OVERVIEW ON
FISHERY, AQUACULTURE AND MARKETING OF CLIMBING PERCH

This book comprehensively describes on the current fishery, aquaculture and marketing of Climbing perch from different points of view including biological aspects, fishing technology, business analysis and its marketing channels. The book contents sourced from the results of research practices that have been published in international scientific journals. Projections of the book content are directed to the students, academicians or researchers who are concerned with Climbing perch studies in wetland environments, as well as socio-economic of fisheries and aquaculture.

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PREFACE

All the praises and thanks are to Allah Almighty for publication of a reference book entitled “**Overview on Fishery, Aquaculture and Marketing of Climbing perch**”. Our gratitude goes to the Ministry of Education and Culture the Republic of Indonesia, the Rector and Director of Graduate Program ULM, and all those who have helped and provided their supports.

This book covers some fundamental aspects related to the current status of Climbing perch’s fishery, aquaculture, and marketing, and it is systematically arranged and developed based on the results of research practices that have been recently published in international scientific journals.

This book provides quick acces to information on how to carry out the field experiments and develop experimental features, and the idea is technically applicable in the fieldwork. Hopefully this book is useful for students, academicians and researchers who are interested in further researching this fish species.

Banjarbaru, November 2020

Ahmadi, S.Pi, M.Sc, Ph.D

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MORPHOMETRIC CHARACTERISTIC AND GROWTH PATTERNS

I. PROLOGUE: WHY CLIMBING PERCH

The Climbing perch (*Anabas testudineus*) of family Anabantidae has become one of the most popular freshwater fish species, not only in Indonesia (Akbar et al., 2016), but also in Malaysia (Zalina et al., 2012), Vietnam (Van and Hoan, 2009), Thailand (Chotipuntu and Avakul, 2010), Lao PDR (Sokheng et al., 1999), Cambodia (Sverdrup, 2002), the Philippines (Bernal et al., 2015), India (Kumar et al., 2013), and Bangladesh (Uddin et al., 2017). It is rich in iron and copper, which are essentially needed for haemoglobin synthesis (Sarma et al., 2010) and has high quality poly-unsaturated fats and many essential amino acids. This species is locally and seasonally common throughout its range, and mostly caught by the traps and gill nets (Iwata et al., 2003; Irhamsyah et al., 2017; Aminah and Ahmadi, 2018).

The presence of this species beneficially supports fish farming business (Khatune-Jannat et al., 2012; Izmaniar et al., 2018), however, its presence in Australia, Papua New Guinea and India, is adversely affected native freshwater and estuarine species such as birds, reptiles, animals and predatory fish due to their sharp dorsal and opercular spines (Storey et al., 2002; Hitchcock, 2008; Paliwal and Bhandarkar, 2014). Like other labyrinth fishes such as Kissing gourami (Zohrah and Haji Kasim, *2002*), Snakeskin gourami (Tate et al., 2017) and Snakehead (Xie et al., 2017), Climbing perch can also be cultured in the earthen pond, tanks and cages (Long et al., 2006; Mondal et al., 2010; Kumar et al., 2013), and most tolerant to low dissolved oxygen, low pH and temperature changes (Sarma et al., 2010; Kohinoor et al., 2009; Be et al., 2017). Pollution, overfishing and wetland conversion may potentially reduce its number (Hossain et al., 2015).

A. Biological and Ecological Studies of Climbing Perch

Numerous studies on th biological and ecological of Climbing perch have been dedicated to describe, for example: food and feeding habits (Roy et al., 2013; Bhattacharjee and Chandra, 2016; Patra et al., 2017), reproductive biology (Hafijunnahar et al., 2016; Uddin et al., 2017), boldness (Binoy, 2015), growth performance and survival rate (Rahman and Marimuthu, 2010; Putra et al., 2016), length-weight relationship and condition factor (Rahman et al., 2015; Kumary and Raj, 2016), morphometric and meristic variation (Hossen, et al., 2017), water quality assessment (Be et al., 2017), phototactic responses (Ahmadi et al., 2018; Ahmadi, 2018a), aquaculture and conservation measures (Sarkar et al., 2005) for this species.

B. The Significance of Length-Weight Relationship

The length-weight relationship is the most common scientific approach that used for analyzing growth pattern or morphometric of an individual fish species (Kumary and Raj, 2016; Asadi et al., 2017) and advanced techniques for morphometric analysis was recently presented (Mojekwu and Anumudu, 2015). It is also useful for understanding condition factor, survival, maturity and reproduction (Bernal et al., 2015; Buragohain, 2018) of various species from different geographical regions, as well as for comparing local and interregional, morphological and life historical among species and populations (Paliwal and Bhandarkar, 2014; Awan et al., 2017). It can be a character for the differentiation of small taxonomic units. The mathematical relationship established makes it possible to convert length into weight and weight into length. After all, the length-weight relationship and condition factors of fish provide useful information for both aquaculture and fishery management.

C. The Reason behind Morphometric Study

Fishing activity in Sungai Batang waters is open throughout the year regardless of seasonal periods, which is done by both villagers and beyond. The use of unfriendly fishing method (e.g. electrofishing and poisoning) is still happening beyond the control particularly during nighttime. If it is allowed without forbidden, it will adverse to fish habitat and socio-economic as the whole. Meanwhile, biological aspect of Climbing perch in this river is still not discloded, for far. To manage the Climbing perch fishery resource rationally, it is therefore needed in-depth knowledge of its biology, feeding habit and ecology. As part of the whole research, we started investigating the length-weight relationship and condition factor of Climbing perch to provide some fundamental suggestions for better fisheries management.

II. FOLLOW-UP RESEARCH

A. Study site

The research was conducted in Sungai Batang River, Martapura of South Kalimantan Province (Figure 1.1), located on 03°22'36" S and 114°49'29" E, determined by GPS-60 Garmin, Taiwan. The river supports the local economic activities such as fishery, agriculture and irrigation (Figure 1.2). The village consists mostly of wetland area with water level fluctuation between 0.5 and 2 m, which is intensely affeacted by seasonal changes. Dry season was started from June to November, while rain season was from December to May, and our study was coincided perfectly with the rain season with rain-fall of 268-326 mm.

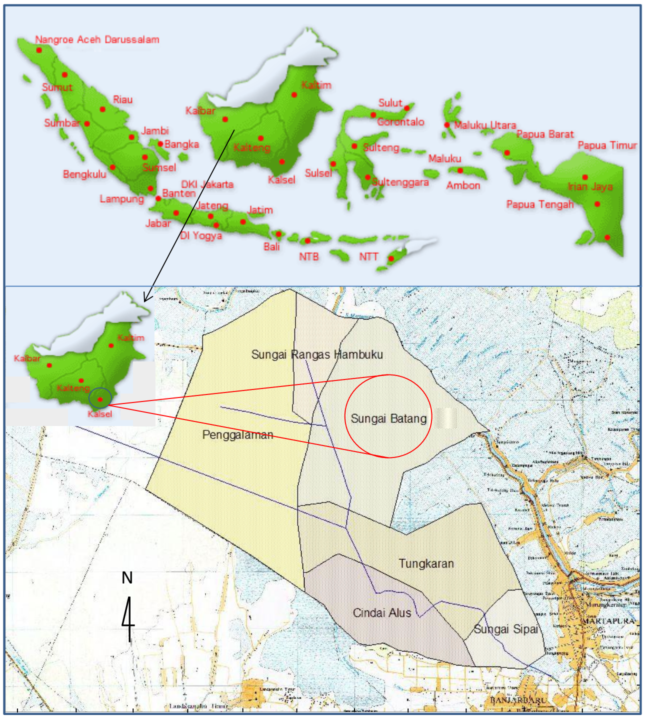

Figure 1.1. The location of sampling site in Sungai Batang River, Indonesia

Figure 1.2. Fishery and aquaculture activities in Sungai Batang River

B. Morphological Characteristic of Climbing perch

The Climbing perch is locally called '*papuyu'* (Figure 1.3). It has dorsal spines: 16 - 20; dorsal soft rays: 7-10; anal spines: 9-11; anal soft rays: 8 - 11. Color in life dark to pale greenish, very pale below, back dusky to olive; head with longitudinal stripes ventrally; posterior margin of opercle with a dark spot; iris golden reddish. Body form variable, affected by age and amount of food consumed. Scaled head with 4-5 rows between eye and rear margin of preoperculum. Scales are large and regularly arranged ciliate.

Figure 1.3. A fish sample of Climbing perch (*Anabas testudineus*)

C. Description of Fishing Gear and Fishing Method

The Climbing perch are quite difficult to catch during rainy season (October-April) since fish spread out in the wetland, but very easy to collect them during dry season (May-September) because they are being concentrated on the sludge holes backwater or shallow water. The fish are being caught from the river or swamp using *lukah* (fish pot), *tempirai* (stage-trap) and also electricity. ***Lukah*** is an elongated tube-shaped made of bamboo (128 cm) diameter of 18 cm containing one entry funnel mounted on the inside of conical-shape and tapering inside to about 2.5 cm, called *hinjap* (one-way valve, made of elastic rattan; about 40 cm one to other), and containing one exclusion funnel at the opposite side. Thus, fish can enter easily but it is difficult to escape. *Lukah* are deployed in the swamp under highly vegetated habitats with slow or no current at morning and retrieved at afternoon. *Lukah* are submerged partly at an oblique angle of about 15° so that fish can take oxygen on the water surface. ***Tempirai*** is similar to Pengilar but bigger in the size. It is made of heart-shaped bamboo, 52 cm high, 37 cm width, and 5 cm wide opening of the entrance slit. A small trap door on the top allowed for removal of catches. The snail (*Achanita* sp.) is used as bait and placed inside the trap. The trap is set in the riverbank before sunset and retrieved the next morning or mounted on a high tide and removed after low tide. The size of *Tempirai* is typically smaller than that of *Tempirai* used in Bangkau swamp (Irhamsyah et al., 2017). The gear specification of Lukah and Tempirai are shown in Figure 1.4. We are not able to describe the detailed electrofishing equipments used in this study due to a technical barrier (unwillingness of fishermen).

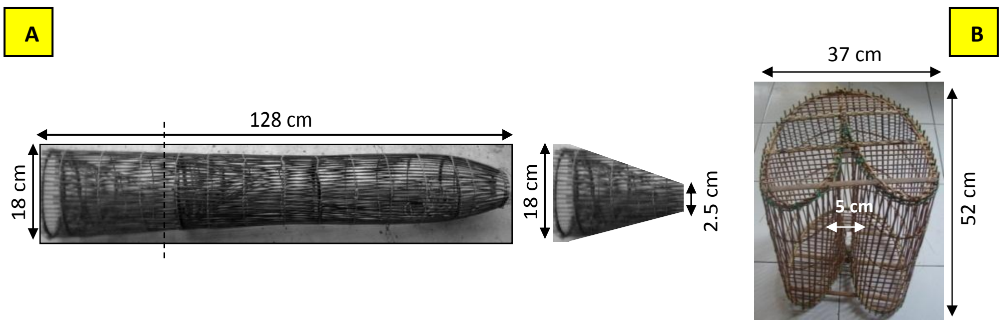

Figure 1.4. Gear specification of *Lukah* (A) and *Tempirai* (B)

D. Measurement Procedures

A total of 156 individuals of Climbing perch comprising 77 males and 79 females were bought from local fishermen during April 2017. All fishes were individually identified for sex, and measured for total length (TL) and body depth (BD) and weight (W). Total length was taken from the tip of the snout to the extended tip of the caudal fin. Body depth was measured from the dorsal fin origin vertically to the ventral midline of the body. The total length and body depth of each individual were measured with a ruler to the nearest mm, while whole body weight was determined with a digital balance to an accuracy of 0.01 g (Dretec KS-233, Japan). The ratios of W/TL and BD/TL were empirically determined with non-dimension number. The size distribution of fish sampled was set at 5-interval class for total length and weight, and was stated in percent.

E. Data Analysis

The length-weight relationship (LWR) of fish can be expressed in either the allometric form (Froese, 2006):

$$\mathbf{W = aL^b}$$

Where W is the total weight (g), L is the total length (mm), *a* is the constant showing the initial growth index and *b* is the slope showing growth coefficient. The *b* exponent with a value between 2.5 and 3.5 is used to describe typical growth dimensions of relative wellbeing of fish population (Bagenal, 1978). King (1996) observed that the marked variability in the value of *b* may reflect changes in the condition of individual related to feeding, reproductive or migratory activities.

This *b* value has an important biological meaning; if fish retains the same shape and grows increase isometrically (b = 3). When weight increases more than length (b > 3), it shows positively allometric. When the length increases more than weight (b < 3), it indicates negatively allometric. Isometric growth indicates that the body increases in all dimension in the same proportion of growth whereas the negative allometry indicates that the body become more rotund as it increases in length and a slimmer body (Jobling, 2008). Determination coefficient (R^2) and regression coefficient (r) of morphological variables between male and female were also computed. The condition factor of fish was estimated using the following formula (Weatherley and Gill, 1987):

$$\mathbf{K = 100(W/L^3)}$$

Where K is the Fulton's condition factor, L is total length (cm) and W is weight (g). The factor of 100 is used to bring K close to a value of one. The metric indicates that the higher the K value the better the condition of Climbing perch. The K value is used in assessing the health condition of fish of different sex and in different seasons. Since Fulton's condition factor, K is a measurement involving the length and weight for a particular fish, therefore it could be influenced by the same factors as LWR.

F. Statistical Analysis

The t-test was applied to compare the body sizes and condition factor between male and female. All tests were analyzed at the 0.05 level of significance using SPSS-16 software.

III. RESEARCH FINDINGS

All estimated length-weight relationship and the ratio of body sizes of Climbing perch from Sungai Batang River are presented in Table 1.1 and Table 1.2. A total of 156 individuals comprising 77 males and 79 females were analyzed. The ratio of male to female was 1 : 1. The body size of male ranged from 57 to 125 mm (90.95 ± 13.87 mm) total length and from 5 to 47 g (15.94 ± 7.81 g) weight. While the body size of female varied from 55 to 111 mm (87.92 ± 10.52 mm) total length and from 3 to 26 g (14.04 ± 4.49 g) weight. In the other word, males have the body size larger than females.

Table 1.1. Total length, weight and condition factor of Climbing perch sampled from Sungai Batang River.

Sex	N	Total length (mm)			Weight (g)			a	b	R^2	r	Growth pattern	K
		Min	Max	Mean ± SD	Min	Max	Mean ± SD						Mean ± SD
Males	77	57	125	90.95 ± 13.87	5	47	15.94 ± 7.81	0.00003	2.8791	0.8771	0.9365	A-	1.99 ± 0.30
Females	79	55	111	87.92 ± 10.52	3	26	14.04 ± 4.49	0.00005	2.7766	0.8383	0.9156	A-	2.01 ± 0.33
Pooled	156	55	125	89.42 ± 12.34	3	47	14.97 ± 6.40	0.00004	2.8353	0.8625	0.9287	A-	2.00 ± 0.31

a = constant, b = exponent, R^2 = determination coefficient, r = regression coefficient, A- = negative allometric, K = condition factor

Table 1.2. The ratio of body sizes of Climbing perch from Sungai Batang River.

Sex	n	W/TL	a	b	R^2	r	BDD/TL	a	b	R^2	r
Male	77	0.12 ± 0.02	0.00003	1.8791	0.7524	0.8674	0.32 ± 0.02	0.5260	-0.1120	0.0652	0.2553
Female	79	0.16 ± 0.04	0.00005	1.7766	0.6798	0.8245	0.32 ± 0.04	0.5221	-0.1120	0.0306	0.1749
Pooled	156	0.16 ± 0.05	0.00004	1.8353	0.7244	0.8511	0.32 ± 0.02	0.5180	-0.1100	0.0432	0.2078

a = constant, b = exponent, R^2 = determination coefficient, r = regression coefficient, BDD = body depth, W = body weight, TL = total length

Significant differences were observed at length-weight relationship of male and female (Figure 1.5A), while *b* values implied that the body shape displays a negative allometric growth pattern (*b* < 3), which means that the length increases more than weight. The estimated *b* values obtained from allometric equations were 2.8791 for male and 2.7766 for female; with the R^2 values ranged from 0.8771 and 0.8383 indicating that more than 83% of variability of the weight was explained by the length. The regression coefficients (r) of male and female were 0.9365 and 0.9156, found to be higher than 0.5, showing that the length-weight relationship was positively correlated. Statistical analysis showed that there were no significant differences in the total length, body depth and body weight between female and male ($P > 0.05$).

It was also clearly demonstrated in Figure 1.5B, there was no statistically significant difference in the mean ratio of body weight to total length between male and female ($P > 0.05$). The ratio of W/TL for male ranged from 0.0769 to 0.3760 (0.17 ± 0.06), while for female varied from 0.0545 to 0.2342 (0.16 ± 0.04). As described in Table 1.2, the R^2 values were found between 0.6798 and 0.7524 indicating that more than 67% of variability of the ratio is expounded by the length. The 'r' values of male and female were 0.8674 and 0.8245, found to be higher than 0.5, showing the ratio relationship is highly correlated.

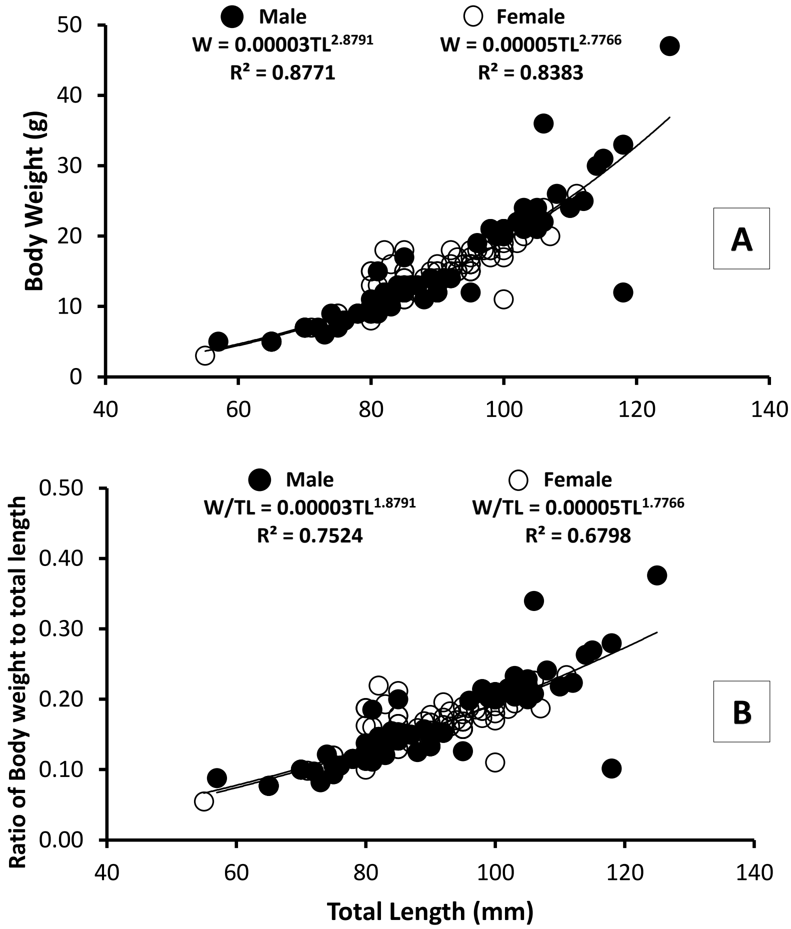

Figure 1.5. [A]. Climbing perch grew negatively allometric. [B]. There was no significant difference in the W/TL ratio values between male and female

The increased of body depth was directly proportional to the total length (Figure 1.6A). The exponent values obtained from the equation curve were 0.8876 for male and 0.8878 for female. There was no significance difference in the mean ratio of body depth to total length between male and female ($P > 0.05$) (Figure 1.6B). The BD/TL ratio for male ranged from 0.2373 to 0.5882 (0.32 ± 0.02), while for female varied from 0.2600 to 0.4024 (0.32 ± 0.04).

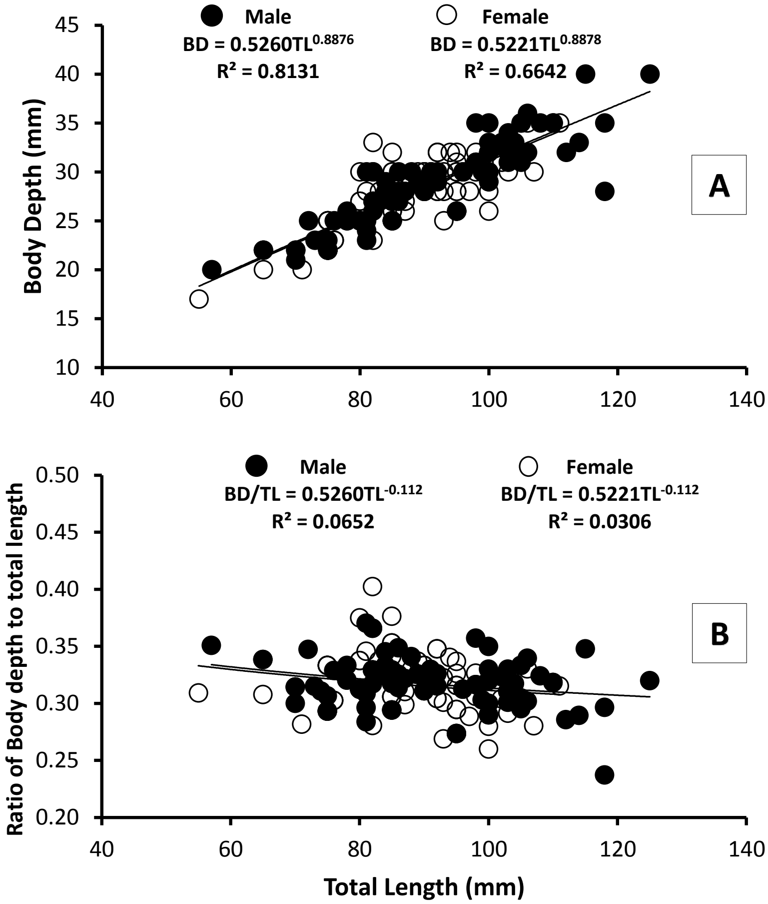

Figure 1.6. [A]. The body depth of Climbing perch increases proportionally to the total length. [B]. No significant difference in the BD/TL ratio values between male and female was identified.

The size distribution of Climbing perch samples in the present study is displayed in Figure 1.7. The highest number of catch was distributed between 80 and 84 mm TL (20.78%) for male and between 85 and 89 mm TL (18.99%) for female. A low number of catch was observed for larger size class more than 114 mm TL. The heaviest catches of male (40.26%) and female (45.57%) weighted between 10 and 19 g. Considering the number of catch on the bar chart, the percentages of fish size distribution both length and weight was more visible in male than in female. We could find none of female catch between 30 and 49 g weight sizes.

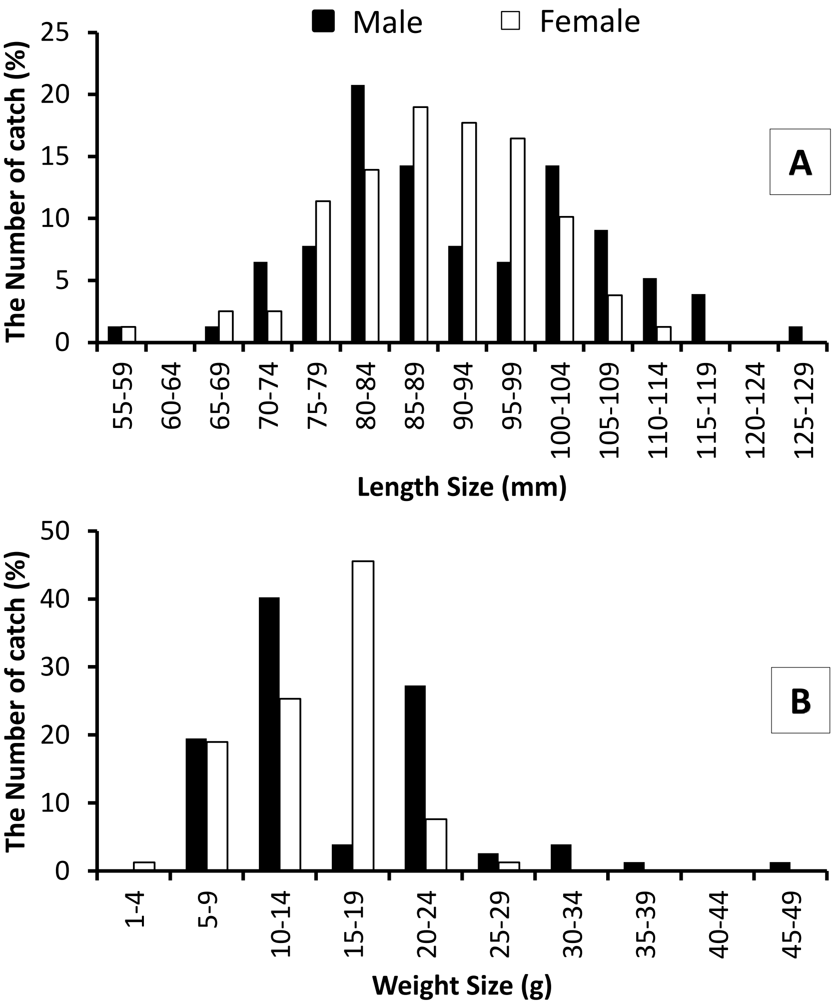

Figure 1.7. The length size [A] and weight size [B] distribution between male and female of Climbing perch taken from Sungai Batang River.

Regardless the sex, we observed that there was a difference in the exponent value for smaller length class as compared to larger ones indicating that the species has two growth levels (Figure 1.8). The smaller individuals (< 85 mm TL) grew isometrically with the exponent being equal to the cubic value

(W = 0.00001 $TL^{3.0877}$, R^2 = 0.9296). While the larger individuals (≥ 85 mm TL) grew negatively isometric with the exponent lower than the cubic value (W = 0.00003 $TL^{2.9206}$, R^2 = 0.9747), indicating that more than 92% of variability of the fish growth is explained by the length.

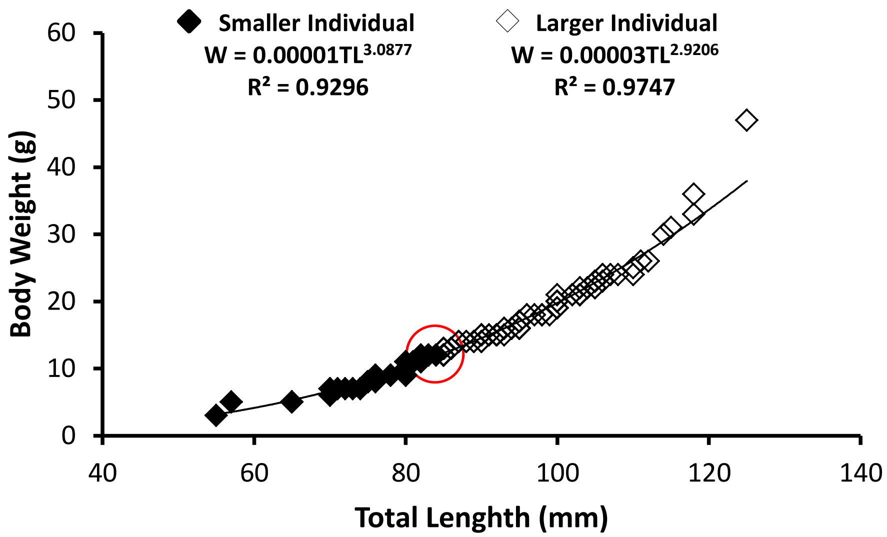

Figure 1.8. The circle mark on the curve indicates the intersection points of smaller (< 85 mm TL) and larger individuals (≥ 85 mm TL) of Climbing perch growth pattern

Dealing with the condition factor (K) of the fish, there was no statistically significant difference in the mean K values between male and female (P > 0.05) as presented in Figure 1.9. The mean K values obtained ranging from 0.7304 to 3.0226 (1.99 ± 0.30) for male and from 1.1000 to 3.2646 (2.01 ± 0.33) for female. In the other word, female relatively achieved better condition for weight gain than male.

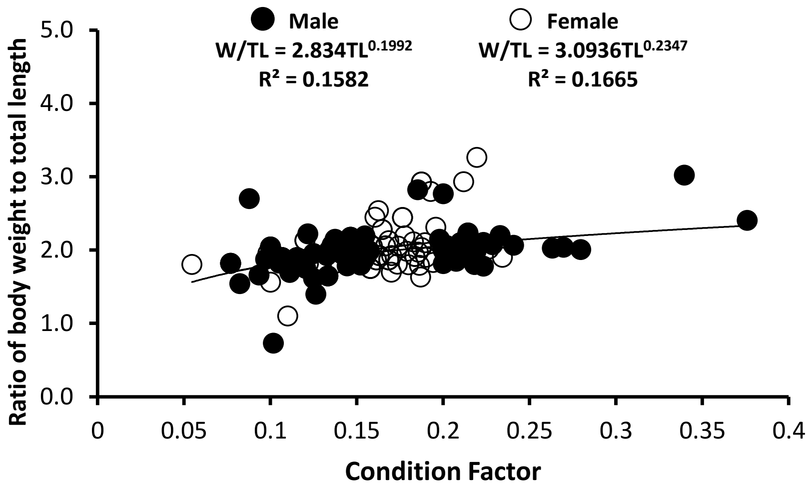

Figure 1.9. The relationship of the W/TL ratio and condition factor between male and female of Climbing perch. No statistically significant difference in this relationship was observed

IV. DISCUSSION

Local people in Sungai Batang village made a point of balancing between economic, social and environmental sustainability of commercially important fish species including Climbing perch fishery resource. It is quite reasonable because fish have high economic value around IDR 45,000 - 60,000 per kg and have good acceptance by the consumers. Like other fish species, Climbing perch is also vulnerable to destructive fishing practices. Therefore, It is categorized by the International Union for Conservation of Nature and Natural Resources (IUCN) as a vulnerable species (Singh et al., 2012). On the other word, Climbing perch formed a major part of the fish catch in the Sungai Batang River. Contrariwise, some researchers found none of Climbing perch during their sampling periods, for example in Betwa and Gomti Rivers, India (Sani et al., 2010); in the Keniam River of Taman Negara Pahang (Azham Yahya and Singh, 2012), in River Orogodo of Niger Delta, Nigeria (Meye and Ikomi, 2012), in Malaysian Waters (Khairul Adha et al., 2013), in Bukit Merah reservoir, Malaysia (Mohd Shafiq et al., 2014), in Lubuk Lampam floodplain of South Sumatera, Indonesia (Jubaedah et al., 2016), in Shahrbijar River, Iran (Asadi et al., 2017), as well as in Narreri Lagoon of Sindh, Pakistan (Awan et al., 2017). This is likely attributable to sample size variation, typical fishing gear used, and environmental factors.

The maximum size (125 mm TL) of Climbing perch in the present study were larger than those collected from Chandpur, Matlab of Kalipur, Bangladesh: 93 mm (Begum and Minar, 2012), but they were lower than maximum size of Climbing perch from Kausalyaganga of Orissa, India: 175 mm (Kumar et al., 2013), from Deepar Beel of Assam, India: 134 mm (Rahman et al., 2015), from Mohanpur of West Bengal, India: 170 mm (Ziauddin et al., 2016), or from a fish pond Banjarbaru of South Kalimantan, Indonesia: 170 mm (Ahmadi, 2018b). During fishing season, it is very likely to collect Climbing perch smaller than 55 mm TL and 3 g weight using the nets, but fishermen prefer release them back to the river rather than sold them with no or lower price, conversely the smaller fish might be untrappable because of fishing gear selectivity (Ahmadi and Rizani, 2013). The other way, it is also possible for fishermen to collect fish with the size larger than 125 mm TL in the study; however, it is beyond our investigation due to the transactional selling of fish is usually occurred in early mooring before the fish transported to the local market.

In the present study, Climbing perch grew negatively allometric ($b < 3$), which was similarly documented in the previous studies (Begum and Minar, 2012; Kumar et al., 2013; Hossain et al., 2015; Kumary and Raj, 2016; Ahmadi et al., 2018). Our finding is contrary to Climbing perch collected from Deepar Beel of Assam, India that showed a positive allometric growth pattern (Rahman et al., 2015). Dealing with variation of these growth types, some of other studies may provide much lower *b* values than these findings (Froese and Pauly, 2018). The length-weight relationships are not constant over the entire year and vary according to the following factors: food availability, feeding rate, gonad development and spawning period (Amin et al., 2010; Wong et al., 2015), fecundity (Ziauddin et al., 2016), temperature (Lopez-Martinez et al., 2003), salinity (Chotipuntu and Avakul, 2010) and inherited body shape (Yousuf and Khurshid, 2008).

From the exponent values obtained, we can say that Climbing perch male (*b* = 2.8791) grow faster than female (*b* = 2.7766). Such growth pattern was similarly found in our previous study (Ahmadi, 2018b). The exponent value (*b* = 2.9206) for the larger individuals (85-125 mm TL) was lower as compared to other fish species like *M. cavasius* (*b* = 3.150) from Indus River, Pakistan observed at the maximum size of 148 mm (Muhammad, 2017). It meant that such ontogenic variations in the cubic law differ from other fish species; however, a more detailed analysis regarding the reasons contributing to such variations is necessary. There was a variability of the ratios of body weight to total length among Climbing perch species from different geographical areas (Table 1.3). The average W/TL ratio of Climbing perch in the present study (0.167) was relatively higher than that of those sampled from Deepar Beel of Assam, India: 0.162 (Rahman et al., 2015), from Chandpur, Matlab of Kalipur, India: 0.069 (Begum and Minar, 2012) or from Tetulia River, Bangladesh: 0.083 (Hossain et al., 2015). However, this ratio was considerably lower as compared to those sampled from Kausalyaganga of Orissa, India: 0.390 (Kumar et al., 2013), from Kuttanad of Kerala, India: 0.363 (Kumary and Raj, 2016) or from Mohanpur of West Bengal, India: 0.353 mm (Ziauddin et al., 2016).

The average K value obtained (2.00) for Climbing perch in the present study were slightly lower than those collected from Kuttanad of Kerala, India: 2.06 (Kumary and Raj, 2016) or from Kausalyaganga of Orissa, India: 2.07 (Kumar et al., 2013). Barnham and Baxter (1998) suggested that if the K value is 1.00, the condition of the fish is poor, long and thin. A 1.20 value of K indicates that the fish is of moderate condition and acceptable to many anglers. A good and well-proportioned fish would have a K value that is approximately 1.40. Based on this criterion, the Climbing perch from Sungai Batang River were in good condition although fish grew negatively allometric.

Regardless the sex, Bagenal and Tesch (1978) documented the K value between 2.9 and 4.8 for mature freshwater fish species; meanwhile the K values in the current study ranged from 0.7304 to 3.2646, indicating that some of individual fish are being mature when captured. Condition factor is a quantitative parameter associated with determination of present and future population success through its influence on biology (growth, reproduction and survival) of the fish. In fish, the condition factor (K) reflects, through its variations, information on the physiological state of the fish in relation to its welfare (Le Cren, 1951). K also gives information when comparing two populations living in certain feeding, density, climate and other conditions; and when following up the degree of feeding activity of a species to verify whether it is making good use of its feeding source (Bagenal and Tesch, 1978). The body proportions of the fishes changed as fish grew in size during various life cycle stages (Kumar et al., 2013). Variation in the value of the mean K may be attributed to biological interaction involving intraspecific competition for food and space between species including sex, stages of maturity, changes in appetite, parasitic infections and physiological factors, season, state of stomach contents and availability of food (Le Cren, 1951;

Braga, 1986; Bagenal and Tesch, 1978; Sani et al., 2010). Moreover, body condition provides an alternative to the expensive in vitro proximate analyses of tissues (Sutton et al., 2000). Therefore, information on condition factor can be vital to culture system management because they provide the producer with information of the specific condition under which organisms are developing (Araneda et al., 2008; Kumar et al., 2013).

Table 1.3. Comparative parameters of length-weight relationships and growth patterns of Climbing perch from different geographical areas

Locations	Country	n	W/TL	a	b	R^2	r	Growth pattern	K	References
Sungai Batang River	Indonesia	156	0.167	0.00004	2.8353	0.8625	0.9287	A-	2.000	Present study
Banjarbaru, South Kalimantan	Indonesia	608	0.216	0.0005	1.8049	0.4339	0.6587	A-	2.115	Ahmadi (2018b)
Kuttanad, Kerala	India	246	0.363	0.0003	2.8452	0.9556	0.9775	A-	2.060	Kumary and Raj (2016)
Mohanpur, Nadia District	India	30	0.353	-2.025	2.316	0.5396	0.7346	A-	-	Ziauddin et al. (2016)
Kausalyaganga, Orissa	India	544	0.390	-1.432	2.7201	0.0821	0.9264	A-	2.070	Kumar et al. (2013)
Deepar Beel, Assam	India	120	0.162	-2.540	3.645	0.8500	0.9220	A+	1.000	Rahman et al. (2015)
Chandpur, Matlab, Kalipur	Bangladesh	73	0.069	-1.518	2.423	0.9660	0.9828	A-	1.085	Begum and Minar (2012)
Tetulia River	Bangladesh	176	0.083	0.0220	2.90	0.9740	0.9869	A-	-	Hossain et al. (2015)

a = constant, b = exponent, R^2 = determination coefficient, r = regression coefficient, BDD = body depth, W = body weight, TL = total length

In the investigated area, local fishermen mostly used *lukah* (fish pot), *tempirai* (stage-trap) and also electrofishing for catching Climbing perch from its natural habitats, while other workers used the seine nets in the cultured ponds, Bangladesh (Kohinoor et al., 2009), fish nets in local ditches in Adra Purulia, West Bengal India (Bhattacharjee and Chandra, 2016), gillnets in flood plain swamp, South Sumatera Province or in Batang Kerang Floodplain, Balai Ringin, Sarawak (Muthmainnah and Gaffar, 2017; Khairul Adha et al., 2009), *Khepla Jal* (cast net) in the Chalan Beel, Bangladesh (Sultana and Islam, 2017), *tampirai* (wire stage-trap) in Sebangau River, Central Kalimantan Province (Thornton et al., 2018), a conical trap in the ponds, West Bengal India (Patra et al., 2017), *lalangit* (horizontal set gillnet) in Bangkau swamp, South Kalimantan Province (Irhamsyah et al., 2017), *pukot* and electrofishing in floodplain Lakes of Agusan Marsh, Philippines (Jumawan and Seronay, 2017), light traps in the cultured ponds, South Kalimantan Province (Ahmadi et al., 2018; Ahmadi, 2018a). According to Aminah and Ahmadi (2018), the catchability of the gear is higher during the dry season compared to the wet season, because the fish are being concentrated on the sludge holes or shallow areas and allow for catching them easily. While Kamaruddin et al. (2011) found the opposite condition, with the reason is the wet season indicates the main feeding and growing time for the fish (Meye and Ikomi, 2012), and it is very likely to catch the fish. In addition, female Climbing perch showed a marked increase in their food intake early in the wet season (Bernal et al., 2015). Variation in the catches may be attributed to the catchability of the gears, species target, fishing ground characteristic, fishing operation, and the abundance of the fish in that area (Sultana and Islam, 2017; Ahmadi, 2018c).

There are three main constraints being faced in this area of study: the first, there is no daily record for Climbing perch catch in quantity (e.g. number, length and weight) because fishes are directly sold to traders or consumers in some places; secondly, fishing activity is on-going throughout the year regardless of seasonal periods, thus resulted in the ratio of the fish exploitation rate to the fish growth rate in this river is still unpredictable; and the thirdly, the use of electrofishing is still beyond the control because it is usually undertaken at the night. So, it is a great challenge for Marine and Fisheries Services of Banjar District to improve the quality of inland fishery statistical data and manage the fishery resources through EAFM program.

V. EPILOGUE: CONCLUSION AND RECOMMENDATION

The Climbing perch sampled from Sungai Batang River were in good condition and grew negatively allometric. The scientific information on the length-weight relationship and condition factor of climbing perch could be used to estimate the stock population and to take conservation measures.

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CHAPTER - II

PHOTOTAXIS RESPONSES

I. PROLOGUE: THE ROLE OF CLIMBING PERCH

The Climbing perch (*Anabas testudineus* Bloch, 1792) plays a significant role in fisheries and aquaculture practices because of having a high market value as important food fish, not only in Indonesia (Akbar et al., 2016) but also in Lao PDR (Sokheng et al., 1999), Cambodia (Sverdrup, 2002), Vietnam (Van and Hoan, 2009), southern Thailand (Chotipuntu and Avakul, 2010), Malaysia (Zalina et al., 2012), the Philippines (Bernal et al., 2015), Bangladesh (Hossain et al., 2015a; Uddin et al., 2017), and India (Kumar et al., 2013). It contents high iron and copper that support haemoglobin synthesis (Sarma et al., 2010) and has high quality poly-unsaturated fats and many essential amino acids (Kohinoor et al., 1991). It also provides 19.50% of protein and 2.27% of lipid (Ahmed et al., 2012). In nature, they can be found in all freshwater bodies such as rivers, streams, swamps, ponds, lakes, canals, reservoirs, and estuaries (Sarkar et al., 2005; Rahman and Marimuthu, 2010), and can also be cultured at cages, tanks and ponds (Long et al., 2006; Mondal et al., 2010; Kumar et al., 2013) with different culture strategies (Trieu et al., 2001; Phu et al., 2006; Chotipuntu and Avakul, 2010; Putra et al., 2016). Climbing perch are also well-known as a unique fish species because they can breathe air and are capable of spending 4-6 days out of water (Storey et al., 2002) by using their labyrinth organ (Rahman et al., 2015). Some of studies are dedicated to describe on breeding biology (Hafijunnahar et al., 2016), boldness (Binoy, 2015) and morphometric characteristic of this species (Hossain et al., 2015b).

A. Potential Impact

In Australia, Papua New Guinea and India, the presence of climbing perch is thought result in competition between wild birds, reptiles, animals and predatory fish from river or reservoir by using their sharp dorsal and opercular spines (Storey et al., 2002; Hitchcock, 2008; Paliwal and Bhandarkar, 2014).

The other side, Climbing perch statistically contributes about 12% (8.31 tons) of total inland capture fisheries production (69.97 tons) in South Kalimantan Province. It is abundantly found in three different types of swamp areas, namely “monotonous swamp” located on Hulu Sungai Selatan District (452.704 ha), “rain reservoir swamp” in Banjar, Tanah Laut, and Pulau Laut Districts (169.094 ha), and “tidal swamp” in Barito Kuala, Tanah Laut, and Kota Baru Districts (372.637 ha). High fishing intensity can greatly influence the fish population structure and reproductive potential of Climbing perch. Besides that, indiscriminate harvesting of fry and fingerlings, habitat modification, reduced water flow, growing human interventions on wetlands may also potentially threat for this fish population (Rahman et al., 2012; Kalita and Deka, 2013; Hossain et al., 2015b).

B. The reason behinds phototaxis study

Climbing perch encompasses a divergence feeding behaviour. They are a fierce predator, and will also eat other fish if they can master them. Some are omnivorous, which feeds on invertebrates, fish and plants. They appear to be visual feeders, feeding primarily during the day (Patra, 1993), and become active at night in search of prey. Local fishermen usually utilize their feeding behaviour to attract them into the traps or the nets with or without baits (Iwata et al., 2003; Bernal et al., 2015; Hossain et al., 2015b; Kumary and Raj, 2016; Irhamsyah et al., 2017). At the same time, study on the light-induced behavioral response in Climbing perch is completely lacking in these publications. By learning from previous studies (Ahmadi and Rizani, 2013; Aminah and Ahmadi, 2018) and combining with the present study, we believe that trapping with lights shows the promising option to harvest Climbing perch both from nature and culture pond. It is therefore improvement of the harvesting procedures is essential. For this reason, we carried out a series of trapping experiments to investigate phototactic responses of Climbing perch to various intensities and colors of light emitting diode (LED) underwater lamps in the pond experiment. In addition, the size distribution, length-weigh relationship and condition factor of the catches were also analyzed.

II. FOLLOW-UP RESEARCH

A. Ponds and Animal Experiment

The research activies were carried out in Banjarbaru, Kalimantan Selatan Province. In the first trial, trapping experiment was performed in a tarpaulin pond (3×2×0.9 m) filled with tap water of 0.60 m deep and 300 specimens of Climbing perch (Figure 2.1); while for the second experiment, it was conducted in a concrete pond (11.5×10×1.55 m, 0.50 m deep), belonged to the Faculty of Marine and Fisheries, Lambung Mangkurat University (Figure 2.2). The fish population in pond was estimated more than 1000 fishes. Fish were fed three times a day with commercial pellet at feeding ratio of 5% body weight. Water transparency was 28.35 cm observed from the surface using a Secchi disk, while turbidity of the water was 40.9 NTU (Nephelometric Turbidity Unit). The water surface temperature ranged of 29.0-30.5 °C through the trials. The fishing trials were conducted for 14-day sampling period.

Figure 2.1. A tarpaulin pond used for the trapping experiment with the light

Figure 2.2 A concrite pond belongs to the Faculty of Marine and Fisheries, Lambung Mangkurat University

B. Trap Design and Lamp Types

In the first experiment, a total of four circle-shaped traps were created with the same dimensions and materials (Figure 2.3A), consisted of trap with one-lamp, trap with two-lamp, trap with three-lamp, and trap without lamp as a control. The trap was made of black waring net (material usually used for cages), which fastened around two-wire (∅ 2 mm) ring frames; 1540 mm perimeter was placed on the top and bottom with diameter of a circle 490 mm and 270 mm high. The trap had three entry funnels located around the trap with a 50 mm inside ring entrance. A sheet of Polyethylene (PE) nylon multifilament was placed on the top allowed for removal of the catch and another was placed on the bottom where the lamp was attached. Except the control trap, each of trap was assigned with 0.9-2.7 W LED (Light Emitting Diode) Torpedo lamp (215×50 mm, Fishing Net Industry Co. Ltd. China) containing blue (460 nm), green (530 nm), yellow (590 nm), orange (620 nm), red (625 nm) and white, powered by 3 V dry-cell batteries respectively. In addition, white LED cannot be differentiated by wavelength because it appears "cool", "neutral" or "warm" white due to its color temperature. The lamps are constructed with advance circuit design technology and latest high-brightness LED component, as well as safe to use, convenience and more durable. The light intensity was ranged from 8.4 ± 1.65 lx to 6730 ± 533.33 lx, and measured with a light-meter LX-100 (Lutron, Taiwan) at the Basic Laboratory of the Faculty of Mathematic and Natural Science, Lambung Mangkurat University.

In the second experiment, a total of 13 circle-shaped traps were constructed with the same dimensions and materials (Figure 2.3B), comprising six continuous light traps, six blinking light traps and a control (trap without lamp). The trap made of Polyamide (PA) nylon monofilament (31.75 mm mesh size), was fastened around two wire ring frames (wire dia. 2 mm); 1540 mm perimeter, was placed on the top and bottom (490 mm diameter). The net height was 270 mm with a hanging ratio of 0.45. Each trap had four entry holes located on each side of the trap with about ~5 cm opening mesh. A sheet of Polyethylene (PE) nylon multifilament was placed on the bottom where the lamp was attached and another was placed on the top, allowing for catch removal. Each of the light traps was assigned with 0.9 W LED (Light Emitting Diode) Torpedo light (215 × 50 mm, Fishing Net Industry Co. Ltd. China) containing blue (8.4 ± 1.65 lx), orange (42.5 ± 2.68 lx), yellow (332.0 ± 37.14 lx), red (376.4 ± 93.40 lx), white (1282.6 ± 91.35 lx), and green (3116 ± 342.74 lx), powered by 3 V dry-cell batteries, respectively. The light intensity of each lamp was measured by a light-meter LX-100 (Lutron, Taiwan) with the same procedure.

Figure 2.3 Type of traps and lamps used for the trapping experiments

C. Experimental Procedures

Trapping experiments with the lamps were carried out at night under ambient light environment. The traps were spread out around the pond and retrieved the following morning. The traps were rotated each night with soaking time of 10 h and 5 times repeatedly used. The experiments consisted of 168-trap hauls per lamp type for the first trial and 140-trap hauls per lamp type for the second trial. After retrieval, the catches were counted, identified for sex, measured for total length and weight, and released back into the pond. Total length (TL) was measured from the tip of the snout (mouth closed) to the end of the caudal fin using a standar ruler to the nearest 0.1 mm. A digital balance with an accuracy of of 0.01 g (Dretec KS-233, Japan) was used to weigh body weight (W). The ratio of W/TL was empirically determined with non-dimension number. The size distribution of fish captured was set at 10-interval class for TL and 5-interval class for weight group.

D. Data Analysis

The relationship of length-weight of Climbing perch was expressed in the allometric form:

$$\mathbf{W = {}_{a}L^{b}}$$

Where W is the total weight (g), L is the total length (mm), *a* is the constant showing the initial growth index and *b* is the slope showing growth coefficient. If fish retains the same shape and grows increase isometrically, it is therefore $b = 3$. When weight increases more than length ($b > 3$), it shows positive allometric. When the length increases more than weight ($b < 3$), it indicates negative allometric (Morey et al., 2003). The condition factor of fish was calculated using formula (Wootton, 1998):

$$\mathbf{K = 100W/L^3}$$

Where K is condition factor, L is total length (cm) and W is weight (g). The CPUE (catch per unit effort) was determined as average number of fish per net per night (Baker et al., 2008), which is adapted for this study. The YPUE (yield per unit effort) was calculated using the following equation (Godoy et al., 2003):

$$YPUE = \frac{\sum weight}{\sum \ number\ of\ nets * \sum \ fishing\ trials}$$

E. Statistical Analysis

The Mann-Whitney test was used to determine whether or not significant difference in number of catches, weight, CPUE or YPUE between two light traps or between light trap and control. The Kruskal-Wallis test, the analysis of variance by ranks, was employed to determine if there were significantly differences in the total number of catches, weight, CPUE or YPUE of each trap group. All statistical tests were evaluated at the 95% confidence level using SPSS 18.0 software.

III. RESEARCH FINDINGS

A. Trapping Experiment with Various Light Intensities

The results of trapping experiments with various intensities and colors of LED underwater lamps were presented in Table 2.1. The daily averages of catch for male were 9 (2-24) fishes and 149 (28-399) g weights; while for female were 17 (1-43) fishes and 262 (22-785) g eight. Many more females caught than males ($P < 0.01$) indicating that females were more attractive to color tested than males. Females were also heavier than males ($P < 0.05$). The mean body size of male ranged from 82.00 ± 0.55 to 127.00 ± 34.93 mm TL and from 9.33 ± 2.31 to 38.50 ± 26.42 g weight; while for female ranged from 86.39 ± 9.49 to 104.17 ± 27.49 mm TL and from 10.89 ± 3.91 to 25.83 ± 25.33 g weight (Table 2.2). Except yellow and orange light traps, there were significantly differences in the number catch of blue, green, red and white light traps ($P < 0.01$) as well as found in the total catch (Table 2.3). In other word, the use of light traps is more effective in catching climbing perch as compared to the trap without lamp ($P < 0.001$). No significant difference was observed in condition factor between male and female ($P > 0.05$). It can be pointed out that Climbing perch was able to differentiate various colors.

Table 2.1. Number of catch, total catch, and condition factor (K) of Climbing perch collected from a pond experiment.

Light Trap	Treatment	Intensity (lx)	Number of catches			Total catch (g)			K Mean ± SD	
			Male	Female	Total	Male	Female	Total	Male	Female
Blue	1-lamp	8.4 ± 1.65	24	29	53	371	408	779	1.47±0.22	1.43±0.29
	2-lamp	13.9 ± 1.73	8	21	29	100	340	440	1.47±0.16	1.51±0.17
	3-lamp	20.4 ± 2.12	11	23	34	130	347	477	1.45±0.23	1.47±0.17
	Control	-	4	9	13	65	128	193	1.57±0.17	1.49±0.13
Green	1-lamp	3116 ± 342.74	6	12	18	78	166	244	1.61±0.16	1.66±0.23
	2-lamp	5277 ± 395.48	3	13	16	28	185	213	1.68±0.20	1.63±0.14
	3-lamp	6730 ± 533.33	2	18	20	22	196	218	1.51±0.16	1.63±0.12
	Control	-	-	-	-	-	-	-	-	-
Yellow	1-lamp	332 ± 37.14	10	42	52	211	694	905	1.60±0.16	1.67±0.22
	2-lamp	593.2 ± 38.85	4	15	19	65	253	318	1.65±0.22	1.55±0.37
	3-lamp	757.6 ± 33.88	12	43	55	234	785	1019	1.56±0.18	1.64±0.36
	Control	-	6	10	16	110	156	266	1.48±0.24	1.54±0.21
Orange	1-lamp	42.5 ± 2.68	21	12	33	318	168	486	1.47±0.18	1.47±0.19
	2-lamp	79.1 ± 3.25	7	11	18	89	147	236	1.38±0.19	1.56±0.11
	3-lamp	92.5 ± 3.92	11	10	21	163	154	317	1.41±0.21	1.54±0.17
	Control	-	6	7	13	108	78	186	1.48±0.16	1.47±0.31
Red	1-lamp	376.4 ± 93.40	24	35	59	399	547	946	1.53±0.23	1.67±0.45
	2-lamp	414.8 ± 49.43	14	28	42	231	453	684	1.54±0.14	1.64±0.41
	3-lamp	554.4 ± 38.02	12	22	34	178	321	499	1.58±0.36	1.59±0.16
	Control	-	7	8	15	107	121	228	1.41±0.14	1.41±0.23
White	1-lamp	554.4 ± 38.02	4	12	16	102	310	412	1.56±0.13	1.77±0.74
	2-lamp	1756.3 ± 78.71	8	9	17	240	150	390	1.66±0.19	1.96±0.72
	3-lamp	2220 ± 351.85	6	8	14	231	160	391	1.66±0.28	1.74±0.20
	Control	-	-	1	1	-	22	22	-	1.56±0.00
Daily average of catch			9	17	25	149	262	411	1.41±0.18	1.52±0.25

Table 2.2. Mean ± standard deviation of total length and weight of male and female of Climbing perch

Light Trap	Treatment	Intensity (lx)	Mean ± SD of TL (mm)		Mean ± SD of weight (g)	
			Male	Female	Male	Female
Blue	1-lamp	8.4 ± 1.65	100.54 ± 12.20	98.31 ± 12.76	15.46 ± 5.52	14.07 ± 5.24
	2-lamp	13.9 ± 1.73	94.25 ± 11.60	102.05 ± 9.66	12.50 ± 3.63	16.19 ± 1.89
	3-lamp	20.4 ± 2.12	92.45 ± 12.60	99.78 ± 12.34	11.82 ± 4.35	15.09 ± 4.97
	Control	-	100.75 ± 12.69	97.56 ± 14.28	16.25 ± 4.57	14.22 ± 5.40
Green	1-lamp	3116 ± 342.74	92.83 ± 10.24	94.33 ± 0.13	13.00 ± 3.42	13.83 ± 2.27
	2-lamp	5277 ± 395.48	82.00 ± 0.55	94.69 ± 8.99	9.33 ± 2.31	14.23 ± 3.90
	3-lamp	6730 ± 533.33	90.00 ± 7.07	86.39 ± 9.49	11.00 ± 1.41	10.89 ± 3.91
	Control	-	-	-	-	-
Yellow	1-lamp	332 ± 37.14	109.20 ± 8.42	98.98 ± 11.80	21.10 ± 5.07	16.52 ± 5.02
	2-lamp	593.2 ± 38.85	99.50 ± 12.69	103.80 ± 22.43	16.25 ± 4.11	16.87 ± 5.87
	3-lamp	757.6 ± 33.88	106.58 ± 11.32	103.35 ± 11.20	19.50 ± 6.33	18.26 ± 4.94
	Control	-	107.50 ± 5.24	99.70 ± 13.31	18.33 ± 3.14	15.60 ± 5.17
Orange	1-lamp	42.5 ± 2.68	100.62 ± 11.36	96.42 ± 13.96	15.14 ± 3.81	14.00 ± 6.32
	2-lamp	79.1 ± 3.25	95.00 ± 16.33	93.82 ± 12.03	12.71 ± 6.40	13.36 ± 4.74
	3-lamp	92.5 ± 3.92	100.91 ± 14.07	99.40 ± 10.77	14.82 ± 4.81	15.40 ± 4.27
	Control	-	106.17 ± 9.39	89.43 ± 10.95	18.00 ± 4.60	11.14 ± 5.24
Red	1-lamp	376.4 ± 93.40	99.13 ±19.93	97.17 ± 13.26	16.63 ± 5.02	15.63 ± 5.49
	2-lamp	414.8 ± 49.43	101.43 ± 12.29	98.79 ± 13.72	16.50 ± 5.14	16.18 ± 5.47
	3-lamp	554.4 ± 38.02	97.75 ± 12.73	95.68 ± 13.01	14.83 ± 4.43	14.59 ± 5.76
	Control	-	101.86 ± 10.12	100.75 ± 15.12	15.29 ± 4.64	15.13 ± 5.28
White	1-lamp	554.4 ± 38.02	110.50 ± 30.07	104.17 ± 27.49	25.50 ± 23.84	25.83 ± 25.33
	2-lamp	1756.3 ± 78.71	111.38 ± 33.34	89.33 ± 16.43	30.00 ± 31.00	16.67 ± 16.44
	3-lamp	2220 ± 351.85	127.00 ± 34.93	95.63 ± 27.44	38.50 ± 26.42	20.00 ± 24.86
	Control	-	-	80.00 ± 0.00	-	8.00 ± 0.00

Table 2.3. Total number of catches, total catch and significance test of Climbing perch taken from a pond experiment

Light Traps	No. Trials	Total number of catches and Values of the test						Total catch (g) and Values of the test					
		Blue	Green	Yellow	Orange	Red	White	Blue	Green	Yellow	Orange	Red	White
1-lamp	5	53	18	52	33	59	16	779	244	905	486	946	412
2-lamp	5	29	16	19	18	42	17	440	213	318	236	684	390
3-lamp	5	34	20	55	21	34	14	477	218	1019	317	499	391
Control	5	13	0	16	13	15	1	193	0	266	186	228	22
Significance test		$P<0.01$	$P<0.05$	$P>0.05$	$P>0.05$	$P<0.01$	$P<0.05$	$P<0.01$	$P<0.05$	$P>0.05$	$P>0.05$	$P<0.01$	$P<0.05$
Chi-square (χ^2)		12.496	9.894	2.901	7.502	12.573	9.875	12.496	9.894	2.901	7.502	12.573	9.875

Morphometric analysis showed that the mean ratio of body width to total length (W_d/TL) of female was significantly higher than male across the trials ($P < 0.0001$). The W_d/TL ratios obtained for male were ranged from 0.188 to 0.299 (0.230 ± 0.02) and for female were from 0.176 to 0.417 (0.252 ± 0.03) (Figure 2.4A). No significant difference was observed in the mean ratio of body weight to total length (W/TL) between male and female ($P < 0.05$). The W/TL ratios obtained for male and female were 0.160 ± 0.06 (0.067 - 0.509) and 0.155 ± 0.05 (0.052 - 0.583) (Figure 2.4B).

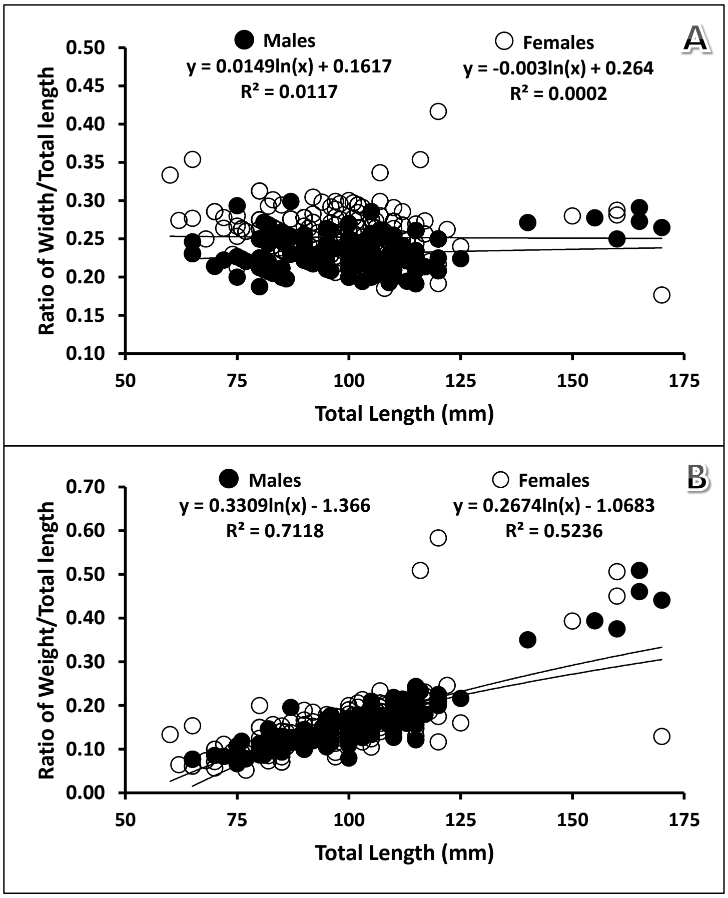

Figure 2.4 Climbing perch female had the mean ratio of body width to total length significantly higher than male [A], but no significant difference in the mean ratio of body weight to total length was observed [B].

The size distribution of the catch is given in Table 2.4. The positive group responses of fish were more pronounced at the length sizes between 100 and 109 mm, where more than 30% individual (72 males and 127 females) were caught. Over 119 mm TL, only a few of fish was collected or less than 3% of total catch. The heaviest catch for male (62.38%) and female (59.30 %) was exactly found in the lower class between 11 and 20 g weight.

Table 2.4. The size distribution of length-weight relationship of Climbing perch sampled from trapping experiments.

Class interval	Number of catches				Class interval	Number of catches			
of Total length	Male	%	Female	%	of Weight	Male	%	Female	%
60-69	2	0.95	7	1.76	01-10	38	18.10	96	24.12
70-79	7	3.33	22	5.53	11-20	131	62.38	236	59.30
80-89	26	12.38	72	18.09	21-30	35	16.67	61	15.33
90-99	38	18.10	79	19.85	31-40	-	-	-	-
100-109	72	34.29	127	31.91	41-50	1	0.48	-	-
110-119	53	25.24	78	19.60	51-60	1	0.48	2	0.50
120-129	6	2.86	9	2.26	61-70	1	0.48	1	0.25
130-139	-	-	-	-	71-80	2	0.95	1	0.25
140-149	1	0.48	-	-	81-90	1	0.48	1	0.25
150-159	1	0.48	1	0.25					
160-169	3	1.43	2	0.50					
170-179	1	0.48	1	0.25					

Comparative fishing showed that the daily averages of CPUE for blue, green, red and white light traps were considerably higher than the control ($P < 0.05$), but not for yellow and orange light traps ($P > 0.05$). The values obtained ranged between 0.04 and 2.36 fish trap^{-1} night^{-1}. Dealing with the daily average of the estimated YPUE, each light trap was found to be higher than the control ($P < 0.05$), except yellow light trap ($P > 0.05$). The values obtained ranged between 0.32 and 40.76 g trap^{-1} trial^{-1} (Table 2.5).

Table 2.6 shows comparative variables tested to show significances of the daily averages of CPUE for each group of light traps used. Blue trap with 1-lamp or 2-lamp was significantly higher than control ($P < 0.05$); meanwhile, trap with 1-lamp was greater than 2-lamp ($P < 0.05$). For the green trap, all lamps tested were considerably higher than control ($P < 0.05$), but no significant differences among them was observed ($P > 0.05$). There were no statistically significant differences in the yellow traps across the trials ($P > 0.05$). The only orange trap with 1-lamp or 3-lamp was found to be higher than control ($P < 0.05$). For the red and white traps, all lamps tested were considerably higher than control ($P < 0.05$), but no significant difference was observed between trap with 1-lamp and 2-lamp, as well as trap with 2-lamp and 3-lamp ($P > 0.05$).

From available data, it can be pointed that Climbing perch female condition was healthier than male. The K value of female was about 8% higher than that of male. The mean K values obtained for male and female were 1.41 ± 0.18 and 1.52 ± 0.25, respectively (see Table 2.1).

Table 2.5. Daily averages CPUE, YPUE and significance test of Climbing perch taken from the trapping experiments

Light Traps	No. Trials	Daily averages of CPUE (fish trap^{-1} night^{-1})						Daily averages of YPUE (g trap^{-1} night^{-1})					
		Blue	Green	Yellow	Orange	Red	White	Blue	Green	Yellow	Orange	Red	White
1-lamp	5	2.12	0.72	2.08	1.32	2.36	0.64	31.16	9.76	36.2	19.44	37.84	16.48
2-lamp	5	1.16	0.64	0.76	0.72	1.68	0.68	17.6	8.52	12.72	9.44	27.36	15.6
3-lamp	5	1.36	0.8	2.2	0.84	1.36	0.56	19.08	8.72	40.76	12.68	19.96	15.64
Control	5	0.52	-	0.64	0.52	0.56	0.04	7.72	-	10.64	7.44	9.12	0.32
Significance test		$P<0.01$	$P<0.05$	$P>0.05$	$P>0.05$	$P<0.01$	$P<0.05$	$P<0.01$	$P<0.05$	$P>0.05$	$P<0.05$	$P<0.01$	$P<0.05$
Chi-square (χ^2)		12.496	9.894	2.901	7.502	12.573	9.875	11.623	9.729	2.636	10.177	12.527	9.268

Table 2.6. Comparative variables tested to show significances of the daily averages of CPUE for each group of light traps used.

Type of trap	Variable tested[1]	Daily averages of CPUE[1]	Variable tested[2]	Daily averages of CPUE[2]	Mann-Whitney test	z	P
Blue	1-lamp	10.60	2-lamp	5.80	1.00	-2.417	P<0.05
	1-lamp	10.60	3-lamp	6.80	3.50	-1.892	P>0.05
	1-lamp	10.60	control	2.60	0.00	-2.652	P<0.001
	2-lamp	5.80	3-lamp	6.80	10.00	-0.527	P>0.05
	2-lamp	5.80	control	2.60	1.50	-2.341	P<0.05
	3-lamp	6.80	control	2.60	3.50	-1.940	P>0.05
Green	1-lamp	3.60	2-lamp	3.20	11.50	-0.211	P>0.05
	1-lamp	3.60	3-lamp	4.00	12.00	-0.106	P>0.05
	1-lamp	3.60	control	0.00	2.50	-2.362	P<0.05
	2-lamp	3.20	3-lamp	4.00	9.00	-0.738	P>0.05
	2-lamp	3.20	control	0.00	0.00	-2.795	P<0.001
	3-lamp	4.00	control	0.00	0.00	-2.785	P<0.001
Yellow	1-lamp	10.40	2-lamp	3.80	7.50	-1.061	P>0.05
	1-lamp	10.40	3-lamp	11.00	12.00	-0.105	P>0.05
	1-lamp	10.40	control	3.20	6.50	-1.257	P>0.05
	2-lamp	3.80	3-lamp	11.00	7.500	-1.061	P>0.05
	2-lamp	3.80	control	3.20	11.00	-0.319	P>0.05
	3-lamp	11.00	control	3.20	6.50	-1.265	P>0.05
Orange	1-lamp	6.60	2-lamp	3.60	5.50	-1.494	P>0.05
	1-lamp	6.60	3-lamp	4.20	6.50	-1.281	P>0.05
	1-lamp	6.60	control	2.60	1.50	-2.348	P<0.05
	2-lamp	3.60	3-lamp	4.20	9.00	-0.747	P>0.05
	2-lamp	3.60	control	2.60	8.50	-0.894	P>0.05
	3-lamp	4.20	control	2.60	3.00	-2.081	P<0.05
Red	1-lamp	11.8	2-lamp	8.4	6.50	-1.261	P>0.05
	1-lamp	11.8	3-lamp	6.8	3.00	-1.997	P<0.05
	1-lamp	11.8	control	3	0.00	-2.635	P<0.001
	2-lamp	8.4	3-lamp	6.8	10.50	-0.424	P>0.05
	2-lamp	8.4	control	3	0.50	-2.530	P<0.05
	3-lamp	6.8	control	3	0.50	-2.538	P<0.05
White	1-lamp	3.2	2-lamp	3.4	11.50	-0.224	P>0.05
	1-lamp	3.2	3-lamp	2.8	11.00	-0.230	P<0.05
	1-lamp	3.2	control	0.2	0.00	-2.712	P<0.001
	2-lamp	3.4	3-lamp	2.8	9.00	-0.752	P>0.05
	2-lamp	3.4	control	0.2	0.00	-2.730	P<0.001
	3-lamp	2.8	control	0.2	3.00	-2.132	P<0.05

Figure 2.5 clearly demonstrates that male and female of Climbing perch had negative allometric growth pattern, which means that length increases more than weight. The *b* values obtained for males and females were 2.8247 and 2.7255 respectively. No significant difference in the slope between males and females was observed ($P > 0.05$). The length and weight relationships were expressed as: $W = 3\times10^{-5}\ TL^{2.8247}$ for males and $W = 6\times10^{-5}\ TL^{2.7255}$ for females. The determination coefficient (R^2) obtained for males and females were 0.9000 and 0.8274, indicating that 90% of variability of the weight was explained by the length. The regression coefficients (r) gained for males and females were 0.9487 and 0.9096, found to be higher than 0.5, showing that the length-weight relationship was positively correlated. The trend lines of curves closed each other indicating an identical growth pattern between males and females.

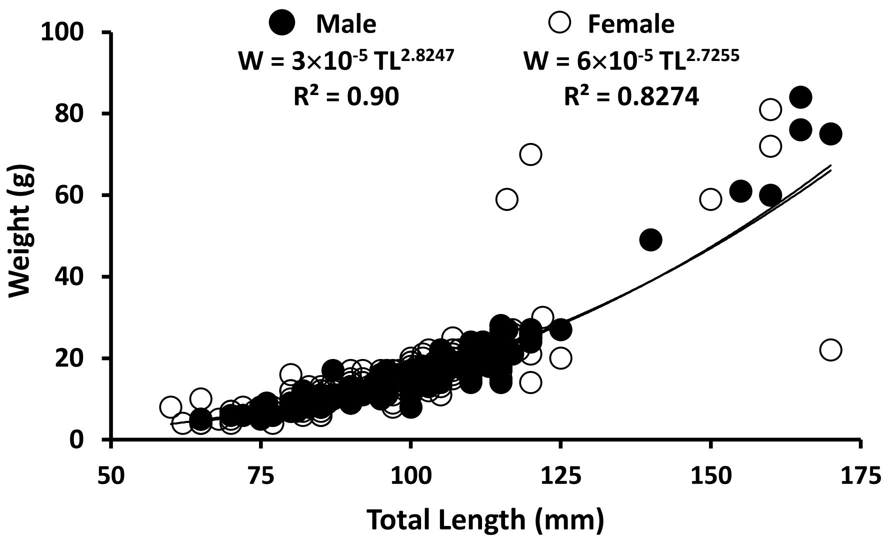

Figure 2.5. The regression curve of length-weight relationship of Climbing perch. Males and females showing a negative allometric growth pattern.

B. Trapping Experiment with Continuous and Blinking lights

A total of 96 individuals of Climbing perch (2,155 g) consisted of 34 males (791 g) and 62 females (1,364 g) with the sex ratio of male to female: 1:2, collected from pond experiment using the continuous, blinking light traps, and the control (Table 2.7). There were more females caught than males ($P < 0.05$) indicating that females were more attracted to color than males. The body sizes of Climbing perch ranged from 76 to 135 mm TL and from 8 to 55 g weight. There were significant differences in the number of fish caught among the three trap treatments ($P < 0.001$).

Both continuous and blinking light traps captured more Climbing perch than the control ($P < 0.001$), but no significant differences in the number of fish caught between them was observed. Similarly, no significant difference was found in the weight of the catch and YPUE, consequentially. On the other hand, the use of continuous light traps was found to be as effective as the blinking light traps in catching Climbing perch from a pond. The YPUEs for continuous, blinking light traps, and control were ranged from 9.21 to 20.63, from 5.07 to 19.50 and 5.14 g trap^{-1} trial^{-1}. The mean Y PUEs for males and females were 4 ± 2.25 and 7 ± 4.50 g trap^{-1} trial^{-1}, respectively. The mean K values of 2.10 ± 0.40 for males and 2.13 ± 0.34 for females indicated fish in better condition.

There was no significant difference in the number of catches and CPUE for each light trap (blue, green, yellow, orange, red and white) as shown in Table 2.8. The CPUEs for continuous, blinking light traps and control ranged from 0.43 to 0.93, from 0.21 to 0.86 and 0.21 fish trap^{-1} night^{-1}, respectively. It can be said that Climbing perch was able to differentiate between various colors of light, as exhibited in this analysis.

Table 2.7. Number of catch, weight, YPUE and condition factor (K) of Climbing perch from the pond experiment

Light Trap	Treatment	Number of catches			Weight (g)			YPUE			Mean ± SD of K	
		Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Without lamp	Control	2	1	3	57	15	72	4.07	1.07	5.14	2.31±0.73	2.44±0.00
Blue	Continuous	5	2	7	117	42	159	8.36	3.00	11.36	2.03±0.73	2.10±0.04
	Blinking	1	5	6	25	161	186	1.79	11.50	13.29	2.29±0.00	2.14±0.35
Green	Continuous	4	3	7	101	56	157	7.21	4.00	11.21	2.34±0.41	2.07±0.13
	Blinking	1	2	3	30	41	71	2.14	2.93	5.07	1.74±0.00	1.74±0.08
Yellow	Continuous	4	7	11	74	150	224	5.29	10.71	16.00	2.43±0.58	2.11±0.61
	Blinking	4	8	12	76	197	273	5.43	14.07	19.50	1.70±0.00	2.12±0.37
Orange	Continuous	2	4	6	39	90	129	2.79	6.43	9.21	1.78±0.19	2.22±0.35
	Blinking	3	6	9	70	133	203	5.00	9.50	14.50	1.67±0.30	1.85±0.58
Red	Continuous	3	11	14	90	208	298	6.43	14.86	21.29	2.17±0.49	1.99±0.20
	Blinking	3	4	7	68	77	145	4.86	5.50	10.36	1.78±0.76	2.55±1.06
White	Continuous	1	6	7	22	135	157	1.57	9.64	11.21	2.57±0.00	2.11±0.40
	Blinking	1	3	4	22	59	81	1.57	4.21	5.79	2.41±0.00	1.94±0.63
Total		34	62	96	791	1,364	2,155	56.50	97.43	148.79	-	-
Mean ± SD		3±1.39	5±2.80	7±3.36	61±31.49	105±62.99	166±71.36	4±2.25	7±4.50	12±5.10	2.10±0.40	2.13±0.34

Table 2.8. The summary of number of catches, CPUE, YPUE, and weight of Climbing perch From the pond experiments

Light Traps	No. Trials	Number of catches or values of the test							Weight (g)					
		Blue	Green	Yellow	Orange	Red	White		Blue	Green	Yellow	Orange	Red	White
Continuous	14	7	7	11	6	13	7		159	157	224	129	285	157
CPUE		0.50	0.50	0.79	0.43	0.93	0.50	YPUE	11.36	11.21	16.00	9.21	20.36	11.21
Blinking	14	6	3	12	9	7	4		186	71	273	203	145	81
CPUE		0.43	0.21	0.86	0.64	0.50	0.29	YPUE	13.29	5.07	19.50	14.50	10.36	5.79
Control	14	3	3	3	3	3	3		72	72	72	72	72	72
CPUE		0.21	0.21	0.21	0.21	0.21	0.21	YPUE	5.14	5.14	5.14	5.14	5.14	5.14
Total		16	13	26	18	23	14		417	300	569	404	502	310
Significance test		$p>0.05$	$p>0.05$	$p>0.05$	$p>0.05$	$p>0.05$	$p>0.05$		$p>0.05$	$p>0.05$	$p>0.05$	$p<0.05$	$p>0.05$	$p>0.05$
Chi-square (χ^2)		1.65	0.52	0.51	1.36	1.60	0.32		1.57	1.57	0.49	0.49	1.30	0.35

Table 2.9 showed the mean ± standard deviation of total length, weight and the ratio of body sizes of Climbing perch. Statistically, there were no significant differences in the said parameters between males and females ($P > 0.05$) caught by both the continuous and blinking light traps. On the other hand, the mean total length, weight and the W/TL ratio of males in the trap without lamp (control) were comparatively higher than those of females ($P < 0.05$). Males had the mean total length, weight and the W/TL ratio were 1.3, 1.9 and 1.4 times higher than females.

The size distribution of length-weight relationship of Climbing perch that caught by the continuous and blinking light traps was presented in Table 2.10. It was clearly demonstrated that the light traps collected more individuals of Climbing perch at the length sizes between 90 and 109 mm TL (26.47 - 41.94%) or between 16 and 25 g weight (30.30 - 45.16%). In the other word, the positive group responses of Climbing perch were more pronounced in the middle size classes compared to lower or higher classes. The highest number of catch for males (26.47 %) and females (41.94 %) was found in the length size between 100 and 109 mm. While the largest amount of catch was recorded between 16 and 20 g (45.16 %) for females and between 21 and 25 g (33.33 %) for males. None of Climbing perch was caught between 60 and 69 mm TL or between 140 and 169 mm TL. It was similarly found in the weight size classes between 1 and 5 g or between 36 and 40 g.

Table 2.9. Mean ± standard deviation of total length, weight and the ratio of body sizes of Climbing perch

Light Trap	Treatment	Mean±SD of TL (mm)		Mean±SD of Weight (g)		W/TL	
		Male	Female	Male	Female	Male	Female
Without lamp	Control	108 ± 23.33	85 ± 0.00	28.5 ± 9.19	15.0 ± 0.00	0.26 ± 0.03	0.18 ± 0.00
Blue	Continuous	107 ± 13.96	100 ± 2.83	23.4 ± 15.84	21.0 ± 1.41	0.22 ± 0.13	0.21 ± 0.01
	Blinking	103 ± 0.00	112 ± 13.04	25.0 ± 0.00	32.2 ± 15.83	0.24 ± 0.00	0.28 ± 0.10
Green	Continuous	102 ± 17.45	96 ± 2.89	25.3 ± 9.74	18.7 ± 1.53	0.24 ± 0.06	0.19 ± 0.01
	Blinking	120 ± 0.00	106 ± 7.78	30.0 ± 0.00	20.5 ± 3.54	0.25 ± 0.00	0.19 ± 0.02
Yellow	Continuous	92 ± 3.00	101 ± 15.99	18.5 ± 3.79	21.4 ± 6.43	0.20 ± 0.04	0.21 ± 0.04
	Blinking	110 ± 17.15	105 ± 6.78	19.0 ± 4.08	24.6 ± 4.00	0.18 ± 0.05	0.23 ± 0.03
Orange	Continuous	103 ± 0.00	101 ± 5.68	19.5 ± 2.12	22.5 ± 2.08	0.19 ± 0.02	0.22 ± 0.02
	Blinking	112 ± 10.02	107 ± 12.42	23.3 ± 2.08	22.2 ± 7.08	0.21 ± 0.21	0.21 ± 0.05
Red	Continuous	112 ± 12.50	98 ± 5.12	30.0 ± 3.46	18.9 ± 2.36	0.27 ± 0.02	0.19 ± 0.02
	Blinking	110 ± 10.00	92 ± 12.30	22.7 ± 8.33	19.3 ± 7.14	0.21 ± 0.08	0.17 ± 1.42
White	Continuous	95 ± 0.00	102 ± 6.41	22.0 ± 0.00	22.5 ± 4.68	0.23 ± 0.00	0.22 ± 0.04
	Blinking	97 ± 0.00	102 ± 12.86	22.0 ± 0.00	19.67 ± 0.58	0.23 ± 0.00	0.19 ± 0.02

Table 2.10. The size distribution of length-weight relationship of Climbing perch taken from pond using the light traps

Interval Class	Number of catches				Interval Class	Number of catches			
of Total length	Male	%	Female	%	of Weight	Male	%	Female	%
60 - 69	0	0.00	0	0.00	1 - 5	0	0.00	0	0.00
70 - 79	0	0.00	1	1.61	6 - 10	1	3.03	0	0.00
80 - 89	3	8.82	2	3.23	11 - 15	1	3.03	5	8.06
90 - 99	9	26.47	21	33.87	16 - 20	10	30.30	28	45.16
100 - 109	9	26.47	26	41.94	21 - 25	11	33.33	17	27.42
110 - 119	6	17.65	8	12.90	26 - 30	3	9.09	7	11.29
120 - 129	6	17.65	2	3.23	31 - 35	6	18.18	3	4.84
130 - 139	1	2.94	2	3.23	36 - 40	0	0.00	0	0.00
140 - 149	0	0.00	0	0.00	41 - 45	0	0.00	1	1.61
150 - 159	0	0.00	0	0.00	46 - 50	1	3.03	0	0.00
160 - 169	0	0.00	0	0.00	51 - 55	0	0.00	1	1.61
Total	34	100	62	100	Total	33	100	62	100

Both male and female of Climbing perch had a negative allometric growth pattern (Figure 2.6), which means that length increased more than weight. The *b* values obtained for males and females were 1.7271 and 1.8828 respectively. No significant difference in the slope was observed between males and females captured ($P > 0.05$). The relationships of length and weight were expressed as: $W = 7.2 \times 10^{-4}\ TL^{1.7271}$ for males and $W = 3.5 \times 10^{-4}\ TL^{1.8828}$ for female. The determination coefficient (R^2) obtained for males and females were 0.3723 and 0.4955, indicating that about 50% of variability of the weight was explained by the length. The regression coefficients (r) gained for males and females were 0.6101 and 0.7039, found to be higher than 0.5, it meant that the length-weight relationship showed positive correlation. Regarding relative fishing efficiency, there was no significant difference in the ratio of YPUE to mesh size between continuous and blinking light trap used ($P > 0.05$), as given in Figure 2.7.

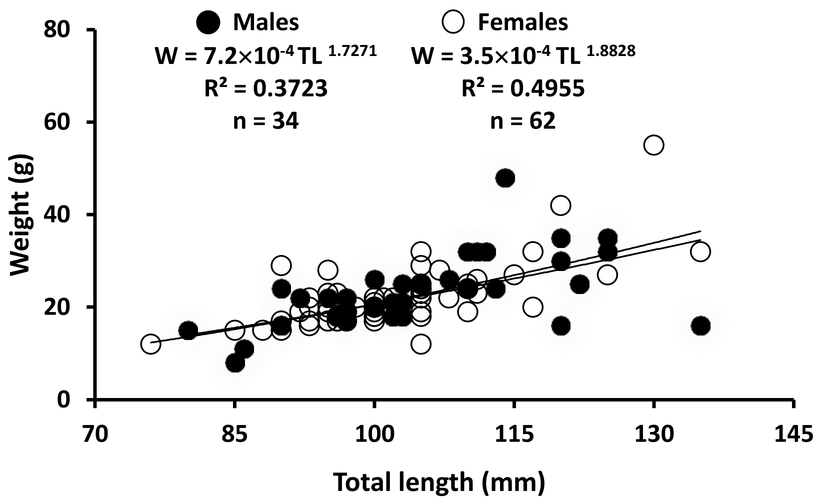

Figure 2.6. The length and weight relationship of Climbing perch obtained from the pond experiment using continuous and blinking light traps.

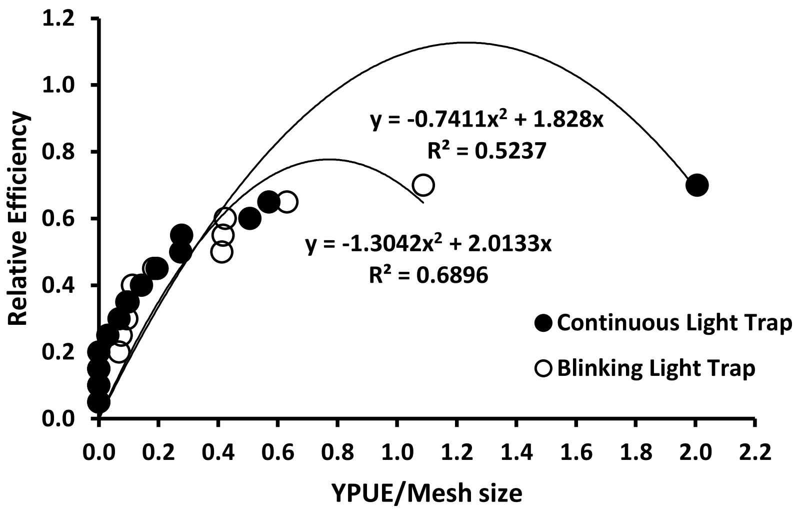

Figure 2.7 The ratio of YPUE to mesh size showing no significant difference in the relative fishing efficiency between continuous and blinking light.

IV. DISCUSSION

The most important result of the first experiment was that Climbing perch positively responded to various intensities and colors tested. The results also clearly confirmed that the six different light traps differed significantly in CPUE, with the red trap having the highest performance of all traps used. Furthermore, the differences in specific CPUEs appeared to depend not only on the probability of fish to enter the different light traps, but also on differences in the spectral colors. At short-wavelengths (blue-orange), the traps with 1-lamp yielded the catches as effectively as traps with 3-lamp. Otherwise, at longer wavelength, the use of red or white traps with 1-lamp found to be more effective as compared to traps with 3-lamps (see Table 6). In the following way, the implications of these findings are useful for energy saving and improving the harvesting procedures for climbing perch light trap fishery.

It is acknowledged that research on LED light fishing rapidly developed (Li, 2010; Hua and Xing, 2013) instead of chemical light sticks (Kissick, 1993; Marchetti et al., 2004), incandescent, halogen, or metal halide illuminations (Baskoro et al., 2002; Matsushita et al., 2012). According to Hua and Xing (2013), LED fishing lights should meet the following requirements; A) the light source should have wide lighting range and sufficient illumination that can be applied to trap fish, B) the starting operation should be easy and quick, C) lights should be sturdy, shock-proof, pressure-proof and durable. It should be noted that the LED light spectrum is almost entirely concentrated in the visible light frequency bandwith, with the optical efficiency up to 80-90%. The light intensities of LED underwater lamps used in our trapping experiment was much lower as compared to those used for squid jigging boats (Yamashita et al., 2012; Matsushita et al., 2012), artisanal fishing net (Mills et al., 2014) or lift net fishery (Puspito et al., 2015; Susanto et al., 2017) that using high electricity power. The light intensities (8.4 ± 1.65 lx to 6730 ± 533.33 lx) of LED lamps used in the present study were adaptable for climbing perch in the pond without incurring visual damage, and potentially used for catching them from wild source.

Dealing with practical applications, it is also a great challenge for us to test this experiment results to other commercially important fish species (e.g. snakehead, giant snakehead, snake-skin gourami, and giant freshwater shrimp) since inland fishery in South Kalimantan Province is not optimally utilized yet; meanwhile the characteristics of endemic fish species that behave positively or negatively phototaxis are poorly studied. This research is imperative in an effort to support aquaculture and fisheries conservation of these species. The use of LED underwater fishing light appeared to be a promising option. By doing all these, it would become a significant work in our historical phototactic studies (Ahmadi et al., 2008; Ahmadi, 2012; Ahmadi and Rizani, 2013; Aminah and Ahmadi, 2018).

The color of light is one of important variables for light trap use. Of the colors tested in the first experiment, red (25%) appeared to be the strongest attractor for Climbing perch, followed by yellow (23%), blue (21%), orange (13%), green (10%) and white (9%), indicating that magnitude response of fish tend to shift from long- to short-wavelength of the spectrum. Meanwhile, yellow (575 nm) was found to be the strongest attractor in the second experiment. In the present study, the ability of Climbing perch to sense different colors of lights at 40.9 NTU was visually acceptable. Our results suggest that Climbing perch preferred red and yellow wavelengths compared to other colors in the LED light spectrum. Since Climbing perch are able to alter independently their behavioral responses to different colors, it is therefore they are considered to have true color vision. Kong and Goldsmith (1977) stated that the true color discrimination is only possible when the fish has at least two receptor types with distinct but overlapping spectral ranges. Color discrimination requires inputs of different photoreceptor cells that are sensitive to different wavelengths of light. In this case, Climbing perch has multichromatic visual system between blue and red, suggesting that result of this study is valid. In addition, Marchetti et al. (2004) reported that cyprinid larvae in the Sacramento River, USA were more attractive to green than red of chemical light sticks. Meanwhile golden perch *Macquaria ambigua* and silver perch *Bidyanus bidyanus* in floodplain habitat preferred to yellow/orange (Gehrke, 1994). Dealing with the spectral emissions, most teleost (marine finfish) responds to red (600 nm), green (530 nm), blue (460 nm), and ultraviolet (380 nm) because of having four types of cone cells in their retinas (Helfman et al., 1997; Moyle and Cech, 2000). The behavioral response of most fish species depends on vision, and visual ability of fish will be affected by the physical conditions of their environment e.g. illumination, wavelength and turbidity (Utne, 1997; Marchetti et al., 2004).

Experimental evidence demonstrated female-biased attraction to the lights. The sex ratio of male to female was 1 : 1.9, indicating that female was more responsive to colors as compared to male across the trials. Many females with the eggs captured in this study. In some cases, female with the eggs are usually less active during the breeding season and are not responded to the baited trap (Holdich, 2002). They become more active after releasing the young and preparing for matting (Faller et al., 2006). On other words, the use of light traps for sampling the egg-bearing females may benefit from this study. In South Kalimantan, the Climbing perch production mostly depends on natural harvest (Azizi and Noveny, 2001), meanwhile the fish farming measures are still deficient due to high mortality at fingerling stage and slow growth, and moreover the wild seed demand for culture pond is still high. Therefore, understanding the food habits, habitat and reproduction biology of fish at different stages is necessary before going fishing (Ansyari et al., 2008; Rupawan, 2009; Yunita, 2010). According to Bernal et al. (2015), female climbing perch showed a marked increase in their food intake early in the wet season. They appear to be visual feeders, feeding primarily during the day (Patra, 1993) and also active at night to search for food. For this reason, the use of lights seems feasible for trapping juvenile (fingerling) and adults to fill the gap, particularly during rainy season/flood when using conventional gears (e.g. lift net, cast net or scoop net) are considered not useful (Ahmadi and Rizani, 2013). In term of light pattern, the continuous light trap contributed to 54%, the blinking light trap 43%, and the control trap 3% of total catches.

Regression analysis depicted the growth slope of Climbing perch was negatively allometric, where the *b* values were significantly lower than the critical isometric value ($b < 3$). This suggests that the species becomes leaner as the length increases. Negative allometric growth pattern was also reported in Climbing perch collected from cages, tank, ponds and river in India (Kumar et al., 2013; Kumary and Raj, 2016) and Bangladesh (Begum and Minar, 2012; Hossain et al., 2015b). It is contrary to Climbing perch caught from Deepar Beel (wetlands) of Assam, India that exhibited positive allometric growth pattern (Rahman et al., 2015). Dealing with variation of these growth types, some of other studies may provide much lower *b* values than these findings (Froese and Pauly, 2018). The weight-length relationships are not constant over the entire year and vary according to factors such as food availability, feeding rate, gonad development and spawning period (Amin et al., 2010; Wong et al., 2015), temperature (Lopez-Martinez et al., 2003), inherited body shape (Yousuf and Khurshid, 2008), salinity (Chotipuntu and Avakul, 2010) and fecundity (Lawson, 2011). There is a strong correlation between feeding frequency and response of fish to lights. Since Climbing perch in the pond were fed to satiation three times a day with pellet, it may disadvantageous for light trap use. Therefore, it is not surprising that there was a low catch presented in this study. Similar behavioural responses were also demonstrated in American crayfish (*Procambarus clarkii*) during trapping experiments with lights in the pond (Ahmadi et al., 2008).

From available data (second trial), we found that there was a difference in the exponent between smaller and larger length class indicating that the species has two growth levels. The smaller individuals (< 90 mm TL) grew with the exponent significantly smaller than the cubic value ($W = 0.5599\ TL^{0.7064}$ with $R^2 = 0.0269$). The largest individual (≥ 90 mm TL) grew with exponents significantly higher than the cubic value ($W = 0.0163\ TL^{1.5553}$ with $R^2 = 0.3301$). Table 2.11 shows the ratio of body weight in comparison to total length of Climbing perch. The W/TL ratio (0.2161) in the present study were higher than those collected from the Deepar Beel of Assam India: 0.162 (Rahman et al., 2015), or from the paddy field in Chandpur, Matla, and Kalipur Bangadesh: 0.069 (Begum and Minar, 2012). However, the value of this ratio was lower than that collected from the Kuttanad wetlands of Kerala India: 0.363 (Kumary and Raj, 2016) and in Kausalyaganga of Orissa India: 0.390 (Kumar et al., 2013).

With regard to condition factor of fish, the K value obtained from this study was in agreement with the results of previous studies (Table 2.11). The K value greater than 1 indicates the fish is in better condition (Le Cren, 1951), suggesting that result of this study is valid. Variation in the value of the mean K may be attributed to biological interaction involving intraspecific competition for food and space between species including sex, stages of maturity, state of stomach contents and availability of food (Gayanilo and Pauly, 1997; Arimoro and Meye, 2007; Abowei et al., 2009; Gupta et al., 2011).

Information on condition factor of fish is considerably needed for culture system management and control particularly to understand specific condition and healthy of fish being cultured (Kumar et al., 2013). When the fish becomes leaner as the length increases, the manager or fish farmer should take management strategies, for example, by improving the quality of feed contents and its feeding ratio, and rearranging fish density to reduce competition for food and space.

Table 2.11. Comparative parameters of length-weight relationships of Climbing perch from different geographical areas. a = constant, b = exponent, R^2 = determination coefficient, r = regression coefficient, A = allometric, K = condition factor.

Locations	Country	n	W/TL	a	b	R^2	r	Allometric pattern	K	References
Banjarbaru, South Kalimantan	Indonesia	608	0.216	0.0005	2.8247	0.9000	0.9487	A-	1.410	Ahmadi, 2018a
Banjarbaru, South Kalimantan	Indonesia	96	0.216	0.0007	1.8049	0.4339	0.6587	A-	2.115	Ahmadi, 2018b
Sungai Batang River	Indonesia	156	0.160	0.0000	2.8353	0.8625	0.9287	A-	2.000	Ahmadi, 2019
Kuttanad, Kerala	India	246	0.363	0.0003	2.8452	0.9556	0.9775	A-	2.060	Kumary and Raj, 2016
Kausalyaganga, Orissa	India	544	0.390	-1.432	2.7201	0.0821	0.9264	A-	2.070	Kumar et al. 2013
Deepar Beel, Assam	India	120	0.162	-2.540	3.645	0.850	0.9220	A+	1.000	Rahman et al. 2015
Chandpur, Matlab, Kalipur	Bangladesh	73	0.069	-1.518	2.423	0.9660	0.9828	A-	1.085	Begum and Minar, 2012
Tetulia River	Bangladesh	176	0.083	0.0220	2.90	0.9740	0.9869	A-	-	Hossain et al. 2015b

A number of interesting facts have been found in the second experiment; in normal condition, Climbing perch usually appear on the water surface for air-breathing and can survive on low levels of oxygen because of having the labyrinth organ (Rahman et al., 2015). Climbing perch even are able to walk on the land for some time. When the fish are caught in the net trap by the gills; the probability of mortality increases quickly. The survival ability of fish depends on the individual's health condition and how long the fish has been stuck in the trap. In our experiment, it was found that healthy fish can survive for more than 6 h. The more the fish tried to escape from trap net, the more energy they consumed, leading to eventual mortalities.

It is suggested that shortening the residence time of the trap in the water, and replacing the nylon material with polyethylene (PE) or black 1.5 cm hexagonal mesh wire (16 gauge PVC-coated wires) may provide improve fish condition prior to capture. In addition, refining the trap instalment technique in pond culture systems to improve the fish housing ecosystem could also improve fish condition.

V. EPILOGUE: CONCLUSION AND RECOMMENDATION

Light traps collected more climbing perch compared to control trap. The use of trap with 1-lamp seemed to be as effective as trap with 2-lamp or 3-lamp in term of battery energy saving. There were no significant differences in YPUE and CPUE between continuous and blinking light traps. The climbing perch has multichromatic visual system between blue and red, and the magnitude responses of fish tend to shift from long- to short-wavelength of the spectrum. The current culture system needs to be improved since the fish in the pond grew negatively allometric.

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CHAPTER - III

SELECTIVE BREEDING TECHNIQUE

I. PROLOGUE: THE IMPORTANT OF CLIMBING PERCH

Climbing perch (*Anabas testudineus* Bloch 1792) is one of commercially important freshwater fish species that beneficially supports fish farming and domestic market particularly in Indonesia (Akbar et al., 2016), Malaysia (Zalinaet al., 2012), Philippines (Bernal et al., 2015), Thailand (Piwpong et al., 2016); Cambodia (Sverdrup, 2002), Lao PDR (Sokhenget al., 1999), and Viet Nam (Phuonget al., 2006), Bangladesh (Uddinet al., 2016) and India (Ziauddin et al., 2016). It has high quality meat, easy breeding, disease resisting, good consumer acceptance, and very adaptable to adverse environmental conditions such as low dissolve oxygen (DO). It has a high nutrition value of 19.50% of protein and 2.27% of lipid (Ahmed et al., 2012). It is also rich in iron and copper that support haemoglobin synthesis (Sarmaet al., 2010) and has high quality poly-unsaturated fats and many essential amino acids (Kohinoor et al., 1991). It can be found in all freshwater bodies such as rivers, streams, swamps, ponds, lakes, canals, reservoirs, and estuaries (Sarkar et al., 2005; Rahman and Marimuthu, 2010), and can also be cultured at cages, tanks, nylon hapas and ponds (Hasanet al., 2010; Mondalet al., 2010; Kumar et al., 2013) with different culture strategies (Chotipuntu and Avakul, 2010; Putra et al., 2016, Izmaniar et al., 2018). It is categorized by the International Union for Conservation of Nature and Natural Resources (ICUN) as avulnerable species. Destructive fishing practices and polluted habitats may potentially threat this species (Kalita and Deka, 2013; Hossainet al., 2015).

A. Previous Research Findings

Some fundamental studies have been addressed to describe on biological, physiological and ecological of Climbing perch including its growth performance (Muchlisin et al., 2017), fecundity (Marimuthu et al., 2009; Ziauddin et al., 2016), stocking density (Habib et al., 2015; Uddin et al., 2016); breeding biology (Singh et al., 2012; Hafijunnaharet al., 2016), boldness (Binoy, 2015), morphometric characteristic (Hossain et al., 2015), length-weight relationship and condition factor (Kumar et al., 2013; Rahman et al., 2015), genetic characteristics (Sekino and Hara, 2000; Jamsari et al., 2010); feeding and social behavior (Zworykin, 2018), as well as environmentally friendly fishing practices for this species (Irhamsyah et al., 2017; Ahmadi, 2018; Ahmadi et al., 2018).

In South Kalimantan Province, the demand of Climbing perch for consumption reaches 800 kg per day, where almost entirely sourced from the wild and only 10% produced from fish farming. Climbing perch contributes about 12% (8.31 tons) of total inland capture fisheries production (69.97 tons). It is abundantly found in three different types of swamp areas, namely “monotonous swamp” located on Hulu Sungai Selatan District (452.704 ha), “rain reservoir swamp” in Banjar, Tanah Laut, and Pulau Laut Districts (169.094 ha), and “tidal swamp” in Barito Kuala, Tanah Laut, and Kotabaru Districts (372.637 ha). Climbing perch from swamp monotonous has the body colour of blue yellowish and a little dark, the size reaches about 25 cm length and 300 g weight, good taste and the growth is faster than those from rain reservoir swamp and tidal swamp. It is quite different from climbing perch of rain reservoir swamp, which has the body colour of yellow bluish, the size reaches 17 cm length and 150 g weight, the meat taste a little smell of mud and slower growth. While climbing perch of tidal swamp, it has body colour of green bluish, the size reaches 24 cm length and 300 g weight, the flavour of meat tasteless and growth faster than those of rain reservoir swamp (Slamat et al., 2011).

B. The Reason behind Selective Breeding Technique

Recently aquaculture development of Climbing perch on the controlled land is still much depended on the following factors such as the quality of seed, genetic, behaviour and its reproduction (Slamat, 2013). Climbing perch in habiting in different ecosystems will have different genetic diversity and the phenotype. The climbing perch of monotonous swamp have genetic diversity greater than that of rain reservoir swamp and tidal swamp. The genetic diversity of climbing perch can be seen from the diversity of meristic phenotype and of the DNA. It was already well-adapted for Climbing perch sampled from different swamp ecosystems (Slamat et al., 2011).

Analysis of genetic diversity is very important especially for endemic fish species to be used as brood stocks to produce superior seeds in aquaculture system. Griffit et al. (2000) suggested using the map of genetic diversity as a basic reference in performing the process of hybridization or breeding to look the pattern of gene dispersion that possibly forms organism body structure. Meanwhile, diversity of meristic phenotype is used to determine the level of the genetic diversity of fish. According to Frankham et al. (2002), the map of meristic diversity can be used as a tool in carrying out the process of breeding in animals and plants. The results of identification and the characterizing of the meristic phenotype of fish are divided into two groups of phylogenetic, i.e. the first group: monotonous and tidal swamps and the second group: rain reservoir swamp (Slamat et al., 2011). The characterizing of this meristic phenotype will be used as a basic of conducting hybridization research to provide high yield seeds.

Increased productivity of climbing perch is being intensively done by both hatchery center and community hatchery units, but efforts to breeding them to produce superior seeds are still lacking. In line with population growth and economy improvement, it is predicted that market needs of climbing perch to meet public consumption for next 5 years ranging from 1.5 - 2 tons per day. For this reason, we carried out a series of laboratory and field experiments to make a breakthrough in generating superior seeds with rapid growth, marketable size (8-10 fish/kg), low mortality, high fecundity, tolerant of the adverse environment and more responsive to artificial feed. The result of this research will be the pioneer in breeding of swamp local fish species as part of the wetland excellent research of Lambung Mangkurat University.

II. FOLLOW-UP RESEARCH

A. Study sites

The research was carried out from June to December 2018 at Pokdakan (Fish Farmer Group) Rawa Sejahtera Amuntai in Hulu Sungai Utara District of South Kalimantan Province, Indonesia (Figure 3.1). The brood stocks climbing perch were sampled from three different types of habitats namely monotonous swamp, rain reservoir swamp and tidal swamp (Figure 3.2). Each group of Climbing perch has own characteristics as described in Table 3.1. The samples of broodstocks were transferred to the Ichthyology Laboratory belongs to the Faculty of Marine and Fisheries, Lambung Mangkurat University for further observation and analysis.

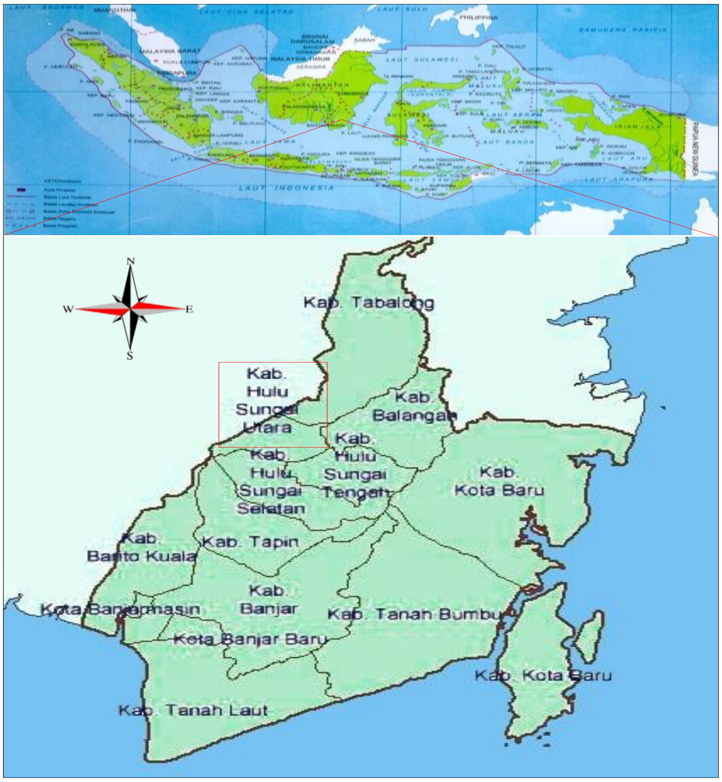

Figure 3.1 The map showing the study site in Hulu Sungai Utara District of South Kalimantan Province

Table 3.1. The biological characteristics of Climbing perch originated from three different habitats

Biological Characteristic	Rain reservoir swamp	Tidal swamp	Monotonous swamp
Max. body size	17 cm, 150 g	25 cm, 300 g	25 cm, 300 g
Color	Greenish yellow	Bluish green	Yellowish blue
Growth	slower than tidal swamp	Faster than rain reservoir swamp	Fastest of all
Fecundity	High	Moderate	Moderate
Mortality rate	Low (< 25%)	High (> 45%)	Moderate (< 35%)
Feed Conversion Ratio (FCR)	1.8 - 2.0	1.8 - 2.0	1.7 - 1.8
Meat taste	Smell of mud	Tasteless	Good taste

Source: Slamat et al. (2011)

Figure 3.2 Types of Climbing perch: [A] monotonous swamp, [B] tidal swamp, and [C] rain reservoirs

B. Experimental Design

A complete random design was used as a research method with method with three treatments and nine repetitions. The hybridization process was undertaken by crossing bred of the brood stocks sampled, for example: monotonous swamp X tidal swamp, monotonous swamp X rain reservoir swamp, and tidal swamp X rain reservoir swamp. The tools and equipment used are a spawning pond, climbing perch brood stocks, spuit, hormone ovaprim, artificial feed, and fertilizer compost, microscope, camera, and digital balance. A series of observation was made to determine fecundity, gonadosomatic index (GSI), fertilization rate, hatching rate, the relative length growth, relative weight growth, feed conversion ratio (FCR), and the percentage of male and female of Climbing perch.

C. Parameter Observed

Fecundity

Fecundity is one of the important factors of the biology and population dynamics of fish (Alam et al., 2012). Fecundity is the number of ovum incurred in one cycle of spawning. Fecundity analysis is done to predict the number of offspring to be released in a spawning season. Fecundity is calculated bythe following formula (Hartman and Conkle, 1960):

$$\text{Fecundity} = \frac{\text{The average number of eggs x weight of gonads}}{\text{Weight of sub samples}}$$

Gonadosomatic Index

Gonadosomatic index (GSI) is an alternative method to determine sexual maturity or reproductive activity (Wang et al., 2003). GSI is the percentage of gonad weight to the total weight of the fish. It is used as an indicator for gonadal development in fish. GSI is determined using the following formula (Hafijunnahar et al., 2016):

$$\text{GSI} = \frac{\text{Gonad weight}}{\text{Total body weight}} \text{ x } 100$$

Fertilization

Fertilization is the process in which an egg and a sperm cell come together to form a zygote or the embryo. Observation on the eggs was done after spawning. The process of the embryo formation to the stage of the morula was observed under a camera microscope to ensure whether or not the ovum has been fertilized. After the morula phase, the observation is made every two-hour up to the hatching phase. The fertilization rates of eggs were determined by randomly sampling 100 eggs in a petri dish. Fertilized eggs with an intact nucleus were counted to determine the percent fertilization. The fertilization rate was calculated by using formula (Amornsakun, 2017):

$$\text{Fertilization rate} = \frac{\text{Number of fertilized eggs}}{\text{Total number of eggs}} \text{x } 100$$

Hatching Rate

Hatching rate was simply computed by using the following formula (Amornsakun, 2017):

$$\text{Hatching rate} = \frac{\text{Number of hatched eggs}}{\text{Total number of eggs}} \text{x } 100$$

Survival Rate

Survival rate of fish is calculated using the following equation (Yousuf et al., 2016):

$$\text{Survival rate} = \frac{\text{Number of survived fish}}{\text{The initial number of fish}} \text{x } 100$$

Length Growth

The length growth of fish is the increase of the body length (mm) during cultivation process.

Weight Growth

The weight growth of fish is the increase of the body weight (g) during the cultivation process.

Feed Conversion Ratio (FPR)

Feed conversion ratio (FCR) is the amount of feed needed to produce one kilogram of meat. FCR indicating that the energy obtained from the feed for its metabolic activities. The feed conversion ratio was calculated by using the following formula (Asuwaju et al., 2014):

$$\text{FCR} = \frac{\text{Diet fed (g)}}{\text{Weight gain (g)}}$$

Percentage of Male and Female

To differentiate between male and female, it can be easily visually done by observation of physical condition of the fish. Male has a small body, slender, and keep balancing its body in the water. While female has a long and large body, fattish, and brighter colors.

The relationship between the total fecundity and the body length is expressed as **Y = a + bX**. Where, Y is the fecundity, X is the total length, *a* is the values of intercept, and *b* is the slope of the curve.

III. RESEARCH FINDINGS AND DISCUSSION

The overall measurement results on the size of broodstocks and the hybridized Climbing perch taken from three different types of swamp habitats were described in Table 3.2. The sex ratio of broodstock's pair for each group was 2M : 1F. Females had total length and body weight larger than males. However, the body sizes of male and female broodstock pair sampled from rain reservoir swamp was the smallest among others.

The status of the hybridized fish was varying based on the characteristic of the crossbred brood stocks came from (Table 3.3). The highest fecundity (18,500 eggs) produced by the broodstocks of monotonous swamp X tidal swamp, followed by monotonous swamp X rain reservoir swamp (17,110 eggs) and tidal swamp X rain reservoir swamp (16,220 eggs). This indicates that there was an aptness of breeding pairs between brood stocks of different habitats in performing a process of reproduction. The aptness of this breeding pair would optimize the function of hormone to produce new individuals which are superior to their brood stocks.

Table 3.2. The size of broodstocks Climbing perch used for hybridization treatments

Number and Size of Broodstocks	Rain reservoir swamp		Tidal swamp		Monotonous swamp	
	Male	Female	Male	Female	Male	Female
Number of fish sample	30	15	30	15	30	15
Total length (cm)	12 ± 0,5	16.93 ± 0.46	12 ± 0.5	17.07 ± 0.70	12 ± 0.5	17.00 ± 0.57
Body weight (g)	13 ± 0,5	77.67 ± 6.51	35 ± 0.4	80.67 ± 7.04	35 ± 0.5	79.13 ± 8.25

Table 3.3. Descriptive parameters of the hybridized Climbing perch from three different types of swamp ecosystems

Parameter Observed	Hybridized Climbing perch		
	Monotonous × tidal	Monotonous × rain reservoir	Tidal × rain reservoir
Fecundity (eggs)	18,500	17,110	16,220
Gonadosomatic index (%)	18.1	17.7	17.5
Fertilization rate (%)	90.5	90.2	81.0
Hatching rate (%)	89.5	85.12	70.7
Relative length growth (%)	1,375	1,175	1,192
Relative weight growth (%)	1,850	1,550	1,450
Feed Conversion Ratio (Protein 40%)	1.75	1.79	1.90
Percentage of male and female	84 ♀	78 ♀	71 ♀
Mortality (%)	29	33	30

The relationship between fecundity (F) and total length (TL) of Climbing perch female from monotonous swamp was given in the equation: F = 1719.9TL - 10739 (Figure 3.3A). The coefficient of determination (R^2) obtained was 0.7411 indicating that more than 74% of variability of the fecundity is explained by the length. The coefficient of correlation (r) was 0.8609, found to be higher than 0.5, showing the fecundity-length relationship is positively correlated.

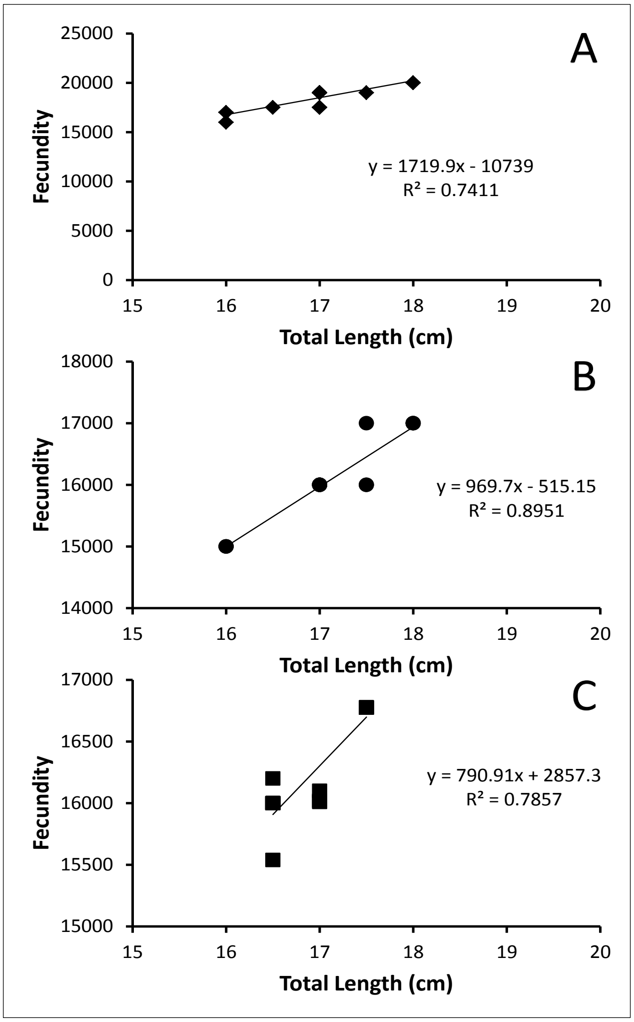

Figure 3.3 The relationship of fecundity and total length of Climbing perch from monotonous swamp (A), tidal swamp (B) and rain reservoir swamp (C)

For females taken from tidal swamp, the relationship between fecundity and total length was given in the formula: F = 969.7TL - 515.15 (Figure 3.3B). The coefficient of determination (R^2) obtained was 0.8951 indicating that more than 89% of variability of the fecundity is explained by the length. The coefficient of correlation was highly positive (r = 0.9461). A linear relationship was also observed between fecundity and total length of Climbing perch sampled from rain reservoir swamp (Figure 3.3C). Such relationship was expressed as: F = 790.91TL + 2857.3 (R^2 = 0.7857), indicating that more than 78% of variability of the fecundity is explained by the length. The relationship showed positive correlation (r = 0.8864).

The relationship between fecundity (F) and body weight (W) of Climbing perch females collected from monotonous swamp was shown in Figure 3.4A, and was expressed as F = 120.92W + 8929.7 (R^2 = 0.7764), indicating that more than 77% of variability of the fecundity is explained by the weight. The coefficient of correlation obtained was highly positive (r = 0.8811). The minimum and maximum numbers of eggs were 16,000 and 19,995 spawned by females weighted 70 g and 95 g respectively. For females sampled from tidal swamp, the relationship between fecundity and body weight was expressed as F = 109.2W + 7257.7 (Figure 3.4B).

The R^2 value obtained was 0.9345, indicating that more than 93% of variability of fecundity is explained by weight. The correlation coefficient (r) was 0.9667, indicating that the fecundity-weight relationship is positively correlated. The minimum and maximum numbers of eggs were 16,000 and 17,000 for corresponding body weight of fish is 70 g and 90 g respectively. A linear relationship was also observed in females sampled from rain reservoir swamp (Figure 3.4C). Such relationship was expressed as: F = 51.826W + 12225 (R^2 = 0.6824), indicating that more than 68% of variability of the fecundity was explained by the weight. The correlation coefficient was found to be positive (r = 0.8261). The minimum and maximum numbers of eggs were 15,540 and 16,776 generated by females with 70 g and 95 g weight respectively.

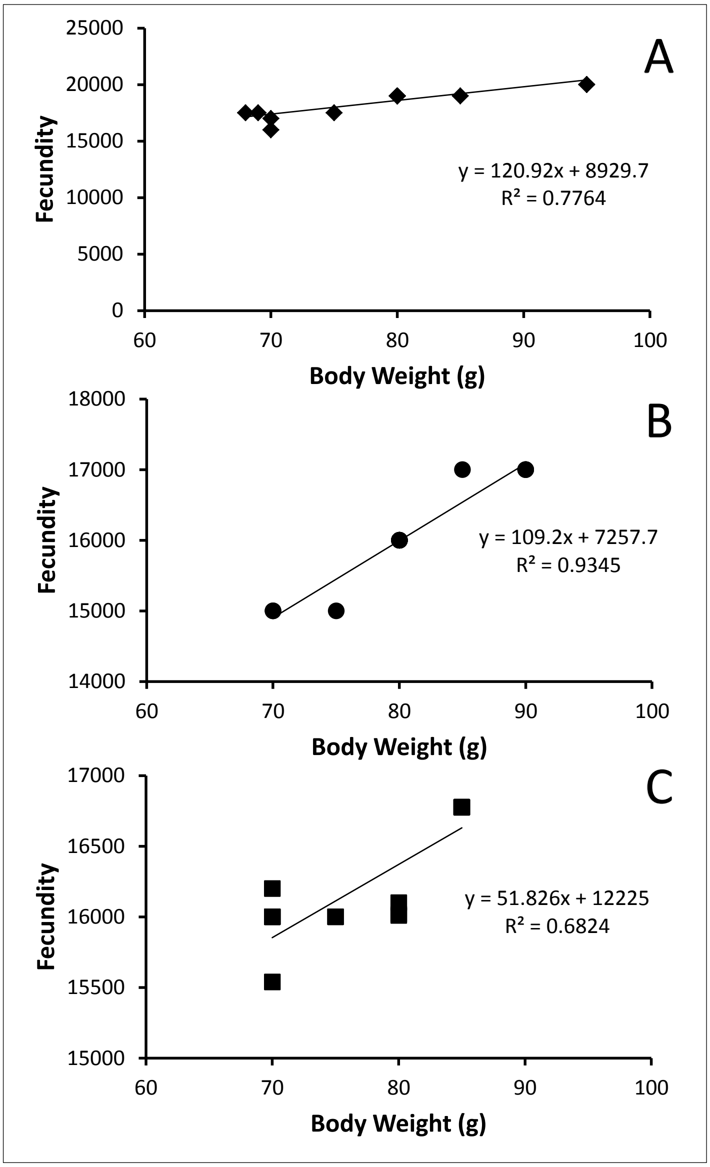

Figure 3.4 The relationship of fecundity and body weight of Climbing perch from monotonous swamp (A), tidal swamp (B) and rain reservoir swamp (C)

Figure 3.5A shows the relationship between fecundity (F) and GSI (%) of Climbing perch females from monotonous swamp. The equation of curve on the graph was F = 484GSI + 9796.5 (R^2 = 0.0848). GSI varied between 17.20 and 19.80% (17.98 ± 0.68%). For females taken from tidal swamp, the relationship was expressed as: F = 285.71GSI + 11095 (Figure 3.5B). GSI falls between 17.00 and 19.00% (17.40±0.63%). A linear relationship was also observed in females sampled from rain reservoir swamp (Figure 3.5C). The fecundity-GSI relationship was shown in equation: F = 234.96GSI + 12184 (R^2 = 0.0527). GSI ranged from 16.80 and 18.00% (17.31 ± 0.40%).

The variation in fish fecundity is not only due to fish length and weight but also influenced by age, nutritional diet, environmental condition in the water bodies and food availability (Sivashanthini et al., 2008; Ghafari and Jamili, 2010; Lawson, 2011). A linear and positive relationship in the present study correspond well with the previous studies (Marimuthu et al., 2009, Zalina et al., 2012; Islam et al., 2012; Hafijunnahar et al., 2016). After all, the use of the fry unisexual female would increase the fish growth 270% faster than the fry male. The fecundity in the present study was considerably lower than that of Climbing perch collected from the Layar Tengah River near Sungai Petani, Kedah, Malaysia (Marimuthu et al., 2009) or from Rupali Fish Hatchery, Bangladesh (Hafijunnahar et al., 2016). The success level of a spawning fish can be assessed from the percentage of fecundity and of juveniles to become adult fish (Alam et al., 2012).

Observation on Gonadosomatic index (GSI) was under taken to comprehend the readiness of brood stocks to spawn. The highest GSI produced by the brood stocks of swamp monotonous X tidal swamp (18.1%), followed by monotonous swamp X rain reservoir swamp (17.7%) and tidal swamp X rain reservoir swamp (17.5%). The present values of GSI were relatively higher than GSI of climbing perch from Layar Tengah Sungai Petani River, Kedah, Malaysia (Marimuthu et al., 2009) or from Rupali Fish Hatchery, Bangladesh (Hafijunnahar et al., 2016).

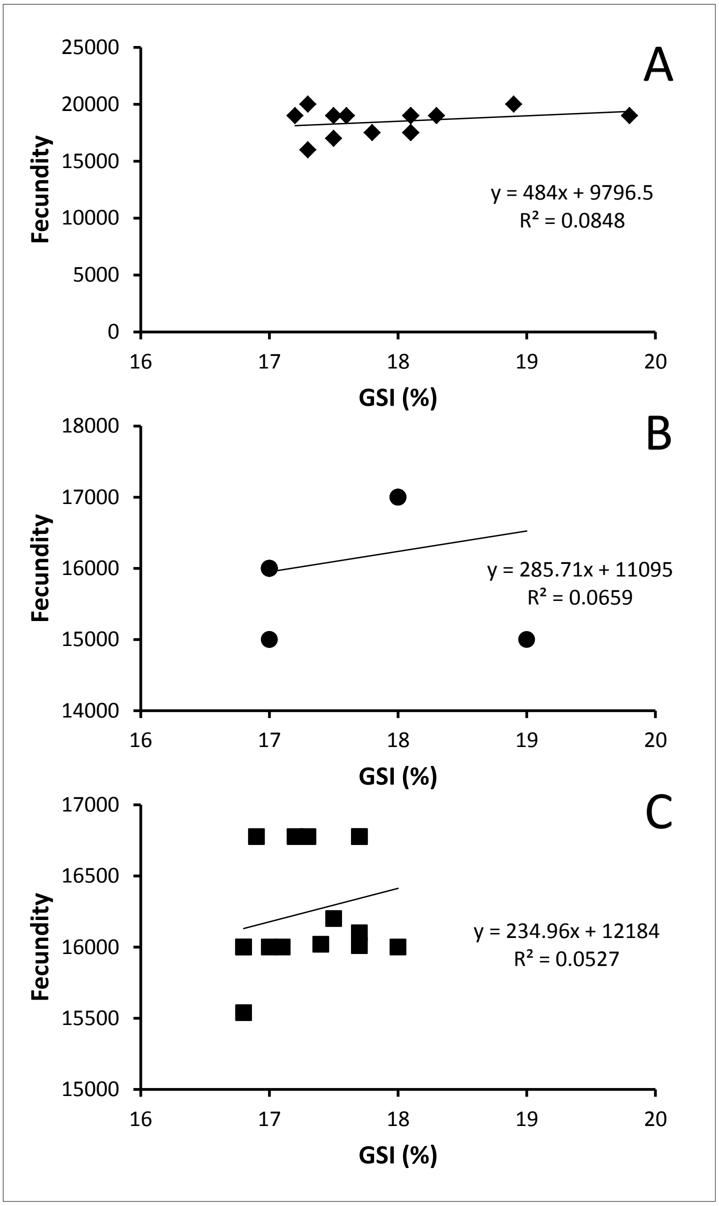

Figure 3.5 The relationship of fecundity and GSI of Climbing perch sampled from monotonous swamp (A), tidal swamp (B) and rain reservoir swamp (C)

The crossbred climbing perch of swamp monotonous and tidal swamp in the present study was closely related to their environmental conditions that more stable, food source in great abundance and greater gonad size (Slamat, 2012). The fertilization and the egg hatchability can be used as indicator to find out the optimal spermatozoa in fertilizing ovum generated by brood stocks from different swamp habitats. The crossbred brood stocks of swamp monotonous and tidal swamp generated the highest rank in fertilization rate (90.5%) and hatching rate (89.5%), followed monotonous swamp X rain reservoir swamp (FR = 90.2%, HR = 85.12%) and tidal swamp X rain reservoir swamp (FR = 81.0%, HR = 70.7%). The fertilization rate obtained in the present study was similar to induced breeding of Climbing perch in laboratory, Siliguri, India (Sarkar et al., 2015). The higher percentage of fertilization and hatching rates the better the quality of eggs and sperm produced by the fish. Variation in the value of fertilization and hatching rates may be attributed to brood stocks health, GSI, environmental conditions, brood stocks origin, age and size of brood stocks and nutrients supply during pregnancy. Observation on the relative length and weight growth was intended to see accumulation of the hybridization treatment that influence the growth of fish tested. Observation on fish larvae was made started from 0 to 60 days. The length and weight growth is a performance indicator to ensure the success of hybridization practices.

The results also clearly showed that the hybridized fish from monotonous swamp X tidal swamp was found to be the dominant characteristic in the length growth (1,375%) and weight growth (1,850%). The functional growth dominance of climbing perch inhabited monotonous swamp is more based on their performance characteristic such as a greater genetic diversity, more adaptable to new environment, great feeding response, tamer and relatively resistant to the negative effects of environment change. Slamat (2013) strongly recommended selecting the broodstocks of monotonous swamp and tidal swamp with the body size of ≥ 300 gr per individual in order to produce offspring greater than their brood stocks. The idea is in line with the previous study reported by Wahyudewantoro and Haryono (2013). Apparently the hybridized fish from monotonous swamp X rain reservoir swamp had a similar character with tidal swamp X rain reservoir swamp especially feeding response resulted in slow growth.

The feed conversion ratio (FCR) is a helpful way of describing efficiency in terms of how much feed is required to produce 1 kg of fish. FCR is the basis of all feed formulations because feeds are compounded to support profitable and healthy growth of the fish. Feed conversion ratios are important calculations for the fish farmers to determine if feeds are being used as efficiently as possible (Goddard, 1996). The feed consumed by the fish should have enough protein to support its growth. In the present study, the fish were fed with pellet containing protein up to 40%. There was a variation in the value of FCR among the hybridized fish tested. The highest percentage of FCR was found in the hybridized fish from tidal swamp X rain reservoir swamp (1.90%), followed by monotonous swamp X rain reservoir swamp (1.79%) and the lowest FCR was provided by monotonous swamp X tidal swamp (1.75%). Environmental conditions that conducive, proper nutrition and source of guaranteed seeds are needed to produce healthy fish. The health indicator of the fish can be seen from a perfect physical condition, normal behavior, great feeding response and optimal growth.

Generally the hybridized fish in the present study was considered fit and healthy, and tends to be better than its brood stocks. One of the success factors of hybridization indicated by the increase percentage of male-female, which is greater than its brood stocks. The hybridized fish from monotonous swamp

X tidal swamp showed the highest percentage of female (84%), followed by monotonous swamp X rain reservoir swamp (78%) and tidal swamp X rain reservoir swamp (71%). If spawned normally, population derived from the same habitat resulted in the ratio of male to female is 50 : 50, and it tends higher percentage of male spawned as compared to female due to some factors such as high temperature, high intensity of sunlight and non-selective brood stocks. By selecting the broodstocks properly, we can produce the unisex female up to 84%. Moreover, the hybridized fish from tidal and monotonous swamp was observed to have the lowest mortality rate among others.

IV. EPILOGUE: CONCLUSION AND RECOMMENDATION

The hybridized Climbing perch from monotonous swamp × tidal swamp was considered the most superior among other treatment approaches for this species. The use of fry-unisexual female is strongly recommended for the success of aquaculture operations.

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CHAPTER - IV

BREEDING AND REPRODUCTIVE PERFORMANCE

I. PROLOGUE: SPECIES PROFILE - CLIMBING PERCH

Like other countries (e.g. Malaysia, Philippines, Thailand, Viet Nam, India and Bangladesh), the presence of Climbing perch (*Anabas testudineus*) in Indonesia also plays important role in both fisheries and aquaculture (Ahmadi et al., 2018) due to its high quality meat, easy breeding, disease resisting, good consumer acceptance, and very adaptable to adverse environmental conditions such as low dissolve oxygen and thermal change (Hafijunnahar et al., 2016; Uddin et al., 2016). It contents iron and copper that support haemoglobin synthesis (Sarma et al., 2010) and has high quality poly-unsaturated fats and many essential amino acids (Kohinoor et al., 1991). It also provides 19.50% of protein and 2.27% of lipid (Ahmed et al., 2012), while carbohydrate to lipid ratio (CHO: L) of 2.29 performed the best for growth performance, feed and protein utilization and whole body composition (Ali et al., 2012). This species inhabiting all freshwater bodies such as swamps, rivers, wetlands, canals, and reservoirs (Bernal et al., 2015; Rahman et al., 2015; Ziauddin et al., 2016), and can be cultured at cages, tanks, nylon hapas, ponds and brackish water (Chotipuntu and Avakul, 2010; Habib et al., 2015; Khatune-Jannat et al., 2012) with different culture management systems (Hasan et al., 2010; Mondal et al., 2010; Putra et al., 2016). It is categorized by the International Union for Conservation of Nature and Natural Resources (IUCN) as a vulnerable species. Habitat modification, destructive fishing practices, and polluted habitats may potentially threat this species

(Rahman et al., 2012; Kalita and Deka, 2013; Hossain et al., 2015).

A. Previous Research Findings

Some fundamental studies have been addressed to describe on breeding biology (Zalina et al., 2012; Sarkar et al., 2015), fecundity (Marimuthu et al., 2009; Islam et al., 2012), stocking density (Uddin et al., 2017), boldness (Binoy, 2015), seasonal gonad cycle (Bernal et al., 2015), length-weight relationship and condition factor (Kumar et al., 2013; Rahman et al., 2015), morphometric characteristic (Hossain et al., 2015), genetic characteristics (Sekino and Hara, 2000; Jamsari et al., 2010), growth performance (Putra et al., 2016; Muchlisin et al., 2017), feeding and social behavior (Zworykin, 2018), food habits (Burmansyah et al., 2013), as well as fishing practices (Irhamsyah et al., 2017; Ahmadi, 2018) or business prospect of this species (Izmaniar et al., 2018).

In South Kalimantan Province, Climbing perch is abundantly found in three different types of swamp areas, namely “monotonous swamp” located in Hulu Sungai Selatan District (452.704 ha), “rain reservoir swamp” in Banjar, Tanah Laut, and Pulau Laut Districts (169.094 ha), and “tidal swamp” in Barito Kuala, Tanah Laut, and Kotabaru Districts (372.637 ha). It contributes about 12% (8.31 tons) of total inland capture fisheries production (69.97 tons). The demand of Climbing perch for consumption reaches 800 kg per day, which is almost entirely sourced from the wild and only 10% produced from fish farming (Slamat et al., 2019). In line with population growth and economy improvement, it is predicted that market needs of Climbing perch to meet public consumption for next 5 years ranging from 1.5-2 tons per day.

B. The Reason behind Breeding and Reproductive Performance

For the time being, the fish farmers are still being constrained by some fundamental factors such as slow growth, high mortality, low hatching rate, and high feed conversion ratio. After all, the broodstocks selection factor with the suitable environmental conditions is essential to success in order to improve the quality of fish seed, reproduction and also its genetics. Moreover, the existence of aquatic plants (e.g. *Eichhornia crassipes* and *Hydrilla verticillata*) in culture system was reported successfully in increasing survival rate, fertility and hatchability of Nile tilapia (Fajriani, 2016), gourami (Ning, 2014), comet goldfish (Wahyuningsih et al., 2012), and pearl gourami (Sukendi et al., 2012); while its implication to Climbing perch is still questionable. For these reasons, we carried out a series of laboratory experiments to find out the best performance of different broodstock sizes and type of aquatic plants used on the basis of breeding process and survival of newly hatched larvae of Climbing perch.

II. FOLLOW-UP RESEARCH

A. Study Sites

This research was conducted in the Wet Laboratory belongs to Faculty of Marine and Fisheries, Lambung Mangkurat University from January to March 2019. The broodstocks of Climbing perch were obtained from local community hatchery unit (UPR Barabai, South Kalimantan Province) and were transferred to the Wet Laboratory as the experimental animals.

B. Experimental Design and Procedure

The experimental design used was Factorial Randomized Completely Design. The first factor (A) was the variation of broodstocks sizes i.e. A1 = 14 cm TL and A2 = 16 cm TL (total length). The second factor (B) was types of aquatic plants i.e. B1 = water hyacinth (*E. crassipes*), B2 = algae (*H. verticillata*), and B3 = without aquatic plants (control); thus there were 6 treatment combinations within 3 repetitions (total 18 experimental units).

The eighteen aquariums (60×40×30 cm) containing the broodstocks associated with aquatic plants and also the control were used. Each aquarium was first sterilized with Potassium Permanganate (KMnO4) of 20 mg L^{-1} for 1 hour, and then washed off with clean water, dried, filled with water to 20 cm height and run aeration accordingly. A total of 54 broodstocks comprising 36 males (67%) and 18 females (33%) with the sex ratio of 2:1 were investigated (Table 4.1). For small individuals, the mean sizes of males were 12.75 ± 0.56 cm TL (12.20 - 13.30 cm) and 35.30 ± 5.31 g weight (31.70 - 42.60 g), while for females were 14.21 ± 0.08 cm TL (14.10 -14.30 cm) and 48.31 ± 0.81 g weight (47.90 - 49.60 g). For large individuals, the mean sizes of males were 15.20 ± 0.08 cm TL (15.10 - 15.30 cm) and 59.37 ± 0.10 g weight (59.20 - 59.50 g), while for females were 16.21 ± 0.08 cm TL (16.10 - 16.30 cm) and 68.32 ± 0.80 g weight (67.40 - 69.20 g).

Table 4.1 The descriptive broodstock sizes of Climbing perch used

Broodstock sizes	Small individual		Large individual	
	Male	Female	Male	Female
Number of sample	18	9	18	9
Total length (cm)	12.74 ± 0.56	14.21 ± 0.08	15.20 ± 0.08	16.21 ± 0.08
Range of total length (cm)	12.20 - 13.30	14.10 - 14.30	15.10 - 15.30	16.10 -16.30
Weight (g)	35.30 ± 5.31	48.31 ± 0.81	59.37 ± 0.10	68.32 ± 0.80
Range of body weight (g)	31.70 - 42.60	47.90 - 49.60	59.20 - 59.50	67.40 - 69.20
Length-weight regression equations	y = 0.0554x + 1.4821	y = 1.8417x - 0.4388	y = 0.1284x + 1.6219	y = 1.0548x + 0.5584
Coefficient determination (R^2)	0.0003	0.0003	0.1713	0.1900

In the preparation, we made *Daphnia* sp. culture by using the fermented straw and banana stems as growth media for a week. During nighttime, both females and males were injected with the ovaprim hormone with doses of 0.2 mL and 0.1 mL per 100 g of body weights, respectively (Figure 4.1).

Figure 4.1 Fermentation process, measurement and injection of Broodstock's Climbing perch

The spawning process was undertaken with waterhycinth, hydrilla and without water plants (Figure 4.2). Females to spawn after the injection process of 5-8 hours. The breeding process ends marked with the eggs floating on the water surface at early morning and the broodstocks were taken out from the aquarium.

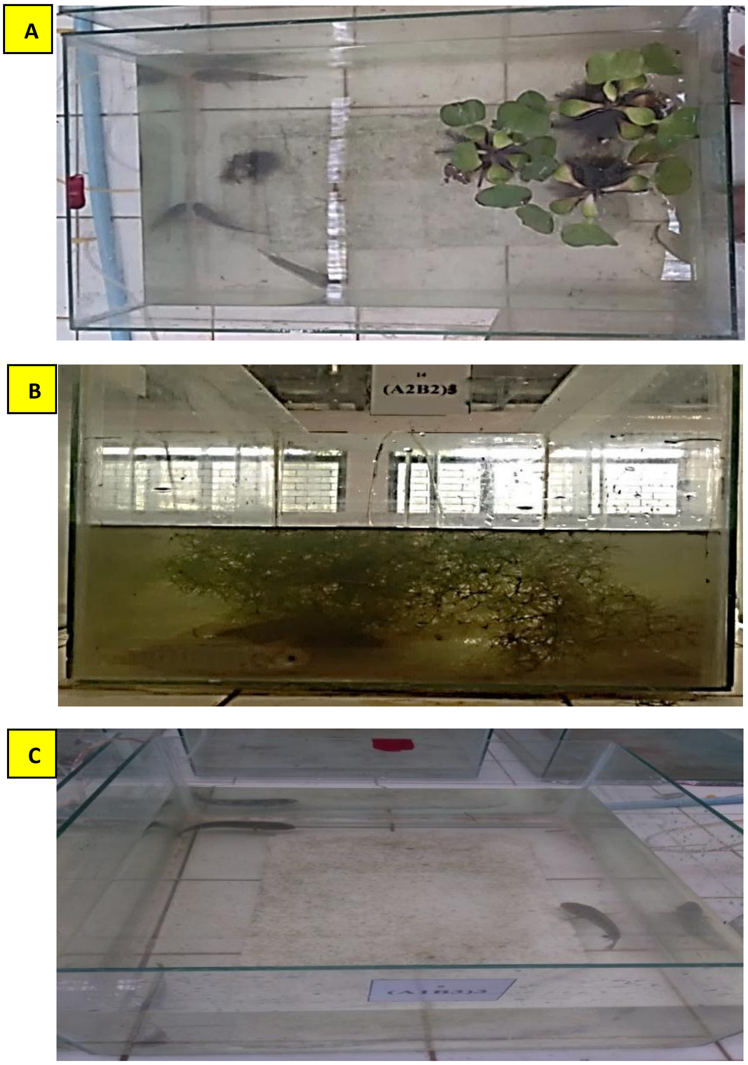

Figure 4.2 Spawning process associated with [A] waterhycinth, [B] hydrilla and [C] without water plants.

Larvae were daily feed with *Daphnia* sp. as much about 1,134 individuals per tank. Natural diets as a result of the fermentation product were visually identified by observing them under an electronic microskop. Water quality parameter was regularly measured during research periods (Figure 4.3).

Figure 4.3 Feeding process, natural diet identification, and water quality measurement

C. Fecundity

Fecundity is one of the important factors of the biology and population dynamics of fish (Alam et al., 2012). Fecundity is the number of ovum incurred in one cycle of spawning. Fecundity analysis is done to predict the number of offspring to be released in a spawning season.

Fecundity was measured with volumetric calculation (Effendie, 1997):

$$R = \frac{n1+n2+n3}{3} \qquad V = \frac{Va}{n} \qquad F = V \times R$$

Where: *R* is the average eggs taken from sample volume, n_s is number of eggs taken for sample, *V* is water volume (*Va*) divided by sample volume (*n*), and *F* s number of eggs.

D. Fertilization and hatching rates

In most fish species, fertilization takes place externally. Fertilization is the process in which an egg and a sperm cell come together to form a zygote or the embryo. Observation on the eggs was done after spawning. A total of 500 eggs were placed in each aquarium and they will hatch become the larvae after 18-24 hours in room temperature. The rate of hatchability of eggs was recorded from each treatment. Aeration was continuously provided till the end of the experiment in all the aquaria.

The fertilization rate and hatching rate were calculated by using the following formulas (Amornsakun et al., 2017):

$$\text{Fertilization rate} = \frac{\text{Number of fertilized eggs}}{\text{Total number of eggs}} \times 100$$

$$\text{Hatching rate} = \frac{\text{Number of hatched eggs}}{\text{Total number of eggs}} \times 100$$

E. Survival and Mortality Rates

After hatching upon the two days old, the larvae just consumed the egg yolk in their bodies as a food reserve. Afterward the larvae were fed with *Daphnia* sp. three times a day for 13 days. At 15 days old, the pellet was given twice a day to increase the survival of the larvae. The larvae were kept in the aquarium for 30 days to observe their survival. The survival rate and mortality rate of larvae are calculated using the formulas (Yousuf et al., 2016):

$$\text{Survival rate} = \frac{\text{Number of survived fish}}{\text{The initial number of fish}} \times 100$$

$$\text{Mortality rate} = \frac{\text{Number of dead fish}}{\text{The initial number of fish}} \times 100$$

F. Length-Weight Relationship

The length-weight relationship of fish can be expressed in both allometric form and logarithmic equation (Froese, 2006):

$$\mathbf{W = aL^b}$$

Where: W is the weight (g), L is the total length (mm), *a* is the constant showing the initial growth index and *b* is the slope showing growth coefficient. The b value has an important biological meaning; if fish retains the same shape, it grows increase isometrically (*b* = 3). When weight increases more than length (*b* > 3), it shows positively allometric. When the length increases more than weight (*b* < 3), it indicates negatively allometric (Kumar et al., 2013). The determination coefficient (R^2) and correlation coefficient (r) of length-weight variables between male and female were also computed. Water quality parameters such as water temperature, pH, dissolved oxygen (DO), and ammonia (NH3) were also recorded.

III. RESEARCH FINDINGS AND DISCUSSION

The overall measurement results on the fecundity, fertilization rate, hatching rate, survival rate and mortality rate of the Climbing perch tested in the experimental tanks were described in Table 4.2. Each treatment has own characteristic of performance and statistically comparable between parameters tested.

Table 4.2. The treatments and parameters observed for Climbing perch in the experimental tanks

Treatment	Mean ± standard deviation of parameters observed				
	Fecundity (egg)	Fertilization rate (%)	Hatching rate (%)	Survival rate (%)	Mortality rate (%)
A1B1	14,880 ± 8,532	69.73 ± 1.49	96.67 ± 2.64	18.22 ± 0.84	81.78 ± 0.83
A1B2	11,040 ± 4,320	72.07 ± 10.99	95.67 ± 5.27	21.14 ± 0.76	78.86 ± 0.75
A1B3	9,920 ± 8,881	74.63 ± 9.18	86.40 ± 11.60	12.76 ± 2.10	87.24 ± 2.10
A2B1	37,440 ± 19,970	81.92 ± 10.33	91.87 ± 7.13	22.41 ± 1.33	77.59 ± 1.33
A2B2	21,760 ± 6,337	80.69 ± 5.81	85.93 ± 8.60	22.50 ± 5.79	77.50 ± 5.78
A2B3	12,320 ± 4,355	81.46 ± 7.60	78.00 ± 17.42	13.70 ± 2.45	86.30 ± 2.45

A1: broodstock 14 cm TL, A2: broodstock 16 cm TL, B1: E. crassipes, B2: H. verticillata, B3: without aquatic plant

A. Fecundity

The highest fecundity was produced by A2B1 treatment: broodstock of 16 cm TL with *E. crassipes* (37,440 ± 19,970 eggs), followed by A2B2: broodstock of 16 cm TL with *H. verticillata* (21,760 ± 6,337 eggs), A1B1: broodstock of 14 cm TL with *E. crassipes* (14,880 ± 8,532 eggs), A2B3: broodstock of 16 cm TL without aquatic plants (12,320 ± 4,355 eggs), A1B2: broodstock of 14 cm TL with *H. verticillata* (11,040 ± 4,320 eggs), and A1B3: broodstock of 14 cm TL without aquatic plants (9,920 ± 8,881 eggs). The variation in fish fecundity is not only due to fish length and weight, but also influenced by age, nutritional diet, broodstocks condition, environmental condition and food availability (Marimuthu et al., 2009; Ziauddin et al.2016; Zworykin, 2018).

The ANOVA test showed that the treatment has a significant effect on the fecundity of fish. Further analysis with Duncan Multiple Range Test (DMRT) revealed that the treatment of A1B2 or A1B3 was significantly different from A2B1, but it was not significantly different from A2B2, A1B1, A2B3, and A1B2. Dealing with the breeding process, it was clearly observed that the broodstock of Climbing perch preferred with the presence of *E. crassipes* as compared to *H. verticillata*. This because *E. crassipes* have roots that stretch down, lush, flexible, smooth, and float on the water served as a good shelter and allow for ovulation process become faster. While *H. verticillata* were a type of sinkable aquatic plants that have a rough and lush texture resulted in the broodstocks sense inconveniently around them so that spawning process may take slightly longer. On the other words, the presence of these aquatic plants in the breeding process showing better results than without aquatic plants.

The broodstock sizes used in the present study are within the range of sizes suggested by other research workers i.e. 12.4-19.2 cm TL (Ziauddin et al., 2016) and 16.3-19.2 cm TL (Slamat and Ansyari 2013). The fecundity produced by the broodstocks of 14-16 cm TL in this research ranged from 4,320 to 59,520 eggs, which is in agreement with the finding of Marimuthu et al. (2009) that is between 3,120 and 84,690 eggs generated by female of 12.4-19.2 cm TL sampled from the river Layar Tengah near Sungai Petani, Kedah, Malaysia. However, it was considerably lower than the fecundity of climbing perch taken from Rupali Fish Hatchery, Bangladesh (Hafijunnahar et al., 2016), which is ranged from 50,610 to 227,378 in individuals of total length from 19-24 cm, indicating that the bigger size of fish the higher fecundity (Figure 4.4).

In addition, Slamat and Ansyari (2013) strongly recommended selecting the broodstocks with the body size of ≥ 300 gr per individual in order to produce offspring greater than their broodstocks. The idea is supported by Wahyudewantoro and Haryono (2013). Fecundity can be used to estimate the number of offspring to be born in a spawning season, broodstock productivity and the age class of the fish (Slamat and Ansyari 2013). No interaction between the broodstock sizes and the aquatic plants to the fecundity of fish was observed (F_{count} = 1,470 < F_{table} = 3.885).

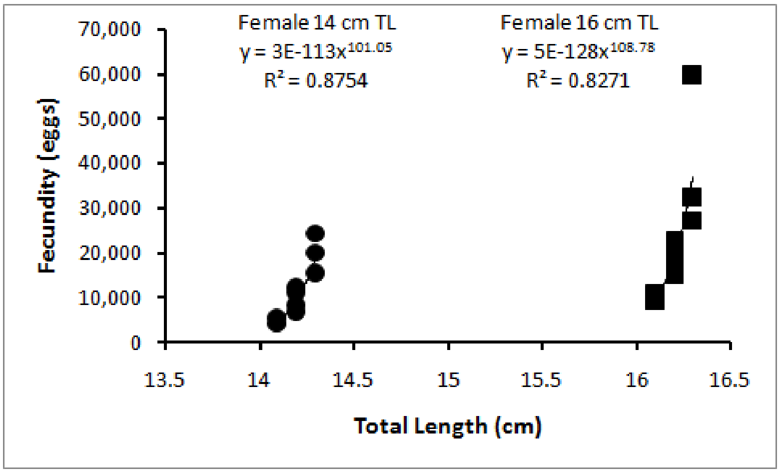

Figure 4.4 The relationship between total length and fecundity of Climbing perch female broodstocks with different sizes.

B. Fertilization rate

The treatment of A2B1 generated the highest fertilization rate (81.92 ± 10.33%), followed by A2B3 (81.46 ± 7.60%), A2B2 (80.69 ± 5.81%), A1B3 (74.63 ± 9.18%), A1B2 (72.07 ± 10.99%), and the lowest one was A1B1 (69.73 ± 1.49%). The fertilization rate obtained in the present study was similar to induced breeding of climbing perch in laboratory, Siliguri, India

(Sarkar et al., 2015). The higher percentage of fertilization and hatching rates the better the quality of eggs and sperm produced by the fish. Variation in the value of fertilization and hatching rates may be attributed to broodstocks health, Gonadosomatic index (GSI), environmental condition, broodstocks origin, age and size of broodstocks and nutrients supply during pregnancy (Zalina et al., 2012; Uddin et al., 2016).

Analysis of variance showed that the fish length significantly affects the fertilization rates of fish (F_{count} = 5.651 > F_{table} = 4.747), but aquatic plants did not. No interaction between the broodstock sizes and the aquatic plants to fertilization rates was observed (F_{count} = 0.165 < F_{table} = 3.885). The fertilization rate in the egg cell is strongly influenced by the quality of sperm, the egg cell produced, movement of spermatozoa to the micropyle hole of the egg cell, and also water quality particularly water temperature (Bobe and Labbé, 2010; Yanagimachi et al., 2017). The fertilization and the egg hatchability can be used as indicator to find out the optimal spermatozoa in fertilizing ovum generated by broodstocks.

C. Hatching rate

The treatment of A1B1 was observed to have the highest hatching rate (96.67 ± 2.64%), followed by A1B2 (95.67 ± 5.27%), A2B1 (91.87 ± 7.13%), A1B3 (86.40 ± 11.60%), A2B2 (85.93 ± 8.60%), and A2B3 (78.00 ± 17.42%). There was no significant difference between treatments and hatching rates of fish (F_{count} = 2.638 < F_{table} = 4.747), as well as interaction between the sizes of broodstock and aquatic plants towards the hatching rates (F_{count} = 0.098 < F_{table} = 3.885). The hatching rates of 85-96% with the sex ratio of male to female 2 : 1 in the present study was higher than those of 40-85% with the sex ratio 1 : 1 reported by Slamat et al. (2012).

Meanwhile, Burmansyah et al. (2013) found no significant differences in the sex ratios (1:1, 1:2, 1:3, 1:4) toward the hatching rates of Climbing perch by mean of semi-natural breeding. The hatching rates of fish are greatly influenced by some factors such as the type of fish, age, nutrient availability, level of gonad maturity, the quality of sperm, fish health, the egg condition, and environmental condition particularly water temperature and water salinity (Sangsawangchote et al., 2010; Zalina et al., 2012; Nadirah et al., 2014; Sarkar et al., 2015).

D. Survival rate

The ANOVA test showed that the treatment significantly affects the survival rates of the fish (F_{count} = 84,129 > F_{table} = 3.885). The best performance for the survival rate was given by the treatment of A2B2 (22.50 ± 5.79%), followed by A2B1 (22.41 ± 1.33%), A1B2 (21.14 ± 0.76%), A1B1 (18.22 ± 0.84%), A2B3 (13.70 ± 2.45%), and A1B3 (12.76 ± 2.10%). The highest survival rate for A2B2 treatment positively corresponds to fecundity, fertilization and hatching rates obtained.

The presence of aquatic plants significantly affects the survival rates of the fish. The treatment of A1B2, A2B1 or A2B2 was considerably higher than that of A2B3, indicating that the presence of aquatic plants can help increasing the survival rates of larvae up to 22.5% or almost two times higher than treatment with no aquatic plants, other than *Daphnia* sp. supply. The survival rates of Climbing perch in the present study are greatly lower as compared to other studies in terms of dietary approaches (Putra et al., 2016; Rahmi et al., 2016; Muchlisin et al., 2017). Some fish species will also use the aquatic plants for their nests, where other smaller fish and zooplankton will use them to hide from predators.

E. Mortality Rate

Mortality is the number of dead fish during culture process. The highest mortality rate was observed in the treatment of A1B3 (87.24 ± 2.10%), followed by A2B3 (86.30 ± 2.45%), A1B1 (81.78 ± 0.83%), A1B2 (78.86 ± 0.75%), A2B1 (77.59 ± 1.33%), and lastly was A2B2 (77.50 ± 5.78%). The ANOVA test showed that the treatment significantly affects the mortality rates of the fish (F_{count} = 16,140 > F_{table} = 3.885). Further analysis was found that the treatments of A1B2, A2B1, and A2B2 were significantly different from A1B3, A2B2, and A2B3. While the treatments of A2B3 and A1B1 were not significantly different from A1B2 and A1B3. No interaction between the broodstock sizes and aquatic plants towards the mortality rates was detected (F_{count} = 0,599 < F_{table} = 3.885).The presence of aquatic plants can help reducing mortality rate of larvae up to 18% as compared to the absence of them; this because aquatic plants provided a good supply of water quality, served as shelter from cannibalism attacks, and can be used as an agent of bioremediation.

It is recognized that making into the fingerling size is crucial to success due to mortality question at larval stage. The critical period of larvae occurs at day 7 to day 14 following the development of larval mouth opening, when the larval yolk has run out and larvae need feed from the outside. If the mouth opening is not well-developed, the larvae will take the trouble with its dietary and potentially causes cannibalism leading to the death. Moreover the average size of *Daphnia* sp. given to the larvae was about 125 μm, which is bigger than the mouth opening of larvae observed at day 3 to day 7. Thus the high mortality rate in the present study was more attributable to this circumstance rather than water quality condition. Rukmini (2018) reported that the average mouth opening of larvae at day 3 and day 7 was 103.11 μm and 106.02 μm respectively, and suggested that the natural feed given should be less than these values.

Figure 4.5 shows the relationship between the treatments and growth rate of the larvae during observation periods. The results clearly demonstrated that the treatment of A2B1 produced the best performance in term of larval growth rate (21.98%), followed by A1B1 (20.88%), A2B2 (16.48%), A1B2 (15.38%), A2B3 (13.19%) and A1B3 (12.09%), indicating that the presence of aquatic plants was beneficial for larvae to grow faster than without aquatic plants. Overall, the larval growth obtained ranging from 0.22 to 0.40 g weight per individual. The use of aquatic plants also capable of increasing the larval survival of catfish in the tank by 95.49% and specific growth rates of 1.53% in length for 28 days (Annisa et al., 2017). Research output contributes to an increasing number of field experimental studies on the function of aquatic plants.

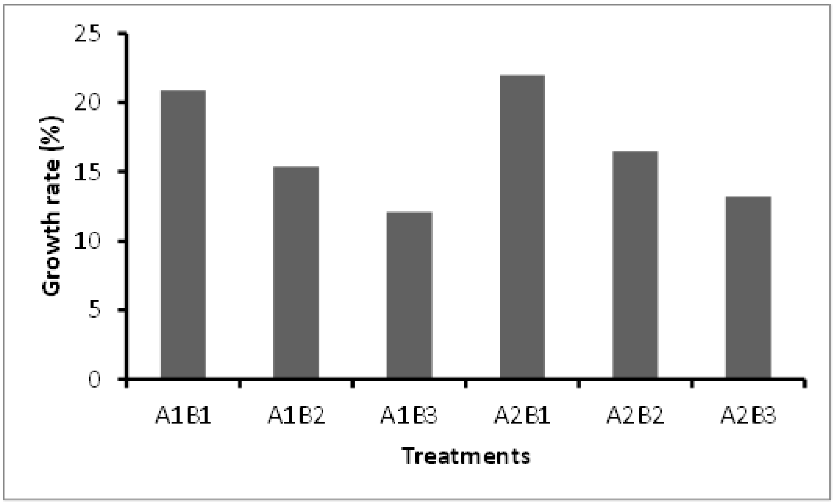

Figure 4.5 The relationship of growth rate and treatments given to Climbing perch associated with the aquatic plants during research periods. A1: broodstock 14 cm TL, A2: broodstock 16 cm TL, B1: E. crassipes, B2: H. verticillata, B3: without aquatic plants.

F. Length-Weight Relationship

The estimated *b* values obtained from the length-weight relationship equations were 2.68 for male and 2.63 for female (Figure 4.6), indicating that Climbing perch broodstocks used in the present study grew negatively allometric ($b < 3$), which means that the length increases more than weight. The values of determination coefficient (R^2) ranging from 0.7898 and 0.9947 representing that more than 99% of variability of the weight is explained by the length. The correlation coefficient (r) obtained for male and female were 0.8887 and 0.9973, found to be higher than 0.5, showing the length-weight relationship is positively correlated.

Negative allometric growth pattern in Climbing perch in the present study was also reported by other research workers (Kumar et al., 2013; Hossain et al., 2015). The weight-length relationships are not constant over the entire year and vary according to factors such as food availability, feeding rate, gonad development and spawning period (Kumary and Raj, 2016).

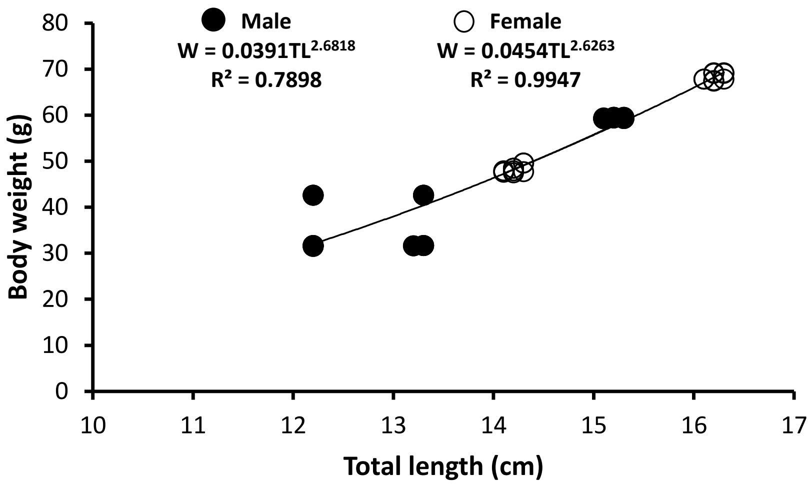

Figure 4.6 The relationship between total length and body weight of Climbing perch broodstocks that grew negatively allometric.

G. Water quality

The measurement results of water quality in the experimental tanks for Climbing perch were presented in Table 4.3. A suitable water quality parameter is an important prerequisite for healthy aquatic environment, better production and breeding success (Hafijunnahar et al., 2016). During the research, water qualities were in tolerance range for Climbing perch larvae rearing (Syamsuddin et al., 2019). According to Widodo et al. (2007), the optimum water temperature for the growth of Climbing perch ranges of 25-30°C, and water temperature measured in this research (26-30°C) was fixed accordingly. The pH value obtained during the study ranges of 6-7. While Widodo et al. (2007) reported that Climbing perch can grow normally in waters with a pH ranged of 4-8. The dissolved oxygen (DO) was recorded between 3.4-4.0 mg L^{-1}. Since Climbing perch are typically labyrinth species, they can still survive even DO less than 3 mg L^{-1} (Sarma et al., 2010). Level of Ammonia (NH3) was measured in the ranged of 0.001 - 0.043 mg $^{L-1}$. Boyd (1990) suggested that the Ammonia concentration should be less than 0.1 mg L^{-1}. There were no significant differences in the water temperature, pH, DO and NH3 in different time of the measurement during the study periods.

Table 4.3. Water quality measurement during observation periods

Parameter	Initial	Middle	End
Temperature (°C)	26 - 29	28 - 30	26 - 29
pH	6 - 7	6 - 7	6 - 7
DO (mg L^{-1})	3.4 - 3.8	3.6 - 4.0	3.6 - 3.9
NH3 (mg L^{-1})	0.001 - 0.041	0.001 - 0043	0.02 - 0.043

IV. EPILOGUE: CONCLUSION AND RECOMMENDATION

The combination of larger broodstock and *Eichhornia crassipes* (A2B1) provided the best performance especially in fecundity and fertilization rates of Climbing perch. Inability of larvae to consume natural food at early days resulted in low survival, while water quality did not affect and was in tolerance range for larvae rearing.

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CHAPTER - V

FISH FARMING BUSINESS ANALYSIS

I. PROLOGUE: ECONOMICS OF CLIMBING PERCH

The Climbing perch (*Anabas testudineus* Bloch, 1792), in South Kalimantan known as “papuyu”, is one of commercially important fish species served as food source. It is also widely marketed and sold throughout local markets in Malaysia (Zalina et al., 2012), Vietnam (Van and Hoan, 2009), Lao PDR (Sokheng et al., 1999), Cambodia (Sverdrup, 2002), Thailand (Chotipuntu and Avakul, 2010), India (Kumar et al., 2013), the Philippines (Bernal et al., 2015), and Bangladesh (Hossain et al., 2015; Uddin et al., 2017). It plays a significant role in fisheries and aquaculture practices due to its high nutrition value, as well as for great taste and flavor. It is rich in iron and copper that support hemoglobin synthesis (Sarma et al., 2010) and has high quality poly-unsaturated fats and many essential amino acids (Kohinoor et al., 1991). It also provides 4.4% of lipid and 19.50% of protein contents (Wimalasena and Jayasuriya, 1996; Ahmed et al., 2012). The demand of this species is very high not only for local consumption but also for restaurants and small enterprises of fish processing.

A. Characteristic and Culture Potential of Climbing Perch

It is a native air-breathing fish, typically found in swamps, rivers, streams, lakes, canals, reservoirs, and estuaries (Sarkar et al., 2005; Chotipuntu and Avakul, 2010; Rahman and Marimuthu, 2010). It can survive in adverse environmental conditions such as low oxygen due to its air breathing ability, wide range of temperature and other poor water conditions (Rahman and Monir, 2013). However, the presence of them is threatened by the ecological degradation, indiscriminate fishing, use of pesticides and fertilizers, habitat modification, obstruction to breeding migration, and management failure (Misra, 1994; Kalita and Deka, 2013; Hossain et al., 2015). Considering the importance of them, the breeding technologies of this species have been developed with varying degrees of success (Kohinoor et al., 1991; Sarkar et al., 2005; Marimuthu et al., 2009; Zalina et al., 2011), as well as the attempts to improve the culture management system of ponds or cages with different culture strategies (Mondal et al., 2010; Habib et al., 2015; Putra et al., 2016; Ali et al., 2016). All these studies outlined above more or less describing on ecological and biological aspects of this species.

B. The Reason behind Aquaculture Business Analisys

To date, biofloc technology application in aquaculture system is widely introduced and had been successfully used for some commercial fish species such as African catfish *Clarias gariepinus* (Ekasari et al., 2016), nile tilapia *Oreochromis niloticus* (Nahar et al., 2015; Ekasari et al., 2015), as well as for shrimp culture such as pink shrimp *Farfantepenaeus duorarum* (Emerenciano et al., 2013), the pacific white shrimp *Litopenaeus vannamei* (Da Silva et al., 2013), Malaysian prawn *Macrobrachium rosenbergii* (Perez-Fuentes et al., 2013). Meanwhile, the use of biofloc technology for air-breathing species cultured like Climbing perch is still rarely done. Moreover in term of economic importance, very little literature is available describing how the business prospect being executed in this culture systems (Izmaniar et al., 2018). The current research will elucidate the secret behind successful of Climbing perch culture business of De' Papuyu Farm on the basis of biofloc technology application. To get clear picture, we analyzed the total cost, profit, and the feasibility of business, as well as provided the business development strategies for this species.

II. FOLLOW-UP RESEARCH

A. Study site

De' Papuyu Farm Banjarbaru was selected purposely for the study area due to the following reasons i.e. (1) Climbing perch with biofloc culture system was commercially introduced first in this city; (2) many farmers around were interested in learning and have adopted such biofloc technology in their fish farming; and (3) De' Papuyu Farm can be a good model for small-scale culture business development in advance.

The total land area for fish farming was about 624 m^2 (24×26 m) including for pond area, recycle pond, security house/warehouse, audience hall, park area and space area. The lay-out of De' Papuyu Farm can be seen in Figures 5.1 and 5.2. A total of 24 pond units used for the growth-out of Climbing perch culture business. The circle-shaped pond made of tarpaulin with the diameter of 3 m, 120 cm height and 90-100 cm depth of water. The fish growth-out period in the ponds appropriated eight months starting from seeding to harvesting. The sorting process was undertaken after rearing for three months, and the only female fish were selected to be grown (50-60 %) due to rapid growth and having the greater size when harvested. The seeds sourced from fish hatchery of Gunung Manau Balangan, about 120 km from Banjarbaru City. The research activity was started from October 2017 to May 2018. De' Papuyu Farm also provides regular training for fish farmers.

B. Data Collection and Analysis

The data collected comprising primary and secondary data. Primary data obtained from farm owner by interview and questionnaires as well as direct observation related to the culture system, fish production, operational cost, profit, distribution and marketing.

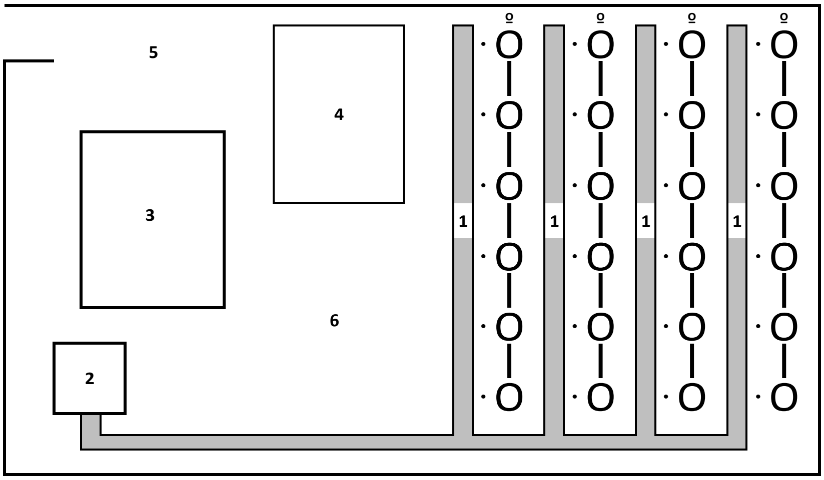

Figure 5.1 The lay-out of De' Papuyu Farm Banjarbaru
(1) Culture pond area, (2) Recycle ponds, (3) Security house/warehouse,
(4) Audience hall, (5) Park area, and (6) Space area.

Figure 5.2 De' Papuyu Farm's facilities: (1) Typical culture pond,
(2) Recycle pond, and (3) Climbing perch production

While secondary data in the forms of annual report, literature, and other document related. The followings are formulas used to estimate the total cost, total revenue, and total profit.

$$\mathbf{TC = FC + VC}$$

Where TC is total cost, FC is fixed cost, and VC is variable cost, stated in IDR

$$\mathbf{TR = Q \times P}$$

Where TR is total revenue, Q is quantity (kg), and P is price (IDR)

$$\boldsymbol{\pi} \mathbf{= TR - TC}$$

Where π is profit, TR is total revenue, and TC is total cost. The profit gained is then compared to the minimum wage of South Kalimantan Province, which is equal to 2,455,671 IDR/month comply with Governor Decree No. 188.44/0492/KUM/2017 about the Minimum Wage of Regency and City, 2018). The feasibility of business is analyzed using four investment criteria, namely Payback Period (PBP), Net Present Value (NPV), Net Benefit Cost Ratio (Net BCR), and Internal Rate of Return (IRR) with the following formulas:

$$PBP = \frac{InCap}{AnnualCF}$$

Where *PBP* is payback period, *InCap* is investment value, and *Annual CF* is annual cash flow

$$NPV = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1+i)^t}$$

Where *NPV* is net present value, B_t is benefit of year-t, C_t is *cost of year-t*, i is interest rate, and t is investment time.

$$NetBCR = \frac{\sum_{t=1}^{n} NPV^{+}}{\sum_{t=1}^{n} NPV^{-}}$$

Where NPV^{+} is positive net present value, and NPV^{-} is negative net present value

$$IRR = i_1 + \frac{NPV^{+}}{NPV^{+} - NPV^{-}}\left(i_2 - i_1\right)$$

Where IRR is internal rate of return, NPV $^{+}$ is positive net present value, NPV $^{-}$ is negative net present value, i_1 is interest rate when NPV positive and i_2 is interest rate when NPV negative. It is assumed that if $NPV \leq 0$; $Net\ BCR \leq 1$; and $IRR \leq 9\%$, indicating the business is unreasonable. Otherwise, if $NPV > 0$; $Net\ BCR > 1$; $IRR > 9\%$, it is therefore the business is reasonable to be developed.

The SWOT analysis is used to formulate the strategy for business development of De' Papuyu Farm starting from the collection of valuable data-information related and internal problems being faced, as well as the external factors that may inhibit the development progress. SWOT Analysis is a tool used effectively to build organizational strategy and competitive strategy. SWOT Analysis has two dimensions: Internal and external. Internal dimension includes organizational factors, also strengths and weaknesses; while external dimension includes environmental factors, also opportunities and threats (Gurel and Tat, 2017). SWOT Analysis is a simple but powerful tool for sizing up an organization's resource capabilities and deficiencies, its market opportunities, and the external threats to its future (Thompson et al., 2007). In other word, SWOT analysis is a technique for assessing the performance, competition, risk, and potential of a business.

III. RESEARCH FINDING AND DISCUSSION

A. Cost Structure and Profit

Investment cost is the initial-capital of De' Papuyu Farm to purchase long-term goods and assets for the Climbing perch culture business (more than one year). To run this business, the total investment cost required was 167,634,000 IDR with depreciation cost of 24,337,800 IDR/year. The highest investment cost was for procurement of 24 ponds reached 72 million IDR; followed by concrete panel fence 40 million IDR and security house 25 million IDR (Table 5.1). The number of purchase units depends on the needs and budget.

It was clearly mentioned in Table 5.2, the pay for 120,000 fish seeds (50-80 mm total length) was the top rank of variable costs reaching 36 million IDR (46.10%), followed by the feed expenses of 29.7 million IDR (40.41%). About 13.49% pay for other variable costs regardless employee's wage. Total variable cost with labor wage was 140.88 million IDR. Total cost for the business was 165,218,200 IDR comprising 24,337,800 IDR for fixed costs and 140,880,400 IDR for variable costs. Fixed cost is the regular outcome regardless of the production volume (e.g. depreciation cost, salary expense, capital rate). While variable cost is the cost variance depends on the production volume (e.g. wages, seeds, feed, electricity, probiotic, and labor).

The total revenue obtained from the selling of fish was 228,000,000 IDR/cycle of production (Table 5.3). There are two types of revenue: (1) the main revenue from the fish being cultured for 8 months and (2) the additional revenue from the selling of male fish after rearing for three months. The main fish were sold to outside of South Kalimantan, especially Central Kalimantan, while the remaining fish were marketed around Banjarbaru City and Banjar Regency.

Table 5.1. Investment cost and fixed cost for culture business of Climbing perch for eight months (000. IDR)

Cost items	Unit	Unit Price	Total Price	Economic life (year)	Depreciation Cost
Investment cost					
Ponds	24	3,000	72,000	5	14,400
Aerator (100 watt)	4	1,500	6,000	5	1,200
Pipe 1/2 inch (rod)	28	24	672	3	224
Roof frame (wood)	1	4,500	4,500	10	450
Tarpaulin roof (8x10)	4	320	1,280	1	1,280
Hapa (roll)	1	375	375	1	375
Electric cable 2×1.5 mm (roll)	1	195	195	5	39
Security house	1	25,000	25,000	10	2,500
Recycle pond	1	6,000	6,000	10	600
Concrete panel fence	100	400	40,000	20	2,000
Jet pump	1	750	750	5	150
Washbasin	2	55	110	2	55
Plastic bucket-cover 40 l	2	75	150	2	75
Plastic bucket-cover 20 l	2	16	32	2	16
Scoop nets	2	45	90	2	45
Filters	2	13	26	1	26
Fish sorter	2	20	40	1	40
Generator set	1	1,300	1,300	5	260
Aerator tube (50 m roll)	3	50	150	2	75
Reservoir 1500 l	1	1,850	1,850	10	185
Frame of reservoir	1	2,000	2,000	10	200
Water pipe 1 inch	17	42	714	5	143
Training certification	1	400	400		
Land (26 × 24 m)	1	4,000	4,000		
Total investment cost			167,634		
Fixed cost					
Total investment depreciation					24,337.8

Table 5.2. Variable cost spent for culture business of Climbing perch for eight months (000 IDR)

Cost items	Unit	Unit Price	Total Cost/ Production
Electricity (kwh)	2,304	1.35	3,110.4
Fish seeds (50-80 mm)	120,000	0.3	36,000
Feed pf 500 (sack)	6	155	930
Feed pf 1000 (sack)	6	155	930
Feed Cargile 1 (sack)	100	297	29,700
Probiotic (l)	24	100	2,400
Molasses (l)	48	20	960
Lime (kg)	200	5	1,000
Salt (kg)	500	3	1,500
Water (m^3)	168	5.15	865,2
Pineapple	24	7	168
Litmus paper (pack)	1	35	35
Transportation	1	500	500
Total variable cost without labor wage			78,098.6
Labor wage (share profit system)			62,781.8
Total variable cost with labor wage			140,880.4

The profit sharing system was 50% for De’ Papuyu Farm’s owner and 50% for the employees, which was equal to 62,781,800 IDR per cycle of production or 7,880,700 IDR per month. Since total revenue was greater than total cost, it meant that this business was considered effective and profitable. This income is more three times higher than the provincial minimum wage of 2,454,671 IDR per month.

Table 5.3. Total revenue of culture business for Climbing perch (000 IDR)

Type of revenues	Production (kg)	Unit Price	Total Revenue
1. The main revenue gained from fish cultured for eight months.	2,880 (120)*	75	216,000 (9,000)**
2. The additional revenue from the selling of male fish that sorted during three months cultivation.	1,200 (50)*	10	12,000 (500)**
Total	4,080 (170)*		228,000 (9,500)**

The values in the brackets indicate the average fish production*) or total revenue gained per each pond**)

B. Feasibility analysis

The payback period refers to the amount of time it takes to recover the cost of an investment. Simply put, the payback period is the length of time an investment reaches a break-even point. The desirability of an investment is directly related to its payback period. Shorter paybacks mean more attractive investments. The payback period is a measure of profitability and liquidity (Hajdasinski, 1993). In the present study, the payback period (PBP) value obtained for Climbing perch culture business was 2.67, showing that the investment capital can return after having three times of productions within two years. It is generally accepted that investments with shorter payback periods are considered to have lower risk (Lohmann and Baksh, 1993; Lin, 2010). It is also considered reasonable that the shorter the PBP, the more liquid and the more viable the business (Kim et al., 2013).

The values of NPV investigated at 7 % and 9 % of interest rates were 568,915,905 IDR and 502,791,869 IDR respectively (Table 5.4), indicating that the business was very feasible. The feasibility of business can also be seen from the Net BCR values of 4.39 at 7 % and 4.00 at 9 % of interest rates. Final evaluation revealed that the IRR value obtained for 10 years of investment period was 57.04%. It means that this culture business provides financial growth by 57.04% per year. This IRR value was higher than MARR (minimum attractive rate of return) 9 %. In other word, a business will be acceptable if IRR is greater than opportunity cost of capital. It was clear from our study that the Climbing perch culture business with biofloc technology was feasible and profitable (Izmaniar et al., 2018). The current IRR value obtained in this study was higher than that of Nile tilapia hatchery rearing in Dera District of Ethiopia (Asmare, 2017), but it was lower than that of Patin culture in Sipungguk Village of Riau Province (Syafii et al., 2017). Overall results of the business feasibility analisys of these important fish species can be seen in Table 5.5.

Table 5.4. Comparative NPVs that calculated at 7 % and 9 % of interest rates (IDR)

Year	NPV at 7 %			NPV at 9 %		
	Total Cost	Revenues	Profit	Total Cost	Revenues	Profit
0	167,634,000	-	(167,634,000)	167,634,000	-	(167,634,000)
1	154,409,533	213,084,112	58,674,579	151,576,330	209,174,312	57,597,982
2	267,358,372	398,288,060	130,929,688	257,637,068	383,806,077	126,169,009
3	134,867,266	186,115,916	51,248,650	27,578,765	176,057,833	48,479,069
4	233,521,156	347,880,217	14,359,060	216,847,965	323,041,896	106,193,931
5	117,798,293	2,560,849	44,762,556	107,380,494	148,184,356	40,803,862
6	203,966,422	303,852,054	99,885,632	182,516,594	271,897,901	89,381,307
7	102,889,591	141,986,941	9,097,350	90,380,013	124,723,808	34,343,795
8	178,152,172	265,396,152	87,243,980	153,620,566	228,851,024	75,230,458
9	89,867,754	124,016,893	34,149,139	76,071,049	104,977,534	28,906,485
10	155,605,007	231,807,277	76,202,271	129,299,357	192,619,328	63,319,971
Total	1,806,069,566	2,374,988,471	568,918,905	1,660,542,200	2,163,334,069	502,791,869

Table 5.5. Comparative feasibility analisys of three important fish species

Fish Species	Investment Criteria			
	NVP (USD)	BCR	IRR (%)	PBP (year)
Climbing perch[(1)]	39.10	4.39	57.04	2.67
Patin[(2)]	48.33	1.37	65.13	4
Nila tilapia[(3)]	1.60	1.82	43.00	2.1

Sources: (1) Izmaniar et al. (2018), (2) Syafii et al. (2017), and Asmare (2017)

C. Business Development Strategy

The internal factor (strength and weakness) and external factor (opportunity and threats) of De' Papuyu Farm have been identified using a SWOT matrix as presented in Table 5.6. By Quantified SWOT analysis and revealing of the coordinates (1.15: 0.4), we found that the position of De' Papuyu Farm was in the first quadrant (Figure 5.3), indicating that the farm has external opportunities for business development (e.g. market expansion, job creation, network building) and internal competing strength (e.g. capacity building, entrepreneur, corporate culture), thus are in the best position for facing future business competition.

Table 5.6. Identification of internal and external factors that interplay the culture business of De' Papuyu Farm using SWOT analysis.

Internal Factor	**External Factor**
Strength	*Opportunity*
1. The only business of climbing perch fish farming with biofloc system in Banjarbaru city. 2. Low feeding rate 3. Can be used in a limited area. 4. Competence of skilled workers who have been trained and have certificate of expertise.	1. Public interest towards climbing perch fish farming business. 2. High demand for climbing perch fish from both local and regional. 3. Fish farming can increase the role of the fishery sector. 4. Creating business partnerships

Internal Factor	External Factor
5. The probiotics used are resistant to uncertain weather conditions 6. Production does not depend on the season.	such as seeding, processing and marketing business. 5. Creating jobs for local people around business areas.
Weaknesses	*Threats*
1. Fish farming business with biofloc system is very dependent on the electricity. 2. Culture facilities not well maintained. 3. The absence of business accounting records. 4. Inexperience of workforce. 5. Location of fish hatchery is quite far from the fish farming (± 200 km). 6. The price of probiotics making is expensive	1. The qualified seeds for fish farming activity are still limited in quantity. 2. Negative paradigm due to the failure of fish culture business in the community. 3. The newly seeds stocked in the pond is threated by wild bird. 4. Unstable electricity causes production failure. 5. Shared concern on fish farming business with biofloc system is still lacking

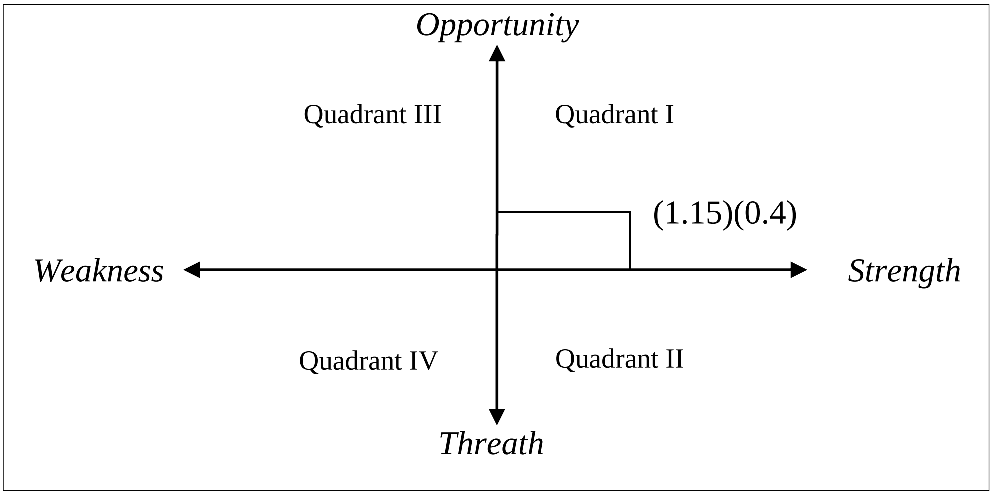

Figure 5.3 The SWOT analysis presenting the position of De' Papuyu Farm was in the first quadrant

In line with this, Chang and Huang (2006) suggested that enterprises in the first quadrant can use their strengths to adopt strategies, such as market penetration, market development, and product development to form competitive strength. In this position, enterprise has extra resources, forward, backward and horizontal integration may be efficient strategies. We used the SWOT matrix to systematically prepare for the future strategic choices, such as: (1) the local government should establish the certified community hatchery units to support the high demand of climbing perch fish production, as well as to reduce transportation cost; (2) improvement of business management by training and internship program; (3) network building with other businessmen related to the hatchery, fish processing and marketing business; (4) product advertising of climbing perch culture business with biofloc system through social media should be encouraged.

IV. EPILOGUE: CONCLUSION AND RECOMMENDATION

It can be concluded that the fish culture business of climbing perch with biofloc system provides the profit more than three times higher than the province minimum wage. The business feasibility can be seen from the following criteria: NPV > 0, Net BCR > 1, PBP and IRR value were 2.67 and 57.04% respectively. The fish farming with biofloc system has the favorable prospect due to high demand and the biofloc technology package can be adopted by small-medium scale enterprises and other fish farmers.

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CHAPTER - VI

MARKETING CHANNELS AND MARKET STRUCTURE

I. PROLOGUE: MARKETABLE FISH PRODUCTION

Indonesia is the world's largest archipelago state and now the second largest global fish producer. The fishery sector contributes about 8% of national gross domestic product. More than 11 million people are working in this sector as fishermen (8.69%), fish farmers (35.06%), fish processors and fish marketers (55.84%), and salt farmers (0.41%). Consuming fish is very good for health as fish provides essential amino acid, calcium, phosphorus, iron, zinc, copper, vitamins (Tilami and Sampels, 2017). Fish arranges for 19.50% of protein and 2.27% of lipid (Ahmed et al., 2012). Fish consumption increases from 47.34 kg to 50.69 kg per capita per year. Nowadays, perception of consumer preferences for consuming fish is highly appreciated (Esilaba et al., 2017). Fish consumption preferences are affected by individuals' socio-economic characteristics (Can et al., 2015).

A. Marketing System

Fish marketing is a crucial factor to success for producers (i.e. fishermen, fish farmers, fish processors) and traders to earn the profit since fish being a highly perishable commodity needs immediately processed or sold after harvest (Rokeya et al., 1997; Ali et al., 2008; Husen, 2019). It spoils soon after death due to microbial actions, which result in disagreeable taste, smell and texture thereby reducing consumer acceptability (Garrow and James, 1994). Meanwhile the fish price fluctuates much depend on the season, the quantity and quality of fish, the type and size of fish, freshness, supply and demand, market structure, market distance, and also long-short of marketing channels (Aswathy and Abdu Samad, 2013; Begum et al., 2014; Rahman et al., 2019). All fish marketed here are in the form of fresh fish, live fish, frozen and smoked fish generated from fishing, aquaculture and fish processing. Nowadays, business transaction can also be done through retail market, fishing port or even via internet order (Ahmed and Hossain, 2012).

Basically the marketing system is the exchange activities associated with transferring property rights to commodities, physically purchasing and allocating resources, handling of products, disseminating information to participants, market intermediaries and institutional arrangements for facilitating these activities (Hussain et al., 2003; Hossain et al., 2015; Husen, 2019). Since many parties who involved in the marketing channels so that the marketing system is needed to be well-managed and integrated (Sathiadhas and Kanagam, 2000; Omar et al., 2014) in order to create the healthy and sustainable business environment.

B. The Reason behind Supply and Demand

For Kalimantan's people, Climbing perch (*Anabas testudineus*), known as "*Papuyu*", is favorably considered as one of commercially important freshwater fish species (Ahmadi, 2019). The fish are usually served as delicious food with high quality meat. The market demand for Climbing perch continuously increase from time to time, meanwhile the market supply is still low in quantity and most highly dependent on the wild catch. Aquaculture may provide a solution to overcome this problem. Biofloc system is recently developed for aquaculture to increase the fish production. With this method, it is expected that (1) the availability of fish in the market is no longer dependent on the season, (2) the price of fish is stable, and (3) the market demand will be able to be met. The price at the retail level will be the basis for determining the price to be paid to the wholesalers and ultimately to fish farmers and vice versa. The price received by fish farmers will determine how much volume of production they produce which is then sold to the wholesalers or retailers. If the price received is satisfactory, the production offered to the market will increase, and vice versa. In the present study, we investigated the marketing channels for Climbing perch of biofloc-based culture system including farmer's share and the profit gained at different levels of marketing, as well as provided specific suggestions for improving the marketing system in this area of study.

II. FOLLOW-UP RESEARCH

A. Study sites

The research activities were started by visiting the fish farmer groups of Climbing perch with biofloc culture system in Banjarbaru and then moved into local fish markets located in Banjarbaru, Rantau, Pelaihari of South Kalimantan Province, and Kapuas District of Central Kalimantan, Indonesia. The sampling sites were shown in Figure 6.1. These locations are purposively selected to exemplify the marketing channels and distribution of Climbing perch at different levels. The fish markets are typically open in the early morning and then close by mid-afternoon. These fish markets are usually joined with the wet market that is also selling fresh meat, dried fish and other perishable goods such as vegetable and fruit. Fish markets are dominated by women. Traditional fish markets usually have the shortest marketing channel because they consist of only two parties - a producer and a consumer. Such channel is categorized as direct channel marketing. All fish buying and selling transcations are made in cash. Official visits to the Fishery Services were also done to complement output of this research. All research activities were consistently documented (Figure 6.2).

Figure 6.1. The map showing the sampling sites (circles marks) of fish marketing for Climbing perch in South Kalimantan Province

Figure 6.2. Research data collection activities

B. Characteristic of Respondents

A total of 22 respondents who directly involved in marketing channels were selected comprising 5 fish farmers, 2 wholesalers and 15 retailers. The ages of respondents varied between 44-51 year olds with the duration of business experience ranged of 2-4 years.

C. Sampling Method

The fish farmers were selected by sensus method while the wholesalers and retailers were determined by snowball sampling method. Snowball sampling is a purposeful method of sampling in qualitative research (Naderifar et al., 2017). The respondents were interviewed using the structured questionnaires. The deep interview was undertaken to get overview and reliable information on the existing fish distribution and marketing systems, marketing channels, and also constraints being faced. All respondents friendly answered all questions during the process of data collection.

D. Marketing Margin

Marketing margin is the difference between the price at the fish farmer level and the price at the end consumer level. It can be simply expressed with this formula (Flowra et al., 2012):

$$MM = Pr - Pf$$

where MM is marketing margin (IDR), Pr is the price at the end consumer (IDR) and Pf is the price at fish farmer (IDR). It can also be calculated using the following formula (Rahman et al., 2012):

$$\text{Marketing Margin (\%)} = \frac{(\text{Selling price} - \text{Purchase price})}{\text{Selling price}} \times 100$$

E. Farmer's Share

The farmer's share is the ratio of price received by the fish farmer to the price paid by the end consumer. It can be calculated using the formula (Saravanapandeeswari and Vanitha, 2017):

$$\text{Farmer'share (\%)} = \frac{\text{Farmer's price}}{\text{Consumer's price}} \times 100$$

Where fish farmer's price and consumer's price are stated in IDR/kg. According to Kohls and Downey (1985), if the portion of the price received by fish farmer is greater than 50%, then the marketing system can be said to be efficient.

F. Market Structure

Market structure is the characteristics of a market that impact the behavior and results of the organizations working in that market. It can be characterized based on the competition levels and the nature of the markets. Basically it provides a starting point for assessing economic environments in business. Market integration analysis can be used to determine market structure by seeing to what extent the price formation of a commodity at one level of a marketing agency is influenced by prices at the level of other marketing agencies. The assumption in market integration is that if the price of other factors is fixed, then the prices at both the producer and consumer levels are linear. The equation model used is as follows:

$$Pfi = \alpha + \beta Pr\, i + ei$$

$$\beta = \frac{\Sigma PriPfi - (\Sigma Pri \Sigma Pfi)/n}{(\Sigma Pri^2 - \Sigma Pfi^2/n)(\Sigma Pfi^2 - \Sigma Pri^2/n)}$$

Where Pfi = prices at the producer level, Pri = prices at the retail level, β_0 = Intersept, β_i = Parameter and ei = error term

Assessment Criteria:

(a) If $\beta < 1$, it means that the market structure is monopsony or oligopsony. An increase in the price of one unit at the retailer level is followed by an increase in the price of less than one unit at the fish farmer level. Monopsony refers to a market with a single buyer, while a *oligopsony* is a market dominated by a few large buyers.

(b) If $\beta = 1$, it means that the market structure is perfect competition. An increase in the price of one unit at the retailer level is followed by an increase in the price of one unit at the fish farmer level. In other words, the formation of inter-market price is more integrated with the unit.

(c) If $\beta > 1$, it means that the market structure is monopoly or oligopoly. An increase in the price of one unit at the retailer level is followed by an increase in the price of greater than one unit at the fish farmer level. Monopoly consist of a market with a single seller, while a *oligopoly* is a market dominated by a few large sellers.

G. Data analysis

The data were tabulated and analyzed using conventional statistical tools of MS Excel 2010, then presented in textual, charts and tabular forms.

III. RESEARCH FINDING AND DISCUSSION

A. Volume and Value of Fish Production

There was about 60-240 kg of fish harvested by individual fish farmer during 8 months of culture period (Table 6.1). The sizes of fish varied between 10 and 12 cm total length and between 38 and 45 g weight. The fish are typically being harvested and sold on the same day. When the fish price was set at 60,000 IDR/kg, the fish farmers received money about 3,600,000 to

14,400,000 IDR. Of 720 kg of total fish, 672 kg (93.33%) was shared to the wholesalers and the rest 48 kg (6.67%) was given to the local restaurants.

In the first channel, there were only two wholesalers, who collected the fish directly from fish farmers to the number of 162-510 kg to be distributed to 15 retailers (6-8 kg per day or 42-56 kg per week per individual). With the selling price of 70,000 IDR/kg, the wholesaler's revenue was ranged from 11,340,000 to 35,700,000 IDR. At retail prices of 75,000-80,000 IDR/kg, each individual retailer receives income ranging from 450,000 to IDR 640,000 IDR/day depends on the quantity of fish sold out to the end consumers. Among variable cost, pellet and fish seed were main purchase account to be borne by the fish farmers (30-41%). While for retailers and wholesalers, it counted for about 93-98% allocated for buying the fish.

The market demand for Climbing perch fish consumption reaches 900 kg per day, which is almost entirely sourced from the wild and only 30% produced from fish farming. In line with population growth and economy improvement, it is predicted that market needs of Climbing perch to meet fish consumption of the community for next 5 years ranging from 1.5 to 2 tons per day. The bioflock technology in aquaculture system had been successfully applied for some commercial fish and shrimp species such as Nile tilapia (Nahar et al., 2015), Indian carp (Kamilya et al., 2017); African catfish (Ekasari et al., 2016), gourami (Rosmawati and Muarif, 2017); pink shrimp (Emerenciano et al., 2013), the pacific white shrimp (Da Silva et al., 2013), Japanese tiger prawn (Zhao et al., 2012), the green tiger shrimp (Megahed, 2010), Malaysian prawn (Perez-Fuentes et al., 2013), the giant tiger prawn (Anand et al., 2014) and most recently applied for Climbing perch and business has favorable prospect (Izmaniar et al., 2018).

Table 6.1. The volume and value of fish production at different marketing levels

Marketing level	n	Share of production (kg)			Price	Revenue (IDR)	
		Quantity	Average	Total	(IDR/kg)	Average	Total
Fish farmers	5	60-240	144	720 [1)]	60,000	8,640,000	43,200,000
Wholesalers	2	162-510	336	672	70,000	23,520,000	47,040,000
Retailers	15	42-56 [2)]	44.8	672	77,667	3,479,482	52,192,224

[1)] About 48 kg of total fish shared to the restaurant (second channel); [2)] Weekly quota (in kg/wk)

B. Marketing Channels

There were two marketing channels for Climbing perch with bioflock-based culture system (Figure 6.3). The first channel, four of five fish farmers sold out the fish to the wholesalers (80%), and then distributed to the 15 retailers and finally marketed to the end consumers. The second channel, one fish farmer sold out the fish through institutional market e.g. the restaurant (20%) and then directly distributed to the end consumers.

The basic reasons why most of fish farmers preferred to the first channel and work closely with the wholesallers are as follows: (1) they do not need to bear the transportation costs and other risks; (2) they do not need to sell the fish by themselves. The presence of wholesallers also provide convenience for fish farmers during the process of harvesting, payment, transportation and distribution; (3) each fish farmer usually has own customer so that the sale transaction can work well; (4) wholesallers also have the fixed customers (retailers) in some market areas so that the sales process can run quickly and timely. The retailers usually make the payment in cash; (5) there is a commitment and trust between fish farmers and fish traders in terms of payments, which is usually done by wholesallers after the fish have been sold out. In line with this, Kwon and Suh (2004) said that a partner's reputation in the market has a strong positive impact on the trust-building process. Success in business is determinable how the key players build a good market communication to generate a sustainable business.

The commitment is also considered an important factor in building successful relationship marketing (Papassapa et al., 2005). A high level of commitment between the parties helps stabilize the relationship and create major barriers to switching suppliers (Ulaga and Eggert, 2006). To complement, Stanko et al. (2007) stated that the commitment has been operationalised in several ways, including desire to continue the relationship, willingness to make short-term sacrifices, confidence in the stability of the relationship, and investments in the relationship, as well as the effort and intention of the buyer to continue the relationship in the future.

The quality of relationships could become a factor that increases the commitment of the relationship, decreasing the chances of abandonment by the parties (Ulaga and Eggert, 2006). Cáceres and Paparoidamis (2007) and Deimel et al. (2008) state that the reliability of the partner and the continuity of the relationship and orientation of the long-term partner are crucial for successful business relationship aspects. In addition, the distribution programme can increase the credibility of the supplier with its distribution channel, making the reseller recognises the effort and rewards it with positive attitudes in the business relationships (Mendonça et al., 2014)

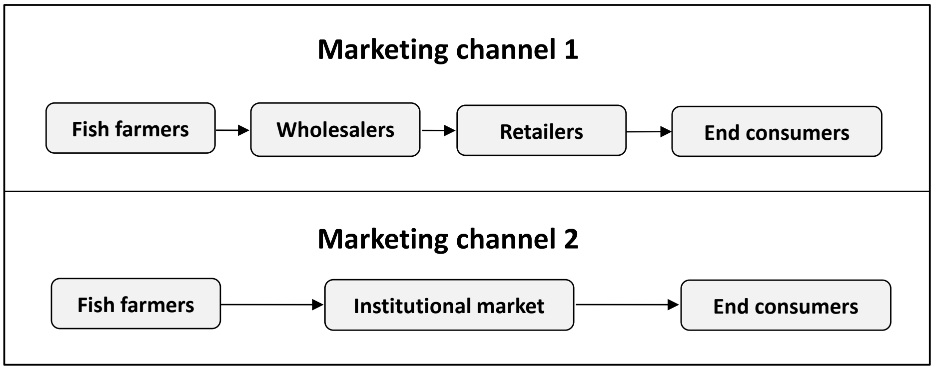

Figure 6.3 Marketing channels of Climbing perch started from fish farmers to the end consumers

C. Marketing margin

Marketing margin analysis was performed to see how big the role of market intermediaries as a link between fish farmers and final consumers in influencing the fish price. There was a variation in the fish prices at different marketing channels. The lowest fish price usually goes to the fish farmer level and then increasingly at the wholesalers or institutional market level and terminates in the retailer level leading to variation in the marketing margin (Table 6.2). It was estimated that the fish farmers received the net margin about 18% of the selling price for their fish production. According to Huger and Hirenath (1984), the higher the value of marketing margin, the lower the efficiency of the marketing system. Rabby et al. (2015) assumed that the producers and intermediaries could be more benefited financially, if efficient marketing was arranged properly. In wholesale market, marketing intermediaries usually perform important role by providing financial assistance, inputs and other marketing facilities to the farmers since their motive is also profit oriented (Keno, 1994). Otherwise generally felt by the consumers is that they have to pay higher price due to the involvement of too many intermediaries in the marketing channels.

In the first channel, there was a price difference of 17,666 IDR/kg derived from the price received by fish farmers (60,000 IDR/kg) and the price paid by the end consumers (77,666 IDR/kg). The percentages of marketing margin for the wholesalers to the fish farmers, the retailers to the fish famers and the retailers to the wholesalers were 14.29%, 22.75% and 9.78% respectively. It was clearly pointed out that the wholesalers had margin (10,000 IDR/kg) greater than retailers (7.666 IDR/kg), this because: (1) they acted as the price maker in the marketing system since they have a good marketing intelligence; (2) they sold out the fish in large quantity in order to reduce the marketing cost; while (3) retailers sold out the fish in small quantity resulted in the marketing cost was relatively high. At the same time, the amount of marketing costs paid by the wholesalers (2,050 IDR/kg) was lower than paid by retailers (2,456 IDR/kg); this because they do not need to pay for stall rental cost, market retribution and other relevant services.

Table 6.2. Market prices, marketing margin and farmer's share for Climbing perch at different levels of marketing channels

Marketing Level	Parameter Observed	Marketing Channel	
		1	2
Fish farmers			
	Production cost (IDR/kg)	49,225.52	49,225.52
	Selling price (IDR/kg)	60,000.00	60,000.00
	Marketing margin (IDR/kg)	10,774.48	10,774.48
	Marketing cost (IDR/kg)	-	-
	Profit (IDR/kg)	10,774.48	10,774.48
Wholesalers			
	Purchase price (IDR/kg)	60,000.00	
	Selling price (IDR/kg)	70,000.00	
	Marketing margin (IDR/kg)	10,000.00	
	Marketing cost (IDR/kg)	2,050.32	
	Profit (IDR/kg)	7,949.68	
	Wholesaler margin to fish farmer (%)	14.29	
Retailers			
	Purchase price (IDR/kg)	70,000.00	
	Selling price (IDR/kg)	77,666.67	
	Marketing margin (IDR/kg)	7,666.67	
	Marketing cost (IDR/kg)	2,456.00	
	Profit (IDR/kg)	5,210.67	
	Retailer margin to fish farmer (%)	22.75	
Restaurant (Institutional market)			
	Purchase price (IDR/kg)	-	60,000.00
	Selling price (IDR/kg)		120,000.00
	Marketing margin (IDR/kg)		60,000.00
	Marketing cost (IDR/kg)		29,000.00
	Profit (IDR/kg)		30,500.00
	Restaurant margin to fish farmer (%)		50.00
Consumers			
	Purchase price (IDR/kg)	77,666.67	120,000.00
	Total margin (IDR/kg)	28,441.15	10,774.48
	Total marketing cost (IDR/kg)	4,506.32	29,000.00
	Total profit (IDR/kg)	23,934.82	41,274.48
	Farmer's share: → efficient (> 50%)	77.25	50.00

In the first channel, the highest net profit was received by fish farmers (45%), followed by wholesalers (33%) and retailers (22%). While in the second channel, the restaurant earn profit (74%) almost 3 times higher than fish farmers (26%) corresponding to marketing cost spent. It was calculated that the marketing margin of restaurant to fish farmer was 50%. The profit received by the wholesalers (7,950 IDR/ kg) was comparatively higher than received by retailers (5,210 IDR/kg). It means that the market intermediaries can be said to be efficient because they create the business much more profitable. Aktar et al. (2013) reported that 80% of the fish retailers in Noakhali District of Bangladesh have improved their livelihood status through fish trading. Omar et al. (2014) suggested that efficient marketing system should be developed by reducing marketing cost and increasing marketing services to make the business more profitable. Moreover, the fish farmers should also follow standard scientific culture practices and regularly access information on the fish prices (Kumar et al., 2010).

D. Farmer's Share

The selling price of fish at fish farmers was 60,000 IDR/kg, while the price at retailer level falls between 75,000 to 80,000 IDR/kg or 77,666 IDR/kg in average. The price portion received by the fish farmers was ranged of 75-80% or about 77.25% of the price paid by the end consumers (see Table 6.2), which was found to be higher than 50%, indicating that fish marketing system here was considered to be efficient (Kohls and Downey, 1985). Compared to other single-species from different geographical areas, the percentage of farmer’s share obtained in the present study being equal to the trout marketing in Kohgiloye and Boyer Ahmad Province of Iran (Shahi et al., 2012), but it was higher than European anchovy (54%) or Atlantic horse mackerel (60%) traded in Trabzon province (Dağtekin, 2010).

The great portion of the price received by fish farmers was closely related to the marketing system itself that has been formed between them and wholesalers due to some reasons: (1). Fish farmers willing to get greater profits without any risks to be borne; (2) since fish farmers have a limited fish production, it was better to sell out the fish directly to the wholesalers rather than selling it the retail market; and (3) Fish farmers have also the bargaining power to determine a reasonable price based on the quality and size of fish because they also knew well about the market price of this species as important food fish. Such bargaining interaction was also shown by both the aquafarmer's association in Thambikottai village of Tiruvarur District and fishermen associations in Kombuthurai, Tamil Nadu of India (Kumar et al., 2010).

Market information is needed by the fish farmers as a part of market transparency and also reference for arranging a competitive pricing strategy. In this regard, there was a good lesson learned from Aquachoupals model in Andhra Pradesh of India that provides access to prices on a daily basis, in which the farmers were able to take the critical decisions on when and where to sell their productions (Kumar et al., 2010). A tangible deliverable was also demonstrated by Ghana's farmers who received significantly higher prices for their productions after using mobile phone-based Marketing Information Services (MIS) program and how information affects a farmer's decision to sell at the farmgate rather than at the market (Courtois and Subervie, 2014). In the present study, the retailers have more bargaining power when they sold out the fish to consumers than they purchased from wholesalers, because the bargaining power between retailers and wholesalers is almost equal, as well as the bargaining power between fish farmers and wholesalers. Dealing with the purchase ability of the party, most of wholesalers and retailers use their own capital to do business. It was similarly reported by

Jamali et al. (2013) that about 70% retailers in Gopalpur Upazila of Tangail District used their own money for fish trading.

E. Market Structure

In market structure, the price at retail level will be the basis for determining the price to be paid to wholesalers and ultimately to producers and vice versa. Furthermore, the price received by producers will determine how much production volume will be served for wholesalers or retailers. The production offered to the market will increase if the price received is satisfactory and vice versa (Apituley et al., 2018). There are three main elements in the market structure, namely market share, market concentration and barrier to entry (Lelissa and Kuhil, 2018). According to Shepherd (1972), each market structure is somewhere in the range between monopoly (a high market share and entry barrier) and pure competition (low share and barriers). Market structure affects the ability of producers or traders to set prices. Producers or traders have no the power to form or influence prices in a perfect competitive market, all market participants act as price takers. However, the ability to influence prices arises when the market structure is imperfect, even producers/traders can act as price makers if the market structure is monopoly.

There was a strong correlation between the prices at the fish farmers (Pf) and the retailers (Pr) level (r = 0.953). The determination coefficient (R^2) values range was 0.908 indicating that more than 90% of price variability at the fish farmers was explained by the price at the retailers. The market structure of Climbing perch can be seen from its regression coefficient. A linear regression model can be written as Pf = 20.308 + 0.529 Pr. The β value obtained was 0.529 or not equal to one (β < 1), which implies that any increase in price of 1 IDR at retail level will be followed by an increase in price of 0.529 IDR at the fish farmers level. The value of $\beta < 1$ explains that the market was not perfectly integrated, while the market structure was an oligopoly. This condition describes an inefficient marketing system. The increase in price for one unit at the consumer level was followed by an increase in price was less than one unit at the fish farmer level.

At least, there were four reasons behind the formation of oligopoly market structure of Climbing perch: (1) the distance between the two markets was relatively far, which impact on the high cost of transportation. It was more convenience for fish farmers to cooperate with the wholesalers to avoid uncertain risks. (2) Fish farmers already have own customers (wholesalers) so that the buying and selling transactions take place on the spot. (3) Fish farmers were highly dependent on the wholesalers in selling their fish; as a result the wholesalers have a big role in determining the price. (4) Retailers also have a close relationship with the wholesalers who guarantee the availability of fish production; besides that, the retailers did not need to pay marketing costs to buy the fish from fish farmers.

At the fish farmer level, some constraints being faced such as the availability of superior fish seeds, electrical supply and the limited capital for fish production are crucial to success. For the wholesalers, it takes time to collect the fish harvested since the fish farming sites are scattered. Moreover, asynchronous fish harvested by individual fish farmer resulted in high cost of fish marketing. While for the retailers, the quantity of fish which is shared by the wholesalers does not correspond with the retailer's demand, this because the supply of fish obtained from the fish farmers is still lacking. Occasionally if there is more demand of fish among the retailers, the wholesalers preferred to deliver the fish to a location that is closer from fish farming than far-off to reduce marketing costs. Specific suggestions for improving the current marketing systems should incorporate: the certified fish hatchery to produce superior seeds, improvement of bioflock technology for small scale fish farming to increase fish production, introduction of modern wholesaling and retailing facilities, the strengthening of institutional marketing, and promotion of mobile phone-based Marketing Information Services to find out the global and local market transparency. In the long term, it is necessary for interested parties to form the cooperative society with legal entity. The defined role of the cooperative society will support beneficially for fish marketing system as a whole (Rabby et al., 2015).

Recommedations are made to improve the current marketing performance of Climbing perch: (1) There is a need for partnerships with related agencies for aquaculture business development through training and counseling to expand the market share. (2) In order to have a fair profit share, the fish farmers should have accurate market information, especially about prices and bargaining position in the market. The use of mobile phone-based Marketing Information Services program should be familiarized. (3) The fish farmers are encouraged to be a member of aquafarmer's association or other business entity to strengthen their bargaining power.

IV. EPILOGUE: CONCLUSION AND RECOMMENDATION

The fish marketing channel through market intermediaries was considered less efficient than through institutional market. The highest net profit per kg was received by the fish farmers followed by the wholesalers and retailers. The marketing margin of institutional market was 2-3 times higher than that of wholesalers and retailers. The market was not perfectly integrated, while the market structure was an oligopoly. It is a great challenge to increase fish production, and the prospect of culinary business is open. To the best our knowledge, the present study provides the first reference on the bioflock system-based fish marketing of Climbing perch in the investigated areas.

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GLOSSARIES

Crossbreeding	A breeding program that tries to find mating combinations between different populations of fish which produce superior offspring for grow-out, offspring that are said to exhibit hybrid vigour.
Condition factor	Factor that influencing the length-weight relationship of the fish (e.g. food availability, environmental condition, stage of maturity, sex, state of stomach and seasons).
CPUE	Catch per unit effort is the number of fish caught by an amount of effort, which is a combination of gear type, gear size, and length of time the gear is used.
Fecundity	A measure of the number of offspring produced by an organism over time or during the spawning season.
FCR	Feed conversion ratio is the amount of feed a fish needs to gain one kilogram of body weight.
GSI	Gonadosomatic Index is the calculation of the gonad mass as a proportion of the total body mass
Isometric	The length and weight are growing at the same rate.
LED	A semiconductor light source that emits when current flows through it.
Ligh trap	The use of trap equipped with underwater lamp to catch fish
Light intensity	The level of light power from a lamp to measure an organism's response to different light stimuli
LWR	Length-weight relationship is the estimation the fish weight based on the given length.
Negative allometric	The length increases more than weight.
Positive allometric	The weight increases more than the length.
Phototaxis	Movement of all organisms in responding ligt stimulation.
Marketing channel	The people, organizations, and activities necessary to transfer the ownership of goods from the production point to the consumption point.
Meristic	Area of ichthyology which relates to counting quantitative features of fish, such as the number of fins or scales.
Morphometric	A technique of taxonomic analysis using measurements of the form of organisms.
YPUE	The yield per unit of effort over a time

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Synopsis

This book comprehensively describes on the current fishery, aquaculture and marketing of Climbing perch from different points of view including biological aspects, fishing technology, business analysis and its marketing channels. The book contents sourced from the results of research practices that have been published in international scientific journals. Projections of the book content are directed to the students, academicians or researchers who are concerned with Climbing perch studies in wetland environments, as well as socio-economic of fisheries and aquaculture.