2022

Association of size structure, diet composition, endo-parasites of Snakehead fish *(Channa striata,* Bloch*)*, in Lake Mainit, Caraga Region, Philippines

Rosannie Joy T. Paglinawan, Ruby A. Paylangco, Jesiel Cris C. Paylangco, Archie A. Along, and Florence Jhun F. Almadin

Date received: June 14, 2021
Revision accepted: September 29, 2022
Similarity index: 8%

Abstract

Channa striata Bloch is a type of indigenous freshwater fish abundant in Lake Mainit, and it serves as a source of food and finances for the people. This species was reported as an intermediate host of many helminth parasites. This research aimed to determine the association of endo-parasites, diet composition, and length and weight in snakehead fish, *C. striata* Bloch in three selected municipalities along Lake Mainit, Caraga Region, Philippines. The results revealed that food items found in the stomach of the fish were mostly composed of shrimps, plant debris, fish, crab, detritus (dry & wet seasons), aquatic insects, and snails (wet season). Among the seven food items, the highest index of relative importance (IRI) value observed are shrimps in both wet and dry seasons. A nematode parasite was recovered in the gut of the fish samples. Out of 180 fish samples, 133 were infected with *Procamallanus* sp. The prevalence was higher in the dry season compared to the wet season. However, parasite intensity and diet count of *C. striata* Bloch. showed no significant variations between sampling sites and seasons. On the other hand, there were no significant differences between the intensity of the parasite count to the length and weight of the fish; the association between parasite count and diet count during dry and wet seasons showed a strong positive correlation. The results indicated that *C. striata* Bloch is susceptible to *Procamallanus* sp. nematode infection because of its carnivorous diet and serves as the vector or intermediate host in freshwater. Thus, more fish samples, the host's age, the host's sex, the study gap, the infection rate of the fish organs, and the assessment of the physico-chemical parameters in future studies must be used.

Keywords: Procamallanus sp., food security, *haluan,* helminth, Surigao del Norte

Author Information:

Rosannie Joy T. Paglinawan
joypaglinawan7@gmail.com
Graduate Student

Ruby A. Paylangco
rubypaylangco@gmail.com
Instructor

Jesiel Cris C. Paylangco
jcrispaylangco@gmail.com
Instructor

Archie A. Along
orcid.org/0000-0002-9836-7278
archiealong427@gmail.com
Instructor

Florence Jhun F. Almadin
orcid.org/0000-0002-8711-323X
florencefarol@gmail.com
Instructor

College of Mathematics and Natural Sciences, Caraga State University
Butuan City, Philippines

doi.org/10.53899/spjrd.v27i2.135

Parasitism is one of the severe problems among fishes (Suliman & Al-Harbi, 2016). The common parasitic helminths that infect freshwater fish are trematodes, nematodes, and cestodes (Northrop-Clewes & Shaw, 2000). These parasites have diverse effects on their hosts (Koepper, 2022). Helminth parasites can cause lethargic behavior, lessen appetite, cause the fish to stay eminent, infect all organs of the host, causing loss of function of the damaged area resulting in anemia, skinniness, unthriftiness, and reduced vitality (Klinger & Floyd, 2002). Parasites displace the fish's internal organs, which rapidly weakens and leads to fish-killing (Velasquez, 1999). They also transmit diseases to other fishes and affects the marketability of aquaculture and fisheries products (Bouwmeester et al., 2020). The length and weight are critical in fishing assessment (Usip, 2013) as they help predict the condition, reproductive history, and life history of fish species (Arslan et al., 2004).

Endoparasites are typically transmitted alongside the food web when intermediate, transport, or from time to time the unintentional fish hosts feed on parasitized prey (Poulin & Valtonen, 2002). As part of the food web, fish serves as a carrier or vector of various parasite infections (Faruk et al., 2018). It is thought that the diet of the fish host strongly influences its parasite abundance and richness (Cirtwill et al., 2015). It is essential to assess the diet composition of the fishes to locate the possible source or route of parasite transmission. Stomach content material analyses can monitor crucial records of the trophic interactions and the feeding ecology of fishes (Cox et al., 2002; Graham et al., 2007). The host diet records in endoparasite studies can contribute to additional knowledge on parasite transmission and the current condition of the host's ecology (Klimpel et al., 2006; Kleinertz et al., 2012). For example, water pollution can result in the increased burden of some fish parasite species due to a decrease in fish immunological defenses (Sasal et al., 2007). In contrast, fish parasites can also suffer secondary extinctions due to biodiversity loss due to complex life cycles and host species diversity (Lafferty, 1997). For these reasons, fish parasites can also make good indicators of ecosystem integrity (Wood et al., 2010) and indicators of environmental contaminants and stress (Sures, 2004) if the dynamics of their parasitism are consistently observed within selective fish hosts.

On the other hand, the snakehead, *Channa striata* Bloch is a type of freshwater fish locally known as *haluan* and belongs to the family of Channidae (Miah et al., 2013). This species served as a food source because of its delicious taste and its versatility as dishes. Also, it is a source of livelihood for the community living along the lake (Miah et al., 2013). This species is highly carnivorous (Muthmainnah, 2013), and the diet composition includes shrimps, snails, fishes, insects, crabs, plants, frogs, snakes, and earthworms. This broad diet exposes the fish to a wide variety of many helminth parasites (Vankara & Chikkam, 2015). The *C. striata* Bloch inhabits ponds, streams, rivers, swamps, and stagnant and muddy water and is also very common in freshwater plains (Li et al., 2016). It is one of the most abundant fish found in Lake Mainit (de Guzman et al., 2008).

Lake Mainit is one of the most valuable freshwater resources in the Caraga Region that are wide open (Lampert & Sommer, 1997). People living nearby or surrounding the lake rely mainly on fishing and farming as their food source and finances. However, nowadays, the lake is suffering environmental agitations that include irresponsible mining, poor agricultural practices, human-induced activities, soil erosion, and fishing malpractices, among others. The lake is becoming more susceptible to pollution due to some environmental pressures and activities (Lake Mainit Development Alliance [LMDA], 1999) that slowly affect the fish's health condition. Throughout time a decline in species composition of the lake fish resources is observed, leading to local fish extinction (Uy et al., 2015).

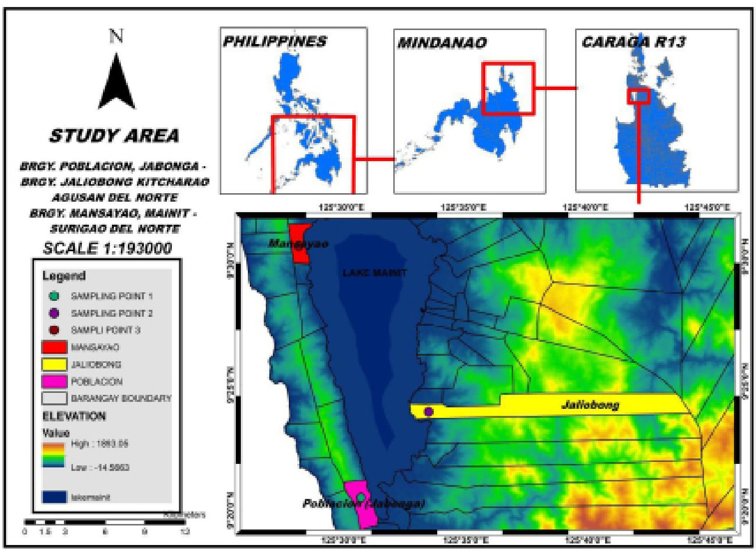
Lake Mainit experiences the typical syndrome of threatened fisheries resources: biodiversity loss, high fishing pressure, declining fish catch and catch-per-unit-effort, decreasing the size of fish caught, and marginal or meager fisher incomes barely enough to provide for the basic daily needs like food and health (Biña-de Guzman, 2013). Thus, this study aimed to determine the association of endo-parasite present in the gut, diet composition, and length and weight of *C. striata* Bloch collected in three selected municipalities of Lake Mainit, Caraga Region. This study intended to contribute to the fish parasites listing of Lake Mainit and, in turn, assess potential host and parasite species that may serve as keystone biological markers for the lake's environmental monitoring and conservation in the future. Also, this study is relevant to public health and animal health.

Materials and Methods

Lake Mainit was one of the most productive lakes in the country and is covered by four municipalities, Mainit and Alegria in the province of Surigao del Norte, and Jabonga and Kitcharao of Agusan del Norte province (Figure 1). The people living in the Barangay Poblacion in Jabonga, Barangay Jaliobong in Kitcharao, and Barangay Mansayao in Mainit, surrounding the lake were trusted primarily in fishing and farming as the source of their food and finances. A higher level of health awareness was essential because the lake was a susceptible area for studying various parasites.

Figure 1

Map of Lake, Mainit, Philippines, showing the three selected municipalities



Fish collections

A total of 180 wild fish samples were collected from Lake Mainit, especially from the municipalities of Jabonga (n=60), Kitcharao (n=60), and Mainit (n=60), surrounding Lake Mainit, in Caraga Region, in the Philippines. The fish collection was done in two index seasons (June and November, 2019) in each of the municipalities. A minimum of 30 fish samples were collected per season purposively with the help of local fishers, and the collection interval per town was taken in a one-week duration. The fish were collected through gill nets, sorted by relative size, and stored in a bucket with ice (Bekele & Hussien, 2015). The fish samples were transported to the Caraga State University Biology laboratory for further examination.

Size structure (length and weight) determination

The fish weight was taken using a digital weighing balance, and the total length was taken using a measuring tape (Abdel- Gaber et al., 2015). The length and weight of the fish were taken in *situ*.

Isolation and identification of diet components in fish

The gut of the fish was carefully removed via cutting and opening the abdominal part with the support of a scalpel or a knife (de Guzman et al., 2015). Then it was placed in Petri dishes for examination (Obande et al., 2017). A spatula was used as a tool for scraping the contents of each gut. The contents were placed on a Petri dish for examination, wherein all the food items in the stomach were counted and identified under a dissecting or compound microscope (Motic) under 40X (Iqbal & Waseem, 2008). The food items of the individual fish were grouped into seven categories: detritus (defined as a dead living thing that has changed in some way that renders it unlike its original form), insect form, snail, shrimp, crab, fish, and plant materials (Mol & Van Der Lugt, 1995).

Isolation and identification of endo-parasites

Each fish was sliced up through the abdomen by making a longitudinal slit on the ventral surface from the anus to a point level with the pectoral fins using a surgical blade. *C. striata* Bloch's alimentary tract was isolated, pulled out, and grouped into the esophagus, stomach, and intestine. The organs were positioned into three separate Petri dishes containing 0.6% physiological saline. For that isolated organ, it was cut longitudinally and observed for parasites under a dissecting microscope (Kawel et al., 2016). The identification of helminth parasites was made according to the study by Moravec & Van (2015), da Silva Pinheiro et al. (2018), and Neves et al. (2020). All recovered endo-parasites were preserved in 70% ethyl alcohol (Leela & Rama Rao, 2014).

Data analysis

Analysis of gut contents

The feeding diet of fish was analyzed through Pearson correlation coefficients wherein it is used to test whether similar prey rankings were obtained using the percentage occurrence (F %), percentage number (N %), and percentage volume (V %).

$$\text{Percentage occurrence (F\%)} = \frac{\text{Number of stomachs that contain a given food item}}{\text{Number of fish stomachs examined}} \times \mathbf{100}$$

$$\text{Percentage numbers (N\%)} = \frac{\text{Number of the stomach which contains a given food item}}{\text{Number of total food items in all fish samples}} \times \mathbf{100}$$

$$\text{Percentage volume (V\%)} = \frac{\text{Volume of one food item found in all fish}}{\text{Volume of all food items in all fish samples}} \times \mathbf{100}$$

Then, the Index of Relative Importance (IRI) for each prey was calculated using the formula.

$$\text{IRI} = (\text{N\%} + \text{V \%}) \times \text{F\%}$$

Determination of food volume

The displacement method was used in measuring the volume of the food item. The volume measurement of each food item was immersed into 10 ml of distilled water in a calibrated graduated cylinder (50 ml). The volume of each food item was calculated using the formula:

$$Vi = Vt - Vw$$

Where;
Vi = is the volume of each food item;
Vt = is the final volume in which food item was already immersed and;
Vw = is the initial known volume of water.

The volume of all food items in all fish samples was calculated this way and was used in obtaining the percentage volume (V%) of diet composition. IRI values are appropriate only for ranking the relative importance of food items and cannot be associated with two groups of the same species (Perpetua et al., 2013; George et al., 2013; Manko, 2016).

Fish parasites

$$\text{Prevalence (\%)} = \frac{\text{Total number of infected fish}}{\text{Total number of fish examined}} \times \mathbf{100}$$

$$\text{Mean Intensity} = \frac{\text{Total number of recovered parasite}}{\text{Number of only infected fish}}$$

IBS SPSS version 20 was used to analyze the correlation and comparison of means tests. To correlate the intensity of recovered endo-parasites, the diet composition, and the length and weight of *C. striata* Bloch, Spearman's rho, and Pearson's correlation analysis were used. To compare the mean intensity of recovered endo-parasites and the diet composition between two index seasons, paired samples T-test was used.

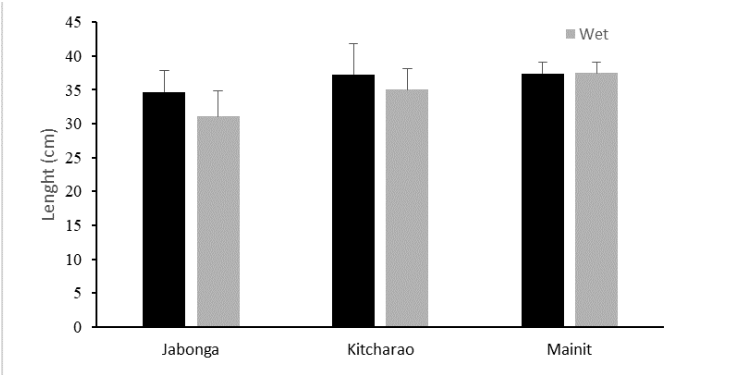
Results and Discussion

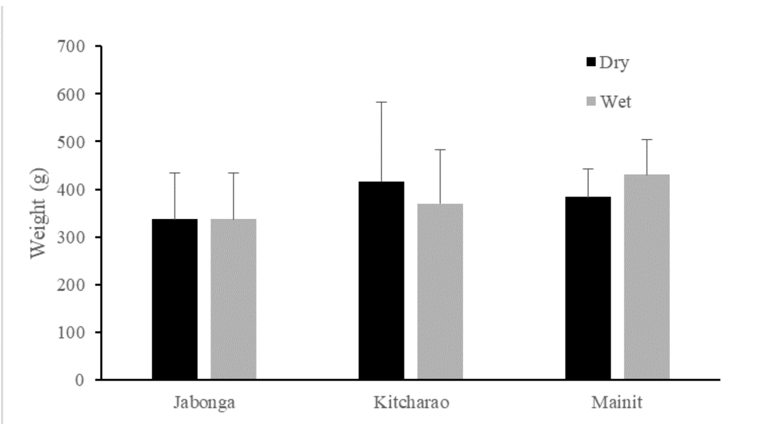
Length and weight distribution of wild fish, *C. striata* Bloch

The distribution of size structures of *C. striata* Bloch collected from the three selected municipalities along Lake Mainit, Caraga Region, Philippines, varies in length and weight between dry and wet seasons (Figure 2). The mean length of *C. striata* was 35.5 ± 3.9 cm (n=90) across sites and highest in Brgy. Mansayao, Mainit (37.5 ± 1.6 cm, n=30) during dry season. Meanwhile, the mean weight was 379 ± 111 cm (n=90) and the highest in Brgy. Mansayao, Mainit (430 ± 73 cm, n=30) during wet season. As to seasonal variations of size structures, the dry season recorded a higher mean length of *C. striata* (36.5 ± 3.5) than the wet season. Both seasons recorded similar mean weight (378 g) of the fish in the three municipalities. The correlation between the length and weight size of *C. striata* Bloch collected from the three municipalities in two indexed seasons (wet and dry) shows a positively high correlation (r2 = 0.76, p<0.05) during the dry season (Figure 3A). In contrast to wet season data shows a positively low correlation (r2= 0.24, p<0.05) (Figure 3B).

Figure 2

The average (a) length and (b) weight of C. striata Bloch collected during two indexed seasons (dry and wet) from the three selected municipalities (Barangay Poblacion, Jabonga; Barangay Jaliobong, Kitcaharao, and Barangay Mansayao, Mainit) along Lake Mainit, Caraga Region, Philippines

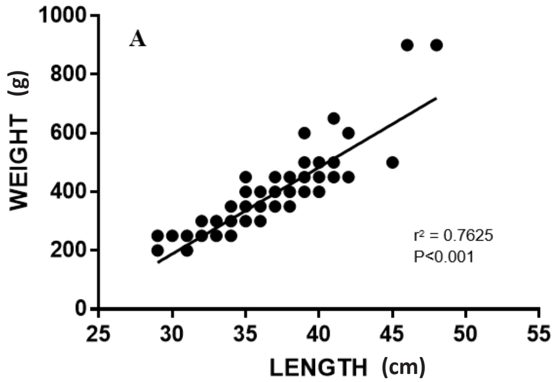


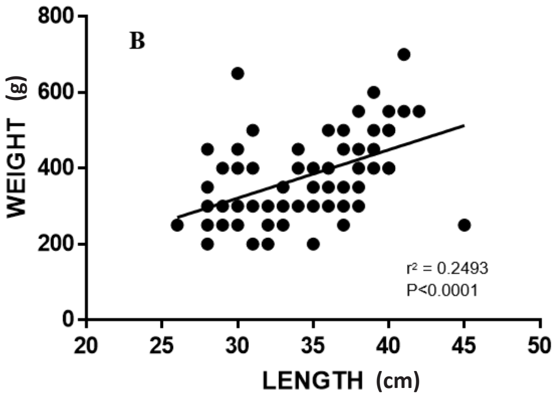


The importance of length and weight is enough in the computation of the average weight at a given length group, and also it is used in assessing the relative well-being of a fish population (Ndiaye et al., 2015). The relationship between total length and other body weights is essential for stabilizing the taxonomic character of the species (Usip, 2013). The growth of fish generally indicates increased length and weight, which is a suitable characteristic for determining the population analysis at a particular time (Sastrellas, 2014). Changes in the LWR can vary by significant factors such as the population, season, food availability, sex, environmental conditions, or physiology (Froese, 2006). Apart from these factors, which are directly related to the fish, the ecosystem's health associated with the effects of human activities such as logging and aquaculture encompassing the detrimental quality could be another cause (Hamid et al., 2015).

Figure 3

Correlation of the length and weight distribution of C. striata Bloch during (A) dry and (B) wet seasons in three selected municipalities (Barangay Poblacion, Jabonga; Barangay Jaliobong, Kitcaharao, and Barangay Mansayao, Mainit) along Lake Mainit, Caraga Region, Philippines



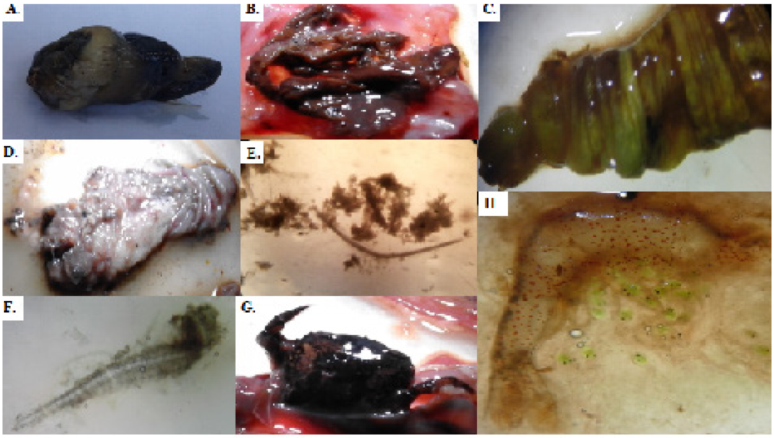


Food composition of wild *C. striata* Bloch

The food composition in the stomach of *C. striata* Bloch was obtained during the dry and wet seasons. The collected food items of the fish samples were identified and categorized as detritus, insect, snail, shrimp, fish, plant debris, and crab (Figure 4). The IRI value suggests that shrimps were an essential food item consumed in both seasons among the seven food types of fish samples. Indeed, during the wet season, the shrimp has the highest IRI percentage value of 47.52, followed by the fish (24.36), plant debris (20.67), crab (6.21), snail (19.81), insect (0.21), and detritus (1.38). In the dry season, the shrimp has the IRI % value of 44.52, plant debris (19.17), fish (14.06), crab (2.06), and detritus (0.38).

Figure 4

Food items found in the stomach of Channa striata Bloch in three selected municipalities along Lake Mainit, Caraga Region: (A.) snail; (B.) detritus; (C.) aquatic insect; (D.) fish; (E.) plant debris; (F.) part of the fish; (G.) crab; and (H.) shrimp



Fishes were fed a variety of food items that they could find in the water bodies. However, the food and feeding habits of the fishes vary in factors, like the seasons of the year, the size of fish, and the phenomenon of the ontogenicity (Alam, 2013). In both seasons, shrimps were the essential food item of the fish samples because the shrimp was abundant in the aquatic ecosystem, and shrimp and the fish samples dwell in the same habitat (Adedokun & Fawole, 2015). Aside from that, the food and feeding habits of *C. striata* Bloch were related to the size of the fish because most of the sizes of fish samples ranging from 30-42 cm, are preferred to prey on shrimps. This research has supported the study of diet composition of freshwater fish chevron snakehead *C. striata* Bloch conducted in the subtropical island that for those fish samples standard length ranging of 35-45 cm they are mainly to prey on the shrimps (Li et al., 2016). Hence, shrimps were the most important prey item in both seasons.

The aquatic insect and detritus in this study have a minimal occurrence because, according to the study in Miami, Florida indicates, the seasons of the year can influence fish feeding patterns (Hammerschlag et al., 2010), that it might be the availability of the prey item was limited on the habitat (George et al., 2013). However, the prey item such as plant debris in this study was also in the maximum occurrence of 20.67% in the IRI percentage because most of the fish samples, during their spawning season, gathered more plants to use as the source of their foods and especially for their niche breeding (Yulintine et al., 2017). Moreover, the food items such as crab and snail were reported as incidental food items in the fish samples in this study may be due to their voracious habits, or maybe these species were not desirable by many other fishes (Krumme et al., 2007).

Table 1

Percentage of the most important food item found in the stomach of C. striata Bloch between dry and wet seasons in three selected municipalities along Lake Mainit, Caraga Region, Philippines

Season	Food Category	Percentage Occurence (O%)	Numerical Percentage (N%)	Volumetric Percentage (V%)	IRI* (%)
Dry	Detritus	1.11	1.75	7.40	0.38
	Aquatic insect	-	-	-	-
	Snail	-	-	-	-
	Shrimp	20.00	31.58	28.57	44.52
	Fish	11.11	17.54	16.67	14.06
	Plant debris	16.67	26.32	4.76	19.17
	Crab	3.33	5.26	11.50	2.06
Wet	Detritus	3.33	4.05	9.09	1.38
	Aquatic insect	1.11	1.35	4.76	0.21
	Snail	7.78	12.28	56.52	19.81
	Shrimp	22.22	33.78	33.33	47.16
	Fish	16.67	20.27	25.93	24.36
	Plant debris	20.00	27.02	5.66	20.67
	Crab	5.56	6.76	28.57	6.21

**IRI = Index of Relative Importance.*

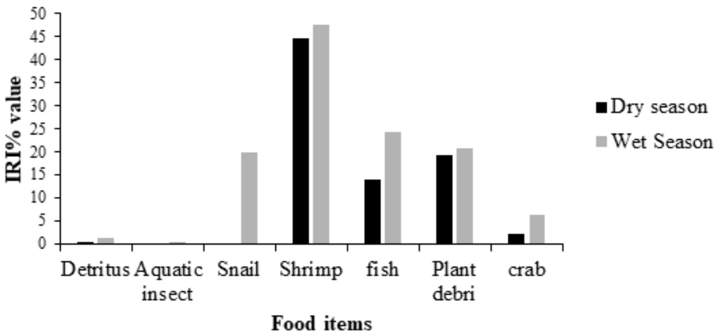
Seasonal variation of diets in the stomach of wild *C. striata* Bloch

There were changes in the food items of the fish samples between the two index seasons. The results showed that during the wet season, food items were more abundant than in the dry season (Figure 5). The food volume of the fish samples in this study was similar to the study conducted at three floodplain lakes in Agusan Marsh wildlife sanctuary in the Philippines (Talde et al., 2004). The study reported that the food volume of *C. striata* Bloch and other important fishes dwelling in Agusan marsh was bigger at the onset of rainy seasons starting from late November than during the following dry seasons in late May or early June. The study revealed that during wet seasons there are numerous possibilities that the food items can be found in the water bodies because the availability of the prey item exists in large numbers; hence, it can supply and provide the demands of foods for the fishes (Talde et al., 2004).

However, in the dry season, according to Vijaysundardeva et al. (2018), the dropping water level can affect the availability of the prey item, causing less production of fish food organisms. During the low water period, the fish might be devoted to other activities such as resting or digesting (Krumme et al., 2007). This result was supported by the study of Hammerschlag et al. (2010); the seasonal diet and feeding habits of some fishes showed that the feeding intensity of the fishes was significantly lower during the dry season because the water temperatures fluctuated, and their result consisted with the others data suggesting that fish feeding rates decrease as water temperature drops and these can reduce the food abundance and lowered the fish metabolism (Hammerschlag et al., 2010). Additionally, *C. striata* Bloch had a large percentage of empty stomachs during the dry season, which increased as the dry season proceeded (Talde et al., 2004). The aquatic insect and the snail in this study were retrieved during wet seasons and not obtained in dry seasons. Kakkeo et al. (2014) reported that it might be the *C. striata* Bloch that showed an intensive feeding pattern that when the resources of the prey item become deficient, the fish shift to other available diets. Other authors suggested that it might be due to the quick digestion of the prey item inside the stomach of *C. striata* (Punchihewa & Krishnarajah, 2013).

Figure 5

Index of Relative Importance (IRI) percentage values of Channa striata Bloch diet composition between two index seasons in three selected municipalities along Lake Mainit, Caraga Region, Philippines



According to the study of Punchihewa & Krishnarajah (2013), during the breaking down of the foods inside the stomach of *C. striata* Bloch, the food item was precisely prepared to run out in just 45-50 seconds. This event can hinder the identification of the food item inside the stomach of the fish. In addition, some studies revealed that due to the limited availability of the prey item in the habitat or the phenomenon of ontogeny (George et al., 2013). According to the study of dietary habits of some fish species in the Pansipit River in Lake Taal, Luzon, Philippines, the fish *Glossogobius giuris* undergo various ontogenic diet shifts (Mendoza et al., 2015). The study reported that during the ontogeny of the fish, they often change their diet because of morphological changes to utilize sequentially series of prey ranging from small to much larger prey (Bejer, 2015). However, this research study corroborated the study of the food and feeding habit of *C. punctatus* that the feeding behavior of the fish showed a variation due to fluctuation in the availability of different food items in different seasons. Their data agreed with those who reported that *Tilapia nilotica* changed its food habit with the change in its season (Saikia et al., 2015).

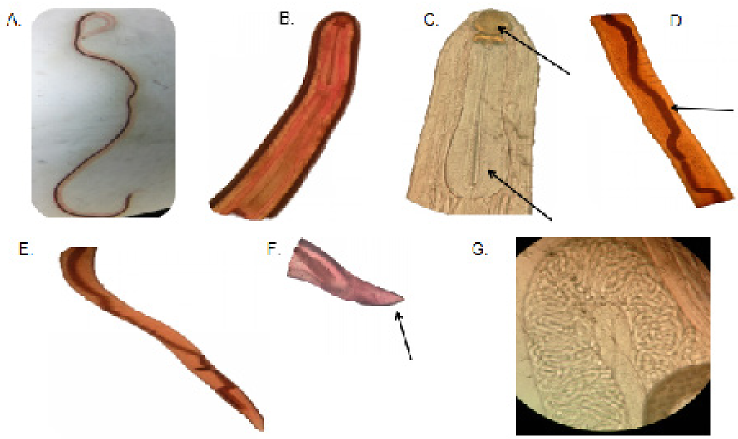
Endoparasites (Nematode)

In the examination period, only one group of parasite species recovered from the gut of wild *C. striata* Bloch in three selected municipalities in Lake Mainit, the nematodes. The isolated nematode parasites were identified as *Procamallanus* sp. (Figure 6).

The *Procamallanus* sp. is a group of parasite species occupying the largest nematode genera (Tajbakhsh et al., 2012). Most of this parasite is inhibited in the fish's intestine and stomach. Inside the gut, this parasite was recognized through its color until its third and fourth stage larvae (Santos et al., 1999). Through the aid of a microscope, these parasites were noticed to be colorless, but the adult was identified as a red-like worm and medium in size. Most of these parasites are too tiny and cannot be seen without a dissecting microscope. The morphology of this nematode parasite was cylindrical and slightly had a narrowed front (Iyaji & Eyo, 2008). It has an esophagus and the presence of spicules. The males had a gubernaculum; however, this parasite's conical tail had a digit-like tail process. The female reproductive organ and this parasite's eggs can be seen via scanning electron microscope supplemented with molecular analyses (Gallas et al., 2015).

Figure 6

Procamallanus sp. parasite isolated from the gut of C. striata Bloch in three selected municipalities along Lake Mainit, Caraga Region. (A.) Whole mount (LPO:100X); (B.) anterior end (HPO: 400X); (C.) buccal capsule and esophagus (HPO:400X); (D.) intestine (HPO:400X); (E.) posterior end (HPO: 400X); (F.) caudal end (HPO: 400X); (G.) larvae (OIO Lens)



The *Procamallanus* sp. possessed a thin cuticle, but striations of this parasite species were not present on the body (Iyaji & Eyo, 2008). Several studies throughout the world revealed some evidence regarding the infection of *Procamallanus* sp. that this parasite does not infect humans and others. However, it can only parasitize freshwater, brackish water, marine fishes, and, less often, amphibians (Agrawal, 2011). *Procamallanus laevionchus* and *Spirocamallanus spirallis* are examples of nematode parasites reported from fish hosts of six different families. *Procamallanus* sp. parasite was said to be nonpathogenic despite the secure attachment of their buccal capsule to the stomach mucosa (Mashego et al., 2015).

Seasonality of parasite load of wild *C. striata Bloch*

During the examination of the study in the dry season, 70 of the fish individuals were infected, and in the wet season, 63 of the fish samples were also infected by *Procamallanus* sp. A total of 334 *Procamallanus* sp. were recovered out of 180 wild fish *C. striata* Bloch (Table 2). The proliferation of the parasites in their freshwater hosts can be influenced by specific factors such as the water temperature and the breeding season of the fish samples (Iyaji et al., 2009). Parasite count and the number of infected hosts varied between dry and wet seasons due to the water temperature in the water bodies. The study by Ningthoukhongjam et al. (2015) revealed that when the environmental condition, such as the water temperature and the food items of the fish samples, become favorable for mass production of the parasites, the parasitic diseases may spread very quickly. However, during wet seasons, the less production of the parasites was due to the presence of estrogen in the fish that can inhibit the growth of the parasites. Yulintine et al. (2017) state that in nature, snakehead fishes will breed once a year, and it will happen during rainy seasons. Accordingly, the occurrence of the parasites was fewer in the fish samples. The result of this research was corroborated by the study conducted in west Bengal, India. It was suggested that the occurrence of the parasites in the hosts was less due to the presence of estrogen in the hosts (Vijaysundardeva et al., 2018).

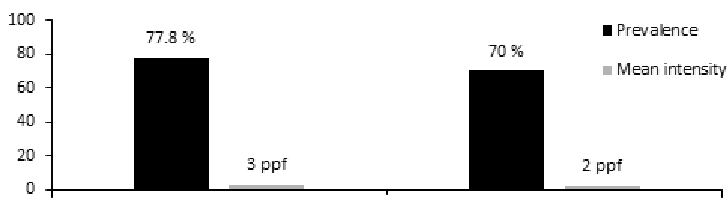
Prevalence and mean intensity of endo-parasites in wild fish, *C. striata* Bloch

The overall result of the prevalence and mean intensity of recovered endo-parasites in the gut of *C. striata* Bloch were calculated between two index seasons. The genus of *Procamallanus* sp. was the most prevalent parasite, 77.8% during the dry season and 70% during the wet season, with a mean intensity of 2 and 3, respectively (Figure 7).

Parasitic diseases of fish are widespread throughout the world. Fish parasites are an integral part of aquatic ecosystems and are commonly found in wild and aquacultural systems (Ningthoukhongjam, 2015). Seasons of the year can influence parasite collection. The result of the high prevalence of the *Procamallanus* sp. during dry compared to wet was due to the factors that could influence the collection of the parasite in the host. Factors such as physiology, water temperature, and feeding habits directly influence the seasonality of parasitic fauna of the fish samples (Khundo & Bhuiyan, 2016). It was reported that the prevalence and mean abundance of the four parasites species were higher during dry months than wet months, and it was explained that increasing transmission in the dry season was probably due to higher evaporate-transpiration rate leading to reduced water volume, habitat of the fish, contraction, higher host and parasite densities and due to this event more contact was made between the host and the parasite that can cause parasite transmission (Okoye et al., 2014).

Figure 7

Prevalence and mean intensity of Procamallanus sp. in Channa striata Bloch between dry and wet seasons in three selected municipalities along Lake Mainit, Caraga Region, Philippines. Mean intensity (parasite per fish-ppf)



Seasonality comparison of parasite count and diet count in three selected municipalities along Lake Mainit

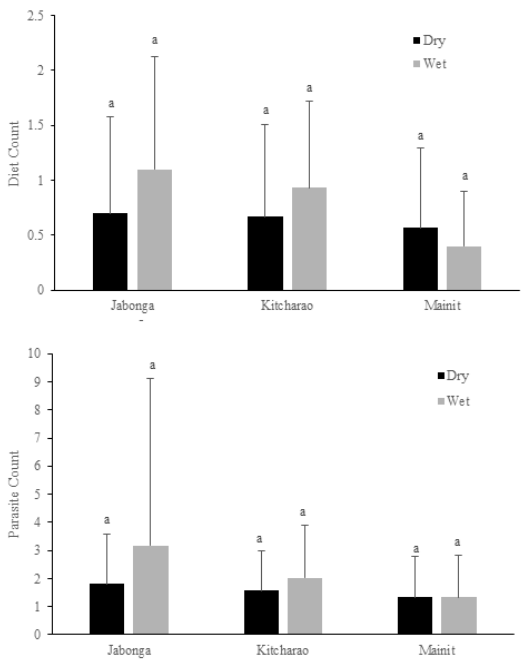
A comparison of the intensity of parasite count and diet count between dry and wet season were obtained. Results revealed that the parasite count and diet have no significant variations among sampling sites (Figure 8A). It was noted that fish obtained from the municipality of Jabonga have the highest parasite count and also showed the highest diet count (Figure 8B). Similarly, the parasite and diet count did not vary between dry and wet seasons.

Lake Mainit was rich in aquatic biota, including the emergent and submerged plants, and *C. striata*

Bloch was one of the abundant among the other fishes that inhabit Mainit Lake. The negative comparison between the parasite count and the diet count in both seasons might be due to the competition and predation risk of the fish samples. The competition for food items may possibly be higher among related species with overlapping food preferences. The result of this study was supported by the studies of Hammerschlag (2010) and Talde et al. (2004), who suggested that competition for the food item among fish was high, ultimately driving their resource. However, predation risk could be a factor because some fish should come before searching for food for their safety and their relative (Hammerschlag, 2010).

Figure 8

Comparison of means of (a) parasites count and (b) diet count of C. striata Bloch in three selected municipalities along Lake Mainit, Caraga Region, Philippines. Error bars indicated the standard deviation of the mean



Correlation of the intensity of the recovered endo-parasites and length and weight of *C. striata Bloch*

The association between the intensity of the parasite load and the length and weight of *C. striata* Bloch was also determined in this study. This research study found that most of the length and weight of the fish samples show no significant relationship to the parasite count. However, the length ($r= 0.485$, $p= 0.007$) and weight ($r= 0.415$, $p= 0.023$) showed significant relationship (Table 2).

The correlation between the intensity of the parasitism was not influenced by the host size of the fish samples may be due to the development of the immunity reaction of the fish (Iyaji et al., 2009). This result was supported by the study conducted in Lake Manzala, Egypt. The study revealed that there was no significant difference in the host size and parasitic infection of the parasites (Abdel-Gaber et al., 2015) as this may be attributed to probably low-level immunity in small size of fish. The study also reported that parasitic helminth infection was recorded in different weights, but helminth parasites were more infested in smaller weight groups, and the smaller size was more susceptible to parasitic infections than bigger ones (Usip, 2013). Thus, small fish tend to harbor many helminth parasites.

Table 2

Association between the intensity of parasite and the length and weight of C. striata Bloch in three selected municipalities along Lake Mainit, Caraga Region. Tested in Spearsman's rho

Sampling area	Season	Variable	Correlation Coefficient	p-value
Brgy. Poblacion, Jaboanga	Dry Season	Length	0.256	0.173
		Weight	0.293	0.116
	Wet Season	Length	-0.299	0.224
		Weight	- 0.222	0.238
Brgy. Jaliobong, Kitcharao	Dry Season	Length	0.485	0.007*
		Weight	0.415	0.023*
	Wet Season	Length	-0.189	0.318
		Weight	-0.190	0.315
Brgy. Mansayao, Mainit	Dry Season	Length	-0.028	0.882
		Weight	0.066	0.729
	Wet Season	Length	-0.057	0.767
		Weight	0.000	1.000

**Significant in p=0.05 level.*

On the other hand, the significant relationship in this study shows that the intensity of the parasite count influences the host size. Therefore, the growth of the fish samples was stunted but not as strong according to the other studies (Kaur et al., 2013) due to the feeding habits of the host. According to the study, parasites showed selective infestation in the larger host because the host of the large size covers more extensive areas in searching for food, and this could expose them to infection by more parasites, and also the host of bigger size have more space, more flux of energy and hence, they are micro-habitats for parasites than small hosts (Iyaji et al., 2009). According to the study, the normal growth of the fish samples was impeded if they were heavily infested with endo-parasites (Alam et al., 2010).

Correlation of the intensity of the parasite count and diet count of *C. striata* Bloch

The results of the study indicated that parasite count and diet count have a strong positive correlation as shown in the table below.

The feeding habits of the fish are among the most influential factors in the information of parasitic fauna (Carvallho et al., 2015). *C. striata* Bloch was reported as a highly carnivorous species. This kind of behavior exposed the fish to the easy transmission of the parasites from invertebrate intermediate hosts and fish intermediate hosts (Bekele & Hussien, 2015) because the fish samples were fed on already infected fish and other animals that serve as the second hosts of the parasites (Carvallho et al., 2015). In accordance with the study conducted in Brazil, the feeding habits of the *C. gariepinus* were found to be the most susceptible species to helminth infection due to its less prey selection or the carnivorous behavior of the fish (Bekele & Hussien, 2015). Thus, the intensity of the parasite load was associated with the diet count of the fish samples.

Table 3

Association between parasite count and the diet count of C. striata Bloch in three selected municipalities along Lake Mainit, Caraga Region, Philippines. Tested in Pearson Correlation.

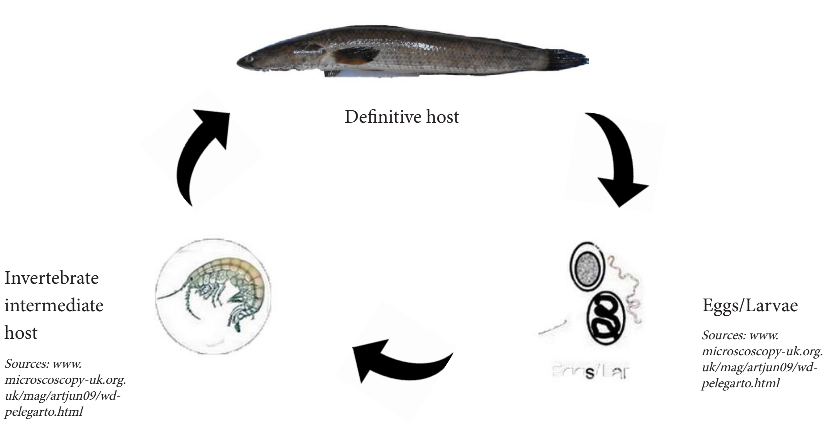
Sampling area	Season	Correlation Coefficient	p-value
Brgy. Poblacion, Jaboang	Dry Season	0.693	0.000*
	Wet Season	0.902	0.000*
Brgy. Jaliobong, Kitcharao	Dry season	.577	0.001*
	Wet season	.891	0.000*
Brgy. Mansayao, Mainit	Dry season	.713	0.000*
	Wet season	.881	0.000*

**Significant in p=0.05 level.*

Procamallanus sp. was the only parasite isolated from the gut of *C. striata* Bloch between two index seasons. Mostly these nematode parasites were inhibited in the intestine of the host. It had a complex indirect life cycle that needed an invertebrate intermediate host or intermediate fish hosts for parasite transmission (Figure 9).

Figure 9

Showing the indirect life cycle of Procamallanus sp. in their freshwater hosts.



The adult of *Procamallanus* sp. release their eggs/larvae in the water and are eaten by the intermediate hosts such as the aquatic insect, shrimps, and fish. Since shrimps were more copious food items of the fish samples in both seasons and served as invertebrate intermediate hosts, it is possible that shrimp containing third-stage larvae (L3) of the parasite was eaten by the fish and became definitive hosts of the parasite. Once the shrimp carry the L3 stages was eaten by a fish and digested Santos et al. (1999). The nematode parasites migrate into the body cavity and over the external surface of internal organs. The host's death might stimulate the nematodes to emerge from their cysts, migrate through the body wall to the surface of their dead host, and may survive for over 24 hours when a dampened condition exists. In accordance to the study conducted in California that the fish *Atherinopsis californiensis* was harbored by *Procamallanus (Spirocamallanus) pereirai* due to heavily preying on white shrimps *(Penaues setiferus)* containing at third stage larvae of *P. (S.) pereirai* was the cause of the infection (Santos et al., 1999).

Conclusion

A total of 180 wild *Channa striata* Bloch having a standard mean length (31-40 cm) and mean weight (200-500 grams) were used in the study between dry and wet seasons. A total of 334 *Procamallanus sp.* were obtained in this study. The prevalence of *Procamallanus sp.* during the dry season was 77. 8% and 70% in the wet season. The food item recovered was the shrimp in both seasons, with the highest IRI percentage value of (47.16%) in wet and (44.52%) in dry. The association between the length and weight of the fish and the parasite count shows a negative relationship. However, the association between the parasite count and the diet count shows a strong positive correlation at the level of $p=0.05$. The comparison of means intensity of the parasite count and diet count in this study generally shows a negative relationship between the two index seasons. Thus, *C. striata* Bloch is susceptible to *Procamallanus sp.* nematode infection because its carnivorous diets serve as the vector of helminth parasites in freshwater. It is recommended further to use a large population of fish size to examine and determine the presence of other parasites. The hosts' age, sex, the infection rate of the fish organs, and assessment of the physico-chemical parameters for future studies must be assessed.

References

Abdel- Gaber, R., El- Garhy, M., & Morsy, K. (2015). Prevalence and intensity of helminth parasites of African Catfish *Clarias gariepienus* in Abuja, Sokoto. *Journal of Veterinary Sciences*, *14*, 26-33.

Adedokun, M. A. & Fawole, O. (2015). Diet composition of african catfish pike *Hepsetus odoe* (Bloch) in Ikole/lluju Reservior, Oyo State, Nigeria. *International Journal of Engineering and Advanced Research Technology*, *1*(1).

Agrawal, V. (2011). On a new nematode, P*rocamallanus inuelleri n.s.p.* from the stomach of a freshwater fish. *Heteropnuestes fossilis*.

Alam, J. Md., Rakibuzzaman, Md., & Mahmudul Hassan, M. (2010). Comparative study of endo-parasitic infestation in *Channa punctatus* (Bloch, 1793) collected from hatchery and sewage lagoon. *Nature and Science*, *8*(5), 152-56.

Arslan, M., Yildirim, A., & Bektas, S. (2004). Length- weight relationship of Brown trout, *Salmo trutta* L., Inhabiting Kan Stream, Coruh Basin, North- Eastern Turkey. *Turkish Journal of Fisheries and Aquatic Sciences*, *4*, 45-48.

Bejer, J. B. (2015). Ontogenetic variation in the diet composition of *Glossogobius guiris* from Lake Taal, Batangas, Philippines. *Asia Pacific Journal of Multidisciplinary Research*, *3*(4), 95-100.

Bekele, J. and Hussien, D. (2015). Prevalence of internal parasites of *Oreochromis niloticus* and *Clarias gariepinus* fish species in Lake Ziway Ethopia. *Journal of Aquaculture Research and Development*, *6*, 308.

Biña-de Guzman, A., Uy, W. H., Gorospe, J. G., & Openiano, A. E. (2013). A fisheries in crisis: Threatened biodiversity and fish production of Lake Mainit, northeastern Mindanao. In M. L. C. Aralar, A. S. Borja, A. L. Palma, M. M. Mendoza, P. C. Ocampo, E. V. Manalili, & L. C. Darvin (Eds.). *LakeCon2011: Building on the pillars of Integrated Lake Basin Management* (Second National Congress on Philippine Lakes) (pp. 314-15). Los Baños, Laguna, Philippines: PCAARRD-DOST.

Bouwmeester, M. M., Goedknegt, M. A., Poulin, R., & Thieltges, D.W. (2020). Collateral diseases: aquaculture impacts on wildlife infections. *Journal in Applied Ecology*, *58*(3), 1365–2664:13775. https://doi.org/10.1111/1365-2664.13775

Carvallho, R. P. S., Takemoto, R. M., Melo, C. M., Jeraldo, V. L. S., & Madi, R.R. (2015). Structure of the parasite infracommunity of Sciades proops from the Japaratuba River Estuary, Sergipe, Brazil. *Brazillian Journal of Biology*, *75*(4), 906-13.

Cirtwill, A. R., Stoufer, D. B., Poulin. R, & Lagrue, C. (2015). Are parasite richness and abundance linked to prey species richness and individual feeding preferences in fsh hosts? *Parasitology*, *143*, 75–86. https://doi.org/10.1017/S003118201500150X

Cox, S. P., Essington, T. E., Kitchell, J. F. et al. (2002). Reconstructing ecosystem dynamics in the central Pacifc Ocean, 1952–1998. II. A preliminary assessment of the trophic impacts of fishing and effects on tuna dynamics. *Canada Journal Fish Aquatic Science*, *59*, 1736–1747. https://doi.org/10.1139/f02-138

Cuayan, G., Briones, J. C., De Leon, E., Gonong, J. A., Pasumbal, E. O., Pelayo, M. C. I., Pinera, M. A, & Papa, R. D. (2013). Initial assessment of parasite load in *Clarias batrachus*, *Glossogobius giuris* & *Oreochromis niloticus* in Lake Taal Philippines. *Philippine Science Letters*, *6*(1), 21-28.

de Guzman, A. Dr., Uy, W. H. Dr., Gorospe, J. Dr., Openiano, A., Acuna, R., Roa, R.L., Garcia, J.P., Ologuin, M. M., & Santamina, J. R. (2008). *Sustainable Fisheries Management Program for Lake Mainit Progress Report*. MSU Naawan Foundation for Science and Technology Development, Incorporation.

de Guzman, C. E., Tampus, A. D., Valdez, S. A. L., Tumang, V. M. C., Moneva, C. S. O., & Cnanalita, E. E. (2015). Species composition and gut analysis of fishes in Mandaluyong River system, Iligan City. *Advances Environmental Biology*, *9*(19), 23-31.

da Silva Pinheiro, R. H., de Vasconcelos Melo, F. T., Monks, S., Dos Santos, J. N., & Giese, E. G. (2018). A new species of *Procamallanus baylis*, 1923 (Nematoda, Camallanidae) from Astronotusocellatus (Agassiz, 1831) (Perciformes, Cichlidae) in Brazil. *ZooKeys*, *790*, 21.

Froese, R. (2006). Cube Law, condition factor and length-weight relationships: history, meta-analysis and recommendation. *Journal in Applied Ichthyology*, *22*, 241-253.

Gallas, M., Calego- Marquez, C., & Bencke-Amato, S. (2015). *Procamallanus (Spiculoguber naculus Agarwal*, 1958 *(Nematoda: Camallanidae)* from stinging catfish, Heteropneustes fossilis in India: Morphological characterization and molecular data. *Helminthologia*, *54*(1), 68-76.

George, U. U. (2013). Diet composition and condition factor of Ethmalosa fimbriata in the Cross River Estuary. *Greener Journal of Biological Sciences*, *3*(6), 244-252.

Graham, B., Grubbs, D., Holland, K., & Popp, B. N. (2007) A rapid ontogenetic shift in the diet of juvenile yellowfin tuna from Hawaii. *Springer*, *150*, 647–658. https://doi.org/10.1007/s00227-006-0360-y

Hamid, M. A., Mansor, M., & Mohd Nor, S. A. (2015). Length-weight relationship and condition factor of fish populations in temengor reservior: Indication of Environmental Health. *Sains Malaysiana*, *44*(1), 61-6.

Hammerschlag, N., Ovando, D., & Serafy, J. E. (2010). Seasonal diet and feeding habits of juvenile fishes foraging along a subtropical marine ecotone. *Aquatic Biology*, *9*, 279-290.

Iqbal, Z. & Waseem, M. (2008). Gut content of freshwater catfish Rita rita (Hamilton) from river Sutlej, District Kasur, Pakistan. *Punjab University Journal Zoology*, *23*(1), 27-35.

Iyaji, F. O., & Eyo, J. E. (2008). Parasites Assemblages in Fish Host. *Biology of Research*, *7*(2), 561-570.

Iyaji, F. O., Etim, L., & Eyo, J. E. (2009). Parasite Assemblages in Fish Hosts. *Biology Research*, *7*(2), 561-570.

Kakkaeo, M., Chittapalapong, T., & Villanueva, M. C. (2004). Food Habits, Daily Ration and Relative Food Consumption in Some Fish Populations in Ubolratana Reservior, Thailand. *Asian Fisheries Science*, *17*, 249-259.

Kaur, P., Shrivastav, R., & Qureshi, T. A. (2013). Effect of helminth parasitic load on the length weight-ratio of fresh water fish, *Channa striatus*. *Bioscience Biotechnology Reseach Communications*, *6*(2), 208-2011.

Kawel, S. M., God'spower, R. O., Balarabe, M. R., & Akaniru, R. I. (2016). Prevalence of gastrointestinal helminth parasites of *Clarias gariepinius* in Abuja, Nigeria. Sokoto. *Journal of Veterinary Sciences*, *7*, 26-33.

Khundo, S., & Bhuiyan, A. L. (2016). Abundance of helminth parasite in *Channa striatus* (Bloch,1793) from punarbhaba and atrai rivers. *Dhaka University Journal of Biology Science*, *25*(1), 39-46.

Kleinertz, S., Klimpel, S., & Palm, H. W. (2012). Parasite communities and feeding ecology of the European sprat *(Sprattus sprattus L.)* over its range of distribution. *Parasitology Research*, *110*, 1147–1157. https://doi. org/10.1007/s00436-011-2605-z

Klimpel, S., Rückert, S., Piatkowski, U., Palm, H. W., & Hanel, R. (2006). Diet and metazoan parasites of silver scabbard fish *Lepidopus caudatus* from the Great Meteor Seamount (North Atlantic). *Mar Ecol Prog Ser*, *315*, 249–257. https://doi.org/10.3354/meps315249

Klinger, R. E. & Floyd, R. F. (2002). *Introduction to Freshwater Fish Parasites*. Institute of Food and Agriculture Sciences. http://edis.ifas.ufl.edu.

Koepper, S., Nuryati, S., Palm, H. W., Wild, C., Yulianto, I., & Kleinertz, S., (2022). Metazoan endoparasite fauna and feeding ecology of commercial fishes from Java, Indonesia. *Parasitology Research*, *121*, 551–562.

Krumme, U., Keuthen, H., Saint-Paul, U., & Villwock, W. (2007). Contribution to the feeding ecology of the banded puffer fish *Colomesus psittacus* (Tetraodontidae) in north Brazilian mangrove creeks. *Brazillian Journal of Biology*, *67*(3), 383-392.

LMDA-Lake Mainit Development Alliance. (1999). Agusan del Norte and Surigao del Norte. *PWG NRM Alliance Documentation Visit Report*. 19 to 22 February 2007.

Lafferty, K. D. (1997). Environmental parasitology: what can parasites tell us about human impacts on the environment? *Parasitology Today*, *13*(7), 251–255. http://dx.doi.org/10.1016/

Lampert, W. & Sommer, U. (1997). *Limnoecology*. The Ecology of Lakes and Streams New York, Oxford University Press.

Leela, B. & Rama Rao, K. (2014). Nematode parasites in a freshwater fish *Glossogobius giuris* (Hamilton-Buchanan, 1822) at Lower Manair Dam, Karimnagat Dt. Andhra Pradesh, India. *Journal of Pharmacy and Biological Sciences*, *9*(2), 37-40.

Li, K.c., Shieh, B., Chiu, Y., Huang, D., & Liang, S. (2016). Growth, Diet Composition and reproductive Biology of the Invasive Freshwater Fish Chevron Snakehead *Channa striata* on a subtropical Island. *Zoological Studies*, *55*, 53.

Manko, P. (2016). *Stomach content analysis in freshwater fish feeding ecology*. Institute of Vertebrate Biology, Academy of Sciences (pp.49-50).

Mashego, J. E. (1981). Observations on the prevalence of nematode parasites of the catfish, Clarias gariepinus (Burchell 1811), in Lebowa, South Africa. South African. J*ournal of Wildlife Research*, *11*(2), 46-48.

Mendoza, U. T., Legaspi, K. L., Acojido, M. G., Cabias, A. C., de Guzman, J. L., Favila, A. M., Lazo, S. M., Rivera, J. B., Briones, J. C., & Papa, R. D. (2015). Dietary Habits and Distribution of Some fish Species in the Pansipit River- Lake Taal Connection, Luzon, Island, Philippines. *Journal of Environmental Sciences*, *18*(2), 1-9.

Miah, F. Md., Deb, M., Ali, H., Quddus, M. M. A, & Ahmed, K. (2013). Comparative Surveillance of Parasitic Infestation in *Channa punctatus* (Osteichthys: Channidae) collected from open and closed water in sylhet, Bangladesh. *Advances in Zoology and Botany*, *1*(1), 17-23.

Mol, J. H. & Van Der Lugt, F. L. (1995). Distribution and feeding ecology of the african tilapia *Oreochromis mossambicus* (Teleostei, Perciformes, Cichlidae) in Suriname (South America) With Comments on the Tilapia-Kwikwi *(Hoplosternum littorale)* (Teleostei, Siluriformess, Callichthyidae) interaction. *Acta Amazonica*, *25*(1/2), 101-16.

Moravec, F. & Van As, L. L. (2015). *Procamallanus (Procamallanus) spp.* (Nematoda: Camallanidae) in fishes of the Okavango River, Botswana, including the description of *P.(P.) pseudolaeviconchus n. sp.* parasitic in *Clarias spp.(Clariidae)* from Botswana and Egypt. *Systematic parasitology*, *90*(2), 137-149.

Muthmainnah, D. (2013). Growout of stripe snakehead *(Channa striata)* in swamp water system using fences and cages. I*nternational Conference on Biology Environmental and Chemistry*, *58*(11).

Ndiaye, W., Diouf, K., Samba, O., Ndiaye, P., & Panfili, J. (2015). The Length-Weight Relationship and Condition Factor of white grouper (*Epinephelus aeneus*, Geoffroy Saint Hilaire, 1817) at the South-West coast of Senegal, West Africa. *International Journal of Advanced Research*, *3*(3), 145-53.

Neves, L. R., Silva, L. M. A., Florentino, A. C., & Tavares-Dias, M. (2020). Distribution patterns of *Procamallanus* (Spirocamallanus) *inopinatus* (Nematoda: Camallanidae) and its interactions with freshwater fish in Brazil. *Revista Brasileira de Parasitologia Veterinária*, *29*.

Ningthoukhongjam, I., Singh Ngasepam, R., Chabungbam, B., & Shomonrendra, M. (2015). Helminthes Parasites Infection of the fishes of Nambol locality, Bishnupur District, Manipur. *International Journal of Current Research*, *7*(1), 11299-302.

Northrop-Clewes, N. & Shaw, C. (2000). Parasites. *British Medical Bulletin*, *56*(1), 193-208.

Obande, R. A., Omeji, S., & Adadu, M. O. (2017). Length-weight relationship, Diet compositon and

Condition Factor of Clarotes laticeps from Lower River Benue. *Journal of Research Forestry, Wildlife & Environment*, *9*(1), 114-121.

Okoye, I., Abu, S., Obiezue, N. N. R., & Ofoezie, I. E. (2014). Prevalence and seasonality of parasites of fish Agulu lake, Southeast Nigeria. *African Journal of Biotechnology*, *13*(3), 508-532.

Pantoja, W., Neves, L. R., Dias, M., Marinho, R. Montagner, D., & Tavares-Diaz, M. (2012). Protozoan and metazoan parasites of Nile tilapia *Oreochromis niloticus* cultured in Brazil. *Rev. MVZ Cordoba*, *17*(1), 2812-19.

Perpetua, M. D. (2013). Diet composition based on stomach content of the Streaked spinefoot *(Siganus javus)* from three coastal bays in Mindanao, Philippines. *Advances in Environmental Sciences*, *5*(1).

Poulin, R. & Valtonen, E. T. (2002). The predictability of helminth community structure in space: a comparison of fsh populations from adjacent lakes. *International Journal Parasitology*, *32*, 1235-43.

Punchihewa, N. N. & Krishnarajah, S. R. (2013). Relative importance of mysids as a food item in the diet of two small fish species, *Galaxias maculates* and *Athrinidae sp.* in the Kakamatua stream, Auckland Region, New Zealand.

Saikia, A. K., Abujan, S. K. S., & Biswas, S. P. (2012). Food and feeding Habit of *Channa punctatus* (Bloch) from the Paddy Field of Sivsagar District, Assam. *Bulletin of Environment, Pharmacology and Life Sciences*, *1*(5), 10-15.

Santos, C. P., Cardenas, M. Q., & Lent, H. (1999). Studies on *Procamallanus (Spirocamallanus pereirai Annereaux*, 1946 (Nematoda: Camallanidae), with new host records and new morphological data on the larval stages. *Memeories do Instituto Oswaldo Cruz*, *94*(5), 635-40.

Sasal, P., Mouillot, D., Fichez, R., Chifflet, S., & Kulbicki, M. (2007). The use of parasites as biological indicators of anthropogenic influences in coral-reef lagoons: A case study in *Apogonidae* parasites in New Caledonia. *Marine Pollution Bulletin*, *54*, 1697-1706.

Sastrellas, N. (2014). *Fish inventory, length-weight relationship, condition factor and gonad histology of freshwater fishes along river system of Rosario and Bunawan brook Agusan del Sur, Philippines* [BS Biology Undergraduate Thesis].

Sinsch, U., Balczun, C., Scheid, P. & Dehling, J. M. (2021). Component Endoparasite Communities Mirror Life-History Specialization in Syntopic Reed Frogs (Hyperolius spp.). *Diversity*, *13*(12), 669. https://doi.org/10.3390/d13120669

Suliman, E. A. M. & Al-Harbi, A. H. (2016). Prevalence and seasonal variation of ectoparasites in cultured Nile tilapia *Oreochromis niloticus* in Saudi Arabia. *Journal of Parasitology*, *40*(4), 1487-93. https://doi.org/10.1007/s12639-015-0717-6

Sures, B. (2004). Environmental parasitology: relevancy of parasites in monitoring environmental pollution. *Trends in Parasitology*, *20*, 170-177.

Tajbakhsh, F., Golzarianpour, K., & Abdoli, A. (2012). A survey in infection of T*urcinoemacheilus kosswigi*, first record of the genus Procamallanus (Nematoda Camallanidae) from Iran. *Turkish Journal of Zoology*, *36*(3), 395-398.

Talde, C. M., Mamaril, A. C. Sr., & Palomares, M. L. D. (2004). The diets composition of some economically important fishes in three floodplain lakes in Agusan Marsh wildlife sanctuary in the Philippines. *Sri Lanka Journal of Aquatic Sciences*, *9*, 45-46.

Usip, L. P. E. (2013). Length weight relationships and parasite of *Chrysichthys nigridigitatus* in Cross River Estuary Itu local Government area Akwa Ibom State, Nigeria. *Basic Research Journal of Agricultural Science and Review*, *2*(7), 154-165.

Uy, W. H., de Guzman, A., Acuna E., & Roa, R. L., (2015). Aquatic Biodiversity of Lake Mainit, Southern Philippines. *ResearchGate*, 1-15.

Vankara, A. & Chikkam, V. (2015). Community structure analysis matazoan parasites of *Channa punctatus* (Bloch, 1800) from Meghadrigedda Reservoir of Visakhapatnam district, Andhra Pradesh, India. *The Journal of Advances in Parasitology*, *2*(3), 57.

Velasquez, C. (1999). *Fish Parasitology and Aquaculture Management in the Philippines*.

Vijaysundardeva, G., Dash, G., Ramudu, K. R., Abraham, T. J., & Shyam, K. U. (2018). Prevalence of Parasitic diseases of Indian major carps in selected districts of west bengal, India. *International Journal of Current Microbiology and Applied Sciences*, *7*(8), 2784-2805.

Wood, C. L., Lafferty, K. D., & Micheli, F. (2010). Fishing out marine parasites? Impacts of fishing on rates of parasitism in the ocean. *Ecology Letters*, *6*, 761-75. https://doi.org/10.1111/j.14610248.2010.01467.x

Yulentine, Bugar, H., Wulandari, L., & Harteman, E. (2017). Snakehead fish *(Channa striata)*: semi-induced Breeding and larval growth. *Indian Journal of Science and Technology*, *10*(11), 4-7. https://doi.org/10.17485/ijst/2017/v10i11/107588