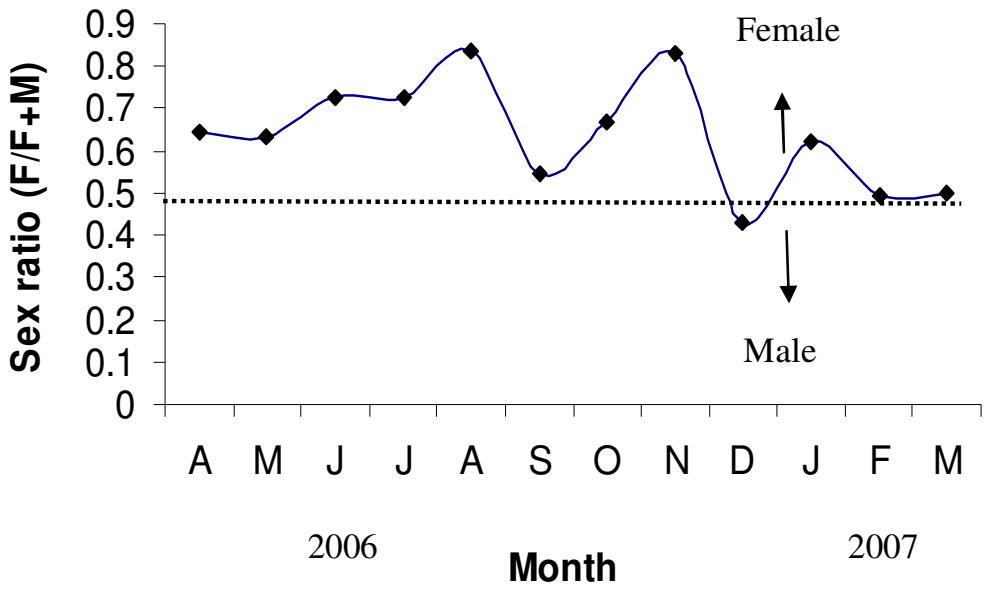

Figure 2. Temporal variation of sex ratio of *A. japonicus* in coastal waters of Malacca, Peninsular Malaysia. The dotted line indicates a ratio of 1:1 (females : males).

along the coast of Klebang Besar, Malacca. The fishing effort was one man power per hour and the towing length was approximately 1000 m. Immediately after capture, the samples were preserved in 10% formalin and transported to the laboratory for further analyses.

Sex ratio

A 20 g sub-sample of *Acetes* was taken randomly from the monthly total catch after separation from fin fish larvae and other shrimps. The species *A. japonicus* was identified from the sub-sample under Nikon dissecting microscope (Nikon-122764, Japan) based on Omori (1975). Sexes were determined on the basis of external characters. The species of *A. japonicus* were separated into male and female on the presence of a petasma in males. Monthly sex ratio (females/total) was calculated and the result was tested by chi-square analysis (χ^2 tests) for the differences from the hypothetical ratio of 1:1.

Ovary examination

About 30 to 32 females were examined monthly for gonadosomatic index (GSI) estimation from April 2006 to March 2007. The female *A. japonicas* were dissected under microscope in order to investtigate the ovaries. Prior to dissection, body weight was measured (± 0.1 mg). The dissection was done using fine forceps and the ovary was taken out immediately and preserved in 5% formalin in a labeled vial and stored for examination. The ovary weight was recorded to the nearest 0.01 mg with an electronic digital balance. The maturity of the ovary was classified into four categories based on its morphological characteristics according to Wu and Cheng (1957): stage I (immature ovaries), stage II (mature ovaries), stage III (near spawning ovaries) and stage IV (spent ovaries). The GSI was estimated as follows (Oh and Jeong, 2003):

$$GSI = \frac{\text{Ovary wet weight}}{\text{Female body wet weight}} \text{ x } 100$$

RESULTS

Sex ratio

A total number of 491 specimens of *A. japonicus* were examined comprising 351 females and 240 males. Overall, yearly sex ratio was found to be 1:1.46 (males: females). In most samples, there was a predominance of females except for the month of December (Figure 2). The peak female's abundance in the samples was in November. During the months of February and March, the sex ratio indicated that the male and female ratio was about 1:1. Chi-square test revealed that the total number of females was significantly greater than males in the samples throughout the sampling period (χ^2 = 92.6, df = 10, $P < 0.001$) although the sex ratio varied from month-to-month.

Length at first maturity

To estimate the length at first maturity, the percentage composition of females at each ovarian maturity stage according to total length classes was examined using the year round samples (Figure 3). The minimum size having the mature-phase ovaries (Stage II and III) was at 17 to 18 mm TL (total length) class. Stages II and III first reached more than 50% at 17.5 mm total length. The percentage of maturity in females increased with the increasing total length. The percentage of matured females gradually increased after 17.5 mm size (Figure 5). These results indicated that size at first sexual maturity of female *A. japonicus* was observed at 17.5 mm of the total length.

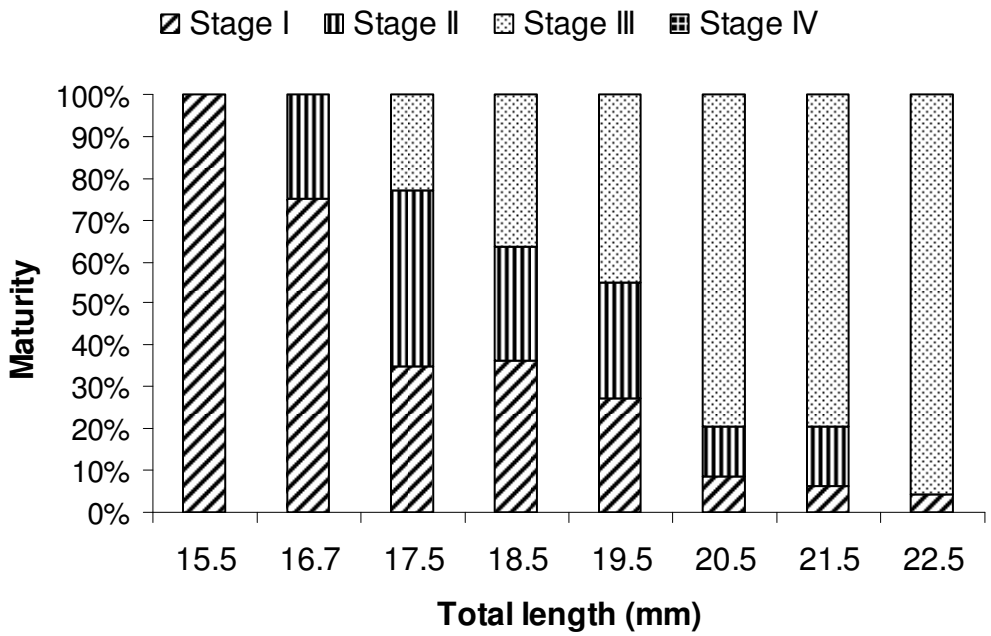

Figure 3. Percentage occurrence of each ovarian maturity stage against size class (total length, TL) for female *A. japonicus* in coastal waters of Malacca, Peninsular Malaysia.

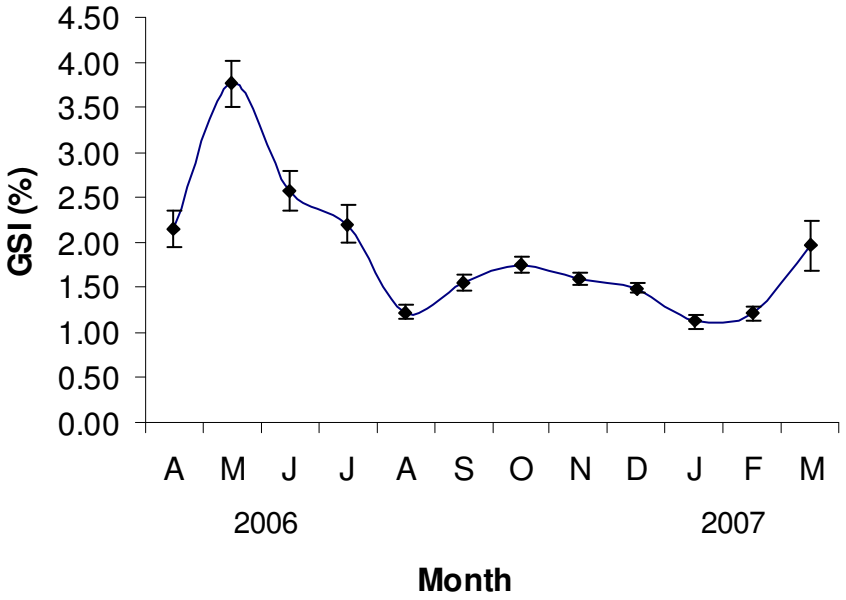

Figure 4. Monthly changes in mean gonadosomatic index (GSI) of female *A. japonicus* in coastal waters of Malacca, Peninsular Malaysia. Solid squares indicate the mean GSI and vertical bars indicate standard error, respectively.

Spawning season

The mean GSI of females were higher between April and July. The maximum value (GSI = 3.76) was observed in May and the minimum value (GSI = 0.91) was observed in August (Figure 4). The mean GSI for females increased from April, reaching a maximum peak in May, and gradually declined until the lowest peak in August. The mean GSI gradually increased again until October but declined from November to January before it increased again in February. The GSI of females showed three obvious peaks in the months of March, April and May. The highest value was 3.76 in May, indicating that most of the females were found in a matured stage. The

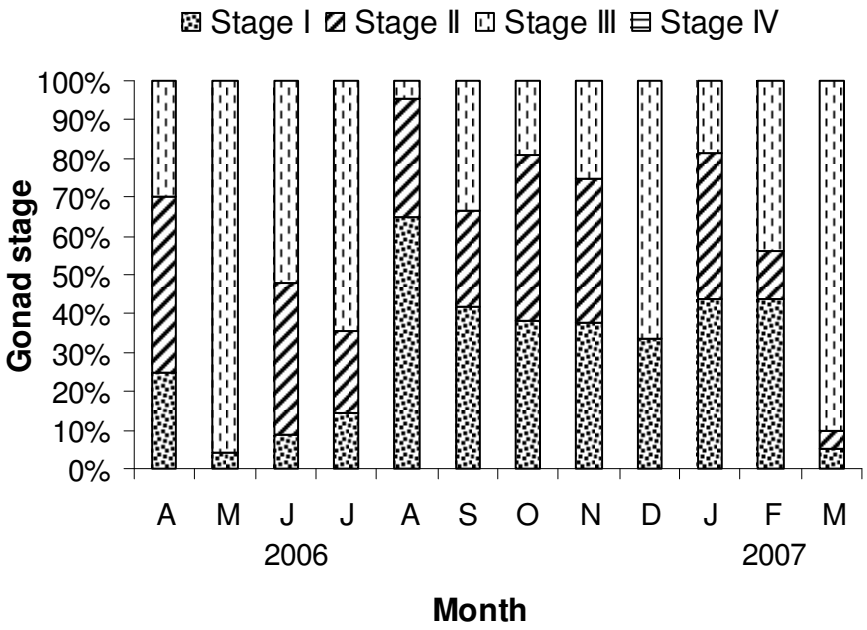

Figure 5. Monthly changes in percentage occurrences of each ovarian maturity stages of female *A. japonicus* in coastal waters of Malacca, Peninsular Malaysia.

lowest GSI value was 0.91 in August which indicated that most of the females were in an early active or immature phase.

Monthly distribution by percentage of the different stages of the ovary maturation is shown in Figure 5. The immature phase (stage I) occurred every month but its lowest value was recorded in May when the mean GSI was at maximum value (Figure 4). The mature and near spawning stages (stage II and III) occurred in every month of the year (>50%) except in August. The highest percentage of near spawning stage was observed in May (95.83%), indicating that most spawning occurred during this month. The main breeding season (percentage of females with mature ovaries greater than 50%) was from April to July and also in December and March. Similar pattern also could be found in monthly changes of GSI (Figure 4), showing relatively higher mean GSI during this breeding season. No females with spent ovaries were observed during the study period.

DISCUSSION

The annual sex ratio of *A. japonicus* population in the coastal waters of Malacca was observed at 1:1.46 (males: females). In general, sex ratio is known to be close to 1:1 (males: females) in nature (Fisher, 1958). But in the present study, it was in favour of females in most months of the year. Similar results were observed in several other *Acetes* species (Arshad et al., 2007; Amin et al., 2009; Chaitiamvong, 1980; Henry, 1977; Oh and Jeong, 2003; Zhang, 1992). Female dominance was recorded for *A. japonicus* in the Ariake Sea of Japan (Yasuda et al., 1953) and eastern Guangdong Province of China (Lei, 1988). Skewed sex ratio can be caused by different mortality between sexes and different behavioral characteristics such as migration (Kim, 2005). The sex ratio seems to vary seasonally and the real causes of such seasonal variation are unknown. It could be influenced by the growth, mortality and behavior of the shrimp's populations. The faster growth in females leading to the biased proportions toward females is because of their greater sizes, and hence dominance especially in commercial catches (Xiao and Greenwoods, 1993). According to Ikematsu (1953), males of *A. japonicus* in Ariaka Sea were faced with the early death after copulation but this phenomenon cannot be applied to populations in Seto Inland Sea (Yasuda et al., 1953). According to Luo and Zhang (1957), spawning migration and vertical migration of *Acetes* showed strong annual and spatial variations. They also found that seasonal migration possibly leads to the biasness in the sex ratio. They concluded that migration of *Acetes chinensis* in Liaotung Bay may be associated with changes in water temperature and food availability. In this study, no females with spent ovaries were found. Similar observa-tions were made on both *A. chinensis* in the coastal areas of Korea (Oh and Jeong, 2003) and *A. japonicus* in the Ariake Sea (Ikematsu, 1953).

The size at first maturity of female *A. japonicus* in the coastal waters of Malacca was estimated at 17.5 mm total length. The size at first maturity of *A. japonicus* in the coastal waters of Malacca is much larger than *A. japonicus* in the Ariake Sea. In the Ariake Sea, *A. japonicus*

matured at >12 mm (TL) and has two generations with different size at sexual maturity in a year (Ikematsu, 1953). The average total length of the winter generation is more than 1.5 times that of the summer generation. Generally, size at sexual maturity of *A. japonicus* varies considerably depending on the locality and the time of year (Omori, 1975).

Omori (1975) asserted that *A. japonicus* spawned generally a few days after copulation. The monthly changes in GSI of *A. japonicus* in the coastal waters of Malacca, suggest that the major spawning season occurred from April to July and peak spawning was in May. Despite the geographical location, this result is generally consistent with observations of Wu and Cheng (1957) that reported that *A. japonicus* matured from May to September in Liaotung Bay. The spawning season of *A. japonicus* was from April to August in western Korea (Yoshida, 1949) and from early May to early October in Laizhou Bay and southern Pohai (Zhang, 1992). Similarly, *A. japonicus* reached maturity from early May to early October in the Ariake Sea (Ikematsu, 1953), although the completion of spawning differed slightly. As reported by Ikematsu (1953) for *A. japonicus* in Ariake Sea, Wu and Cheng (1957) for *A. chinensis* in Liaotung Bay and by Henry (1977) for *Acetes sibogae* in the Tuggerah Lakes, the gonad maturation of *Acetes* seems to be related to water temperature, since the highest spawning activity always occur in warmer months.

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