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Species composition and length-weight relationship of twelve fish species in the two lakes of Esperanza, Agusan del Sur, Philippines

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Abstract
Species composition and length-weight relationship (LWR) of fish species of Lake Oro and Lake Dakong Napo in Esperanza, Agusan del Sur, Philippines were assessed in this study. Fishes were collected using hook and line, lift net and cast net. A total of 12 species belonging to nine families were collected and where most species (75%) were introduced to Philippines freshwater bodies. Family Osphronemidae has the most number of species collected (25%) followed by Gobiidae (17%). *Cyprinus carpio* has the most number of individuals collected (n=124 and d=9.8/10 m^2). Most number of species were collected from Lake Oro (n=10) however, diversity index was highest in Lake Dakong Napo (H=1.501). The "b" value of LWR shows that *Oreochromis niloticus* (b=3.1382) and *C. carpio* (b=2.9196) had an isometric growth while *Anabas testudineus, Osphronemus goramy* and *Trichopodus trichopterus* had negative allometric growth (b<3), which means that these fishes do not grow isometrically.
Keywords: Ichthyofauna, introduced, Lake Dakong Napo, Lake Oro.
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Introduction

The Philippines is blessed with water systems that houses 3,010 fish species in which 343 are freshwater dwellers (Labatos and Briones 2014). One of the largest and widely studied freshwater systems in the country is situated in the province of Agusan del Sur, the Agusan Marsh. However, the province still has to offer unique and significant freshwater habitat. The Bureau of Fisheries and Aquatic Resources of the Philippines (2000) listed 241 lakes in the country however, only the status of freshwater fishes in major lakes had been studied with smaller lakes being left out (Labatos and Briones 2014), these may include Lake Oro and Dakong Napo which are situated in Esperanza, Agusan del Sur.

Length-weight relationship (LWR) establishes the mathematical relationship between length and weight of fish (Beyer 1987). Like other morphometric measurements, LWRs may change during the events of life cycle like metamorphosis, growth and onset of maturity (LeCren 1951). Furthermore, LWR studies of fishes are considered as an important tool in fishery (Garcia et al. 1998) particularly in monitoring the well-being of fish population (Ecoutin et al. 2005) that happens during their life cycle.

Data concerning the biodiversity of Lake Oro and Lake Dakong Napo are scarce, only freshwater molluscs were documented in the two lakes (Sularte and Jumawan 2016; Cabuga et al. 2017). Thus, this study was conducted to assess the composition and condition of other freshwater taxa in the area i.e. the fish fauna. The results of the study will serve as an important reference for future studies as well as addressing conservation measures and management of fish resources in the area.

Material and Methods

Study Area: This study was conducted at Lake Oro and Lake Dakong Napo, Esperanza, Agusan del Sur, Philippines which lies geographically at 08°34.688'N, 125°41.106'E; and 08°38.929'N, 125°39.2232'E, respectively. Having an area of 35 ha (Dakong Napo Lake) and 10 ha (Lake Oro), the two lakes are economically important since it provide fisheries to the populace of the nearby community (Fig. 1).

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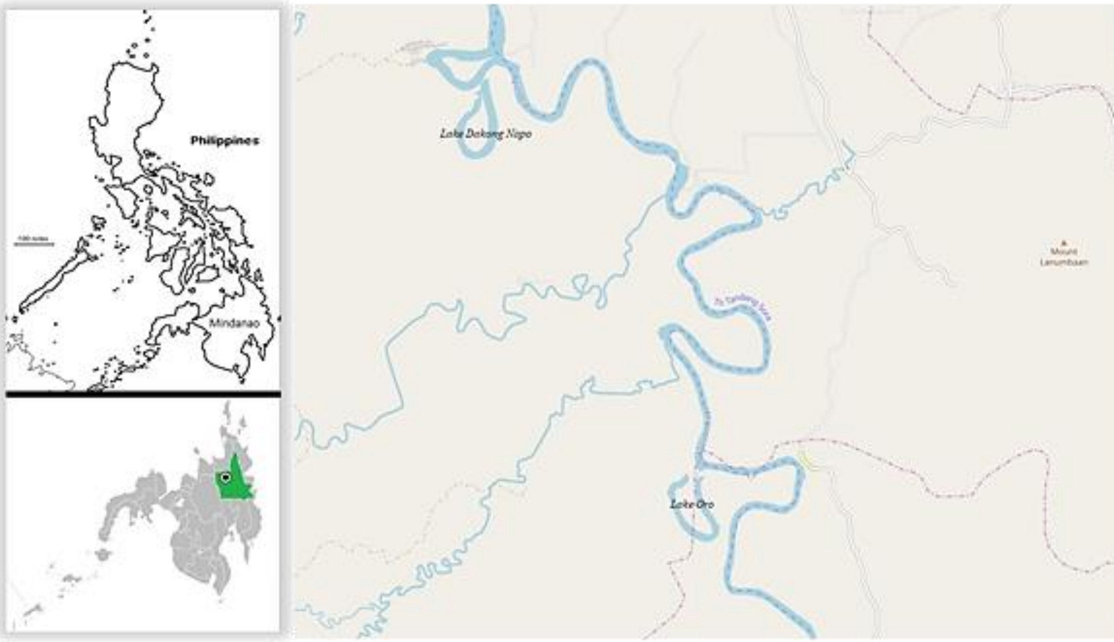

Figure 1. Map showing the locations of Esperanza, Agusan del Sur in Mindanao, Philippines and the location of the two sampling stations.

Fish Collection and Processing: Fish samples were collected or purchased on site from local fishermen operating in Lake Oro and Dakong Napo on September to October, 2017. Multiple fishing gears were used such as hook and line, lift net and cast net. Fish samples were then blot-dried to remove excess water. Total length was taken from the tip of snout to the caudal fin end in cm using tape measure and weight was taken in gram using a digital scale. Fish samples were also counted and identified up to its lowest possible taxon using the identification key guides and checklist of Bucol and Carumbana (2010), and Conlu (1986). Fish Base (Froese and Pauly 2018) was used to checked other fish descriptions.

Data Analysis: The data collected were statistically analysed using PAST to obtain biodiversity indices such as Dominance index (D), Shannon-Weiner index (H`) and Evenness index (e^H/S). Fish density was calculated using the formula of Labatos and Briones (2014):

$$d = \text{number of individual species} / 10\ m^2$$

LWR of fish was estimated from the equation: $W=aL^b$ (Pauly, 1984). The relationship was transformed into a linear form using the logarithm equation: LogW=a + bLogL. Where, W = weight of fish (g), L = standard length of fish (cm), a= regression constant and b = the allometric coefficient. When the parameter 'b' is equal to 3, the growth is called isometric; the growth is positive allometric when the 'b' value is more than 3; and negative allometric when the 'b' value is less than 3 (Dutta et al. 2012).

Results

A total of 295 individuals belonging to 12 species from nine families were collected during the sampling period in the two lakes of Esperanza, Agusan del Sur. Figure 2 shows the percent composition of fish family collected in the two lakes. Among these nine families, Osphronemidae comprises the largest group (25%) represented by three species (*Trichogaster trichopterus, T. pectoralis* and *Osphronemus goramy*), followed by Gobiidae (17%) with two species (*Glossogobius celebius* and *G. giuris*). Other fish families include Anabantidae (*Anabas testudineus*), Chaniidae (*Channa striata*), Cichlidae (*Oreochromis niloticus*), Clariidae (*Clarias batrachus*), Cyprinidae (*Cyprinus carpio*), Loricariidae (*Pterygoplichthys disjunctivus*) and Mugilidae (*Paramugil parmatus*) which are all represented by a single species. In addition, nine of the collected species were introduced (75%)

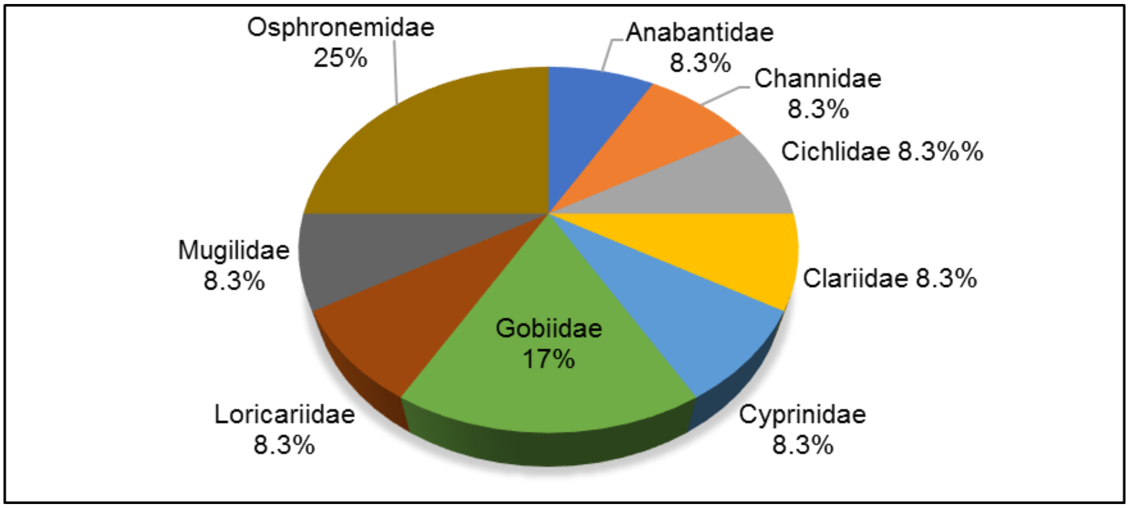

Figure 2. Family composition of fish fauna in the two lakes of Esperanza, Agusan del Sur, Philippines.

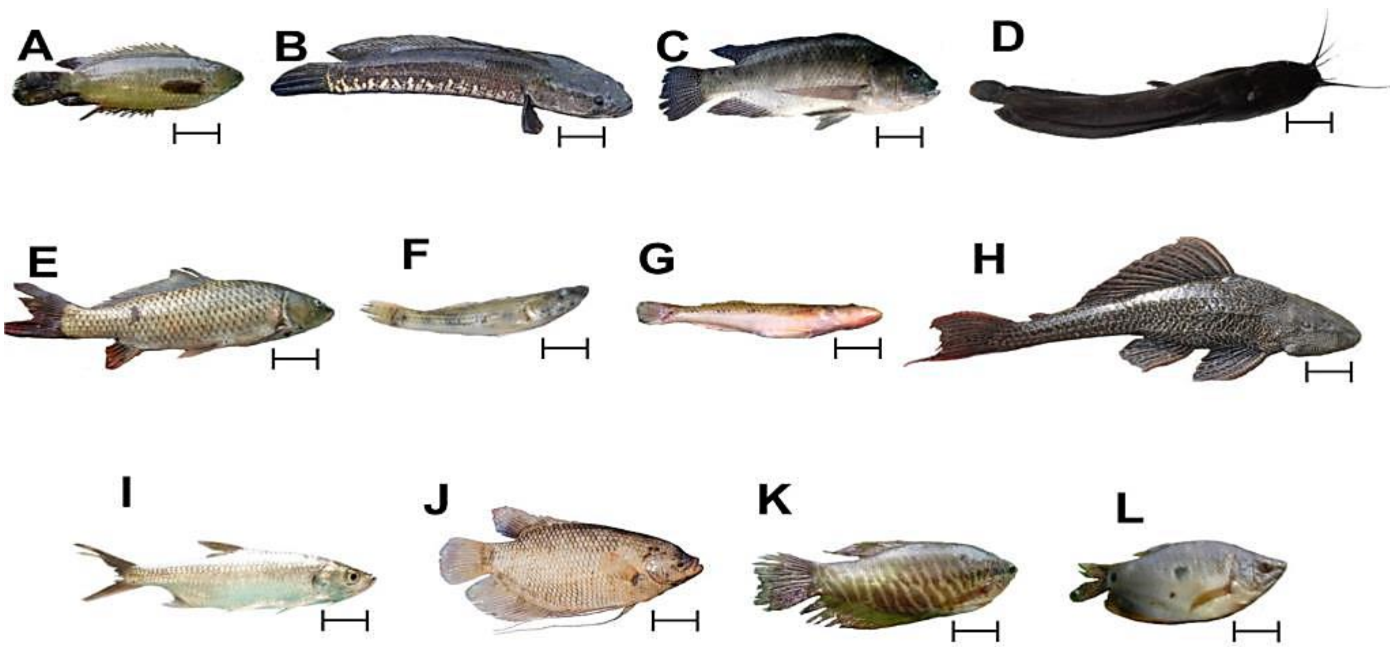

Figure 3. Representative of the 12 fish species collected in the two lakes of Esperanza, Agusan del Sur, Philippines. (A) *Anabas testudineus,* (B) *Channa striata,* (C) *Oreochromis niloticus,* (D) *Clarias batrachus,* (E) *Cyprinus carpio,* (F) *Glossogobius celebius,* (G) *Glossogobius giuris,* (H) *Pterygoplichthys disjunctivus,* (I) *Paramugil parmatus,* (J) *Osphronemus goramy,* (K) *Trichopodus pectoralis,* and (L) *Trichopodus trichopterus.* Scale bar = 2 cm.

in freshwater bodies of the Philippines, including *T. trichopterus, T. pectoralis, O. goramy, A. testudineus, C. striata, O. niloticus, C. batrachus, C. carpio,* and *P. disjunctivus* (Fig. 3). These introduced species dominated the native species (*G. celebius, G. giuris* and *P. parmatus*) which comprises only 25% of the total fish population in the areas (Fig. 4). Currently, two introduced species for culture that became invasive are found in the two lakes of Esperanza: *C. striata* and *C. batrachus.* Another invasive alien species (IAS) being recorded in the areas is the *P. disjunctivus.*

There were 10 fish species found in Lake Oro and only seven species in Lake Dakong Napo. While fish population in Lake Oro is higher than Lake Dakong Napo, it has lesser H’ as it was confounded by lower evenness value (Table 1).

Table 1. Biodiversity indices of fish species collected in the two lakes of Esperanza, Agusan del Sur, Philippines.

	Lake Dakong Napo	Lake Oro
Taxa_S	7	10
Individuals	118	177
Dominance_D	0.2975	0.3749
Simpson_1-D	0.7025	0.6251
Shannon_H	1.501	1.391
Evenness_e^H/S	0.641	0.402

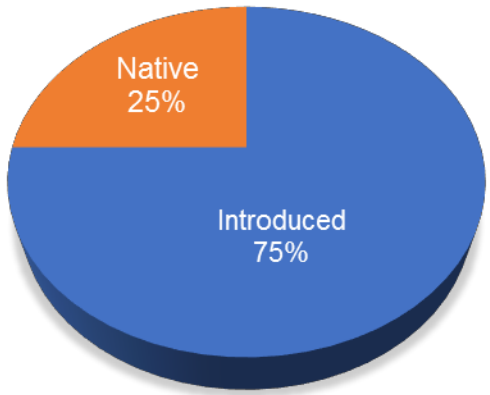

Figure 4. Precent distribution status of fish species collected in the two lakes of Esperanza, Agusan del Sur, Philippines.

Data concerning maximum and minimum length and weight of the 12 species and the parameters a and b of length-weight relationships (LWR) of *A. testudineus*, *O. niloticus*, *C. carpio*, *T. pectoralis* and *O. goramy* were summarized in Table 2. Species of fish of the two lakes showed variations in sizes ranging from 7 cm (*G. celebius*) to 59 cm (*C. striata*) and weight ranging from 19.3 g (*T. trichopterus*) to 960.5 g (*P. disjunctivus*). Of the five species where LWR was obtained, four (*A. testudineus*, *C. carpio*, *T. pectoralis* and *O. goramy*) exhibit negative allometric growth (b<3) while *O. niloticus* has positive allometric growth with the value of the exponent b = 3.1382.

Discussion

The result of the current study with regards to family composition concurs with the result of Jumawan and Seronay (2017) who also collected the same families in the eight flood plain lakes of Agusan Marsh. These imply that these nine families are the most commonly caught in the lakes of Agusan del Sur, Philippines. However, the number of species collected of the current study is lower compared to the latter.

Most of the collected species in the two lakes of Esperanza, Agusan del Sur, Philippines were introduced and considered Invasive Alien Species (IAS) in the country. Several authors obtained similar results that introduced species dominated in the freshwater bodies of the country (Escote and Jumawan 2017; Jumawan and Seronay 2017; Briones et al. 2016; Ismail et al. 2014). As early as 1905-1988, 34 freshwater fishes have already introduced in the country for different purposes (Juliano et al. 1989), resulting for the well-establishment of these ichthyofauna in the country's freshwater bodies. Guerrero (2014) reported that out of 28 species introduced for aquaculture, 24 have been beneficial and four became invasive. Introduction is the key reason pointed by some authors for the loss of some endemic and native fish species (Juliano et al. 1989; Escudero 1993 in Guerrero 2014; Ismail et al. 2014).

Table 2. Length-Weight relationship of fishes in the two lakes of Esperanza, Agusan del Sur, Philippines.

Family	Species	n	Length Range	Weight	a	b	r²	Status
Anabantidae	*Anabas testudineus* [a b]	18	13.4-19.2	40-60.4	0.0501	2.5331	0.8029	Introduced
Channidae	*Channa striata* [a b]	5	25-59	151-783.2	-	-	-	Introduced
Cichlidae	*Oreochromis niloticus* [a b]	92	11.4-36.1	29-760.1	0.0109	3.1382	0.9545	Introduced
Clariidae	*Clarias batrachus* [b]	1	31	325	-	-	-	Introduced
Cyprinidae	*Cyprinus carpio* [a b]	124	11.4-27.4	30.2-296.1	0.0208	2.9196	0.924	Introduced
Gobiidae	*Glossogobius celebius* [b]	4	7-11.4	10.1-20.1	-	-	-	Native
	Glossogobius giuris [b]	4	11.4-14	20.1-30	-	-	-	Native
Loricariidae	*Pterygoplichthys disjunctivus* [b]	5	37.5-44	600-960.5	-	-	-	Introduced
Mugilidae	*Paramugil parmatus* [b]	2	9.5-12	20-26.3	-	-	-	Native
Osphronemidae	*Osphronemus goramy* [a]	14	12.1-18.2	27.2-70.1	0.0433	2.5341	0.8986	Introduced
	Trichopodus pectoralis [a b]	23	18.5-23.8	49.4-84.2	0.0806	2.6671	0.9086	Introduced
	Trichopodus trichopterus [a]	3	11.2-12.1	19.3-30	-	-	-	Introduced

[a] Collected in Lake Dakong Napo; [b] Collected in Lake Oro

The dominance of introduced species could pose many dangers to the aquatic habitat (Jumawan and Seronay, 2017). The spread of IAS could be a serious threat to local biodiversity as they could be a predator and competitor for food and space, hence, displacing the native and endemic fish species. On the other hand, aside from the negative impact that these invasive alien species brings to the native species, it could also affect the socio-economic status of the community, for it fed on the juveniles of the economically important fish species, and destructing fishing gears of local fishermen (Hubilla et al. 2007). There is a need for both decision makers and locals of the area to have initiatives and take serious actions for the occurrence of these IAS particularly on *P. disjunctivus* in the area.

Nevertheless, some of the introduced species such as *C. striata*, *O. niloticus*, *C. batrachus* and *C. carpio* are important sources of protein and have been utilized as major part of the diets of the residents surrounding the lakes. Some of the economically important fishes found in the area are *C. carpio* which is highly abundant in Lake Oro (d=9.8/10 m^2) and *O. niloticus* in Lake Dakong Napo (d=5.6/10 m^2) (Fig. 5). Other species with economic value (Guererro 2014) includes *C. striata*, *C. batrachus* and *Trichopterus* spp. These species were caught and consume, if not, sold by local fishermen in the nearby community.

Diversity indices of the two studied lakes yielded almost the same value with Visto et al. (2014) in their study of ichthyofauna diversity in Bega Watershed, considering this as low diversity index. Lake Oro has an evenness of 0.402 which is far from 1, implying for an uneven distribution of fishes in the area. According to Kumar et al. (2014), evenness value closer to 1 such as in Lake Dakong Napo (S = 0.641) indicates that each species consists of the same number of individuals, however if the value is close to zero, it indicates that most of the individual belongs to one or a few species such as in the case of Oro Lake given that only two species (*O. niloticus* and *C. carpio*) dominated the area in which the number of individuals are noticeably higher compared to other species in the lake.

Low diversity index (H`) was recorded in the two lakes. The low number of fish species in the two lakes could be attributed to different factors such as most of the collected species were introduced that possibly displaced native and endemic fish species. Human activities are also proliferating in the area especially in the uplands which are currently utilized for various agricultural practices. Another reason is that overfishing possibly happened in Lake Dakong Napo. According to the local folks in an informal interview, fishermen from neighboring communities also come, hence, further increasing fishing effort in the lake. The local government

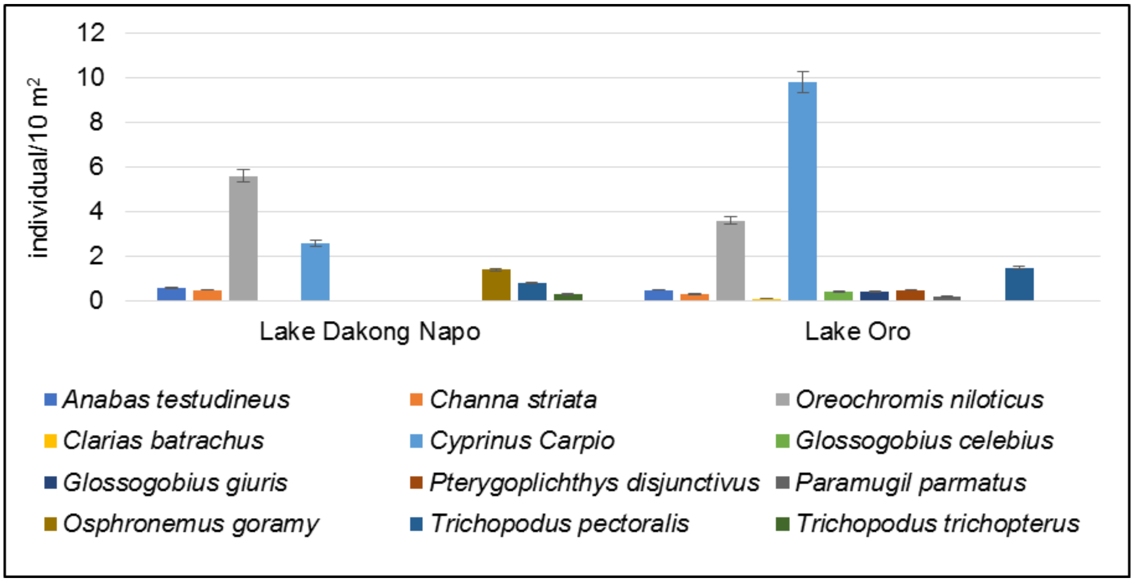

Figure 5. Species abundance of fishes in the two lakes of Esperanza, Agusan del Sur, Philippines.

of Esperanza have regulated fishing activities such as prohibiting the use of small-eyed fishing nets in the area.

The results for the positive allometric growth of *O. niloticus* and negative allometric growth of *A. testudineus* and *T. pectoralis* concurs with the result of Jumawan and Seronay (2017), however, the result of the present study for *C. carpio* and *O. goramy* is in contrast with the result of them. The length-weight relationship is important since it can provide valuable information on the habitat where the fish lives (Pauly 1993), modeling aquatic ecosystems (Kulbicki et al. 2005) and of fish stocks (King 2007). The collected fish species of the two lakes exhibited negative and positive allometric growth pattern based on the analysis of the length-weight relationship. This means that the fishes do not grow symmetrically or it becomes thinner with increasing length (Tesh 1968; King 1996). Various factors could contribute to the differences on the growth of fish, these includes the habitat, fish activities, food habits, seasonal and growth rates (Lowe-McConnell 1987; Mizuno and Furtado 1982 in Isa et al. 2010), temperature, trophic level and food availability in the community (Isa et al. 2010). The present study provides pioneering data with regards to the current condition of fish fauna in the Oro and Dakong Napo lakes. Hence, study in a longer period of time with seasonal variation, including physico-chemical parameters of water, sex of fishes and its ecology is suggested better assess the status of fish population in these areas.

Conclusion

The present study provided knowledge about the fish population of Lake Oro and Lake Dakong Napo. A total of 12 fish species can be found in the area, mostly were introduced in the Philippines. Most of the fishes had allometric growth pattern, thus, long-term studies on fish biology in these areas is highly recommended for better understanding on factors that influenced the growth of its fish fauna.

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