Length Weight Relationship and Diet Preferences of Selected Local Fishes

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DECLARATION BY STUDENT

I hereby declare that the data presented in this Dissertation report entitled, "Length Weight Relationship and Diet Preferences of Selected Local Fishes" is based on the results of investigations carried out by me in the Zoology at the School of Biological Sciences and Biotechnology, Goa University under the Supervision of Dr. Preeti Pereira and the same has not been submitted elsewhere for the award of a degreeor diploma by me. Further, I understand that Goa University or its authorities will be not be responsible for the correctness of observations / experimental or other findings given the dissertation.

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Place: Goa University

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This is to certify that the dissertation report **"Length Weight Relationship and Diet Preferences of Selected Local Fishes"** is a bonafide work carried out by **Ms. Amisha Prakash Naik** under my supervision in partial fulfilment of the requirements for the award of the degree of **Masters of Science** in the Discipline Zoology at the School of Biological Sciences and Biotechnology, Goa University.

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PREFACE

The intricate relationship between aquatic ecosystems and the organisms has always fascinated both scientists and conservationists. Among these, the study of fish species is pivotal, providing crucial clues about the overall well-being of water environments. As human impacts continue to reshape these environments, unravelling the ecological dynamics of fish populations becomes ever more essential for effective conservation and management strategies.

This study delves into two fundamental aspects of fish ecology: gut content analysis and length-weight relationships. These areas offer insights into fish feeding behaviours, dietary preferences, and provide critical metrics for understanding growth patterns and overall health. By conducting thorough fieldwork, collecting data, and analysing findings, this study aims to unravel the complexities of these phenomena across various fish species.

Gut content analysis serves as a potent tool for unravelling the trophic interactions within aquatic ecosystems. Through examination of fish stomach contents, researchers can discern prey preferences, feeding strategies, and ecological roles within food webs. Moreover, this analysis offers valuable insights into the potential impacts of environmental disturbances on fish diets, highlighting the resilience or vulnerability of species to changing conditions. In addition, exploring length-weight relationships provides a quantitative understanding of fish biology. Mathematical models correlating length and weight reveal key parameters like growth rates, body condition, and population dynamics. These relationships are essential for fisheries management, guiding stock assessment, harvest regulations, and conservation strategies.

This dissertation presents a comprehensive investigation into gut content analysis and length-weight relationships across selected fish species. Drawing upon combination of field surveys, laboratory analyses, and statistical techniques, the findings contribute to our understanding of aquatic ecosystems and guide evidence-based conservation practices.

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FIGURES

TABLES

ABBREVIATIONS USED

Entity	Abbreviation
Length Weight Relationship	LWR
Total length	TL
Weight	W
Gastrosomatic Index	GaSI
Millimeter	mm
Gram	g
Less than	<

ABSTRACT

The present study illustrates the information of length-weight relationship (LWRs) and feeding biology of four marine fish species namely, *Ambassis gymnocephalus, Glossogobius giuris, Gerres limbatus* and *Scatophagus argus* from the stretch of Zuari estuary, Durbhat, Goa. This study was initiated as the topic for my dissertation to uncover crucial insights into the dietary preferences of fish, which can further offer valuable data for ecosystem health, fisheries management, aquaculture practices, human health consideration and for conservation efforts. A total of 300 and 45 fish samples of each species were analysed for conducting their LWR and gut content analysis respectively. LWR was analyzed by cube law and gut contents were analysed through frequency of occurrence and percentage by number from December 2023 to March 2024. Based on gut content analysis results showed that the fish species comprised of five feeding guilds: fish, crustaceans, debris, plant matter and mollusc. From these plant matter (66.66%) frequency of occurrence is found to be dominant food item in *S. argus* while crustaceans were being dominant food item in other three species: *A. gymnocephalus* (71.11%), *G. giuris* (71.11%), and *G. limbatus* (62.22%). Relative gut length of the *A. gymnocephalus, G. giuris* and *G. limbatus* is 0.83, 0.79 and 0.85 respectively (ranging from 0.63–1.50 for carnivorous) concluding that these fishes are carnivorous while relative gut length of *S. argus* was found to be 3.45 (ranging from 2.14 to 3.96) which is commonly considered normal for an omnivorous fish. Result of length weight relationship revealed positive allometric growth in *A. gymnocephalus* indicating that body weight of an individual was increasing with higher rate compare to body length and negative allometric growth in *G. giuris, G. limbatus* and *S. argus.* The difference found in growth pattern of fish species might be due to length range, season, sex, diet, and gonadal maturity.

Keywords: Gut content, Feeding biology, Length-weight, Estuarine fishes, Gastrosomatic idex, Growth pattern.

CONTENTS

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Fishes account for the highest species diversity among all vertebrates and constitute approximately half the overall number of vertebrates in the world. An estimated 21,723 fish species are currently known to exist globally, out of the 39,900 vertebrate species in the world. They are clubbed under 4,044 genera, 445 families and 39 orders (Shah, 2016). Of these 11,650 are marine and 8,411 are present in fresh water. The total number of fish species that exist today could be close to 28,000 worldwide (Nelson, 1984). In terms of genera, the fish fauna of the main tropical regions Southern Asia, Africa, South America, and Central America varies widely; however, certain families have members in two or all of the continents. The two most common fish species in Southern Asia are catfish (Siluroidea) and carps (Cyprinidae) (Berra,1981). India is one of the mega biodiversity countries in the world and houses about 2,500 species of fishes, of which 930 are freshwater and 1570 are marine (Kar et al., 2006).

1.1.1 Indian Fisheries

India ranks third globally in terms of fish production and is the world's second-largest producer of fish raised for aquaculture. Approximately 7% of the world's fish production comes from India. The country is also home to more than 10% of the global fish biodiversity and is one of the 17-mega biodiversity rich countries. Fisheries and its related industries employ about 14 million people worldwide. West Bengal, Gujarat, and Andhra Pradesh are the next three states in the nation in terms of fish production. Around 70% of the total fish produced in 2017–18 came from the inland sector, and 50% came from culture fisheries, according to estimates of the total fish production for the year. More than 50 different varieties of fish and shellfish products are exported to 75 countries worldwide. With a quantity of 13,77 lakh tonnes and a value of Rs. 45,106,89 crore, fish and fish products are currently the largest category of agricultural exports from India. This represents approximately 10% of the nation's total exports and roughly 20% of its agricultural exports. It also contributes 0.91% to the GDP and 5.23% to the country's agricultural GVA India has a large number of finfish species. As per the database of the National Bureau of Fish Genetic Resources (NBFGR), Lucknow, 2,508 species of native finfish have been recorded, of which 1,518 species are from the marine environment, 113 from brackish waters and 877 are from freshwater habitats. In addition, 291 exotic fish species also occur in India (Sarkar et al., 2012).

Fish is one of the world's most valuable natural resources and is especially significant to the state of Goa because it is a fundamental aspect of Goan culture and daily life. It is considered as a staple diet for more than 90% of the population of Goa. Our Goa has 104 km of coastline that is home to many bays and headlands and the continental shelf area of Goa covers 10,000 km^2 and descends to a depth of roughly 100 fathoms. The current annual average marine and inland fish production is estimated at 86027 and 3669 tonnes, respectively. Goa contributes almost 2 percent of our nation's total marine fish production. In the marine fish landings, about 550 different species of fish and shellfish are registered (Sreekanth & Mujawar, 2021). 200 pelagic, 280 demersal, 95 crustaceans, and 90 species of mollusc were found. About 3% of the state GDP and 17% of the GDP from agriculture are contributed by the marine fisheries industry. Because it contributes significantly to Net State Domestic Product through both domestic and export trade, the fishing industry is therefore essential to socioeconomic development.

Approximately 14 699 tonnes of fish of value Rs. 288.5 crores have been exported from Goa in 2019-2020. In Goa, the average annual per capita fish consumption is 15–17 kg. Many people in Goa rely on the marine fishing industry for their living. Approximately 5–10% of the population as a whole is involved in fishing and related activities. Additionally, the fishing sector is the second-largest sector in terms of earnings and employment. In addition to fishing itself, a large portion of the population also makes a living from numerous auxiliary and subsidiary industries like marketing, drying, processing, and small-scale vending. However, there are a number of obstacles facing the state's fisheries industry, including overfishing, indiscriminate fishing, barriers to fish migration, pollution, habitat degradation, invasive species, climate change, and a lack of an appropriate management structure.

1.2 FOOD AND FEEDING HABITS OF FISH

Fish primarily consume groups of plants and animals that are found in or close Like other animals, fish need the same nutrients that make up food: proteins, carbs, fats, minerals, vitamins, and water. Fish distribution, migration, and growth are all regulated, or at least influenced, by feeding and food-seeking behaviours. The majority of marine fish species can be broadly classified into three major trophic categories based on their feeding habits as herbivorous, omnivorous, and carnivorous. The majority of studies on fish diets use stomach content analysis to measure prey abundance, typically at a coarse taxonomic resolution when the primary focus of the investigation is ecology. Fish diets vary depending on a variety of extrinsic (biotope, region) and intrinsic (species, size, behaviour) factors. Therefore, knowledge of fish diets is essential for comprehending the fundamentals of fish assemblage functioning, which is crucial for creating models for ecosystem-based fisheries management (EBFM) (Jhingran, 1982).

Understanding the food habits and diet is essential to comprehending many facets of fish physiology, biology, and behaviour. From an ecological perspective, these studies enable exploration of trophic interactions, specifically predator-prey relationships and competition between and within the species. Studying fish feeding behaviours is crucial for aquaculture and fisheries as it gives information on the feeding grounds and distribution patterns of both local and regional fish, and it also directly affects fishing equipment like fish traps and long lines that are used as bait which is useful in fisheries. In aquaculture it is necessary to know the different larval food for providing them at their different life stages for their further growth. Bait selection and fishing strategy optimization can be achieved by having knowledge of feeding grounds, daily cycles of feeding activity, and prey preferences. Despite offering a critical evaluation of the current understanding of fish food and feeding behaviours in Indian waters, Qasim (1972) stressed the significance of chemical analyses of fish food since they are vital to comprehending dynamics.

1.3 GUT CONTENT ANALYSIS

The food and feeding habits of fish species are often determined through analysis of the gut contents. Investigation of food habits of the fishes has traditionally been an important field of activity in fisheries biology. Still, it is one in which there are great difficulties in correlating the results with the research made in the other areas. The entire aquatic environment, of which fish are only one component, must be taken into consideration and not the isolation, when conducting research on the eating habits of fish. Studies of resource requirements by various species have been used to understand factors controlling the distribution and abundance of organisms. In addition, studies on the food habits of organisms utilizing each habitat or area it was collected will help illustrate the role of the gut content in the ecology of several organisms. Therefore, food resources have received by far the most attention; many studies about the ecology of organisms in terms of feeding have been conducted for different fish communities e.g., gut content analysis.

Fish feeding patterns and food habits can be quantitatively assessed with the help of this gut content analysis, which is a crucial component of fisheries management in the aquaculture sector. (Noble 1981; DeVries and Stein 1990). Hence, information about the availability of prey can direct management initiatives meant to boost fish production. Knowledge of fish diets and feeding behaviours must also be accurate in order to comprehend trophic relationships in aquatic food webs. (Garvey et al., 1998; Vander et al., 2000). Examining the food and feeding habits of pelagic fish species can provide additional insight into their migratory and shoaling behaviours. This is especially crucial for highly valuable commercial species like mackerel. Diet composition analysis or other techniques, such as stable isotope analysis, can be used to evaluate effects of ontogeny, habitat, or the establishment of exotic species. Lagler (1949) pointed out that the gut contents only indicate what the fish would feed on to provide energy in the species for growth, repair, and development. In connection, the study of feeding habits of fish and other animals based upon analysis of stomach content has become a standard practice. Diets of fishes represent an integration of many ecological components that include behaviour, condition, habitat use, energy intake and inter- and intraspecific interactions. Therefore, food habit studies can be included in a wide range of distinct research objectives. In the simplest case, a food habits study might be conducted to determine the most frequently consumed prey or determine whether a particular food category is present in the stomach of fishes.

1.4 LENGTH WEIGHT RELATIONSHIP

Fish is a cheap protein source that contains nutrients and plays an important role in the development of a nation. Length-weight relationships is an important tool in fisheries biology as it helps to estimate the weight and biomass from length observations (Koutrakis and Tsikliras, 2003). According to Saha et al. (2009) It is a mathematical estimate which helps to obtain weight when length is available or help to compute length when weight is available. Research on length-weight relationships can aid in assessing the well-being and reproductive status of fish (Ayoade and Ikulala, 2007). Shadi et al. (2011) have reported the significance of length-weight relationships as it contributes in stock assessment and population dynamics. This data offers insights into their growth patterns, life cycle, survival rates, and general health (Le Cren, 1951; Christensen and Walters, 2004).

The study of the length-weight relationship in fishes, has been mainly directed towards two objectives, namely, (i) to provide a mathematical relationship between the two measurements as a means of inter conversion and (ii) to calculate the condition factor (Le Cren, 1951). In fishery biology, the welfare or condition factor of fish is very important (Weatherly and Gill 1987). This factor is the quantitative parameter that represents the wellbeing of the fish (Le Cren 1951),which reflects the condition of the fish in its habitat as heavier the species of fish at a given length, the better its physiological state, suggesting it feeds more in that region (Bagenal and Tesch 1978).This condition factor is also an index to understand the lifecycle of fish by referring to the coefficient values derived from the length weight relationship data (Schneider, 2000). In other words, both biotic and abiotic environmental factors also affect the fish condition (Saliu, 2001). This parameter could be used to determine the status of the aquatic ecosystem in which the fish live, whether the ecosystem is in good condition or polluted (Luff & Bailey 2000, Anene 2005).

In general, the change in weight of fish can be described by the relationship M=aL^b where W is observed fish weight, L is observed fish length, and a and b are estimated by log W=log a+log L (i.e. a is the regression intercept and b is the regression slope). Therefore, the case where bB3 represents fish that become less rotund as length increases, whereas when b\3 fish become more rotund as length increases. These are both examples of allometric growth. Growth at b=3 may be isometric (growth with constant body proportions and specific gravity), but shape may vary because of variations in a (Anderson and Gutreuter, 1983).

1.5 AIM AND OBJECTIVES OF THE STUDY

To assess feeding habits of selected fish species by identifying and quantifying their dietary composition and understanding the growth dynamics of these species within the estuarine ecosystem.

- To determine the length-weight relationship for multiple fish species inhabiting the estuarine water body
- To identify and quantify the dietary composition of selected fish species by analysing their gut contents.

1.6 HYPOTHESES OF THE STUDY

Hypotheses of this study proposes that the dietary composition varies significantly among the selected fish species, reflecting species-specific feeding preferences and ecological niches within the estuarine ecosystem. The length-weight relationship of the selected fish species exhibits a significant allometric or isometric growth pattern, indicating differences in body condition and growth rates among species.

1.7 SCOPE OF THE STUDY

This study aims to determine the food or prey items in the gut of 4 species of marine fishes caught in Durbhat estuary. Specifically, it is aimed to assess the frequency of occurrence, percentage of food items in the gut of the fish sample, and the importance of the food items. Study focusing on the gut content analysis and length-weight relationship (LWR) of selected fish species from the estuary in Goa stands as a pioneering endeavour in this geographical context. As there is no prior research conducted in this specific area, the data obtained from this study will be beneficial in filling critical knowledge gaps regarding the dietary habits and growth patterns of these fish species. Since the fish is a staple diet in Goa, the data generated from this research carries substantial implications for both public health and environmental sustainability. Understanding the dietary preferences and growth patterns of these fish species not only contributes to the enhancement of local fisheries management practices but also aids in the preservation of Goa's rich marine biodiversity.

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CHAPTER 2: REVIEW OF LITERATURE

Fish gut content analysis provides an important insight into feeding patterns & a quantitative assessment of feeding habits. Direct observation of the feeding habits of a fish in its natural habitat is nearly impossible and therefore to ascertain the nature of a fish food, the best way is to examine its gut contents.

Feeding ecology of *Ambassis gymnocephalus* in South Africa reported their diet comprised predominantly of crustaceans, fish, insects, and fish eggs and other unidentifiable contents (Martin & Blaber, 1983; Dyer et al., 2015). While Dyer et al. (2015), in South Africa reported that the diet of *Ambassis ambassis* primarily consists of zooplankton and both terrestrial and aquatic insects and documented seasonal variation in trophic levels as drier seasons showed higher trophic positions for fish.

Subsequent inquiries have been done on the feeding behaviour of *Glossogobius giuris* where Achakzai et al (2015) who studied *G. giuris* in Pakistan reported fish, insect and mollusc as its dietary preference including cannibalism and seasonal variations in feeding intensity, with higher consumption rate in spring and summer and lower in rainfall. While, Bejer (2015), in the Philippines revealed that juvenile *G. giuris* primarily consume insect larvae and debris, while adults favor crustacean eggs and fish larvae, and reported *G. giuris* as an omnivore, which is also suggested by Hossain et al (2016), in Bangladesh, that *G. giuris* is primarily carnivorous, with fish being its dominant food source, followed by crustaceans, insects, zooplankton, and algae.

According to Lugendo et al. (2006) who analysed the gut content of fishes from three different habitats in Chawaka Bay, *Gerres oyena* feeds on fishes, detritus and copepods. While Cyrus &

Blaber (1983) who studied the feeding ecology of five species of *Gerres* in South Africa reported that polychaetes and oligochaetes are important food items followed by copepods.

Considerable investigation has been conducted thus far regarding the diet and feeding behaviour of *Scatophagus argus* (Mookerji et al., 1949; Allen, 1984; Datta et al., 1984; Mathew, 1988; Monkolprasit, 1994; Gandhi, 2002; Wongchinawit et al., 2007; Wongchinawit and Paphavasit, 2009; Sivan and Radhakrishnan, 2011; Das et al., 2014; Hashim et al., 2014). *Scatophagus argus* has been documented as omnivorous except for Barry and Fast (1992), who described it as a herbivorous fish species.

Mookerji et al. (1949) have documented the presence of phytoplankton, protozoa, detritus, and copepods in the small size fishes (<50 mm in length) while the large size fishes (136 mm in length) have been reported to feed on unicellular and multicellular algae, higher plants, protozoa, sponges, crustaceans, fish scales, sand, and mud in studied samples from the estuaries of Bengal. Allen (1984) has reported that *S. argus* feeds on worms, crustaceans, insects, and plant matter while Datta et al. (1984) who studied *S. argus* in Uttarpradesh and Monkolprasit (1994) in Thailand have documented aquatic macrophytes, phytoplankton, zooplankton, and macrobenthos in the gut of this fish species.

Mathew (1988) documented that juveniles of *S. argus* from Cochin feed on small food items mainly diatoms and algae. The adults consume mainly algae, diatoms, hydroids, and crustaceans. Crustaceans such as copepods, amphipods, isopods, and mysids have been reported from the gut of adult *S. argus.* No significant variation was observed in the food habit of juveniles and adults, but habitat wise variation has been documented in the gut content (Mathew, 1988). *S. argus* in Tamil Nadu do not have any preference for any particular food item as they are used to feeding on whatever food is available in nature and adults are bottom feeders with a browsing, scrapping, nibbling, and swallowing habit (Gandhi, 2002).

Wongchinawit et al. (2007), have reported that *S. argus* is a benthic omnivore. Microphytoplankton, protozoans, zooplankton, benthos, and detritus have been reported as the dominant food items for this fish species in Thialand. Food preference of *Scatophagus argus* in two different salinity periods reported no significant difference. Microphytoplankton comprised the majority of the diet with variation in diet related to availability of food and morphology of feeding structure in each of the developmental stages of the fish (Wongchinawit and Paphavasit, 2009). *S. argus* is reported to be omnivorous bottom feeders with a pelagic feeding habit in juveniles (Sivan and Radhakrishnan, 2011; Das et al., 2014). While Barry and Fast (1992) in the Philippines reported that adult *S. argus* were primarily herbivorous as their guts were typically full of unidentified plant material. Herbivorous diet of scat was further justified by their small, rasp-like teeth, which seem to be adapted for scraping and shredding plant material, and their long, coiled intestine, which in adults averaged about 3:5 times the body length.

Studies were conducted on the Length Weight Relationship (LWR) of *Ambassis gymnocephalus* (Harrison, 2001; Huang et al., 2018; Karna et al., 2020) which showed isometric growth. Another similar study on *A. gymnocephalus* from Vembanad lake, India showed positive allometric growth (Renjithkumar & Roshni, 2021).

LWR of a *Scatophagus argus* in Gulf of Mannar revealed negative allometric growth which is likely due to the fish's body shape that is deep and laterally compressed (Gandhi et al., 2013).

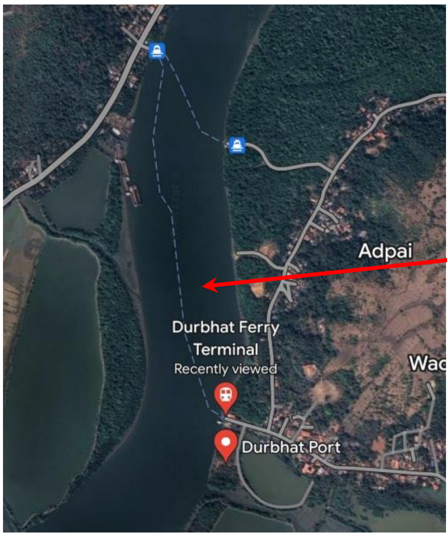
Few investigations have evaluated the Length Weight Relationship of *Glossogobius giuris* by (Khan et al., 2002; Gogoi et al., 2002; Mercy et al., 2008; Hossain et al., 2009; Massood and Farooq, 2011). Mercy et al. (2008) in Kerala and Hossain et al. (2009) in Bangladesh reported isometric growth for *Glossogobius giuris*. Whereas Massood and Farooq (2011) in Pakistan and Khan et al. (2002) in Bangladesh suggested positive allometric growth. However, the study conducted by Gogoi et al. (2002) substantiated negative allometric growth for the same species from the Sessa river, Assam, India.

Gerres filamentosus in Egypt was investigated for the relationship between length and weight. Findings revealed negative allometric growth (El-Nasr & Taher, 2016). While the findings of Mansor et al. (2012) in Pakistan and Renuka et al. (2011) in India showed positive allometric growth for *same species.*

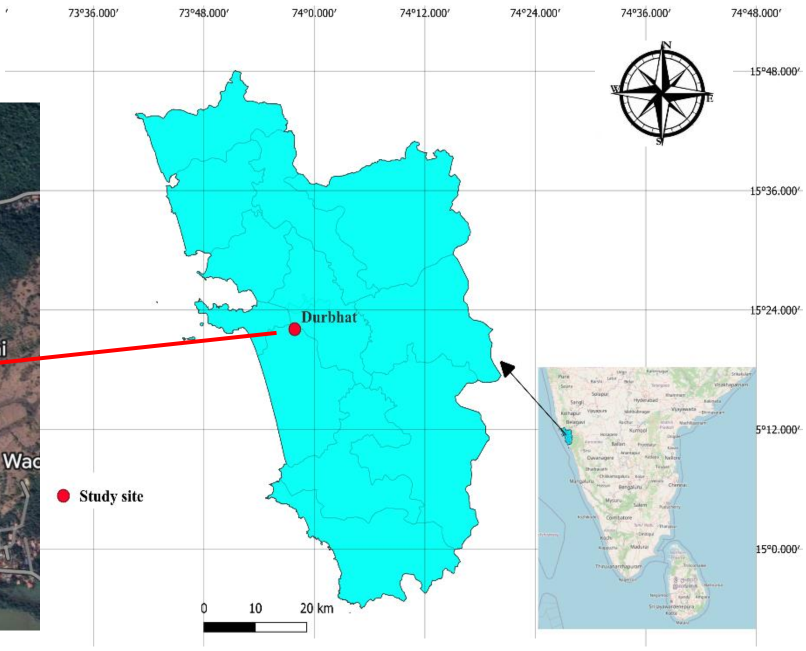
CHAPTER 3: METHODOLOGY

3.1 STUDY AREA

The study area is Durbhat which lies on the banks of river Zuari. The site is along the perennial estuarine water body located in the village of Durbhat in Ponda taluka. This small village is surrounded by mountains, forest and other side by mangrove vegetation. The study site is located at 15° 22' 4.4544" latitude and 73° 57' 51.7968" longitude. The water bodies are surrounded by mangroves trees.



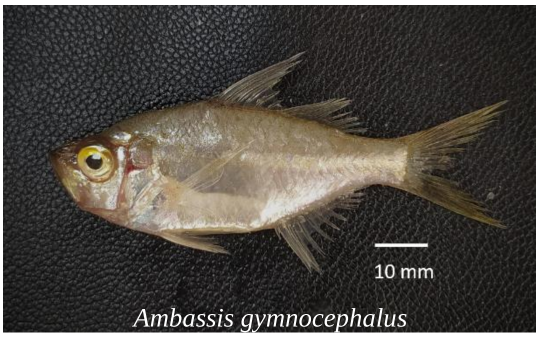
a) Durbhat Study site



b) Goa Map

3.2 STUDY ORGANISMS

1) ***Ambassis gymnocephalus***



Common name: Naked head glassy perchlet

Local name: Burranto

Description: Naked head glassy perchlet are members of Ambassidae family. They are identified as a family by their semi-transparent and small body and single deeply notched dorsal fin. They are found in the shallow depth of coastal waters, brackish estuaries and mangrove shores, although some live entirely in the fresh water rivers. They are mostly nocturnal and feed on small crustaceans, aquatic and terrestrial insects, small fishes, fish eggs and larvae.

2) ***Glossogobius giuris***

Common name: Tank gobi

Local name: Kharchani

Description: Tank goby is a species belonging to family Gobiidae. It is brownish yellow in colour with 5 to 6 dark and rounded spots on its sides. Some specimens living on dark substrates can be very dark also. Some living on very light substrates shows an ivory coloration. It is a benthic species which prefer muddy or sandy estuaries, river mouths and bays. Most species can even survive in freshwater habitats though most live in marine habitats. They feed on small crustaceans such as crabs, shrimps and other small fishes. Grows to a much larger size in brackish water than in fresh water. Cannibalism is relatively common for this species.

3) ***Gerres limbatus***

Common name: Silver biddy

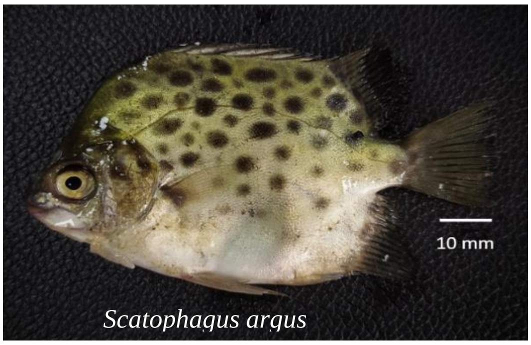
Local name: Shetuk

Description: This species is belonging to family Gerridae. It is silverish white in colour. Dorsal fin faint yellowish, with a dark patch on tip of spinous portion above a line running from middle of second dorsal spine to tip of 6th dorsal spine (rarely broader or otherwise indistinct with growth). Caudal fin pale yellow. Anal fin with anterior half yellow or dull orange, posterior whitish hyaline. Lives in tidal areas of estuaries and very shallow coastal waters. Feeds on small animals living on mud-sand bottoms.

4) ***Scatophagus argus***

Common name: Spotted scat

Local name: Banshire



Description: spotted scat is a species of fish in the scat family Scatophagidae. The body which is rectangular and strongly compressed with the head having a steep dorsal profile. It has a moderately large eye which has a diameter noticeably smaller than the length of the rounded, snout. They have a small, horizontal mouth which is not protractile. The body is greenish-brown to silvery with many brown to red-brown spots. Inhabit harbors, natural embayments, brackish estuaries and the lower reaches of freshwater streams, frequently occurring among mangroves. Feed on worms, crustaceans, insects and plant matter.

3.3 SAMPLE COLLECTION

The study has been carried out for 4 months from December 2023 to March 2024. A total of 300 and 45 fish samples of each species were analysed for conducting their Length-Weight Relationship (LWR) and gut content analysis respectively. Every month during study period specimens of each species were collected from local fishermen from study site. Fishermen traditionally employ their dugout canoes for sampling collection during fishing expeditions. The gears used for the collection is generally gill nets and Rod-lines consisting of 3-8 m long monofilament line with barbed hook. The collected fresh fish specimens were brought to the laboratory and kept in a deep freezer until further processing to prevent further digestion of the stomach contents. In the laboratory, all specimens were measured for morphometric characters and meristematic characters were noted down and identified the fish species following the keys provided by FAO sheets and Jayaram (2009).

3.4 LENGTH WEIGHT RELATIONSHIP

The length–weight relationship (LWR) was calculated using equation W = aL^b where 'W' and 'L' represent weight and length respectively. For LWR, total length (TL) nearest to 0.1 mm and total body weight (BW) nearest to 0.1 g were measured using digital weighing machine. From the frontmost tip of the snout to the caudal fin tip, the TL was measured. The formula Log (BW) = Log(a) + b Log (TL) can be naturally logarithmically transformed (Froese et al., 2011; Bhatt et al., 2021) is used to determine the values of "b" (weight at unit length) and "a" (an exponent that represents the rate of change with respect to length). If b = 3, indicates isometric growth, which is defined as weight and body length increasing in the same proportions. If $b \neq 3$, you have allometric growth, where $b < 3$ indicates negative allometric growth and $b > 3$ indicates positive allometric growth (Morey et al. 2003). Further, 95% confidence limits of a, b and the coefficient of determination were estimated.

3.5 SEPARATION OF GUT CONTENT

Prior to the analyses, the fish specimens were thoroughly cleaned with water and its total length and weight were noted. The fish was held in hand belly facing upward, then with the help of a surgical scissors, an incision was made at the anus. Depending on the type of fish being dissected cut was extended either along the isthmus or anteriorly towards the gills. Care was taken not to cut too deep so that gut remains intact. Subsequently the two body walls were pulled apart and the gut and other internal organs attached to it were exposed. The gut was separated from the other exposed organs and transferred into a petridish, after which the weight and the length of the gut were measured. The guts of each fish were then fixed in a 4% formalin for further analysis of a gut content. The entire contents of the digestive tract were flushed out with saline using a syringe and then incision was made along the gut and the intestine for clearing out a remaining content. The content was emptied into a clean petridish and observed under Stereo zoom microscope (Stemi 508).

3.6 METHODS OF GUT CONTENT ANALYSIS

A combination of both quantitative and qualitative methods is used to analyse the contents of a fish's stomach. This is done in order for the outcomes to serve as a gauge for feeding consistency. This is done to show whether or not the feeding regimen is consistent. Two parameters, the percentage frequency of each dietary item in the stomachs of all fish (%F), and the relative contributions of each dietary item to the number in the stomach of each fish (%N), were used to analyse fish diets. These parameters were first proposed by Hyslop (1980). As recommended by Kow (1950) to measure feeding intensity, monthly variances in the feeding index were derived based on stomach fullness. Fish were categorized as either gorged, full, ¾ full, or ½ full as actively fed whereas those with ¼ full, trace and empty as poorly fed, based on their relative fullness and the amount of space occupied by food.

a) Feeding Intensity

Gorged stomach: - A stomach in which the gut contents occupy the entire stomach and is full. The walls of stomach appear transparent and the organisms inside the stomach could be seen.

Full stomach: - A stomach in which the food items occupy the entire cavity of the stomach is called a full stomach.

¾ full stomach: - A stomach in which the food items occupy ¾ of the stomach.

½ full stomach: - A stomach in which the food items occupy ½ of the stomach.

¼ full stomach: - A stomach in which the food items occupy ¼ of the stomach.

Trace stomach: - A stomach in which very little or few organisms are present in the stomach.

Empty stomach: - No food item present in the stomach or a little digested secretion may be present in the stomach.

b) Relative gut length (RGL)

The relative gut length is the ratio between gut length (cm) to the total body length (cm) of the fish. It is used for the classification of different sized fishes as a carnivore, herbivore and omnivore.

$$\mathbf{RGL}=\frac{Total\ length\ of\ gut}{Total\ length\ of\ fish}$$

c) Occurrence method

In occurrence method, stomach contents are examined and individual food organisms are sorted and identified. The number of stomachs (fishes) in which each item occurs is recorded and expressed as a percentage of the total number of stomachs (fishes) examined. The frequency of occurrence of all the food items among the stomachs examined is summed and the frequency of occurrence of each diet expressed as a percentage of the total number of specimens examined.

Frequency of occurrence, % Oi = $\frac{Ni}{N} \times 100$

% O = Occurrence frequency of a given food i

Ni = Number of stomachs which contain food item i

N = all stomachs which contain food

d) Numerical Occurrence

The number of individuals of each food type in the stomach is counted and expressed as a percentage of the total number of food items in the sample studied, after which the total percentage composition is estimated. It is a suitable method for studying feeding habit of fishes i.e. plankton feeders and piscivorous fishes.

Percentage number (%Ni) = %Ni = $\frac{Ni}{Nt} \times 100$

%Ni = percentage number of given foods i

Ni = number of particular foods i

Nt = total number of food items (gut contents)

d) Gastrosomatic index (GaSI)

The gastrosomatic index is the gut weight expressed as a percentage of body weight. This index indirectly indicates the spawning season as this index is very low during the peak spawning season because of the large number of empty stomachs.

$$\mathbf{GaSI} = \frac{Weight\ of\ gut}{Weight\ of\ fish} \times 100$$

CHAPTER 4: ANALYSIS AND CONCLUSIONS

4.1 RESULT

Length Weight Relationship

The present study illustrates the information of length-weight relationship (LWRs) and feeding biology of four marine fish species namely, *Ambassis gymnocephalus*, *Glossogobius giuris*, *Gerres limbatus* and *Scatophagus argus* from the stretch of Zuari estuary, Durbhat, Goa. To analyse length weight relationship, 300 specimens of each species were measured during December 2023 to March 2024. LWR was analyzed by cube law (Froese, 2006). The descriptive statistics of LWRs, regression parameter 'a' and 'b', and coefficient of determination (R^2) are represented in Table (4.1.1)

Table 4.1.1: Length Weight Relationship of fish species

Fish Species	Length range (cm)	Weight range (gm)	N	a	b	R^2
Ambassis gymnocephalus	4.8 - 13	1 - 20	300	0.009	3.06	0.9
Glossogobius giuris	5.5 - 16	1.5 - 26.1	300	0.01	2.83	0.94
Gerres limbatus	6.1 - 16	3.9 - 39.1	300	0.02	2.72	0.95
Scatophagus argus	6 - 14.1	6 - 75	300	0.03	2.87	0.92

In *Ambassis gymnocephalus*, total length (TL) was recorded in the range of 4.8 to 13 cm with mean (8.13±1.28) cm and weight range of 1 to 20 g with mean (6.10±3.20) g. Length Frequency Distribution of *A. gymnocephalus* shows that majority of individuals grouped within the 7-8 cm length class, with the highest number of individuals (100) in the 7 cm length class. Moderate number of individuals were grouped in 6 and 9 cm class with 43 and 40 individuals respectively while 4 and 13 cm length class represented lowest number of individuals *i.e.* only 1 individual in each length class. The number of individuals decreased for both smaller and larger length classes, suggesting that population sampled included higher number of individuals of intermediate size (Figure 4.1.1).

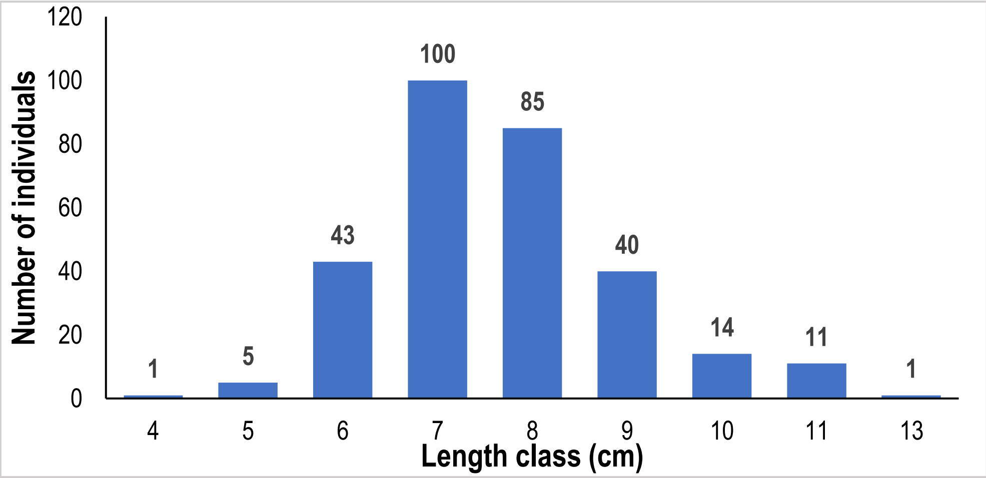


Figure 4.1.1: Length frequency distribution of *Ambassis gymnocephalus*

In the case of *Glossogobius giuris*, TL ranged between 5.5 to 16 cm with mean (9.73±2.05) cm and weight ranged between 1.5 to 26.1 g with mean (8.67±5.45) g. Length Frequency distribution of this species (Figure 4.1.2) showed that majority of individuals were grouped within 7-10 cm length classes, with the highest number of individuals in the 9 cm class (63 individuals), and the frequency generally decreased as the length increased or decreased from this trend.

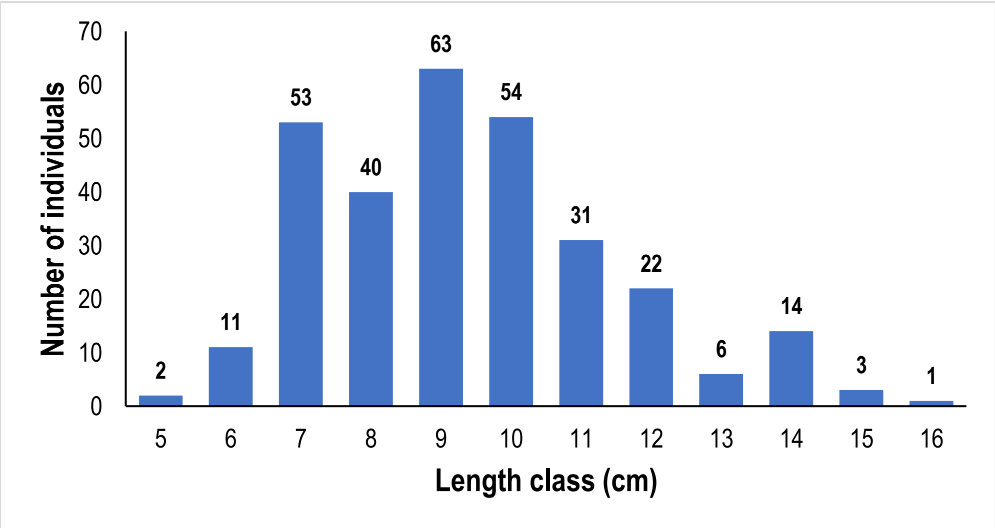


Figure 4.1.2: Length frequency distribution of *Glossogobius giuris*

Gerres limbatus shows TL range of 6.1 to 14.1 cm with mean (10.43±2.26) cm and weight range of 3.9 to 39.1 g with mean (17.73±9.86) g. The majority of individuals (56 number) belonged to 12 cm length class and few individuals in 14 cm length class (8 individuals) (Figure 4.1.3).

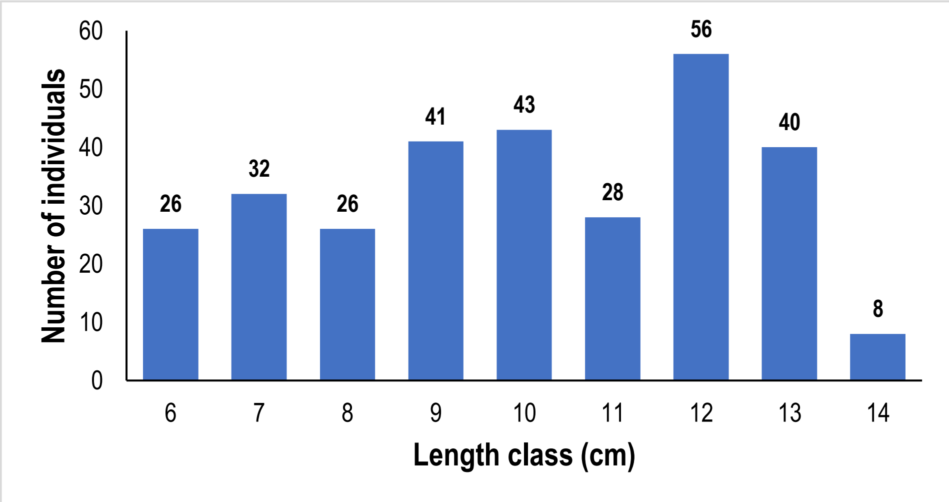


Figure 4.1.3: Length frequency distribution of *Gerres limbatus*

In *Scatophagus argus* TL ranged between 6 to 14.1 cm with mean (10.71±2.04) cm and weight ranged between 6 to 75 g with mean (38.56±18.03) g. The majority of individuals belonged to 10-12 cm length classes, with the highest number in the 10 cm and 12 cm classes with 66 and 67 individuals respectively. The distribution of length is somewhat skewed towards the middle, with few individuals at the extremes (Figure 4.1.4).

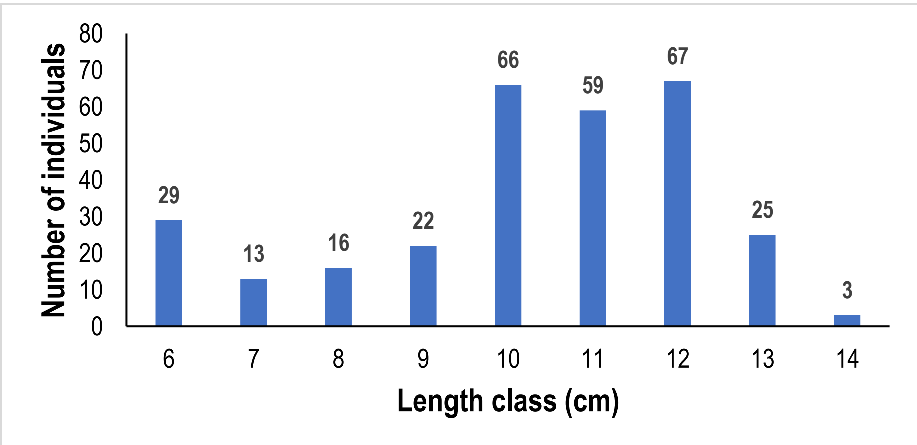


Figure 4.1.4: Length frequency distribution of *Scatophagus argus*

The figure showed a parabolic relation between length and weight indicating the applicability of general cube law to these four species. (Fig. 4.1.5, Fig.4.1.6, Fig.4.1.7 & Fig.4.1.8). LWR were calculated separately for each species and were used to check whether the growth is isometric (b=3) or allometric (negative allometric: b<3 or positive allometric: b>3). The value of exponent ‘b’ was also found within the range of 2.72 to 3.06 (Table 4.1.1). Highest ‘b’ value (3.06) was recorded in *A. gymnocephalus* revealing that L-W relationship of this species followed the cube law suggesting positive allometric pattern of growth. *S. argus* (2.87), *G. giuris* (2.83) and *G. limbatus* (2.72) ‘b’ value is less than ideal value 3.0 showing all 3 species negative allometric pattern of growth.

The r^2 value for the investigated species were recorded in (Table 4.1.1). The r^2 value show a high degree of positive correlation, indicating that length and weight were highly correlated.

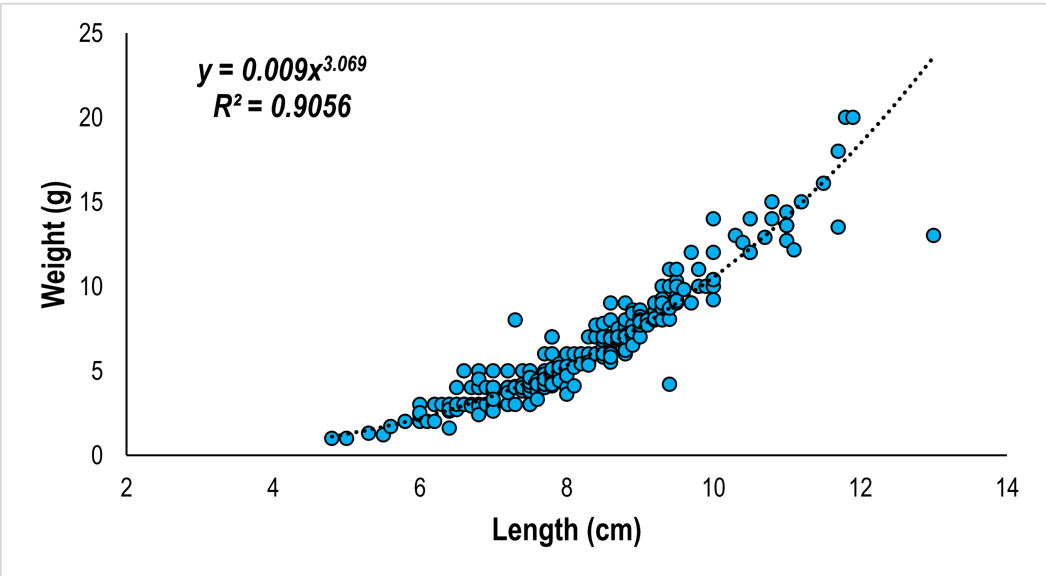


Figure 4.1.5: Length Weight Relationship of *Ambassis gymnocephalus*

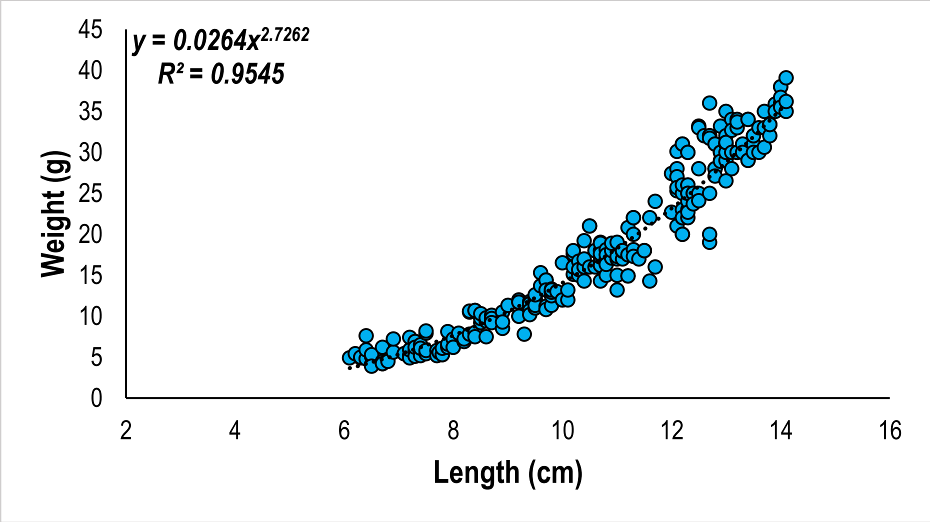


Figure 4.1.6: Length Weight Relationship of *Glossogobius giuris*

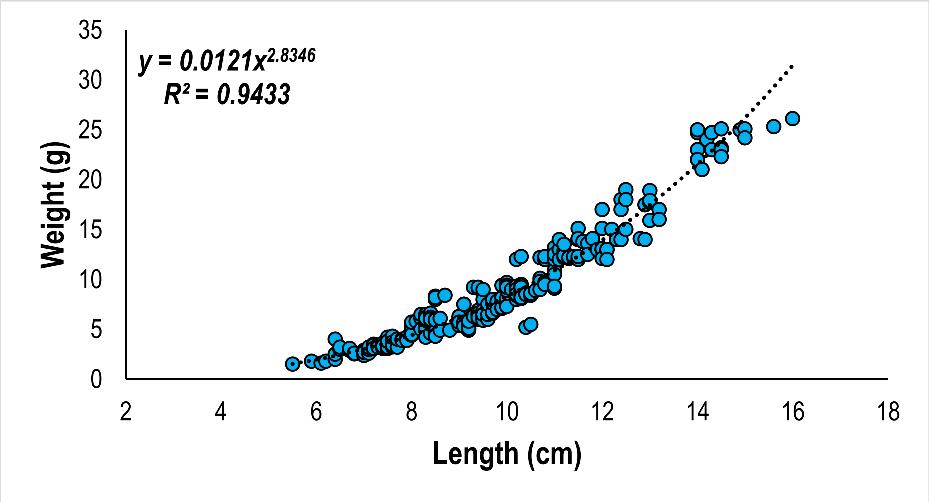


Figure 4.1.7: Length Weight Relationship of *Gerres limbatus*

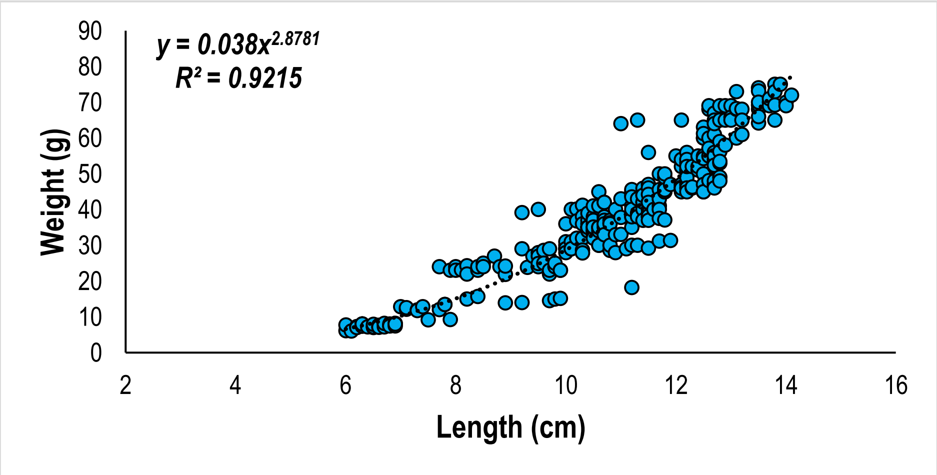


Figure 4.1.8: Length Weight Relationship of *Scatophagus argus*

Feeding Biology

Food and feeding habits of 4 fish species namely *Ambassis gymnocephalus*, *Glossogobius giuris, Gerres limbatus* and *Scatophagus argus* were investigated based on the examination of stomach contents. Total 45 individuals of each species were observed for gut content analysis during the study period.

On analysing the gut content of *A. gymnocephalus*, total 102 number of prey items were found and identified. Diet of this species is composed of mainly 3 groups of prey which are crustaceans, fishes and mollusc (Fig.4.1.10). Percentage numerical occurrence of each food item is given in (Table 4.1.9), representing crustacean (84.31% with shrimp comprising 45.9%, crabs 5.88% and other crustaceans 33.33%), followed by fish (14.70%) and mollusc (0.98%). Figure 4.1.11 depicting the frequency of occurrence revealed that the major prey consumed by *A. gymnocephalus* was crustaceans (71.11%) while mollusc was least consumed with the value of 2.22%.

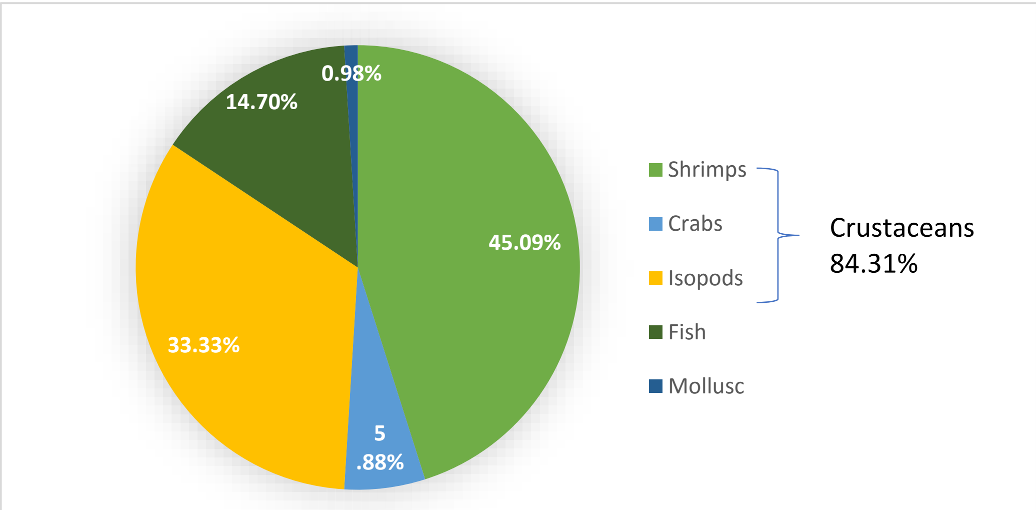


Figure 4.1.9: Numerical Occurrence of *Ambassis gymnocephalus*

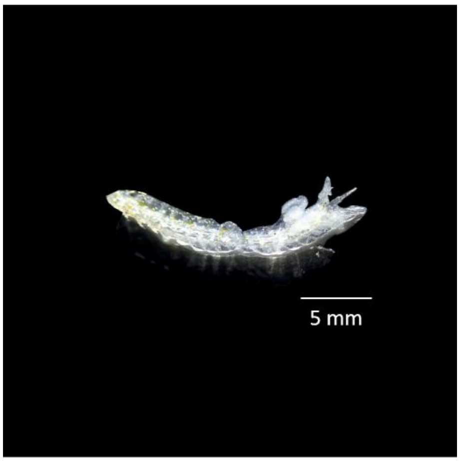
The relationship between gut length and total length of *A. gymnocephalus* was found to be positively correlated (R^2= 0.6505) (Figure 4.1.12).

a) Shrimp

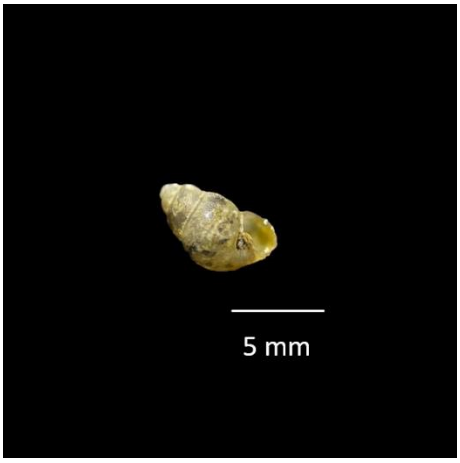
b) Isopods

c) Fighter shrimp

d) Juvenile crab



e) Fish vertebrae



f) Snail shell

Figure 4.1.10: Gut Contents found in *Ambassis gymnocephalus*

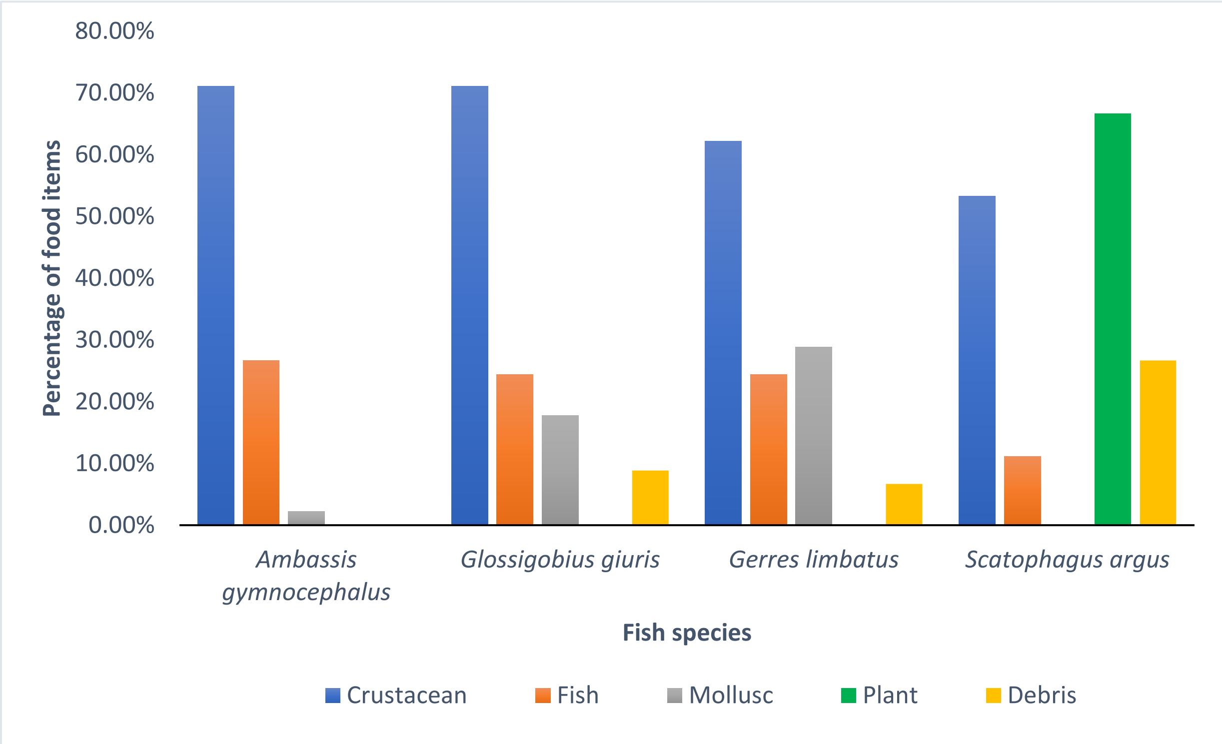


Figure 4.1.11: Frequency of Occurrence of fish species

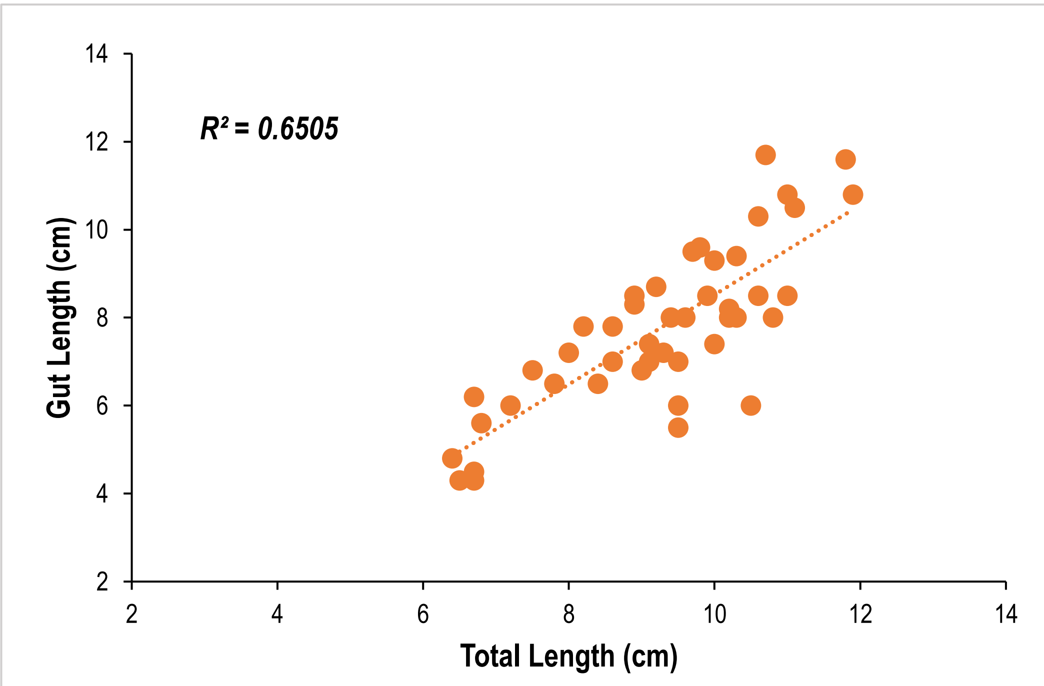


Figure 4.1.12: Relationship between Gut Length (cm) and Total Length (cm) of *Ambassis gymnocephalus*

Stomach distention of this species were categorised into five categories: Empty and trace stomach, filled to 25%, filled to 50%, filled to 75%, and full & gorged stomach (Table 4.1.2). According to this category, even though the specimens were collected at same time it was found that highest number of individuals (31.11 %) had an empty or trace stomach followed by 11 individuals (24.44%) with full and gorged stomach, while stomach filled to 25% and filled to 75% were comprised of only 6 individuals (13.33%).

Table 4.1.2: Number of *Ambassis gymnocephalus* specimens represented in each stomach distention category

Stomach distention categories	Number of specimens	% contribution
Empty and trace stomach	14	31.11
Filled to 25%	6	13.33
Filled to 50%	8	17.78
Filled to 75%	6	13.33
Full and gorged stomach	11	24.44

In figure showing stomach distention in relation with total length of species, the data points are distributed across different levels of stomach distention, indicating that there is no correlation between total length and stomach distention percentage (Figure 4.1.13).

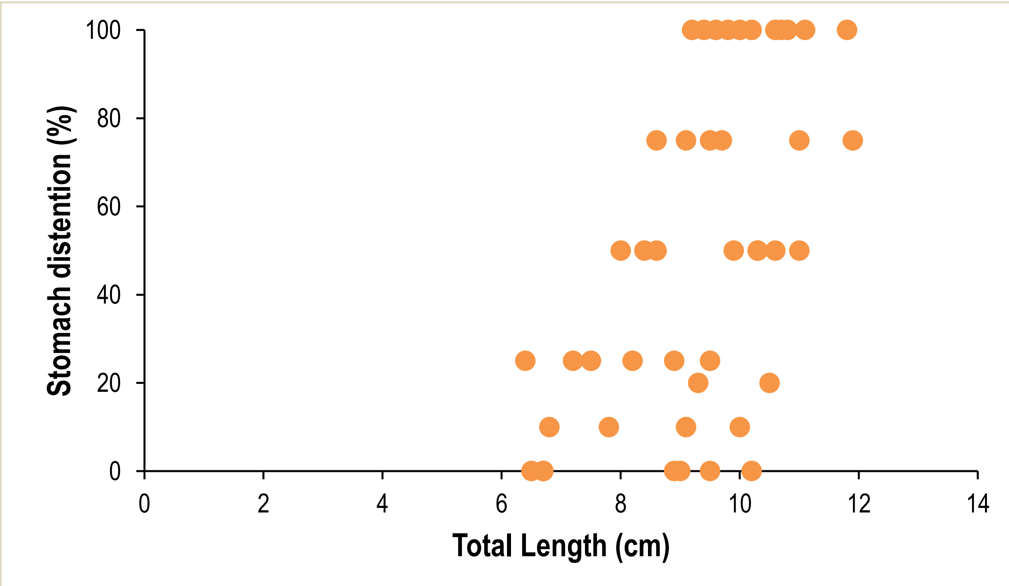


Figure 4.1.13: Stomach distention of *Ambassis gymnocephalus* in relation with Total Length (cm).

Considerable variability was found in the Gastro-somatic index (GaSI) of *A. gymnocephalus*, with values ranging from below 1.0 to nearly 10 (Figure 4.1.14). The index fluctuates significantly from one specimen to another, indicating that the condition of the stomach (in terms of fullness or emptiness) varies widely among the sampled population.

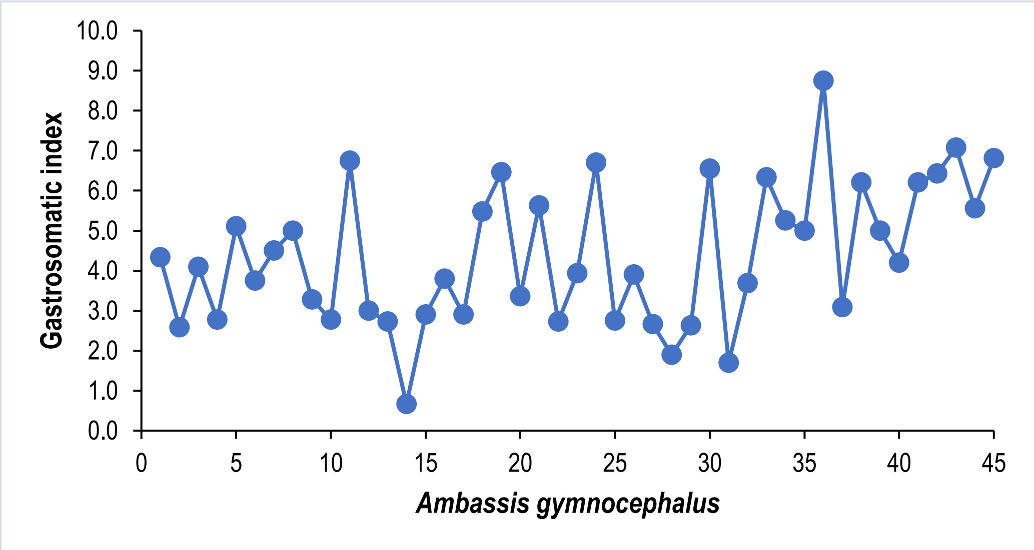


Figure 4.1.14.: Gastrosomatic index of *Ambassis gymnocephalus*

Total 127 food items were found in the gut of *Glossogobius giuris*. Diet of this species was found to be almost similar to that of *A. gymnocephalus* comprising shrimps, isopods, fish, crab, shell pieces with the exceptions of amphipod and copepods (Fig. 4.1.16) Percentage numerical abundance for crustacean is 84.31% with (shrimp comprising 51.96%, crabs 7.87% and isopods with 18.89%), followed by fish (13.38%) and mollusc (7.87%) (Fig. 4.1.15).

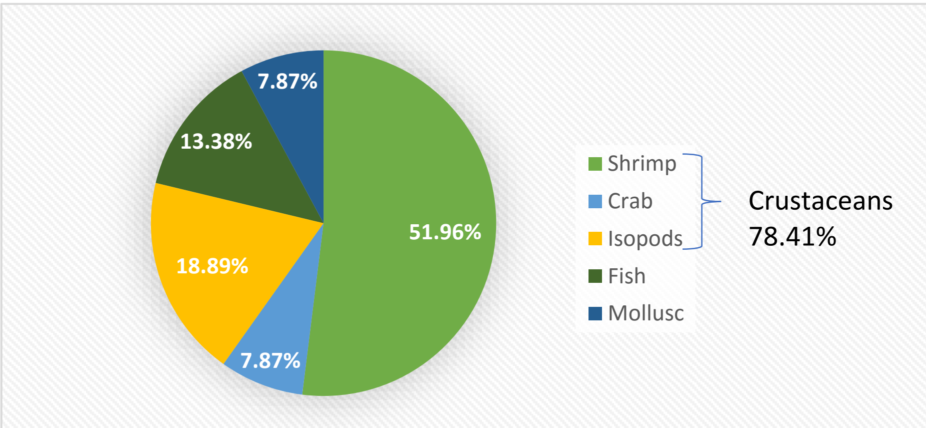
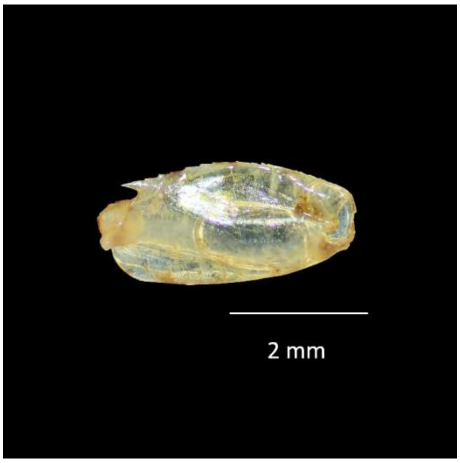


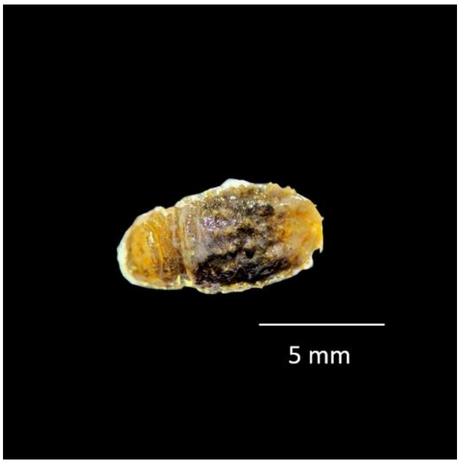
Figure 4.1.15: Numerical Occurrence of *Glossogobius giuris*

a) Partially digested shrimp



b) Carapace of shrimp

c) Juvenile crab



d) Unidentified crustacean

e) Partially digested fish

f) Pieces of bivalve shell

Figure 4.1.16: Gut contents found in *Glossogobius giuris*

The percentage frequency of occurrence of crustaceans (71.11%) and fishes (24.44%) were higher than mollusc (17.77%) as found in the diet of *A. gymnocephalus* (Figure 4.1.11). There is positive correlation between gut length and total length of *G. giuris* (R^2 =0.64) (Figure 4.1.17).

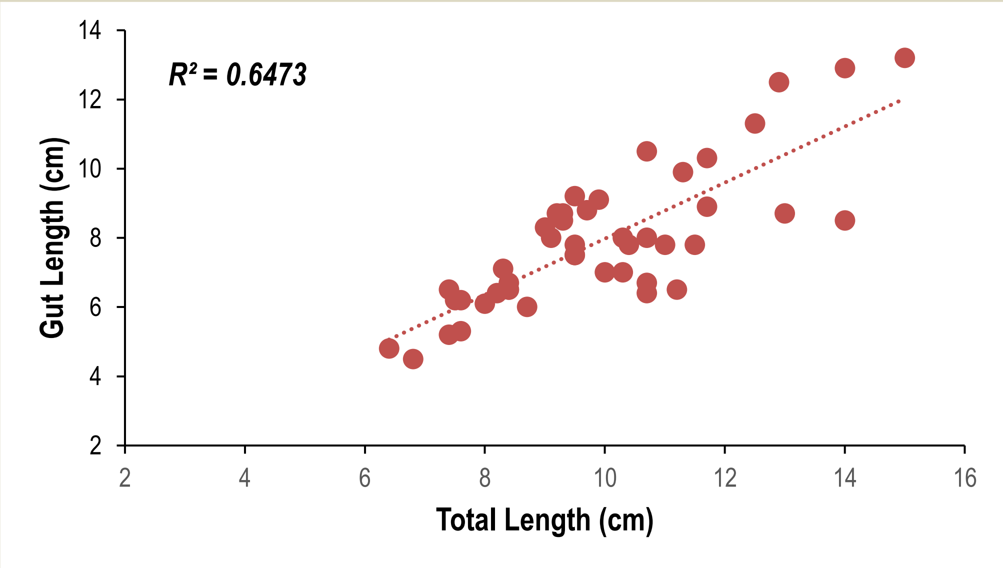


Figure 4.1.17: Relationship between Gut Length (cm) and Total Length (cm) of *Glosssogobius giuris*

According to the stomach distention category (Table 4.1.3) it was found that, 12 individuals were actively feeding on food items with 6 individuals comprising full and gorged stomach and 6 individuals with 75% filled stomach. Highest number of individuals were found with empty and trace stomach comprising (31.11%) while 25% filled and 50% filled stomach comprised of individuals with 9 and 10 individuals respectively. Figure 4.1.18 showing stomach distention percentage in relation with total length of species, shows no correlation between these two variables, as the data points are widely scattered across the plot.

Gastrosomatic index of *G. giuris* shows variability among the specimens (Figure 4.1.19), with some having a higher index, indicating fuller stomachs, while others have a lower index, indicating emptier stomachs. Highest GaSI being 29.36 suggesting fish had significantly more stomach content relative to their body size at the time of sampling and lowest GaSI was 1.81 with empty stomach.

Table 4.1.3: Number of *Glosssogobius giuris* specimens represented in each stomach distention category

Stomach distention categories	Number of specimens	% contribution
Empty and trace stomach	14	31.11
Filled to 25%	9	20
Filled to 50%	10	22.22
Filled to 75%	6	13.33
Full and gorged stomach	6	13.33

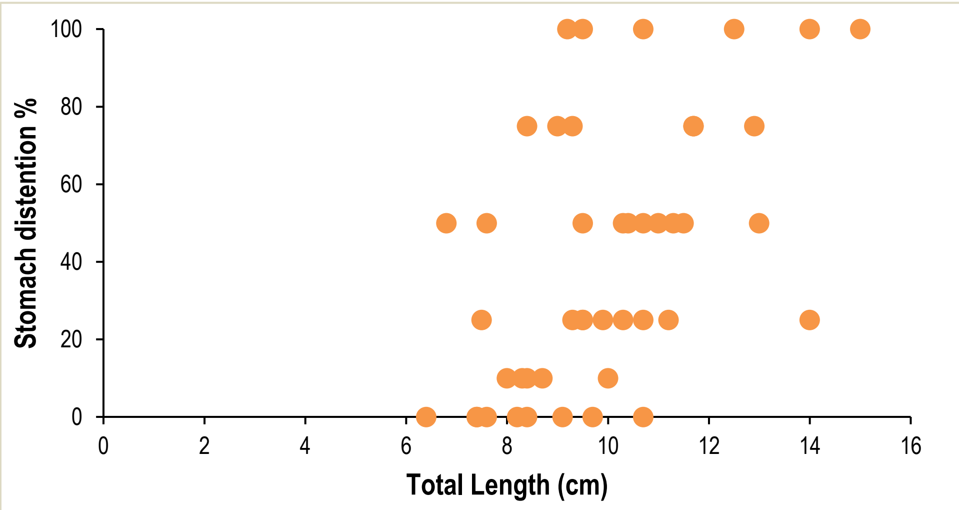


Figure 4.1.18.: Stomach distention of *Glossogobius giuris* in relation with Total Length (cm).

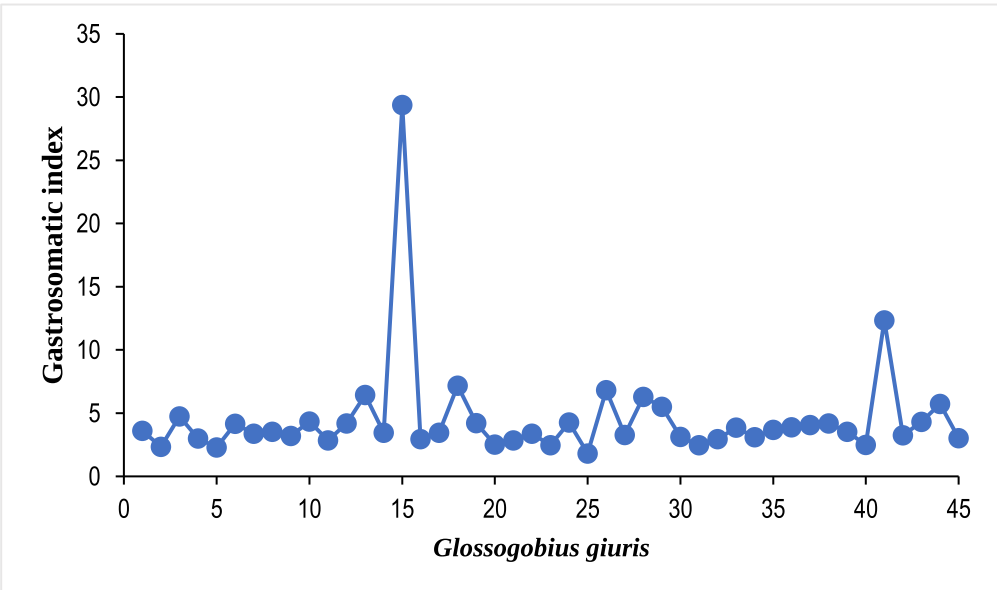


Figure 4.1.19: Gastrosomatic index of *Glossogobius giuris*

In *Gerres. limbatus*, total 148 number of prey items were found and identified. Diet of this species was composed of mainly 3 groups of prey: crustaceans, fishes and mollusc. Juvenile and larval shrimps, juvenile crab, isopodes, fish, and aquatic snail shells were among the prey items found in gut of the *G. limbatus* (Fig. 4.1.22). Percentage numerical occurrence is given in (Fig. 4.1.20) and frequency of occurrence of each food item is shown in (Figure 4.1.11), as crustaceans (62.22%) followed by mollusc (28.88%), fish comprising (24.44%) and debris (6.66%).

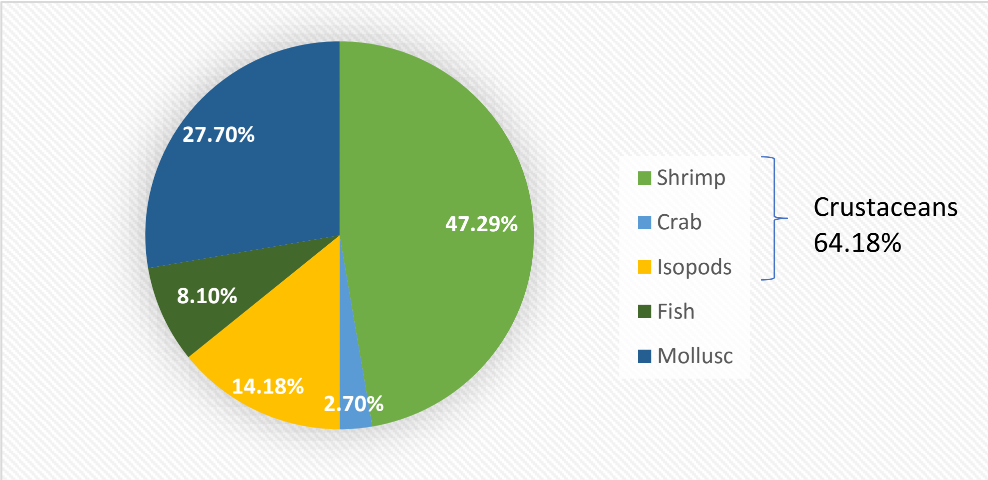


Figure 4.1.20.: Numerical Occurrence of *Gerres limbatus*

The relationship between gut length and total length of *G. limbatus* was found to be positively correlated, indicating that as the total length of the fish increases, the gut length also tends to increase as (R^2= 0.796) (Figure 4.1.21).

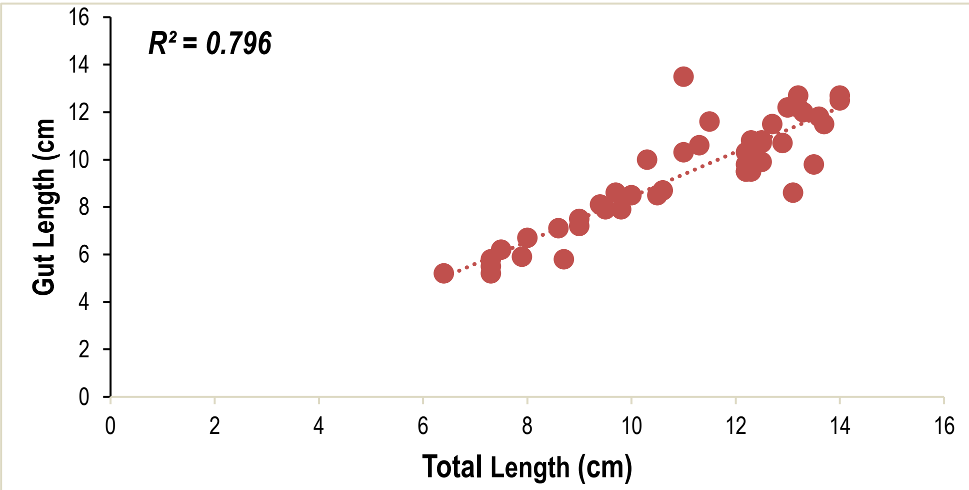
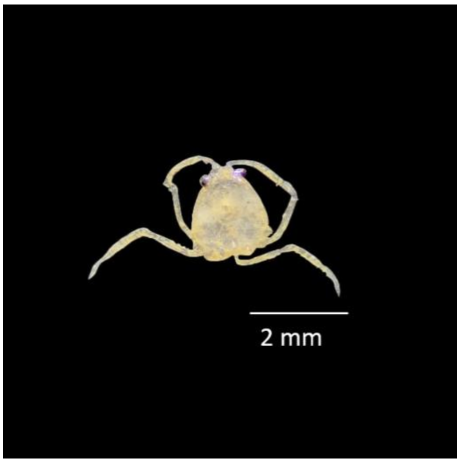


Figure 4.1.21.: Relationship between Gut Length and Total Length of *Gerres limbatus*

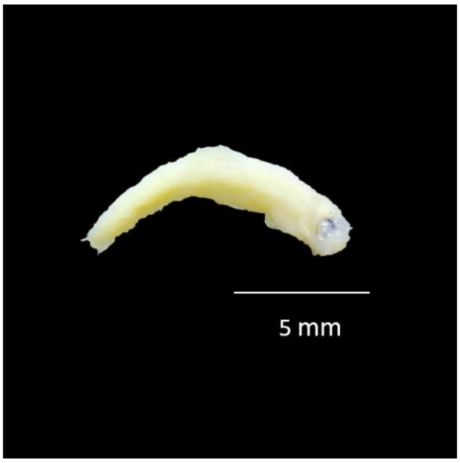
a) Shrimp

b) Isopod

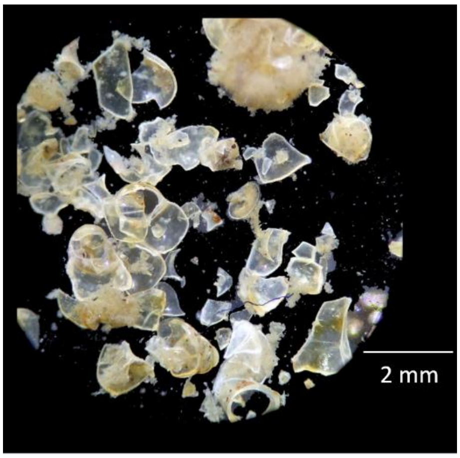
c) Unidentified crustacean body



d) Juvenile crab



e) Fish



f) Partially digested shells

Figure 4.1.22: Gut contents found in *Gerres limbatus*

According to the stomach distention category in this species (Table 4.1.4), "Empty and trace stomach" is the largest category with 16 specimens accounting for 35.56% of the specimens. The other 4 categories (filled to 25%, filled to 50%, filled to 75%, and full & gorged stomach) each have 7 or 8 specimens, with percentage contributions ranging from 15.56% to 17.78%.

Table 4.1.4: Number of *Gerres limbatus* specimens represented in each stomach distention category

Stomach distention categories	Number of specimens	% contribution
Empty and trace stomach	16	35.56
Filled to 25%	7	15.56
Filled to 50%	7	15.56
Filled to 75%	7	15.56
Full and gorged stomach	8	17.78

Figure 4.1.23 showing stomach distention in relation with total length of species, the data points are spread across the plot, indicating that stomach distention varies widely among individuals regardless of their total length.

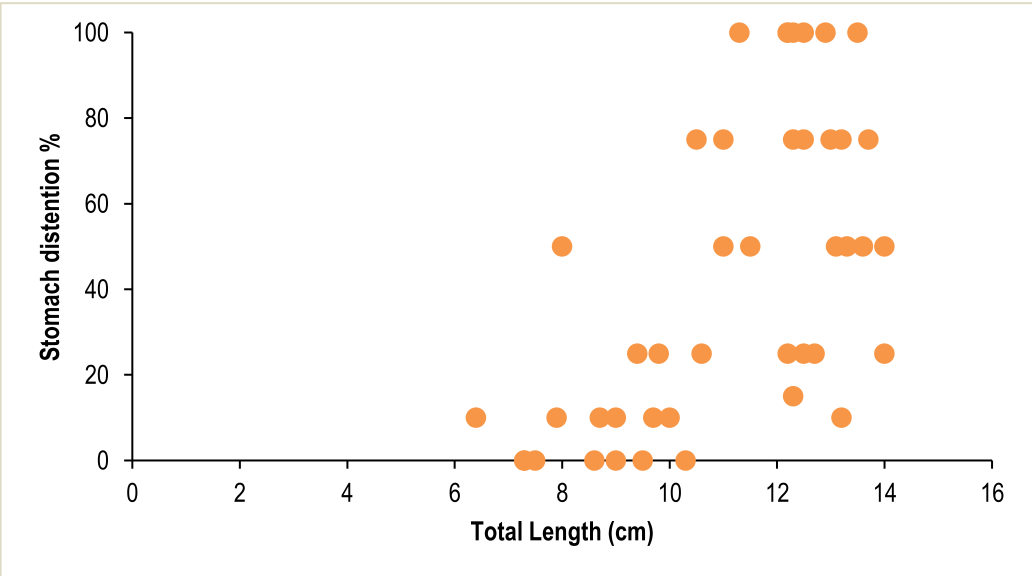


Figure 4.1.23: Stomach distention of *Gerres limbatus* in relation with Total Length (cm).

Considerable variability was found in the GaSI of *G. limbatus*, with most values clustering below 2. Highest value being 10.18 indicating specimen having disproportionately large stomach content relative to their body weight (Figure 4.1.24).

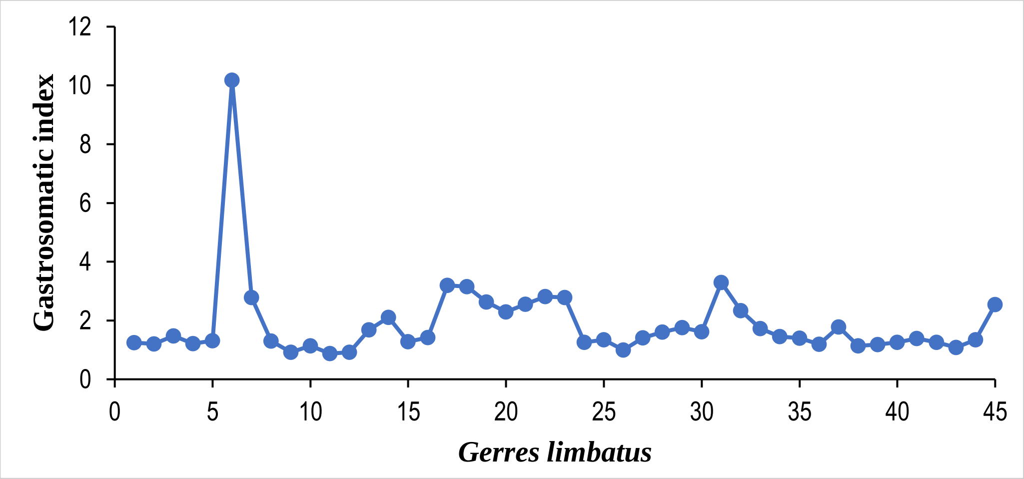


Figure 4.1.24: Gastrosomatic index of *Gerres limbatus*

The analysed gut content of *Scatophagus argus* revealed that, its diet mainly composed of 4 groups of food items: plant matter, crustaceans, fish and debris with different types of plant fibres, juvenile and larval shrimps, fish parts, and isopods with some mud or sand particles (Fig.4.1.26). The frequency of occurrence of plant matter (75.55%) and crustaceans (71.11%) were higher than debris such as mud pellets (26.66%) and fish (11.11%) (Figure 4.1.11). The relationship between gut length and total length of *S. argus* was found to be positively correlated with R² value being 0.83 (Figure 4.1.25).

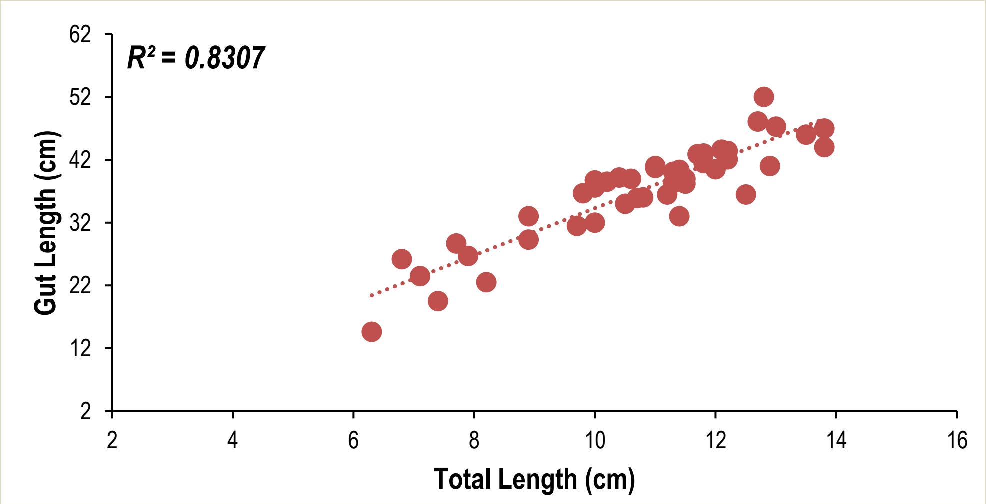
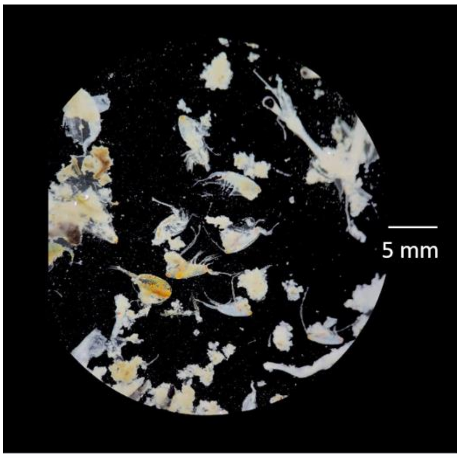
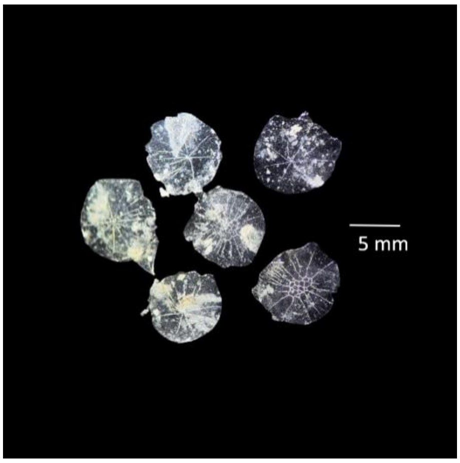


Figure 4.1.25: Relationship between Gut Length and Total Length of *Scatophagus argus*

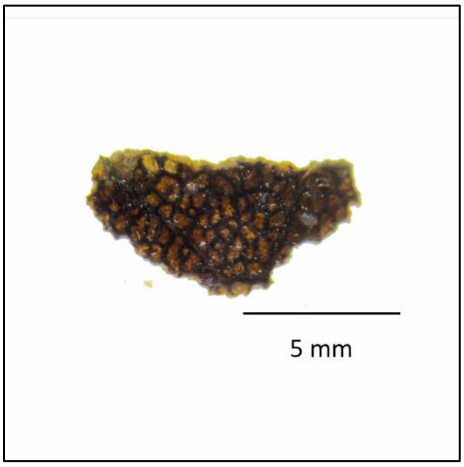
a) Shrimp



b) Planktonic crustaceans



c) Fish scales



d) Unidentified plant matter

e) Unidentified partially digested plant matter

f) Unidentified plant matter

Figure 4.1.26: Gut contents found in *Scatophagus argus*

According to the stomach distention category (Table 4.1.5) in *S. argus* it was found that, 8 individuals accounting for 17.78% had an empty or trace stomach, while 10 specimens accounting for 22.22% had a full and gorged stomach.

Table 4.1.5: Number of *Scatophagus argus* specimens represented in each stomach distention category

Stomach distention categories	Number of specimens	% contribution
Empty and trace stomach	8	17.78
Filled to 25%	11	24.44
Filled to 50%	7	15.56
Filled to 75%	9	20
Full and gorged stomach	10	22.22

Figure 4.1.27 showing stomach distention in relation with total length of species, the data points are distributed across different levels of stomach distention, indicating that there is no correlation between total length and stomach distention percentage.

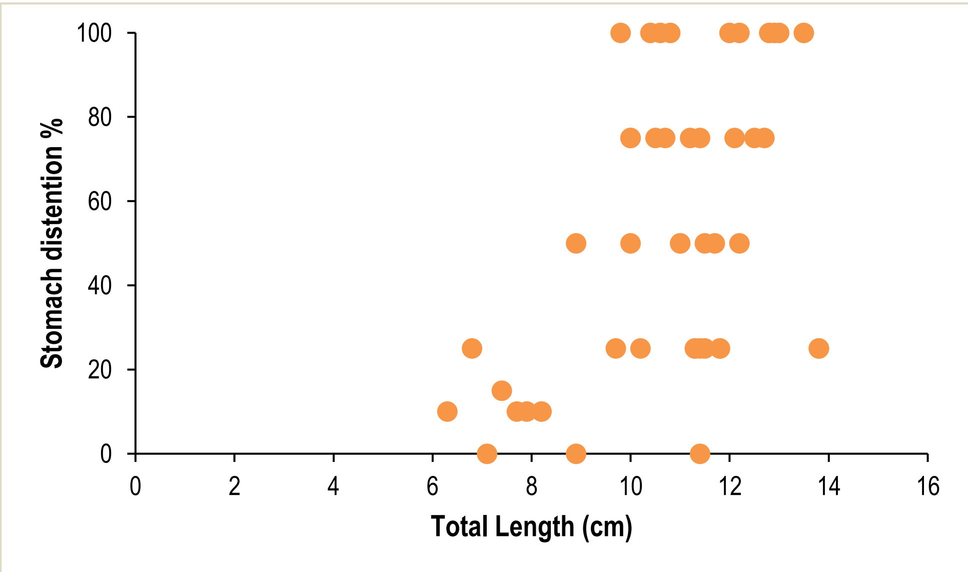


Figure 4.1.27: Stomach distention of *Scatophagus argus* in relation with Total Length (cm).

GaSI of *S. argus* was found to be variable throughout the sample size with highest and lowest being 18.42 and 4.05 respectively (Figure 4.1.28). The index fluctuates significantly from one specimen to another, indicating that the condition of the stomach varies widely among the sampled population.

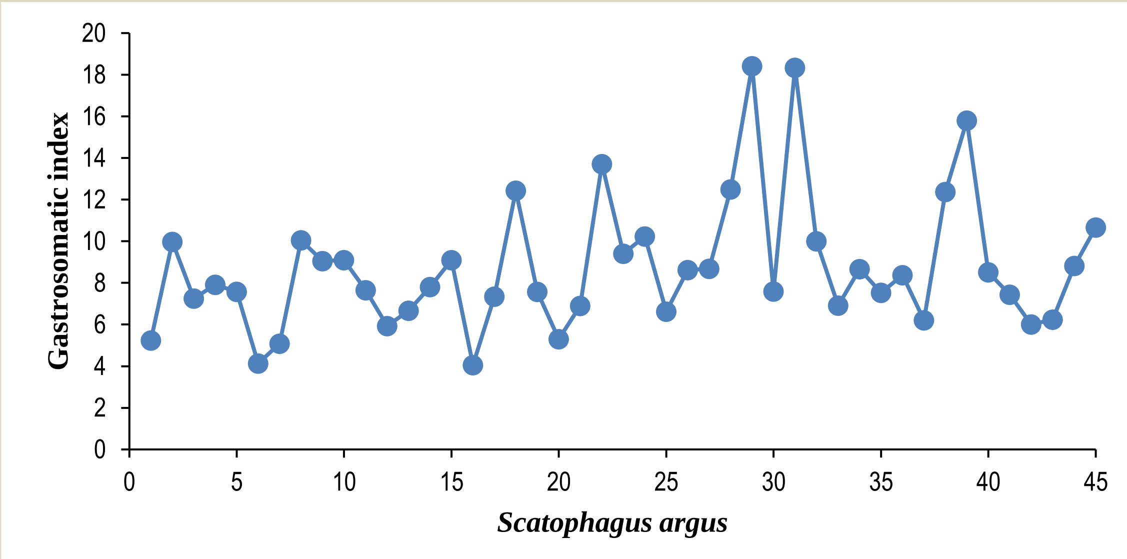


Figure 4.1.28: Gastrosomatic index of *Scatophagus argus*

4.2 DISCUSSION

4.2.1 Length Weight Relationship

The relationships between the total length and weight were estimated for *Ambassis gymnocephalus, Glossogobius giuris, Gerres limbatus* and *Scatophaus argus*. The b values of the four species collected from the Durbhat estuary were within the normal range of 2.5-3.5 as suggested by Froese (2006). The b value of the four species studied ranged from 2.72 to 3.06. The 'b' value of *A. gymnocephalus* (3.06) was slightly higher, indicating positive allometric growth which means body weight of an individual increased at a higher rate as compared to the body length. Length Weight relationship of this species followed the cube law. *Scatophagus argus* (2.87), *Glossogobius giuris* (2.83) and *Gerres limbatus* (2.72) showed highly significant difference from expected cubic value indicating negative allometric growth, which represents decrease in weight at increasing lengths.

The value of coefficient of determination (r^2) used to determine the relationship between length and weight, with values ranging between 0 and 1. Mon et al. (2020) stated that if the value of r^2 higher than 0.5 then, the length weight relationship was positively correlated. In the present study, the r2 values ranged from 0.9 - 0.95 for studied fish species. Hence, the relation between the length and weight of all four fish species was positively correlated and highly significant.

The value of 'b' for *Ambassis gymnocephalus* in present study (3.06) was higher than those reported by Karna et al. (2020) 'b' value of 3.0 from Chilka Lake, India and from those reported by Harrison (2001) 2.98 in South African estuaries and 2.93 in Amoy Bay, East China Sea (Huang et al., 2018). The value obtained shows a positive allometric growth. The values recorded in the present study is the same as those reported from Vembanad lake (Renjithkumar & Roshni, 2021).

In the case of *Glossogobius giuris*, the present study reports the ‘b’ value of 2.83 which shows negative allometric growth, similar to study reported by Gogoi et al. (2002) in the Sessa river, Assam with negative allometric growth but opposed to the studies done by Massood & Farooq (2011) in Pakistan and Khan et al. (2002) in Bangladesh with 3.18 and 3.22 values which shows positive allometric growth. While Mercy et al. (2008) in Kerala and Hossain et al. (2009) in Bangladesh reported isometric growth with 2.95 value.

The present study shows a negative allometric growth pattern in *Gerres limbatus* as the exponential value ‘b was recorded 2.72. Similar value was also observed in *Gerres filamentosus* by El-Nasr and Taher (2016) in Egypt. While *Gerres filamentosus* observed by Renuka et al. (2011) in Sharvathi estuary, India and by Mansoor et al. (2012) in Pakistan showed positive allometric growth.

The ‘b’ value of *Scatophagus argus* was quite similar to that observed by Gandhi et al. (2013) for the same species in Gulf of Mannar with negative allometric growth (2.87). Hence, growth was found to be negative allometric which might be due to the deep, strongly laterally compressed body of spotted scat.

This differences in the current study compared to other studies be attributed to spatial and temporal variations caused by local differences in environmental conditions such as temperature, habitat type, length range, season, sex, diet, gonadal maturity and differences in fish behaviour in different habitats.

4.2.2 Feeding biology

Knowledge on the food and feeding habits is essential in order to understand growth, distribution and general ecology of the fish and changes in the food spectrum during different seasons helps us to study the migratory patterns of the fish.

Analysis of the gut content of *Ambassis gymnocephalus, Glossogobius giuris,* and *Scatophagus argus* was in concurrence with previously published literature and were found to feed on small teleost fishes, crustaceans, mollusc and plant materials.

Current study indicates that *Ambassis gymnocephalus* is a carnivorous fish as food items included crustaceans, fish, and mollusc with crustaceans being dominant food with 80.34% numerical occurrence and Average Relative gut length was 0.83. Martin & Blaber (1983) supported the current findings by stating that *Ambassis gymnocephalus* are commonly fed on crustaceans, fish, insects and fish eggs with fish as dominant food. Dyer et al. (2015) in South Africa reported the similar diet of *Ambassis ambassis* consisting zooplankton and insects indicating carnivorous diet.

Gut content analysis of *Glosssogobius giuris* found out that it feeds on crustaceans, fish and mollusc. Debris was also found with these prey items in few gut samples which is quite common for fishes since they mistakenly taken them as food. Another reason may be due to the fact that this fish is a demersal fish or bottom feeder which creeps on the ground. During fish sampling one sample of *G. giuris* was found with same fish species which was half inside their mouth which may be evidence of cannibalism. Average relative gut length found to be 0.79 cm. The present findings are quite similar with some of the studies on food consumption of this species from other countries as Achakzai et al. (2015) in Pakistan reported fish, insect and mollusc as its dietary preference including cannibalism and Hossain et al. (2016) in Bangladesh stated that *G. giuris* is primarily carnivorous with fish being its dominant food source followed by crustaceans. However, study conducted by Bejer (2015) in Philippines differed from present study as he reported *G. giuris* as omnivore.

The present study on dietary preferences of *Gerres limbatus* found same food items such as crustaceans containing shrimps, juvenile crabs and isopods, fish, mollusc as in *A.*

gymnocephalus and *Glossogobius giuris* with crustacean being dominant food (64.18%) followed by mollusc (27.70%) numerical occurrence. Average relative gut length found was 0.85. So far there have been no reports on the *Gerres limbatus.* While Lugendo et al. (2006) in Chawaka Bay, reported feeding habit of *Gerres oyena* feeding on fish, copepods and detritus. Cyrus & Blaber (1983) studied the feeding ecology of *Gerres acinaces* in South Africa reported that polychaetes and oligochaetes are important food items followed by copepods.
Relative gut lengths (RGL) for all three species were within the range for carnivorous and zoo-planktivorous fish given for cyprinids by Kapoor et al. (1975)

Studies on the *Scatophagus argus* from different places in the estuaries of Bengal by Mookerji et al. (1949) reported the presence of unicellular algae, higher plants, protozoa, sponges, crustaceans, fish scales, sand and mud in the gut. Datta et al. (1984) studied the food of *S. argus* inhabiting both fresh and brackish water ponds and reported that the food comprised of aquatic macrophytes, phytoplankons, zooplanktons and macrobenthos. Gandhi (2002) studied the food and feeding habit of scats from the marine environment in and around Mandapam and reported that in addition to those observed by Mookerji et al. (1949) coral polyps, bivalves, Lepas, prawns, sea anemones and alphaeids were present. The present findings were not fully in agreement with their findings. As the food items included only crustaceans with shrimps, some isopods, partially digested fish, fish scales, fish eggs, plant fibres and detritus with plant materials being dominant food with 66.66% occurrence of frequency followed by crustaceans (53.33%). It was found that detritus in the gut content of *S. argus* was always associated with plant material leading us to conclude that *S. argus* preferred plant material and the fish actually consume detritus while feeding on lower plants attached with substrate. The numerical counts of plant matter fed by *S. argus* could not be calculated. Numerical counts are not suitable in every situation, for example where plants are among the principal food components (Klarberg

& Benson, 1975). Where fish are concentrating upon a few food categories, frequency of occurrence may be equally valid (Frost, 1977).

Average Relative gut length found was 3.45 which mostly in case of herbivorous fish. As reported by Barry and Fast (1992), the present study also found most of guts with full of unidentified plant material but the current findings reveal that it is an omnivorous fish as crustaceans, fish and debris was also present in some of the individuals.

4.3 CONCLUSION

In conclusion, gut content analysis and the length-weight relationship are two valuable tools in fisheries science that provide crucial insights into the feeding habits and growth patterns of fish species. Gut content analysis allows researchers to understand the dietary preferences and ecological roles of fish within their respective ecosystems. By examining the stomach contents, scientists can determine the types and quantities of prey consumed, shedding light on trophic relationships and potential impacts on prey populations. On the other hand, the length-weight relationship is a fundamental metric used to assess the overall health and condition of fish populations. It provides valuable information on growth rates, body condition, and potential changes in population dynamics over time.

The data generated in the present study provides the fundamental information of Length Weight Relationship and feeding habits of four fish species namely, *Ambassis gymnocephalus, Glossogobius giuris, Gerres limbatus* and *Scatophagus argus.* Based on the current study, it was concluded that the length-weight relationship indicated positive allometric growth for *Ambassis gymnocephalus* and negative allometric growth for other three species which might be due to length range, season, sex, diet, and gonadal maturity. Gut content analysis based on laboratory results showed that the fish species comprised five feeding guilds: fish, crustaceans, detritus, molluscs and plant materials. From 4 species *Ambassis gymnocephalus, Glossogobius giuris* and *Gerres limbatus* diets include only crustaceans, fish, and mollusc. Of these, crustaceans feeders were most abundantly represented. On the other hand, plants and debris feeders were represented by only one species *S. argus*. With this, findings of relative gut length also added more evidences concluding *A. gymnocephalus, G. giuris* and *G. limbatus* are carnivorous and *S. argus* as omnivorous fish.

The results of the study could be useful for further assessment of stock and also biological parameters of these fishes in the Durbhat estuary, that will help in their conservation and management. More detailed studies are needed to provide further specific information on seasonal variation of LWRs and feeding habits of these fishes.

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