

## STRIPED CATFISH (*Pangasianodon hypophthalmus*) (SAUVAGE, 1878) MOVEMENT AND GROWTH IN GAJAH MUNGKUR RESERVOIR, CENTRAL JAVA

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### ABSTRACT

Movement is an essential mechanism by which mobile animals acquire the resources necessary for the successful completion of their life-cycles. Striped catfish (*Pangasianodon hypophthalmus*) contributed about 384 tonnes or approximately 40,04% to the total fish production in Gajah Mungkur reservoir. Diversion of Keduang River, one of Gajah Mungkur important inlets, could affect the movement of this fish. The objective of this research was to describe the movement patterns and to analyze growth of *Pangasianodon hypophthalmus*. Field works were conducted from March to December 2011 by tagging experiment of large fish with the PDS-Tags and the T Bar-Tags for the small ones. Fish samples used for the experiment were collected from fisherman catch's in Gajah Mungkur reservoir. The tag numbers, the release time, and the fish size were noted before releasing the tagged fish were released. Fishermen who caught the tagged fish were advised to report the fish tag number, time of catching, and fish size. The results showed that the *Pangasianodon hypophthalmus* could moved as far as 200 m to 15 km in 3- 176 days. In the wet season most of the catfish moved far into the inlet Wiroko and Keduang, and some to the inlet Wuryantoro. *Pangasianodon hypophthalmus* in Gajah Mungkur Reservoir had growth equation of  $L_t = 99(1 - e^{-0.762(t-0.15)})$ , with the growth coefficient (K)= 0.762/year,  $t_0=0.15$  year, infinity length ( $L_\infty$ )= 99 cm. Water diversion of Keduang river, one of Gajah Mungkur inlets, did not fully dried the River during dry season and affected striped catfish movement and growth.

**KEYWORDS:** Movement pattern, growth, striped fish, *Pangasianodon hypophthalmus*, reservoir

### INTRODUCTION

Movement is an essential mechanism by which mobile animals acquire the resources necessary for the successful completion of their life-cycles. It also plays a crucial role in how animals are distributed across the landscape and the persistence of populations and species. Regardless of how little or how far an animal moves, the purpose (e.g., foraging, reproduction, growth, refuge) and intensity (e.g., short, long, energetic, attenuated) of that animal's movement is intricately related to how its life history requirements change daily and/or seasonally (Hoffman & Dunham, 2007). According to Halls & Johns (2013), *Pangasianodon hypophthalmus* (synonym: *Pangasius hypophthalmus*) is a highly migratory riverine fish species that undertakes long-distance migrations over several hundred kilometres between upstream refuge and spawning habitats and downstream feeding and nursery habitats.

Gajah Mungkur, constructed in 1981 and located in Wonogiri Regency Central Java with its surface area of 8,800 ha. Since the introduction of striped catfish in recent years, the production of this fish has reach 384 tonnes that approximately 40.04 % of the total catch production of Gajah Mungkur reservoir after

*mossambicus tilapia* (Dinas Peternakan, Perikanan dan Kelautan Kabupaten Wonogiri, 2010). Therefore information on movement pattern and growth of the catfish in Gajah Mungkur is important to know. Diversion of Keduang river water, one of the inlets of Gajah Mungkur reservoir, to reduce Gajah Mungkur sedimentation in 2009/2010, could influence the success of spawning and recruitment of striped fish. Taking into account that Keduang river is one of spawning of this fish. Gingerich & Hanna (2006) reported that river water diversion is result in decreasing in stream flow and it may cause a continuous decrease of habitat for all species. For diverted conditions, the habitats at the majority of the studied stream sites were observed have only 27 to 57 percent from its original habitat. Restoring even a small amount of water to a diverted stream can have a significant effect on the amount of habitat available. For example, restoring 10 percent of the median baseflow to a stream that is dry owing to diversion would provide about 40 percent of the expected natural habitat.

Study on the movement and growth of small-sized striped catfish in Gajah Mungkur reservoir have been done by Purnomo *et al.* (2003). While studies on the effect of water diversion of Keduang River to striped catfish movement pattern and growth of the larger size

(brooder candidate) specially in reserve area located around aquafarm fish floating net cages have not been recorded yet. According to Utomo *et al.* (2011), area located around Aquafarm fish floating net cages is functioning as striped catfish broodstock reserve at Gajah Mungkur. This area play a role as feeding area of this fish due to the abundance of foods resources escaping from floating net cages, no fishing activities and the water depth around 16 wchich support striped catfish life and growth.

Due to this fact, study in order to know the movement pattern and growth of large size striped catfish in Gajah Mungkur reservoir was conducted in 2011. The data and information obtained from this study will be used as component for fisheries

management and fish resources conservation in Gajah Mungkur Reservoir.

## MATERIALS AND METHODS

Field works on striped catfish movement pattern and growth were carried out in Gajah Mungkur Reservoir, Wonogiri Regency, Central Java from March to December 2011 (Figure 1). Information on striped catfish movement patterns and growth were collected by using a tagging experiment. Prior tagging people around the reservoir were socialized about the objective of the study and the liability of fishermen if they catch the tagged fish (Appendix 1).

### Tagging Methods

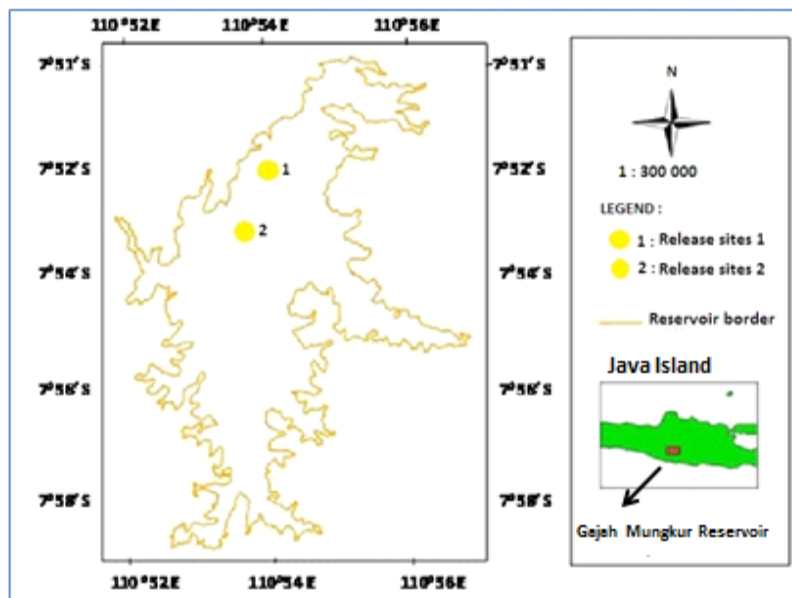


Figure 1. Map of released location.

Note Figure 1: Released 1 = Reserve area, around Aquafarm floating net cages  
Released 2 = Middle of reservoir, west of inlet Wiroko

A total of 868 striped catfish was collected from fishers which caught them from fish reserve area that, located around aquafarm fish floating net cages in Gajah Mungkur reservoir. Only healthy fish were tagged by inserting PDS-tags under dorsal fins of large fish (more than 2 kg/fish) (Figure 1.) and T-Bar tags for small fish (less than 2 kg/fish) (Hoggarth, 1994). Some information such as the number, fork length and total weight of tagged fishes; place, geographical position (GPS), and date of fish released were recorded. Tagged fishes were released in area of Aquafarm fish floating net cages. Fish were released in three phases. The first phase release was in March as much as 200 individuals fish with a length of between 37 to 68 cm and weight of 600-5,000 grams. The second release phase was in June as much as

200 individual fish, with a length from 40 to 63.5 cm and weight 960 to 3,400 grams. The third release phase was in September as much as 468 individuals fish, with a length of 18 to 35.5 cm and weight of 100 to 620 gram.

### Recapture of Tagged Fishes

Information on the tagged fishes caught by the fishermen was obtained monthly. Fishermen caught the tagged fish, submitted the recapture data to either the head of fishermen group, to Fisheries Services of Wonogiri Regency or to the research team during the sampling time (Appendix 1). Those fishermen were rewarded to the T-shirt if their fish recorded was complete.

**Growth Analysis**

Growth of the recapture tagged fishes were analyzed with Von Bertalanffy equation (Pauly,1984);

$$L_t = L_{\infty}(1 - e^{-k(t-t_0)}) \dots\dots\dots(1)$$

where  $L_t$  = length of fish at time  $t$  (cm),  
 $L_{\infty}$  = Length of infinity (cm),  
 $K$  = growth coefficient,  
 $t_0$  = Age at the length of 0 cm.

Fish tag experiment gave the value of  $\Delta L$  (an increment size during release and recaptured). Growth parameters: Length of infinity ( $L_{\infty}$ ) and growth coefficient ( $K$ ) were obtained from linier:  $L' / t = a + b.L'$  (Gulland & Holt *after* Spare & Venema, 1992), where  $L'$  = the average of length increment between released and recaptured period; growth coefficient ( $K$ ) =  $-b$ , and  $L_{\infty} = -a / b$ . Estimation of  $t_0$  was calculated based on empirical equations of Pauly (1984):  $\text{Log}(-t_0) = -0.3922 - 0.2752 \text{Log} L_{\infty} - 1.038 \text{Log} K$ . Length and weight relationships was analyzed based on Carlander equation *after* Effendi (1997):  $W = aL^b$ , where  $W$  = weight (Gram) dan  $L$  = length (Cm). Simulation graph of weight growth ( $W$ ) was made by

entering the value of  $L_t$  obtained from the Von Bertalanffy equation.

**RESULTS AND DISCUSSION**

**Results**

**Fish Movement Patterns**

The first 13 recaptured tagged fish was recorded on July. The total number of recaptured tagged fishes until end of November were 34 fishes or 4% of the total released tagged fishes. Within 13-176 days, the distance of striped catfish movement from their the release site were in the range of 200 m to 15 km. Generally, in wet season most of striped catfish moved far to Wiroko and Keduang inlet, and some to the Wuryantoro inlet (Figure 2 and Appendix 2). Striped catfish which released around Aquafarm floating net cages moved to the northeast toward Keduang inlet, to the southeast towards Wiroko inlet and to the southwest toward Wuryantoro inlet. This phenomenon was also recorded for the striped catfish released in the middle of the reservoir (west of inlet wiroko). Most of the released striped catfish in this site moved to the west toward Wuryantoro inlet and to the east toward Wiroko inlet.

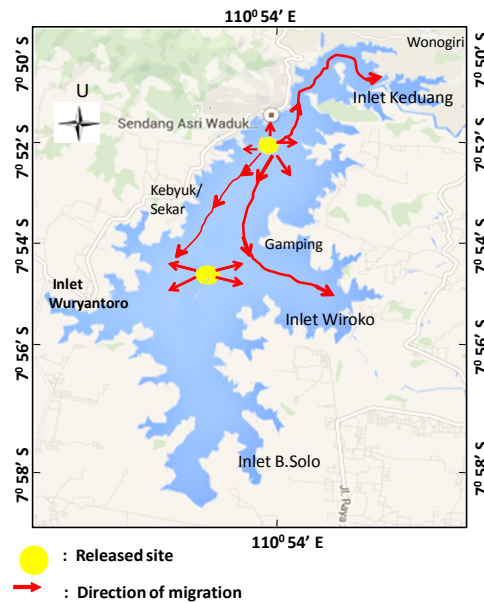


Figure 2. Striped catfish movement pattern map of in Gajah Mungkur Reservoir.

Tagged (marked) striped catfish were often caught by fishermen in Gamping/Nguntoronadi before reaching inlet Wirorko and in Kebyuk/Sekar before reaching Wuryantoro inlet. Both Gamping/Nguntoronadi and Kebyuk/Sekar were movement path of striped catfish in Gajah Mungkur.

In wet season (November to February), both males and females of striped catfish that recorded in Gajah

Mungkur inlet (Keduang, Wiroko & Wuryantoro) were at mature stage (ripe and spent) (Appendix 3). Whereas in dry season (June-September) none of tagged striped catfish were caught in most of Gajah Mungkur inlets. Fishing activities of striped catfish during dry season were inside of the reservoir but none of striped catfish caught in mature stage.

**Individual Striped Catfish Growth**

Out of 34 recaptured tagged fish, only 28 of them had complete information that can be used for further growth analysis (Appendix 4). Regression equation of the length recapture tagged data was  $(\Delta L / \Delta T) = 6.343 - 0.0635 (L')$ . Based on that equations, it was found that growth coefficient (K) was 0.0635 per month or 0.762 / year, asymptotic length ( $L_{\infty}$ ) was 99 cm, and the age of the fish at the time length 0 ( $t_0$ ) was -1.8 months or -0.15 years.

Based on the growth parameters ( $L_{\infty}$ , K and  $t_0$ ) and changing the value of "t" as the independent variable, Vont Bertalanffy growth curve length was found,  $L_t = 99 (1 - e^{-0.762(t+0.15)})$  (Table 1 and Figure 3). Analysis on the length and weight relationship of striped catfish obtained the equation of  $W = 0,005 L^{3,192}$ . Length growth chart in Figure 3 was converted into weight growth as shown in Table 1 and Figure 4.

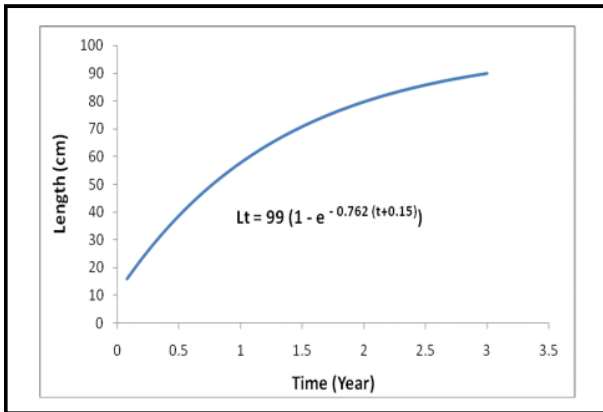


Figure 3. Length growth simulation of striped catfish

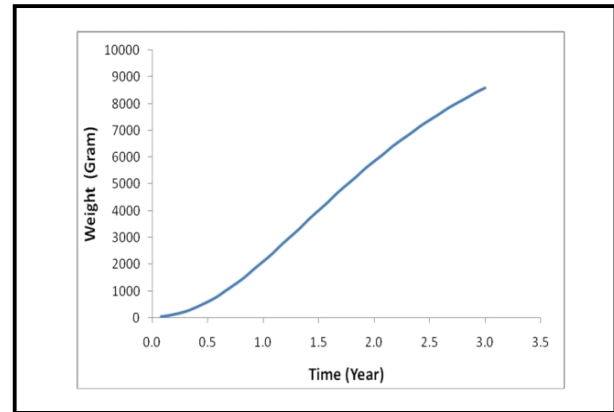


Figure 4. Weight growth simulation of striped catfish

Table 1. Length and weight growth simulation of striped catfish

Age (month)	Length (cm)	Weight (gram)	Age (month)	Length (cm)	Weight (gram)
1	16.1	35.8	25	80.9	6,165.2
2	21.2	86	26	82.1	6,439.3
3	26.0	164.5	27	83.1	6,704
4	30.5	273.5	28	84.1	6,959.2
5	34.7	413.3	29	85.0	7,204.7
6	38.7	583.3	30	85.9	7,440.4
7	42.4	781.5	31	86.7	7,666.4
8	45.9	1,005.6	32	87.4	7,882.7
9	49.1	1,252.8	33	88.1	8,089.5
10	52.2	1,520	34	88.8	8,287
11	55.1	1,804.2	35	89.4	8,475.2
12	57.8	2,102.2	36	90.0	8,654.6
13	60.3	2,411	37	90.6	8,825.2
14	62.7	2,728	38	91.1	8,987.5
15	64.9	3,050.5	39	91.6	9,141.6
16	67.0	3,376	40	92.0	9,287.9
17	69.0	3,702.6	41	92.5	9,426.6
18	70.8	4,028.1	42	92.9	9,558.1
19	72.6	4,351.1	43	93.2	9,682.6
20	74.2	4,669.9	44	93.6	9,800.5
21	75.7	4,983.4	45	93.9	9,912
22	77.2	5,290.5	46	94.2	10,017.5
23	78.5	5,590.3	47	94.5	10,117.2
24	79.8	5,882	48	94.8	10,211.3

## Discussion

### Movement Patterns of Striped Catfish

Total fishes recaptured during the study in the Gajah Mungkur reservoir (8,800 ha) was 4%. Other studies on fish tagging experiments of striped catfish (*Pangasianodon hypophthalmus*) in Kedung Ombo reservoir (4,400 ha) total recaptured much as 10 % (Aida *et al.*, 2013), tagging experiment of fish carp white lady (*Thynnichthys thynnoides*) in Empangau Lake (125 ha) total fishes recaptured much as 24% (Utomo, 2009). Based on the above information, there are indications that the wider of water area then the possibility of fishes recaptured caught is getting smaller.

The occurrence of matured striped catfish males and females in most of Gajah Mungkur inlets is an indicator that this fish move to the inlets either for seeking the refuge area or for spawning. During spawning time the matured striped catfish would move to fast flowing water area which were found and recorded in most of Gajah Mungkur inlets. According to Gustiano & Pouyaud (2005), the original habitat of striped catfish was in the river, and often found in deep water. The matured striped cat fish which ready to spawn were often found in the upstream river with characteristic of fast flowing water. While Kottelat *et al.* (1993) reported that matured striped catfish are often found in the upstream river. After spawning, larvae drift to downstream, clinging to rocks and riparian vegetation. This was supported by the occurrence of matured striped catfish during the wet season. As a peak spawning season. The amount of the wet fall during the wet season was in the range of 288.5 – 460.5 mm/month and while in dry season was 42-194 mm/month (Direktorat Pengelolaan Bengawan Solo, 2010).

Large striped catfish which mostly larger than 50 cm or more than 1,500 gram (appendix 2 and 4) were able to migrate in along distance to the Wiroko and Keduang inlet. Studies conducted by Utomo *et al.* (2005) and Dharyati *et al.* (2010) also found that during wet season (November – January) striped catfish caught in Keduang inlet were larger than 2 kg and ready to spawn. According to Legendre *et al.* (1999) after the Kristanto *et al.* (2005), the gonad of pond cultured striped catfish will mature after 19 month, and spawn during the wet season from October to April. Furthermore, Rahardhianto *et al.* (2012) reported that in its natural habitat, striped catfish spawn in the rainy season with the larvae and juvenile were found from March to May.

Far movement of tagged striped catfish released around Aquafarm floating net cages during the rainy season to the spawning areas in Gajah Mungkur inlets showed that fish reserve around Aquafarm floating net cages had significance role for the availability of striped catfish, could contribute fish production outside the reserve area, and to increase fisheries production in Gajah Mungkur Reservoir. According to Utomo *et al.* (2001) a proper functioned of fish reserve area could increase fish production to others water body. In addition, no fishing activities and the present a lot of feed (pellet and fish feces) that escaped from floating fish net cages supported for the occurrence young striped catfish in Aquafarm floating net cages areas. Dharyati *et al.* (2009) mentioned that the amount of feed waste escaped from the floating net cages in Gajah Mungkur Reservoir was 470 tonnes/ year.

Diversion of Keduang River to decrease the sedimentation of Gajah Mungkur reservoir did not effect much to water depth and fish movement. During dry season, Keduang inlet and other inlet (wiroko) were still inundated by the shallow water. This two Gajah Mungkur inlets inhabited by aquatic plants dominated by *Mimmosa pigra*, locally called *kayu duri*. This finding was similar with Ali (2013) who found small size striped catfish (5-7 cm) in fishermen catch near the Wiroko inlet. These aquatic plants served as feeding, nursery and spawning ground of the fish. According to Utomo & Asyari (1999), aquatic plants such as swamp forests had important role for fish resources. Catfish (*Pangasius nasutus*), known locally as *Seladang* in Kapuas River feed on fruit and seed fallen from swamp forest.

### Individual Growth of striped catfish

Growth parameters obtained in this study was a little bit different from Purnomo *et al.* (2003) with K value of 0.95/year and  $L_{\infty}$  value of 122 cm. High K and  $L_{\infty}$  value reported in Purnomo *et al.* (2003) more related to the small fish size used which, 22 g/fish. While in this study the fish size used was in the range of 100-5.000 g/fish. Large adult fish grow more slowly than small younger fish, yet for adult fish most energy is used for reproductive development and maintenance of old organs (Mantel, 1983 in Utomo, 2005).

Striped catfish in Gajah Mungkur reservoir have a rapid growth, even faster than fish culture intensively. According to Kristanto *et al.* (2005) growth of striped catfish juvenile cultured in ponds for 19 months was 2,249 g/fish, whereas in this study they could reach 4,351g/fish (Table 1 and Figure 4). According to Asyari *et al.* (1997) growth of striped

catfish juvenile cultured in floating cages in the Musi River for 12 months was 926 gram/fish, whereas in this study can reach 2,102 g/fish (Table 1 and Figure 4). Rapid growth of striped catfish in Gajah Mungkur Reservoir is related to the present of food (pellets) and the abundance fish feces escaped from the floating net cages, as well as the abundance of detritus and plankton (Dharyati *et al.*, 2009; Utomo *et al.*, 2011). Similar phenomenon was also recorded by Purnomo *et al.* (2003); striped catfish can grow well in Gajah Mungkur Reservoir, due to a lot of suitable natural foods such as plankton and detritus. In addition, faster growth of striped catfish in Gajah Mungkur may relate to the presence of fish habitat protection (fish reserve) around Aquafarm floating net cages and habitat condition of the nursery ground in inlet Wiroko and inlet Keduang Gajah Mungkur Reservoir suitable for the survival of striped catfish (Aida *et al.*, 2011).

## CONCLUSION

Water diversion of Keduang River, one of Gajah Mungkur inlets, did not fully dried the river during dry season and affected striped catfish movement and growth. In wet season, striped catfish move as far as 15 km away from the release area of reserve area around Aquafarm floating net cages to Keduang and Wiroko inlets for seeking refuge and spawning area. Reserve area around Aquafarm floating net cages play an important role for sustainable fish production of Gajah Mungkur reservoir.

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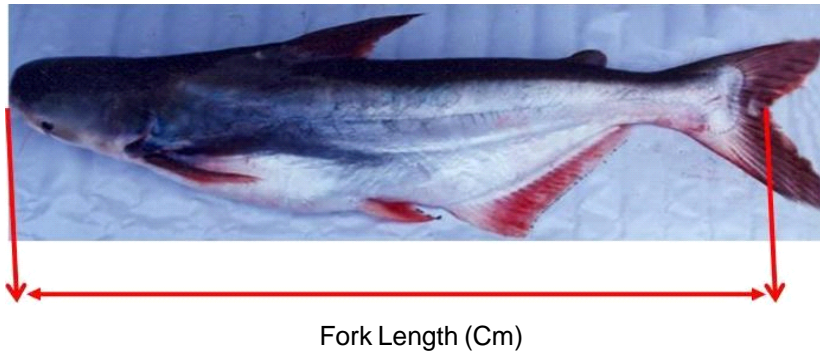
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**Appendix 1.** The explanation of how to noting and sending a note of marked fish recaptured by fishermen.

Whoever catches tagged striped catfish in Gajah Mungkur please noting the following required information:

Tag number:	Date:	Fork Length (Cm):
Caught Location:	Fishing Gear:	Name and Address of fishermen:

Remove the tag which attached at the body of the fish, then the tag and notes submitted to Fisheries Department officer or chairman of a group of fishermen or research team at the moment they come to Gajah Mungkur Reservoir. Each delivery complete note of mark/tag are rewarded in the form of a T-shirt or money worth Rp.75,000 (Seventy Five Thousand). The fish do not need to be submitted, only the tag and notes shall be submitted.



**Appendix 2.** The movement pattern of *P. hypophthalmus* at Gajah Mungkur Reservoir

No	Code. Tags	Location		Distance	Days ( $\Delta T$ )
		Release	Recapture		
A. Released 1 (15 March 2011)					
1	PDS 00111	KJA Aquafarm	Northeast of released site.	200 m	13
2	PDS 00178	KJA Aquafarm	Southwest of released site.	200 m	18
3	PDS 00122	KJA Aquafarm	Northeast of released. Direction to inlet Keduang	2 km	23
4	PDS 00172	KJA Aquafarm	Northeast of released. Direction to inlet Keduang Gamping. Sotheast of	2 km	28
5	PDS 00083	KJA Aquafarm	released .Direction to inlet Wiroko Gamping. Sotheast of	15 km	52
6	PDS 00137	KJA Aquafarm	released. Direction to inlet Wiroko	15 km	78
7	PDS 00153	KJA Aquafarm	East of released. Direction to inlet of Keduang Gamping. Sotheast of	15 km	79
8	PDS 00182	KJA Aquafarm	released. Direction to inlet Wiroko	7 km	80
9	PDS 00046	KJA Aquafarm	Kebyuk. Southwest of released. Direction to inlet Wuryantro	7 km	115
10	PDS 00192	KJA Aquafarm	Gamping. Sotheast of released. Direction to inlet Wiroko	7 km	176



**Appendix 2. Continuation**

B.Released 2 (15 June 2011)					
11	PDS 00333	KJA Aquafarm	Kebyuk. Southwest of released. Direction to inlet Wuryantro	10 km	18
12	PDS 00236	KJA Aquafarm	Southeast of released site. Direction to inlet Wiroko	500 m	18
13	PDS 00323	KJA Aquafarm	Southeast of released site. Direction to inlet Wiroko	500 m	26
14	PDS 00367	KJA Aquafarm	Southeast of released site. Direction to inlet Wiroko	500 m	26
15	PDS 00395	KJA Aquafarm	Northeast of released site. Direction to inlet Keduang.	500 m	31
A.Released 1 (19 September 2011)					
16	PDS 00037	Middle of Reservoir	West of released site	300 m	3
17	PDS 00114	Middle of Reservoir	West of released site.	300 m	3
18	029	Middle of Reservoir	West of released site.	300 m	5
19	PDS 0436	KJA Aquafarm	Southwest of released site.	400 m	14
20	PDS 0404	KJA Aquafarm	Southwest of released site	200 m	6
21	389	Middle of Reservoir	West of released site	200 m	8
22	214	KJA Aquafarm	Kebyuk.Southwest of released site.	300 m	12
23	241	KJA Aquafarm	Inlet Wiroko . Southeast of released site.	15 km	47
24	376	Middle of Reservoir	Gamping. East of released site. Direksions to inlet Wiroko	400 m	38
25	449	Middle of Reservoir	Kebyuk. West of released site	200 m	15
26	334	Middle of Reservoir	Gamping. East of released site. Direksions to inlet Wiroko	400 m	16
27	358	Middle of Reservoir	Kebyuk..West of released site	300 m	25
28	281	Middle of Reservoir	Gamping. East of released site	300 m	13
29	403	Middle of Reservoir	Sekar. West of released site	300 m	18
30	038	Middle of Reservoir	Gamping. East of released site. Direksions to inlet Wiroko	400 m	17
31	164	KJA Aquafarm	Northeast of released site. Direction to inlet of Keduang	500 m	17
32	221	KJA Aquafarm	Northeast of released site.	200 m	7
33	169	KJA Aquafarm	Kebyuk. Southwest of released site	200 m	13
34	217	KJA Aquafarm	Kebyuk.. Southwest of released site	200 m	18

**Appendix 3.** Gonade maturity stage of striped catfish (*Pangasianodon hypophthalmus*) in Gajah Mungkur Reservoir

I. In Wet Season (November- Februari)

Gonade Maturity Stage	Location			
	Inlet of River		Inside of Reservoir	
	(indv.)	(%)	(indv.)	(%)
<b>A. Male</b>				
I.(immature)	0	0	4	11.4
II.(early maturing)	0	0	11	31.4
III.(late maturing)	1	2.7	2	5.7
IV.(ripe)	9	24	0	0
V.(spent)	5	13	0	0
<b>B. Female</b>				
I.(immature)	0	0	3	8.6
II.(early maturing)	0	0	14	40
III.(late maturing)	1	2.7	1	2.9
IV.(ripe)	13	35	0	0
V.(spent)	8	22.6	0	0
<b>TOTAL</b>	<b>37</b>	<b>100</b>	<b>35</b>	<b>100</b>

II. In Dry Season (June - September)

Gonade Maturity Stage	Location			
	Inlet of River		Inside of Reservoir	
	(indv.)	(%)	(indv.)	(%)
<b>A. Male</b>				
I.(immature)	-	-	1	3.3
II.(early maturing)	-	-	4	13.3
III.(late maturing)	-	-	0	0
IV.(ripe)	-	-	0	0
V.(spent)	-	-	0	0
<b>B. Female</b>				
I.(immature)	-	-	4	13.3
II.(early maturing)	-	-	19	63.3
III.(late maturing)	-	-	2	6.8
IV.(ripe)	-	-	0	0
V.(spent)	-	-	0	0
<b>TOTAL</b>			<b>30</b>	<b>100</b>

Note Appendix 3:

(-) = No fishing activity of striped catfish.

**Appendix 4.** Increment size of striped catfish (*Pangasionodon Hypophthalmus*) after fish recaptured

No	No tags:	L1 (cm)	L2 (cm)	$\Delta L$ (cm)	$\Delta t$ ( hari)	L' (cm)	$\Delta L/\Delta T$ cm/Day	$\Delta L/\Delta T$ cm/Month
1	PDS 00111	49	51	2	13	50.0	0.15	4.62
2	PDS 00178	48	52	4	18	50.0	0.22	6.67
3	PDS 00122	61	62	1	23	61.5	0.04	1.30
4	PDS 00172	44	48	4	28	46.0	0.14	4.29
5	PDS 00083	59	64	5	40	61.5	0.13	3.75
6	PDS 00137	56	62	6	78	59.0	0.08	2.31
7	PDS 00153	44	52	8	79	48.0	0.10	3.04
8	PDS 00182	42	52	10	80	47.0	0.13	3.75
9	PDS 00046	53	63	10	115	58.0	0.09	2.61
10	PDS 0192	50	65	15	176	57.5	0.09	2.56
11	PDS 00333	44	47	3	18	45.5	0.17	5.00
12	PDS 00236	59	62	3	26	60.5	0.12	3.46
14	PDS 00367	52	55	3	31	53.5	0.10	2.90
15	PDS 00395	48	55	7	80	51.5	0.09	2.63
16	029	26	27	1	9	26.5	0.11	3.33
17	PDS 0436	51.5	55	3.5	47	53.3	0.07	2.23

**Appendix 4. Continuation**

18	PDS 0404	58	61	3	38	59.5	0.08	2.37
19	214	30.5	32	1.5	16	31.3	0.09	2.81
20	241	21	26	5	25	23.5	0.20	6.00
21	376	26.5	28	2	13	27.3	0.12	3.46
22	449	26	28	2	16	27.0	0.13	3.75
23	334	27	29	2	17	28.0	0.12	3.53
24	281	25	27	2	13	26.0	0.15	4.62
25	403	27	29	2	18	28.0	0.11	3.33
26	38	27	28	1	17	27.5	0.06	1.76
27	169	26	29	3	21	27.5	0.14	4.29
28	217	31.5	33	1.5	16	32.3	0.09	2.81
( X )								( Y )

L 1 : The size of fish when released

" T : Difference in time when released and recaptured

L 2 : The size of fish when recaptured  
recaptured

" T : Difference in size when released and when

L' : The average size of fish when released and after recaptured