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Short communication

Weight and time of onset of female-superior sexual dimorphism in pond reared *Penaeus monodon*

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ABSTRACT

Crustacean females typically grow faster and achieve a larger size than males of the same age. This has implications for aquaculture of such species. Sexual dimorphism may warrant separating males and females during culture to ensure consistent harvest size shrimp from a pond, or in extreme cases mono-sex culture may be justified. We conducted an experiment to study the sex specific growth pattern of *Peneaus monodon* to determine extent of sexual dimorphism in growth and onset of sexual dimorphism. Shrimp were communally reared in two earthen ponds. One pond was for broodstock development at a low stocking density (7/m^2) and the other was stocked at a commercial stocking density (9/m^2). In the broodstock pond, females grew faster than the males after 70 days of culture and consistently maintained an average female-superior difference of 6-10 g. In the commercial pond onset of sexual dimorphism was at 90 days of culture, after which females grew faster than the males. In both pond types, the weight of shrimp at the onset of sexual dimorphism was similar, at 15-20 g. Therefore we conclude that weight is more important than age in determining onset of sexual dimorphism for growth in *P. monodon*. Females were approximately 8 g heavier than males in both ponds after 169 days of culture, so sexual dimorphism will be a major contributor to variation in harvest size if males and females are not reared separately.

1. Introduction

Several crustacean species exhibit sexually dimorphic growth in which females typically grow faster and achieve a larger size than males of the same age (García, 1985; Hartnoll, 1985; Dall et al., 1990; Hansford and Hewitt, 1994; Villegas and Barquero, 2000; Diaz et al., 2001; Otoshi et al., 2003; Perez-Rostro and Ibarra, 2003; Gitterle et al., 2005). The same pattern occurs for a number of species of commercially important penaeid shrimp (Choe, 1971; Hartnoll, 1985; Bray and Lawrence, 1992; Primavera et al., 1998; Hoang et al., 2003). Moss and Moss (2006) demonstrated for *Penaeus (Litopenaeus) vannamei* that size is a key factor in competition for food. They showed larger shrimp out-compete smaller ones, and that females have a higher (although non-significant) feed conversion efficiency (FCE) and apparent digestibility of energy. Similarly higher food efficiency utilization has been reported in other female crustaceans that are sexually dimorphic for growth, including isopods *Ascellus aquaticus* (Needham, 1943) and *Idotea balthica* (Strong and Daborn, 1979) and fairy shrimp *Branchinecta gigas* (Daborn, 1973).

In the case of *Penaeus monodon*, the development of sexual dimorphism in broodstock rearing is well documented. Liao (1977) published growth curves of *P. monodon* showing female-superior sexual dimorphism. Chen (1990) indicated that the body weight at first maturity of *P. monodo*n females was 90 g and 60 g in males. There have been reports that females mature at 70 g, but the quality their eggs is poor and their quantity low (Berglund and Rosenqvist, 1986; Taborsky, 1994; Peterson and Warner, 1998).

Improved understanding of the development of sexual dimorphism for growth of *P. monodon* would be useful for determining when the females should be separated from males during culture in order to ensure consistent size of shrimp in ponds, and to determine if the differences are large enough to warrant mono-sex (all-female) culture. The goal of the present study was to determine the weight and time when sexual dimorphism first emerges in *P. monodon*, and to determine its extent in animals grown for more than 10 months.

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Importantly, animals in this study were reared in mixed sex earthen ponds which simulated commercial grow out environments.

2. Materials and methods

Post larvae from 45 wild caught gravid females were collected from different hatcheries in India located in Tamil Nadu, Andhra Pradesh and Andaman Islands. The post larvae were reared in 500-l or 1000-l tanks at stocking densities of 2/l and 1/l, respectively. Larviculture till tagging size was carried out at two locations, Chennai (Tamil Nadu) and Kakinada (Andhra Pradesh). Post larvae were fed with (500 µ, 1 mm and 2 mm) of pelleted feed (size range between 500 µ and 2 mm) at 10% of the animal's biomass six times per day. Feeding frequency was changed as needed depending upon water quality, amount of eaten food and tank conditions. Every day faecal matter and uneaten feed was siphoned out and 50% water exchange was carried out each morning and evening. Salinity, pH, temperature, ammonia –N and nitrite levels were recorded daily. The post larval shrimp were reared in the tanks until they reached a minimum tagging size of approximately 2-3 g. This took about 20 weeks for the post larvae reared in Chennai and 14 weeks for the shrimp reared at Kakinada. The shrimp were then tagged for family identification with elastomer tags. In all, the number of shrimp tagged and then stocked in ponds was 2360, from thirty seven families. The shrimp tagged at Kakinada were transported by road to Chennai and held in 5 t cement tanks for two days and then stocked in two ponds each of 600 m^2 prepared as follows. An algal bloom was developed in the ponds using inorganic (urea and super phosphate) and organic fertilizers (cow dung, jaggery or unrefined palm sugar and yeast). The bloom-rich pond was checked for pH and adjusted to 8.2 by adding shell lime and lime in combination, before stocking the tagged shrimp. One of the ponds in the study was used to simulate a broodstock pond environment ("broodstock pond") and was stocked at a stocking density of 7/m^2.The other pond was stocked at a higher density (9/m^2) with untagged shrimp along with the tagged shrimp to simulate a commercial pond environment ("commercial pond"). All animals were fed with pelleted feed (1 mm) three times a day for 30 days. No other supplementary feed was given. After 30 days, the pelleted feed size was increased from 1.5 to 2.5 mm, and feed frequency was increased from four to six times per day. Approximately 30 shrimp were sampled from both the ponds every twenty (20) days (fortnightly) using cast nets. The average weight and standard deviation of weight of males and female shrimp was determined for each sample.

3. Results and discussion

The average weight (in grams) of the shrimp grown in the broodstock and commercial ponds increased over the trial period (Fig. 1). The data in the figure starts at 30 days after stocking ("days of culture") as the shrimp could not be sexed accurately before this time. In the broodstock pond, the males initially had slower growth compared to the females but were the same size (22 g) by 70 days of culture. Beyond 70 days females grew faster than the males, consistently maintaining an average difference of 6-10 g. In the commercial pond, the trend was similar but the males and females weighed the same at 50 days of culture and showed very little difference until 90 days. Thereafter, the females grew at a faster rate compared to the males. When the means of each sex were compared with Students t test, they were significantly different ($P<0.05$) at 51, 93, and 169 days of culture in the broodstock pond, and at 125 and 169 days of culture in the commercial pond. Coefficients of variation were large, for example 19.3%, 28.5%, 32.9% and 30.7% at 169 days of culture for females in the broodstock pond, males in the broodstock pond, females in the commercial pond and males in the commercial pond, respectively.

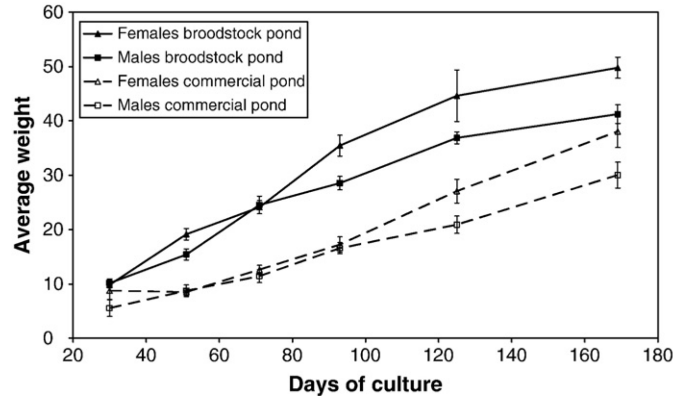

Fig. 1. Average weight in grams and standard deviation (vertical bars) of male and female shrimp grown under broodstock (7/m^2) and commercial pond (9/m^2) conditions.

The sampling of both broodstock and commercial ponds showed that the growth rate between the sexes begins to diverge when the shrimp are approximately 15-20 g. The weight of onset of sexual dimorphism was similar between the broodstock and commercial pond. The later time of onset of sexual dimorphism in the commercial pond could be attributed to slower growth resulting from higher competition for feed and space caused by the higher density in the commercial pond. One female weighing 65 g was found in the broodstock pond which had a developed ovary and spawned approximately 221,000 eggs which had a hatchability rate of 85%. This important observation of pond maturation and spawning is unique as reports of tiger shrimp maturing in ponds are scanty.

Our results have two major management implications for the commercial culture of *P. monodon*. Firstly, the difference in growth rates between male and female shrimp will result in large variation in harvest weight from a pond, which may be undesirable if farmers are aiming to produce a consistent product. This could be solved by segregating males and females into separate ponds. Secondly, the 6-10 g difference between females and males in the commercial pond environment represents an important (~20%) female-superior sexual dimorphic advantage. This implies that commercial production of *P. monodon* could be improved significantly using mono-sex (i.e. all-female) populations.

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