Biological aspects of lelan fish, *Diplocheilichthys pleurotaenia* (Cyprinidae) from the upstream and downstream of the Kampar River, Riau Province, Indonesia

[1,2]Muhammad Fauzi, [1]Dahelmi Dahelmi, [1]Indra J. Zakaria, [2]Usman M. Tang

[1] Faculty of Mathematics and Natural Sciences, Andalas University, Padang, Indonesia;
[2] Faculty of Fisheries and Marine Sciences, Riau University, Pekanbaru, Indonesia.
Corresponding author: M. Fauzi, mfauzi@unri.ac.id

Abstract. *Diplocheilichthys pleurotaenia* is one of native fish present in the Kampar River. This fish used to migrate to downstream area due to reproductive activities. The construction of the Koto Panjang Dam may hamper this activity and also divided the population into 2 groups, the upstream and downstream population. To understand the biological aspects of the fish in both populations and its relationship to the presence of the dam, this study has been conducted from November 2011 to August 2012. The fish was sampled in the Kampar River, in the upstream and downstream of the Koto Panjang Dam. The fish was captured using gill nets monthly for a ten months period. The number of fish captured in the upstream was 7, while that of of the downstream was 228. The sex ratio of the fish is almost balance. The fish from both population shown similar reproductive pattern, there are mature males and females in April and there is no fish caught in May due to reproductive purposes migration. The reproductive activity of the upstream fish is unsucceed as there is no single small fish found. The rarity and the lack of small fish in the upstream population is strongly related to the failure of reproduction due to the construction of the Koto Panjang Dam.
Key Words: *Diplocheilichthys pleurotaenia*, fish migration, Koto Panjang Dam, Kampar River.

Introduction. Kampar River is one of big rivers in the Riau Province, Indonesia. In 1996, a reservoir was built in the river flow and it was designed for a water power plant (PLN 2006). The construction of the dam changed the topography of the river and as a consequence, it changes the water mass and it leads to change the biotic and abiotic characteristics in both sides, in the streams and in the reservoir as well (Mulia 2006). Physically, the reservoir has cut off the river flow, and makes the water flow to the turbine path. The water flow in the reservoir is only opened when the water volume was higher than the normal level (PLN 2006). The construction of 90 m height dam wall, however, has completely blocked any access from the downstream side, causing the separation of aquatic organism populations in the downstream and upstream of the dam. A similar case was also present as there is dam construction in the Parana River, Argentina (Araya et al 2005).

Before the construction of the dam, there was a fish migration phenomenon. Local people stated that after the rainy season there were many types of fish fingerlings migrating from the downstream to the upstream area of the river. Fishermen from villages around the river stated that types of fingerlings present in the migration group were lelan (*Diplocheilichthys pleurotaenia*), paweh (*Osteochilus* sp.) kapiek (*Puntius schwanenfeldii*), pantau (*Rasbora* sp.), and bunga air (*Clupeichthys goniognathus*).

As the dam was constructed, the fish migratory activities must be obstructed. The fish from the upstream may not be able to go to the downstream as the only water channel to the river below is the turbine path that flown the water fastly, up to 384 m^3s^{-1}. The water is directly flush to the turbine system and the fish may not be able to pass it. As well as the upstream fish migration, the downstream fish migratory activities were also disturbed. The fish is not able to go to the upstream as the dam wall is very high and there is no fish path or fish ladder constructed. As a consequence, the fish population in the Kampar River might be separated into two groups, the downstream and the upstream populations.

Larinier (2001), and Winemiller & Jepsen (1998) stated that fish migration may be related to spawning and feeding related behavior. Any changing in fish behavior pattern may affect the fish recruitment and as a consequence changing the fish population pattern in general. Fish migration phenomenon in the Kampar River may also relate to those behaviors and the dam construction may affect the fish population in the river as well as in the dam. Results of several researches indicate that there are fish population and fish diversity changing during the last decade. Around thirty years ago, the diversity of fish present in the Kampar River was high. There was 115 fish species occurred in Kampar River before the Kota Panjang dam was constructed (Pulungan et al 1986), but it was reduced into 20 fish species in 2005 (Nastiti et al 2006).

As well as in the river, in the Koto Panjang dam, the diversity of the fish was also fluctuating. In 2005, there were only 44 species fish present in the dam and there was no dominant species (Mulia 2006). In 2013, however, there were 32 fish species (Sumiarsih 2014). Among those fish species, the most common fish species is *P. schwanenfeldii* which is commonly present around the fish cage culture area. In contrast, *D. pleurotaenia* was not present in the dam, and it is rare in the upstream. Harahap et al (2010) categorized this fish as rare species in the Kampar River. This fish is only found in the downstream of the river (below the dam). As the lelan fish is one of the migratory fish in the Kampar River, it is predicted that the rarity of this fish in the dam and in the upstream of the river might be related to migratory disruption due to the construction of the Koto Panjang Dam.

The species *D. pleurotaenia* is one of native fish species in the Kampar River. The scientific information on this fish, however, is almost none. To understand the biological aspects and its relation to the dam construction, this study is conducted.

Material and Method. The sampling area was divided into two main parts, namely the upstream and downstream of the reservoir. Six sampling locations were determined based on information by local fishermen, there were three sampling sites in the upstream i.e. Bandur Picak Village (0^o23'30,52" N; 100^o30'58,82" E), Tanjung Village (00^o19'28,1" N; 100^o38'28,7" E), and Muara Takus Village (0^o19'51,8" N;100^o38'38,8" E), and other three sites were in the downstream i.e. Pulau Belimbing Village (0^o18'1,45" N; 100^o54'53,23" E), Alam Panjang Village (0^o20'42,69" N; 101^o8'42,70" E), and Danau Bengkuang Village (0^o21'26,16" N; 101^o14'0,23" E) (Figure 1).

Sampling procedure. The fish were sampled by gillnet (0.75 and 1 inch mesh size). Sampling was conducted monthly, for a ten months period (November 2011 to August 2012). The fish was captured two times/day, at 06:00 – 08:00 AM and 04:00 – 06:00 PM. Sampled fish were then counted and the representative of each species were photographed prior to preservation in 10% formaline. The fish was then transported to laboratory in Riau University, Pekanbaru for further identification based on Saanin (1984), Kottelat et al (1993) and Weber & Beaufort (1916). The gonad maturity was defined and classified based on West (1990). The length-weight relationship was calculated using the formula proposed $W = aL^b$ by LeCren (1951), Abedi et al (2011) as follow:

Where, W = individual body weight of fish sample (g), L = total length of the fish sample (mm), ***a*** and ***b*** are constants values of linear model. In addition, T-test was used to analyze the significant level of correlation for both parameters using a formula proposed by Walpole (1992):

$$T_{cal.} = \frac{b-3}{Sb}$$

Where, Sb = standard deviation, b = constant value of linear model.

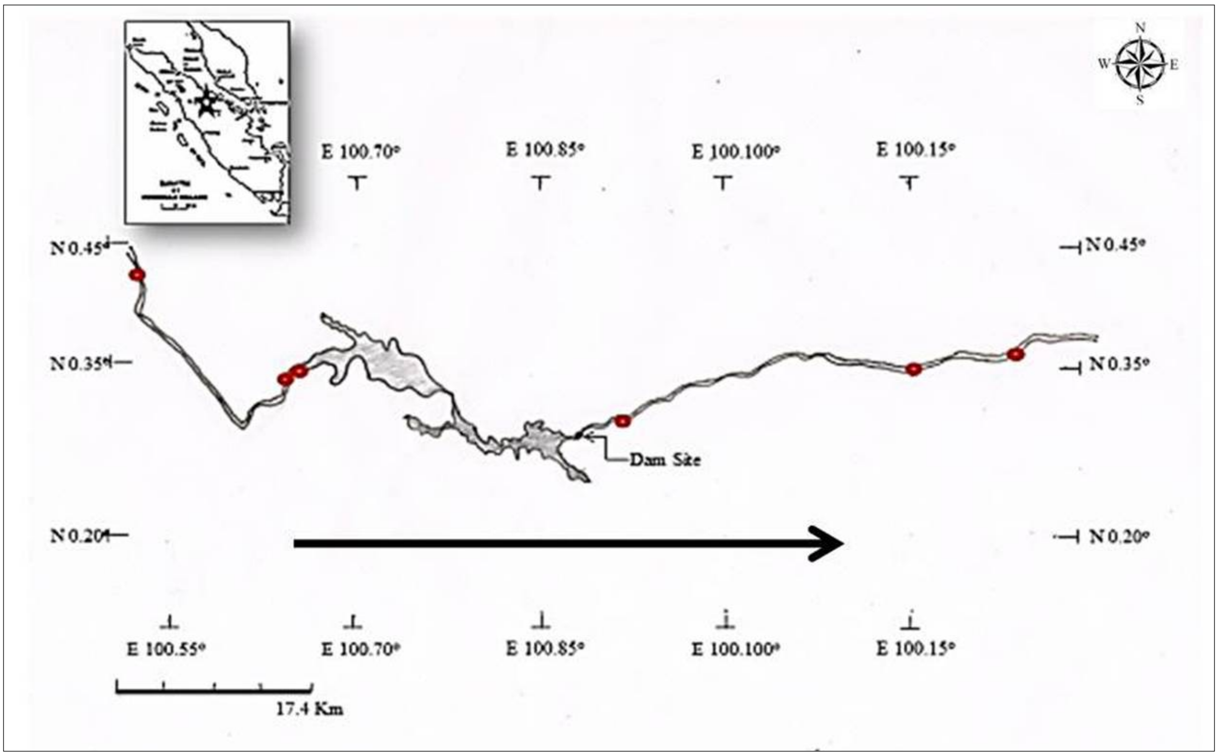

Figure 1. Map of study sites, in the upstream and downstream of the Kampar River. The red circles indicate sampling locations and arrow indicates water flow direction.

Results and Discussions

Sex compositions. Total number of fish captured from both sampling sites was 235 fishes. The number of male and female was almost the same, 119 males and 116 females. The number of each sex, however, is fluctuating throughout the year. More female was recorded on April, while more male was recorded on June. The Chi-squared test result shown that the sex ratio of this species was around one and it means that the number of male and female fish is balance (Table 1).

Table 1

The total number of male and female captured from both sampling areas

No.	*Month*	*Sex*		*Total*
		Male	*Female*	
1	November	0	0	0
2	December	3	8	11
3	January	9	7	16
4	February	6	6	12
5	March	17	11	28
6	April	18	32	50
7	May	0	0	0
8	June	41	23	64
9	July	18	17	35
10	August	7	12	19
	Total	119	116	235

Fish population. A total of 235 fishes were captured from both sampling areas during the study, 7 fishes from the upstream and 228 fishes from the downstream (Table 2). The fish in the upstream were only found in February, April and June. The maximum number of fish captured in during the sampling was only 3 (in June). The rarity of the fish in the upstream area might be related to environmental changing. As *D. pleurotaenia* is a migratory fish, it is predicted that the fish in the upstream used to migrate to the downstream. Before the dam being constructed, the migratory activities may be conducted well. After the dam was built, however, the migration might be disturbed, as the fish could not go to downstream area due to the dam wall. If the fish migrate for reproduction purpose, the dam condition might not be suitable place for that activity, as the depth of the water up to 80 m. The water in the dam is much deeper than that of the Kampar River that has 3–8 m water depth. The reproduction might be unsuccessful and the recruitment of new generation might also be fail. Furthermore the condition in the dam may not be suitable to support the life of *D. pleurotaenia* during the migration. The body form of *D. pleurotaenia* is compressed laterally. This body type indicates that this fish used to live in the running water (Winemiller 1991; Ponton & Merigoux 2000). The water in the dam, however, is static and it may not completely support the life of *D. pleurotaenia*.

Table 2

The number of fish captured in the upstream and downstream areas during the research

Month	*Upstream*			*Downstream*		
	Male	*Female*	*Total*	*Male*	*Female*	*Total*
November	0	0	0	0	0	0
December	0	0	0	3	8	11
January	0	0	0	9	7	16
February	2	0	2	4	6	10
March	0	0	0	17	11	28
April	1	1	2	17	31	48
May	0	0	0	0	0	0
June	0	3	3	41	20	61
July	0	0	0	18	17	35
August	0	0	0	7	12	19
Total	3	4	7	116	112	228

The impact of reservoir for a hydropower plant to fish community has been reported in other regions. In Belgium for example, the reservoir had hampered a Cyprinid species *Barbus barbus* for spawning. During the rainy season, this species migrated through the electric canals, but most of the mature fish were failed to reach the spawning area upstream (Baras et al 1994). In addition, Anteneh et al (2012) reported that there were 16 migratory species of *Labeobarbus* fish in the Lake Tana in Ethiopia. Seven of them spawned as far as 50 km upstream. It occurred during the rainy seasons during July to October. Unfortunately about 75% of these migratory species have been decreased since the years of 1990 to 2000 caused by the intensive used of water for the hydropower plant.

Besides the unsuitable environmental condition, the food resources needed by *D. pleurotaenia* during the stay in the dam was rare. This fish feeds on algae that attached in the surface of immersed objects such as stones and woods. As the water of the dam is deep, there might be lack of immersed object that can be used for algae media, and as a consequence, there is no sufficient food resources during the migration period. These facts indicate that the inadequate environmental condition and the rarity of food resources may the main cause of the rarity of *D. pleurotaenia* in the upstream area.

The population of fish from the upstream does not show any specific pattern and it causes difficulties to understand the migratory and recruitment patterns. Due to this reason, the study on the recruitment and migratory patterns and also its relationship to dam construction will be focused more on the downstream population. The number of monthly fish captured in the downstream area shows a different pattern from that of the upstream. During the sampling period, the number of fish captured range from 0 in May and November to 61 in June (Table 2, Figures 2 and 3). The highest number of fish was obtained in June. The fish occur in December and tend to increase up to April. In May, however, the fish was none, while in June the fish captured was dramatically increased into 61 fishes. The fluctuation of the number of fish captured may be related to the fish's migratory activities. The lack of fish in May might coincidence with the migratory period, as there was relatively high number of mature fish in April (Figure 3). The fish is predicted to migrate to the downstream area, to the lakes or tributaries around the main River of Kampar for spawning. In general the spawning time of tropical fishes are strong correlated to rain fall, for example the spawning season of *Rasbora tawarensis* in Lake Laut Tawar was occurred on March, September December (Muchlisin et al 2010a), this fish migrates to small tributaries in vicinity of lake in to spawn (Muchlisin et al 2011). *Labeobarbus intermedius* in Lake Tana to Arno-Garno River spawned in August to October where they migrate upstream at the end of July (Gebremedhin et al 2012). Generally, fish migrate upstream to spawn when the water level increases during the rainy season, to ensure that the current carries eggs and larvae into nursery areas on the floodplain further downstream (Muchlisin et al 2010a).

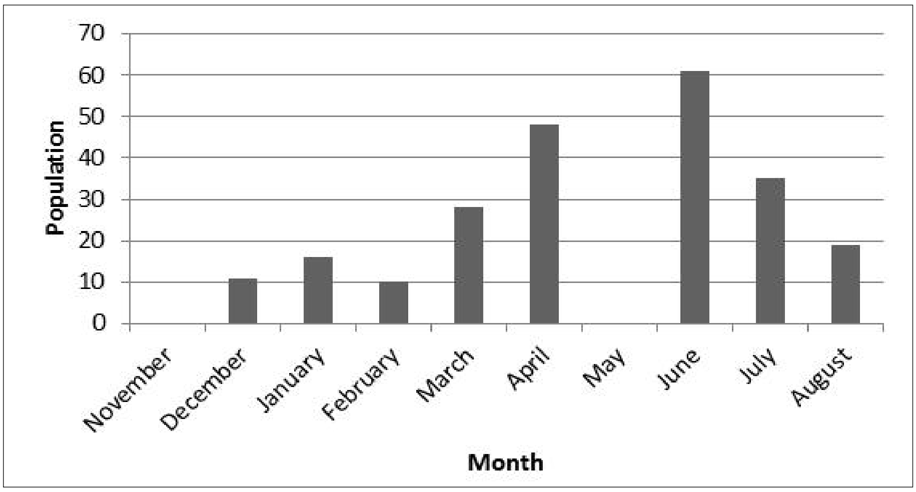

Figure 2. Monthly population of fish captured from the downstream area.

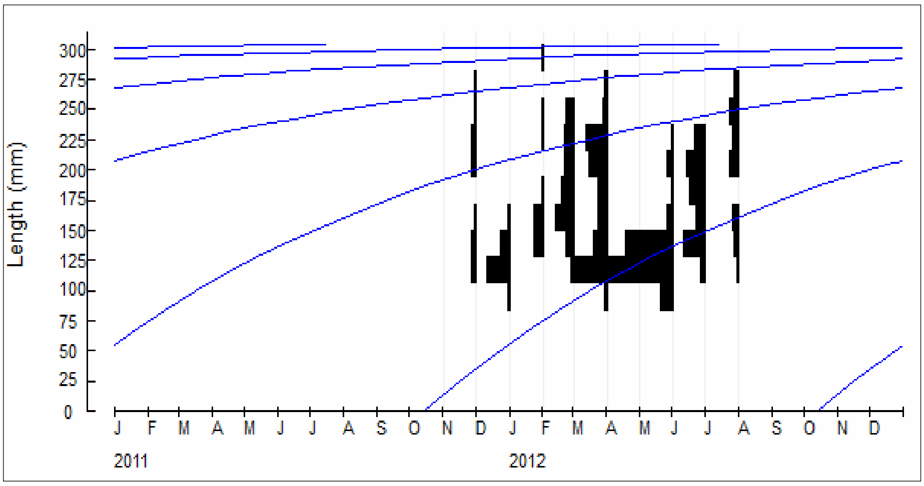

Figure 3. The Von Bertalanfy graph of fish population in the downstream area.

In May, there was no single fish captured. It means that the immature fishes present in April also migrated to another place. This fact suggests that the migration activity may not be caused by the reproductive activities, but it may be caused by environmental conditions changing. Fauzi (2015) stated that the pH of the water in the Kampar River was around 6.8, but during the period of May, it was decreased into 6.4. Many fish species migrate during the dry season due to reducing pH as well as water depth (Sulistiyarto et al 2007). Low pH affects the migration and reproductive behavior of Salmonids (Ikuta et al 2003) in general, especially the sockeye salmon, *Oncorhynchus nerka* (Ikuta et al 2001). In June, the dry season in Riau is ended and the rain start to come, it means that the water condition in the Kampar River is back to normal. The migrated fishes might be back to this river. It is indicated by the presence of several sizes fish, including the small fish. This small immature fish might be the newly recruited fish originated from the spawning season before.

Size composition. The size of fishes captured in each sampling area during the study showed differences. In the upstream, the size of fish captured in general is smaller than that of the downstream. The size of those fishes were 166-150 mm total length and 40.4–133.3 g body weight in male and 153-258 mm TL with 38.84–157.3 gr BW in female. As the number of fish captured is few, however, it is difficult to understand the size distribution of those fish. The size of fish from the downstream was clearly bigger than that of the upstream. Male was around 105–294 mm TL with 10.61–133.38 g BW and that of the female was 95–283 mm TL and 12.01–169.27 g BW. The fish in the downstream start to occur in December and gradually increase during the following 4 months. The size composition of fish captured during these months were various, but most of the fish were small sized (December to February) and only few fishes were categorized as big size. In March and April, in contrast, more big sized fish present. Interesting phenomenon present in May, as there was no single fish captured. It is predicted that the fish might migrate to another places and then back to the Kampar River on June, as many small sized fishes (95-235 mm TL) available in this month. In July and August the size of fish captured in general was bigger than that of the previous month, indicate that the fish has been grown (Table 3).

Table 3

The size of fish captured in the upstream and downstream of the Kampar River during the study period

Month	*Upstream*									
	Male					*Female*				
	Numbers	*Length (mm)*		*Weight (g)*		*Numbers*	*Length (mm)*		*Weight (g)*	
		Min	*Max*	*Min*	*Max*		*Min*	*Max*	*Min*	*Max*
November	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0
January	0	0	0	0	0	0	0	0	0	0
February	2	166	250	40.4	133.3	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0
April	1	232		115.6		1	258		157.3	
May	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	3	153	226	38.84	114.29
July	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0
Month	*Downstream*									
	Male					*Female*				
	Numbers	*Length (mm)*		*Weight (g)*		*Numbers*	*Length (mm)*		*Weight (g)*	
		Min	*Max*	*Min*	*Max*		*Min*	*Max*	*Min*	*Max*
November	0	0	0	0	0	0	0	0	0	0
December	3	241	281	107.3	133.12	8	126	232	16.87	98.37
January	9	133	168	20.01	34.7	7	108	131	12.01	18.17
February	4	188	294	58.9	133.38	6	155	166	30	40.4
March	17	138	236	17.62	94.6	11	180	265	41.65	140.73
April	17	118	244	15.48	113.1	31	108	280	12.01	132.02
May	0	0	0	0	0	0	0	0	0	0
June	41	105	225	10.61	103.13	20	95	230	13.85	140.16
July	18	145	223	28.27	91.24	17	132	241	22.86	107.95
August	7	153	257	28.42	128.36	12	124	283	17.5	169.27

The length weight relationships analysis showed that the **b** values is falling to 2.71 (downstream) and 2.86 (upstream) indicate an allometric growth pattern (Figure 4).

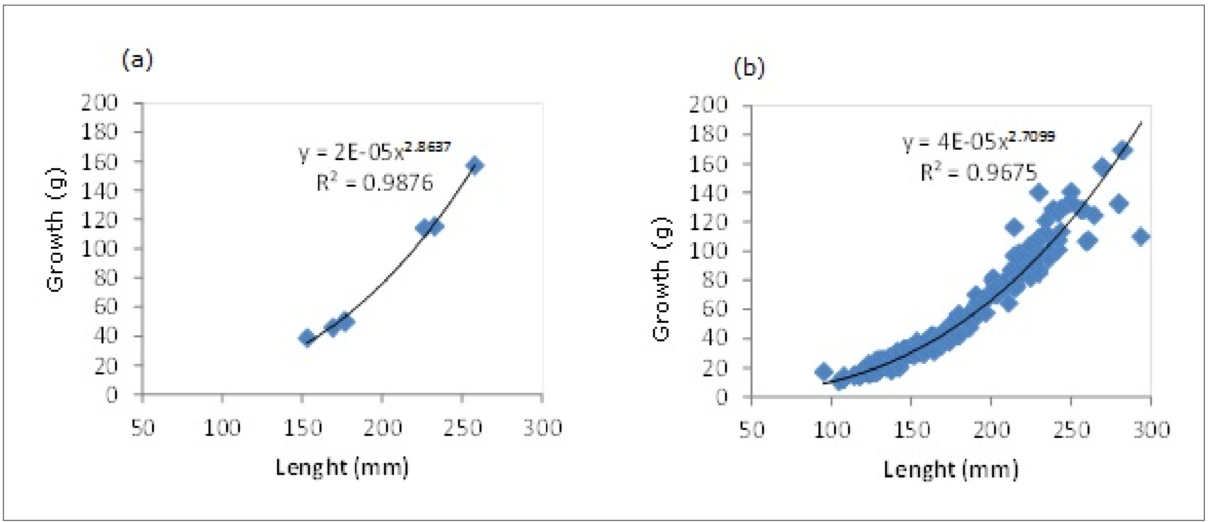

Figure 4. Length weight relationships lelan fish from the upstream (a) and downstream (b) of the Kampar River.

The fish length and weight relationship. The length and weight relationship pattern in the upstream and downstream fishes are different. In the fish captured in the upstream, the coefficients determination of linear model were higher than 90%, where R^2 was 0.9876, while that of the downstream was 0.9675 (Figure 4). These values indicate that 96-98% of weight of fish from both sampling areas was affected by the increase of length. The regression lines of the length-weight parameters in both areas are exponentially formed, the equations was $W = 0.00002\ L^{2.8637}$ for the upstream and $W = 0.00004\ L^{2.7099}$ for the downstream sites. The slope, the *b* values in the upstream was higher than that of the downstream, it means that the growth of fish in the upstream is slightly faster than in the downstream, but both species had negative allometric growth pattern (less than 3). The differences in the growth pattern (*b* value) depend on fish physiology (Le Cren 1951), gonad development (Hossain et al 2013), feeding rate (Tarkan et al 2006) and behavior (Hossain et al 2013). Besides the environmental changing, the food availability is also an important factor for any fish to grow (Sulistiono et al 2001). According to Muchlisin et al (2010b) the *b* value is affected by behavior of fishes where active swimming fish may show lower *b* value compared to passive swimming fish, this is related to the energy allocation for movement and growth. The direct observation showed that the water flow in the upstream of the dam was lower compared to downstream, this is due to the water retained by the dam, this affects the swimming habits of fish where the fish tend to require not a lot of energy against the water flows in the upstream of the dam, and the contrary phenomenon occurs in the downstream the dam region where current flows faster and as compensation the fish allocates more energy for swimming and resulted in slim body shape (low *b* value) as reported by Muchlisin et al (2010b).

The stages of gonad maturity. The gonadal maturity stages of fish from both sampling sites shown similar pattern. In April, there were mature males and females, but in May there was no fish captured and in June the fish was present. This fact indicates that *D. pleurotaenia* from the upstream and downstream area having similar respons to environmental changing happened in May (Figure 5). This condition indicates that the gonad maturity was influenced by rainy and dry seasons as recorded in *R. tawarensis* (Muchlisin et al 2010a) and *Aspidoparia morar* in the Jamuna River (Hossain et al 2013). In addition, the gonad maturity is also influenced by physical and chemical factors of water (Gebremedhin et al 2012; Anteneh et al 2012; Baras et al 1994), and food availability (Sulistiono et al 2001). The information of gonad maturity stages of fish stock is required to evaluate the ratio of gonad maturity of both sexes including the size and the age of the fish that spawning in the first time, this data is crucial for fishery resource management (Effendi 1997; Njiru et al 2006; Udo 2002).

The fish from the upstream may conducted the migration activity for spawning purposes. However, their journey was ended in the dam. As the dam environment is totally different from that of the river's physical condition, the reproductive activity of the fish might be hampered. Kahl et al (2008) stated that the water depth negatively affects the survival of fish larvae. In the case of *D. pleurotaenia* from upstream population, there was no recruitment of the new generation of the fish due to unsucceed reproduction. The lack of small fishes in the upstream population in June (Figure 5) also supports the evidence that the reproductive activity of the fish has failed.

In downstream fish population, many mature female were present in April, but few male were present in this month. As there was no fish captured in May, it is predicted that the fish migrate to other places for reproductive activities. Even though the number of mature male was few, but the reproductive activity might be conducted well. Chung-Davidson et al (2010) stated that the sperm maturity of the male is strongly affected by the presence of mature female. Pheromone produced by mature female induce the sperm maturation process in male. On *D. pleurotaenia*, the male maturity process might happened during the migration. The presence of many small fishes captured in June (Figure 5) indicates that the reproductive activity as well as the recruitment of *D. pleurotaenia* in the downstream area has succeeded.

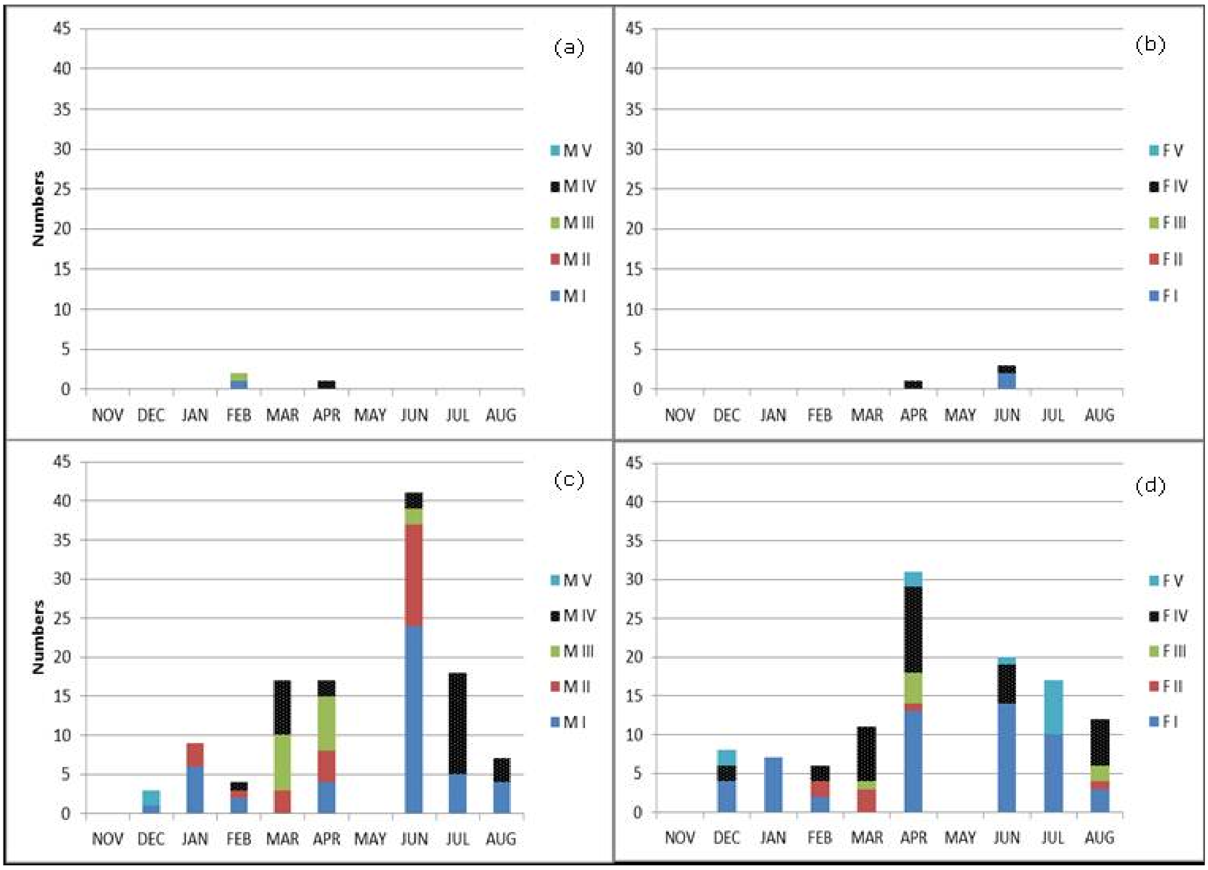

Figure 5. Monthly population of fish from the upstream and downstream areas based on gonadal maturity stages. Explanation: (a) male upstream; (b) female upstream; (c) male downstream and (d) female downstream.

Conclusions. The composition of male and female is almost balance. There were only 7 fishes captured in the upstream and 228 fish captured in the downstream of the Kampar River. The fish from both population showing similar reproductive pattern, there are mature males and females in April and there is no fish captured in May. The size range of the fish is showing different pattern, as there is no small fish (less than 105 mm TL) in the upstream, but plenty small sized fish present in the downstream. The low population of *D. pleurotaenia* and the rarity of the small sized fish in the upstream is resulted from unsuccessfull reproduction due to the construction of the Koto Panjang Dam.

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Authors:
Muhammad Fauzi Faculty of Fisheries and Marine Sciences, Riau University, Jl. HR. Soebrantas Km 12.5 Simpang Baru, Pekanbaru 28293, Indonesia, e-mail: mfauzi@unri.ac.id
Dahelmi Dahelmi, Faculty of Mathematics and Natural Sciences Andalas University, Kampus Limau Manis Padang 25163, Indonesia, e-mail: dahelmi@gmail.com
Indra Junaidi Zakaria, Faculty of Mathematics and Natural Sciences Andalas University, Kampus Limau Manis Padang 25163, Indonesia, e-mail: indrajunaidi@fmipa.unand.ac.id
Usman M. Tang, Faculty of Fisheries and Marine Sciences, Riau University, Jl. HR. Soebrantas Km 12.5 Simpang Baru, Pekanbaru 28293, Indonesia, e-mail: usman_mt@yahoo.co.id

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