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Length-Weight Relationship (LWR) of *Glossogobius giuris*, *Hypseleotris agilis*, *Oreochromis niloticus* and *Cyprinus carpio* of Lake Mainit, Jabonga, Northeastern Mindanao

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Abstract

The length- weight relationship (LWR) parameters of fish are the primary variables used to evaluate the growth pattern of fish. One thousand three hundred twenty-one (1,321) fish individuals were collected from Lake Mainit from the period of November 4 to December 20, 2018. Species obtained were belonged to 4 families with only one species per family and half are native and introduced to the country. LWR was computed using the equation $W=aL^b$, the value of "*b*" in length and weight relationship ranged from 2.476 – 2.830 lower than the Bayesian estimates. The results revealed that *Cyprinus carpio* exhibited isometric growth (3.045), *Hypseleotris agilis* (2.952) negative in growth and *Glossogobius giuris* (3.451) showed positively allometric growth dimensions that are in contrast to the Bayesian estimates. Only the negatively allometric growth patterns of *Oreochromis niloticus* (2.958) exhibited almost the same values in Bayesian estimates (2.93- 3.01). The results of this study could be used as a valuable tool for fishermen and improve fish stocks for the continuous supply to the community of important fish.

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Introduction

Lake Mainit, the fourth largest lake in the Philippines, is geographically shared resources of the provinces of Agusan del Norte and Surigao del Norte in Northeastern Mindanao, flanked by eight municipalities that comprise the Lake Mainit Watershed (LMDA, 2005). It is likewise the deepest with a maximum depth of about 223 m and a mean depth of about 128 m and one of the cleanest lakes in the Philippines, making it as a standout amongst the most beneficial lakes in the nation ranking just third to Laguna de Bay (Balayut, 1983). The lake is a part of the Key Biodiversity Area (KBA) within the Eastern Mindanao Biodiversity Corridor (EMBC) (Demetillo *et al.*, 2015) and is known in the locale for its high diversity of aquatic fauna and a flourishing freshwater fishery (Pauly *et al.*, 1990; Galicia and Lopez, 2000) especially of economically important fishes. Around 31 barangays in the four-lakeshore municipalities are dependent on the lake for food and livelihood (Jumawan *et al.*, 2016).

Fish assumes a critical role in the development of a country. Aside from being a cheap source of exceedingly nutritive protein, it likewise contains other essential nutrients required by the body (Bolarinwa and Popoola, 2013). Moreover, various freshwater fishes fill in as natural indicators and may work as a potential organism in describing ecological condition. Since fishes assume a fundamental role in the state of aquatic biological communities, it is equally important to determine the length- weight relationship and condition factor on the selected sites (Jumawan *et al.*, 2016).

The investigation of length-weight relationship (LWR), condition factor, growth, recruitment and mortality of fishes are important tools and have a noteworthy role in fishery biology (as referred to by Anani and Nunoo, 2016) in light of the fact that they permit interrelated estimation of normal weight of fish of a given length group, change of length growth condition to weight equal (i.e., length at age to weight age) in yield per- recruit and related modes, inter specific and inter population morphometric correlation of fish species and assessing the relative prosperity and natural surroundings of fish populace (Beyer, 1987; Bolger and Connoly, 1989; Pauly, 1993; Bolarinwa and Popoola, 2013). Inadequately conditioned fishes are related with negative allometric growth, which suggests that fish turns out to be slimmer as it increments in weight while fishes with proper condition factor have isometric growth, which infers that the fish turns out to be moderately more profound bodied as it increments length. The condition factor of fish can be influenced by various elements (i.e., stress, sex, season, accessibility of feeds and water quality (Khallaf *et al.,* 2003; Anani and Nunoo, 2016).

Lake Mainit bolsters a high diversity of aquatic fauna and a flourishing freshwater fishery especially of economically important fishes (Galicia and Lopez, 2000; SFM Program, 2009). Two species of goby, the pijanga (*Glossogobius giuris*) and bugwan (*Hypseleotris agilis*), are important native species of the lake, and still occurs but in much reduced abundance than around late 1990s (Galicia and Lopez, 2000).

The introduced tilapia is also abundant in the Lake, together with other common fishes such as carpa (*Cyprinus carpio*), and hayuan (*Channa striata*). Then again, the lake also faces threats of overfishing and habitat degradation because of contamination from agriculture and mining and damaging fishing practices (i.e., fine-meshed nets, electric fishing, and the utilization of synthetic substances or toxic substances) that have decreased the aquatic biodiversity of the lake (LMDA, 2005).

Unsustainable aquaculture practices, for example, introduction of exotic species into the lake, have additionally debilitated a number of rare and endemic species of fish resulting to biodiversity freshwater biological community a critical. It is therefore the interest of the study to assess the species composition and LWRs of some economically fishes, as it becomes a tool to estimate standing stock biomass and yield numerous fishery assessment studies (Goncalves *et al.*, 1997; Escote and Jumawan, 2017). Henceforth,

this will be helpful in decision making on utilization, management and conservation of the resources in the lake. The aimed and objectives of the study are the following: (1) obtained total length of *Glossogobius giuris, Hypseleotris agilis, Oreochromis niloticus* and *Cyprinus carpio*: (2) obtained body weight of *Glossogobius giuris, Hypseleotris agilis, Oreochromis niloticus and Cyprinus carpio*; and, (3) determined the relationship of the total length and body weight of *Glossogobius giuris, Hypseleotris agilis, Oreochromis niloticus and Cyprinus carpio*.

Materials and methods

Description of the study sites

The study was conducted in the Lake Mainit with geographic coordinates 9º 28' N and 125º 31' E in northeastern Mindanao with a surface area of 17, 060 hectares, a shoreline 62.1 km long, and a watershed area of 87, 072 hectares. Twenty- eight river tributaries contribute to the water volume, which is drained by a single outlet- the 29 km Kalinawan River that flows into Butuan City (LMDA, 2005; SFM Program, 2009) Fig. 1.

Fig 1. (A) Map of the Mindanao (upper right panel) and location of Lake Mainit within, indicated by yellow circle. (B) The bottom left panel shows Lake Mainit Watershed, found in the northeast Mindanao, is represented by the different municipalities (yellow arrows) and the star panel (in Jabonga) represents the specific study area (Photo by LMDA, 2005 and SFM Program, 2009).

Collection of samples

Sampling of fishes covered November 4 to December 20, 2018. Samples were either caught by resident fishermen partners together or purchased from the local community fish buyers. Information on the study stations, fish common and scientific name (to be checked in Fishbase.org), total length (cm) and body weight were recorded. Following capture or purchase on site, fishes were measured and sorted according to species. Sex of these species was not determined. Total length (TL) was obtained with a measuring board, tape measure, ruler or a vernier caliper, depending on the length of the fish. Body weights of specimens were measured using a digital weighing scale after blot- drying excess water (Froese and Pauly, 2006; Escote and Jumawan, 2017).

Length- Weight Relationship (LWR)

The fishes were expressed by the equation $W = aL^b$, where W is the total body weight, "a" as the regression intercept, 'L' as the total length and 'b' as the regression coefficient (Froese, 2006).

SPSS software version 15 was used for statistical analysis. The expression of the relationship is represented by the following equation: $\text{Log } W = b \log L + \log a$.

The "a" and "b" for the LWR values were obtained from liner regression of the log- transformed L and W of fish with "W" as the dependent variable. The coefficient of determination (r^2) of the LWR was computed. The "b" is an exponent with a value between 2.5 and 3.5 to describe typical growth dimensions of relative being of the fish samples (Bagenal, 1978). Transformations were made using the natural logarithm of the observed lengths (TLs) and weights (Jumawan and Seronay, 2017).

Results and discussions

A total of 1,321 fish individuals comprising of 4 species (Fig. 2) representing 4 families were collected during the duration of the sampling period and analyzed. Table 1 summarizes the data concerning sample size, minimum and maximum length and weight for each species, the parameters LWR with confidence level of 95%, and for comparison Bayesian estimates were included as well as growth of the samples whether isometric (I), positive allometric (A+) or negative allometric (A-), status of sample species were included whether they are native or introduced in the freshwater ecosystem in the Philippines. Fish species documented in this study were limited to the availability of the partner fishermen.

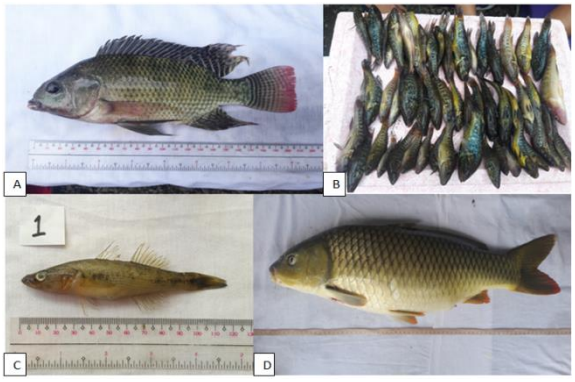

Fig 2. Economically fishes recorded in the Lake Mainit. (A) *Oreochromis niloticus*, (B) *Hypseleotris agilis,* (C) *Glossogobius giuris*, (D) *Cyprinus carpio*.

Glossogobius giuris (Pijanga) had a range of 9.3-27.5cm, which is on the same size range of 2.5-30.5cm on the study of Galicia and Lopez (2000), and 5.7- 24.2cm of De Guzman (2008), Specimens of *Hypseleotris agilis* (Bugwan) had a size range of 6.5-14.5cm, again on the same size range of 4.0- 18.5cm on the study of Galicia and Lopez (2000), and 5.5-13.2cm of De Guzman (2008).

The sample size of fishes ranged from 14 individuals for *C. carpio* to 765 individuals for *H. agilis*. The r^2 values ranged from 0.785 for *C. carpio* to 0.959 for *O. niloticus*. All regressions were highly significant (<0.001). The *b* values ranged from 2.92 for *C. carpio* to 3.38 for *H. agilis*. Carlander, 1969, pointed out that the coefficient *b* in the LWR of fishes usually ranged from 2.5 to 3.5.

In this study, 100% of species evaluated had the values beyond this range. One species showed isometric growth, two negatively growth and one positively allometric growth. Three species were noted to have relatively different mean growth dimensions compared to their Bayesian length-weight estimates (Froese *et al.*, 2014; Jumawan and Seronay, 2017).

Cyprinus carpio exhibited isometric (3.045) growths that are similar to the values (3.015) recorded by Jumawan and Seronay (2017) in the eight floodplain lakes of Agusan Marsh while *H. agilis* (2.952) negative in growth and *G. giuris* (3.451) showed positively allometric growth dimensions that are in contrast to the findings of Jumawan and Seronay (2017). In addition, the results of the study are in contrast to the negative allometric growth Bayesian estimates for *C. carpio* (2.92- 2.96), positively allometric for *Hypseleotris agilis* (3.00- 3.38) and isometric allometric growth estimates for *G. giuris* (3.03- 3.11) (Froese *et al.*, 2014; Jumawan and Seronay, 2017).

These negatively allometric results suggest that sample fish species tend to become thinner as they grow larger (Samat *et al.*, 2008; Escote and Jumawan, 2017) and weight increases at a lesser rate than the cube of the body length (Adeyemi *et al.*, 2009; Escote and Jumawan, 2017). Season, food availability, population, sex, environmental conditions (Fontoura *et al.*, 2010; Escote and Jumawan, 2017), feeding and reproductive phenomena (Idodo- Umeh, 2005; Escote and Jumawan 2017) are some of the contributory factors that can affect the growth pattern of the fishes.

Table 1. Length and Weight Relationship of some economic fishes of Lake Mainit, Jabonga, Mindanao, Philippines.

Family, Species and Local Name	n	Total Length Range (cm)	Body Weight Range (g)	b	Bayesian Estimates (95% Cl)	r^2	Growth	Status
Gobiidae *Glossogobius giuris* Pijanga	380	9.3- 27.5	7- 230	3.451	3.07 (3.03- 3.11)	0.848	A+	Native
Eleotridae *Hypseleotris agilis* Bugwan	765	6.5- 14.5	1- 47	2.952	3.19 (3.00- 3.38)	0.922	A-	Native
Cichlidae *Oreochromis niloticus* Tilapia	162	3.5- 26.0	1- 350	2.958	2.97 (2.93- 3.01)	0.959	A-	Introduced
Cyprinidae *Cyprinus carpio* Carpa	14	35.0- 68.0	380- 3750	3.045	2.94 (2.92- 2.96)	0.785	I	Introduced

n: sample size; b: allometric growth coefficient; Cl: confidence limits; r^2: determination coefficient; I: isometric growth; A+: positive allometric growth; A-: negative allometric growth

Oreochromis niloticus (2.958) negative allometric growth patterns showed nearly the same values in Bayesian estimates (2.93- 3.01). It was known that fish tilapia could tolerate various environmental conditions (Chervinski, 1982; Jumawan *et al*., 2016), such as farm runoff (Mpho *et al*., 2000; Velichovic, 2004), which implies that it can survive in stressful environments (Jumawan *et al*., 2016). In addition, some introduced fishes like *O. niloticus* and *C. carpio* has high tolerance compared to native, *H. agilis* and *G. giuris*, that gave them the advantage of reproduction and proliferation, consequently in the study of Jumawan and Seronay (2017) in Agusan Marsh and Escote and Jumawan (2017) in Sta. Ana Dam Nabunturan showed that introduced species has dominated the areas. These two introduced species are believed to increase and affect other beneficial species and fishing catches.

The present results indicate that both *H. agilis* and *G. giuris* are generally smaller now than in the 1990s. Large proportion of mature or spawning individuals of *H. agilis* was observed between November and February, while in *G. giuris* occurred between January and April. Results of gonadal maturity agree with those of Galicia & Lopez (2000) that spawning in both species occurs throughout the year, but defined peaks were observed during which spawning would be more pronounced. Seox ratios in both species favor the females, while length-weight relationships indicate that both gobies exhibit a positive allometric growth (i.e. increase in weight is faster than length) (De Guzman, 2008).

Conclusions

This study showed that the length- weight relationships of the three fishes in Lake Mainit did not fall within the expected ranges of Bayesian estimates. However, it coincides with the results of the other studies; thus, it provides information on the condition of the fish in relation to its internal and external surroundings.

Recommendations

Further research on the length- weight relationship of certain economic fish in Lake Mainit during the wet and dry season is recommended to broaden the key information on other species biology and growth factors. In addition, the environment, habitat structures, sexes identification and catch gears also need to be considered as factors that can influence growth patterns.

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