DEPARTMENT OF ZOOLOGY

TKM COLLEGE OF ARTS AND SCIENCE

KOLLAM-05

COMPARATIVE ECOMORPHOLOGY OF GUT AND BRAIN OF SELECTED FISHES

Dissertation submitted to the University of Kerala in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF SCIENCE IN ZOOLOGY

(2020-2023)

Comparative Ecomorphology of Gut and Brain of Selected Fishes

Dissertation

Submitted to the University of Kerala in partial fulfillment of the requirements for the award of the Degree of

BACHELOR OF SCIENCE

In

ZOOLOGY

Submitted by

Candidate code	Name
25020142007	APARNA BABU
25020142009	MEGHA G.S.
25020142012	RUKSANA MAJEED
25020142013	SARANYA YASHIKUMAR
25020142016	VIPIN VP
25020142018	AJMI SALIM
25020142028	GOURI S. NAIR
25020142037	SREEJA S.
25020142038	SULTHANA SIDDIQUE
25020142041	AFRAH S.

DEPARTMENT OF ZOOLOGY

TKM COLLEGE OF ARTS AND SCIENCE

KOLLAM- 5

2020- 2023

Comparative Ecomorphology of Gut and Brain of Selected Fishes

Dissertation

Submitted to the University of Kerala in partial fulfillment of the requirements for the award of the Degree of

BACHELOR OF SCIENCE

In

ZOOLOGY

DEPARTMENT OF ZOOLOGY

TKM COLLEGE OF ARTS AND SCIENCE

KOLLAM- 5

2020- 2023

CERTIFICATE

This is to certify that the dissertation entitled **"Comparative Ecomorphology of Gut and Brain of Selected Fishes"** is a bonafide work done by ....GOURI S. NAIR......................................under my supervision as partial fulfillment of the requirements for the ***Degree of Bachelor of Science in Zoology*** and this report has not been submitted earlier for the award of any degree or diploma or any other similar titles anywhere.

Dr. SALINI M.P.

(Supervisor)
Assistant Professor in Adhoc,
Dept. of Zoology

Certified bona fide:

Dr. JASIN RAHMAN V. K.

Assistant Professor and HOD,
Dept. of Zoology

DEPARTMENT OF ZOOLOGY
TKM COLLEGE OF ARTS & SCIENCE
KOLLAM-5

18/05/23 Dr. SHEEBA S.

Examiners: 1.

2. 18/5/2023
(DR. DIVYA. R)

DECLARATION

I do hereby declare that this dissertation entitled **"Comparative Ecomorphology of Gut and Brain of Selected Fishes"** is a bonafide work done by me under the supervision of Dr. Rohini Krishna M. V., Assistant Professor, Department of Zoology, TKM College of Arts and Science, Kollam as partial fulfilment of the requirements for the award of ***Degree of Bachelor of Science in Zoology***. No part of this has been presented earlier for any degrees or diploma of any university.

NAME : GOURI S. NAIR.

SIGNATURE :

CANDIDATE CODE: 25020142028

Karicode

…../…../ 2023

ACKNOWLEDGEMENT

I express my sincere gratitude to my research supervisor Dr. SHALINI MP, Assistant Professor, Department of Zoology, TKM College of Arts and Science for her valuable guidance and encouragement.

I am grateful to Dr. Jasin Rahman V K, Assistant Professor and Head, Department of Zoology, TKM College of Arts and Science for the necessary facilities provided to carry out the work successfully. I also express my sincere thanks to all teachers of Dept. Of Zoology for their advice and encouragement.

.

At last, but not the least, I place my sincere gratitude to the almighty, who have bestowed upon me good health, courage, enthusiasm and whose hands guided me in each and every step towards the completion of this work.

CONTENTS

INTRODUCTION

Aquaculture has been a worldwide phenomenon and the human continuously depends this for major protein demand. Aquaculture has sustained a global growth, continues to grow, and is expected to increasingly fill the shortfall in aquatic food products resulting from static or declining capture fisheries and population increase into the year 2025. Its further growth and development will have to occur under a different socio-economic milieu in the new millennium. The contribution of aquaculture to world food supply of aquatic products has been increasing over the past 10 years, in comparison to capture fisheries, growing from 15 to 28 percent of total production between 1988 and 1997. As the bulk of aquaculture is rural and subsistence, it plays a major role as a provider of direct and indirect employment to the rural poor and, thereby, to poverty alleviation. In many developing countries, aquaculture provides opportunities for diversification on agriculture farms and productive use to otherwise idle land during certain seasons.

Fish and other aquatic foods from both freshwater and marine environments are central to meetin g food and nutrition security goals and potentially providing more environmentally sustainable a nimal-source foods (Jessica *et.al*.,2021).Global demand for freshwater and sea food is rising and an increasing proportion is farmed. Aquaculture encompasses a range of species and cultivation methods, resulting in diverse social, economic, nutritional, and environmental outcomes. As a result, how aquaculture develops will influence human wellbeing and environmental health outcomes. Recognition of this has spurred a push for nutrition-sensitive aquaculture, which aims to benefit public health through the production of diverse, nutrient-rich seafood and enabling equitable access (Béné *et al*.2015;Thilsted *et al.* ;2016 World Health Organization;2018).

India is the third largest fish producing country and the second largest aquaculture fish producer in the world. India contributes about 7% to the global fish production. The country is also home to more than 10% of the global fish biodiversity and is one of the 17-mega biodiversity rich countries. Around 14 million people are engaged in fisheries and its allied activities**.** Andhra Pradesh is the largest fish producer in the country followed by West Bengal and Gujarat. The total fish production during 2017-18 is estimated to be 12.60 million metric tonnes, of which nearly 70% is from inland sector and about 50% of the total production is from culture fisheries. More than 50 different types of fish and shellfish products are being exported to 75 countries around the world. Fish and fish products have presently emerged as the largest group in agricultural exports from India, with 13.77 lakh tonnes in terms of quantity and Rs. 45,106.89 crore in value. This accounts for around 10% of the total exports and nearly 20% of the agricultural exports, and contribute to about 0.91% of the GDP and 5.23% to the Agricultural GVA of the country. 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). Sh Estuties are another spot with fish diversity. Estuaries provides food and other sitable situations for the growing fishes in the community. Estuaries allow young fish to grow strong and healthy because food is abundant and diverse(Morais and Estaer dais; 2021).

Kerala marine system is well established one. Nine Hundred and five species of fishes are recorded from the inland and marine waters of Kerala comprising of 41 orders and 172 families. Close to 30% of the freshwater fish species found in Kerala are endemic to the State. Only 8% of the total fishes of Kerala are listed as threatened in the IUCN Red List, of which the majority are freshwater species. Several hundred fish species occurring in the marine waters of Kerala have not yet been assessed for their conservation status by IUCN(Bijukumar and Raghavan.R;2015). Freshwater ichthyological research in Kerala started in the late 18th century with the description of *Cirrhinus cirrhosus* and *Labeo fimbriatus* by Bloch (1795) from the erstwhile Malabar, followed by the description of *Wallago attu* from the same region by Bloch & Schneider (1801). Over the next century (1800–1900), several naturalists advanced the knowledge of freshwater fishes of erstwhile Malabar District and Cochin State. In the case of freshwater fishes was conducted in two east-flowing and three west-flowing rivers in Kerala part of the Nilgiri Biosphere ,ninety-two species including 2 new species were recorded from the area. Seven species were new records to Kerala. Thirty-seven species are endemic to Western Ghats and 9 strictly endemic to Kerala. Estimation of abundance shows that 22.83% of the total were rare and 11.96% very rare(Easa and Shaji,1997).Kerala has a large diversity of estuarine fish.The fish fauna of the Ashtamudi, the second largest estuarine system in Kerala is listed. 97 species belonging to 39 families have been recorded, of which 69 are cornmercially important contributing to the fisheries of the Ashtamudi Estuary. Mullets, cichlids and the glassy perchlets are the most abundant groups and contribute appreciably to the landings. The estuarine system supports a good capture fishery which is seasonal. Majority of the fish fauna in the estuary are marine elements recruited from the adjoining Arabian Sea.The endemic fish fauna of world is facing the major problems like climate change, pollution etc . so the protection of the species must begin by protecting the ecosystem. The anatomical structure of the digestive tract of fish shows a huge variability associated with both different evolutionary degrees and different types of feeding.In general, the digestive tract of fish is composed of a tubular structure with four regions: the oral cavity; an initial region composed of an esophagus, stomach and pylorus; a medium portion of longer length, where pyloric blind can be found; and a terminal region, which ends with the anus.

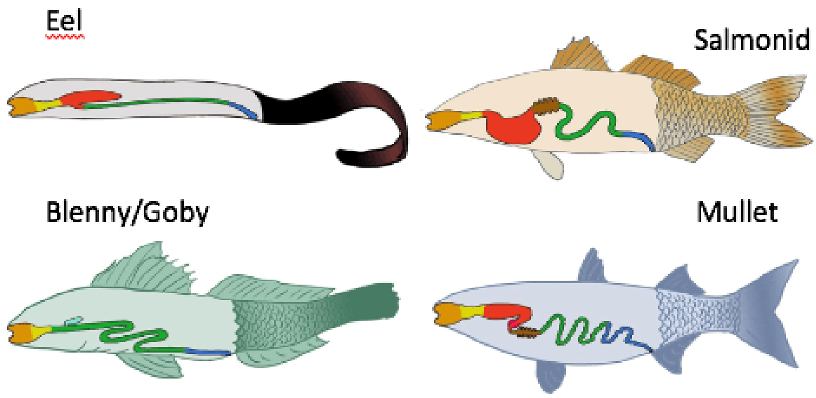


Figure.1. overview of *Digestive tract* of fishes.

An anatomical difference between freshwater aquaculture and marine species is the presence of cardiac sphincter between the esophagus and the stomach. The presence of this anatomical structure is related to osmoregulation. Saltwater animals (hyperosmotic environment), which require continuous water ingestion to maintain their osmotic balance, lack of a cardiac sphincter. On the other hand, freshwater animals (hypoosmotic environment) have cardiac sphincter in order to minimize the entry of water into the animal.

We can classify the different fish species into the following groups based on their feeding habits: herbivorous, detritivores, planktivorous and carnivores.

Herbivorous represent a small percentage and are more frequently found in warm waters, between 40˚N and 40˚S. They are common in tropical freshwater and coral reefs. As a result of their trophic position at the base of the food chain, they are often the most abundant type of fish in the community.This group of animals usually has a short oral cavity, with a blunt snout and many teeth capable of crushing, scraping and even digging. The digestive tract of herbivorous fish is characterized by not having a real stomach and presenting a long gut, which allows the digestion of vegetals. These animals use a great deal of energy to obtain food, as they spend most of the day eating.There are species of herbivores in scaridae, cichlidae and ciprinidae families. Carps (Ctenopharyngodon*idellus, Hypophthalmichthys molitrix, Cyprinus carpio*) and Nile tilapia (*Orechromis niloticus*) are the main species produced in global aquaculture.They are characterized by consuming inert organic matter that accumulates, in different degradation stages, at the bottom of lakes, ponds and certain marine habitats. They have a poorly developed digestive tract generally lacks of a stomach and has a long intestinal tract, like herbivorous species. An example of this type of fish is the flathead grey mullet (*Mugil cephalus*).

Planktivorous are filter fishes that feed by sucking water and screening food particles through gill rakes present in the gills. This type of food has two advantages: very small prey can be ingested by large predators and the feeding can be continuous, day and night, since vision is not needed.Many of this species are able to actively trap individual particles in addition to filtration. These species are known as optional filterers and can change between both modes of feeding, filtration and active capture, depending on the size of the preys, their density and the intensity of light, to optimize the amount of energy used.This group of animals has specialized structures in the gill arches known as epibranchial organs, brush-like structures that allow the water to be siffed through the gills, capture the plankton. In addition, in some species structures known as pharyngeal pockets are observed in the oral cavity, which are capable of storing algae and plankton particles while grazing.Clupeids (pilchard and anchovies) and scombrids *(Scomber japonicus,* pacific mackerel) are the main groups of planktivorous fish. Also, the rohu *(Labeo* *rohita),* one of the main species of Indian carps and one of the main aquaculture species produced worldwide.

Carnivorous is the most common type of feeding within this class of vertebrates. In the trophic pyramid, they are above herbivores, as secondary consumers. Three subtypes can be destinguished.Animales able to filter enough water through their digestive tract to feed on the zooplankton. These include the catla (Catla catla), endemic to India and one of the main species used in polycultures.They are the most abundant group in trtmd of species. Sometimes, they swallow their entire prey and have large mouths with pointed bills to prevent their prey from escaping. The digestive tract of piscivores fish is characterized by having a true stomach and a short intestine. Trout (Oncorhynchus mykiss) and salmon (Salmo salar) are the most relevant species within this group given their importance in industrial aquaculture_(German and Horn(2006).In the case of external morphology of teleost brain is organized in such a way that it reflects the correlation between sensory adaptation and principal modes of activity very clearly. The morphological differences of brain could be undoubtedly correlated with the carnivorous, herbivorous and omnivorous feeding(Rajani sheetal and vaidya(2016). SHERLY, P. (2003) done a study in which the pattern of brain morphology in three South Indian teleost fishes representing different families. An attempt is made to explain them on the basis of feeding habits and feeding releam, that can influence brain structure. The morphological features of the brain of surface feeder (Etroplus suratensis) is compared with those of column feeder (Therapon jarbua) and the bottom feeder (Mystus gulio). The features were again compared between herbivore (E. suratensis), omnivore (M. gulio) and carnivore (Tjarbua).

Aims and objectives of the present study:

1. To display and note the difference in the structure of alimentary tract of some fresh water fishes.

2. To determine the size of internal organs (liver,intestine,brain, gonad) of the selected fishes of different sizes.

3. To estimate the gastrosomatic and hepatosomatic indices of the fin fishes during the study period.

4. To estimate the condition factor and gonadosomatic indices of the fin fishes during the study period.

MATERIALS AND methods.

The present study focus on the ecomorphlogical of selected fishes. For the present study fishes from ecological system were selected; freshwater, esturine and marine. The study focuses on to display and note the difference in the structure of alimentary tract of some fishes of these three ecosystems. Also want to study about the internal organs (liver, brain, intestine, gonad) of the fishes of different sizes. Other parameters were condition factor, gastrosomatic, gonadosomatic, relative gut length, Somatogastric index and hepatosomatic indices of the sampled fishes. Through these study we also want to check if there is any relation between the brain morphology ad the ecomorphology of the fishes.

Following fishes were collected for the study.

Freshwater fishes under study

Mugil cephalus(Blue spot mullet)

Phylum Chordata
Superclass Actinopteri
Class Teleostei
Order Perciformes
Family Mugilidae
Genus ***Mugil***
Species ***cephalus***

Mugil cephalus are found in highly salty to fresh waters that are warm or temperate from 8 to 24 C. The maximum length of striped mullet is 120 cm, with a maximum weight of 8 kg. The body of striped mullet is subcylindrical and anteriorly compressed. They have a small, terminal mouth with inconspicuous teeth and a blunt nose. Pectoral fins are short, not reaching the first dorsal fin. The origin of the second dorsal fin is posterior to the origin of the anal fin. The lateral line is not visible. The mouth is triangular in shape when viewed from above, with Striped mullet are catadromous, that is, they spawn in saltwater yet spend most of their lives in freshwater. During the autumn and winter months, adult mullet migrate far offshore in large aggregations to spawn. Mullet are diurnal feeders, consuming mainly zooplankton, dead plant matter, and detritus. Mullet have thick-walled gizzard-like segments in their stomach along with a long gastrointestinal tract that enables them to feed on detritus. Feeding by sucking up the top layer of sediments, striped mullet remove detritus and microalgae. They also pick up some sediments which function to grind food in the gizzard-like portion of the stomach. Mullet also graze on epiphytes and epifauna from seagrasses as well as ingest surface scum containing microalgae at the air-water interface.

***Cynoglossus semifasciatus*(Sole fish)**

Phylum Chordata

Superclass Actinopteri

Class Teleostei

Order Perciformes

Family Cynoglossidae

Genus *Cynoglossus*

Species *semifasciatus*

Cynoglossus semifasciatus is a genus of fish in the family Cynoglossidae. Most species are indigenous to the Indo-Pacific region, but there are also a few in warmer parts of the East Atlantic. They are commonly found in shallow waters on a muddy or sandy bottom, including estuaries and a few species are restricted to fresh water. The fish mainly adapted to bottom habitat feeding on polychaetes, crustaceans, molluscs, detritus sand-mud, miscellaneous.

***Lutjanus argentimaculatus*(Mangrove red snapper)**

Phylum Chordata

Superclass Actinopteri

Class Teleostei

Order Siluriformes

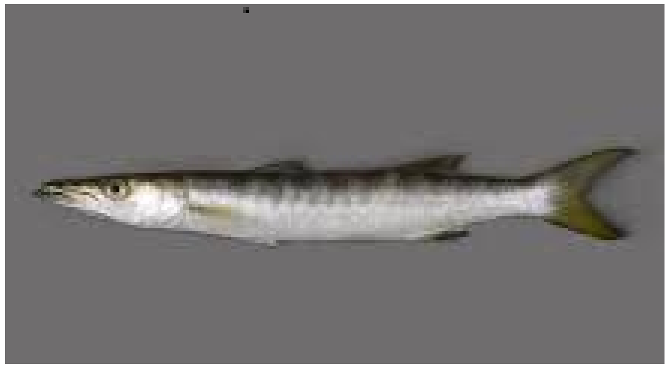
Family Ariidae

Genus *Arius*

Species *maculatus*

The mangrove red snapper is also known as mangrove jack is native to the Indian Ocean .As its name implies, the mangrove red snapper is commonly found in mangrove-lined estuarine systems, however some also make their way into complete freshwater systems, particularly at a juvenile age. They are also known to migrate to offshore reefs to spawn. As they mature, mangrove red snappers move into open waters, sometimes hundreds of kilometers from the coast to breed. The species is carnivorous; they are predators, feeding mainly at night on fish, crustaceans, gastropods, and cephalopod molluscs.

Sphyraena jello (Barracuda).



Phylum Chordata

Superclass Actinopteri

Class Teleostei

Order Carangiformes

Family Sphyraenidae

Genus *Sphyraena*

Species *jello*

The silver body of the Pickhandle barracuda is outlined with approximately 20 wavy bars along the body of the fish, along with the dark marks. These dark markings fade under preservation. There is also a yellow caudal fin on the fish.One of its many features similar to other Barracuda is its underbite.It has been shown that *Sphyraena jello* feeds after releasing its gonads to spawn. This release creates space for the stomach to magnify its capacity for appropriate feeding.Barracuda is a carnivorous species and attacks its prey through either camouflage or in an ambush and tears it into pieces by its sharp jaws15.

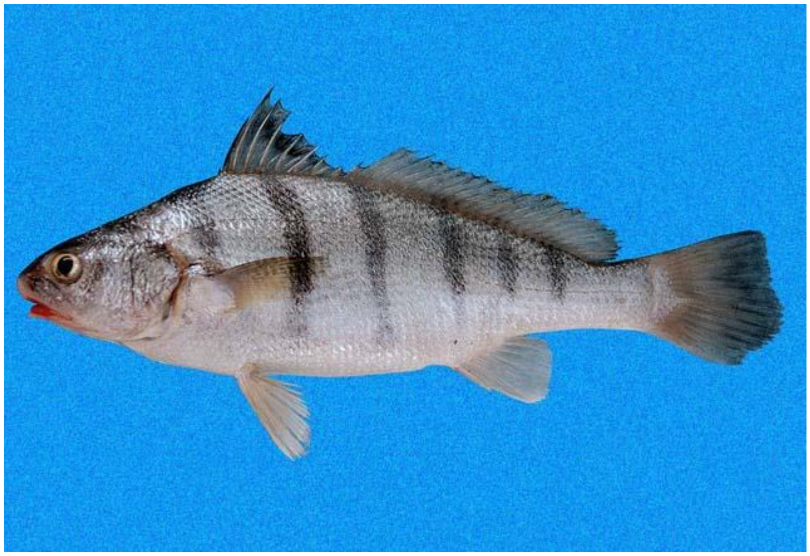
Arius maculatus

Phylum	Chordata
Superclass	Actinopteri
Class	Teleostei
Order	Siluriformes
Family	Ariidae
Genus	*Arius*
Species	*maculatus*

Arius maculatus is endemic to Indo-West Pacific: off the west and east coast of India, Sri Lanka, Pakistan, Bangladesh, Myanmar. Adults occur in inshore waters and estuaries. Occasionally form schools. Feed on invertebrates and small fishes. Males incubate eggs in buccal cavity. During incubation, males starve which sometimes make them resort to swallowing one or two eggs probably to maintain basal metabolism Early hatching embryos commence feeding on inhaled particles by the female when still in possession of large yolk.

Marine fishes under study

Paraloanchurus peruanus



Phylum Chordata

Superclass Actinopteri

Class Teleostei

Order Percformes

Family sciaenidae

Genus *Paraloanchuru*

Species *peruanus*

Body and head pale grey with coppery reflections, lighter below; 7-8 faint dark bars on upper 2/3 of body and tail base; fins pale, pelvics and anal darker; inside gill chamber dark. Body elongate, rounded; back narrow; head low, broad, blunt; snout bulbous, projecting beyond upper jaw; mouth inferior, ~ horizontal; teeth in villiform bands, none notably enlarged; chin and lower jaw with row of 12-15 slender barbels along inside; top lip notched; gill rakers small, 20-25; margin of preopercle finely serrated; dorsal with deep notch separating spiny and soft parts, X + I, 25-27, soft part long and low; anal small, with II small spines, 8-9; pectoral narrow, pointed; tail fin S-shaped, the longest rays below middle of fin; pored lateral-line scales 53-57; soft dorsal and anal fins with basal scaly sheath on inner quarter; scales on operculum rough.

They grow up to a size of 45 cm. they found in the shallow sandy caosts and bays. They are carnivore.

Otolithoides pama (Poa fish)

Phylum: Chordata

Class: Osteichthyes

Order: Perciformes

Family: Sciaenidae

Genus: *Pama*
Species : *P. pama*

It is an amphidromous fish. It is a at benthopelagic. The species is a macrophagous carnivore and feeds mainly small fishes and prawns. The feeding intensity was more in juveniles stages with prawns and fishes dominated the gut contents while teleosts preferred by the adults.

Dasyatis pastinaca(Stingray)

Phylum Chordata
Superclass Actinopteri
Class Teleostei
Order Myliobatiformes
Family Dasyatidae
Genus *Dasyatis*
Species *pastinaca*

The common stingray is typically inhabits sandy or muddy habitats in coastal waters shallower than 60 m (200 ft), often burying itself in sediment. Usually measuring 45 cm (18 in) across, the common stingray has a diamond-shaped pectoral fin disc slightly wider than long, and a whip-like tail with upper and lower fin folds. It can be identified by its plain coloration and mostly smooth skin, except for a row of tubercles along the midline of the back in the largest individuals.The predominant prey of the common stingray are bottom-dwelling crustaceans, though it also takes molluscs, polychaete worms, and small bony fishes. It is aplacental viviparous: the embryos are nourished by yolk and later histotroph ("uterine milk") produced by the mother. Females bear 4–9 young twice per year in shallow water, after a gestation period of four months. The common stingray can inflict a painful, though rarely life-threatening, wound with its venomous tail spine.

Sillago bassensis (Southern school whitng)

Phylum Chordata
Superclass Actinopteri
Class Teleostei
Order perciformes
Family sillaginidae
Genus *Sillago*
Species *bassensis*

This is a marine fish. Marine; demersal; oceanodromous. Dorsal spines (total): 11 - 13; Dorsal soft rays (total): 18-19; Anal spines : 2; Anal soft rays : 18 - 20; Vertebrae : 33 - 35. No dark spot at the base of the pectoral fin; a series of oblique broken rusty brown bars on the back and upper sides, without a longitudinal row of rusty brown blotches along the bilateral silver stripe. Live close to the sea bed over sandy substrates. Occur in the surf zone of beaches and quiet waters of bays and sandbanks. Are trawled in offshore waters to at least 55 m and possibly deeper. Feed mainly on crustaceans, amphipods, decapods, mysids and copepods. Juveniles consume mostly copepods .Feed on crustaceans, including amphipods, decapods, mysids and copepods. Juveniles consume mostly copepods.

Esturine **fishes under study**

Crescent grunter (Terapon jarbua)

Phylum Chordata

Superclass Actinopteri

Class Teleostei

Order Perciformes

Family Terapontidae

Genus *Terapon*

Species *jarbua*

The species grows to 25 cm in length.The Crescent Grunter can be identified by curved stripes on the body and across the tail. The species occurs in shallow coastal waters, mangroves and freshwaters.The Crescent Grunter can be recognised by the curved stripes on the body. There are stripes across the tail and a large blotch on the first dorsal fin.The species occurs in shallow coastal waters, mangroves and freshwaters. It is found in tropical and warm temperate waters of the Indo-west Pacific.

Thornycheek grouper (Epinephelus diacanthus)

Phylum Chordata

Superclass Actinopteri

Class Teleostei

Order Perciformes

Family Serranidae

Genus *Epinephelus*

Species *diacanthus*

It is confined in the Indian Ocean: continental shelf of the northern Indian Ocean from the Gulf of Aden to Sri Lanka and Madras, India. Occurs over muddy sand or mud substrata and caught in depths of 63 to 100 m off the Kerala coast.The spiny-cheek grouper is one of the most abundant species in trawl catches (18-45m). It is abundant on muddy trawling grounds in Pakistan, where it forms large schools at depths of 20-50m.A medium size serranid fish with body depth contained 2.8 to 3.5 times in standard length (for fish 10 to 34 cm standard length).

Head large, its length contained 2.2 to 2.4 times in standard length, interorbital region flat or slightly convex, the dorsal profile convex. Preopercle with 1 to 5 prominent spines at the angle. Upper edge of operculum straight or slightly convex, operculum with 3 flat spines the middle spine nearer to lower than upper one. Nostrils subequal, anterior nostrils tubular, the margin usually with a large, bilobed flap of skin. Maxilla reaches to or almost to vertical at rear edge of eye, the lower edge smoothly curved, midlateral part of lower jaw with 2 rows of short, subequal teeth, a pair of canines on each side of symphysis in each jaw. Gill rakers 8 to 10 on upper limb, 15 to 17 on lower limb, numerous bony plates on sides of gill arches. Caudal-peduncle depth contained 3.7 to 4.7 times in head length. Lateral-body scales ctenoid, with auxiliary scales in adults, lateral-line scales 52 to 60, lateral-scale series 103 to 121. Pyloric caeca 7 or 8.

Porcupine fish *(Diodon holocanthus Linnaeus)*

Phylum Chordata

Superclass Actinopteri

Class Teleostei

Order Tetraodontiformes

Family Diodontidae

Genus *Diodon*

Species *holocanthus*

The long-spine porcupinefish (*Diodon holocanthus*), also known as the freckled porcupinefish among other vernacular names, is a species of marine fish in the family Diodontidae. They are found over the muddy sea bottom, in estuaries, in lagoons or on coral and rocky reefs around the world in tropical and subtropical seas.The long-spine porcupinefish is pale in color with large black blotches and smaller black spots; these spots becoming fewer in number with age. It has many long, two-rooted depressible spines particularly on its head. The teeth of the two jaws are fused into a parrot-like "beak". Adults may reach 50 cm (20 in) in length.[3] The only other fish with which it might be confused is the black-blotched porcupinefish (*Diodon liturosus*), but it has much longer spines than that species.porcupine fish is an omnivore that feeds on mollusks, sea urchins, hermit crabs, snails, and crabs during its active phase at night.[5] They use their beak combined with plates on the roof of their mouths to crush their prey such as mollusks and sea urchins that would otherwise be indigestible.

Study area

The freshwater fishes were collected from the Kanjiramkodu Kayal,Kollam . Marine fishes were collected from the Harbour of Kollam Port, Estuarine fishes were collected from the Pozhikara estury, paravoor, kollam ,Kerala. Other studies were carried out at the Physiology and Biochemistry Lab, Department of Zoology, TKM college of Arts and Science, Kollam, India during the period from January 2023 to March 2023.

Procurement of fishes, Dissection and analysis

A total of four(04) of fresh water fishes, three (03) of esturine fishes,four (04) of marine fishes (with more than one specimen of dissimilar weight) were studied to record the shape of alimentary tract, size of internal organs and the values of biological parameters. The fishes were procured in dead but fresh condition were maintained throughout the experiment. The fishes after being brought to laboratory were correctly identified up to the species level following the comprehensive account of taxonomic description and identification keys as described by, MPEDA guidebook (2002) and Ghosh (2006). Before commencing dissection, the total length, standard length, head length and eye diameter and all other parameters of all the fishes were recorded properly using one foot long scale, divider and thread.

Sterile biological stainless steel equipment like bone cutter, scissors, forceps were used for dissection. The internal organs like intestine, liver, ovary and testis were exposed, carefully detached from main body and their size was determined. The structures of intestine, liver, intestine, and gonads were carefully observed, existing similarities and differences of the same in difference fishes were noted down. The weight of intestine, liver and gonads was taken in laboratory electronic balance (Model: Aafcoset electronic balance, Bombay –Burma trading Co. Ltd).

The morphometric features viz. total length, standard length, head length and eye diameter of the fin fishes and the biological parameters were measured and determined following standardized protocols. Brief information on the fundamental aspect of these features and the general biological parameters studied are mentioned below:

Total length: It is the maximum elongation of the body from end to end. Thus from the most anterior projecting part of the head to the posterior most tip of caudal fin in included in total length (Biswas, 1987).

Standard length: This is the distance from the anterior most part of the head (snout) to the end of the vertebral column (caudal fin).

Head length: It is a straight measurement of the distance from the tip of the snout up to the posterior most edge of the opercular bone (Grant and Spain, 1975).

Condition factor of fish is expressed by relating the standard length of the fish to its weight (Beckman, 1948).

It is calculated by the formula= 100W/L3 where

'K' is the coefficient of condition

'W' is the weight of fish (in gram)

'L' is standard length of fish (in cm)

***Gonadosomatic index**:* The development of gonad is estimated by determining its weight relative to the body weight of the fish (Hopkins, 1979). This can be expressed as: Weight of the gonad (testis or ovary) in gram x 100 / Weight of the fish in gram.

***Gastrosomatic index**:* It is the weight of gut as percentage of total body weight of gut as percentage of total body weight of the fish (Desia, 1970).

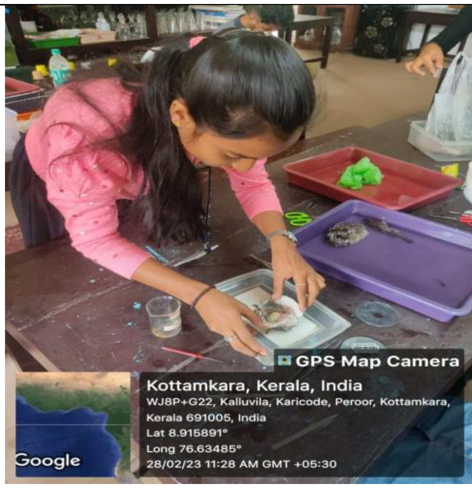
It is expressed as: Weight of the gut and contents in gram x 100 / Weight of the fish on gram

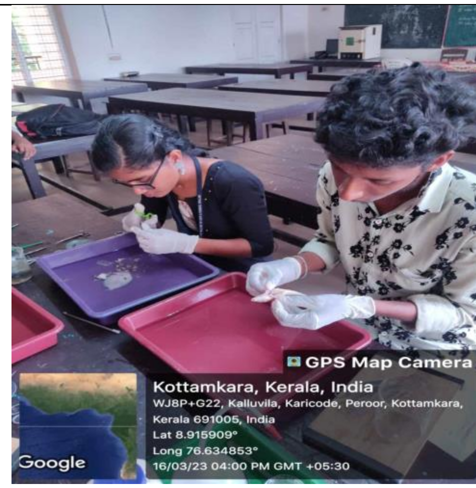
Hepatosomatic index: It is defined as the ratio of liver weight of body weight.

It is expressed as: Weight of liver in gram x 100 / Weight of fish-weight of its gonad

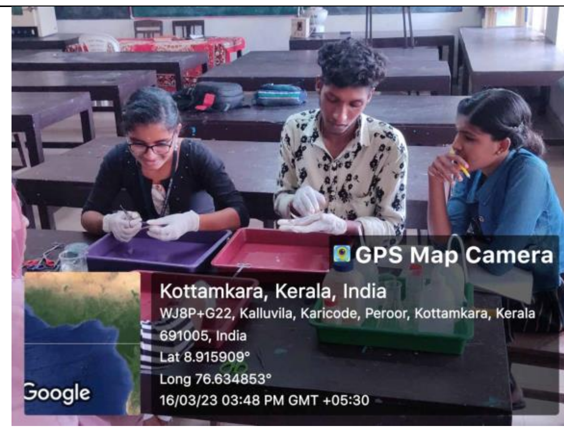
Relative length of gut: It is defined as the ratio of the length of intestine of fish to standard body length (Biswas, 1987). It is calculated as: Intestine length / standard body length

Somatosogastric index may be defined as the ratio of the total body length to total intestine length.


GPS Map Camera
Kottamkara, Kerala, India
WJ8P+G22, Kalluvila, Karicode, Peroor, Kottamkara, Kerala 691005, India
Lat 8.915891°
Long 76.63485°
28/02/23 11:28 AM GMT +05:30
Google


GPS Map Camera
Kottamkara, Kerala, India
WJ8P+G22, Kalluvila, Karicode, Peroor, Kottamkara, Kerala 691005, India
Lat 8.915909°
Long 76.634853°
16/03/23 04:00 PM GMT +05:30
Google


GPS Map Camera
Kottamkara, Kerala, India
WJ8P+G22, Kalluvila, Karicode, Peroor, Kottamkara, Kerala 691005, India
Lat 8.915909°
Long 76.634853°
16/03/23 04:02 PM GMT +05:30
Google


GPS Map Camera
Kottamkara, Kerala, India
WJ8P+G22, Kalluvila, Karicode, Peroor, Kottamkara, Kerala 691005, India
Lat 8.915909°
Long 76.634853°
16/03/23 03:48 PM GMT +05:30
Google


GPS Map Camera
Kottamkara, Kerala, India
WJ8P+G22, Kalluvila, Karicode, Peroor, Kottamkara, Kerala 691005, India
Lat 8.915878°
Long 76.634787°
20/02/23 01:31 PM GMT +05:30
Google


GPS Map Camera
Kottamkara, Kerala, India
WJ8P+G22, Kalluvila, Karicode, Peroor, Kottamkara, Kerala 691005, India
Lat 8.915909°
Long 76.634853°
16/03/23 04:04 PM GMT +05:30
Google

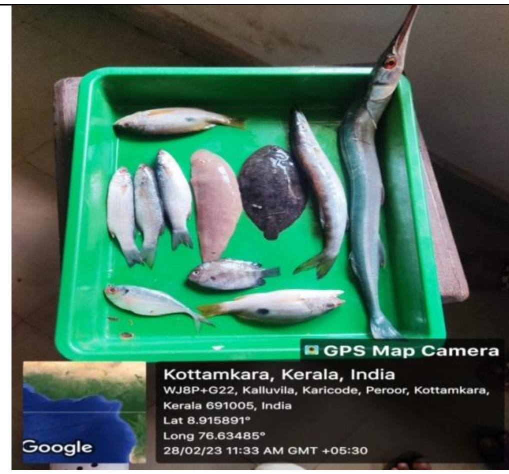


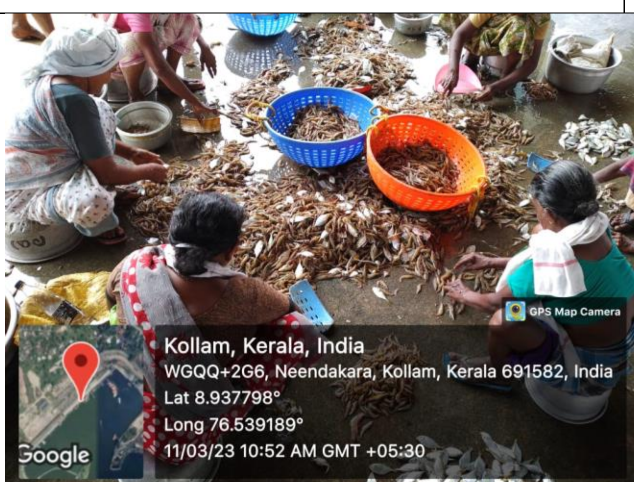
Figure.2. Students engaged in dissection of collected samples in the Physiology and Biochemistry lab, during their experiment


GPS Map Camera
Kollam, Kerala, India
WGQR+FRF, Harbour Road, Neendakara, Kollam, Kerala 691582, India
Lat 8.93892°
Long 76.541672°
11/03/23 11:19 AM GMT +05:30
Google


NEENDAKARA FISHING HARBOUR
DTPC Kollam
NEENDAKARA FISHERY HARBOUR
NEENDAKARA
2023/3/11 11:20


GPS Map Camera
Kollam, Kerala, India
WGQQ+CVF, Neendakara, Kollam, Kerala 691582, India
Lat 8.939027°
Long 76.539598°
11/03/23 11:05 AM GMT +05:30
Google


GPS Map Camera
Kollam, Kerala, India
WGQQ+2G6, Neendakara, Kollam, Kerala 691582, India
Lat 8.937759°
Long 76.539113°
11/03/23 10:58 AM GMT +05:30
Google


GPS Map Camera
Kollam, Kerala, India
WGQQ+2G6, Neendakara, Kollam, Kerala 691582, India
Lat 8.937798°
Long 76.539189°
11/03/23 10:52 AM GMT +05:30
Google


GPS Map Camera
Kollam, Kerala, India
WGQQ+2G6, Neendakara, Kollam, Kerala 691582, India
Lat 8.937719°
Long 76.539066°
11/03/23 10:54 AM GMT +05:30
Google

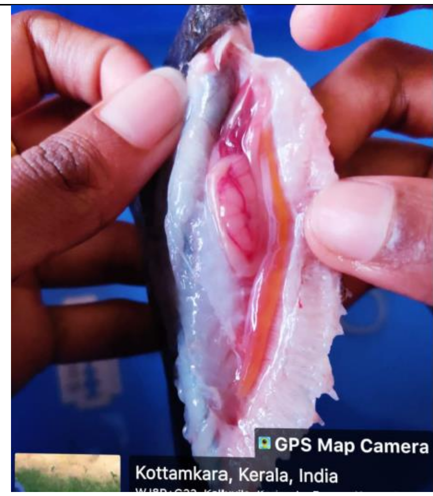
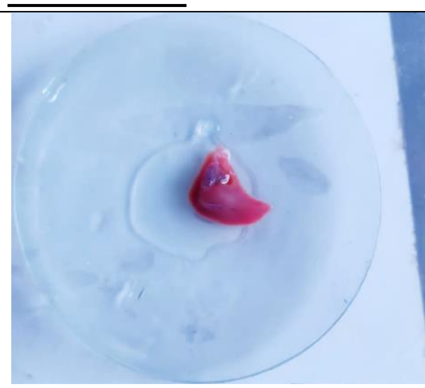
Figure.3. Sample collection

RESULT

Blue spot mullet (*Mugil cephalus*).

	
Fish	Brain
	
Gonad	Intestine
	
liver	

<u>Sole fish</u>

	
<u>Whole fish</u>	<u>Viscera</u>
	
<u>Gonad</u>	<u>Liver</u>
	
<u>Intestine</u>	

Lutjanus stellatus

	
Whole fish	**Brain**
	
Gonad	**Liver**
	
Intestine	

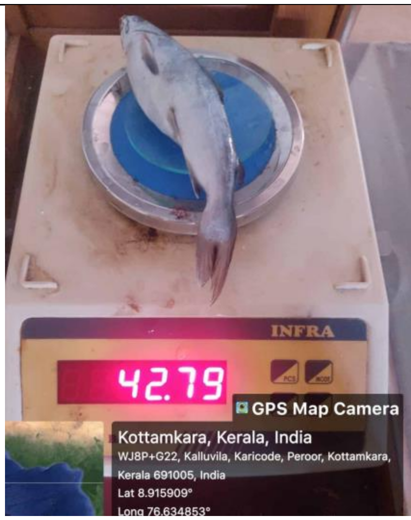
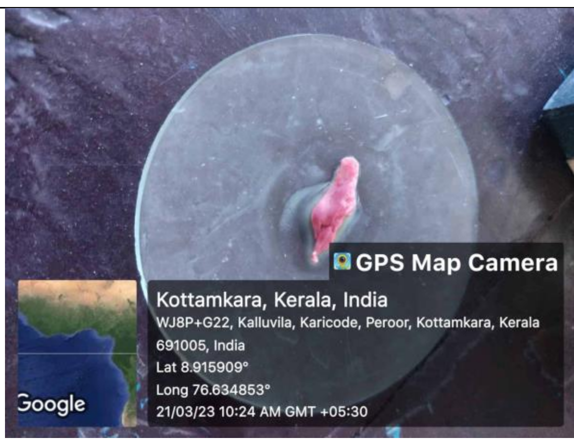
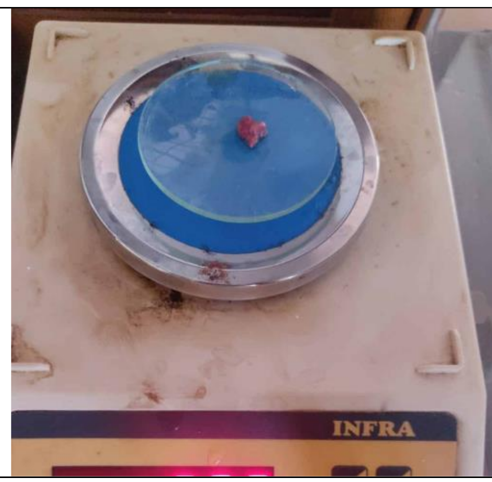
Barracuda(*Sphyraena jello)*

	
Whole fish	
	
Intestine	Liver

Mangrove red snapper

	
Whole fish	Brain
	
Intestine	Gonad

Arius maculatus

<table>
<tr><td>
</td><td></td></tr>
<tr><td>Cat fish</td><td>Intestine</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Brain</td><td>Liver</td></tr>
</table>

<u>Estuarine fish</u>

Crescent grunter

	
Whole fish	Brain
	
Intetine	Gonad
	
Liver	

Thornycheek Grouper

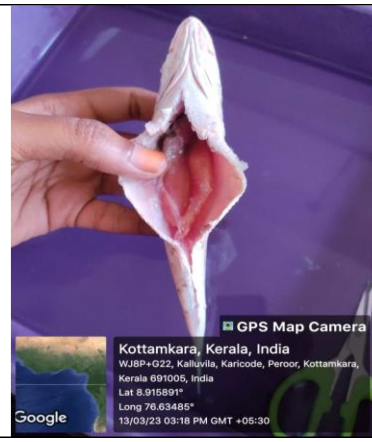
	
Whole fish	**Viscera**
	
Brain	**Intestine**

Porcupine fish

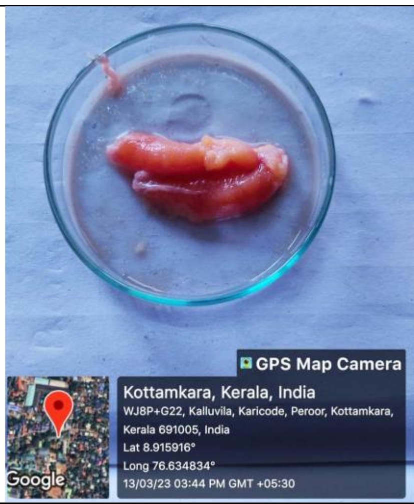
	
Whole fish	Viscera
	
Intestine	Liver
	
Gonad	

Marine fish (P*aralanchurus peruanus)*

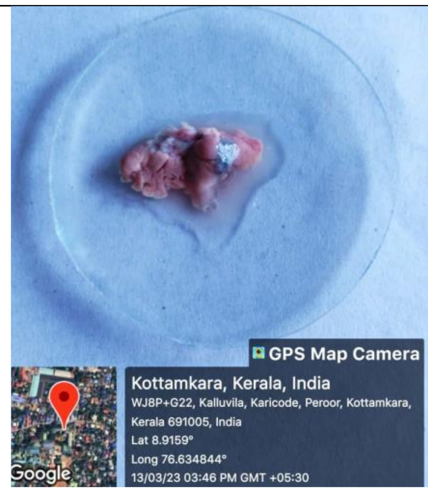
Whole fish



Viscera



Gonad



Liver

Intestine

Poa fish

	
Whole fish	Viscera
	
Intestine	Gonad
	
Liver	

Stingray

	
Whole fish	Brain
	
Intestine	Gonad

Southern school whiting

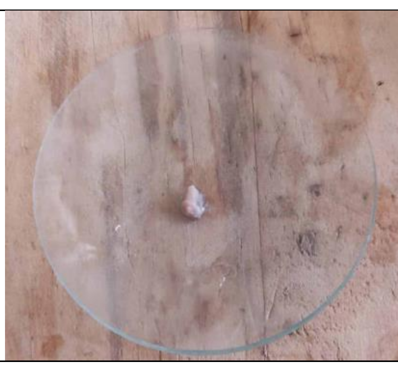
	
Whole fish	Viscera
	
Gonad	Intestine
	
Brain	Liver

Table.1.Summarized data on the quantitative length- weight relationship between body- brain of freshwater fishes.

Name of fishes	Length of fish (SL) cm	Body weight of fish (g)	Brain Length of fish (cm)	brain weight of fish (g)
Mugil cephalus	12.60±1.02 cm	32.16±0.01 g	0.9±1.03mm	2.01±0.09g
Cynoglossus semifasciatus	12.70±1.08cm	35.07±1.23g	0.7±0.04mm	1.98±0,23 g
Lutjanus argentimaculatus	10.2±1.23cm	41.21±1.34g	1.2±0.08 cm	1.97±1.23g
Sphyraena jello	24.2±0.08cm	55.22±0.08g	1.10±0.02 cm	2.41±0.02g
Arius maculatus	13.00±0.02cm	42.70±0.02g	0.90±0.01 mm	1.09±1.02 g

The freshwater fishes collected were *Mugil cephalus, Cynoglossus semifasciatus, Lutjanus argentimaculatus, Sphyraena jello, Arius maculates.* The body length and body height were recorded and tabulated. The brain length and brain weight were recorded tabulated and all data were tabulated in Table.1. From the data it was clear that as the body weight and body length increases there will be a corresponding increase in the brain morphometry.

Table.2.Morphometric analysis of freshwater fishes under study.

Sl. No.	Parameter	*Mugil cephalus*	*Cynoglossus semifasciatus*	*Lutjanus argentimaculatus*	*Sphyraena jello*	*Arius maculatus*
1	Body weight (gm)	32.16±0.01 g	35.07±1.23 g	41.21±1.34g	55.22±0.08g	42.70±0.02g
2	Total length (cm)	15.70±1.22	14.10±0.08	13.50±1.23	26.20±1.00	15.5±1.20
3	Standard length (cm)	12.60±1.02 cm	12.70±1.08 cm	10.2±1.23cm	24.2±0.08cm	13.00±0.02cm
4	Fork length (cm)	14.50±1.09	13.80±0.00	13.00±0.09	25.30±2.01	15.50±0.09
6	length of intestine (cm)	15.09±0.02	14.70±2.12	4.02±0.2	6.70±0.01	10.10±0.03
7	weight of liver(gm)	0.11±0.02	1.93±1.02	1.85±2.14	0.51±0.02	0.28±0.02
8	weight of ovary(gm) weight of testis(gm)	2.63±1.02	0.91±0.03	1.18±1.11	0.49±0.09	0.14±1.00
9	Weight of gut	0.78±1.00	12.53±0.01	2.15±1.03	0.49±10.09	0.27±0.01

Total body weight of collected samples was monitored. Major length parameters monitored were total length, standard. Length and fork length. All are tabulated in Table.2. In the case of *Mugil cephalus* , standard length is 12.60±1.02 cm. Total weight of the fish is 32.16±0.01 g. Weight of gut is 0.78±1.00g; weight of liver is 0.11±0.02g. Weight of gonad is

2.63±1.02g. In the case of *Cynoglossus semifasciatus,* standard length *is* 12.70±1.08cm. Length of the intestine is 14.70±2.12 cm. Total body weight of the fish is 35.07±1.23g. Weight of intestine, liver and gonads were 12.53±0.01g, 1.93±1.02 g and 2.63±1.02 were respectively. In the case of *Lutjanus argentimaculatus* , standard length is 10.2±1.23cm. Total weight of the fish is 41.21±1.34 g. Weight of gut is 2.15±1.03 g; weight of liver is 1.85±2.14 g.weight of gonad is 1.18±1.11g. In the case of *Sphyraena jello, standard length is* 24.2±0.08cm. Length of the intestine is 6.70±0.01 cm. Total body weight of the fish is 55.22±0.08g. Weight of intestine, liver and gonads were 0.49±10.09 g, 0.51±0.02 g and 0.49±0.09 g were respectively. In *Arius maculatus*, standard length is 13.00±0.02cm. Total weight of the fish is 42.70±0.02g. Weight of gut is 0.28±0.02g; weight of liver is 0.28±0.02g.weight of gonad is 0.14±1.00g.

Table.3.Morphometric analysis of brain of freshwater fishes under study.

Sl.No.	Parameter	***Mugil cephalus***	***Cynoglossus semifasciatus***	***Lutjanus argentimaculatus***	***Sphyraena jello***	***Arius maculatus***
1	Weight of brain(g)	2.01±0.09g	1.98±0,23 g	1.97±1.23g	2.41±0.02 g	1.09±1.02 g
2.	Length of cerebrum (cm)	0.20±0.02	0.20±0.01	0.40±0.12	0.20±0.03	0.05±0.02
3.	Length of optic lobe (cm)	0.30±0.00	0.1±0.03	0.50±0.90	0.40±1.20	0.10±0.90
4	Length of telencephalon(cm)	0.40±0.11	0.40±0.00	0.30±2.00	0.50±1.00	0.30±0.00

Details about the brain morphology were tabulated in the Table.3.In brain morphology *Sphyraena jello has highest brain weight.* The total length of the brain was highest in *Lutjanus argentimaculatus*. Smallest brain weight was recorded in

Arius maculates(1.09±1.02 g). Smallest length of the brain was also noted in *Cynoglossus semifasciatus* and *Arius maculatus.*

Table.4. Index value and condition factor of **freshwater fishes under study.**

Sl. No.	Parameter	*Mugil cephalus*	*Cynoglossus semifasciatus*	*Lutjanus argentimaculatus*	*Sphyraena jello*	*Arius maculatus*
1	Condition factor	1.60±0.02	2.10±1.00	3.88±1.11	0.38±1.09	1.94±1.45
2	Gonadosomatic index	8.17±2.00	2.11±1.00	2.86±1.09	0.85±1.99	0.32±1.00
3	Gastrosotic index	0.48±1,00	29.09±0.00	5.21±1.90	0.88±1.00	0.63±1.23
4	Hepatosomatic index	2.42±1.00	4.48±1.88	4.48±3.00	0.92±0.04	0.65±2.78
5	Relative gut lengh	0.34±1.00	1.15±1.00	1.51±1.22	0.27±1.99	0.77±1.00
6	Somatogastric index	2.71±1.00	0.32±0.09	0.32±0.08	0.47±0.24	1.08±3.23

Table 4, figure 4 to figure 10 denotes the main index and condition factor of the freshwater fishes under study. Highest condition factor was noted in the *Lutjanus argentimaculatus*(3.88±1.11). Smallest condition factor were observed in the *Sphyraena jello* (0.38±1.09). Gonadosomatic index were higher in the *Mugil cephalus* (8.17±2.00). Smallest recorded in the *Arius maculates*(0.32±1.00). Gastrosotic index were higher in the *Cynoglossus semifasciatus* (29.09±0.00). Smallest were observed in the *Mugil cephalus* (0.48±1,00). Hepatosomatic index were higher in both *Cynoglossus semifasciatus and Lutjanus argentimaculatus* (4.48±1.88 and 4.48±3.00). Relative gut length was higher as above that is

1.15±1.00 and 1.51±1.22. Smallest Relative gut length is noted in the 0.27±1.99. Somatogastric index is higher in the *Mugil cephalus* (2.71±1.00); lowest Somatogastric index were noted in *Cynoglossus semifasciatus and Lutjanus argentimaculatus*(0.32±0.09 and 0.32±0.08).

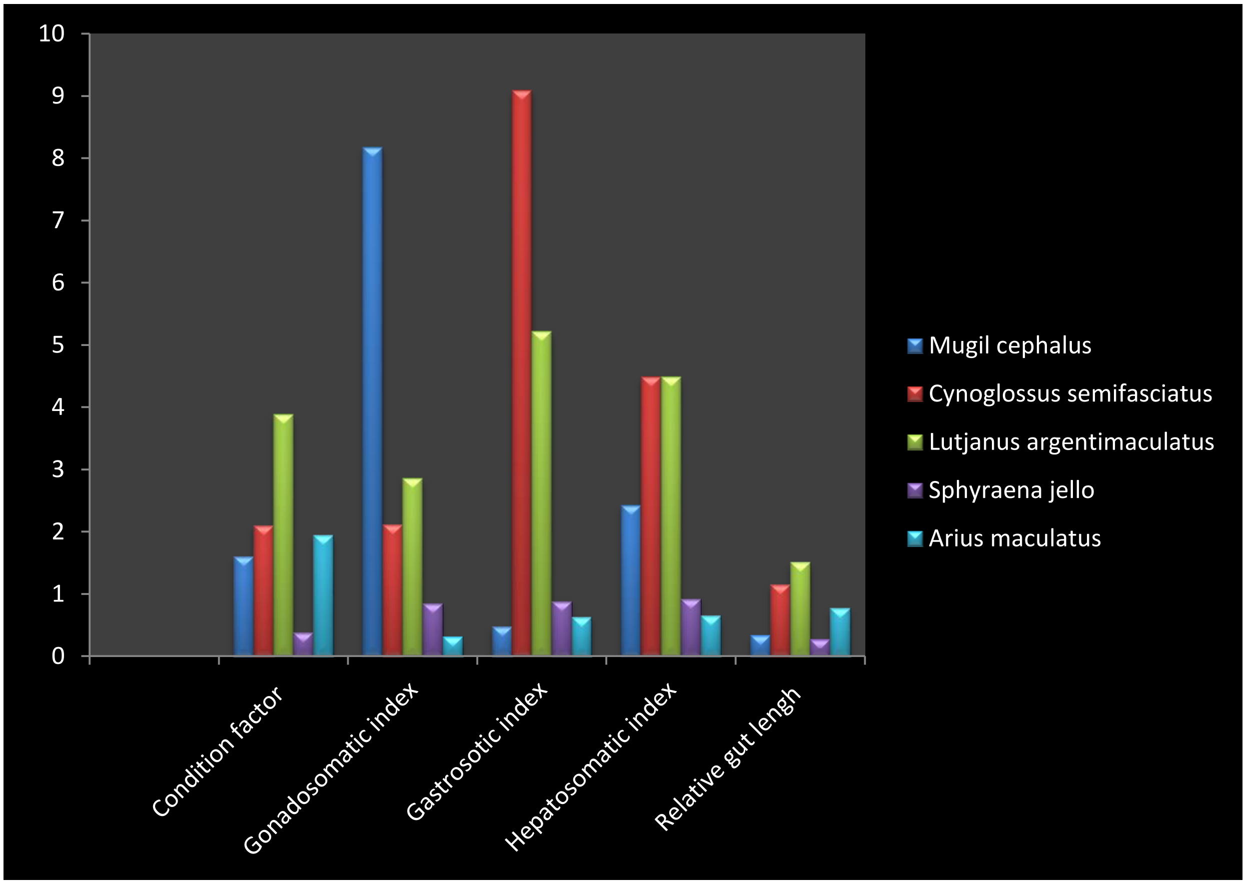


Figure.4. Index value and condition factor of freshwater fishes under study.

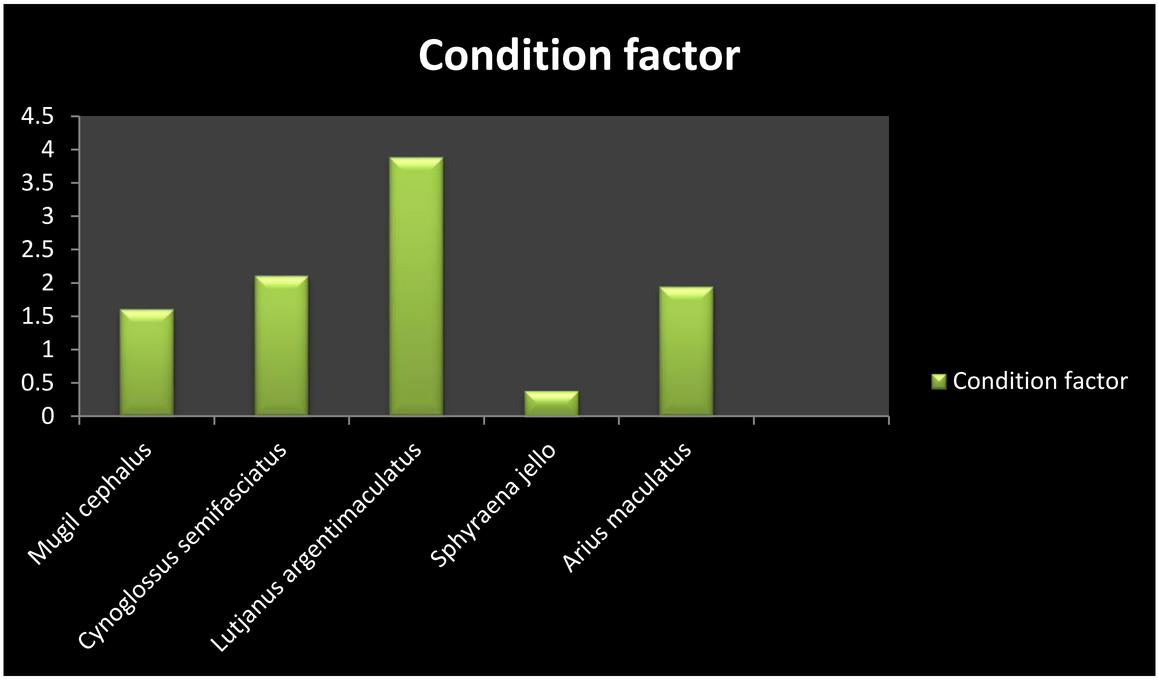


Figure.5. condition factor of freshwater fishes under study.

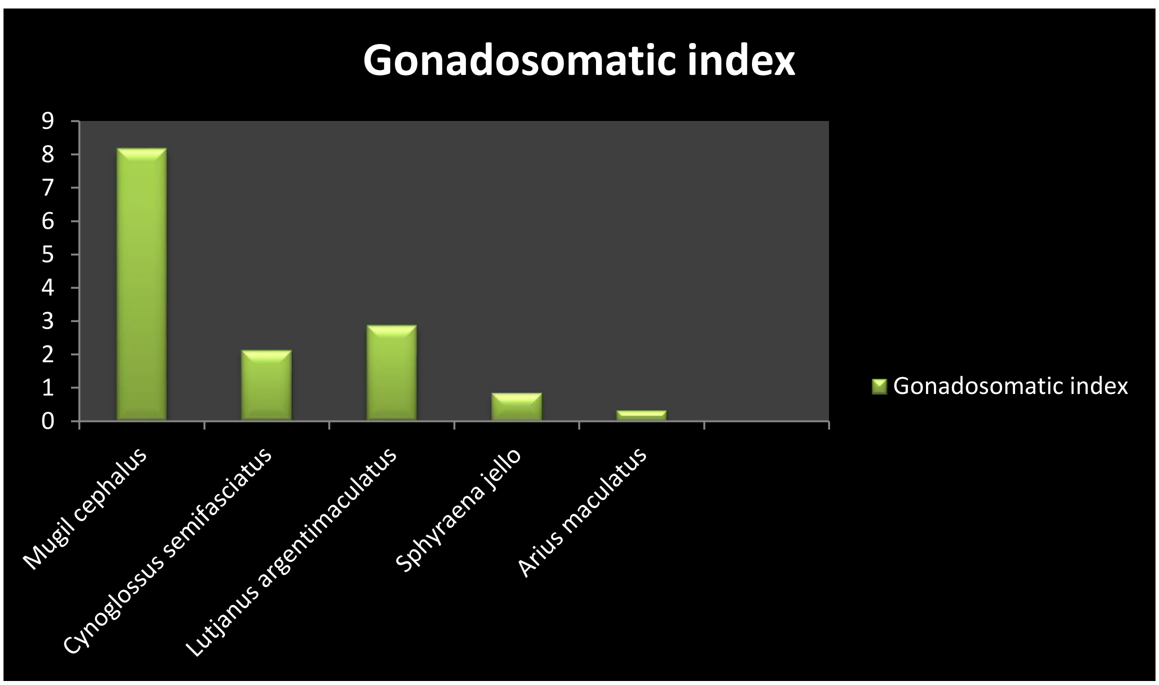


Figure.6. Gonadosoamtic index of freshwater fishes under study.

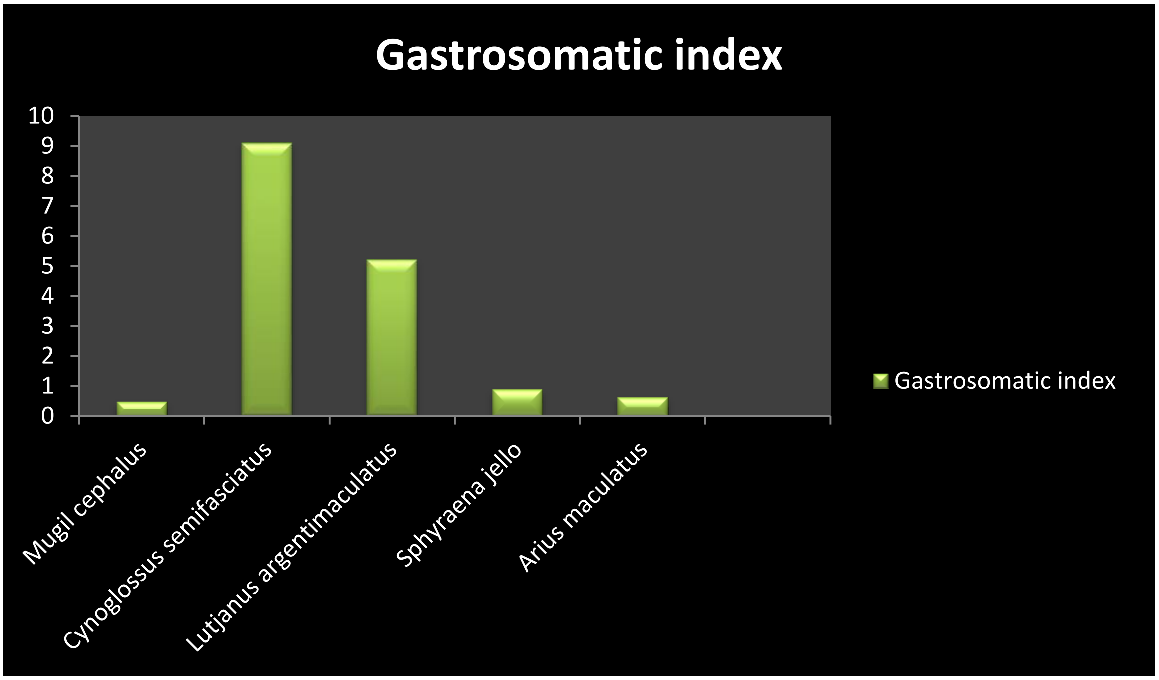


Figure.7. gastrosomatic index of freshwater fishes under study.

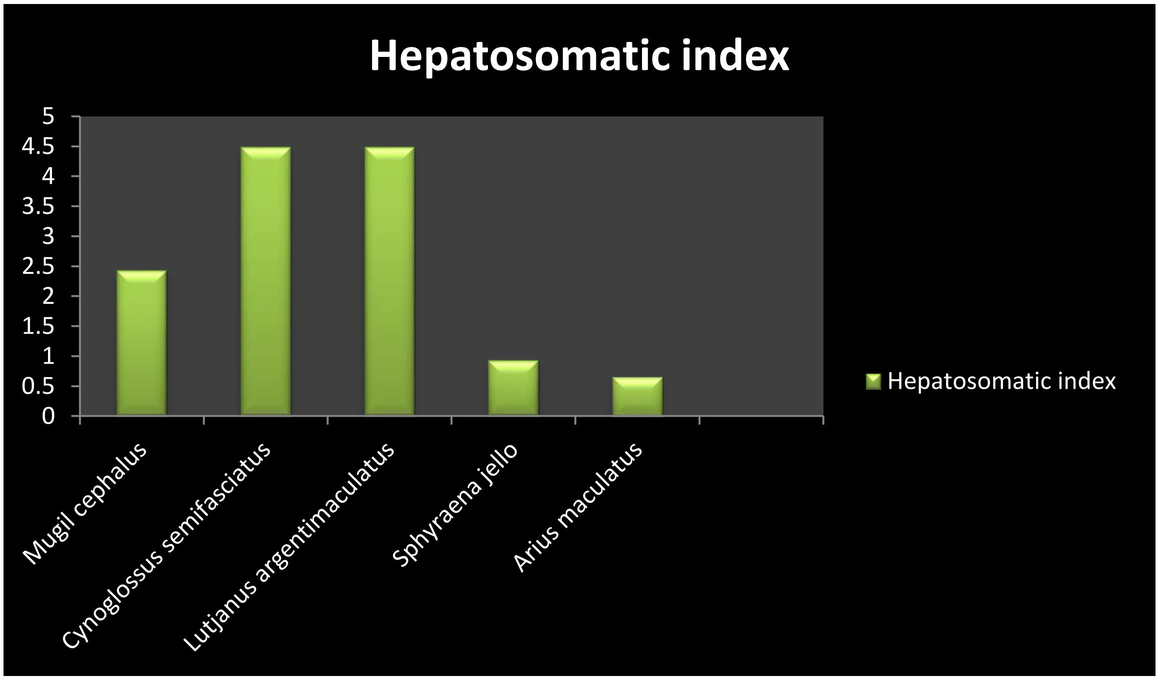


Figure.8. Hepatosomatic index of freshwater fishes under study.

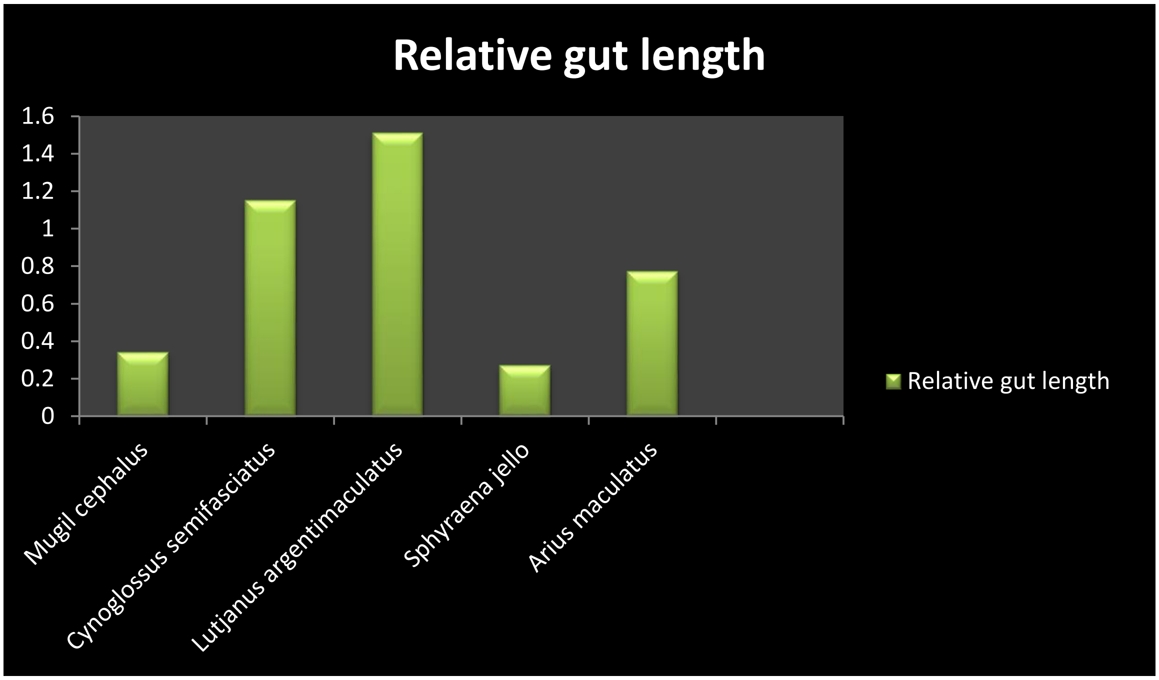


Figure.9. Relative gut length of freshwater fishes under study.

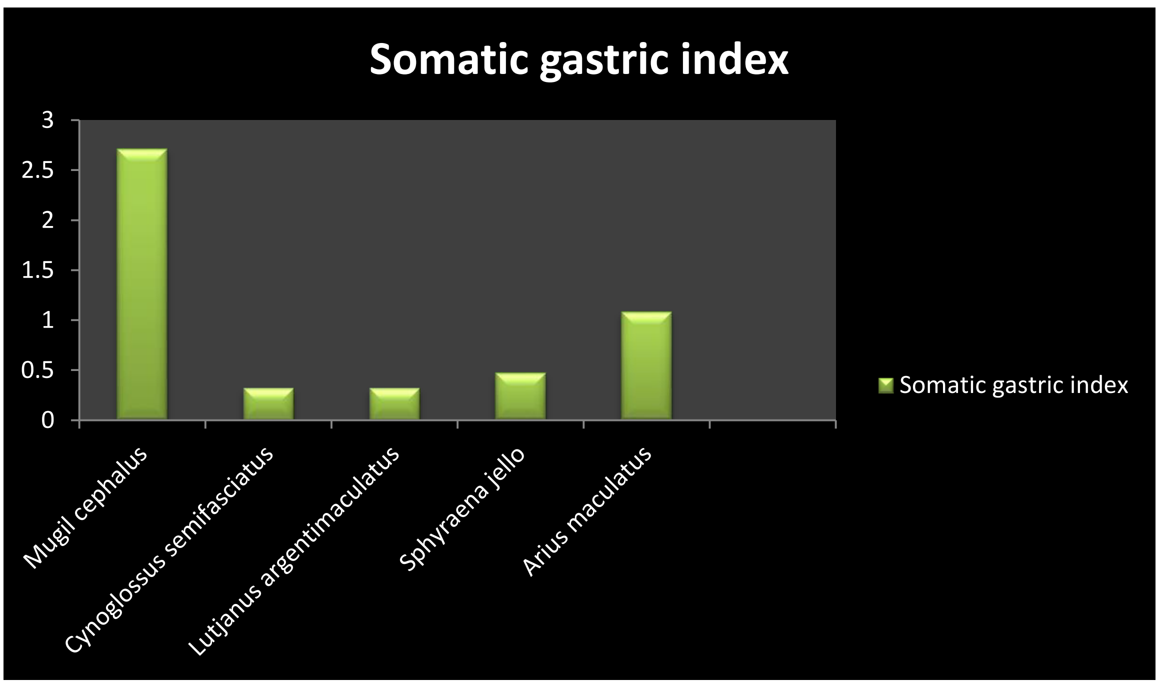


Figure.10. Somatic gastric index of freshwater fishes under study.

Marine fish

Table.5.Summarized data on the quantitative length- weight relationship between body-brain of Marine fishes under study.

Sl. No.	Length of fish (SL) cm	Body weight of fish (g)	Brain Length of fish (cm)	brain weight of fish (g)
Paraloanchurus peruanus	17±0.00	104.92±0.99	0.08±1.00	0.15±2.13
Otolithoides pama	10±1.34	21.41±0.02	0.71±0.04	0.09±1.00
Dasyatis pastinaca	10.10±2.45	20.24±1.22	1.5±1.00	0.23±1.22
Sillago bassensis	13±1.88	42.79±2.89	0.39±2.00	0.05±1.99

The marine collected were for the study were *Paraloanchurus peruanus, Otolithoides pama*, *Dasyatis pastinaca* and *Sillago bassensis.* The body length and body height were recorded and tabulated. The brain length and brain weight were recorded tabulated and all data were tabulated in Table.7. From the data it was clear that as the body weight and body length increases there will be a corresponding increase in the brain morphometry.

Table.6.Morphometric analysis of marine fishes under study.

Sl. No.	Parameters	*Paraloanchurus peruanus*	*Otolithoides pama*	*Dasyatis pastinaca*	*Sillago bassensis*
1	Body weight (gm)	104.92±1.00	21.41±1.00	20.24±1.00	42.79±1.11
2	Total length (cm)	19.60±2.23	11.70±1.33	22.00±2.11	15.50±1.34
3	Standard length (cm)	17.00±3.78	10.00±2.00	10.10±1.99	13.00±1.00
4	Fork length (cm)	19.60±1.00	11.70±2.00	22.00±0.90	15.50±0.00
6	length of intestine (cm)	9.40±4.00	12.60±0.07	9.40±0.05	10.10±0.07
7	weight of liver(gm)	0.89±1.09	0.11±2.00	0.80±0.00	0.28±1.00
8	weight of ovary(gm) weight of testies(gm)	5.20 ±0.00	0.58±0.09	0.30±0.06	0.14±1.09
9	Weight of gut	0.77±0.03	0.31±1.00	0.57±0.04	0.27±1.00

Total body weight of collected samples was monitored. Major length parameters monitored were total length, standard. Length and fork length. All are tabulated in Table.2. In the case of *Paraloanchurus peruanus* , standard length is 17.00±3.78cm. Total weight of the fish is 104.92±1.00 g. Weight of gut is 0.77±0.03 g; weight of liver is 0.89±1.09 g. Weight of gonad is 5.20 ±0.00g. In the case of *Otolithoides pama* , standard length *is* 10.00±2.00 cm. Length of the intestine is 12.60±0.07 cm. Total body weight of the fish is 21.41±1.00 g. Weight of intestine, liver and gonads were 0.31±1.00 g, 0.11±2.00g and 0.58±0.09 g were respectively. In the case of *Dasyatis pastinaca*, standard length is 10.10±1.99 cm. Total weight of the fish is 20.24±1.00g. Weight of gut is 0.57±0.04 g; weight of liver is 0.80±0.00g.weight of gonad is

0.30±0.06 g. In the case of *Sillago bassensis*, *standard length is* 13.00±1.00cm. Length of the intestine is 10.10±0.07cm. Total body weight of the fish is 42.79±1.11 g. Weight of intestine, liver and gonads were 0.27±1.00 g, 0.28±1.00 g and 0.14±1.09 g were respectively.

Table.7.Morphometric analysis of brain of marine fishes under study.

Sl.No.	Parameters	*Paraloanchurus peruanus*	*Otolithoides pama*	*Dasyatis pastinaca*	*Sillago bassensis*
1	Weight of brain	0.15±0.02	0.09±1.23	4.23±2.89	0.05±1.45
2.	Length of cerebrum	0.01±0.09	0.10±0.09	0.40±1.34	0.09±0.09
3.	Length of optic lobe	0.03±0.08	0.30±1.22	0.50±1.89	0.10±0.09
4	Length of telencephalon	0.04±0.067	0.31±2.39	0.60±0.06	0.20±1.80

Details about the brain morphology were tabulated in the Table.7.In brain morphology brain weight is highest in *Dasyatis pastinaca.*The total length of the brain was also highest in *Dasyatis pastinaca*. Smallest brain weight was recorded in *Sillago bassensis.*Smallest length of the brain was also noted *Sillago bassensis***.**

Table.8. Index value and condition factor of **marine fishes under study.**

Sl.No.	Parameters	*Paraloanchurus peruanus*	*Otolithoides pama*	*Dasyatis pastinaca*	*Sillago bassensis*
1	Condition factor	2.13±0.09	2.14±2.00	0.19±1.00	1.20 ±4.07
2	Gonado somatic index	4.95±0.09	2.70±1.02	1.82±0.08	0.61±0.07
3	Gastro somtic index	0.73±0.10	1.44±2.09	2.81±1.00	0.45±1.11
4	Hepatosomatic	0.84±0.03	0.51±1.00	0.56±0.05	0.49±2.35

	index				
5	Relative gut length	0.55±0.00	1.26±1.56	0.93±0.09	0.56±1.89
6	Somato gastric index	0.18±0.07	0.54±1.99	1.08±2.00	0.61±1.09

Table 8, figure 11 to figure 17 denotes the main index and condition factor of the marine fishes. Highest condition factor was noted in the *Otolithoides pama* (2.14±2.00).Gonadosomatic index were higher in the *Paraloanchurus peruanus* (4.95±0.09). Smallest recorded in the *Sillago bassensis* (0.61±0.07). Gastrosomatic index were higher in the *Dasyatis pastinaca* (2.81±1.00). Smallest were observed in the *Sillago bassensis* (0.45±1.11). Hepatosomatic index was higher in *Paraloanchurus peruanus (*0.84±0.03).Relative gut length was higher as above that is 1.15±1.00 and 1.51±1.22. Smallest Relative gut length is higher in *Otolithoides pama* (1.26±1.56). Somatogastric index is higher in *Dasyatis pastinaca(Sillago bassensis).*

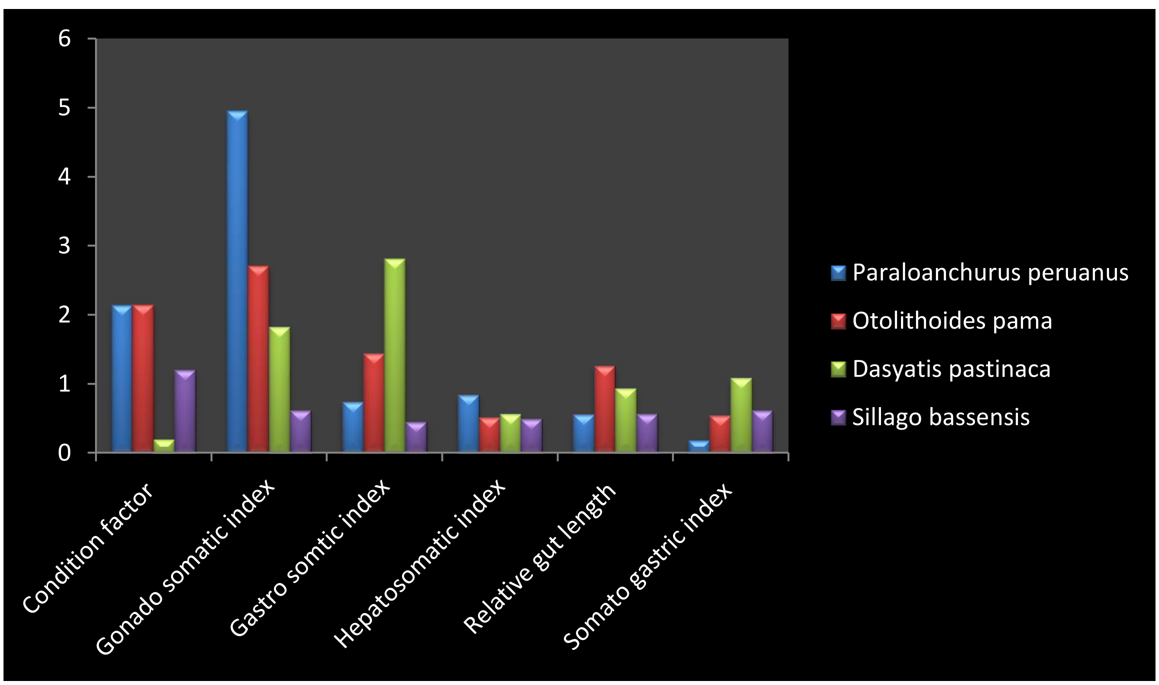


Figure.11. Index value and condition factor of marine fishes under study.

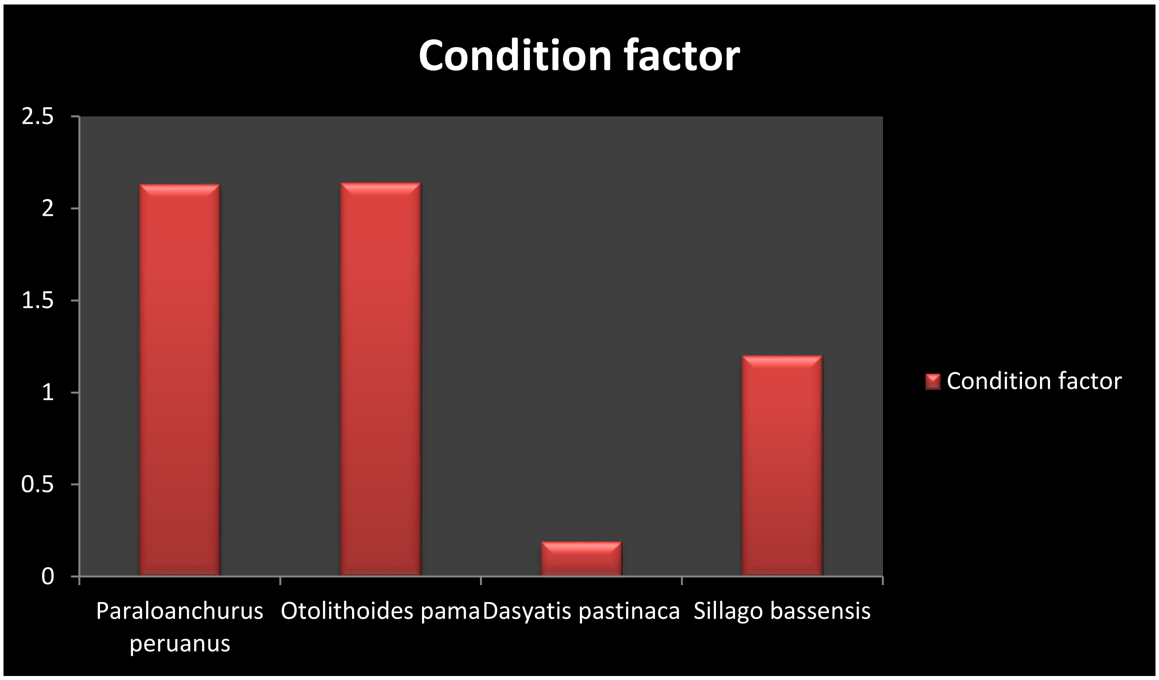


Figure.12. condition factor of marine fishes under study.

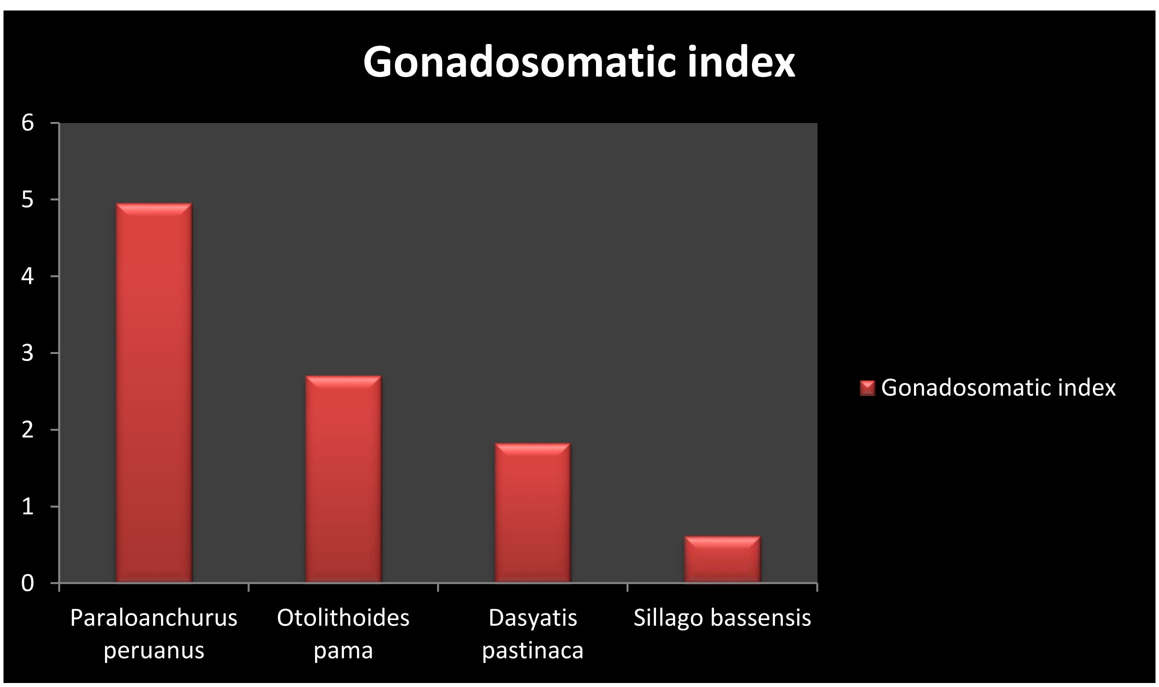


Figure.13. Gonadosomatic index of marine fishes under study.

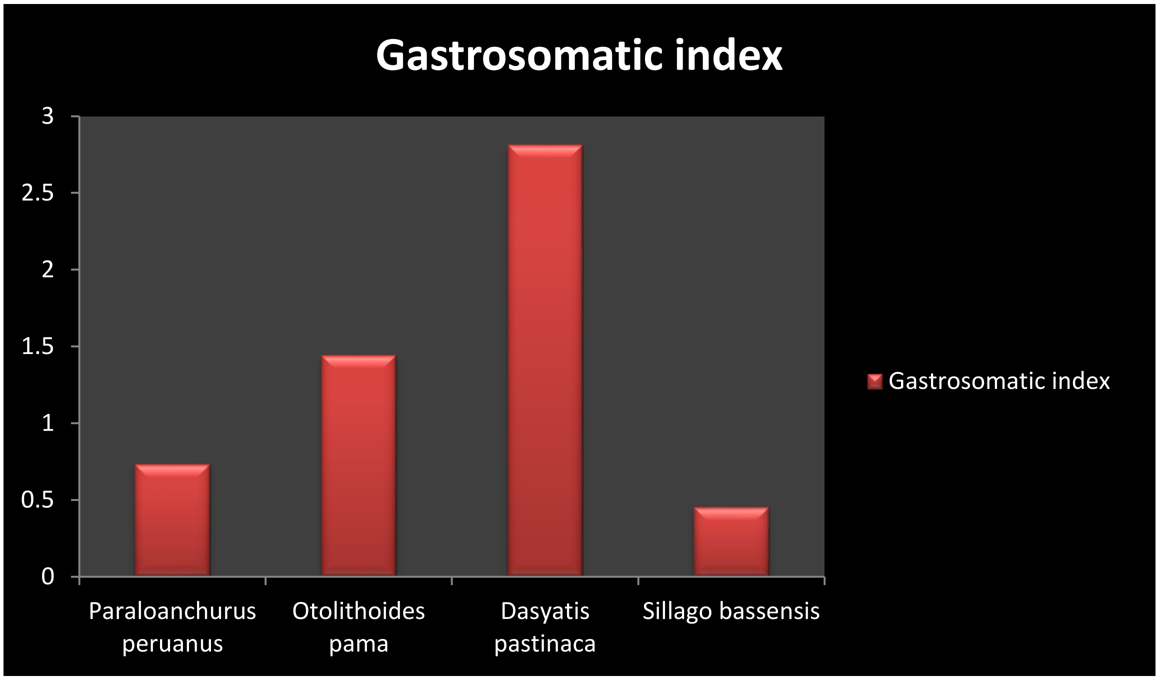


Figure.14. Gastrosomatic index of marine fishes under study.

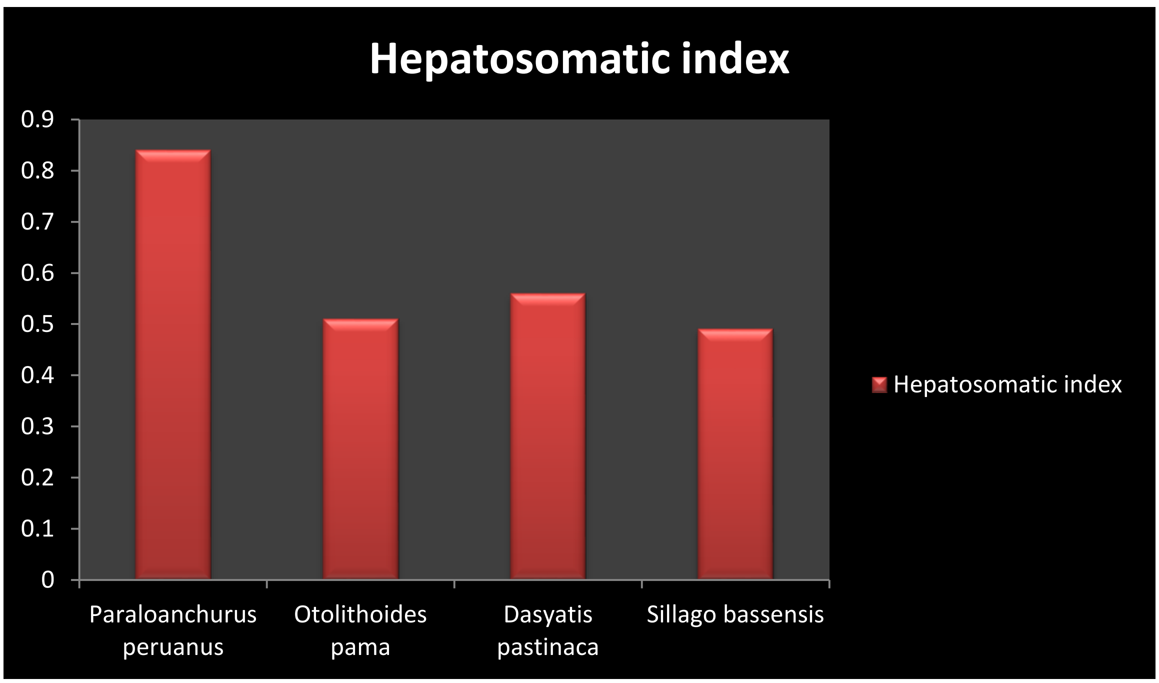


Figure.15. Hepatosomatic index of marine fishes under study.

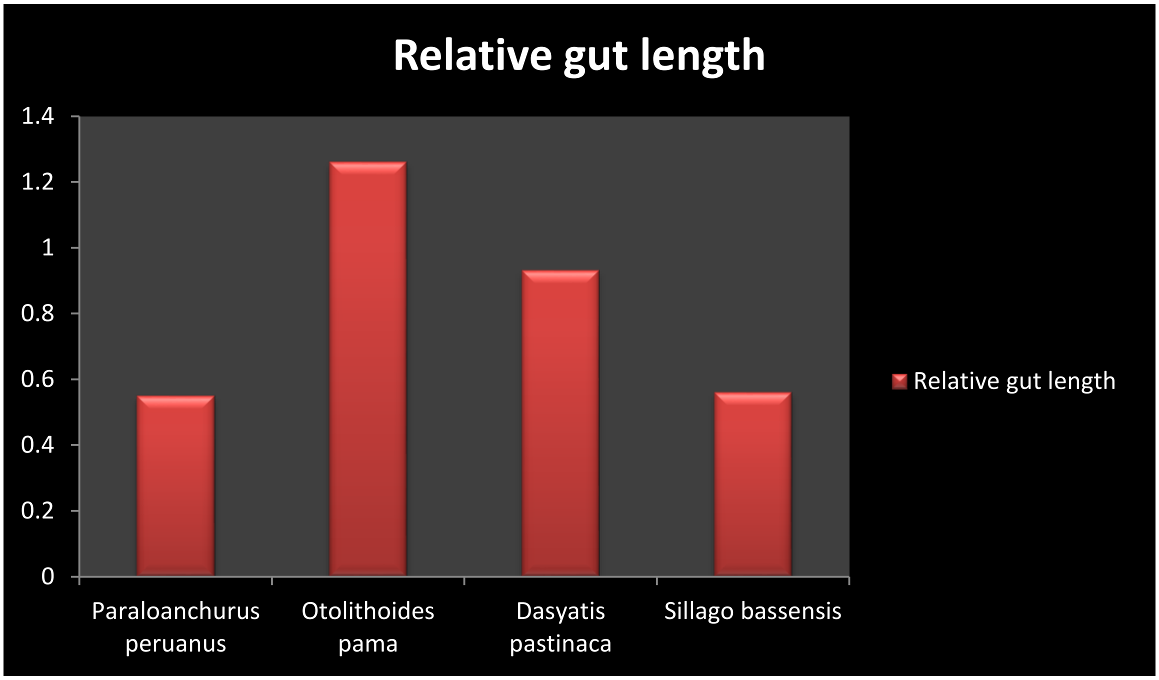


Figure.16. Relative gut length of marine fishes under study.

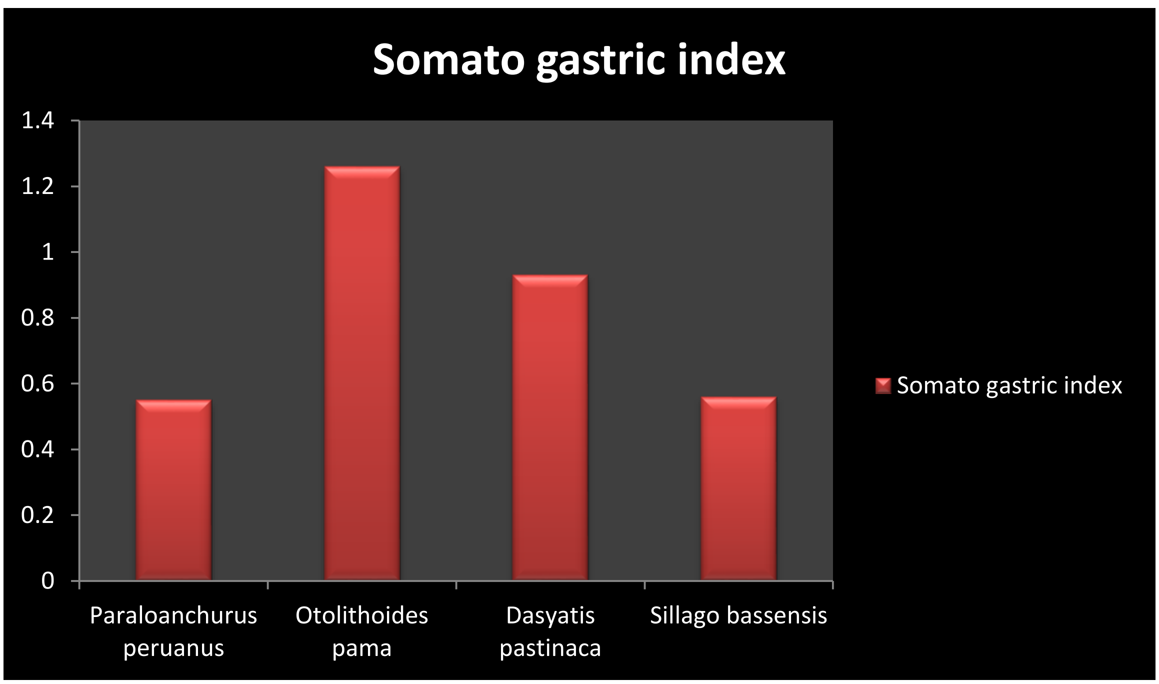


Figure.17. Somato gastric index of **Marine fishes under study.**

Estuarine fish

Table.9.Summarized data on the quantitative length- weight relationship between body- brain of Estuarine fishes.

Sl. No.	Length of fish (SL) cm	Body weight of fish (g)	Brain Length of fish (cm)	brain weight of fish (g)
Terapon jarbua	8.50±0.09	15.97±4.09	0.9±0.02	0.2±0.22
Epinephelus diacanthus	11.00±1.08	39.51±3.77	1.2±1.05	0.15±1.00
Diodon holocanthus Linnaeus	9.70±1.00	60.43±0.06	0.90±1.00	0.18±1.00

The estuarine fishes collected for the study were *Terapon jarbua* , *Epinephelus diacanthus* and *Diodon holocanthus Linnaeus*.The body length and body height were recorded and tabulated. The brain length and brain weight were recorded tabulated and all data were tabulated in Table.11.

Table.10.Morphometric analysis of Estuarine fishes under study.

Sl. No.	Parameters	*Terapon jarbua*	*Epinephelus diacanthus*	*Diodon holocanthus Linnaeus*
1	Body weight (gm)	15.97±0.02	39.51±1.56	60.43±3.00
2	Total length (cm)	10.20±0.09	14.20±0.80	10.80±1.23
3	Standard length (cm)	8.50±0.01	11.00±2.00	9.70±2.09
4	Fork length (cm)	9.60±2.89	14.20±2.09	10.80±1.22
6	length of intestine (cm)	3.90±1.11	9.70±0.00	6.60±1.22
7	weight of liver(gm)	0.11±1.12	0.12±2.00	0.04±0.89
8	weight of gonad (g)	0.16±1.20	0.19±3.33	1.64±1.00
9	Weight of gut	0.50±2.00	0.27±2.09	0.07±1.90

All the measurements were tabulated in Table.10. In the case of ***Terapon jarbua*** , standard length is 8.50±0.01 cm. Total weight of the fish is 15.97±0.02 g. Weight of gut is 0.50±2.00 g; weight of liver is 0.11±1.12 g. Weight of gonad is 0.16±1.20 g. In the case of *Epinephelus diacanthus*, standard length *is* 11.00±2.00 cm . Length of the intestine is 9.70±0.00 cm. Total body weight of the fish is 39.51±1.56 g. Weight of intestine, liver and gonads were 0.27±2.09 g, 0.12±2.00 g and 0.19±3.33 g were respectively. In the case of *Diodon holocanthus Linnaeus* , standard length is 9.70±2.09 cm.Total weight of the fish is 60.43±3.00 g. Weight of gut is 0.07±1.90 g; weight of liver is 0.04±0.89 g. weight of gonad is 1.64±1.00 g.

Table.11.Morphometric analysis of brain of Estuarine fishes under study.

Sl.No.	Parameters	*Terapon jarbua*	*Epinephelus diacanthus*	*Diodon holocanthus Linnaeus*
1	Weight of brain	0.20±2.00	0.15±2.09	0.18±1.24
2.	Length of cerebrum	0.20±2.00	0.30±1.19	0.20±2.89
3.	Length of optic lobe	0.30±2.45	0.40±1.90	0.30±1.77
4	Length of telencephalon	0.40±1.00	0.501.78	0.40±1.00

Details about the brain morphology were tabulated in the Table.11. brain weight is highest in 0.20±2.00 g. lowest brain weight is recorded in the 0.15±2.09 g. The total length of the brain was highest in *Lutjanus argentimaculatus*. Smallest brain weight was recorded in *Epinephelus diacanthus* .Smallest length of the brain was noted in *Terapon jarbua.*

Table.12. Index value and condition factor **of Estuarine fishes under study.**

Sl. No.	Parameters	*Terapon jarbua*	*Epinephelus diacanthus*	*Diodon holocanthus Linnaeus*
1	Condition factor	2.60±1.00	0.03±2.06	6.62±1.04
2	Gonadosomatic index	1.00±1.66	1.33±2.44	2.71±1.33
3	Gastrosotic index	3.13±4.78	0.68±2.30	0.11±1.28
4	Hepatosomatic index	0.69±2.66	0.30±1.77	0.07±0.09
5	Relative gut	1.49±1.88	0.88±2.78	2.34±0.05

	lengh			
6	Somatogastric index	0.64±0.07	0.36±0.46	0.17±2.90

Table 12 , figure 18 to 24 denotes the main index and condition factor of the estuarine fishes under study. Highest condition factor was noted in the *Diodon holocanthus Linnaeus* (6.62±1.04). Smallest condition factor were observed in the *Epinephelus diacanthus* (0.03±2.06). Gonadosomatic index were higher in *Diodon holocanthus Linnaeus* (2.71±1.33). Smallest recorded in the *Terapon jarbua* (1.00±1.66). Gastrosotic index were higher in *Terapon jarbua* (3.13±4.78). Smallest were observed in *Diodon holocanthus Linnaeus* (0.11±1.28). Hepatosomatic index were higher in *Terapon jarbua* (0.69±2.66). Relative gut length was higher in *Diodon holocanthus Linnaeus(*2.34±0.05). Somatogastric index is higher in *Terapon jarbua(*0.64±0.07).

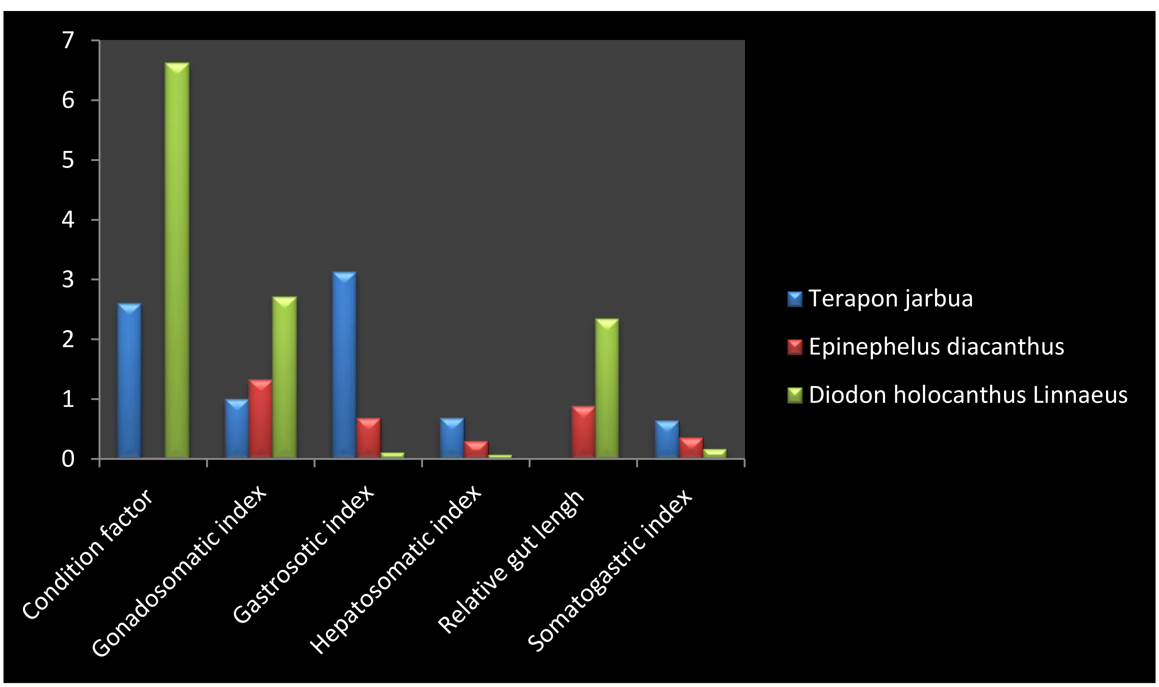


Figure. 18. Index value and condition factor **of Estuarine fishes under study.**

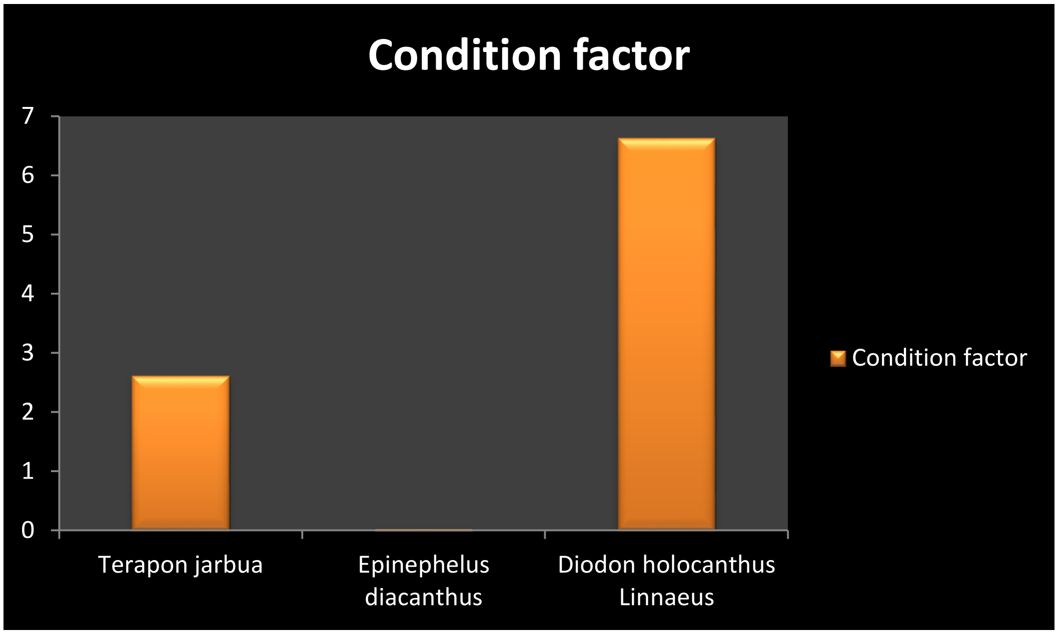


Figure. 19. Condition factor of **Estuarine fishes under study.**

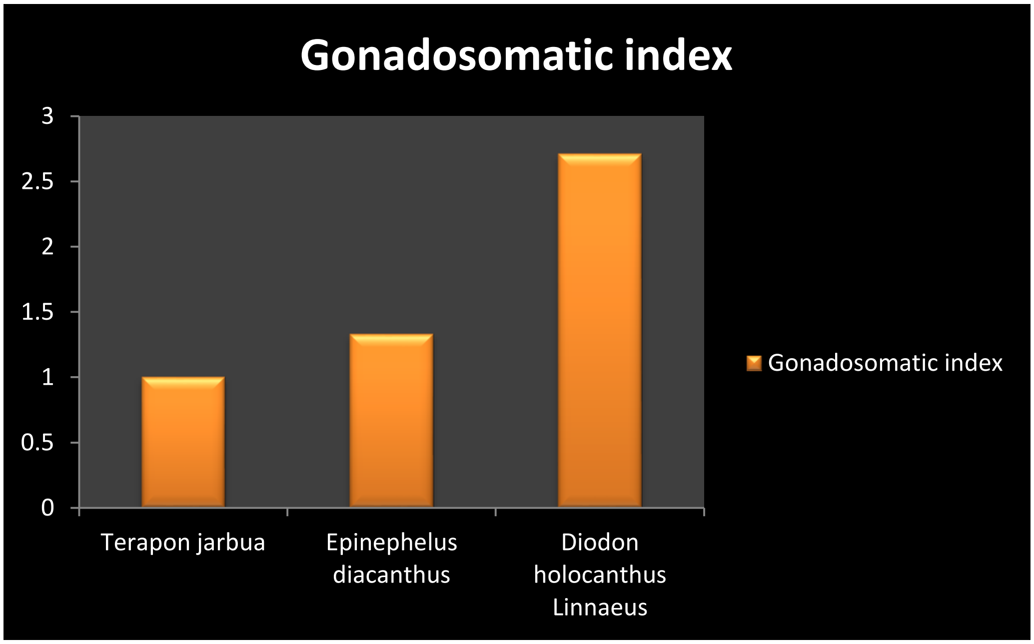


Figure. 20. Gonadosomatic index of **Estuarine fishes under study.**

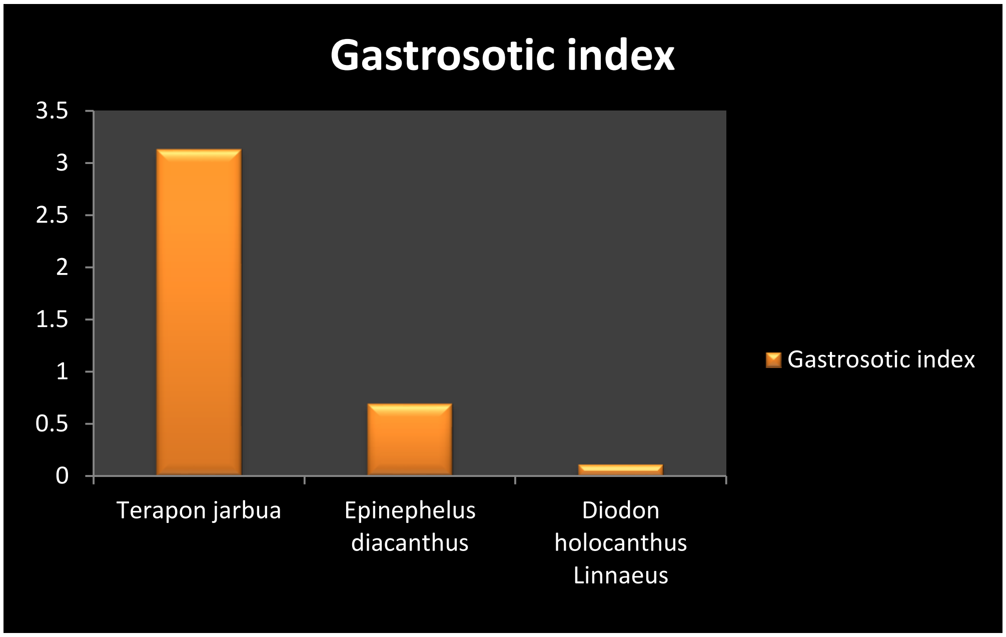


Figure. 21. Gastrosomatic index of **Estuarine fishes under study.**

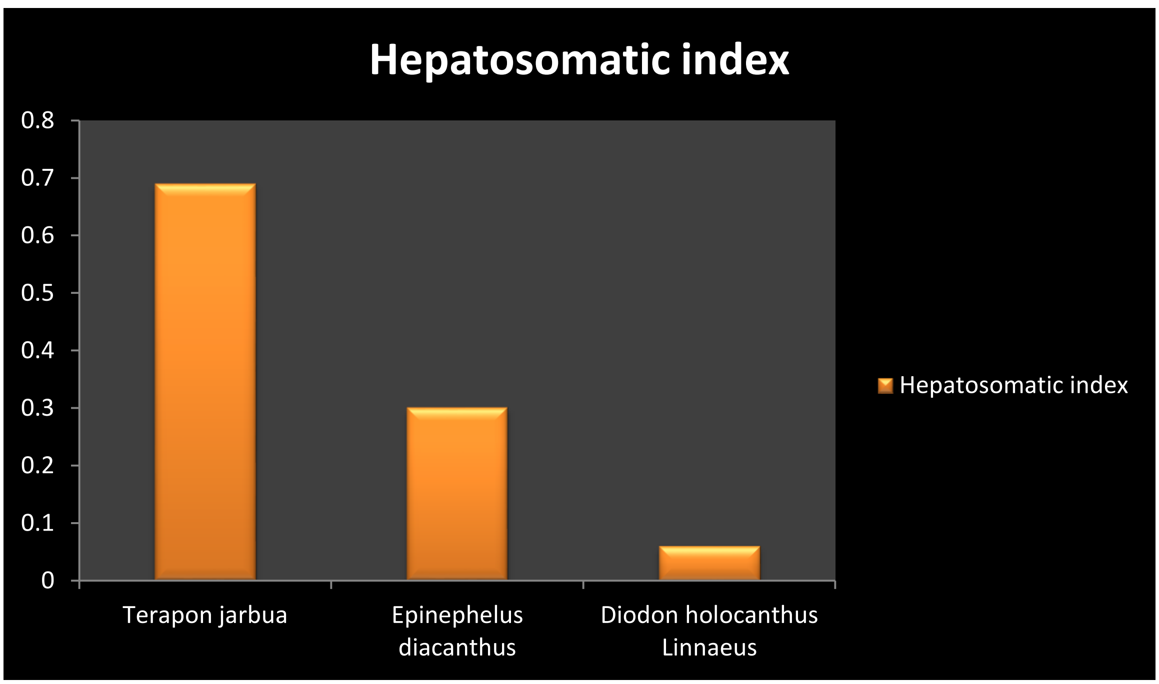


Figure.22. Hepatosomatic index of **Estuarine fishes under study.**

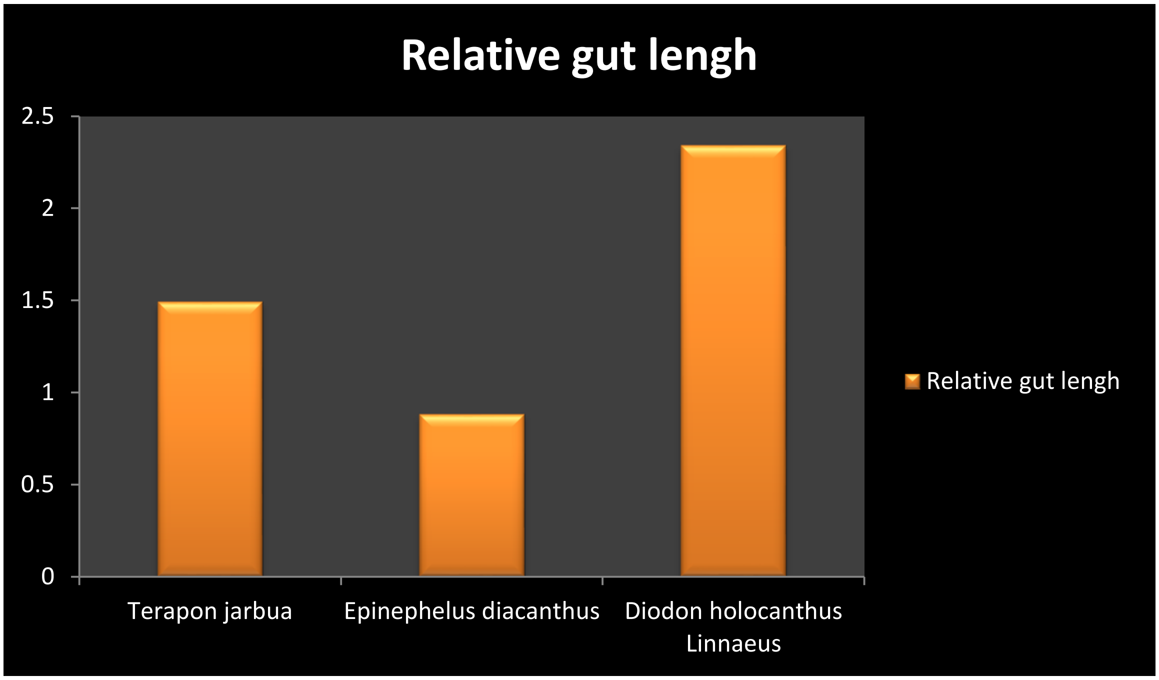


Figure. 23. Relative gut length of **Estuarine fishes under study.**

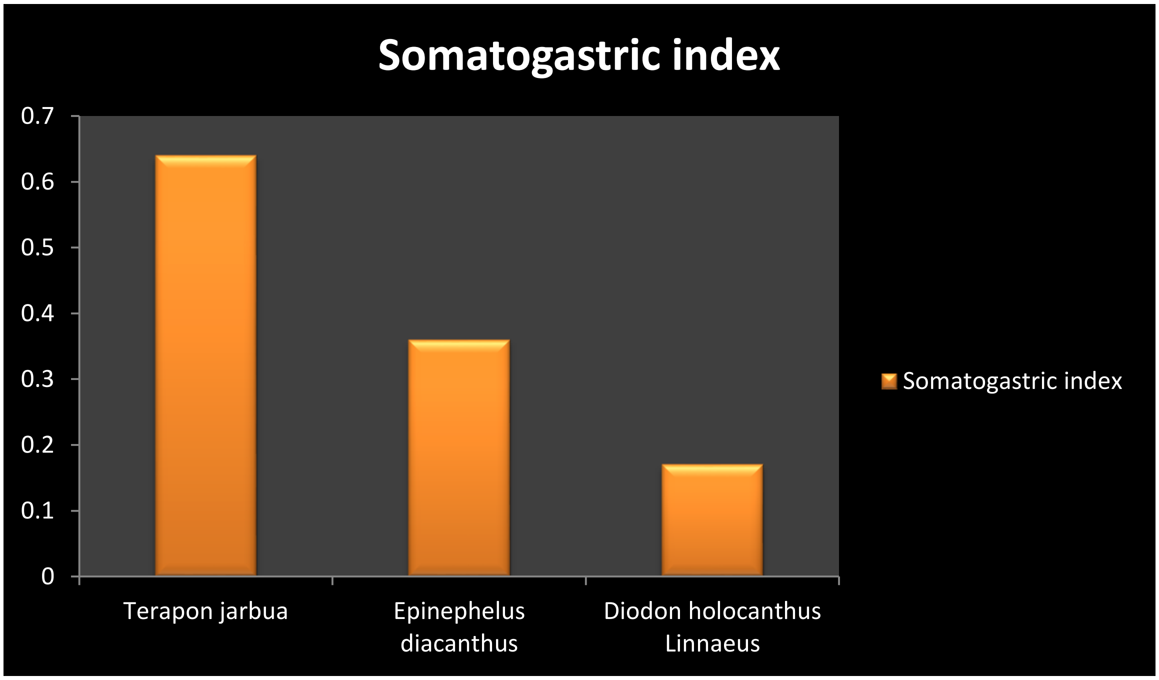


Figure. 24. Somatogastric index of **Estuarine fishes under study.**

DISCUSSION

There are numerous works are there relate to the ecomorphology of fish. In the present study we did a comparison of the brain and gut of some selected fishes. Sigh *et, al.,* 2015 also done a similar work related to the structure of fishes. The study was carried out to determine the morphological and anatomical characters of three freshwater air-breathing fishes *Clarias Batrachus, Channa Punctatus, Anabas testudineus* and to characterize the length, weight of alimentary tract and reproductive aspects like condition factor (k), Gastrosomatic Index(GSI), Gonadosomatic Index (GnSI), Hepatosomatic Index (HSI), Relative length of Intestine and Somatogastric Index. The result obtained indicated adverse effects on the gonads as well as on liver weight. The remarkable factor of Gastrosomatic Index (GSI) of three different fishes were significantly decreased as compared to their increase in body weight. The average Gastrosomatic Index (GSI), Gonadosomatic Index (GnSI), Hepatosomatic Index (HSI) and condition factor (k) of *C. Batrachus, C. Punctatus* and *A. testudinas* were (4.42, 4.60, 4.62), (3.74, 3.59, 1.48), (4.10, 3.41, 3.46), (0.91, 1.63, 2,88) were reported respectively. The weight length relationship, Gastrosomatic Index, Gonadosomatic Index, Hepatosomatic Index and Condition factor were found to be differed in three freshwater fishes analyzed. The relative length of Intestine and somatogastric Index value were found to be inconsistent in all the fishes studied.

On comparing the mode of feeding; fishes can be classified as herbivores, carnivores and omnivorous fish. On comparing omnivorous and carnivorous fishes are more in number when comparing with the herbivorus fishes. In herbivorus fishes the gut has more length compared with other two (Dejo *et.al.,*2022). This is for increasing the surface area fir absorption. In the case of brain morphology the optic lob is larger in the surface feeder; in bottom feeder the optic lobe os small when compared with the surface feeder. In column feeder the lobe is in moderate than others (Sherly;2003). It has been generally acknowledged that environment could alter the morphology and functional differentiation of vertebrate brain. Fish brain was composed of six parts, including olfactory bulb, telencephalon, hypothalamus, optic tectum, cerebellum, and medulla oblongata.In addition, compared to elasmobranchs and non-teleost bony ray-finned fishes, grass carp lost the hypothalamo-hypophyseal portal system, instead the hypophysiotropic neurons were directly terminated in the pituitary cells(Singh *et.al.*,2015). The telencephalon was deemed to be involved in the regulation of appetite and reproduction.The optic tectum might play important roles in the vision system and feeding.The hypothalamus could regulate feeding, and reproduction process.The medulla oblongata was related with the auditory system. It is conceivable that variously modified brains might evolve under the conditions of natural selection so that the brains help fit the teleost species for diverse ecological niches. In the present study we compared the marine, freshwater and estuarine fishes gut and brain study. The samples checked were omnivore and carnivores fishes. So the omnivore's fish has moderated gut length than the carnivores' fishes. Most of the fishes in the three ecology were omnivores. In the brain study also revealed that the brain with larger optic lobe is surface feeder. Other s like sting ray the optic lobe is not so prominent. On comparing Carnivorous fishes have relatively smaller intestine than herbivorous fises. (Fange and Grove ,1979;bon,1979).Longer guts have higher surface area and allow a longer retention time of the food, consequently enhancing nutrient absorption. Additionally, digestive tissues are very expensive to maintain, so it is critical to adjust them to an optimal energy intake/maintenance balance. Such animals can display high plasticity in their digestive systems because they often shift to different types of food that have different digestive requirements (e.g. animal vs. plant food). There is a strong correlation between the anatomical structure of the digestive tract and the feeding habits of the fish. Herbivorous fish that depend on fibrous foods such as phytoplankton and macrophytes differ anatomically and behaviorally from carnivorous fish that consume meat and other more digestible feeds. Carnivorous fishes have a relatively simple and short gut, with thick mucosa for absorption. Herbivorous fishes have an accessory masticatory apparatus or other physiological adaptation to help in breaking down plant cell walls before the digestion process starts, and a long, thin gut to increase gut retention time and enhance digestion and absorption(Epa and Narayanan;2016). So from the work it is clear that the ecomophology of a fish deeply related with the ecology and biology of a fish. It will influence the structure of the fish also.

REFERENCE

1. Jessica A. Gephart, Christopher D. Golden, Frank Asche, Ben Belton, Cecile Brugere, Halley E. Froehlich, Jillian P. Fry, Benjamin S. Halpern, Christina C. Hicks, Robert C. Jones, Dane H. Klinger, David C. Little, Douglas J. McCauley, Shakuntala H. Thilsted, Max Troell & Edward H. Allison.(2021). "Scenarios for Global Aquaculture and Its Role in Human Nutrition", *Reviews in Fisheries Science & Aquaculture*, 29:1, 122-138.

2. Uttam K Sarkar, JK Jena, Shri Prakash Singh, AK Singh and SC Rebello.(2012). "Documenting Coastal Fish Biodiversity of India: Status, Issues and Challenges". *Conference Paper, International Day for Biological Diversity,* Marine Biodiversity, 22 May 2012, Uttar Pradesh State Biodiversity Board, Lucknow, pp. 22-28.

3. Pedro Morais and Ester Dias. https://kids.frontiersin.org/articles/10.3389/frym.2021.613862

4. Béné C, Barange M, Subasinghe R, Pinstrup-Andersen P, Merino G, Hemre G-I, Williams M. (2015). "Feeding 9 billion by 2050 – Putting fish back on the menu". *Food Sec.* 7(2):261–274.

5. Thilsted SH, ThorneLyman A, Webb P, Bogard JR, Subasinghe R, Phillips MJ, Allison E H.(2016). "Sustaining healthy diets: the role of capture fisheries and aquaculture for improving nutrition in the post-2015 era". *Food Policy*. 61:126–131.

6. World Health Organization. 2018. A healthy diet sustainably produced: information sheet (No. WHO/NMH/NHD/18.12). WHO.

7. Bijukumar, A. & R. Raghavan (2015). "A checklist of fishes of Kerala, India". *Journal of Threatened Taxa* 7(13): 8036–8080.

8. Bloch, M.E. (1795). "Naturgeschichte der ausländischen Fische". Berlin. v. 9: i-ii + 1-192, pls. 397–429.

9. Bloch, M.E. & J.G. Schneider (1801). M.E. Blochii, Systema Ichthyologiae Iconibus cx Ilustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit Jo. Gottlob Schneider, Saxo. Berolini. Sumtibus Auctoris Impressum et Bibliopolio Sanderiano Commissum. i-lx + 1-584, Pls. 1-110pp.

10. Easa P. S. and Shaji C. P.1997. "Freshwater fish diversity in Kerala part of the Nilgiri Biosphere Reserve". Current Science.73(2), 180-182.

11. Shrestha, R., & vaidya, sheetal. (2016). "Brain Morphology and Feeding Habits of Some Fresh Water Teleosts of Nepal". *International Journal of Applied Sciences and Biotechnology*, *4*(1), 79–81. https://doi.org/10.3126/ijasbt.v4i1.14586.

12. Donovan P. German and Michael H. Horn.(2006). "Gut length and mass in herbivorous and carnivorous prickleback fishes (Teleostei: Stichaeidae): Ontogenetic, dietary, and phylogenetic effects". *Marine Biology* 148(5):1123-1134. DOI:10.1007/s00227-005-0149-4.

13. Sherly, P. (2003). Patterns of brain morphology in teleosts. *Uttar pradesh journal of zoology*, *23*(1), 15–21. Retrieved from .https://www.mbimph.com/index.php/UPJOZ/article/view/386.

14. Samuel Segun Ashley-Dejo*, Ijabo Samuel Ogah & Yahya Usman Department of Fisheries and Aquaculture, Federal University Gashua, Yobe State, Nigeria. (2022). "Length-Weight Relationship and Condition Factor of *Tillapia zilli* in River Yobe, Northeast, Nigeria". *Jurnal perikanan.* 24 (1), 55-61.

15. Sanatan Singh*, PK Dixit and AK Patra. (2015). "Studies on comparative morphology and anatomy of certain body tissues of three freshwater teleosts". *Asian Fisheries Science* 29 (2016):151-163.

16. U. P. K. EPA* and N. M. A. J. NARAYANA.(2015). "Feeding Ecology and Length-weight Relationship of Indian Glass Barb, *Laubuka laubuca* (Hamilton 1822) at Maguru Oya Stream (Deduru Oya River Tributary), Sri Lanka". International journal of bioassays ISSN: 2278-778X CODEN: IJBNHY.

17. Olaosebikan, B.D & A. Raji. 2004. Field guide to Nigerian freshwater fishes. 2nd Edition, Federal College of Freshwater Fisheries Technology, New Bussa. 111.

18. Fange.R and Grave,D.1979.Digesion. In Hoar,W.S.Randall.D.J and J.R Brett(EDs),Fish Physiology,Vol.VIII.Academic Press ,New York.N.Y.pp.162-260.

19. Biswas SP (1987): Studies on the intestine length in relation to feeding habits of five, commercially important fishes from Assam. J.As. Sci. Soc. Vol.28 (1), 10 -13pp.

20. Grant P and Spain RA (1975): Reproduction, growth and size allometry of *Mugil cephalus* from North Queensland inshore waters. Aust. Jour.Zool., Vol. 23, 181-221 pp

21. Beckman CW (1948): The length weight relationships and coefficients of condition for seven Michigan fishes. Trans. Am. Fish. Soc., Vol.75, 237-256.

22. Hopkins R (1979): Reproduction in Galaxias fasciatus.N.Z.J. Mar. Freshwater Vol. 13 (2), 225-230.

23. Desai VR (1970): Studies on fishery and biology of *Tor tor* from river Narmada. J. Inland. Fish. Soc. India, Vol.2, 101-112 .

24. Ghosh A (2006): Fishes of the Hooghly-Matla Estuary. CIFRY (ICAR) Publication 1-10 pp