Uttar Pradesh Journal of Zoology

Volume 45, Issue 16, Page 173-188, 2024; Article no.UPJOZ.3783
ISSN: 0256-971X (P)

An Assessment of Some Meristic and Metric Characteristics and Biological Indices of the Introduced Largemouth Bass *(Micropterus salmoides)* in Pantabangan Reservior, Nueva Ecija, Philippines

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i164298

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/3783

Original Research Article

Received: 14/05/2024
Accepted: 17/07/2024
Published: 27/07/2024

ABSTRACT

The study was conducted to characterize the invasive largemouth bass in Pantabangan Reservoir, Nueva Ecija in terms of meristic, metric and some biological indices. This study aimed to provide critical information on the size composition, length and weight relationship, body condition, sex ratio, stomach fullness and content, and other biological indices. Samples of largemouth bass were collected through the aid of commissioned fishers and subjected to meristic and biometric

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Cite as: *Mendoza, Gerondina C., and Erriz Gio R. Vigilia. 2024. "An Assessment of Some Meristic and Metric Characteristics and Biological Indices of the Introduced Largemouth Bass (Micropterus Salmoides) in Pantabangan Reservior, Nueva Ecija, Philippines". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (16):173-88. https://doi.org/10.56557/upjoz/2024/v45i164298.*

assessments. The data were consolidated and analyzed using descriptive statistics and simple linear regression. Results revealed some similarities with previous studies in terms of dorsal spine and rays and lateral line scales. Also, the biometric characteristics were found to be within the commonly reported range. The established model for the length and weight of fish showed high level of significance (p<0.01). As to condition factor, the range of the computed value of fish is 2.08 to 6.50 with a mean of 3.77. The range of hepatosomatic index of the fish is 0.1142 to 2.4623 with a mean of 1.0390 while gastrosomatic index recorded a range of 0.9132 to 6.8376 with a mean of 3.8560. Analysis of stomach content and food indices revealed that majority (61.00%) of fish samples exhibited empty stomachs. Furthermore, analysis of food items showed that the IRI percentage of fish is 88.96% while plant materials are negligible with IRI percentage of <10%. The obtained information showed some characteristics of the introduced fish; however, further assessment is imperative to have better insight of its status in the area.

Keywords: condition factor; sex ratio; gonad maturation; stomach content.

1. INTRODUCTION

The largemouth bass (*Micropterus salmoides*) is a carnivorous freshwater species from the family Centrarchidae, which is native to cold-water regions, specifically to the central and eastern United States and northern regions of Mexico [1]. The species occupies wide habitat spectra but preferred to inhabit clear, vegetated lakes, ponds, swamps, creeks and rivers [2]. It is regarded as one of the most highly-valued game fish in the world. Hence, the fish was introduced in 50 countries for sport fishing purposes [3]; however, because of its predatory and adaptative capacity the fish has been considered as one of the world’s worst invasive species nowadays [1]. In the Philippines, reports indicated that the fish can be found in major lakes and reservoirs such as Lumot and Caliraya (in the province of Laguna), and Pantabangan (in the province of Nueva Ecija) [4]. Although regarded as an invasive species threatening native fishes in Pantabangan Reservoir, the species became part of the local capture fisheries and provides some economic contributions. It has been reported that the fish provides food and livelihood in the fishing communities surrounding the Pantabangan Reservoir [5]. However, they have suggested that dissemination of information regarding its status is imperative, as well as the identification of interventions to be applied in order to control its proliferation and reduce its impact on the reservoir’s biodiversity. Assessment of invasive fish population has great preponderance on the part of fishery managers to maximize their knowledge in crafting policies and programs to efficiently and sustainably manage a certain resource. Moreover, comprehensive assessment provides better view on the relative condition of aquatic environments, which is critical for management and conservation [6]. Among the most often-cited gaps in crafting and implementing management measures is the absence of biological data, particularly at the level of species. Qualitative and quantitative assessments of invasive fish populations are vital to determine their potential impacts in an ecosystem, as well as their possible influence on the socio-economic well-being of fishing community [7].

The meristic and metric characters of fish provide quantitative description for the identification of fish and are considered dynamic elements commonly used to differentiate populations of the same species [8]. Moreover, these indicate the development pattern, habitat conditions, overall health, adaptive mechanisms, feeding behavior, growth, reproductive pattern, size range and life history of a fish [9]. The use of biological indices such as length-weight relationship analysis and examination of condition factor determines the growth pattern and body fitness of the species, as well as the interaction between biotic and abiotic factors in the feeding and physiological conditions of the fish [10-14]. These indices are widely used to understand the dynamics of the existence and growth of native [15] and introduced fish species [16]. Meanwhile, information on the diet and food habits of an invasive species are vital to estimate the threat to native populations [17]. Thus, analysis of stomach content and related indices could also be incorporated into a variety of research objectives, particularly on many aspects of fish biology and ecology [18]. At present, information on some biological aspects of largemouth bass in Pantabangan Reservoir is lacking. Hence, this study was conducted.

2. MATERIALS AND METHODS

2.1 Location of the Study

The study was conducted at the Pantbangan Reservoir, Pantabangan, Nueva Ecija, Ecija Philippines (Lat 15° 50' 32" N, Long 121° 9' 3" E). The reservoir is situated at 230 m above sea level, has a surface area of 8900 ha and a maximum depth of 28.9 m [19]. The catchment supplying water to the reservoir covers 853 km^2 and is located in the townships of Pantabangan and Carangalan (Nueva Ecija), Alfonso Cataneda and Dupax del Sur (Nueva Vizcaya), and Maria Aurora (Aurora) [20]. Agriculture is the main source of livelihood in the catchment [9]. Largemouth bass become a source of staple food and livelihood which accommodates the basic needs of fisherfolks within the reservoir [5].

2.2 Collection and Transport of Samples

Samples were collected through the aid of commissioned fishers operating in Pantabangan Reservoir from December 20, 2023 to February 30, 2024. These commissioned fishers use gillnets, hook and line, and spearguns in capturing the resource. Information available on Fish Base was used to verify the collected fish. The samples (100 pieces of different sizes) were transported to the laboratory in chilled condition to prevent enzymatic degradation that will affect the quality of the target organs for morphometric and gravimetric measurements.

2.3 Meristic and Metric Measurements

In terms of meristic properties, the number of dorsal spines, dorsal rays and lateral scales were included. These properties were counted manually. Meanwhile, metric properties such as total length (TL), body depth (BD), head length (HL) and eye orbital length (EOL) (Fig. 1) were measured using a foot rule and expressed to the nearest 0.1 cm. Lastly, gravimetric measurement was done using a digital weighing balance with a sensitivity of 0.1 g. Gravimetric properties include total weight, gonad weight, liver weight and gut weight. To obtain the target internal tissues, the specimens were dissected using sterile blades. The stomach of the fish was removed and stored in freezing condition until further analysis.

2.4 Sex Differentiation

The samples were determined whether male or female. The gonad of the fish was taken and identified based on its morphological characters and with the aid of a microscope if the gonad in the development phase. The gonad maturity was based on an available publication for largemouth bass and classified as developing, recovering, maturing, mature and spent. The data obtained was used to determine the sex ratio and gonad stages. However, samples that are not recognizable as male or female were marked as undifferentiated and the count was included in determining sex ratio.

2.5 Determination of Stomach Fullness and Content

Prior to the processing of stomach, the specimen was thawed at room temperature. About 10% of the total stomachs were subjected to the analysis. To reveal the food items of the fish, the stomach was dissected. Each unique item was separated and mounted into a Petri dish. Identification was aided with a magnifying glass. After identification, each food item from the stomach was weighed and the data was used for different feeding indices.

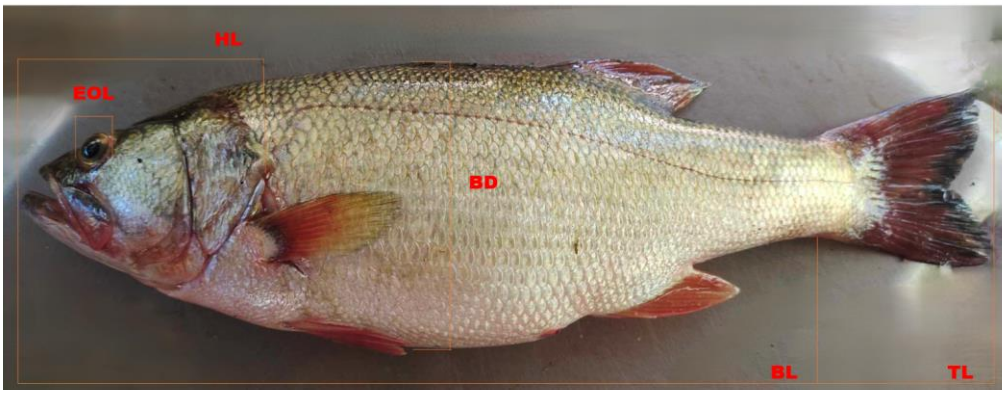

Fig. 1. The metric characteristics of fish

2.6 Computation of Biological Indices

The total length and total weight of individuals was used to ascertain the length-weight relationship with an equation of: $W= aL^b$ where W = weight (g), L = length (cm, a = constant/intercept, and b = growth exponent. Furthermore, the equation was converted into linear function by taking the logarithm of both sides, and thus will give: log W = log a + b log L. Meanwhile, the growth pattern was determined by comparing the obtained growth exponent to the isometric value (b=3) using the modified t-test [21]. The condition factor on the other hand was computed using the method proposed by Bagenal & Tesch [22]: $K_a = 100\ W/L^b$ where W=weight, L = length, b = growth coefficient and K_a = condition factor.

Concerning gonado-somatic index, the equation was used [23]: GSI = GoW/GW*100 where GoW = gonad weight and GW = gutted weight. The hepato-somatic index was estimated using HSI = LW/TW*100 where LW = liver weight and BW = Total weight of fish [24]. In terms of gastrosomatic index, the equation was used: GaSI = SW/TW*100 where SW = stomach weight and TW = total weight.

With regard to the measurement of fullness index, the equation was used: FI = SCW x 10,000/TW where SCW = weight of stomach contents and TW = total weight of fish. The vacuity index was calculated following the formula [25,26]: VI = NES/TNS*100 where NES = number of empty stomachs and TNS = total number of stomachs analyzed. The occurrence index was expressed as: OI = Nei/Net*100 where Nei = the number of stomachs containing the food item (i) and Net = number of full stomachs examined [27]. The numerical index of abundance was expressed as: NI = Ni/Nt*100 where Ni = total number of individuals of item i and Nt = total number of all food items [28,29]. The percentage of food item weight was estimated using the formula: WI = Wi/Wfi*100 where Wi = total weight of item i and Wfi = total weight of all food items inventoried [30]. The diet of the fish was determined using the index of relative importance [31]. This index combines the occurrence (OI), numerical (NI) and weight (WI) percentages obtained: IRI = OI x (NI + WI). The percentage of IRI of each food item has been expressed by the equation [32,33]: IRI% = (IRI / Σ IRI) × 100. If the computed IRI is <10, the food item was considered to be negligible in the diet.

2.7 Data Treatment and Analysis

The data obtained was subjected to the analysis using descriptive statistics such as minimum and maximum values, mean, standard error and standard deviation. The relationship of the length and weight was analyzed using simple linear regression and the strength of this relationship was determined using correlation analysis.

3. RESULTS AND DISCUSSION

3.1 Meristic and Metric Characteristics

Table 1 shows the recorded values of meristic, and metric characteristics of the fish. The study on metric and meristic characters in fishes is important because they can be used for the differentiation of taxonomic units and are able to spot differences between fish population [34]. Meristic features in fish are countable structures. Morphometrics are measurable characteristics related to length, width or height of the fish body. Meanwhile, gravimetric characteristics are based on weighing the whole or part of a fish body.

In terms of meristic characters, it was found that the number of dorsal spines (DS) range from 8.00 to 9.00 with a mean of 8.95±0.21904 while dorsal fin rays range from 13.00 to 14.00 with a mean of 13.89±0.31. Furthermore, the number of lateral scales is in the range of 70 to 79 with a mean of 72.90±1.43. The obtained number of dorsal spines of largemouth bass is comparable with the previous report of 9-11 [35]. Also, the number dorsal fin rays are in agreement with the findings from Bulgaria [36]. The typical number of lateral scales is in the range of 58 to 73 [37]. The obtained mean number of lateral scales obtain in this study is within this range. The result suggests that there is insignificant variation to other assessed populations despite the introduction of the species to a distant area from its native range (North America). Largemouth bass is among the introduced species in the country and reported to have established population in Pantabangan Lake [5]. The fish population in the lake has apparently adapted well to the local waters, of which there are reports of congregation on submerged trees. Meristic counts are partially determined by environmental conditions during egg and larval development, so variations in meristic counts can indicate some degree of geographic separation between populations during early life stages, which is informative for stock identification [38].

Table 1. Meristic and metric characteristics of samples

Characters	N	Min	Max	Mean	Std. Error	Std. Deviation
Meristic Characters						
Number of dorsal spines	100	8.00	9.00	8.95	0.02	0.22
Number of dorsal fin rays	100	13.00	14.00	13.89	0.03	0.31
Number of lateral scales	100	70.00	79.00	72.90	0.14	1.43
Morphometric Characters						
Eye orbital length (cm)	100	1.00	1.80	1.26	0.02	0.16
Head length (cm)	100	5.30	13.80	8.06	0.14	1.35
Body length (cm)	100	18.30	80.50	25.92	0.66	6.57
Total length (cm)	100	21.00	86.50	29.78	0.48	4.80
Body depth (cm)	100	5.40	14.00	8.02	0.15	1.52
Gravimetric Characters						
Total weight (g)	100	150.60	1865.30	440.01	27.25	272.51
Gutted weight (g)	99*	142.40	1750.20	408.65	25.99	258.63
Gonad weight (g)						
• Male		1.10	6.00	1.45	0.19	0.95
• Female		0.30	9.40	1.94	0.27	1.83
Liver weight (g)	100	0.50	14.00	4.31	0.25	2.54
Gut weight (g)	90*	4.00	89.20	18.19	1.58	15.01

**Not all samples were subjected to weighing*

The eye orbital length has a range of 1.00 to 1.80 cm with a mean of 1.26±0.16 cm. In terms of head length, the range is from 5.30 to 13.80 cm and a mean of 8.06±1.35 cm. The head length recorded in this study is within the range reported for adult largemouth bass [36]. In addition, the eye orbital length is 11.47% of the head length in adult fish while 25.28% in juveniles. With regard to body length, the samples varied from 18.30 to 80.50 cm with a mean of 25.92±6.57 cm. The total length of individuals has a range of 21.00 to 86.50 cm with a mean of 29.78±4.80 cm. The recorded minimum body depth is 5.40 while the maximum is 14.00 cm, and has a mean of 8.02±1.52 cm. The largemouth bass can grow to a maximum length of 97 cm, with a typical range of 30 to 40 cm. In comparison with other studies, the body length and total length obtained indicates that the samples are matured individuals. In the study [39], the maturity (L_{50}) for males was estimated to range from 18.0 to 20.9 cm while females reached sexual maturity at bigger sizes (24.0-26.9 cm). Sexual maturity of the fish is believed by some investigators to depend on size rather than on age, therefore, the age at maturity could vary widely [40]. Most reports indicated a minimum total length of about 25.0 cm for female.

As to gravimetric characteristics, the total weight of fish, gutted weight, gonad weight, liver weight and gut weight were considered. The total weight of individual samples has a range of 150.60 to 1865.30 g with a mean of 440.01±272.51 g. In the study [36], adult weights range from 118 to 635 g. Maximum recorded adult weight is 1001 g, with atypical range of 450 to 1360 g. The recorded gutted weight is in between 142.40 and 1750.20 g with a mean of 408.65±258.63 g. The gonad weight of males was recorded 1.10 to 6.00 g with a mean of 1.45±0.95 g while the gonad of females was in the range of 0.30 to 9.40 g with a mean of 1.94±1,83 g. In terms of liver weight, the range is 0.50 to 14.00 g, and has a mean of 4.31±2.54 g. Lastly, the gut weight has a range of 4.00 to 89.20 g with a mean of 18.19±15.01 g. The obtained standard error for all characteristics is lower than the mean value, indicating the reliability of the obtained data.

3.2 Length-Weight Relationship and Growth Pattern

The ascertained length and weight relationship of the largemouth bass is presented in Table 2 and its corresponding graphical representation is shown in Fig. 2. Based on the result of the analysis, the established model for the length and weight of fish showed high level of significance ($p<0.01$), suggesting that the equation could be used to predict the weight of the species, provided that length values are available. The r value (correlation coefficient) of the established model for the length-weight relationship is 0.8864, indicating that the length and weight of the fish has strong positive relationship or association. The computed r^2 (coefficient of determination) is 0.7858, suggesting that 78.58% of the variation in weight can be explained by the established model. Therefore, the length of the fish can be a good predictor of weight. Meanwhile, the a (intercept) and b (slope) values are -3.3005 and 2.7392, respectively. These values suggest that the relationship of length to the weight is linear; as the length increases there is also a corresponding increase in the weight of fish. However, further analysis using the modified T-test revealed that the obtained b value is not comparable with the isometric value (=3). This result indicates that the rate of increase in the length of fish is not proportionate to the increase of its weight.

Determining the growth pattern of fish and other aquatic animals depends on the functional regression "b" value of the length-weight relationship [41]. According to Pauly [42], this represents the body form, and it is directly related to the weight affected by ecological factors such as temperature, food supply, spawning conditions and other factors, such as sex, age, fishing time and area and fishing vessels. Furthermore, he describes the growth of fish as isometric or allometric. When $b = 3$, growth pattern is called isometric, meaning that rate of increment in weight is uniform to the increment in length. On the contrary, when $b \neq 3$, growth is said to be allometric, indicating that length and weight of the organism does not proceeds in similar rate of increase. Allometric growth can be either positive ($b > 3$) or negative ($b < 3$). Positive allometric growth indicates that the increase in weight is higher than the length and the species tend to have stouter body while negative allometric growth suggests that the increase in length is faster than the increase in weight and fish may exhibit an elongated body (Mon et al., 2020). Based on the derived b value, the growth pattern of the fish can be said as negative allometric. The length-weight relationships of largemouth bass usually have slopes above 3.0 according to Carlander [43]. However, the obtained value in this study fell within the range observed by VanDenAvyle & Carlander [44] in largemouth bass captured from a reservoir during their assessment in the period of September to November. Moreover, this was in agreement with the findings of Chalabia et al. [45] in Keddara Dam from September (b=2.29) to December (b=3.4). In an assessment conducted in Al-Massira Dam Lake [46], largemouth bass exhibited a positive allometric growth pattern (b = 3.2816). Moreover, similar findings have been reported in other areas such as reservoir in Southern Brazil [47], three reservoirs in Japan [48] and Lake Naivasha, Kenya [49]. Meanwhile, isometric growth was observed by Taylor & Weyl [50] in Wriggleswade, South Africa. Although not directly studied, the variation of the present finding to the previous reports could be linked to various factors such as habitat condition, physiological state, competition and anthropogenic disturbances.

The length-weight relationship is considered an essential tool in studying the biology and ecology of fishes [51,52]. It is a widely used approach in fisheries management, as it provides information on the status of fish stocks in an aquatic ecosystem [22]. Moreover, the length-weight relationship is commonly used in predicting the weight of fish, knowing its length, particularly when assessing the yields from fisheries [53]. According to Ouahb et al. [46], the obtained parameters from this biological tool provide information about the status of the fish in its habitat and also used for the comparison among various populations of similar species living in the same or different ecosystems. In addition, it can be applied to studies focusing on gonadal development, maturity condition, feeding rate, growth response, lifespan, mortality, and production of fishery resources [54,55,56]. Hence, determining the length-weight relationship of fish is of great importance in fisheries management since it provides basic information on fish growth and its general well-being [54]. However, LWRs differ among fish species and among separate populations depending on factors such as body shape, age, sex, gonad stages, spawning, feeding preferences and intensity, stomach fullness, habitat condition, and among others [55]. Furthermore, this relationship might change over seasons or even days in accordance with various influencing factors.

Table 2. Summary of the length-weight relationship and growth pattern of samples

N	r	r^2	a	b	t-test	Growth pattern
100	0.8864	0.7858	-3.0035	2.7392	b≠3	-allometric

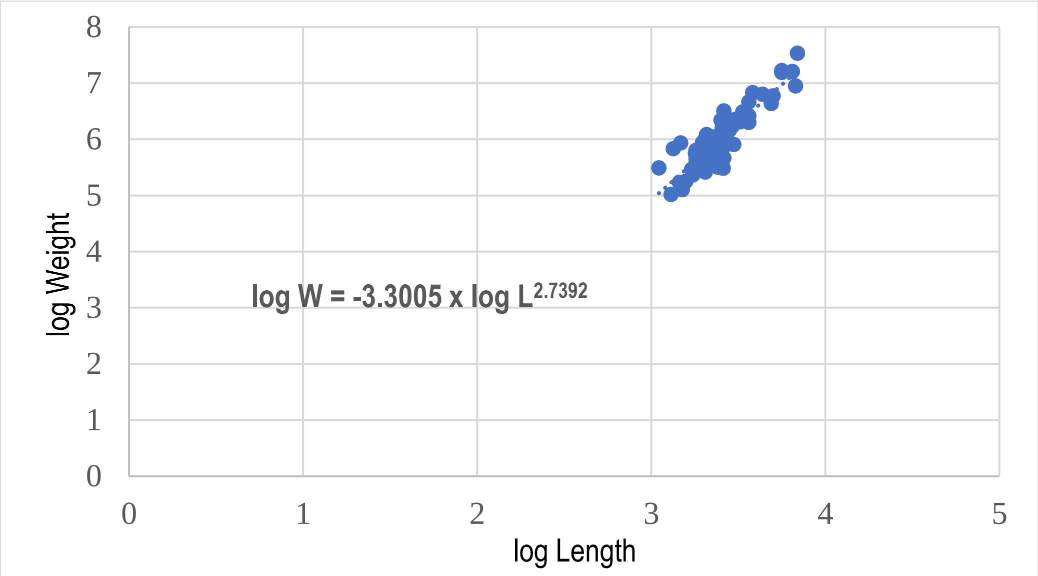

Fig. 2. Graphical representation of the established relationship between the length and weight of largemouth bass

3.3 Condition Factor and Other Biological Indices

The average condition factor and other biological indices of largemouth bass is presented in Table 3. Biometric indices such as condition factor (K_a) as well as the gonadosomatic index (GSI), the hepatosomatic index (HSI) and gastrosomatic index (GaSI) are essential to evaluate how the species obtained and utilized resources from their habitat. These indices also indicate the physiological condition of the specimens based on fat accumulation, gonadal development, general well-being, and adaptation to the environment [57].

The range of computed condition factor of fish is 2.08 to 6.50 with a mean of 3.77. The obtained value is higher than 1, suggesting that this species is in good condition in Pantabangan Reservoir. In the study of Ouahb et al. [46] in Al-Massira Dam Lake, the condition factor of the species ranged from 0.757 to 1.278 with a mean of 1.005. In comparison to the present finding, this value is lower. The observed K_a can be attributed to the age of the specimens, given that all the collected samples are already in maturing stage. In fish, condition factor is computed to determine the well-being of the species. It indicates the suitability of a specific body of water for fish growth [58]. There are several factors that could influence the index, which include food availability, reproductive cycles, and environmental conditions [54].

The range of hepatosomatic index of the fish is 0.1142 to 2.4623 with a mean of 1.0390. As of date, studies on the assessment of this biometric parameter in largemouth bass is still limited. In comparison with the findings of Orlando et al. [59] in the Escambia and Blackwater Rivers in Florida, the obtained values in this study are relatively higher. According to Dambo et al. [60], the index reflects the physiological condition of fish, as well as its metabolic health. Previous undertakings also revealed its association with energy reserves, especially in fish [61,62]. Hence, along with GSI the index is used to assess reproductive condition. The liver produces vitellogenin which is a yolk precursor thus plays an important role for the development of eggs [24]. HSI increases at early ripening, then decreases at late ripening [57]. In males, HSI does not follow the same tendency of females, and presents less expressive variations during the reproductive cycle. However, the cyclical variations of HSI are not always found in most fish species, probably due to other functions of the liver such as detoxification of substances in impacted environments [57]. In a poor environment, fish usually have a liver with less energy reserve [60]. In some species, lower HSI was observed in individuals exposed to various levels of pollutants [63,64,65]. However, a previous study showed highest HSI in individuals from sites near pollutant discharges [66]. Meanwhile, largemouth bass contracted with a novel liver disease exhibited an increasing HSI of which the average is about 1.5 times heavier than healthy individuals [67]. As compared to the calculated HSI of some fishes in different environments, the result of the present undertaking may suggest that the species is in good condition and its habitat is conducive for its growth and survival.

In terms of gastrosomatic index, pooled samples recorded a range of 0.9132 to 6.8376 with a mean of 3.8560. This index provides insights on the relationship between the weight of the alimentary canal and the biomass of fish, which helps in determining the feeding condition in different months and seasons [68]. The GaSI sometimes indirectly indicates the spawning season in certain species of fish. According to Ahmed et al. [69], GaSI in fishes reduced in the reproduction period and increased before and after reproduction, representing an inverse relationship between feeding intensity and reproduction season.

3.4 Sex Ratio and Distribution of Female Gonad Maturity Stages

Table 4 indicates the sex ratio of samples, including individuals that were not identified as male or female. Based on the result, the number of females is accounted for the 44.00% of samples individuals. Meanwhile, males have 27.00% distribution. However, about 29.00% of samples were not identified as male or female. The computed sex ratio is 1 male and 1.63 females. This result seems so close to the findings of Taylor & Weyl [50] in Wriggleswade (1 male:1.13 females) and Mankazana (1 male: 1.14 females) in South Africa, but differ with the values reported by Beamish et al. [70] in Lake Manyame, Zimbabwe (2.05 males: 1 female) and Chalabia et al. [45] in Keddara Dam, Algeria (2.33 males: 1 female).

Information on sex ratio is important to understand the relationship between individuals, the environment and the state of the population [41]. A sex ratio of 1:1 implies healthy fish population. However, different factors normally cause a deviation from this ratio, which may include habitat preference, environmental condition, vulnerability of females to their predators, migratory phases, reproductive stress and other ecological hazards [39,45]. In this study, higher proportion of females was recorded. In fish, the reproductive success of females is normally related to the access to resources and environmental conditions, and not to the number of mating partners as in the case of males [71]. In this regard, the food resources present in Pantabangan Lake could be in abundance to support the requirement of female population for growth and reproduction. The obtained sex ratio may suggest that there is higher rate of recruitment as many females could potentially increase egg production. However, the success of recruitment is still dependent on the capability of male population to effectively fertilize the eggs.

Presented in Table 5 is the distribution of gonad stages among female samples. Gonad examination revealed that most (45.45%) of the female samples have maturing gonads. This was followed by females with recovering gonads (29.54%). Meanwhile, only 2.27% were identified to have gonads in the matured and spent phases. Of the total identified females, about 20.47% have gonads that were not determined. This result suggests that during the period of the study, females are undergoing gonad development.

According to Magqina & Mhere [39], the size at 50% sexual maturity (L_{50}) was reached between 240 to 26.9 cm in females. In this size class, 53% fish were found to have mature gonads whilst 47% still had immature gonads. Mature individuals before the L_{50} size class range were also observed in 21.0 to 23.9 cm size class (26%), 18.0 to 20.9 cm size class (15%) and the 15.0 to 17.9 cm size class (9%). After the L_{50} size class range, they have observed that 39% immature fish were in the 27.0 to 29.9 cm size class and 9% in the 3.30 to 35.9 mm size class. However, it was observed in the present study that most individuals at a size class of 21.0 to 30.0 size class are exhibiting gonads that are still maturing stage. This result may suggest that most females during the period of the assessment are still not undergoing spawning and they may still require additional amount of energy from their environment in the process of gonad ripening. However, the distribution of gonad stages observed in this study may indicate an annual reproductive cycle. Lorenzoni et al. [72] stated that the reproduction of largemouth bass is closely related to environmental condition. Lee et al. [73] suggested that decreasing water temperatures and photoperiod primary factors triggering the onset of spermatogenesis and oocyte maturation, with flooding acting as the proximal factor. Meanwhile, in the study of Magqina & Mhere [39] in Tugwi Mukosi Reservoir, Zimbabwe (a temperate water body) largemouth bass spawned mainly from

September to January, with a peak in October. This is different from what was observed in this study. The differences can be explained by the differences in geographic location where the researches were conducted and that perhaps the increasing temperatures could be the ideal growing conditions for phytoplankton and zooplankton which are food for fry. The collection of samples was done from December to January, in which the temperature is low.

3.5 Stomach Content and Food Indices

Table 6 presents the distribution of full and empty stomachs among samples. Based on the result, majority (61.00%) exhibited empty stomachs. A quarter (25.00%) of the samples are composed of individuals with full stomach while the remaining 4.00% have partially filled stomach. A full stomach contains food items that occupied the entire cavity while empty stomach contains no food item but a little digested secretion may be present.

The average values of stomach and food indices, which include the fullness index (FI), vacuity index (VI), frequency of occurrence (F), numeric index of abundance (NA), percentage of food item weight (WFI) and the index of relative importance (IRI) are indicated in Table 7.

The fullness index illustrates the feeding intensity of fish [74]. This is measured as the ratio of food mass to body mass of fish. Fullness is expressed on a scale from 0% to 100%. Possibilities of fullness expression have been used and published, of which Garrido et al. [75] used a scale of 1 to 4 (1 – empty; 2 - <50%; 3 - >50%; and 4 – bursting). During the period of the study, the mean value of stomach fullness of the fish is 61.82. The obtained value indicates that the most of the samples' stomach are filled with food items.

Table 3. Average condition factor and other biological indices of samples

Index	N	Min	Max	Mean	Std. Deviation	Remarks
K_a	100	2.08	6.50	3.77	0.81	Good
GSI						
• Female	45	0.1307	1.540	0.3727	0.0318	-
• Male	25	0.1226	0.9296	0.3764	0.0361	-
HIS	100	0.1142	2.4623	1.0390	0.3658	Good
GaSI	90	0.9132	6.8376	3.8560	1.0957	-

Table 4. Sex ratio of samples

Sex	Frequency	Percentage (%)	Sex Ratio
Male	27	27.00	
Female	44	44.00	1:1.63
Unidentified	29	29.00	-

Table 5. Distribution of gonad stages among female samples

Gonad Stage	Frequency	Percentage
Maturing	20	45.45
Matured	1	2.27
Spent	1	2.27
Recovering	13	29.54
Not Determined	9	20.47

Table 6. Distribution of full and empty stomachs among samples

Stomach Fullness	Frequency	Percentage
Full	25	25.00
Partially filled	4	4.00
Empty	61	61.00
Not Determined	10	10.00

Table 7. Average values of stomach and food indices

Index	N	Computed Value (%)
FI	25	61.82
VI	92	66.03
OI	25	
• Shrimp		28.00
• Fish		68.00
• Plant		4.00
NI	25	
• Shrimp		28.00
• Fish		66.00
• Plant		6.00
WI	25	
• Shrimp		15.17
• Fish		81.57
• Plant		3.26
IRI	25	
• Shrimp		1208.80
• Fish		10,034.50
• Plant		37.05
IRI%	25	
• Shrimp		10.72
• Fish		88.96
• Plant		0.33

According to Sakamoto et al. [76], the vacuity index or empty stomachs' ratio is an inverse indication of feeding intensity which vary in accordance to the variations in the abundance of fish, spawning time, seasonal changes in water temperature and food item. In this study, analysis revealed a mean value of vacuity index of 66.03. This means that out of the 92 samples subjected to analysis, majority of the stomachs are empty. In the study of Chalabia et al. [45], a vacuity index of 20.0% and 52.6% for the early September) and late of the autumn (December) season, respectively. Most of the samples used in the analysis were captured in the month of December.

The occurrence index describes the percentage of stomachs having a specific food item to the total food items found in the examined stomachs [77]. As revealed, there were three groups of food items found in the stomach of samples. These include fish, shrimp and plant materials. As observed, most of these food items are partially digested. Of these food items, fish has the highest OI with 68.00% and followed by shrimp with 28.00%. It is surprising that plant materials (OI = 4.00%) were also observed in the stomach of an individual as the fish is known to be a carnivorous species. The numeric index refers to the percentage of a specific food item to the total number of food items in stomachs containing foods [77]. Based on the result, the NI for shrimp, fish and plant materials are 28.00%, 66.00% and 6.00%, respectively. In terms of weight index, fish recorded the highest WI (81.57%). WI indicates the percentage of the weight of a specific food item to the total weight of stomachs containing food [77]. To determine the importance of prey items in stomach contents, the index of relative importance was applied. In relation to the percentage of IRI, fish (=88.96%) is the most important prey item. Meanwhile, plant materials are negligible (<10%).

Gut content analysis provides and important insight into feeding patterns and quantitative assessment of feeding habits [78]. The present study provides basic information on the feeding habit of largemouth bass in Pantabangan Reservoir. It was found that the diet of the largemouth bass comprised mainly of fish. As observed, small fishes such as juvenile tilapia, goby and silver perch were common. However, the result of the study indicates that the fish is not exclusively piscivorous. This is in agreement with previous studies. According to Uzunova et al. [36], the fish is an opportunistic top predator, exploiting prey from the bottom to the surface of a water body. It has an alimentary range depending on the environment and on the feeding resources [40]. Warren [79] claimed that adult populations feed primarily on fishes, but crayfish, amphibians and aquatic macroinvertebrates are also part of their diet. In a small lake in Japan [80], the principal foods of the bass regardless of size consisted of gobies. In the study [81], juvenile largemouth bass showed prey selection. Fish that were 50 mm or less in length selected prey mostly in the range of 1-5 mm and fish that were >80 mm consumed prey mostly 6 mm or greater in length. An earlier study in Big Creek Lake revealed young largemouth bass preferred insects but transitioned at about 125 mm TL when fish became the prominent food item [82]. In an experiment, the distance at which largemouth bass can locate the fish increases with prey size, with prey motion (when prey is small), and with light intensity [83]. In the pursuit phase of the predation cycle, largemouth bass are more likely to choose prey with large apparent size, closer proximity, or greater motion [82]. In terms of seasonal variation, Marinelli et al. [40] observed that crustaceans were more abundant in late winter and spring, whereas fish were the most abundant preys in summer. In Lake Lillinonah and Pickerel Lake, the IRI of aquatic insects decreased and the IRI of fish increased with increasing fish length; aquatic insects were most important in largemouth bass less than 300 mm [84]. In this study, highest IRI was recorded for fish and could be linked to the size of largemouth bass samples.

4. CONCLUSION

The meristic, metric and gravimetric characteristics as well as the length and weight relationship and body condition of largemouth bass were comparable to other studies conducted previously, indicating that the fish population in the lake has apparently adapted well to the local waters. There is higher proportion of female population than male during the period of assessment. Majority exhibited empty stomachs and only few were recorded with filled stomachs. Shrimp, fish and plant-like materials were seen in the stomach of the fish. Among these, fish has the highest relative importance.

It is recommended to have a continuous data collection. A follow-up study with wider scope must be conducted, considering a spatio-temporal analysis of biological characteristics, fishing impact and habitat condition. Assessment of reproduction and recruitment must also be conducted to provide a better insight on the status of largemouth bass in Pantabangan Reservoir to effectively manage its population.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the local government unit (LGU) of Pantabangan, Nueva Ecija, Philippines for the assistance during the collection of samples.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Frietas MO, Rebeiro VM, Abilhoa V, Vitule JRS. Reproduction of the invasive largemouth bass Micropterus salmoides (Lacepède, 1802) in a Neotropical reservoir with suggestions to management and control. Acta Limnologica Brasiliensia. 2023;35(1). Avaialble:https://doi.org/10.1590/s2179-975x6822
2. US Fish and Wildlife Service. Largemouth bass; 2008. Avaialble:https://www.fws.gov/species/largemouth-bass-micropterus-salmoides.
3. Pereira FW, Vitule JRS. The largemouth bass Micropterus salmoides (Lacepède, 1802): impacts of a powerful freshwater fish predator outside of its native range. Reviews in Fish Biology and Fisheries. 2019;29:639-652.
4. Guerrero III RD. Impacts of introduced freshwater fishes in the Philippines (1905-2013): a review and recommendations. Philippine Journal of Science. 2014; 143(1):49-59.
5. Tad-O AB, Ayanan DA, Barangan TG, Bautista JC, Gagelonia JD, Galayugo AC, Hoggang CGB, Kiw-is KB, Madrid FGN, Ramos HAR, Tacaca JO, Tolentino CRS, Ziegler JT, Reyes AT. Assessment of fisherfolk profile and their awareness and

belief regarding introduced American largemouth bass Micropterus salmoides in Pantabangan reservoir. AACL Bioflux. 2023;16(4): 2097-2113.
6. Maloney KO, Krause KP, Cashman MJ, Daniel WM, Gressler BP, Wieferich DJ, Young JA. Using fish community and population indicators to assess the biological condition of streams and rivers of the Chesapeake Bay watershed, USA. Ecological Indicators. 2022;134:108488. Avaialble:https://doi.org/10.1016/j.ecolind.2021.108488
7. Mohamed KS, Sathianandan TV, Vivekanandan E, Kuriakose S, Ganga U, Pillai SL, Nair RJ. Application of biological and fisheries attributes to assess the vulnerability and resilience of tropical marine fish species. PLoS One. 2021;16 (8):e0255879. Avaialble:https://doi.org/10.1371/journal.pone.0255879
8. Mehmood S, Ahmed I, Ali MN. Length-weight relationship, morphometric and meristic controlling elements of three freshwater fish species inhabiting North Western Himalaya. Egyptian Journal of Aquatic Biology & Fisheries. 2021;25(6): 243-257.
9. Masood Z, Hawa N, Hassan HU, Mahboob S, Chatta AM, Mushtaq S, Ahmed AE, Swelum AA, Zulfiqar T, Khan T, Al-Misned F. Study of some morphometric and meristic characteristics of Alepes vari (Cuvier, 1833) collected from the Arabian coast. Brazilian Journal of Biology. 2021; 84:e257023. Avaialble:https://doi.org/10.1590/1519-6984.257023
10. Datta SN, Kaur VI, Dhawan A, Jassal G. Estimation of length-weight relationship and condition factor of spotted snakehead Channa punctata (Bloch) under different feeding regimes. Springerplus. 2013;2:436. Avaialble:https://doi.org/10.1186/2193-1801-2-436
11. Getso BU, Abdullahi JM, Yola IA. Length-weight relationship and condition factor Clarias gariepinus and Oreochromis niloticus of Wudil River, Kano, Nigeria. Journal of Tropical Agriculture, Food, Environment and Extension. 2017;16(1):1-4.
12. Samir O, Dina R, Sutrisno Haryani GS, Lukman, Nasution HS. Introduced fish species and their characters in Lake Maninjau, West Sumatra. IOP Conference Series: Earth and Environmental Science. 2021;89:012024.
13. Pereira FW, Vitule JR. The largemouth bass Micropterus salmoides (Lacepède, 1802): impacts of a powerful freshwater fish predator outside of its native range. Reviews in Fish Biology and Fisheries. 2019;29:639-52.
14. Tidwell JH, Coyle SD, Bright LA, Van Arnum A, Yasharian D. Effect of water temperature on growth, survival, and biochemical composition of largemouth bass Micropterus salmoides. Journal of the World Aquaculture Society. 2003;34(2): 175-83. Avaialble:https://doi.org/10.1088/1755-1315/789/1/012024
15. He J, Wu Z, Huang L, Li Y, Sun Y, Wang D, Feng J, Lin Y, He A. Length-weight relationships of twenty-nine native fish species from Hongshui River, Southern China. Journal of Applied Ichthyology. 2023;1744641. Avaialble:https://doi.org/10.1155/2023/1744641
16. Nasution SH, Akhdiana I, Muchlis AM, Cinnawara HT. Size distribution and length-weight relationship of invasive species flowerhorn (Cichlasoma trimaculatum) (Günther, 1867) in Lake Mahalona, South Sulawesi. IOP Conference Series: Earth and Environmental Science. 2022; 1062: 012002.
17. Reyes AT, Fernando SID, Divina MB, Baltazar FR, Daus AA, Fajardo DBL, Fernandez MPM. Assessment of abundance, diversity and stomach content of freshwater fishes in Pampanga River along the municipality of Cabiao, Nueva Ecija, Philippines. International Journal of Fisheries and Aquatic Studies. 2019; 7(5):49-53.
18. Mahesh V, Gop AP, Nair RJ. Stomach content analysis techniques in fishes. In: ICAR Sponsored Winter School on Recent Advances in Fishery Biology Techniques for Biodiversity Evaluation and Conservation. 2018:104-115:1-21.
19. Magbanua FS, Mendoza NYB, Uy CJC, Matthaei CD, Ong PS. Water physicochemistry and benthic macroinvertebrate communities in a tropical reservoir: The role of water level fluctuations and water depth. Limnologica. 2015;55:13-20.

20. Lasco RD, Cruz RVO, Pulhin JM, Pulhin FB. Assessing climate change impacts, adaptation and vulnerability: The case of the Pantabangan-Carranglan Watershed. World Agroforestry Centre and College of Forestry and Natural Resources, University of the Philippines Los Baños, Los Banos, Laguna. 2010:95.
21. Lleonart J, Salat J, Torres GJ. Removing allometric effects of body size in morphological analysis. Journal of Theoretical Biology. 2000;205:85-93.
22. Bagenal TB, Tesch FW. Methods of assessment of fish production in fresh waters. IBP Handbook No. 3, 3rd ed. Oxford Blackwell Scientific Publication, London. 1978:101-136.
23. Maddock DM, Burton MPM. Gross and histological observations of ovarian development and related condition changes in American plaice. Journal of Fish Biology. 1998;53(5):928-944. Avaialble:https://doi.org/10.1111/j.1095-8649.1998.tb00454.x
24. Jan M, Jan N. Studies on the fecundity (F), gonadosomatic index (GSI) and hepatosomatic index (HSI) of Salmo trutta fario (Brown trout) at Kokernag trout fish farm, Anantnag, Jammu and Kashmir. International Journal of Fisheries and Aquatic Studies. 2017;5(6):170-173.
25. Hureau J. [Comparative biology of some Antarctic fish (Nototheniidae)]. Bulletin de l'Institut océanographique de Monaco. 1970;68:139-164.
26. Ouakka K, Yahyaoui A, Mesfioui A, El Ayoubi S. Stomach fullness index and condition factor of European sardine (Sardina pilchardus) in the south Moroccan Atlantic coast. AACL Bioflux. 2017;10 (1):56-63.
27. Rosecchi E, Nouaze Y. Comparaison de cinq indices utilisés dans l’analyse des contenus stomacaux. Revue des Travaux de l’Institut des Pêches Maritimes. 1987; 49(3-4):111-123.
28. Hyslop EJ. Stomach content analysis: a review of methods and their applications. Journal of Fish Biology. 1980;17(4):411-429.
29. Khelifi N, Boalleg C, Sahtout F, Kaouachi N, Mouaissia W, Bensouillah M. Feeding habits of Carassius carassius (Cyprinidae) in Beni Haroun Dam (north-east of Algeria). AACL Bioflux. 2017;10(6):1596-1609.
30. Lauzanne L. [Qualitative and quantitative aspects of the feeding of fish in Chad]. Thesis of State Paris ORSTOM. 1977:284.
31. Pinkas L, Oliphant MS, Iverson ILK. Food habits of albacore, bluefin tuna, and bonito in California waters. California Department of Fish and Game Fish Bulletin. 1970;152: 1-105.
32. Cortes E. A critical review of methods of studying fish feeding based on analysis of stomach contents: application to elasmobranch fishes. Canadian Journal of Fisheries and Aquatic Sciences. 1997;54: 726-738.
33. Sumon A, Gabr M, Al-Harbi M. Analysis of food and feeding habits of Gerres longirostris in the Red Sea coast of Jeddah, Saudi Arabia. Egyptian Journal of Aquatic Biology and Fisheries. 2020;24(7): 471-484.
34. Aisyah S, Syarif AF. Morphometric and meristic characters of Selangat Fish (Anodontostoma sp.) from Kelabat Bay and Tukak Strait, Bangka Belitung. Advances in Engineering Research. 2018; 167:13-16.
35. Page LM, Burr BM. Field guide to freshwater fishes of North America north of Mexico. Peterson Field Guides series. 2nd Edition. Houghton Mifflin Harcourt, Boston, MA; 2011.
36. Uzunova E, Studenkov S, Dashinov D. First records of largemouth bass Micropterus salmoides (Lacépède, 1802) from Bulgaria (Balkan Peninsula). BioInvasions Records. 2019;8(2):427-436.
37. Robins RH, Page LM, Williams JD, Randall ZS, Lowe CH. Fishes in the freshwaters of Florida: an identification guide and atlas. University of Florida Press, Gainesville, FL.; 1995.
38. Chase PD. Meristics. In Cadrin SX, Kerr LA, Mariani S. (eds.) Stock identification methods: Applications in fishery science, Academic Press. 2009:171-184. Avaialble:https://doi.org/10.1016/B978-0-12-397003-9.00009-6
39. Magqina T, Mhere A. Size at maturity, maturity stages, and sex ratio of Micropterus salmoides (Lacepède, 1802) in Zimbabwe’s largest inland reservoir, Tugwi Mukosi: a baseline study. Journal of Fisheries. 2020;8(3):912-919.
40. Marinelli A, Scalici M, Gibirtini G. Diet and reproduction of largemouth bass in a recently introduced population, Lake

Bracciano (Central Italy). BFPP/Bull. Fr. Pêche Piscic. 2007;385: 53-68.

41. Kalayci F, Samsun N, Bilgin S, Samsun O. Length-weight relationship of 10 fish species caught by bottom trawl and midwater trawl from the Middle Black Sea, Turkey. Turkish Journal of Fisheries and Aquatic Sciences. 2007;7(1).
42. Pauly D. Some simple methods for the assessment of tropical fish stocks. FAO. Fisheries Technical Paper. 1983;234.
43. Carlander KD. Handbook of Freshwater Fishery Biology, Vol. 2. Ames: Iowa State University Press; 1977.
44. VanDenAvyle MJ, Carlander KD. Seasonal variation in weight-length relationships of largemouth bass in a 3-hectare reservoir. Proceedings of the Iowa Academy of Science. 1977; 84(8):1-4.
45. Chalabia C, Khadra F, Leila L, Habiba EH, Karima Z, Amine BM, Rachida I, Halim C, Ismail B, Aimen RM, Amira D. Eco-biological study of the Largemouth bass, Micropterus salmoides Lacépède, 1802 (Perciformes Centrarchidae), from Keddara Dam (Boumerdes, Algeria). Biodiversity Journal. 2023;14(3):421-429.
46. Ouahb S, Bousseba M, Ferraj L, El Moujtahid A, Hasnaoui M. Weight-length relationship and relative condition factor of Micropterus salmoides (Lacépède, 1802), Cyprinus carpio (Linneaus, 1758) and Oreochromis niloticus (Linnaeus, 1758) caught in the Al-Massira Dam Lake. E3S Web of Conferences. 2021;314:01005.
47. Schulz UH, Leal ME. Growth and mortality of black bass, Micropterus salmoides (Pisces, Centrachidae; Lacapède, 1802) in a reservoir in southern Brazil. Brazilian Journal of Biology. 2005;65(2):363–369.
48. Yokogawa K. Morphological variations in the largemouth bass Micropterus salmoides with particular emphasis on growth-related changes. Aquaculture Science. 2014;62(4):361-374.
49. Keyombe JL, Obiero K, Waithaka E, Outa N, Donde O, Kyule D. Understanding selected growth aspects in redbelly tilapia, Coptodon zilli (Gervais) and largemouth bass, Micropterus salmoides (Lacepède) in Lake Naivasha, Kenya; Fisheries Management Perspective. Pan African Scientific Journal. 2020;1(2):11-23.
50. Taylor GC, Weyl OLF. Age, growth and reproduction of non-native largemouth bass Micropterus salmoides (Lacépède, 1802) populations in two temperate African impoundments. Journal of Applied Ichthyology. 2017;33(4):767-775.
51. Bolognini L, Domenichetti F, Grati F, Polidori P, Scarcella G, Fabi G. Weight-length relationships for 20 fish species in the Adriatic Sea. Turkish Journal of Fisheries and Aquatic Sciences. 2013; 13: 555-560.
52. Li Y, Feng M, Huang L, Zhang P, Wang H, Zhang J, Tian Y, Xu J. Weight–length relationship analysis revealing the impacts of multiple factors on body shape of fish in China. Fishes. 2023; 85(5):269. Avaialble:https://doi.org/10.3390/fishes8050269
53. Froese R, Thorson JT, Reyes RB. A Bayesian approach for estimating length-weight relationships in fishes. Journal of Applied Ichthyology. 2014;30(1):78-85.
54. Jisr N, Younes G, Sukhn C, El-Dakdouki MH. Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. Egyptian Journal of Aquatic Research. 2018;44(4):299-305.
55. Jerin JF, Akhter S, Debnath J, Saha D. Length-weight relationships and condition factor of four threatened riverine catfish species in the Meghna River Estuary, Bangladesh. Journal of Applied Ichthyology. 2023: Article ID 6651843. Avaialble:https://doi.org/10.1155/2023/6651843
56. Ak O, Kutlu S, Kutlu S, Aydin I. Length-weight relationship for 16 fish species from the Eastern Black Sea, Türkiye. Turkish Journal of Fisheries and Aquatic Sciences. 2009;9:125-126.
57. Rizzo E, Bazzoli N. Reproduction and embryogenesis. Biology and Physiology of Freshwater Neotropical Fish. 2020;287-313.
58. Asadi H, Sattari M, Motalebi Y, Zamani-Faradonbeh M, Gheytasi A. Length-weight relationship and condition factor of seven fish species from Shahrbijar River, Southern Caspian Sea basin, Iran. Iranian Journal of Fisheries Sciences. 2017;16(2): 733-741.
59. Orlando EF, Denslow ND, Folmar LC, Guillette Jr LJ. A Comparison of the reproductive physiology of largemouth bass, Micropterus salmoides, collected from the Escambia and Blackwater Rivers in Florida. Environmental Health Perspectives. 1999;107(3):199-204.

60. Dambo A, Solomon SG, Ayuba VO, Okayi RG. Study on condition factor and hepatosomatic index of Bagrus bayad (Forsskal, 1775) and Synodontis nigrita (Valenciennes, 1840) from Kangimi Reservoir, Kaduna State, Nigeria. Bayero Journal of Pure and Applied Sciences. 2021;14(2):192-197.
61. Lenhardt M, Jaric I, Cakic P, Cvijanovic G, Gacic Z, Kolarevic J. Seasonal changes in condition, hepatosomatic index and parasitism in starlet (*Acipenser ruthenus* L.). Turkish Journal of Veterinary and Animal Science. 2009; 33: 209-214.
62. Gurkan S, Taskavak E., Innal D. Some observations on relationships of the liver, ovary and body weights for pipefish species at the Lake Bafa Coasts (Muğla). Turkish Journal of Agriculture - Food Science and Technology. 2019;7(3):536-538.
63. Singh S, Srivastava AK. Variations in hepatosomatic index (HSI) and gonadosomatic index (GSI) in fish Heteropneustes fossilis exposed to higher sub-lethal concentration to arsenic and copper. Journal of Ecophysiology, Occupation & Health. 2015;15(3-4): 89-93.
64. Pandit DN, Priyanka, Gupta M. Heapto-somatic index, gonado-somatic index and condition factor of Anabas testudineus as bio-monitoring tools of nickel and chromium toxicity. International Journal of Innovations in Engineering and Technology. 2019;12(3):25-28.
65. Aly W, Abouelfadl KY. Impact of low-level water pollution on some biological aspects of redbelly tilapia (Coptodon zillii) in River Nile, Egypt. Egyptian Journal of Aquatic Research. 2022;46(3),273-279. Avaialble:https://doi.org/10.1016/j.ejar.2020.08.001
66. Morado CN, Araujo FG, Gomes ID. The use of biomarkers for assessing effects of pollutant stress on fish species from a tropical river in Southeastern Brazil. Acta Scientiarum Biological Sciences. 2017;39 (4):431-439.
67. Huang X, Liu S, Zhang H, Yao J, Geng Y, Ou Y, Chen D, Yang S, Yin L, Luo W. Pathological characterization and cause of a novel liver disease in largemouth bass (Micropterus salmoides). Aquaculture Reports. 2022;23:101028. Avaialble:https://doi.org/10.1016/j.aqrep.2022.101028
68. Mahaseth VK. Food and feeding habit of Tor putitora of Mahakali River, Nepal. Bibechana. 2016;13:121-131.
69. Ahmed I, Bano A, Siddique S. Relative gut length and gastro-somatic index of Acanthopagrus arabicus (Iwatsuki, 2013) from the offshore waters of Pakistan. Natural and Engineering Sciences. 2022; 7(1):67-79.
70. Beamish CA, Booth AJ, Deacon N Age, growth and reproduction of largemouth bass, Micropterus salmoides, in lake Manyame, Zimbabwe. African Zoology. 2005;40:63-69.
71. Hart PJB, Reynolds JD. Behavioural Ecology of Fishes. In Handbook of Fish Biology and Fisheries. 2002;1:225-247.
72. Lorenzoni M, Martin Dorr AJ, Erra R, Giovinazzo G. (2002). Growth and reproduction of largemouth bass (Micropterus salmoides Lacépède, 1802) in Lake Trasimeno (Umbria, Italy). 2002;56(1):89-95.
73. Lee WO, Lee IR, Song HY, Bang IC. Genetic differentiation of the largemouth bass, Micropterus salmoides, from the major rivers and reservoirs in Korea assessed by AFLP. Korean Journal of Limnology. 2008;41:395-401.
74. Ekpo IE, Mandu A, Essien J, Joseph NN. Food and feeding habits and condition factor of fish species in Qua Iboe River estuary, Akwa Ibom State, Southeastern Nigeria. International Journal of Fisheries and Aquatic Studies. 2014;2(2):38-46.
75. Garrido S, Murta AG, Moreira A, Ferreira MJ, Angelico MM. Horse mackerel (*Trachurus trachurus*) stomach fullness off Portugal: index calibration and spatio-temporal variations in feeding intensity. ICES Journal of Marine Science. 2008; 65(9):1662-1669. Avaialble:https://doi.org/10.1093/icesjms/fsn169
76. Sakamoto T. Studies on fishery biology of the ribbon fish, Trichiurus lepturus, Linne, in the Kii channel. Wakayama Prefecture Exp Stat Special Issue. 1982;1-113.
77. Rizkalla S, Philips A. Feeding habits of the Atlantic stargazer fish Uranoscopus scaber (Linnaeus 1758) (Family: Uranoscopidae) in Egyptian Mediterranean waters. Egyptian Journal of Aquatic Biology and Fisheries. 2008;12:1-11.
78. Manko P. Stomach content analysis in freshwater fish feeding ecology. University of Presov; 2016.

ISBN9788055516134: 114.
79. Warren M. Centrarchid identification and natural history. In: Cooke, S., Philipp, D. (eds), Centrarchid Fishes: Diversity, Biology, and Conservation. Wiley-Blackwell, Chichester. 2009; 375–533. Avaialble:https://doi.org/10.1002/9781444316032.ch13
80. Azuma M, Motomura Y. Feeding habits of largemouth bass in a non-native environment: the case of a small lake with bluegill in Japan. Environmental Biology of Fishes. 1998;52:379–389. Avaialble:https://doi.org/10.1023/A:1007476104352
81. Goodwill TR. Feeding habits of juvenile largemouth bass Micropterus salmoides (Lacepede). Honors Thesis. 1996;167. Avaialble:https://scholarworks.wmich.edu/honors_theses/167
82. Paragamian V. Food habits of largemouth bass (*Micropterus salmoides*) at Big Creek Lake. Proceedings of the Iowa Academy of Science. 1978;85(1):31-34.
83. Howick GL, O'Brien O. Piscivorous feeding behavior of largemouth bass: An experimental analysis. Transactions of the American Fishery Society. 1983;112(4): 508-516.
84. Ward SM, Neumann RM. Seasonal and size-related food habits of largemouth bass in two Connecticut Lakes. Journal of Freshwater Ecology. 1988; 13(2):213-220.

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