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Age and Reproductive Potential of Domesticated Golden Spinefoot, *Siganus guttatus* (Bloch) Breeders

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ABSTRACT

The supply of eggs and fry is one of the major constraints in the future development of aquaculture. Domestication of broodstock requires complete control of the reproductive biology for year-round spawning of the fish. Domestication of *Siganus guttatus* broodstock could alleviate broodstock shortages, enable selection of stock with desirable attributes, and allow continuous and sustainable production of juveniles. In this study, the reproductive potential of *S. guttatus* broodstock of different ages was assessed in terms of spawning frequency, fecundity, fertilization rate, number of larvae produced per spawning, and larval survival. Three age groups of siganid broostock were used in the study, namely, 5-6, 4-5 and 1-2 years old. The age of broodstock significantly affected spawning frequency and larval survival. No significant difference was observed among the different broodstock in terms of fecundity, fertilization rate, and number of larvae produced per spawning event.

Keywords: domestication, broodstock, reproductive performance, aquaculture

INTRODUCTION

The development of domesticated stocks of the golden spinefoot or rabbitfish, *Siganus guttatus* (Bloch, 1787) in breeding programs is important for the future sustainability and profitability of farming this commercially important fish species. Unlike crustaceans, finfish broodstock have to be maintained in captivity for sustained spawning activities. Domestication refers to the rearing of fish for two or more generations in captivity. It requires complete control of the reproductive biology of the fish, year-round reproduction of the fish to produce juveniles for stocking in grow-out culture, and selective breeding of both parental lines to improve production efficiency (Harel *et.al*., 1995). Domestication of *S. guttatus* could alleviate problems of broodstock shortages, enable selection of stocks with genetically desirable attributes, and allow continuous and sustainable production of juveniles. Broodstock management involves proper handling and nutrition of broodfish, genetic and selective breeding, and fry and juvenile production.

In this study, several batches of domesticated broodstock of various ages ranging from 5-6, 4-5 and 1-2 years old were assessed in terms of their reproductive performance. Reproductive performance was evaluated in terms of spawning frequency, fecundity, fertilization and hatching rates, egg diameter and volume of food reserves, larval population per spawning, and survival rates. Egg quality refers to the set of characteristics that determine the capacity of the egg to survive (Bromage *et al.,* 1994). Fertilization rate, for example, is often used as a measure of egg quality. Assessment of egg quality can be used as basis in the selection of eggs or larvae for larval rearing and should be carried out as simply as possible. Tandler *et al.* (1995) reported that the age of broodstock could account for a change of up to 300% in larval survival. This parameter is often used as the basis by which selection of broodstock for spawning is done.

MATERIALS AND METHODS

In this study, three sets of spawners of different ages were used to determine the reproductive performance and the number of productive years of *S. guttatus* (*i.e.* within which the fish can produce viable eggs and larvae). The study was conducted from January 2006 to November 2007. The broodstock from each age group were stocked in 40-ton concrete tanks; each broodstock serving as replicate for each treatment. Monthly sampling of broodstock from each age group was done 2-3 days after the first quarter of the moon. Broodstock ready to spawn were stocked in 500 L fiberglass tanks at a ratio of 1 female: 2 males. After spawning, the broodstock were returned to their respective broodstock tanks. The ages and body weights of the broodstock (F2, F6 and F7) used in the study are shown in Table 1.

Table 1. Age and weight of three groups of *S. guttatus* broodstock used in comparing reproductive performance in siganid.

Broodstock Group	Age of Broodstock (Years)	Number of Individuals	Ave. Body Weight (grams)	
			First year (2006)	Second year (2007)
F6	5-6	33	658	741
F2	4- 5	16	465	526
F7	1-2	10	400	526

The original stock of siganid broodstock was collected from Lopez Jaena, Misamis Oriental. The F6 and F7 broodstock were produced from several spawnings of the original stock, while the F2 broodstock came from another batch of wild spawners caught from Lopez Jaena waters. The F6, F2 and F7 broodstock in the study were 5-6, 4-5 and 1-2 years old, respectively, and have undergone selection and domestication for a number of years. Selective breeding was carried out by choosing potential breeders that displayed fast growth (or "shooters") and individuals that survived heavy mortalities during the larval and juvenile stages. The broodstock were fed with shrimp grower feed and supplemented with fresh diets of squid, beef liver and marine annelids seven to ten days before spawning (on the first quarter lunar phase). Daily water management was done through replacement of 50-100% of the tank volume especially before the spawning period of the fish.

The effect of age and domestication of broodstock on the reproductive potential of *S. guttatus* were considered in this study. Assessment of reproductive potential was carried out by measurements of the following parameters on every spawning activity: spawning frequency, fecundity, fertilization rate, egg diameter, number of larvae produced per spawning and larval survival. Spawning frequency refers to the number of spawning events that a broodstock exhibits each month. Due to the difficulty of counting siganid eggs which are adhesive and demersal, fecundity was determined through a back calculation method based on the number of larvae produced per spawning over fertilization rate. Fertilization rate was measured by taking three replicate samples of 50 eggs and examining the fertilized and unfertilized eggs under a compound microscope. Egg diameter was measured using the method described by Blaxter and Hempel (1963). The larvae produced per spawning (day 0) was determined by counting three aliquot samples from the spawning tanks before stocking them in larval rearing tanks.

Larval rearing was done following the protocol established by Gorospe (2010). Day 0 larvae were stocked in 7-ton larval rearing tanks. Larvae were stocked at 30-50 larvae per liter. Larvae were fed with rotifer, *Artemia* and artificial feeds. Larval survival was measured on day 24 when the post-larvae were transferred to new tanks. Measurements of reproductive performance and larval survival were analyzed statistically using one-way ANOVA. Data on fertilization rate and survival rate were transformed to arc-sine values for statistical analysis.

RESULTS AND DISCUSSION

The golden spinefoot or rabbitfish *Siganus guttatus* mature in the wild at 10 months in males and 12 months in females (Duray, 1990). Siganid cultured in cages, on the other hand, were observed to attain sexual maturity in 6-7 months with a body weight of 200 to 220g. In this study, broodstock were observed to spawn at 17 months from larvae grown in land-based tanks (Gorospe *et al*., 2003). The method of larval rearing and culture system affect age of attainment of sexual maturity in this fish. Stocking of fish at high densities and culture of fish in cages were observed to affect growth and ability of fish to reproduce.

Effect of domestication on three generations of broodstock is shown in the regular monthly spawning of the broodstock, where age of the broodstock was inversely proportional to spawning frequency. The 5-6 year-old (F6) broodstock consistently had the lowest spawning frequency compared to the 4-5 (F2) or the 1-2 year-old (F7) broodstock (Fig. 1). A significant difference was observed in the spawning frequency between the 4-5 and 5-6 year old broodstock. The highest peak in monthly spawning activity was exhibited by the 4-5 year group (40.62%) followed by the 1-2 year group (29.21%) while spawning in the 5-6 year old breeders was significantly low (21.58%) (Table 2). No significant difference was observed between the 4-5 and 1-2 year-old breeders. The youngest batch of broodstock (17 months old) started to spawn during the later part of the study, however, spawning activity was erratic. A particular broodstock is capable of spawning for three to four consecutive months followed by a conditioning or resting period of one to two months after which spawning activity resumes (Gorospe, *et al*., 2004). This explains the fluctuation in spawning activity of the broodstock in this study. In an earlier study (Gorospe *et al*., 2003) using F6 broodstock, a low spawning percentage (0-30%) among female broodstock 1-2 year old was noted while a higher spawning percentage (90-100%) was observed in broodstock more than 2 years old.

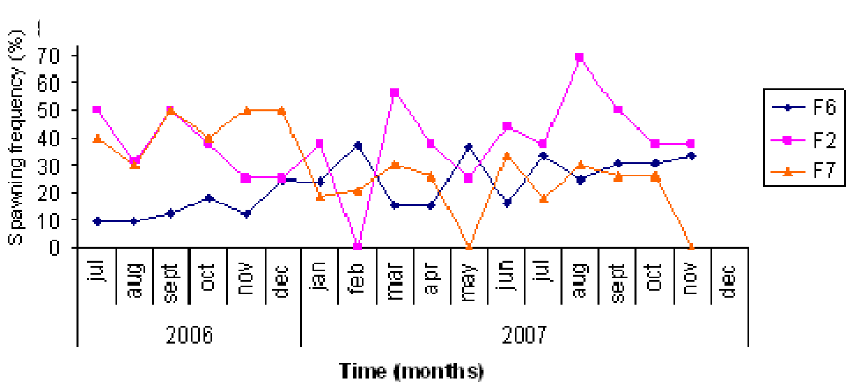

Figure. 1. Monthly spawning frequency of *Siganus guttatus* broodstock.

The fecundity or the number of eggs produced per spawning of the 5-6, 4-5 and 1-2 years old broodstock differed between the first and the second year of the study (Fig. 2). Higher fecundity was generally observed with the F6 and F7 broodstock, however, no significant difference was observed among treatments. During the first year, higher fecundity was observed in the 5-6 (735,301 eggs) and 1-2 (786,848 eggs) year old broodstock compared to the 4-5 year old broodstock (488,714 eggs). The 1-2 year old broodstock had higher fecundity compared to the 4-5 year old broodstock. This could be explained by the effect of domestication on the reproductive performance of the broodstock. The 5-6 (F6) and 1-2 (F7) year old broodstock came from the same parental line which were exposed to a longer domestication period. The 4-5 year old broodstock came from a different parental line. The following year, the average number of eggs produced by the breeders increased to 887,898.

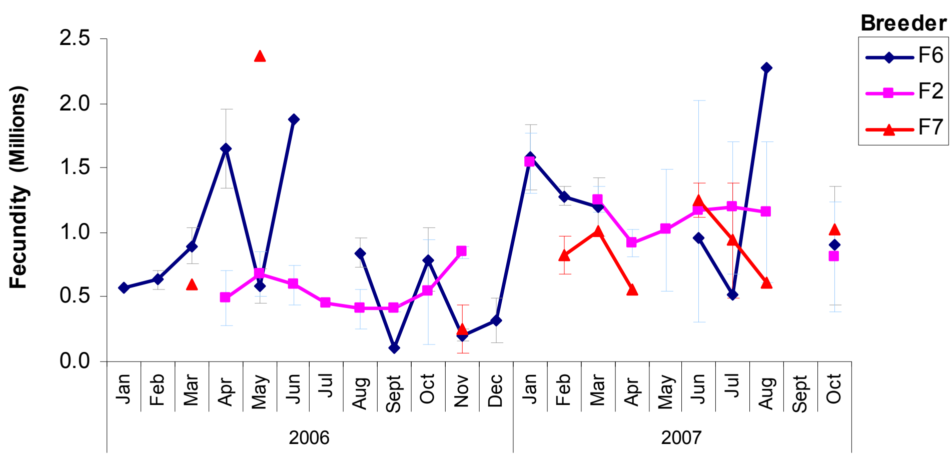

Figure 2. Average number of eggs (± SE) produced by the different ages of *Siganus guttatus* broodstock.

Higher fertilization rate was observed in F2 broodstock as compared to F6 and F7 broodstock (Fig. 3). Female broodstock were paired with males coming from the same stock or age group. Lower fertilization rates were observed in the oldest and youngest sets of broodstock although the differences were not significant. Fertilization rate and assessment of cell symmetry at early cleavage stage provide reasonable indicators of egg quality (Bromage *et al*., 1994), however, fertilization rate cannot be used as a basis for the selection of batches of eggs for larval rearing in siganid. The mean egg diameter from the different broodstock was 0.56 mm, apparently not influenced by age of broodstock.

Higher larval population was obtained per spawning (Day 0) by the 5-6 and 1-2 year old broodstock compared to 4-5 year old individuals, however, these differences were not significant. The day 0 larvae produced per spawning activity is a function of fecundity and fertilization rate. As shown in Fig. 4, 4-5 year old consistently spawned and produced larvae each month. The 5-6 year old broodstock produced larvae inspite of the lower spawning activity of the fish because of its high fecundity. The 1-2 year old broodstock, on the other hand, started to produce larvae when the broodstock was two years old.

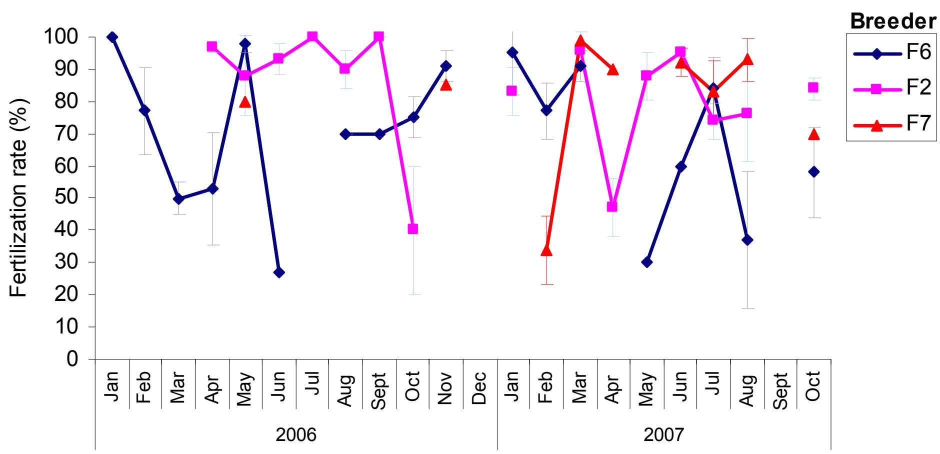

Figure. 3. Average fertilization rate (± SE) of *Siganus guttatus* broodstock.

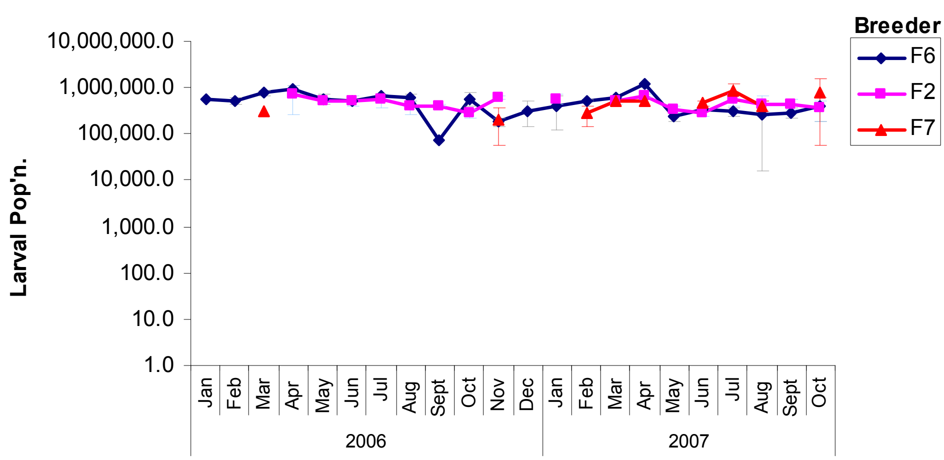

Figure 4. Average larval population (in log scale) produced per spawning activity by *Siganus guttatus* broodstock.

Data on juvenile survival collected from October 2007 to August 2008 (Fig. 5) showed that higher survival was obtained from older broodstock than from younger ones. The F6 broodstock exhibited consistently higher fecundity, fertilization rate, larval and juvenile production, however, fewer broodstock individuals spawned each month.

Survival of siganid juveniles is dependent upon the production of good quality eggs and larvae. Zero to low juvenile production was encountered in some months (December and January) due to problems encountered with food supply during larval rearing.

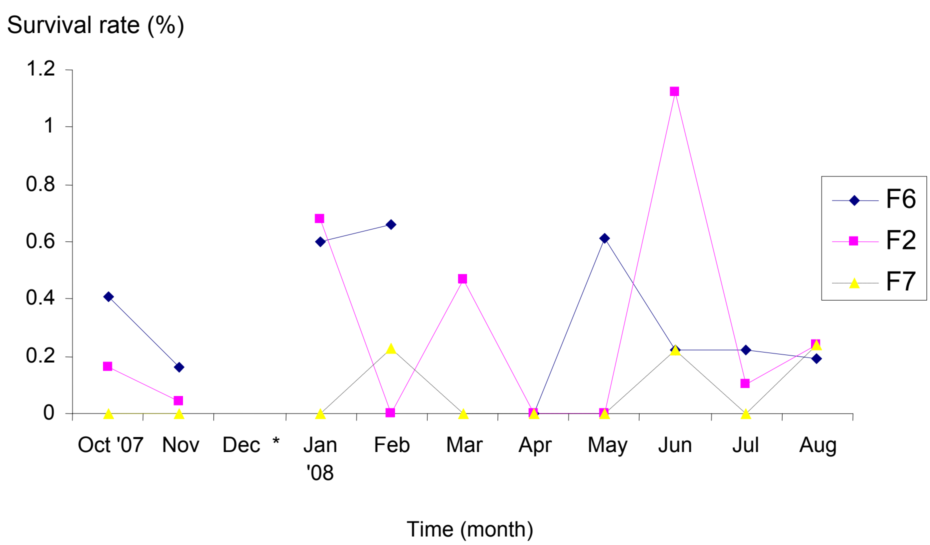

Figure 5. Survival rate of juveniles produced from different siganid broodstock. There is no siganid juvenile production for December due to the collapse of algal culture.

Spawning frequency of the F6 broodstock (which is now 6 years old) have declined (21.58%). The spawning frequency indicates the number of spawning incidents per month. Higher spawning frequency means an increase in the number of eggs produced and, consequently, reduce the number of broodstock to maintain. The cost of broodstock maintenance is a major consideration in the hatchery.

Increase in fecundity of the breeders could be due to the increase in body weight corresponding to an increase in gonad weight. Berkeley *et al*. (2004) reported that the age of the maternal breeders affects gonad weight and fecundity. Spawning activity in siganids is influenced by interrelated factors such as nutrition, stocking density, and environmental conditions during culture. Early onset of spawning was experienced by siganid broodstock, however, this does not guarantee successful production of juveniles. Gonadal development and fecundity are affected by certain essential dietary nutrients, especially in continuous spawners with short vitellogenic periods (Isquierdo *et al*., 2001). The 5-6 year old broodstock have been observed to spawn for three to four months after which they undergo a conditioning period of two months.

Higher juvenile survival was obtained from older broodstock compared to younger ones. Berkeley *et al*. (2004) reported that female age was a far better predictor of larval performance than female size. This is due to the greater provisioning of larvae with energy-rich triacylglycerol (TAG) lipids as female age increases. The volume of the oil globule (composed primarily of TAG) present in larvae at parturition increases with maternal age and is correlated with subsequent growth and survival. The results of the study suggest that progeny from older females can survive under a broader range of environmental conditions compared to progeny from younger females.

Age of the broodstock affected spawning frequency and larval survival with broodstock at 4-5 years old having the highest spawning frequency and the 5-6 year-old broodstock with the highest larval survival. The 4-5 year old broodstock (F2) were at the peak of its reproductive potential in terms of spawning frequency and larval survival. The youngest batch of broodstock (F7) was capable of spawning at two years old, however, the fish have to accumulate more maternal reserves in the form of energy-rich triacylglycerol to produce high quality eggs and larvae.

The use of older 5-6 year old broodstock (F6) could still lead to reliable larval survival, however, spawning frequency could further decrease as they grow older. The 4-5 year old broodstock will remain productive in terms of fecundity, larval count, frequency of spawning, and larval survival for the next one to two years. Proper maintenance of broodstock should be done since this would be the source of juveniles for the next years. The 1-2 year old, on the other hand, is expected to perform better in the next several years.

Siganid broodstock are at the peak of their reproductive years starting three to four years of age. Domestication of broodstock should be considered in commercial production of siganid to prevent problems of broodstock shortages, enable selection of stocks with genetically desirable attributes, and allow continuous and sustainable production of juveniles. Since siganids are continuous spawners with short vitellogenic periods, proper nutrition should be provided for efficient gonadal development and fecundity.

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LITERATURE CITED

Berkeley, S.A., C. Chapman, and S. Sogard. 2004. Maternal age as a determinant of larval growth and survival in a marine fish, *Sebastes melanops*. Ecology85(5): 1258-1264.

Blaxter, J.H.S and G. Hempel. 1963. The influence of egg size on herring larvae. J. Mar. Biol. Assoc. U.K., 46:219-234.

Bromage, N., R. Shields, C. Yound, M. Bruce, N. Basavaraja, J. Dye, P. Smith, M. Gillespie, J. Gamble and K. Rana. 1991. Egg quality determinants in finfish with special reference to the timing of stripping and methods of fertilization in the Atlantic halibut (*Hippoglossu*s *hippoglossus*). LARVI'91. Fish & Crustacean Larviculture Symposium. P. Lavens, P. Sorgeloos, E. Jaspers and F. Ollevier (eds). European Aquaculture Society, Special Publication No. 15, Gent, Belgium. 201 p.

Duray,M. 1998. Biology and Culture of Siganids. SEAFDEC Aquaculture Department, Tigbauan, Iloilo City, Philippines. 53 pp.

Gorospe, J.N. 2010. Hatchery production of siganid fry. In: National conference and workshop on the biology and culture of siganids held on July 23-24, 2010 at Function House, MSU-Naawan Campus, Naawan, Misamis Oriental.

Gorospe, J. N., M.I. Tumanda Jr., E. Y. Adan, W. H. Destajo, E. G. Tubio, M. B,Quiñones, R.D. Gaid, R. L. Roa, A. J. Laurden and M. M. Ologuin. 2004. Refinement of siganid hatchery and grow-out technology in Mindanao. A Terminal Report submitted to DA-BAR. 104 p.

Gorospe, J. N., M.I. Tumanda Jr., W. H. Destajo, E. Y. Adan, M. B,Quiñones, M. M. Ologuin, E. G. Tubio, A. J. Laurden, R. L. Roa, R.D. Gaid, and D.D. Gonzales, 2003. Reproductive performance of siganid fed broodstock diets. Proceedings of the 8th Annual Zonal RD &E Review S&T Planning Workshopp. Naawan Beach Resort. November 12-13, 2003. Mindanao State University at Naawan, Misamis Oriental. Pp. 212- 228.

Harel, M., A. Tandler, G.W. Kissil and S.W. Applebaum. 1995.The role of broodstock dietary protein in vitellogenic synthesis and oocyte development and its effect on reproductive performance and egg quality of gilthead seabream *Sparus aurata*. Proceedings of the Fifth Symposium on the Reproductive Physiology of Fish. Univ. of Texas. Pp. 2-8.

Isquierdo, M.S., H. Hernandez-Palacios and A.G.J. Tacon. 2001. Effect of broodstock nutrition on reproductive performance of fish. Aqua.197: 25-42.

Tandler, A,, M. Harel, W.M. Koven and S. Kolkovski. 1995. Broodstock and larvae nutrition in gilthead seabream *Sparus aurata* – New findings on its mode of involment in improving growth, survival and swimbladder inflation. Israeli.J.Aquacult. – Bamidgeh, 47(3-4). 95-111.