Gut Content Analysis of Siganus canaliculatus (Danggit)

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ABSTRACT

The study aims to identify the gut content of Siganus canaliculatus (Danggit) found in a mangrove forest at Brgy. Tagabuli, Sta. Cruz, Davao del Sur. Sampling was done in two sampling stations namely: Area 1 (mangrove area) and Area 2 (aquaculture area). Results showed that percentage composition of prey items in Area 1 are composed of algae (78%), plankton (13%) and detritus (9%), while Area 2 is composed mostly of detritus (62%), algae (30%), planktons (7%) and others such as stone sediments, small shell crustacean and nylon fragments (1%). Proximate composition of Siganus canaliculatus flesh in Area 1 has Crude fat (11%), Crude protein (48%) and Ash (6%) while Area 2 has Crude fat (10%), Crude protein (51%) and Ash (28%). Siganus canaliculatus gathered in mangrove and aquaculture area consumed similar prey items like Melosira spp. (Diatoms), Meridion spp. (Diatoms), Nitzschia spp. (Diatoms), Ascartia spp. (Copepod) and Dreissena spp. (Zooplankton). Based on gut content analysis of Siganus canaliculatus, it is herbivorous. Hence, algae as the primary prey item of Siganus canaliculatus should be conserved, and harvesting of commercially important fishes should be monitored.

Keywords: Gut, content, analysis, Danggit, Siganus canaliculatus

INTRODUCTION

Fish gives more than one billion destitute individuals with a large portion of their day-by-day protein needs. As a reasonably priced animal protein source in the least prosperous nations, fish is the essential wellspring of nourishment, creating a developing interest for this staple (World Fish Center, 2015). A data from Philippine Statistics Authority (2017) on Fisheries Statistics of the Philippines showed that the volume of production by sector in the country from 2014 to 2016 was 4,689,084.71 to 4,355,792.42 metric tons.

In 2018, the Philippines ranked 8th among the top fish producing countries in the world with its total production of 5.35 million metric tons (MT) of fish, crustaceans, mollusks, and aquatic plants (including seaweed). The production of 211.87 million MT (FAO, 2020).

In 2020, the total volume of fisheries production in the Philippines reached 4.40 million metric tons, a slight decrease from 4.42 million metric tons produced in 2019. This decline was attributed to a decrease in production across aquaculture and municipal capture fisheries, partially affected by an increase in commercial capture fisheries.

Philippine Statistics Authority (2024) provided a data that the Philippine fisheries sector saw a total production of 4.04 million metric tons, with aquaculture accounting for the largest share at 54.9%. Specifically, aquaculture production was 2.22 million metric tons, followed by marine municipal fisheries at 802.77 thousand metric tons (19.8%) and commercial fisheries at 857.33 thousand metric tons (21.2%). Inland municipal fisheries contributed the smallest share at 166.17 thousand metric tons (4.1%).

In 2024, Davao del Sur's aquaculture production reached 18, 369.69 metric tons. Brackish water fishponds and marine cages are subsectors with notable positive growth especially in 2024. Unfortunately, fish supplies are neglecting to satisfy demands, and there are real deficiencies in some emerging nations where they are required most (Sertori, 2009).

According to Naylor, Goldburg, Primavera, Kautsky, Beveridge, Clay, Folke, Lubchenco, Mooney and Troell (2000), roughly one-third of yearly wild fish landings in Southeast Asia are mangrove dependent. It is crucial to thoroughly understand the diet of these commercially important fishes found in the area and the most frequently used technique for determining the degree of food selectivity is gut content analysis. Gut content analyses are advantageous in that one can identify selection from a wide range of natural prey (Mantyka & Bellwod, 2007). Additionally, the gut content analysis gives an overall consideration about the type of food material available to the animals in the food chain and ultimately it is a representation of food in the ecosystem (Babare, Chavan & Kannewad, 2013). Moreover, the knowledge of diet composition and feeding habits is an essential introduction to the natural history of any species (Ahlbeck, Hansson & Hjerne, 2012).

There are only a few comprehensive researches on the food habits of many fishes inhabiting mangrove forest and their trophic group classification (Nanjo, Kohno & Sano, 2008). One example of fish species inhabiting mangrove forest is Siganus canaliculatus. The International Union for Conservation of Nature (2016) reported that Siganus canaliculatus are commercially exploited and conservation is needed. Understanding the fish diet of Siganus canaliculatus would provide an idea of what food to conserve to increase the production of Siganus canaliculatus in the community. Locally, little or no extensive work yet has been conducted on the stomach content of Siganus canaliculatus (Danggit) most especially in Sta. Cruz, Davao del Sur which has a mangrove area of 124 hectares (Municipal Assessor's Office, Sta. Cruz, Davao del Sur). Thus, this study investigates the gut content of Siganus canaliculatus (Danggit) at Sta. Cruz, Davao del Sur to determine the types of prey items it consumes. Moreover, the comparison of the percentage of food availability to its gut content would lead to the identification of its primary food.

LITERATURE REVIEW

Siganus canaliculatus are highly esteemed food fish throughout the western Pacific, like Guam, Palau, and the Philippines (Bagarinao, Solis, Villaver & Villaluz, 1986). Siganus fishes have important commercial value; most species are suitable, desirable for consumption and fetch medium to high prices in the markets. Although Siganus fishes have relatively small sizes, they are delicious and have high demand in the markets (Tharwat & Al-Owafeir, 2003). Siganids are herbivores that thrive in marine and brackish waters, found on the Indo-west Pacific (Abdel-Aziz, Mohammed, Abou-Zied & Allam, 2016). It is commercially exploited, and local population declines are suspected because of massive exploitation. It is a component of fisheries in many parts of its range, but even where it is heavily exploited such as in the Philippines (International Union for Conservation of Nature, 2016). Understanding the role of autotroph in estuary food webs has important implications for management and conservation. Early food web studies attempted to use gut content analysis of organisms at higher trophic levels to clarify trophic dynamics (Melville & Connolly, 2003). Since the study of the feeding habits of fish and other animals based upon analysis of stomach content has become standard practice, a sustenance propensity study may be led to decide the most consumed prey or to choose the general significance of various food types to fish nourishment and to evaluate the utilization rate of individual prey types (Hyslop, 1980).

A lot of food products are being harvested directly within the mangrove system through hunting, gathering, and fishing operations, making it vital coastal resources of commercial and fishery products (Kathiersan and Bingham, 2001). Fish that live in mangrove waters are grouped into five according to feeding habits: herbivorous, iliophagus, zooplanktivorous, benthic invertebrate feeder, and piscivorous species. These feeding groups represent the results of a large number of studies devoted to analyses of fish gut contents (Robertson and Blaber, 1992). Moreover, based on the study conducted by Grey, Thackeray, Jones & Shine (2002) on the gut content analysis of Ferox Trout the researchers emphasizes that gut content analysis allows the stomach contents of a predator to be quantified in terms of specific taxa ingested, but not necessarily assimilated. It provides only information about feeding immediately before capture unless the predator in question exhibits little diet heterogeneity. Another study conducted by Johannsson, Leggett, Rudstam, Servos, Mohammadian, Gal, Dermot and Hesslein (2001), was about the diet and feeding rates of Mysis relicta. The results showed that Mysis function as an essential intermediary, funneling energy from several pathways to the fish community. Mysis may dampen fluctuations in energy flow within individual channels, helping to stabilize the fish community because Mysis are a broad conduit. These have been traditionally determined through the analysis of gut contents.

Moreover, Linde, Grau, Riera, and Massuti-Pascual (2004) investigated the trophic ontogeny quantitatively in

Epinephelus marginatus by testing and quantifying the effect of size on diet composition, and analyzing complementary aspects of food preferences to clarify the importance of fish size on feeding habits. The results showed that Epinephelus marginatus is a necto-benthic species that predate on a broad spectrum of decapod and fish species frequenting rocky bottoms, as well as on the littoral cephalopods. According to the pattern found, crustacean decapods are important preys of smaller groupers. However, as predators grow fishes and cephalopods are incorporated into the diet, which together with crustaceans, are the principal preys of intermediate fishes. Cephalopods were the preferred prey for larger fishes. Hence, the quantitative study of the trophic ontogeny of E. marginatus represents a solid basis for the management of rocky littoral systems in which this species would be implicated.

Importance of Proximate Composition of Fishes to Human.

Proximate composition refers to the percentage of the four main constituents namely: water, protein, lipid (fat or oil) and ash (minerals). These major constituents make up the edible portion of fishes (Vikaspedia, 2019). Fishes are valuable sources of food for human beings and other animals by most of the countries in the world. They are rich in proteins and vitamins, especially, vitamin A. Thus, they play a significant role in the socioeconomic aspect of the South-Asian countries. Fish consumption now exceeds that of all other animal protein in tropical countries (Khabade, 2015).

Among the commercially important species are; Oreochromisniloticus, Clariasgariepinus, Tilapia zilli, Schlibeintermediu, Mormyrusrume, Brycinius nurse, Heterotisniloticus, Hemichromisbimaculatus, Hemichromisfasviatus, Labeus sp., Protopterusannectus, Synodontis spp., and Siganus spp. These species are economically exploited for food and ornamental purpose (Wakil, Haruna, Mohammed, Ndirmbita, Yachilla, & Kumai, 2014).

The study entitled "Proximate composition, amino acid and fatty acid estimation of Siganus lineatus" conducted by Rajesh, Annadurai, Sattanathan and Shankar (2018), revealed that Siganus lineatus or Rabbit fish species could compete with more commercially utilized species in terms of nutritional value. The Siganus are preferred and consumed by all the economic group of people considering it as a low-cost fish. The fish sample collected from Parangipettai and Cuddalore contained protein, carbohydrate, fat, ash and moisture content (63.2, 87.18%), (19.23, 20.94), (124.1, 126.8), (10.29, 6.06), (13.39, 12.43) respectively. It was evident that these species comprised of high protein, carbohydrate, lipid, and fatty acids. Also, they also contain essential and non-essential amino acids, making it much more suitable for human consumption.

Prey Items Commonly Consumed by Fishes

Pollution of rivers and reservoirs in recent time affects the zooplankton population and changes in the trophic levels of different food materials. This condition leads to changes in food and feeding habit of top carnivores in the aquatic food chain including fishes. Therefore, it is essential to determine the food composition in the gut of economically important fish species. The gut content analysis gives an overall consideration about the type of food material available to the animals in the food chain, and ultimately it is a representation of food in the ecosystem (Babare, Chavan & Kannewad, 2013).

All fish require energy for growth, breeding, and migration, obtained from its food sources (Bankole, Sule, Okwundu & Amadu, 2001). The potential food resources of fish consist of all materials present in its environment. They have been known to feed in an extensive variety of food items ranging from sand particles, zooplankton, phytoplankton, plant leaves, roots, insects, insect larvae, crustaceans, worms, fishes, etc. (Omondi, Yasindi & Magana, 2011). Fishes in the temperate environment are seasonal in their feeding. Digestion and metabolic activities are slowed down at a lower temperature, so the amount of feed required in warm water conditions is higher than that in cold water (David, Edward, Adass & Jesse, 2010). Meanwhile, Eya, Lacuna, and Espra (2011) described the diet composition of selected economically important reef fishes in Maigo and Kauswagan, Lanao del Norte, Philippines. Nine fish species belonging to seven families: Gerreidae (Gerresoyena), Leiognathidae (Leiognathussplendens), Lethrinidae (Lethrinusinsulindicus), Scaridae (Scarusbowersi), Siganidae (Siganus guttatus and Siganus vermiculatus), Theraponidae (Theraponjarbua and Therapon sp.) and Mullidae (Upeneuscaeruleus) were used in the study. The result of the gut content analysis showed that the majority of the fish species (Gerresoyena, Leiognathaussplendens, Lethrinusinsulindicus, Theraponjarbua, Therapon sp. and Upeneuscaeruleus) preyed on zooplankton and benthic animals. While some species such as Scarusbowersi, Siganus guttatus, and Siganus vermiculatus entirely fed on algae and were characterized as strict herbivores. The abundance of zooplankton between stations in Maigo, and Kauswagan, Lanao del Norte showed no significant difference ($p > 0.05$) in both areas. Moreover, it showed that despite the abundance of zooplankton in the environment, planktivorous fishes preferred to prey on some zooplankton groups like copepods, amphipods, and crab. In their natural environment, Siganus feed on low energy and protein algae, which results in sub-optimal growth and inconsistent production. However, in captivity, rabbit fish can be trained to readily accept artificial feeds, making them suitable for commercial aquaculture (Parazo,1990).

Moreover, Sheaves and Molony (2000) investigated the extent to which Epinepheluscoioides, E. malabaricus and Lutjanusargentimaculatus from 3 mangrove systems on the northeast coast of tropical Australia prey on sesarmid crabs, and how closely these species are linked to mangrove productivity relative to sympatric species. Sheaves and Molony utilized three estuaries on the northeastern coast of Australia for the study sites: Gentle Annie Creek, Press's Pocket and the Hinchinbrook Channel. Crabs of the brachyuran subfamily Sesarrninae dominated the diets of Epinepheluscoioides, E. malabancus and Lutjanusargentimaculatus in the mangrove systems studied. The proportion of empty stomachs decreased, and the percentage of sesarmids in the diets increased during the first part of the falling tide. During the low and early rising tide, there was an increase in the proportion of empty stomachs and a decrease in the sesarmid content. During the late flood tide, the percentage of empty stomachs stopped increasing and leveled out, indicating that many fish had captured fresh prey. In turn, the diet of E. coioides, E. malabaricus, and L. argentimaculatus imply that they derive much, or even most, of their nutrition from primary consumers. Recent work using stable isotopes of Lugendo, Nagelkerken, van der Velde and Mgaya (2006) has confirmed the earlier work on fish diets but has clarified gut contents previously labeled 'detritus,' 'indistinguishable,' or "amorphous."

Furthermore, Wakil, Haruna, Mohammed, Ndirmbita1, Yachilla and Kumai (2014) conducted a study on the contents of two commercially important fish species of Catfish and Tilapia fish (Clariasgariepinus and Oreochromisniloticus) respectively from Lake Alau, North – Eastern Nigeria. The results obtained indicated that 121 (35%) fish had empty stomach content in Clariasgariepinus and 145 fish had empty stomach content in Oreochromisniloticus representing 41% out of the three hundred and fifty (350) individual fish of each species examined. It showed that the stomach contents of Clariasgariepinus consisted of animal and plant materials, planktons, and others. Fish prey was the dominant animal material (51%) with a mean contribution of 32% by volume, and plant material consisted of leaves and debris (6% by volume). On the other hand, Oreochromisniloticus contained primarily of animal and plant materials, planktons and detritus. Algae from the group Chlorella, Volvox, Scenedesmus, Pediastrum, and Spirogyra species accounted for 66% by volume followed by detritus and mud with 20%, zooplankton represented by Daphnia and Moina species represented the low food content by volume with 8%. The study revealed the importance of algae, fish, insects and plant materials as food for fish in Lake Alau, and zooplanktons form essential items in the diet of the species examined. Both species are omnivorous and occupy the same ecological niche; hence, according to authors, there is the need to control pollution into the lake to prevent eutrophication.

Finally, El-Sayed (1994) conducted a study of the feeding habits of Siganus canaliculatus and Siganus javus fingerlings in the Arabian Gulf waters of Qatar. The investigation revealed that seagrasses and benthic filamentous algae are the primary dietary component of S. canaliculatus and S. javus during their fingerlings and juvenile stages. However, many studies conducted analyzing the gut content of other species of Siganids showed that the algae preferred by captive fish were not always those found in greatest quantity in the gut. Aside from algal food, they can also feed accidentally on some nondigestible substances such as mollusk shells and other invertebrates attached to algae (Sabour & Lakkis 2007).

MATERIALS AND METHODS

Sampling Area

Sampling was conducted in the mangrove forest of Brgy. Tagabuli, Sta. Cruz, Davao del Sur. Sta. Cruz is also part of the Davao Gulf ecosystem. It has eleven barangays with wide coastal areas, namely: Inawayan, Darong,

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Astorga, Coronon, Zone I, Zone II, Zone III, Zone IV, Tuban, Tagabuli and Bato. Its shoreline is 24.8 kilometers, and the municipal water is 37,200 hectares. Mangrove area is 124 hectares with “bakhaw, pagatpat, potutan and tangal” (Rhizopora spp. and Sonneratia spp.) as dominant species (Municipal Assessor’s Office, Sta. Cruz, Davao del Sur). The sampling site was situated within longitudes 125°16'10" and 125°29'25" E and latitudes 6°46'46" and 6°59'22" N, bounded on the North by Davao City; on the East by Davao Gulf; and on the West and South by Digos City. Two different stations were plotted along the mangrove forest (Figure 2). Area 1 is a mangrove area away from the aquaculture zone while Area 2 is situated near the aquaculture zone. The locations of each station were established through GPS (GPS Google Map).

Figure 2a. Map of Sta. Cruz, Davao del Sur. (Source:https://www.google.com/maps/place/ Tagbuli,+Santa+Cruz+Davao+del+Sur)

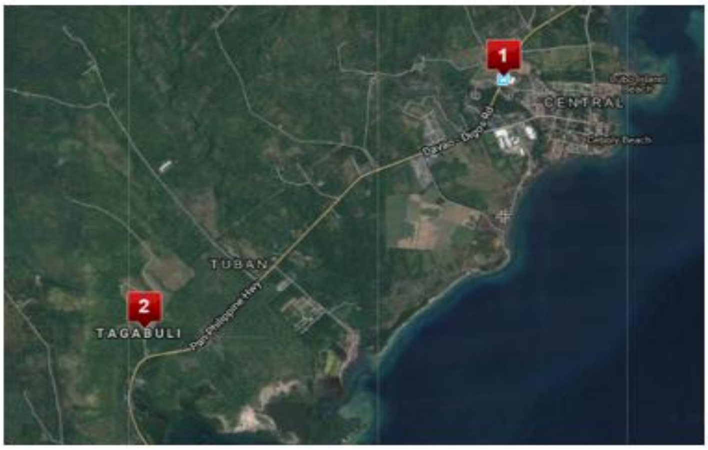

Figure 2b. Map of Brgy. Tagabuli. (Source: Https://www.google.com/maps/place/Tagabul, +Santa+Cruz,=Davao+del+Sur)

Figure 2c. Plotted sampling areas along the mangrove forest of Brgy. Tagabuli. *(Source: https://www.google.com/map s/place/Tagabuli,+Santa+Cruz,+Da vao+del+Sur)*

Collection of Siganus Canaliculatus

Twenty (20) individuals of Siganus canaliculatus (Danggit) from two different areas were bought from the fishermen who collected the fish samples. Collection of fishes by the fisher folks was done using a fishing net with a height of 5 to 10 m, length of 300 m and a small size mesh. The collection of fish samples was done twice a month until twenty (20) individuals of Siganus canaliculatus (Danggit) was attained from each sampling station. The collected Siganus canaliculatus (Danggit) from each station were placed in separated cellophane and were labeled with its local name, sampling station number and the date and time of collection. All collected fishes were put in an icebox partially filled with ice to slow down metabolic activities of Siganus canaliculatus (Danggit) (David et al., 2010). For photo documentation and fish identification, the collected Siganus canaliculatus fishes are taken to the laboratory of the BFAR at Brgy. Tagabuli, Sta. Cruz, Davao del Sur.

Identification of Siganus Canaliculatus

The collected Siganus canaliculatus (Danggit) species were examined for the identification of its morphological structure, and each was photo documented. The total and standard length of each fish individual was measured to the nearest 1cm. It was also weighed individually to obtain total weight to the nearest 1g, and all the data were recorded (Zacharia and Abdurahiman, n.d.). Preliminary identification of the fish sample used in the study was made by the researchers based on the morphological characteristics documented. The atlas and journals available online were used as reference and guide for the identification. Moreover, the researchers also consulted the fisher folks who are knowledgeable about identifying the common fishes they found in the area. For further verification in the identification of the collected fish species, an expert from the Bureau of Fisheries and Aquatic Resources in the region was consulted.

Gut Content Analysis of Siganus canaliculatus

Abdominal cavity of Siganus canaliculatus (Danggit) individuals was opened by carefully cutting along the mid-ventral axis from the anus to below the gill chambers to avoid cutting of the stomach. Intact stomach was removed from the fish and was weighed. The weight of the stomach with its content was recorded. For the analysis, a longitudinal cut was made across the stomach, and the contents were preserved with 70% ethanol. The empty stomach was weighed again. The total weight of the stomach contents was determined by getting the difference between the importance of the intact stomach and the weight of the empty stomach. Preserved stomach contents were examined under the electric compound microscope, and contents were identified up to the genus level depending on the state of digestion (Eya et al., 2011).

Following the standard method of Hobson (1974), each prey item was scaled from 0 to 1 using 0.05 point method, with the total contents considered as 1. The volumetric scale value of each prey item was examined from the result of the point method. The product of the total weight of stomach content and its volumetric scale provides the weight of each prey item in the stomach of each fish (Eya et al., 2011).

The formula for the Ranking Index of each prey item is: RI = (A/B) where:

RI = Ranking Index of each prey item
A = number of fish individuals per taxa containing each prey item
B = total number of the fish individual per taxa with stomach content
C = percentage of each prey item which can be computed as:
C=Volumetric scale of the prey item / Volumetric scale of all prey items combined x 100

The point method is significantly used in this study because it accounts for both the abundance and volume of food items, providing a more comprehensive view than counting alone, especially for food items that are difficult to count, like plant material or small organisms. It is a rapid and easy method that assigns points to different food items based on their visual assessment, with more points given to more common or larger items. This allows for the estimation of a diet's composition, even when contents are partially digested or have different sizes. Furthermore, ranking indexes are a highly important tool in diet composition studies because they provide a standardized, quantitative, and holistic way to measure and compare diet quality.

In this study, comparison of prey items in the gut of Siganus canaliculatus to its sizes was also done. On the other hand, recorded total length of each fish individual was also classified. The different size group of Siganus canaliculatus has measurements of 9-11 cm, 12-14 cm, 15-17 cm, 18-20 cm and 21-23 cm (Al-Marzouqi et al., 2013).

Analysis of the Proximate Composition of Siganus canaliculatus Flesh

Analysis of the proximate composition of Siganus canaliculatus (Danggit) flesh was done by the laboratory analyst of Davao Analytical Laboratory. Proximate analysis refers to the study of the four essential constituents of fish muscle, which is the edible portion of fish. These four significant constituents include water, protein, lipid (fat or oil) and ash (minerals). The percentage composition of the major components of fish muscle is defined as the proximate composition (Vikaspedia, 2019).

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In this present study, proximate composition of the fish muscle major constituent (protein, fat and ash content) was analyzed for three months and the results of the proximate composition from two different sampling areas were compared.

Statistical Analysis

One-way analysis of variance (ANOVA) was used to get the variations of each prey items in the gut of Siganus canaliculatus (Danggit) from each sampling station. The same tool was used in determining the significant difference of the proximate composition of Siganus canaliculatus flesh and Siganus canaliculatus lengths between the two areas. The analysis of variance test is vital for analyzing factors that affect a given data set. The test allows a comparison of more than two groups at the same time to determine whether a relationship exists between them. It analyzes multiple groups to identify the types between and within samples (Investopedia, 2018).

RESULTS AND DISCUSSION

The food composition of Siganus canaliculatus (Danggit)

Preliminary identification of the gut content of Siganus canaliculatus (Danggit) found in a mangrove forest at Brgy. Tagabuli, Sta. Cruz, Davao del Sur was presented in Table 1. The food composition was categorized into four major food categories namely: algae, planktons, detritus, and "others." In Area 1, the algae group includes green and brown macroalgae. The other preliminary identified prey items under algae group include Rhodophycean such as Audouinella spp., a dinoflagellate like Peridinium spp., and diatoms such as Aulacoseira spp., Melosira spp., Meridion spp., and Nitzschia spp. The algae group in Area 2 was composed of seaweeds as well as diatoms including Diploneis spp., Melosira spp., Meridion spp., Nitzschia spp., and Synedra spp. Other algae present involved Cylindrocapsa spp., Eremosphaera spp., Tolypothrix spp., and Stylonema spp.

The copepods such as Ascartia spp., and Cyclops spp., and other zooplankton such as Dreissena spp., and Globigerinoides spp., constitutes the plankton group found in the gut of Siganus canaliculatus (Danggit) collected from Area 1.

Table 1. Prey items found inside the gut of *Siganus canaliculatus* (Danggit)

Prey Item	**Sampling Stations Area 1 (mangrove area)**	**Area 2 (aquaculture area)**
Algae	Seaweeds	Seaweeds
	Audouinella spp. (Rhodophyta)	*Diploneis spp.* (Diatoms)
	Aulacoseira spp. (Bacillarophyta)	*Melosira spp.* (Diatoms)
	Peridinium spp. (Dinoflagellate)	*Meridion spp.* (Diatoms)
	Melosira spp. (Diatoms)	*Nitzschia spp.* (Diatoms)
	Meridion spp. (Diatoms)	*Synedra spp.* (Diatoms)
	Nitzschia spp. (Diatoms)	*Cylindrocapsa spp.*
		Eremosphaera spp.
		Tolypothrix spp.
		Stylonema spp.
Planktons	*Ascartia spp.* (Copepod)	*Ascartia spp.* (Copepod)
	Cyclops spp. (Copepod)	*Paracalanus spp.* (Copepoda)
	Dreissena spp. (Zooplankton)	*Pseudocalanus spp.* (Copepoda)
	Globigerinoides spp.	*Balanus spp.*
		Dreissena spp.
		Globigerinoides spp.
Detritus	Degraded food	Degraded food
Others	Stone sediments	Stone sediments
	Small shell crustacean	Small clamshell
		Nylon fragment

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In Area 2, the copepods namely Ascartia spp., Paracalanus spp., and Pseudocalanus spp., together with Balanus spp., Dreissena spp., and Globigerinoides spp., constitutes the plankton group.

Another prey item group labeled in the food composition was the detritus or degraded fragment and "others." The other food materials found in Area 1 are stone sediments and small shell crustacean while in Area 2 are sediments, small clamshell and nylon fragment respectively.

Percentage composition of each prey items

The gut of Siganus canaliculatus typically lies on the left side of the body. The intestinal wall is rather thick, becoming thinner in the lower regions (Bryan, 1975). According to Al-Marzouqi, Al-Nadhi, and Al-Habsi (2009), the functional morphology of the gut of Siganus canaliculatus is designed for herbivore feeding. Thus, the result shows that the food mostly consumed were consisted of macroalgae, microalgae and some planktonic species. Additionally, the identified gut content in this study was categorized in terms of algae, plankton, detritus, and others.

In area 1, algae occupied the highest percentage found inside the gut which is 78% then planktonic species fall second at 13% (Fig. 3). Since microalgae, macroalgae and phytoplankton communities showed high production yields in mangrove areas (Cuenca, Macusi, Abreo, Ranara, Andam & Cardona, 2015), this supports the reason why the Siganus canaliculatus caught nearby the mangrove expanses had a high consumption of such food items.

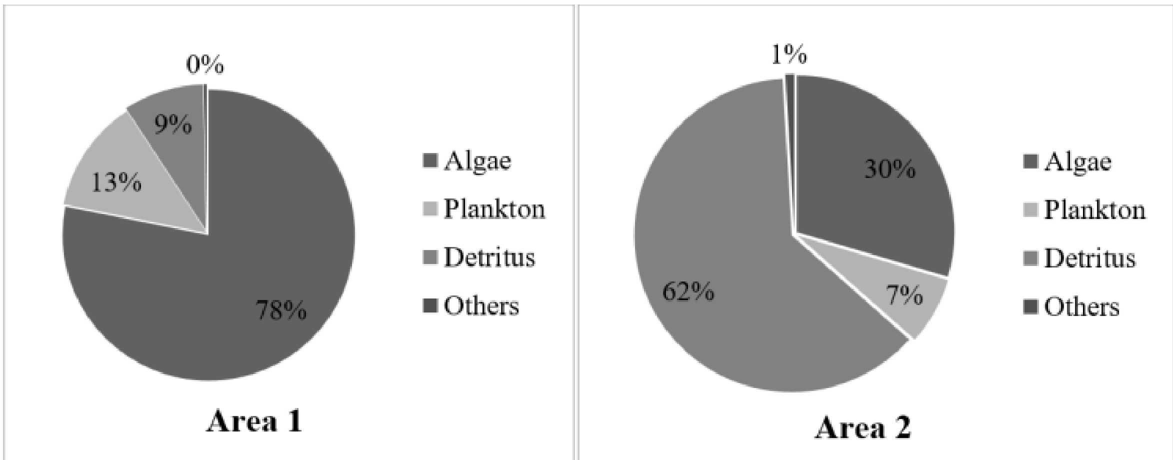

Figure 3. Percentage compositions of prey items

In Area 2, detritus ranks the highest having 62% of the total food consumption of Siganus canaliculatus, and the algae come second having 30% (Fig. 3). Since area 2 is plotted near the aquaculture zone, the fishes usually consume commercial fish feeds, and this shows why degraded food fragment or detritus contributes the highest in the whole prey composition found inside the gut. Seemingly, commercial fish feeds take a little time to be degraded by fishes than the other prey items (Pupulawaththa, 2018).

Rank of each prey items in terms of percentage composition

Figure 4 illustrates the ranking index of each prey item in Area. Algae (45.24) rank first as the most consumed prey, followed by detritus (41.337), then planktons (2.033) and lastly "others" (0.051). This implies that Siganus canaliculatus mostly feeds on macroalgae and microalgae making them herbivore feeding type of fish. It indicates that the diet of Siganus canaliculatus is usually on the availability of the resources in different areas. This is also supported by the study of Al-Marzouqi et al. (2009) which states that most of the Siganus canaliculatus feed mainly on seaweeds and seagrasses. Also, the research conducted by Bariche (2006) in East Mediterranian showed that Siganus rivulatus ingest majority of macrophytes which also supports the claim that Siganus canaliculatus are indeed herbivore feeding fishes.

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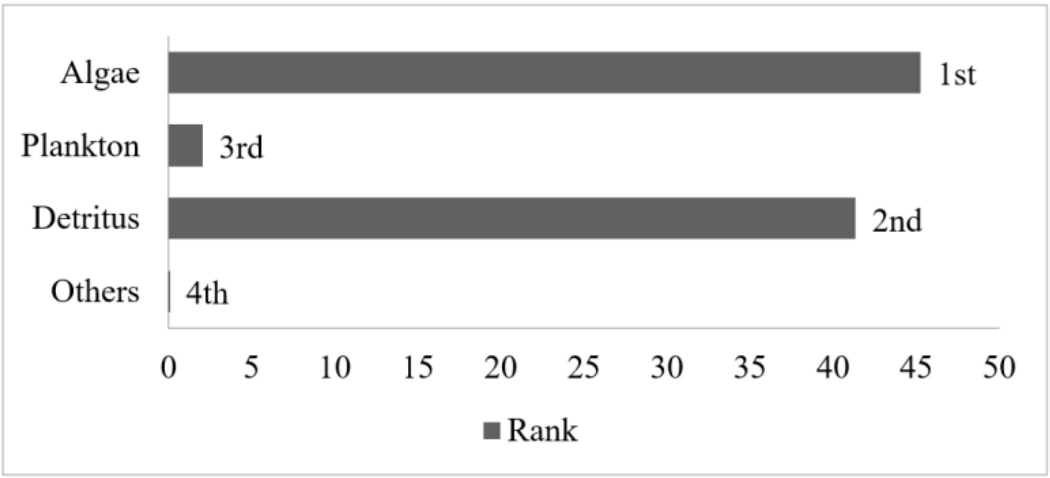

Figure 4. Rank of each prey item in Area 1.

In Figure 5, detritus or degraded food (35.64) ranks the highest in Area 2. It was followed by algae (27.75), then plankton (0.82) and lastly "others" (0.054). It indicates that Siganus canaliculatus frequently consume easily digested prey items which could be fish feed pellets. This can also be proven in the proximate composition of the fish.

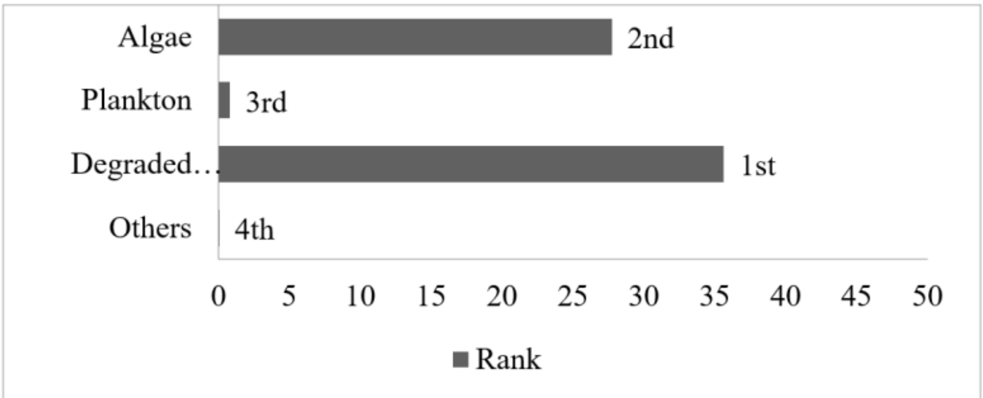

Figure 5. Rank of each prey item in Area 2.

Prey items in the gut of Siganus canaliculatus in various size groups

As shown in Figure 6, the prey items of Siganus canaliculatus (Danggit) in Area 1 indicate high algae consumption with 71.43% in size group measuring 9-11 cm, 70.80% in size group 12-14 cm, and 69.00% in size group 15-17 cm.

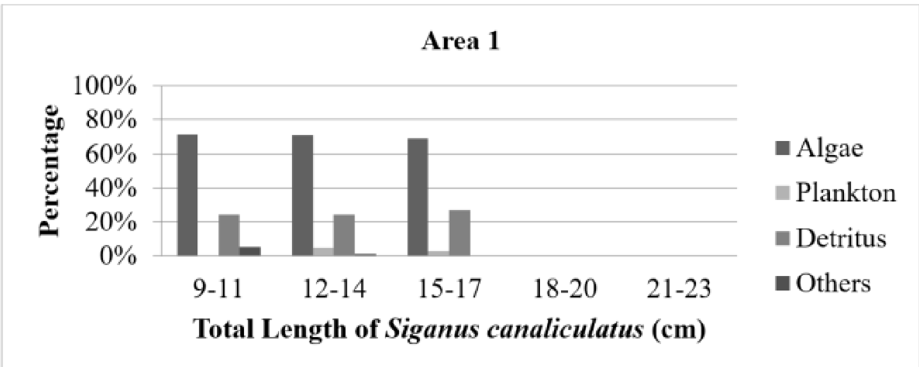

Figure 6. Percentage of each prey item in various size groups of *Siganus canaliculatus* in Area 1

Area 2 has a different data output as shown in Figure 7. The percentage of prey items specifically the detritus occupied mostly the highest percentage with 71.00% in size group 12-14 cm. In size group 15-17 cm, it held 67.00%; in size group 18-20 cm, it has 43.00% and; in size group 21-23 cm, it has 67.00%.

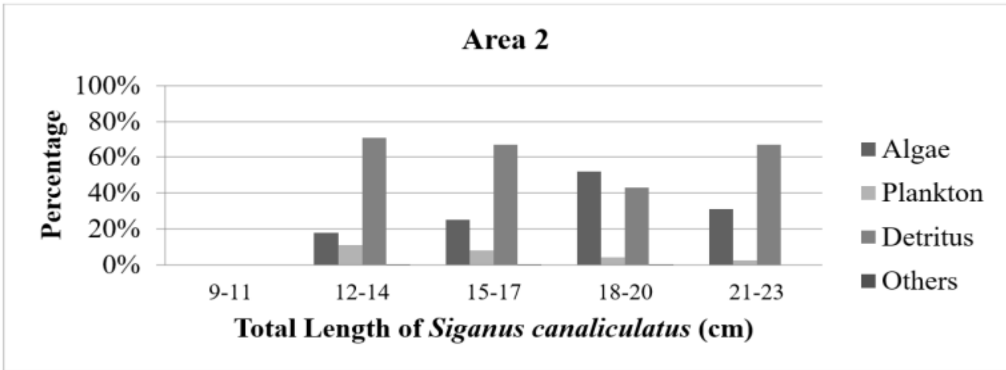

Figure 7. Percentage of each prey item in various size groups of *Siganus canaliculatus* in Area 2

It can be observed that the Siganus canaliculatus size in Area 1 has a minimum of 9 cm and a maximum of 17 cm. In Area 2, the minimum size is 12 cm, and the maximum size is 23 cm. This data suggests that the food consumed by the Siganus canaliculatus had a significant impact on their volumes. Since Area 2 is plotted near an aquaculture zone, the detritus is composed mainly of washed away commercial fish feeds, and this gave a growth advantage to the fishes that grew in Area 2. Prepared or artificial diets such as the commercial fish feeds are considered complete diets; complete diets supply all the ingredients (protein, carbohydrates, fats, vitamins, and minerals) necessary for the optimal growth and health of the fish. Most fish farmers use complete diets, those containing all the required protein (18-50%), lipid (10-25%), carbohydrate (15-20%), ash (< 8.5%), phosphorus (< 1.5%), water (< 10%), and trace amounts of vitamins, and minerals (Craig, 2002). In contrast, supplemental (incomplete, partial) diets are intended only to help support the natural food (insects, algae, small fish) ordinarily available to fish (Houlihan, Bouiard, & Jobling, 2001). This supports the idea in Area 1 where a high percentage of algae consumption covers an incomplete diet.

Proximate composition of Siganus canaliculatus flesh

Total crude fat, crude protein and ash contents of Siganus canaliculatus flesh from two sampling areas are shown in Table 2. It presents the average percentage of the proximate composition of Siganus canaliculatus tested from September to November 2018. Crude fat content was higher in Area 1 with a percentage of 10.60% while Area 2 has 9.53%. Crude protein was higher in Area 2 with a value of 50.60% whereas Area 1 has 48.30%. Ash content was also higher in Area 2 with the value of 27.83% compared to Area 1 which has only 6.13%.

Table 2. Proximate Composition of *Siganus canaliculatus* (Danggit) flesh

Proximate composition	Area 1 (Mangrove)	Area 1 (Aquaculture)
Crude Fat	10.60%	9.53%
Crude Protein	48.30%	50.60%
Ash	6.13%	27.83%

As presented in Figure 1, algae occupied the highest percentage (78%) of the prey items found inside the gut of Siganus canaliculatus (Danggit) in Area 1. This algae group encompasses phytoplankton (microalgae) floating in the water, to large seaweeds (macroalgae) attached to the ocean floor. The role of phytoplankton as the essential nutritional source of fish and its biochemical composition was emphasized in an article. According to the author, phytoplankton provides important phytonutrients and biological components especially fatty acids, amino acids, organic minerals, sterols, enzymes, trace elements, vitamins, carotenoids, and chlorophyll. With regards to the biochemical composition of phytoplankton, the most nutritional and highest in amount are lipids or fat, which has an impact on the growth, health, and reproduction of fish species (Napiórkowska-Krzebietke, 2017). Thus, it supports the idea why crude fat content was higher in Area 1 than in Area 2 because algae were found to be the highest in the percentage of the prey items found inside the gut of Siganus canaliculatus.

In contrast to Area 1, the food composition of Siganus canaliculatus (Danggit) in Area 2 constituted mainly of detritus where it occupied the highest percentage (62%) of the prey items instead of algae. The detritus components were described to contain degraded commercial fish feeds because the area sits near the aquaculture zone. As described by Pupulawaththa (2018), in comparison to other food items, the degradation of commercial fish feeds takes a little time inside the gut of fishes. Generally, commercial fish feeds contain the highest percentage of protein (18-50%) and the other natural components fortified in commercial fish feeds include lipids, carbohydrates, ash and trace amounts of vitamins and minerals (Craig, 2017). Proximate composition of Siganus canaliculatus (Danggit) in Area 2 contains the highest percentage of crude protein (50.60%) followed by ash content with 27.83%. It is because Siganus canaliculatus (Danggit) collected in Area 2 feeds on the washed away commercial fish feeds supplied by the fish cages located near the area.

The Result of Statistical Analysis

Table 3 shows the ANOVA result on the difference of the prey items in Area 1 and Area 2. The obtained P-value (0.996925) is higher than (0.05) level of significance. Hence, there is no significant difference in the prey items found between the two (2) sampling stations. This indicates that the prey items are available in both areas whether if it is along the mangrove area or near the aquaculture owned by BFAR and some local owners in Brgy. Tagabuli, Sta. Cruz, Davao del Sur. Therefore, Siganus canaliculatus (Danggit) feeds on the available prey items in the areas. Similar results were obtained from a related study conducted on the diet of Streaked spinefoot (Siganus javus) from three coastal bays in Mindanao. It shows that the diet of Siganus fishes is usually on the availability of the resources in different environments S. javus inhabits.

Table 3. ANOVA result showing the difference of prey items in Area 1 and Area 2

Prey Items	Count	Mean	Variance	F	P-value	F=crit
	2	0.5382	0.118292	1.75E-05	0.996925	10.12796
Plankton	2	0.09775	0.001619			
Degraded Food	2	0.356	0.142578			
Others	2	0.0062	1.68E-05			

Legend: P-value = level of significance (< 0.05)

Table 4 presents the statistical analysis for the proximate composition of Siganus canaliculatus (Danggit) flesh in Area 1 and Area 2. The obtained P-value (0.394051) is higher than (0.05) level of significance. Hence, the result shows no significant difference in the proximate values found in the Siganus canaliculatus flesh collected from two areas. This indicates that Siganus canaliculatus collected in the mangrove area can compete with the Siganus canaliculatus collected from the mangrove area situated near the aquaculture zone in terms of nutritional value. The study of Rajesh, Annadurai, Sattanathan & Shankar (2018) on proximate composition of Siganus lineatus supported this observation wherein it showed that in terms of nutritional value Siganus lineatus could compete with more commercially utilized species.

Table 4. ANOVA result showing the proximal composition of *Siganus canaliculatus* flesh in Area1 and Area 2

Proximal Composition	Count	Mean	Variance	F	P-value	F=crit
Crude Fat	2	0.10065	5.72E-05	1.16043	0.394051	18.51282
Crude Protein	2	0.4945	0.000265			
Ash	2	0.1698	0.023545			

Legend: P-value = level of significance (< 0.05)

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Table 5 presents the statistical analysis of the fish lengths of Siganus canaliculatus in Area1 and Area 2. The obtained P-value (0.771245) is higher than (0.05) level of significance with no differences between size classes detected, concerning the plotted areas. According to Linde, Grau, Riera, and Massuti-Pascual (2004), it is possible to obtain a function that could be used to estimate the mass proportions of prey items ingested by a stock based on its size structure. However, the prediction is limited to the percentage variation of the gut content associated with the evaluated factor, so one prediction would be more or less approximate to the current diet of a stock according to the magnitude of this percentage. In this study, the result showed that there is no significant difference between the percentage of prey items ingested in Area 1 and Area 2. Thus, explains the reason why there is no significant difference between fish sizes.

Table 5. ANOVA result showing the difference of *Siganus canaliculatus* total lengths in Area1 and Area 2

Prey Items	Count	Mean	Variance	F	P-value	F=crit
9-11 cm	2	0.35715	0.255112	0.0968	0.771245	7.708647
12-14 cm	2	0.709	0.000002			
15-17	2	0.68	0.0002			
18-20	2	0.215	0.09245			
21-23	2	0.335	0.22445			

Legend: P-value = level of significance (< 0.05)

Gut content analysis of Siganus canaliculatus (Danggit) found in a mangrove forest at Brgy. Tagabuli, Sta. Cruz, Davao del Sur was identified. The percentage of each prey item in the gut of Siganus canaliculatus (Danggit) from Area 1 (mangrove area) and Area 2 (aquaculture area) was determined and ranked. Moreover, the percentage of crude fat, ash and crude protein of Siganus canaliculatus from the two sampling areas were also established.

Results showed that the percentage composition of food items in Area 1 was composed of algae (78%), plankton (13%) and detritus (9%). In Area 2, percentage composition was comprised of detritus (62%), algae (30%), plankton (7%) and others (1%). Crude fat content was higher in Area 1 with a percentage of 10.60% while Area 2 has 9.53%. In area 2, crude protein was higher with the value of 50.60% whereas Area 1 has 48.30%. Ash content was also higher in Area 2 with the value of 27.83% compared to Area 1 which has only 6.13%.

The following conclusions are made by the researchers based on the findings of the study:

1. The identified gut content of Siganus canaliculatus (Danggit) was consists of macroalgae, microalgae, detritus and some planktonic species.
2. Percentage composition of food items in Area 1 was composed of algae (78%), plankton (13%), and detritus (9%). On the other hand, the percentage composition in Area 2 was composed of detritus (62%), algae (30%), plankton (7%), and others (1%).
3. Algae rank first as the most consumed prey item in the gut of Siganus canaliculatus in Area 1 while it ranks second in Area 2. Hence, Siganus canaliculatus are herbivores.
4. In terms of proximate composition, crude fat was higher in Area 1 while crude protein and ash contents were higher in Area 2.
5. There is no significant difference in the percentage of each prey item found in the gut of Siganus canaliculatus (Danggit).

Based on the above-mentioned findings and conclusions of this study, the proponents came up with the following recommendations:

1. Sta. Cruz community. The Sta. Cruz community could benefit from seminars and community meetings hosted by local government units or BFAR about environmental preservation and conservation of food materials (prey items). Since Siganus canaliculatus preyed on these prey items, it would, in turn, leads to conservation of this fish species. This would also help in maintaining a balanced ecosystem and for them

to not experience a scarcity on fish products most especially Siganus canaliculatus (Danggit). Hence, algae as the primary prey item of Siganus canaliculatus should be conserved, and harvesting of commercially important fishes should be monitored.

2. Bureau of Fisheries and Aquatic Resources. More studies can be conducted by BFAR internally to better give future researchers a baseline data on diet composition and gut content analysis of Siganus canaliculatus (Danggit) and other fishes.
3. Department of Environment and Natural Resources. The DENR can collaborate with the local community to conduct mangrove planting activities to ensure that mangrove forests are not depleted on the parts where commercial fishing is done.
4. Future Researchers. Interested researchers can conduct this study on different study locale or in the same sampling area but on different types of fishes aside from Siganus canaliculatus (Danggit).

Studying other fish species in Tagabuli, Sta. Cruz, Davao del Sur would be highly recommended as they play a vital role in maintaining the ecological balance of the area and knowing what they consume could give us an overview of how long they will be able to keep their population. Moreover, seasonal sampling is recommended to see variations on the fish gut content. Furthermore, since Siganus canaliculatus consume phytoplankton and zooplankton, it would be more accurate to identify the plankton and algae species if DNA barcoding is

CONCLUSION

Gut content analysis is crucial in understanding the feeding habits, dietary preferences, and the role of a Siganus canaliculatus in an ecosystem, providing insights into fish health, ecological interactions, and resource management.

The following conclusions were drawn from the study.

The identified gut content of Siganus canaliculatus (Danggit) was consists of macroalgae, microalgae, detritus and some planktonic species. The percentage composition of food items in Area 1 was composed of algae (78%), plankton (13%), and detritus (9%). On the other hand, the percentage composition in Area 2 was composed of detritus (62%), algae (30%), plankton (7%), and others (1%). Algae rank first as the most consumed prey item in the gut of Siganus canaliculatus in Area 1 while it ranks second in Area 2. Hence, Siganus canaliculatus are herbivores. In terms of proximate composition, crude fat was higher in Area 1 while crude protein and ash contents were higher in Area 2. Statistically, there is no significant difference in the percentage of each prey item found in the gut of Siganus canaliculatus (Danggit).

RECOMMENDATIONS

Based on the findings, the following recommendations were made:

1. Algae, the primary prey item of Siganus canaliculatus should be conserved, and harvesting of commercially important fishes should be monitored regularly.
2. Extensive studies can be conducted by BFAR to better give future researchers a baseline data on diet composition and gut content analysis of Siganus canaliculatus (Danggit) and other commercially important fishes.
3. The Department of Environment and Natural Resources (DENR) together with the local community must conduct mangrove planting activities to ensure that mangrove forests are not depleted on the parts where commercial fishing is done.
4. Seasonal sampling is recommended to see variations on the fish gut content. Furthermore, since Siganus canaliculatus consume phytoplankton and zooplankton, it would be more accurate to identify the plankton and algae species through DNA barcoding.

Conflict Of Interest

No conflict of interest exists.

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