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The Effect of Broodstock Age on the Spawning Performance of Cultured *Haliotis discus hannai*

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ABSTRACT

The effect of broodstock age on the spawning performance of cultured abalone, *Haliotis discus hannai*, was assessed for five age groups (3, 4, 5, 6, 7 years old). Spawning performance of the five age groups was assessed in terms of the percentage of spawning abalone, eggs per spawning female, fertilization rates, hatch rates and attachment rates per spawning. The percentage of spawning abalone increased along with broodstock age, reached maximum in female groups of 5- and 6-year age (60%), and in male group of 6-year age (100%), subsequently decreased in 7-year age group. The number of eggs produced per spawning also increased with broodstock age, and the maximum was found in 6-year age. Although the number of spawned eggs for the oldest abalone declined, it still spawned much more eggs than 3, 4, and 5 years old females. The fertilization and hatch rates were obviously larger for 4-6 years old group than the younger and older abalones. The maxima were found in 5-year age group (96.0% and 84.5%), and the minimum were appeared in 7-year age group (79.3% and 58.2%). The attachment rate increased with broodstock age, reached maximum in 6-year age group (33.6%), although the increment gradually declined. The attachment rate for 7-year age group rapidly decreased (16.6%). These results suggested that broodstock age affected the spawning performance of *H. discus hannai*, which peaked between 5 and 6 years old, and broodstock should be bred during this period for hatchery production.

Key words: *Haliotis discus hannai*, Broodstock, Age, Spawning

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INTRODUCTION

Abalone is an economically important marine gastropod commanding moderate to high prices. The culture of abalone has been investigated for a number of decades in Japan and China (Ino, 1951; Chen *et al.*, 1977), and a rapid improvement in culture techniques on abalone production in recent years has had a significant impact, especially in Japan and Taiwan (Chen, 1989). Recently, the techniques of abalone culture, especially the seed production, such as the induction of spawning, fertilization and hatch, larval rearing and induction to settle, have been well established (Fleming, 1996). Most of these studies on abalone focused on the reproductive biology, characterizes of embryonic development, environmental conditions for larval rearing (Capinpin Jr. *et al.*, 1998; Chen *et al.*, 1977; Liu *et al.*, 1985; Lu *et al.*, 2001; Yang *et al.*, 1975), and nutritional requirements of various developmental stages (Kawamura *et al.*, 1996; Mai, 1998; Tan and Mai, 2002; Zhu *et al.*, 2002). In contrast, the effect of broodstock age on the spawning performance, which was obvious in several penaeid shrimp (Coman and Crocos, 2003; Crocos and Coman, 1997; Hoang *et al.*, 2002), has seldom been

investigated in abalone. In the present study, the influence of broodstock age on the spawning performance of cultured abalone *Haliotis discus hannai* was assessed for five age groups (3, 4, 5, 6, and 7 years old), in terms of the percentage of spawning abalone, eggs per spawning female, fertilization rates, hatch rates and attachment rates per spawning. The optimum age of broodstock for hatchery production also was discussed.

MATERIALS AND METHODS

1. Abalone broodstock

Abalone broodstocks were obtained from a shellfish hatchery on Yosu, and bred in the laboratory recirculating systems, during the reproductive season. The age of abalone broodstock used in the present study ranged between 3-7 years, and their shell length and body weight were showed in Table 1.

Table 1. Measurement of *Haliotis discus hannai* used in the experiment for spawning induction at different age.

Broodstock age (Year)	Specimens No.	Shell length (cm)	Body weight (g)
3	15	5.8 ± 2.8	58.0 ± 5.1
4	15	8.0 ± 3.0	79.3 ± 4.2
5	15	9.2 ± 3.4	104.2 ± 10.2
6	15	10.9 ± 4.6	148.8 ± 8.3
7	15	12.4 ± 1.7	187.7 ± 7.8

Data presented as Mean ± SD

2. Spawning induction

For every age group, ten females and five males were inducted to spawn by general method, such as dry in shadow for 1-1.5 hr, treatment with the seawater irradiated by ultraviolet light of 500 mw.h/L and change in water temperature. After spawning the percentage of spawning abalone and eggs per spawning females were counted.

3. Artificial fertilization and larval rearing

Four thousand eggs per spawning (50 eggs/ml) were fertilized with sperm obtained from the males of same age group in an approximate ratio of 1 egg to 1000 sperm. The fertilization rates were calculated according to the release of Poly body. The fertilized eggs were washed 3 times and incubated in tanks at 22-23℃ (1 egg/ml) containing settlement plates coated with benthic diatoms. After hatch the hatch rates were examined and larvae were fed by *Cocconeis* spp. and *Navicula* spp. The seawater was changed regularly every day. When the larvae begin to settlement they were cultured with flowing water and the attachment rates were counted.

RESULT

1. Percentage of spawning abalone

The percentage of spawning abalone increased along with broodstock age, reached maximum in female group of 5- and 6-year age (60%), and in male group of 6-year age (100%). Subsequently, the spawning female and male all decreased in 7-year age group, while the percentage of spawning was still larger than that of younger abalones (3 and 4 years old) (Table 2).

2. Eggs per spawning female

The number of eggs produced per spawning increased rapidly along with the broodstock age, reached peak in 6-year age group (1,153,000 eggs per spawning), and declined in 7-year age group. However, the 7-year age group still spawned much more eggs

Table 2. Spawning reaction of *Haliotis discus hannai* at different age after spawning induction.

Broodstock age (year)	No. of Specimens		No. of Spawning		Percentage of spawning (%)	
	Female	Male	Female	Male	Female	Male
3	10	5	3	3	30	60
4	10	5	4	3	40	60
5	10	5	6	4	60	80
6	10	5	6	5	60	100
7	10	5	5	4	50	80

Table 3. Eggs per spawning female *Haliotis discus hannai* at different age.

Broodstock age (year)	No. of Specimen	No. of Eggs per spawning (mean)
3	3	85,000-155,000 (12,000)
4	4	9,000-685,000 (355,000)
5	6	156,000-1,265,000 (703,000)
6	6	986,000-1,656,000 (1,153,000)
7	5	638,000~1,623,000 (1,131,000)

(1,131,000 eggs per spawning) than 3, 4 and 5 years old females (Table 3).

3. Rates of fertilization, hatch and attachment per spawning

The fertilization and hatch rates were obviously larger for 4-6 years old groups than the younger and older abalones. The maximal rates of fertilization and hatch were found in 5-year age group (96.0% and 84.5%), and those for 6-year age group (93.0% and 80.8%) declined under 4-year age group (94.0% and 84.3%). The minimum appeared in 7-year age group (79.3% and 58.2%).

The attachment rate increased with broodstock age, reached maximum in 6-year age group (33.6%), although the increment declined gradually. The attachment rate for 7-year age group decreased rapidly (16.6%), like its rates of fertilization and hatch (Table 4).

Table 4. Rates (%) of fertilization, hatch and attachment per spawning female *Haliotis discus hannai* at different age.

Broodstock age (Year)	Fertilization rate	Hatch rate	Attachment rate
3	86.0	66.8	22.6
4	94.0	84.3	28.2
5	96.0	84.5	32.3
6	93.0	80.8	33.6
7	79.3	58.2	16.6

DISCUSSION

In abalone culture, the seed production has been determined by the fertilization rate, embryonic development rate, hatch rate, attachment rate and survival and growth of post-settlement larvae, which are affected directly by many environmental factors, such as illumination, water temperature, salinity and pH value *etc.* (Capinpin Jr *et al.*, 1998; Chen *et al.*, 1977; Liu *et* al., 1985; Lu *et al.*, 2001; Yang *et al.*, 1975), and nutritional requirements at various developmental stage (Kawamura *et al.*, 1996; Mai, 1998; Tan and Mai, 2002; Zhu *et al.*, 2002). These aspects have been well investigated in many abalone species. In addition, the maturity degree of broodstock gonad also can influence the seed rearing, since temperate abalone species usually have distinct annual spawning seasons with some spawning once or twice a year. The obtaining of eggs with high quality is an important step in hatchery production. Seasonality of spawning also has been observed for a number of temperate abalone. The broodstock age had a significant effect on spawning performance in the present study as it had been proved in several prawn species (Coman and Crocos, 2003; Crocos and Coman, 1997; Hoang *et al.*, 2002).

After the spawning induction, the percentage of spawning abalones and the number of eggs produced per spawning all had increased along with broodstock age in 3-6 years old groups, and then decreased in 7-year age group, although the numbers of spawning and eggs produced per spawning were still larger than those of younger abalones (3 and 4 years old). It suggested that the sensitivity of spawning induction and spawning ability peaked in 6-year age group, and declined subsequently.

Furthermore, the fertilization and hatch rates were obviously larger for 4-6 years old groups than the younger and older abalones. The peaks of fertilization and hatch were found in 5-year age group (96.0% and 84.5%), 6-year old group began to decline, and rapid decrease appeared in 7-year age group (79.3% and 58.2%). The attachment rate also increased with broodstock age, reached maximum in 6-year age group

(33.6%), although the increment declined gradually, and then decreased rapidly in 7-year age group (16.6%) like its fertilization and hatch rates.

These results suggested that broodstock age affected the spawning performance of *Haliotis discus hannai,* which peaked between 5 and 6 years old, and broodstock should be bred during this period for hatchery production.

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