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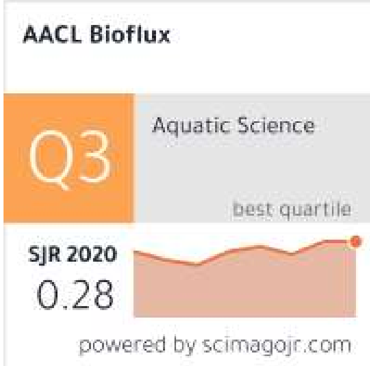

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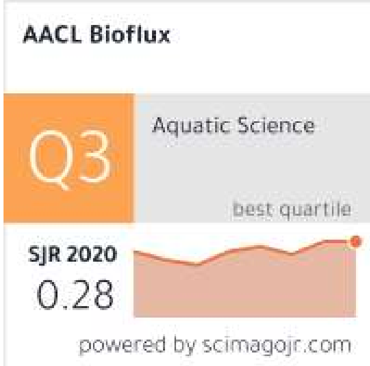
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The analysis of factors influencing carp (*Cyprinus carpio*) seed production in Bungur District, Tapin Regency, South Kalimantan

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Abstract. Seed production has become one of the factors supporting the continuity of fish farming activity. Carp, *Cyprinus carpio* is one of the largest freshwater fish productions that support the human food needs in the world. This study aims to know several factors affecting carp seed production. The study locality was purposively selected in Bungur District, Tapin Regency, South Kalimantan, and samples were collected through census from 42 carp farmers. The primary data were descriptively quantitatively analyzed using multiple regression. Results showed that there were 4 factors affecting the seed production, number of male spawners, feed amount for fry, spawning frequency, and the use frequency of the same female spawners. Carp seed production development could be done by considering the supply of enough number and good quality spawners, good protein feeding and efficient feeding technique, and spawning recovery time of the female spawners.
Key Words: fish farmer, pond, stocking density, spawners, feeding.

Introduction. World human population in 2019 reached 7.7 billion people and is estimated to be 9.7 billion in 2050 (United Nations 2019). Increase in human population causes increase in world food needs including fisheries products. In 2016, the world fisheries production also reached 170.9 million tons, from which 151.2 million tons were used for human consumption and 19.7 million tons for non consumption need. This production comprises fishing fisheries and aquaculture. Nevertheless, the world fishing fisheries production has declined from 2011 to 2016 from 92.2 to 90.9 million tons, while world aquaculture production has significantly risen from 61.8 to 80.0 million tons in the same period (FAO 2018). Systematic fishing in tremendously high numbers, weak reporting, and other complex pressures added with ecosystem change consequences have resulted in decline in fishing fisheries production (Allan et al 2005). Hence, fish farming becomes a very important sector that plays important roles in world food security due to increasing human population and food needs (Wang et al 2017).

Indonesia as the fourth highest human population country, 267.6 million people (United Nations 2019) required fish consumption up to 43.94 kg capita^{-1} in 2016. This need was supported by 16.68 million tons of aquaculture and 6.83 million tons of fishing fisheries. Total fisheries production of Indonesia in 2016 reached 23.51 million tons and has contributed to 13.75% of world fisheries production (Ministry of Marine Affairs and Fisheries (MMAF) of RI 2018a). The need of Indonesian fisheries products can be achieved by 70% from aquaculture. This condition makes aquaculture be very crucial. There are several fish commodities developed in Indonesia, one of which is carp, *Cyprinus carpio*. This species becomes the fourth largest freshwater aquaculture commodity in Indonesia with a volume of 316,646 tons in 2017 (MMAF RI 2018b). This species also became the third largest fish culture commodity in the world (Xu et al 2012; FAO 2018) and one of the fish species that can reach high biomass and its distribution has been developed by human due to its important economic value (Arteni & Rosca 2010; Saikia & Das 2009).

The magnitude of carp culture commodity needs fish seed availability as important prerequisite of carp cultivation (Bhuyan et al 2011). The supply of good quality fish seeds is necessary for faster development of aquaculture industry. Hatchery efforts are also needed to reduce the dependence of aquaculture upon the use of wild seeds (Ghosh et al 2019). The development of carp seed quality has been conducted through various techniques, such as application of certain treatment to carp seeding production factors. The treatment could be implemented by previously knowing which production factor yields significant effect on the seeding quantity and quality (Mizuno et al 2012; Karim et al 2016; Hariani & Pungky Slamet 2019). Studies on the effect of various factors on carp condition have been done a lot, such as how the intestinal microbes affect the fish growth (Li et al 2013) up to how the toxin effect, such as cobalt chloride, on the hematological condition of carp (Saravi et al 2009). Nevertheless, there are very few studies on carp seeding quality and quantity development. Nowadays, the development of good fish seed quality production is needed in order to meet the seed demand in aquaculture and make the public hatchery be a profitable business (Ismi et al 2013).

Tapin Regency, South Kalimantan province, is one of the regions that run carp culture activities during 2013-2017 with mean production level up to 13,198,600 ind yr^{-1} (Animal Husbandary and Fisheries Service of Tapin Regency 2018). Bungur District is one of the largest carp seeding localities in Tapin Regency. The seed production must be raised due to increasing human population and food demand, fisheries product in particular. Increased fish seed production is expected to be able to maintain the sustainability of the carp culture industry. Developing the carp seeding production requires a right strategy. This study aims to know factors affecting the carp seed production in Bungur District, Tapin Regency, the province of South Kalimantan.

Material and Method

Study site description. The work was carried out from January to May 2019 in Bungur District, Tapin Regency, South Kalimantan province with an area of 148.98 km^2. Bungur District is the largest aquaculture area in Tapin Regency, where 75% is located in Bungur District, and most of it is used for fish hatchery business, including carp seeding (Statistic Center of Tapin Regency 2019). This study site selection was done since Bungur District is the fish seeding center of Tapin Regency with the biggest aquaculture area and number of fish farmers.

Population and samples. Fish hatchery farmers in Shabah village and Kalumpang village, Bungur District are 42 people. All population members were taken as research samples through census method.

Data analyses. Factors influencing carp seed production were analyzed using descriptively quantitative method and OLS multiple regression with Cobb-Douglas-typed production function approach. This function has been widely used in the field of agricultural economy to show the relationship between number of inputs and outputs (Singh 2008; Osuagwu & Olaifa 2018). It was selected for the following potentials: (1) the Cobb-Douglas (C-D) function estimation will give the regression coefficient that indicates the elasticity, (2) the elasticity indicates the return to scale rate, and (3) the calculation is relatively easier than other functions (Soekartawi 1994; Bhanu Murthy 2002; Vergos et al 2010).

The model applied in this study was as follows:

$$Y = a\, X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7} X_8^{b8} X_9^{b9} X_{10}^{b10} D_1\, e$$

$$\ln Y = \ln a + b_1 \ln X1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + b_9 \ln X_9 + b_{10} \ln X_{10} + D_1 + e$$

where a is constant, b_1-b_{10} are regression coefficients, Y is the fish seeding production (ind $year^{-1}$); X_1 is pond size (m²), X_2 is number of female spawners (ind), X_3 is number of males (ind), X_4 is feed volume for spawners (kg), X_5 is total feed volume for fry (kg), X_6 is amount of manure fertilizer (pack), X_7 is spawning frequency (times), X_8 is use frequency of the same female spawners, X_9 is number of labor used (HOK), X_{10} is fish farmer's experience (year), D_1 (dummy variable) is trained fish farmer = 1, untrained fish farmer = 0, and e is error term.

The precision of the C-D production function model was tested with classic assumption tests which include test normality, multicollinearity, and heteroscedasticity, then test goodness of Fit (R2), simultaneous variable coefficient test (F test), and partial variable coefficient test (t-test) were done. If all requirements are fulfilled, the model could be used for prediction (Gujarati 1988). The regression coefficients of all inputs used in the model were *a priori* assumed as positive (Ogundari & Akinbogun 2010; Asamoah et al 2012), except the frequency of the same female spawners utilization. Dummy variable coefficient, trained fish farmers D1, was assumed to be positive (Onianwa et al 2004; Hyuha et al 2011).

Results

Seeding activity description. The Public Hatchery Unit has been done by the farming group in Bungur District for 8 years in average. The hatchery business run for 1-5 years was 48%, 6-10 years was 24%, and more than 10 years was 29%. The construction of carp seeding pond used by fish farmers in Bungur District was soil ponds with area around 1,490-18,212 m^2 and number of ponds managed were 4-29 units $hatchery^{-1}$ (Table 1) with total labors of 12-306 working days. Number of labors in each hatchery was 2-3 people depending upon number of spawning ponds operated. The pond localities are generally near the irrigation route so that the ponds are close enough to the water source. Before use, the fish farmers have fertilized the pond with manure. The organic fertilizer is effective to grow natural food that the productivity and fish growth can be increased (Kour et al 2016). The fertilizer applied in the study site was about 160-2,000 bags yr^{-1} $hatchery^{-1}$ or about 14 bags m^{-2}.

Fish spawner is major production factor in seed production, in either quality or quantity. Both females and males were prepared by the fish farmers. The female spawner candidates were 1.5-3 years old with individual weight of about 2-4 kg, the males were older than 6 months old with an individual weight of 0.2-1 kg. In general, number of spawners prepared by the fish farmers were 4-53 females and 14-178 males per business unit. The female and male spawners ratio was 2:8 each spawning.

Table 1

Carp hatchery production and input production description in Public Hatchery Unit in Bungur district

Description	*Unit*	*Value*		
		Maximum	*Minimum*	*Average*
Fish seeding production	ind yr^{-1}	2,080,000	100,000	340,520
Total pond size	m²	18,212	1,490	6,874
Number of ponds	unit	29	4	9
Pond size	m² $unit^{-1}$	1,197	298	782
Number of female spawners	ind	53	4	16
Weight of female spawners	kg ind^{-1}	4	2	3
Number of male spawners	ind	178	14	61
Weight of male spawners	kg ind^{-1}	1	0.2	0.34
Feed volume of spawners	kg yr^{-1}	840	40	318
Feed volume for fish fry	kg yr^{-1}	1,560	200	647
Volume of manure fertilizer	bags yr^{-1}	2,000	160	651
Spawning frequency	no yr^{-1}	32	4	7
Use frequency of the same female spawners	no yr^{-1}	6	2	4
Number of labor used	working days	306	12	83
Fish farmer's experience	year	18	1	8

Total time utilized for spawning in one-year is about 8 months. One production cycle requires more or less 60 days, and it could be done 1-2 times mo^{-1} or 4-32 times yr^{-1}. To maintain the quality of the produced seed, the frequency use of the same female spawners was 2-6 times yr^{-1}, and every year the new spawners are prepared to replace the old ones. Total number of seeds produced by the hatchery were 100,000-2,080,000 ind yr^{-1}.

These are the fry size ranges that are commonly prepared by the hatchery to the fish farmers under different selling price, 1-3 cm, 3-5 cm, and 5-8 cm total length that need about 15 days, 20 days after, and 30 days after, respectively. In this stage, the seeds were given fine pellet with total feed weight of 200-1560 kg y^{-1} per business unit. Similarly, the spawners were fed with artificial feed as much as 40-840 kg y^{-1} per business unit.

Fincancial analysis*.* Profit is the main goal of a business. The amount of profit gained will determine the fish farmer's decision making in the business production planning. Carp hatchery business needs an investment of IDR 2.9 million – IDR 254.23 million (Table 2) depending upon land size, number of ponds used, and other supporting facilities, such as keeping house and storage, net/happa, kakaban/egg substrate, bucket, sorting box, and scoop net. Each business unit required the operational costs of IDR 29.69 million – IDR 159.34 million yr^{-1} with the highest in feed preparation for the seeds, IDR 1.05 million – IDR 94 million yr^{-1} depending upon the seed numbers produced. The additional feed was administered at the life stage of about 7-day old larvae (with yolk sac) up to be ready for sale.

The second highest operational cost is labor's wages, IDR 16.4 million – IDR 27 million. It was allocated for pond preparation or processing, dyke improvement, and feeding. The lowest cost was recorded in male spawner supply, IDR 135,000 – IDR 1,750,000 yr^{-1}. Previous studies found no enough difference, with total costs of IDR. 66,262,510.89, approximately 31% is used for feed costs (Shivakumar et al 2014). This finding is in agreement with Kholifah et al (2012) that carp hatchery business has good prospectus with a profit of IDR. 7,329,301.90 $cycle^{-1}$, but different from that of Yulinda (2012) concerning the business financial analysis of catfish *Clarias gariepinus* with much lower profit, averagely IDR. 1,745,194 $cycle^{-1}$. It could result from higher market price of carp fry than that of catfish.

Table 2

Investment, operational costs, and profit of carp hatchery unit in Bungur District

Description	*Unit*	*Value*		
		Maximum	*Minimum*	*Mean*
Investment (total):	IDR	**254,225,000**	**2,935,000**	**46,256,475**
Pond	IDR	200,000,000	1,800,000	32,222,500
Other supporting facilities	IDR	54,225,000	1,135,000	14,033,975
Operational costs (total):	IDR yr^{-1}	**201,600,000**	**21,995,000**	**61,318,505**
Female spawner preparation	IDR yr^{-1}	7,500,000	480,000	2,139,500
Male spawner preparation	IDR yr^{-1}	1,750,000	135,000	621,038
Spawner's feed preparation	IDR yr^{-1}	22,800,000	900,000	6,181,167
Seed feed preparation	IDR yr^{-1}	94,000,000	1,050,000	19,699,750
Manure fertilizer	IDR yr^{-1}	33,500,000	2,680,000	10,445,300
Other input preparation	IDR yr^{-1}	14,750,000	350,000	3,081,750
Labor's wages	IDR yr^{-1}	27,300,000	16,400,000	19,150,000
Revenue and profit:				
Revenue	IDR yr^{-1}	268,000,000	57,600,000	120,215,750
Business profit	IDR yr^{-1}	66,400,000	35,605,000	58,897,246

The revenue (from seed sales) obtained by a hatchery business unit ranged from IDR 57.6 million to IDR 268 million. The amount of revenue is dependent upon the number of production, seed size, and selling price. The larger the seed size is, the more expensive the seed will be. Under an agreement among the fish farmers, the selling price was IDR

250 ind^{-1} for 1-3 cm total length seed, IDR 300 ind^{-1} for 3-5 cm total length seed, and IDR 350 ind^{-1} for 5-8 cm total length seed, respectively. Therefore, the business profit varied as well from IDR 35,6 to IDR 66,4 million yr-^{1}.

***Production and production factors*.** The effect of production factors on the carp seed production showed that several production factors (input) involved in the production function model gave the consistent values with the theoretical estimate. The production factors of positive value and significant effect on production were number of male spawners, feed volume for seeds, and spawning frequency done by the fish farmers. However, the use of the same female spawners for several spawning activities during the reproductive cycle will cause seed production decline as well (Table 3).

Table 3

Factors influencing the production of common carp hatchery

Variable	*Coefficient*	*SE*	*t-Statistic*	*P value*
Intercept	7.543	1.264	5.945	0.000
Total pond size (m^2)	0.059	0.123	0.477	0.637
No. female spawners (ind.)	0.065	0.106	0.620	0.540
No. male spawners (ind.)	0.343	0.116	2.951**	0.006
Feed volume for spawners (kg)	-0.071	0.088	-0.813	0.423
Feed volume for seeds (kg)	0.381	0.138	2.760**	0.010
No. manure fertilizer (bag)	0.094	0.103	0.920	0.365
Spawning frequency (times)	0.910	0.110	8.241**	0.000
Use frequency of the same female spawners (times)	-0.324	0.139	-2.338**	0.026
Labor’s working days	-0.204	0.113	-1.802	0.082
Fish farmer’s experience (year)	-0.048	0.079	-0.608	0.548
Trained fish farmers (dummy)	0.112	0.139	0.808	0.425
R-squared		0.828		
Adjusted R-squared		0.765		
Standard error		0.321		
Observations		42		
F-statistic		13.154		
Prob (F-statistic)		0.000		
Durbin-Watson		2.190		

Note: double asterisks (**) denote significance at 1% level, respectively.

Hence, to increase the seed production, the fish farmers could increase several inputs and reduce the use frequency of the same female spawners to give them some time to recover and to have perfect maturation.

Discussion. Fish gamete quality, male or female, is determined by a number of factors, such as age, management, food, chemical and physical factors, water quality, and so on, that will impact the survivorship of the embryos, larvae, and/or fry in short or long term (Valdebenito et al 2013). Fish spawners are a major production factor in the hatchery business. The use of higher number of spawners in spawning activity will positively influence the number of eggs produced. The more the spawners are spawned, the higher the spawning frequencies could be done and the higher the number of eggs will be produced (Syaifudin et al 2007). The female carp spawner appropriate for spawning should be 1.5-3 years old with minimum weight of 1.5 kg ind^{-1}, while the male should be at least 6 months old with minimum weight of 0.5 kg ind^{-1} (Mantau & Rawung 2004; Aliniya et al 2013). The weight ratio of female and male is 1:1 (kg m^{-2}) meaning that a 2 kg ind^{-1} female could be balanced by 3 males of 600-700 g ind^{-1}.

Some fish hatchery businesses showed that female-male ratio became factor determining the quality and quantity of seeds produced. For instance, in rainbow fish (*Iriatherina werneri*) spawning, it is known that the use of sex ratio with 1:3 of total weight is more efficient than 1:1 and 1:2 ratios. It is possible that more male spawners will give higher opportunity to fertilize the eggs. Also, the seed quality produced at the spawner sex ratios of 1:2 and 1:3 gave 5-day old seeds with good survival rate (Herjayanto et al 2016). The climbing perch *Anabas testudineus* at 1:4 ratio spawners yields good fecundity (Burmansyah et al 2013). However, the female-male ratio practiced by the fish farmers in the study site indicated that total weight of male spawner was still below the total weight of female spawner. Thus, number and weight of male spawners need to be added in order to increase the seed production.

C. carpio naturally showed 2 clear reproductive cycles per year. Each reproductive cycle is divided into 4 phases. Males have growth phase, maturation, spawning, and resting, while females have preparatory phase, pre-spawning, spawning, and post-spawning (Guha & Mukherjee 1991). At 2 years of age, carp has fecundity of 523,500 eggs and at 3 years of age, the fecundity reaches 657,701 eggs (Aliniya et al 2013). Thus, the more the number of spawners spawned are, the more the number of eggs and eventually more larvae are produced. The availability of spawners spawned will also interchangeably give the opportunity to the spawners to have perfect reproductive cycle. The spawning frequency using the same female spawners gave impact on the seed growth. This study found that the seeds obtained from the spawners often used had lower body mass and shorter size. Also, the larvae produced from the often used spawners looked paler than those from the less used spawners.

Commercial feasibility of intensive fish culture depends on market demand and production costs. The largest part of the production costs is feed, so that it is important to know the optimal feeding and the right feed management strategy implementation (Jia et al 2016). For instance, the right feeding frequency can reduce the production costs and prevent water quality degradation (Daudpota et al 2016). Higher feeding frequency gives positive impact on the fish growth and makes the feed conversion ratio value be more efficient (Ganzon-Naret 2013a). Besides that, the percent of feeding becomes important factor for fish growth and the percentage of optimal feeding determines the aquaculture success (Deyab & Hussein 2015; Aryani et al 2017). The percent feed amount given will influence the fish growth rate as weight increment (Ganzon-Naret 2013b; Sofia et al 2013).

Feed is an important component for the spawners in order to produce good quality eggs and seeds in high number. The fish spawners spawned at the high frequency need good quality feed. Specific additional feeding also affects the aquaculture production. For example, addition of tauge extract in gold fish *Carrasius auratus* feed gives faster spawning cycle (Fajrin et al 2012). Addition of probiotic to the feed can also increase body weight and fish endurance, so that the production rises and feed costs decline (Aitkaliyeva et al 2019). Besides feeding technique, the fish farmers should understand how to store the feed before use. According to Solomon et al (2016), storage in closed condition can prevent the nutritional damage of the feed.

Carp seeds produced need different feed treatments with life stages divided into 3 nursing phases. First, this stage was done for 7-day old larvae (0.6-0.7 cm total length) at a stocking density of 100 ind m^{-2} and in a pond of about 60 cm deep. At this stage, they were fed with the aquatic biota living in the pond and fine pellet. In about 15 days of rearing, the fish grew to 1-3 cm total length. Second, this stage was conducted at the stocking density of about 50 ind m^{-2} in about 20 days of rearing up to producing 3-5 cm total length fish. Third, the stocking density of this stage was about 25 ind m^{-2} at rearing period of about 30 days until 5-8 cm total length fish were obtained. After these nursing phases, the seeds are ready to sell, and they are sold when reaching the individual size of 3-5 cm and 5-8 cm long.

So far, feeding in each nursing phase still relied upon the artificial feed so that the operational cost for the fry feed was very high. On the other hand, the economic return of the larvae produced in the hatchery is more important than the fry growth. Therefore, alternative additional feed and feed cost efficiency need to be applied in order to increase the survivorship. One of these is bloodworm (*Tubifex* sp.) supplement. According to Rawat et al (2019), 5% tubifex supplement can be used to increase the fish survivorship, especially in indoor seed rearing.

Conclusions. There were 4 factors affecting the production of *C. carpio* hatchery, three of which had positive effect on seed production, namely the number of male spawners, the amount of feed for the fry, and the spawning frequency. While the use frequency of female spawners during the production cycle negatively impact the seed production. This finding suggested that the fish farmers need to pay attention on the availability of sufficient number of good fish spawners, good protein feeding, efficient feeding technique, and longer post-spawning recovery time for female spawners.

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