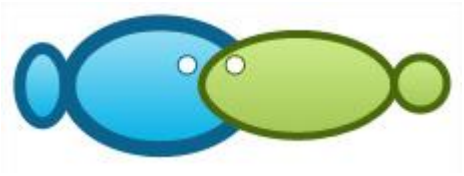

Fish species composition and diversity in a river, a swamp, and a reservoir in Banjar District, South Kalimantan Province

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Abstract. Freshwater fish is a component of biodiversity in river, swamp, and lake ecosystems. Over-exploitation of fish can change the characteristics of waters and result in the decrease in the abundance and diversity of fish. This study aimed to assess the species composition and diversity of fish community in three mainland water systems, i.e., river, swamp and reservoir. Purposive sampling of fish was done in three stations for each type of water. The data were analyzed descriptively and quantitatively, using the Shannon-Wiener index of diversity, evenness idex, Simpson index of dominance (C) and similarity index of Sørensen (ISs) and Bray-Curtis (C_{BC}). A total of 35 species belonging to 18 families were found in the three water types, where the river having the highest species richness (17 species), followed by the swamp (15) and the reservoir (11). The family Cyprinidae had the highest number of species. The index value of fish species diversity ranged from 1.20 to 2.55, considered as medium, the evennes index 0.5-0.9, considered medium to high, and the dominance index 0.09-0.39 considered as low. The Sørensen similarity index ranged from 0.12 to 0.29, and the Bray-Curtis similarity index 0.05-0.38, considered as low. The river and swamp fish community had higher similarity index than the reservoir and the river, and the reservoir and the swamp. No common species was found in all the three water types. The water physico-chemical parameters met the quality standards to support fish life, namely pH 6.0-7.88, temperature 26.4-30.1°C, DO 6.2-8.1mg L^{-1}, transparency 97-130 cm.
Key Words: freshwater fish, habitat types, species diversity.

Introduction. Fish constitutes a large portion of the biodiversity of aquatic ecosystems, and consequently, play significant roles in maintaining the aquatic ecosystem services of which benefit the human communities (Arthington et al 2016). Approximately 43% or 11,952 species of fish occupy freshwater ecosystems (Nelson 2006), such as rivers, lakes, and swamps (Kottelat et al 1993). These freshwater fish contribute significantly to the livelihood of the people, especially in the developing world (Sayer et al 2018). However, the water where fish live is needed by many sectors, such as agriculture, energy, industries and domestic purposes (Taylor et al 2016), which lead to the competition for water uses among sectors, threatening the freshwater ecosystems which cause the decline of freshwater fish diversity (Dudgeon 2019).

Pollution from industrial, agricultural and domestic uses have detrimental effects on both, marine and freshwater fish (Ganguly 2013). Freshwater swamps are rich in fish diversity in Southeast Asia have been threatened due to conversion to other landuses (Ho et al 2018). River systems are also severely threatened ecosystems on the earth due to several acitivities, one of which is the construction of dam which alters the natural flow of rivers (Schneider et al 2017). Since many species require migration to complete their life cycles, the construction of dams impede the migration of fish (Leirmann et al 2012). In Yangtze River basin of China, sprawning sites of some migration fish has been lost due to the construction of a dam, resulting in the decline of growth and reproduction (Yi et al 2010). Another study in the upstream from the upper Parana River floodplain, Brazil,

showed that the construcion of a dam has simplified the the functional diversity of fish (Oliveira et al 2018).

The threats to freshwater ecosystems has reduced the diversity of freshwater fish, nearly a third of which are in danger of extinction (Dudgeon 2012), and many species have been extinct already (Baillie & Butcher 2012). With the loss of freshwater biodiversity, their essential support to human well-being will be lost too (Albert et al 2020). It is, therefore, urgent to protect the freshwater ecosystems to ensure the sustainability of freshwater fish consumption for the welfare of human communities. The first step to do is to improve the assessment of the production in order to have science-based fishery management, because the accurate and complete information of freshwater fish is not sufficient at local, national and global level (Taylor et al 2016).

In Kalimantan there are about 350 species of freshwater fish, 135 of which are endemic to this island. One of the districts in South Kalimantan Province which has large prouction of freshwater fish is Banjar District, with an area of +466,850 ha, producing 4,053.3 tonnes of freshwater fish in 2018 (Office of fisheries Banjar District 2020). The freshwater esosystem types in Banjar District are swamps, rivers and dams or reservoirs (Office of fisheries Banjar District 2020). The Ir. P. M. Noor Riam Kanan Dam (hereafter referred to as Riam Kanan Dam), located in Banjar District, is a multi-use dam with an area of 9,730 ha, used for hydroelectric power, agricultural irrigation, raw water for local drinking water company, tourism and fisheries.

The construction of Riam Kanan Dam certainly has impacts on fish diversity like what happened in other places (Yi et al 2010; Leirmann et al 2012; Schneider et al 2017; Oliveira et al 2018). The impact of Riam Kanan Dam construction on fish diversity in the river has not been studied. Meanwhile, the dam itself has been used by the regional government for the development of fishery. The first step to be taken in making management plan of the Riam Kanan Reservoir fishery and other waters is to gather information of fish diversity and abundance, in order to avoid over exploitation that will deplete the fish resource.

The objective of this study was to assess the species composition and diversity of fish in three mainland water systems, i.e., Martapura river, Lebak swamp and Riam Kanan reservoir. We hypothesized that the species composition among the three water systems would be different due to differences in the habitat's characteristics including the water quality.

Material and Method

Study site. The research was conducted two months from April to June 2020 in Riam Kanan reservoir, Martapura river and Lebak swamp in Banjar District, South Kalimantan Province. The study sites were selected purposively by considering the characteristics of the population based following Usman & Purnomo (2008). Sampling points were selected systemically with a random starting point at 9 points in different water sytems (Figure 1) based on information from fishermen who usually catch at that locations. In the river, the government has introduced non native fish species, i.e., *Oreochromis niloticus* and *Cyprinus carpio*, while in the reservoir, *C. carpio*, *Colossoma macropomum*, and *Pangasianodon hypophthalmus.*

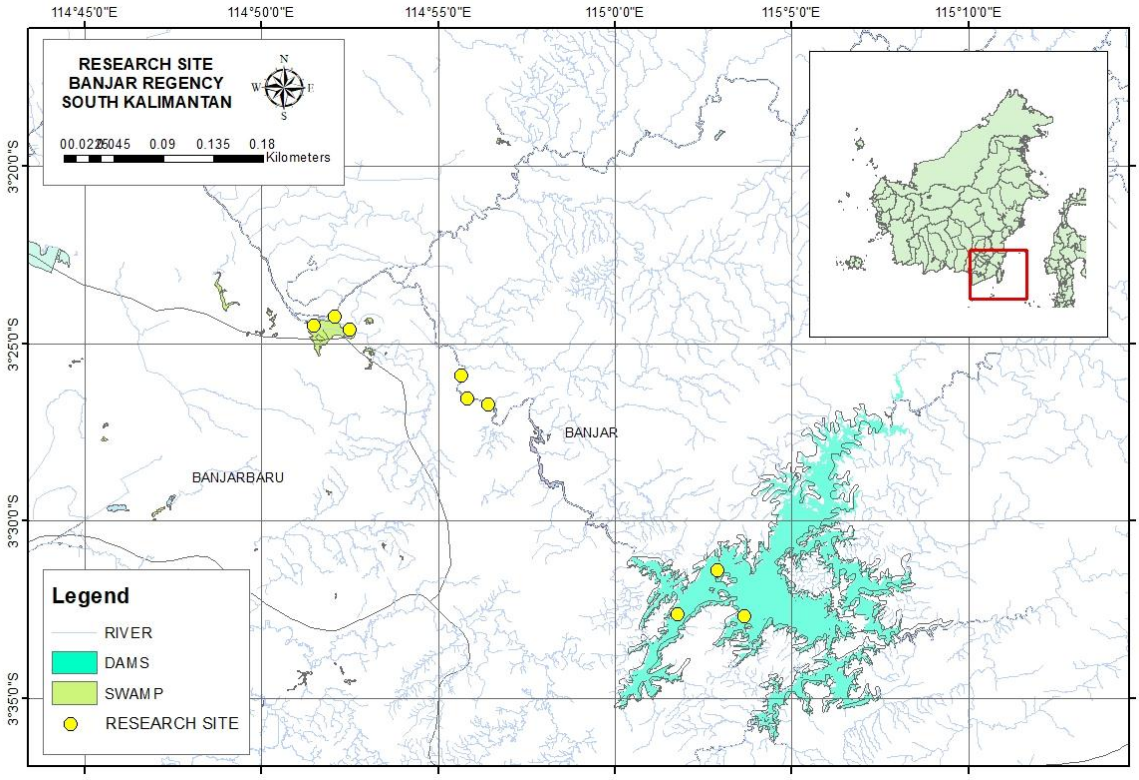

Figure 1. The sites of study at a Lebak swamp, Martapura river and Riam Kanan reservoir in Banjar District, South Kalimantan Province, Indonesia.

Data collection. Fish samples were taken using fishing gill net, trammel net, portable lift net, hand line, stage trap and cast net, fish pots and scoop net, hand line, bamboo's split with one day trip catching time. The fish caught were collected by separating each species of catch and counting the number of each species of fish. Identification of fish species was carried out by observing their morphometric and meristic characteristics by referring to the fish identification key book (Saanin 1984). Sampling at each sample point was carried out 3 times with a time interval between sampling of 1 week to obtain an accurate sample. Each fish caught was identified and counted. The number of sampling was considered sufficient because at the third sampling, no more new species was found in each water system (Table 1).

Table 1

Total species found in each sampling period according water system

Sampling period	*Total species*		
	River	*Swamp*	*Reservoir*
First sampling	14	10	16
Second sampling	17	11	16
Third sampling	17	11	16

The water quality parameters, namely brightness, temperature and pH were measured in situ as supporting data. In addition, water samples were taken for dissolved oxyeg (DO) measurement in the laboratory.

Data analysis. The data were analyzed using the diversity Shannon-Wiener index (H'), the evennes index (E), the dominance index (C), and Sørensen similarity index (Krebs 1972) and Bray-Curtis similarity index (Chao et al 2006).
Shannon-Wiener diversity index was calculated using the following equation:

$$H' = -\sum_{i=1}^{s} (pi)(\log \quad pi)$$

Where:
H' - species diversity index
s - number of species
pi - proportion of species i = ni/N = (number of individual i/number of individuals of all species).

Evennes index was calculated using formula:

$$E = \frac{H'}{\ln(s)}$$

Where:
E - evennes index
H' - species diversity index
s - number of species

Simpson dominance index was calculated with formula:

$$C = \sum_{i=1}^{s} (pi)^2$$

Where:
C - Simpson dominance index
pi - proportion of species i = ni/N

Similarity index of species composition was determined using Sørensen index and Bray-Curtis index, with the following formulas:

$$\text{Sørensen index} = IS_S = \frac{2c}{A + B}$$

A - number of all fish species in community A
B - number of all fish species in community B
c - number of common species (present in both communities A and B)
(Ludwig & Reynolds 1988)

$$\hat{C}_{BC} = \frac{2\sum_{i=1}^{D_{12}} \min(X_i, Y_i)}{\sum_{i=1}^{D_1} X_i + \sum_{i=1}^{D_2} Y_i}.$$

CBC - Bray-Curtis similarity index
$Min(X_i,Y_i)$ - the minimum count of the i^{th} species in the first community (X) and second community (Y).
D_1 - species found in the first community (X)
D_2 - species found in the second community (Y)
D_{12} - common species found in the first and second community
(Chao et al 2006)

Results and Discussion

Species composition. The fish community in the sampling sites in Martapura river was composed of 17 species from 13 families, in Lebak swamp 11 species from 8 families, and in Riam Kanan reservoir 15 species from 6 families, with a total of 35 species from 18 families in all the three water systems (Table 2). The species composition differed among the water systems. The Sørensen similarity index of species composition among the water systems ranged from 0.12 to 0.29, while the Bray-Curtis index 0.05 to 0.38 (Table 2). No single common species was found in all the three water systems, but there were four common species found the river and swamp waters, two common species

between the river and reservoir, and two common between the swamp and the reservoir (Table 2). The low similarity index of species composition indicates that the environmental factors or human disturbances among the three water sytems were different.

Table 2

The list of species and family of fish caught in Martapura river, Lebak swamp and Riam Kanan reservoir in Banjar District, South Kalimantan Province

Species	*Family*	*Number of individuals*			*Total*
		River	*Swamp*	*Reservoir*	
Trichopodus trichopterus	Anabantidae	265	740		1005
Trichopodus pectoralis	Anabantidae	216	500		716
Helostoma temminckii	Helastomatodae	220	380		600
Anabas testudineus	Anabantidae	141	325		566
Oxyeleotris marmorata	Eleotridae			396	396
Channa striata	Channidae		175	81	256
Barbonymus schwanenfeldii	Cyprinidae			241	241
Osteochilus vittatus	Cyprinidae	26		84	184
Mystacoleucus padangensis	Cyprinidae		170		175
Mystus nigriceps	Bagridae		148	27	175
Rasbora argyrotaenia	Cyprinidae			168	168
Clarias batrachus	Claridae		168		168
Pangasianodon hypophthalmus	Pangasidae	166			166
Pangasius nasutus	Pangasidae	152			152
Oreochromis niloticus	Cichidae	108			108
Osphronemus goramy	Osphronemidae	46		45	91
Kryptoterus macrocephalus	Siluridae	89			89
Hampala macrolepidota	Cyprinidae			87	87
Channa micropeltes	Channidae			82	82
Cyprinus carpio	Cyprinidae	74			74
Belontia hasselti	Osphronemidae		61		61
Hemisilurus heterorhynchus	Siluridae	56			56
Osteochilus vittatus	Cyprinidae		49		49
Mystus gulio	Bagridae	46			46
Macrobrachium rosenbergii	Palaemonidae	45			45
Barbonymus gonionotus	Cyprinidae	25			25
Monopterus albus	Synbranchidae		21		21
Pterygoplichthys sp.	Loricaridae	15			15
Oxygaster anomalura	Cyprinidae			14	13
Chitala lopis	Notopteridae	8			8
Cyclocheilichthys apogon	Cyprinidae			7	7
Mastacembelus erythrotaenia	Mastacembelidae			7	7
Hemibagrus nemurus	Bagridae			6	6
Mystacoleucus marginatus	Cyprinidae			5	5
Osteochilus repang	Cyprinidae			3	3
Total individuals		1698	2737	1253	5698
Number of families		13	8	6	
Number of species		17	11	15	

Family Cyprinidae constituted the largest portion of the fish community by having the highest number of species, i.e., twelve, followed by family Anabantidae, three species. Each of the following families, i.e., Channidae, Bagridae, Osphronemidae and Siluridae was represented by two species, while each of other families had only one species. The four most abundant species were *Trichopodus trichopterus*, *Trichopodus pectoralis*, *Helostoma temminckii* and *Anabas testudineus* (Table 3).

Table 3

Common species and similarity index of species composition among water systems

Species	*Family*	*Water systems*			*Similarity index*	
		River	*Swamp*	*Reservoir*	*Sørensen*	*Bray-Curtis*
Trichopodus trichopterus	Anabantidae	265	740		River and swamp	
Trichopodus pectoralis	Anabantidae	216	500			
Helostoma temminckii	Helastomatodae	220	380		0.29	0.38
Anabas testudineus	Anabantidae	141	325			
Osphronemus goramy	Osphronemidae	46		45	River and reservoir	
Osteochilus vittatus	Cyprinidae	26		84	0.12	0.05
Channa striata	Channidae		175	81	Swamp and reservoir	
Mystus nigriceps	Bagridae		148	27	0.15	0.05

Species diversity. In addition to number of species or species ricness, diversity index, which integrate the species richness and abundance, has been used by ecologists to determine the species diversity. In the river of Martapura the Shannon-Wiener index of species diversity was 2.57, in Lebak swamp 2.09 and in Riam Kanan reservoir 2.16, which could be considered medium. The evennes index was high in all three water systems, i.e., 0.91 in Martapura river, 0.84 in Lebak swamp and 0.78 in Riam Kanan reservoir, indicating that the abundance of each species was relatively equal. This was evident from the low value of Simpson dominance index, i.e., 0.09 in Martapura river, 0.15 in Lebak swamp and 0.09 in Riam Kanan Reservoir.

In Martapura river, all the community indexes had the same value among the sampling sites, while in Lebak swamp and Riam Kanan the values varied among sampling sites (Table 4).

Table 4

Indexes of diversity, evennes and dominance of fish community in the nine sampling sites in three water systems

Community indexes	*Habitat type / Sampling site*								
	River			*Swamp*			*Reservoir*		
	Site 1	*Site 2*	*Site 3*	*Site 1*	*Site 2*	*Site 3*	*Site 1*	*Site 2*	*Site 3*
Species diversity (H')	2.55	2.54	2.55	2.23	1.98	1.86	1.69	1.43	1.20
Evenness index (E)	0.90	0.89	0.90	0.89	0.80	0.75	0.77	0.56	0.5
Dominance index (C)	0.09	0.09	0.09	0.12	0.18	0.22	0.15	0.38	0.39
Species diversity (H')		2.57			2.09			2.16	
Evenness index (E)		0.91			0.84			0.78	
Dominance index (C)		0.09			0.15			0.09	

Water quality. The parameters of water quality are shown in Table 5. The pH of water in the study sites ranged from 6.0 to 7.88, the lowest of which was found in Lebak swamp and the highest in Martapura river. The lowest temperature was also found in the swamp, i.e., 26.4°C while the highest in the reservoir, i.e., 30.1°C. The reservoir also had the highest dissolved oxygen, i.e., 8.1 mg L^{-1}, while the lowest in the river, i.e., 6.2 mg L^{-1}. Meanwhile, the highest clarity was found in the river, and the lowest in the swamp. The salinity was zero in all water systems. Overall, the water quality in all the tree habitats

was within the normal range for fish habitat, except that the water clarity was too high, because its optimum value for fish growth is 30-80 cm (Bhatnagar & Devi 2013).

Table 5

The water quality in Martapura river, Lebak swamp and Riam Kanan reservoir

Water quality	*River*			*Swamp*			*Reservoir*		
pH	7.88	7.78	7.16	6.39	6.17	6.0	7	6.9	6.8
Temperature (°C)	28.5	28.4	28.7	26.4	26.3	27.1	30.0	30.1	29.9
Salinity (‰)	0	0	0	0	0	0	0	0	0
Dissolved oxygen (mg L^{-1})	6.8	7.2	6.2	7.45	7.65	7.6	8.1	7.8	7.5
Clarity (cm)	130	124	130	98	97	99	102	102.4	102.2

Species composition. The species composition in the river, swamp and dam in this study was different from each other as indicated by low similarity indexes, both the Sørensen dand Bray-Curtis indexes. The Bray-Curtis Index is more accurate because it is based not only on the presence or absence of common species but also on the abundance of those species, while the Sørensen index was based only on the absence and presence of species (Chao et al 2006). In this study, Bray-Curtis index showed the pronounced difference in species composition of fish community between the dam and the two other water types, i.e., 0.05. Meanwhile, the similarity of species composition between the fish community in the river and in the swamp was higher, i.e., 0.38 because they had not only higher number of common species but also the higher abundance of those common species. The four common species between the river and swamp also became the most abundant species in the study sites. i.e., *Tr. trichopterus*, *T.s pectoralis*, *H. temminckii* and *A. testudineus*. Two of these four species, i.e., *T. trichopterus* and *T. pectoralis* were also found as the most dominant species in Bankau swamp of Hulu Sungai Selatan District, South Kalimantan Province (Irhamsyah et al 2017). On the contrary, these four species were not found in the Riam Kanan dam. The most abundant species found in the dam was *Oxyeleotris marmorata* (Table 2).

Differences in species composition among the water systems in this study may reflect the differences in the habitat's characteristics. In Colorado river basin of the United States, the fish community composition was associated with differences in water temperature, concentrations of dissolved solids and suspended sediment, elevation, habitat, and land use which in turn was the effects of natural and human factors (Deacon & Mize 1997). In this study sites, the water of dam had higher temperature (29.9-30.1°C) than the water in the river (28.3-28.7°C) and swamp (26.3-27.1°C) (Table 5). The optimum temperature for fish is 20-30°C (Effendi 2003), so the temperature in the dam was on the higher end of range of the optimum. The depth was also different among the three water systems, i.e., Riam Kanan dam 52 m, Martapura river 4-8 m, and Lebak swamp 1-4 m. Another difference was the water clarity, with the river having the highest clarity while the swamp the lowest.

In a stable small stream, the fish species found are those which have have evolved various morphological and behavioral adaptations to exploit that habitat, while over geographical and habitat scales, the species found are determined by environmental filtering and anthropogenic effects (Gebrekiros 2016). In our study sites, the anthropogenic factor might have affected the species composition. In the river and swamp, fishermen sometime used poison and electric current to catch the fish, while in dam these activities were absent.

In this study the Cyprinidae was the most often found family, similar with the finding of Rashid et al (2015) in Tembeling and Pahang rivers, Pahang, Malaysia, and that of Samitra & Rozi (2019) in Lakitan river, South Sumatera. In Brunei Darussalam, among 104 freshwater species found, 40 of which belong to famili Cyprinidae (Sulaiman et al 2018). These results are in accordance with the statement of Lowe-McConnell (1987) that freshwater fish in tropical Asia are dominated by the family Cyprinidae. The family Cyprinidae can live in both river areas that have strong currents and weak currents with good water quality (Nikolsky 1963). Buwono et al (2017) stated that the Cyprinidae is a

family with a relatively large number of species in freshwater. Cyprinidae is a very large family and occurs almost everywhere except in Australia, Madagascar, New Zealand, and South America; to date, 2420 species in 220 genera in the fish family Cyprinidae have been found (Karahan & Ergenen 2010). The very large number of species in the family Cyprinidae shows good adaptability and fast breeding processes, so species from this family are always found in freshwater almost all parts of the world (Beamis et al 2006). Cyprinidae dominate 20% of the world's freshwater fish and 8% of all fish (Berra 1997).

Three of the four most abundant species found both Martapura river and Lebak swamp, i.e., *A. testudineus*, *T. pectoralis*, *T. trichopterus* belong to the family Anabantidae which have additional respiration in the form of grooved bony bones like coral waste called a labyrinth which is used to take oxygen directly from the air (Muflikhah 2007). *Channa striata* which is ranked 5th in abundance also has labyrinth. Meanwhile, the most abundant species in Riam Kanan dam was *O. marmorata*, the most expensive fish in Banjar district.

Three of the introduced species, i.e., *P. hypophthalmus*, *O. niloticus* and *C. carpio,* were found in Martapura river, but not in Riam Kanan dam although those species were also introduced in the dam. The introduction of exotic species was intended to enrich freshwater fish diversity, because according to Fisheries Office of Banjar District, several freshwater fish had begun to disappear, namely *Osteochilus melanopleurus*, which is the mascot of Banjarmasin City, *Eleutheronema tetradactylum*, *Channa pleurophthalma*, *Channa lucius*, *Leptobarbus hoevenii*, *Barbonymus schwanenfeldii* and *Wallago attu*. Despite the good intention of the government, introduction of allien species may result in the demise of native species of fish, and even jeopardize the ecosystem service of the fish habitat (Kiruba-Sankar et al 2018). Introduced species may also reduce the functional diversity of the invaded fish community (Milardi et al 2019). In Martapura river, *P. hypophthalmus*, *O. niloticus* and *C. carpio* ranked 4th , 7th and 9th in abundance respectively. Thus, the the detrimental effect of exotic species in the fish community in dam was not evident in Martapura river. In Riam Kanan dam the introduced species did not even survived.

Species diversity and fish abundance. The Martapura river had higher species richness and diversity index than Lebak swamp and Riam Kanan reservoir. The number of fish species in Martapura river (17) was lower than that in Lakitan river (20) in South Sumatra (Samitra & Rozi 2019), in Trembeling river (47) also in Malaysia (Rashid et al 2015). The high number of species found in Trembeling river (47 species), however, was the resut of two years of sampling (Rashid et al 2015), while the sampling in our study was done only in three weeks. Within two years of sampling there were several seasons, and each season might have different species composition as reported in the study in Ayeyarwady River in Sagaing Region, Upper Myanmar (Win & Myint 2015), so the total species diversity of two year-sampling would be higher than that of three week-sampling.

Fish density in a river is affected by several factors, such as substrate type, stream type and disturbance (Ahmad et al 2011). Martapura river has slow current, sandy and stony bottom and experiences disturbance from human activities such as the passing of boats and the fishing activities, sometimes using the destructive methods, i.e., electrofishing and poisoning.

Lebak swamp had the lowest number of species, i.e., 11, lower than Nee Soon freshwater swamp forest of Singapore, i.e., 21 species (Ho et al 2018), Shadegan marshland in Iran, i.e., 26 species (Hashemi et al 2015), and Beriah Kanan River (21 species), but higher than that in Ulu Sedili (10 species) in Malaysia (Zakaria et al 1999). Both Beria Kanan and Ulu Sedili rivers are mostly freshwater swamp. The study in peat swamp forest even found much higher number of species, i.e., 55 species in Sebangau watershed, Central Kalimantan (Thornton et al 2018), and 73 in species Tripa peat swamp forest in Aceh (Muchlisin et al 2015). This comparison, however, does not give the comprehensive information because of differences in the areas and duration of sampling.

Although Lebak swamp had the lowest diversity of fish, it had the highest fish abundance, presumably due to the presence of aquatic plants such as parupuk

(*Phragmites karka*), Hydrilla (*Hydrilla verticillata*), *mendong* (*Fimbristylis globulosa*), common susum (*Hanguana malayana*), common water hyacinth (*Eichhornia crassipes*), water snowflake (*Nymphoides indica*) and spiny false fiddleleaf (*Hydrolea spinosa*). Growns et al (2003) stated that aquatic plants in the swamp support fish stocks. According to Welcomme (1985) the lowland swamp fish community is influenced by three key factors, namely the inundation cycle, the pressure of fishing activities and a decrease in environmental quality.

Water quality. Fish has tolerable range of the water quality in which they live. Physical, chemical and biological factors determine the water quality which in turn influence the survival and growth of fish, and consequently the fish production (Bhatnagar & Devi 2013). The quality of water in three water sytems in this study was within the range of tolerance for the survival of fish, except the water clarity which was too high. The pH in this study sites was 6.0–7.88, with the lowest one being found in the swamp due to the presence of abundant aquatic plants. Also, a freshwater swamp may contain several inches of peat layer (Whitten et al 1984). However, the pH in the swamp was still within normal range for fish, i.e., 6-9, and certain fish may even survive in more acidic water (Effendi 2003). However, in acidic water the release of heavy metals from waste into water is high (Li et al 2013) which may have detrimental effect on fish. The temperature in the study sites was 26.4–30.1^{o}C, while the optimun temperature for fish according to Effendi (2003) is 20-30^{o}C. Some fish may tolerate higher temperature, i.e., 30-35^{o}C (Bhatnagar & Devi 2013), but at higher temperature (30-35^{o}C) the release of heavy metals from waste into water is high (Li et al 2013). The dissolved oxygen in the study site was 6.2-8.1 mg L^{-1}, while the optimum DO for fish is >5 mg L^{-1} (Bhatnagar & Devi 2013). The water clarity in the study sites was too high because the optimum range for fish health is 30-80 cm (Bhatnagar & Devi 2013). At higher clarity light penetrates deeper encouraging the growth of macrophytes, reducing the growth of plankton as fish food.

Conclusions. In conclusion, this study has shown that Martapura river, Lebak swamp and Riam Kanan reservoir had clear distinction in species composition. The fish species diversity in the reservoir was lower than that of the other water systems, but the diversity between the river and swamp did not differ significantly. However, since the time period of sampling was only three weeks and the number locations of sampling was only three for each water system, many parts of each habitat has not been adequately sampled. Therefore, further studies covering wider area and longer sampling period should be conducted to get comprehensive data of fish community as the basis for the fishery management.

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