CHAPTER ONE

INTRODUCTION

1.1 Background study:

Mugilidae fishes are euryhaline fishes that live in tropical, subtropical, and estuarine environments. There are 18 genera and 81 species in this family worldwide (Schultz,1946). A revised checklist of Ocean Fishes of Bangladesh lists eight Mugilidae species: *Chelon parsia, Ellochelon vaigiensis, Mugil cephalus, Liza parsia, Planiliza subviridis, Osteomugil cunnesius, Planiliza planiceps, Valamugil speigleri, and Paramugil parmatus* (Islam et al. 2020). According to the list of marine fishes reported from Bangladesh Fishbase, there are 8 species present such as *Minimugil cascasia, Mugil cephalus, Osteomugil cunnesius, Paramugil parmatus, Planiliza parsia, Planiliza Planiceps, PlaniLiza subviridis, Rhinomugil corsula.* On the other hand, there are six different species. The Red list of Bangladesh Volume 5: Freshwater Fishes includes *Paramugil parmata, Liza parsia, Liza subviridis, Mugil cephalus, Rhinomugil corsula,* and *Sicamugil cascasia*. Mullets are commercially important fish that migrate from freshwater to seawater and back. Furthermore, it is an important source of food both in and out of season because it is imported from different countries.

Bangladesh has achieved fish culture self-sufficiency, with per percentage of population fish consumption of 62.58 g/day, going to exceed the benchmark of 60 g/day (DoF, 2020). The continuous growth of the fisheries sector has made a contribution to fish production of 45.03 lakh MT in 2019-20 which is near fish farming of 45.52 lakh MT in 2020-21, with marine fisheries accounting for 14.90% of total fish production (DoF, 2020).

The economic output of the marine fishing sector is 6.71 lakh MT, with an approximate annualized return of 1.7 percent, of which 1.15 lakh MT is industrial and 5.56 lakh MT is artisanal (DoF, 2020). The fisheries sector accounts for 3.52 percent of national GDP and more than a quarter of total agricultural GDP (26.37 percent) (DoF, 2020).

Mugilidae family species are tasty, and their nutrition and market value are also high, making them commercially important for harvesting throughout the year, including the offseason, regardless of stock, size, or maturity. According to Lan et. al (2017) overfishing has recently reduced the catch of these fishes. To meet the demand for these fish species, it is critical to conserving their biodiversity, and large-scale aquaculture is also required. A variety of methods are employed for identification, but morphometric and meristic phenotyping is considered one of the first and most valid ways for fish species identification in fish biology (El-Saidi et al. 2017). Morphometric methodologies have lately advocated the utility of morphometric research in the identification of fish populations to support the sustainable use of fisheries resources and the conservation of biological diversity. Morphometric differences between stocks of a species are regarded to be essential in determining population structure and identifying distinct fish races and/or populations from one another (Ara et al. 2021).

1.2 Importance of morphology:

Meristic characters are those that represent themselves numerically, whereas morphological characteristics are those that can be seen through their external appearances. Morphometric traits are numbered and measured on a scale that considers the length, weight, and meristic features. Both morphometric and meristic characteristics are important in fisheries science. It is possible to consider morphometric and meristic work to be the starting point and base for any more complex molecular level exploration based on the idea of Fish morphology that seals up the initial protocol in stock assessment (Ainsworth, 1992).

The experiments on morphometric and meristic features, according to Ahmed et al. (2017) and Hanif et al. (2017) include an initial technique in cohort estimate, asymptotic length, identifying the distribution of a specific species, and a record of new species in different geological locations. Another application of morphological and meristic traits in aquaculture is measuring hormone treatment (Yanong et al., 2010). Estimating the nutritional value of fish feed is an important stage in aquaculture. As feed nutrition requirements consider factors such as body weight and age, morphology regulates feed estimation to some extent because weight is a morphological character and age can be determined by morphology (Timm-Davis, 2015). Scientific groups are increasingly emphasizing morphometric characteristics. In each of these circumstances, the outcome is expressed in terms of weight or length. Age is an essential aspect in breeding biology, and the circuli on the scales, marks, or unique patterns on the body may reveal the fish's age, Carbonara et al. (2019). The identification of fish is the most important use of morphometric and meristic features. In order to tell apart closely related species, morphological and meristic characteristics are heavily relied upon. The suspected fish sample is first morphometrically examined, and then it is subjected to a genetic test for further confirmation.

In genetic experiments like as hybridization, inbreeding, and comparing the parents' generation to the F1 and F2 generations, morphometric features produce the greatest results (Khan et al., 2013). This decision is also taken based on morphometric and meristic characters, especially when selecting the strain. Morphological and meristic characteristics play a role in cryopreservation and live conservation. Individuals of a species with remarkable growth or quality are frequently preserved for the future. Fish morphometric variation patterns may represent changes in development and rate of development because body form is a product of ontogeny.

Morphometric landmark and Outline techniques approaches are the two main types of morphometric examination (Stransky, 2014). For example, a landmark strategy examines morphometric points, direct distances between points, as well as mathematical correlations between them; an outline strategy examines boundary shapes. As computerized imaging frameworks and scientific methodologies improve, morphometric testing has seen significant changes (Cadrin and Friedland, 1999). In any event, the application of complicated geometric processes to give distinguishing evidence lags behind other organic disciplines such as scientific classification and biomedical analysis (Cadrin, 2000).

Meristic traits, such as fin spines and rays, are fish elements that form in a calculable, sequential order (Cadrin, 2005). Meristic is commonly used to define body fragment features including fin rays and vertebrae. Regardless, the term is now applied to any countable feature, including scales, gill rakers, branchiostegal rays (Helfman and Winkelman, 1997). It might be directed indoors or outwards, but it must be visible. When analyzing any fish family or population, it is essential to evaluate the expansion of a species. The length-weight relationship (LWR) is an essential metric for comprehending the growth dynamics of a fish population, and it is used to compute the growth rate in fisheries research (Bintoro et al. 2019). Knowledge can be used to determine a species' growth pattern, and the growth pattern indicates the species' status in a region characterized and measured in either case, making them useful features for analyzing cases.

1.3 Importance of Mugilidae family:

Mugilidae fish belong to the class Actinopterygii, which has the greatest number of species, the most recent expansion, and the most pronounced evolutionary trends toward thin and swift forms. There are 75 valid species of Mugilformes in the world (Nirchio et al. 2018). Mugilidae fishes are normally medium to large in size, with a maximum size of 120 cm standard length and an average size of 30 cm standard length. Mugilidae species are recognized not only by their remarkable outward uniformity but also by their remarkable internal uniformity. Large modified scales may be present at the insertion of the pectoral and pelvic fins (axillary scales) and the commencement of the first dorsal fin (dorsal obbasal scales). There have been reports of depths exceeding 300 meters (Harrison, 2002). Filter-feeding mullet have unique oral and branchial gill rakers, together with an exceptionally large, denticulate, pharyngobranchial organ across each side of the pharyngobranchial chamber. Dorsal and caudal fins are usually dusky (sometimes yellowish), but anal, pelvic, and anal fins may be yellowish; the anal and pelvic fins are usually silvery or pale; the dorsal and caudal gill plates are usually dusky (sometimes yellowish); the anal and pelvic fins are usually silvery or pale; the anal and pelvic gill plates are usually silvery or pale; A point of controversy has been and remains the evolutionary connections of the Mugiliformes order, represented by a single family (Harrison, 2002). The Atherinidae, Mugilidae, and Sphyraenidae were classified by Berg (1940) as Subperciformes in the order Mugiliformes. They were all categorized as Perciformes because of their subordinal location by Greenwood et al. (1966). Later, Nelson (1994) categorized them as Mugiliformes. Because of their high nutritional content and delectable flavor, Mugilidae fish are in high demand across the world, although Bangladesh has shown minimal interest in the species. As a result, Mugilidae fish species should be given more attention.

1.4 Chattogram coast:

Bangladesh has an abundance of water resources and is a world leader in the production of fish with a total outcome of 45.03 lac MT in FY 2019-2020, with marine production accounting for 14.9 percent of total fish production and growing at a 1.70 percent annual rate (DoF, 2020). The Chattogram coast is one of the most diverse in Bangladesh, particularly in terms of marine and estuarine fish. At Cox's Bazar, the Chattogram coastal region is 245 kilometers long, with a continuous 125 kilometers of gently sloping sandy beach (Khan et al. 2019). Chattogram division contributes 5137.15 MT, while Chattogram and Cox's Bazar districts contribute 305 MT and 4225 MT, respectively, to total fish production (DoF 2019-2020).

1.5 Objectives

• To identify all the available species under the Mugilidae family on Chattogram coast.

• To deduce seasonal variation of availability and the regional distribution of the species under the Mugilidae family.

CHAPTER TWO

REVIEW OF LITERATURE

Islam et al. (2009) conducted a one-year experiment on *Mugil cephal*us in the Chattogram region based on monthly inspection of gut contents of 120 samples and it feed diatoms, algae, copepods, decayed organic matter. Points methods were used to analyze the food content of gut and found that the greatest abundance was about 48% diatom. From research, it can conclude that *Mugil cephalus* is a bottom feeder and herbivorous.

Hossain et al. (2013) studied *Rhinomugil corsula* biometrics in the Ganges, Northwestern Bangladesh. The gender ratio was not dramatically different from the expected rate of return of 1:1. However, the length-frequency deductions of the sexes differed significantly (P=0.03). In males, females, and mixed sexes, the LWR morphometric coefficient b showed negative allometric growth (b3.00). Furthermore, no significant differences in KF were found between sexes (P=0.57). However, the mean WR of *R. corsula* in this experiment varied greatly from 100 for males (P=0.03) and females (P=0.001) revealing a habitat-food accessibility imbalance relative to predator presence.

Another study on Landmark-Based Morphometric and Meristic Varieties in Mullet Population densities was conducted by Hossain et al. (2015). For *Rhinomugil corsula* morphometric and landmark measurements first discriminant functions (DF) taken into account for 89.8 percent and 83.3 percent respectively, while the second DF taken into account for 10.2 percent and 16.7 percent, respectively, explaining 100 percent of combined amount among band discrepancies. Graph discriminant functions for morphometric and truss network measurements did not show well-separated subsets in the stocks. There's also a high great disparity in morphological characteristics among 3 distinct stocks of *Rhinomugil corsula* based on environmental modification and separate geographical area (the Meghna, Padma, and Ichamoti).

Khayyami et al. (2015) looked at the different shapes of *Mugil cephalus* from Bandar abbas port and Qeshm island in the northeast Persian Gulf. Using univariate analysis of variance, they found that the means of the two groups were very different for 17 of 25 standardized morphometric measurements. Principal Component Analysis (PCA) results for morphometric data showed that plot lines between data points from Bandar Abbas Port and Qeshm Island were more different from each other. In DFA , the proportion of individuals appropriately classified into their original groups was 100%.

Konan et al. (2014) looked at how the genus *Mugil* changed in shape in the lagoons of Ebrié and Grand-Lahou. They found that meristic characters, such as the number of branchiospines on the upper and lower parts and the number of microbranchiospines with the first branchial arch, could be used to tell each species apart. The number of branchiospines on the interesting parts of *Mugil curema*, *Mugil bananensis*, and *Mugil cephalus* varies between 27 and 44, 19 and 39, and 43 and 58, respectively. On the lower part of that arch, *M. curema* (57–70) and *M. bananensis* (34 to 45) were separate and did not meet. *M. cephalus* and *M. bananensis* were also separate and did not meet (62 to 89).

Multivariate analyses for morphometric data were used to estimate *Mugil cephalus* differentiation (Hassanien and associates, 2020). The principal component analysis (PCA) discovered that the majority of the genetic variations for *Mugil cephalus* populations was observed on the first 3 axes, accounting for more than 87.96 percent of the variation. With only two functions, the DFA stepwise findings state 100% of the deviation. Dorsal fin length (DFL), pectoral fin length (PecFL), maximum body height (MBH), caudal peduncle depth (CPD), and condition factor were the most important differences between populations. Using a simple, fast, and low-cost morphometric analysis, the existing screening easily distinct the *M. cephalus* examined.

Mukherjee and Chanda (2020) conducted a survey on the Rupnarayan River's fish faunal diversity and discovered *Rhinomugil corsula* for perhaps the first time, and its dispersion is being expanded inland to the freshwater region of the river less adversely affected by tidal flow.

Ara et al. (2021) studied the relationships of various body measurements with overall length and head size with the five relevant actors of *R. corsula* from the Bay of Bengal's Sitakunda coast, and the results were incredibly significant (P=.01) for connections between TL and 21 meaningful characters, the 'b' value varies from 0.967 to 1.346, and for relationships between HL and 5 relevant characters, the value ranges from 0.906 to 1.236. Such parameters vary from the usual value b=1 noticeably (P>0.01), stating that the plotlines have isometric interactions.

According to Sultana et al. 2013, the total length (cm), standard length (cm), head length (cm), length of upper jaw (cm), body depth (cm), and body weight (g) of *Rhinomugil corsula* usually ranges from 19-24, 15-20, 3.1-4.6, 0.90-1.10, 3.20-4.50, and 64-124, respectively. The taxonomic formula for the genus was as continues to follow: D1. 4, D2. 7, P1. 13-14, P2. 5-6, A. 9/11, C. 18, RC. 4. The number of measures on, above, and below the transverse processes ranged from 46 to 49, 7 to 9, and 10 to 12. The biological investigation discovered that the fish weight (g), gonad weight (g), fecundity, GSI, liver weight (g), gut weight (g), alimentosomatic and hepatosomatic index, and condition factor values ranging from 100 to 202, 8.13 to 27.64, 8924 to 82642, 8.13 to 13.99, 0.96 to 2.00, 3.81 to 6.57, 2.78 to 5.06, 0.83 to 1.14 and this investigation revealed that the species feeding habits are omnivorous. The hepatosomatic and alimentosomatic indices had higher mean values, indicating increased feeding intensity.

Durairaja et al. (2020) investigated the length-weight relation and condition factor of *Mugil cephalus* in Tiruvallur (dt), Tamil Nadu. Standard lengths for men varied widely from 70 to 165 mm, while female standard lengths fluctuated from 100 to 200 mm. The slope value 'b' for males was calculated to be 2.7638, for females to be 2.7624, including both sexes to be 2.7653. For male and female, W= 0.00038 L2.7638 and W= 0.00040 L2.7624 were determined. The 'b' value was nearer to 3, indicating a portly, highly streamlined shape. The estimated combined sexes coefficient value is 0.9068. The average ailment factor value both for sexes were 1.0155, suggesting that such fish was in healthy life.

Liza subviridis was studied by Khan et al. (2013) for its length-weight relationship and condition factor on India's southeast coast. Male specimens of comparable length weighed more than twice as much as female specimens. The equilibrium constant 'b' was found to be 2.7106 in males and 2.8927 in females. W = 0.0462L (2.7106) was the male equivalent parabolic illustration, and W = 0.0382L was the female equivalent (2.8927). Equilibrium constants for males deviated significantly from the cube law at the time. *L. subviridis* appeared to be doing well in Parangipettai waters, with a relative condition factor of around 1 and a little higher.

In Malaysia's Pinang River Estuary, *Liza subviridis* was studied by Zolkhiflee et al. (2017) for its length-weight relationship and relative condition factor. For pooled samples (male and female combined), the length-weight interaction and economic expansion pattern were W = 0.0117, L= 2.9989 (isometric), W = 0.0157 L2.8787 (negative allometric), and W= 0.0109 L= 3.0284 (isometric). An independent sample t revealed that the female b value was greater than the male b value. However, there was no significant disparity between wet and dry seasons or between male and female samples (independent t-tests, p>0.05) in the Kn of *L. subviridis.*

Fillet yields, dress-out percentages, as well as the phenotypic link between key grey Mullet features were all examined by Ali et al. (2013). As a result, the specimens had an average condition factor (K) of 1.10.13, which indicated that they were healthy. The mean fillet yield was 60.73 percent, while the overall dress-out yield was 64.70 percent. Male and female condition factors, fillet percentage, and dress-out percent were not vastly different (p>0.05). There was a close agreement between all of the actual features. Because they were estimated traits that were fully independent of the fish's size and weight, the correlations between fillet percentage and dress-out percentage were moderately low (r=0.5). Two types of regression analysis were performed to obtain the best suited model: bivariate and multivariate regression. The coefficient of determination of total weight on L, BD, TrW, and DW was assessed to be 7.6, 30.16, 1.19, and 1.35 using bivariate linear regression (arithmetic). DW, L, BD, TrW, and DW arithmetic coefficient of determination were 4.93; 0.66; 20.04; 0.79 and 0.94, respectively, for the weights of the fillets. The equations TW= -64.4 + 3.76 L+ 18.1 BD, FW= -43.9 + 2.14 L+ 13.2 BD, and DW= -47.3+2.30L+14.1 BD were determined using a quantitative approach of TW, FW, and DW.

Liza subviridis and *Sillago sihama* were studied by Gondal et al. (2014) in Sonmiani Bay (Miani Hor), Pakistan, for various morphometric characteristics. *Liza subviridis* has both favourable and unfavourable allometry (3.23 in 2002). (2.95 in 2003). (1.95). *Sillago sihama*'s allometry was excellent in 2002 (3.10) and opposite allometry 2003 (3.09), where (3.11) and (3.13) in 2006, Moreover, Bhaira *Sillago sihama* samples showed an acute state (3.02). The length-weight relationship, condition factor, and morphometry of gold spot mullet were studied by Renjini and Nandan (2011). Estuary of Cochin In the words of the poet, "Liza" (Ali et. al, 2013). The length-to-weight ratio of *Liza parsia* was examined. *Liza parsia* male and female gradient values (b) were estimated as 3.1545 and 3.0094, respectively, with a total value of 3.1938. Log W = -2.2147 + 3.1545 Log L was the male regression equation, Log W = -2.0315 + 3.0094 Log L was the female regression equation, and Log W = -2.2596 + 3.1938 Log L was the combined regression equation. It was discovered that *L. parsia* growth is excellent based on the length-weight connection and the condition factor.

In order to assess the taxonomic importance of certain morphometric and meristic scale traits in four mugil belonging to the family Mugilidae, Zubia et al. (2015) undertook comparative research. ANOVA and F-statistics were used to compare the means of each scale parameter among the four mullet species studied in this study and reported to be highly significant at the 5% level of significance ($p<0.05$). It was shown that all of these scale features might be employed as useful alternative methods used to determine the systematic link between such mullet fishes' distinct genera or species.

CHAPTER THREE

MATERIALS AND METHODS

The approach is very much important for every investigation. In logical inquiry, the value of the results is predicated on high anticipation of a suitable technique. This section oversees the investigation's strategies and materials used to achieve the investigation's objectives. The researcher has followed a logical and reasonable mindset throughout this work. This investigation is based on the collection of samples from various natural bodies of water, and data is collected and analyzed to understand the findings.

3.1 Sampling area

The research was conducted along the Chattogram coast of the Bay of Bengal northeastern part to determine the availability of Mugilidae fish. The study on the Chattogram coast mainly focus was on finding available marine and coastal Mugilidae fishes. The sample area was determined according to the purpose of the study. Three sampling areas were selected for this study. The sampling area is as follow:

i. **Sampling station 1 (Patenga, Chattogram)**

In the hub of Chattogram, the new Fishery Ghat region is the place of available fish species having geographical location as the latitude 22°32'97.36"N and longitude 91°84'58.20"E. This station covers an extensive place of Chattogram coast including Patenga seashore area, Pathoarghata, Fishery ghat (New and old), different adjoining fish landing sites of Chattogram.

ii. **Sampling station 2 (Kattoli coast, Chattogram)**

Adjacent to the beach of Sagorika, Halishohor, Chattogram including Foillatoli Bazar, Colonel Hat Bazar was studied under this sampling station 2. The positioning of this station is the latitude 22°34'46,15"N and the longitude 91°77'87.25"E.

iii. **Sampling station 3 (Cox's Bazar)**

Sampling Station 3 includes the area of the BFDC landing center, the coastal sites of the CVASU field station, and the adjacent coasts of Cox's Bazar. The geographical position of St3 is 21°44'53.36"N latitude and 91°97'35.1"E longitude. The stations are shown in Figure 1.

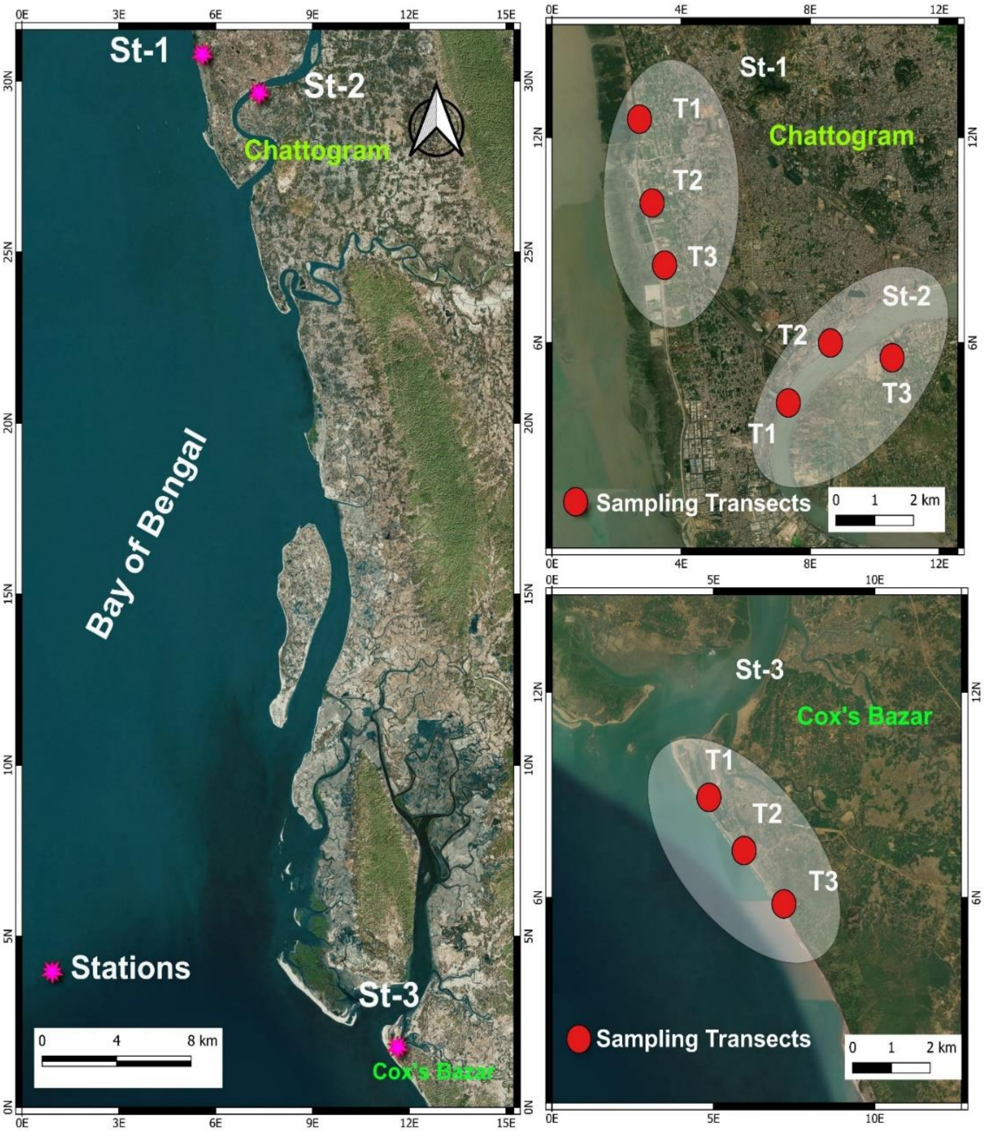


Figure 1: Geological location of the sampling area (St1: Patenga, Chattogram; St2: Kattoli coast, Chattogram; St 3: Cox's Bazar)

3.2 Working schedule

During the study period, a schedule was maintained for data collection as Table 1 and samples were collected from March (2019) to February (2020).

Table 1: Working schedule of whole thesis work

Activities	Feb’19	M	A	M	J	J	A	S	O	N	Dec’19	Jan’20	F
Laboratory Setup													
Sampling					BAN-								
Laboratory Analysis					PERIOD								

3.3 Sample collection

Mugil species were collected from the selected three stations by determining morphological characteristics.Sampling was done using the “Simple Random Sampling” method. At first, the larger size fish specimen with a new appearance and having all weighted in the Figure 2. At that point, the random specimen was gathered from the available fishes. The specimens consistently collected from all the inspecting stations. The samplings were done in each month maintaining the full moon cycle.

Figure 2: Working schedule of whole thesis work

3.4 Sampling frequency and sampling period

Sampling was started following the monthly pattern during February 2019 to complete the target of one year's sampling period, which ended in January 2020.Every month, sampling becomes performed from 3 stations, keeping full moon duration inside 1-2 days’ durations from one station to another. Samples were performed even at the same day of a month.

3.5 Sampling strategy

As known, Sampling was carried out according to the "Stratified Random Sampling" method. It is a probability sampling method in which the whole population is divided into equal groups to carry out the sampling process. Since then, the work has focused on the morphological aspect, and the big fish preferred it. However, sampling was not that way of finding a significant size. To avoid bias three related measurements were categorized into small, medium, and large sample sizes which were taken as a sample to represent the population. A total of 108 samples were taken from 3 stations during the sampling period. Finally, Samples were transported on an ice box to maintain the freshness of species.

3.6 Sample transportation

The collected specimens were shipped in the Oceanography Lab of Chattogram Veterinary and Animal Sciences University via preserving them in an icebox illustrated in Figure 3. In the icebox, the proportion of ice to the fish was 1:2. In any case, the proportion could be changed by circumstances, for example, temperatures, distance, gridlock, and so on (Aleman et al.1982).

Figure 3: Sample transportation from different stations to lab

3.7 Laboratory measurement

Laboratory assessment was carried out immediately after the end of sampling. The laboratory measurements were done in the Oceanography Laboratory under the Faculty of Fisheries of Chattogram Veterinary and Animal Sciences University as shown in Figure 4. This step had some segments.

a. Species of the specimen confirmed under a previous registration.
b. Measured the total weight of the specimen and also measuring the weight of the single specimen
c. Morphometric characteristics measured. The measured morphometric and meristic characteristics are enlisted in Table 2.
d. Counted meristic characters

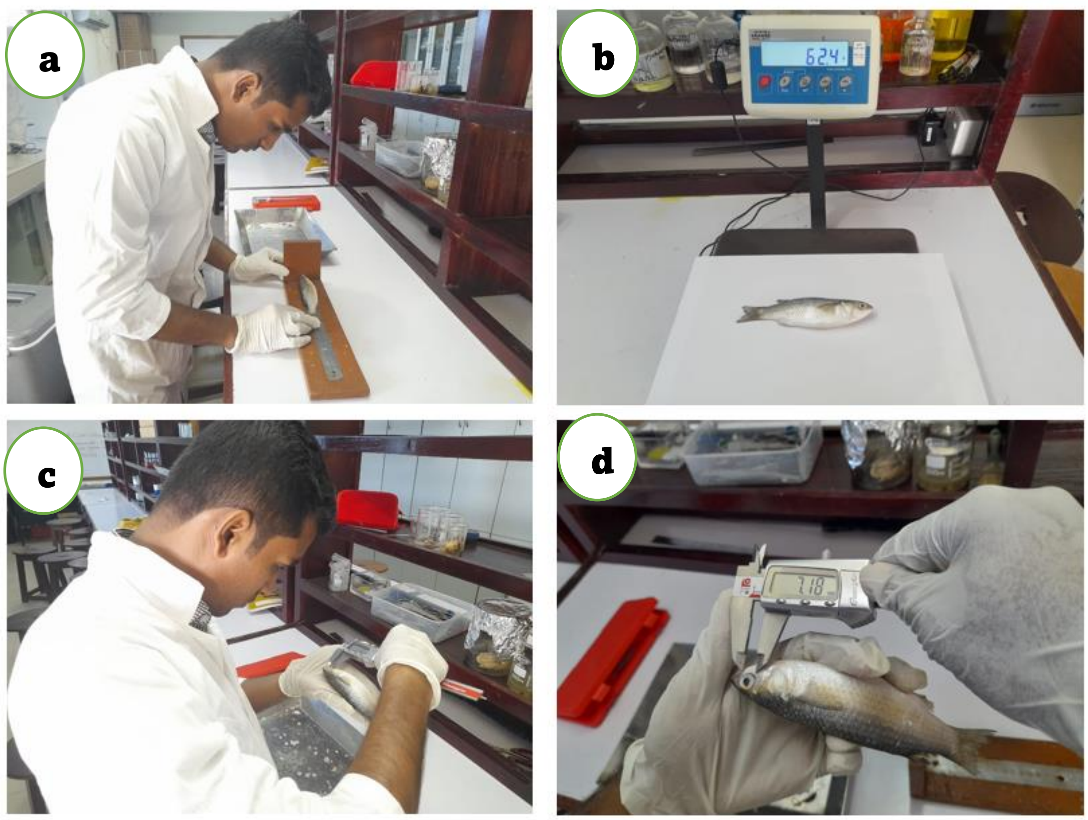


Figure 4 Collecting morphometric data in the laboratory

Also, the graphical representation of the morphometric and meristic characteristics were recorded during this study.

Table 2: Morphometric and meristic characters

Morphometric data		Meristic Data	
Pattern	**Length**	**Fin Rays**	**Scales**
Mouth Caudal fin	Total Length (TL) Standard Length (SL) Head Length (HL) Pre-orbital Length (PrOL) Pre-dorsal Length (PrDL) Pre-pectoral Length (PrPL) Pre-pelvic Length (PrVL) Pre-anal Length (PrAL) Body depth (BD)	Dorsal Fin (DF) Pectoral Fin (PF) Pelvic Fin (VF) Anal Fin (AF) Caudal Fin (CF)	On lateral line

3.8 Morphometric characters

Different morphometric and meristic characters were measured according to the international standards as shown in fig. 5. In addition, a regular scale (Fig. 06) and digital slide calipers (Fig. 07) used to measure the morphometric characters. The measured characteristics were as follows:

- **i.** Total length (TL) = Length of fish in centimeter from starting point of mouth to ending point of the tail.
- **ii.** Standard length (SL) = Length of fish in centimeter from the tip of the head to caudal peduncle.
- **iii.** Head length (HL) = Length of fish in centimeter from the very first point of head to the end of operculum.
- **iv.** Pre-orbital Length (PrOL) = Length of fish in centimeter from the very first point of head to the starting of eye border.

v. Pre-pectoral Length (PrPL) = Length of fish in centimeter from the very first point of head to starting of the pectoral fin base.

vi. Pre-pelvic Length (PrVL) = Length of fish in centimeter from the very first point of head to starting of the pelvic fin base.

vii. Pre-dorsal Length (PrDL) = Length of fish in centimeter from the very first point of head to starting of dorsal fin base.

viii. Pre-anal Length (PrAL) = Length of fish in centimeter from the first point of head to anal-fin base.

ix. Body depth = Maximum distance between dorsal and ventral portion of fish in centimeter.

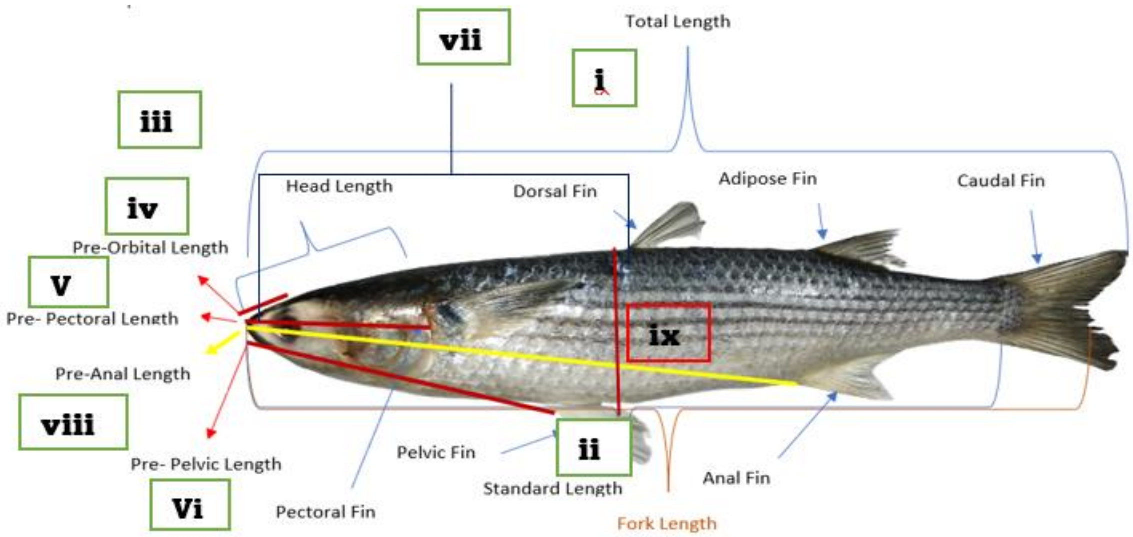


Figure 5 Morphometric and meristic characters measured

Figure 6 Normal manual scale used to measure length

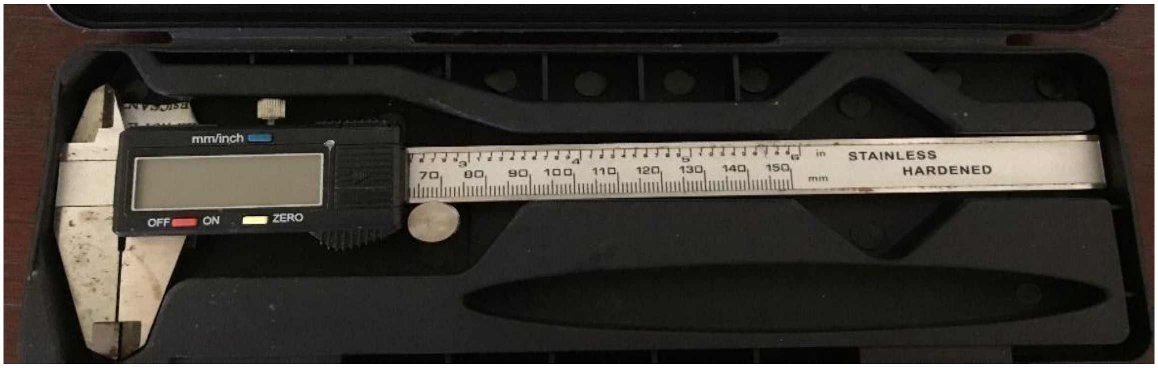


Figure 7 Digital slide calipers used to measure length

3.9 Species identification

Before data collection, species were confirmed by morphological characteristics from previous studies. Some distinct features of species played a very influential role in the identification of species. All these characters were observed from samples, and they showed similarities with the characters documented in work of Latifa *et al*. (2015) and Hossain (2013).

3.10 Formula of Shannon Diversity Index (SDI)

The Shannon Diversity Index calculated as $H = -\Sigma p_i * ln(p_i)$

Whereas,

- Σ: Sum
- *ln*: Natural log
- p_i: The proportion of the whole community made up of species *i*

CHAPTER FOUR
RESULT

This section of the thesis has illustrated the finding of this study. To reach the goal of the investigation, each piece of data was statistically analyzed step by step. In my study period, i identified four species which is *Mugil cephalus*, *Chelon parsia*, *Rhinomugil corsula* and *Liza subviridis.*

4.1 Identification of the Species

Mugil cephalus

English Name: Flathead mullet

Distinct Characters

- **i.** Body stout. Head broad and flattened.
- **ii.** Well-developed adipose eyelid covering most of pupil.
- **iii.** The back of the fish is olive-green, sides are silvery and shade to white towards the bell.

Habitats

freshwater; brackish; marine water

Geographical distribution

It is found in Indian Ocean from India to South Africa (Smith,2012). It is also found From Nova Scotia, Canada, south to Brazil, (Robins CR, 1986).

Fin Formula: D1 IV; D2 I 8; A III 8; P 15; V I 5

Figure 8 ***Mugil cephelus***

Chelon parsia

English name : Goldspot mullet

Bangla name: Bata and Parse

Distinct Characters

i. A golden spot-on operculum.
ii. Body slender with dorsally flattened head.
iii. The second dorsal, anal, and caudal fin bases are pale yellow

Habitats

It is one type of demersal and catadromous fish species which is found in freshwater, brackish water and marine water.

Geographical distribution

Bangladesh; India (including Andaman island), Pakistan and Srilanka (Talwar, 1991)

Fin Formula: D1. IV; D2. 1/8; P1. 14-15; P2. 1/5; A. 3/9

Figure 9 *Chelon parsia*

Rhinomugil corsula

English name: Corsula mullet

Bangla name: Khorsula, Bata, Khalla.

i. Body is sub-cylindrical in the anterior region and moderately compressed in posterior
ii. The Head is flat in above and compressed at sides.
iii. Mouth position is ventral and eye is elevated
iv. Body color is grayish brown on surface, lighter along the abdomen**.**

Habitats

Found in Rivers and estuaries throughout Bangladesh. (Rahman, 2005).

Geographical distribution

It may be found in the southern Asian countries of India, Bangladesh, Nepal, and Myanmar's rivers and estuaries (Rahman, 2005).

Figure 10 *Rhinomugil corsula*

Fin Formula: D1. IV, D2. I/7-8, P1.15-16, P2. I/5, A. 3/9.

Liza subviridis

English name: Greenback mullet

Bangla name: Bata and Bhangan bata

i. Dark greenish color on above and silvery below.

ii. Body robust, head wide, flattened dorsally.

iii. Bases of second dorsal, caudal and anal fins are extensively scaled

Habitats

Tidal rives near Khulna, Bangladesh (Rahman, 2005). It is found in lagoons, brackish waters and estuaries in India (Talwar,1991)

Geographical distribution

Indo-Pacific: Persian Gulf and Red Sea to Samoa, north to Japan, also collected at Natal, South Africa (Heemstra, 1995).

Fin Formula: D1. IV; D2. 1/8-9; P1. 15-16; P2. 1/5; A. 3/9

Figure 11 *Liza subviridis*

4.2 Species composition and abundance

This section displays data on the morphometric and meristic characteristics of the *mugil* species collected through monthly sampling. During the sampling period, 108 samples were taken from three different sampling stations. After examining and analyzing the collected specimens total 4 species were identified as the member of Mugilidae fish family. Among the 108 specimens 33% comprised by *Rhinomugil corsula*, 31% recognized as *Chelon parsia*, 22% as *Mugil cephalus* and others as *Liza subviridis* (Fig. 12).

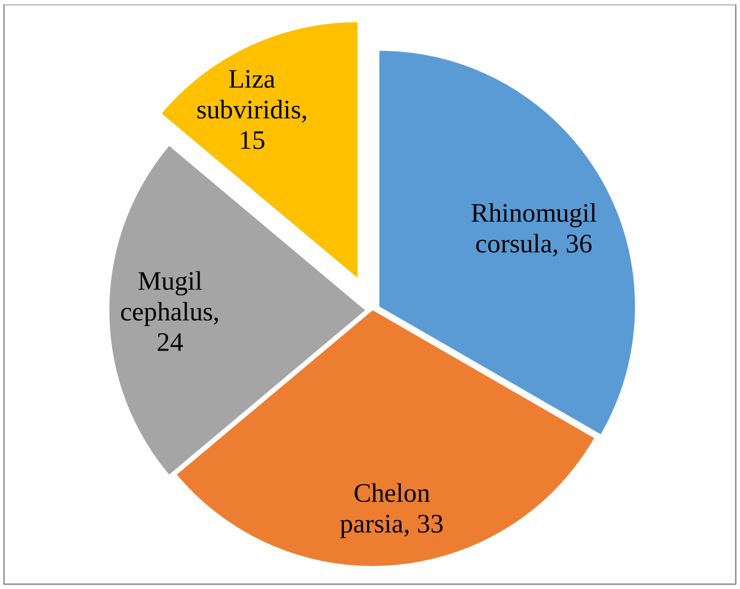


Figure 12 Percentage of collected specimens the total 4 species

4.3 Shannon Diversity Index (SDI)

The Shannon Diversity Index calculated as $H = -\Sigma p_i * \ln(p_i)$

The number of different species in a community increase as H goes up. The lower the value of H, the less diverse the population. A community with a H value of 0 has only one species. The total collected sample number in Chattogram is 65 and Cox's Bazar is 43. According to Shannon diversity index Chattogram calculated value is H=1.35091 which is greater than site-2 Cox's Bazar (1.31028) shown in table 3. Shannon diversity index clearly defined as Chattogram has greater species diversity than Cox's Bazar shown as table 3.

Table 3: Diversity Index

Site- 1	Species	Number	Pi	lnPi	Pi*lnPi	H
Chattogram	*Rhinomugil corsula*	21	0.32308	-1.1299	-0.365	-1.3509
	Chelon parsia	19	0.29231	-1.23	-0.3595	
	Mugil cephalus	15	0.23077	-1.4663	-0.3384	1.3509
	Liza subviridis	10	0.15385	-1.8718	-0.288	
	4 species	**Total =65**				

Site- 2	Species	Number	Pi	lnPi	Pi*lnPi	H
Cox's Bazar	*Rhinomugil corsula*	15	0.34884	-1.0532	-0.3674	-1.3103
	Chelon parsia	14	0.32558	-1.1221	-0.3653	
	Mugil cephalus	9	0.2093	-1.564	-0.3273	1.31028
	Liza subviridis	5	0.11628	-2.1518	-0.2502	
	4 species	**Total=43**				

4.4 Species availability

The availability of Mugilidae fish species in each month was shown in the figure 13. During the sampling period, four different fish species were collected in every month. Most species were found in every sampling month but in March *Liza subviridis* was missed. Among the identified species *Rhinomugil corsula* was the most dominant fish species because 36 indidividaul sample found during my study. Almost in every month, this investigation on different species of this group was conducted and specimens were collected for further analysis.

Table 4: Monthly species availability

MONTH / SPECIES	FEB	MAR	APR	MAY	AUG	SEP	OCT	NOV	DEC	JAN
Rhinomugil cephalus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chelon parsia	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mugil cephalus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Liza subviridis	✓	×	✓	✓	✓	✓	✓	✓	✓	✓

4.5 Intra-species variability

The relation and variation within single species were analyzed by the a) Fin formula b) Correlation and c) Linear regression. Fin formula revealed the unique criteria for every species. Correlation represented the associations between the measured parameters. Test result might show the higher correlation with insignificant value that could symbolize that the ratio of change would not be constant.

4.5.1 *Rhinomugil corsula*

All parameters of *Rhinomugil corsula* were correlated such as TL, SL, HL, PrOL, PrPL, PrVL, PrDL, PAL were correlated with all other parameters except BD.

Fin Formula: D1. IV, D2. I/7-8, P1.15-16, P2. I/5, A. 3/9.

Table 4: Correlation table for *Rhinomugil corsula*

Parameters	TL	SL	HL	PrOL	PrPL	PrVL	PrDL	PAL	BD
TL	1								
SL	.989**	1							
HL	.984**	.977**	1						
PrOL	.934**	.897**	.950**	1					
PrPL	.986**	.975**	.987**	.937**	1				
PrVL	.970**	.939**	.968**	.976**	.968**	1			
PrDL	.881**	.868**	.854**	.845**	.849**	.870**	1		
PAL	.806**	.781**	.775**	.744**	.775**	.781**	.923**	1	
BD	.536**	.442**	.478**	.579**	.544**	.588**	.453**	.440**	1

At the level of 0.01, correlation is meaningful. Here, TL= Total length, SL = Standard length, HL= Head lemgth, PrOL = Preorbital length, PrPL = Pre-pectoral length, PrVL = Pre- pelvic length, PrDL = Predorsal length, PrAL = Pre- anal length, BD = Body depth

4.5.2 *Chelon parsia*

Fin Formula – D1. IV; D2. 1/8; P1. 14-15; P2. 1/5; A. 3/9

Table 5: Correlation table for *Chelon parsia*

Correlations									
Parameters	TL	SL	HL	PrOL	PrPL	PrVL	PrDL	PAL	BD
TL	1								
SL	.987**	1							
HL	.969**	.942**	1						
PrOL	.944**	.924**	.960**	1					

PrPL	.949**	.907**	.987**	.938**	1				
PrVL	.916**	.871**	.971**	.914**	.987**	1			
PrDL	.768**	.691**	.819**	.694**	.856**	.872**	1		
PAL	.565**	.488**	.664**	.500**	.733**	.772**	.906**	1	
BD	.784**	.705**	.843**	.728**	.873**	.878**	.986**	.877**	1

Description- TL= Total length, SL = Standard length, HL= Head length, PrOL = Preorbital length, PrPL = Pre-pectoral length, PrVL = pre-pelvic length, PrDL = Predorsal length, PrAL = pre-anal length, BD = body depth.

Comment- SL and HL were significant correlation with other parameters.

4.5.3 Mugil cephalus

Fin Formula – D1 IV; D2 I 8; A III 8; P 15; V I 5

Table 6: Correlation table for *Mugil cephalus*

Correlations									
Parameters	TL	SL	HL	PrOL	PrPL	PrVL	PrDL	PAL	BD
TL	1								
SL	.976**	1							
HL	.900**	.888**	1						
PrOL	.885**	.881**	.927**	1					
PrPL	.866**	.841**	.948**	.839**	1				
PrVL	.826**	.796**	.901**	.783**	.967**	1			
PrDL	.900**	.906**	.694**	.744**	.610**	.587**	1		
PAL	.972**	.967**	.893**	.842**	.872**	.853**	.910**	1	
BD	.955**	.925**	.940**	.928**	.900**	.841**	.767**	.892**	1

Description- TL= Total length, SL = Standard length, HL= Head length, PrOL = Preorbital length, PrPL = Pre-pectoral length, PrVL = pre-pelvic length, PrDL = Predorsal length, PrAL = pre-anal length, BD = body depth.

Comment -SL significantly correlated with other parameters.

4.5.4 *Liza subviridis*

Fin Formula – D1. IV; D2. 1/8-9; P1. 15-16; P2. 1/5; A. 3/9

Table 7: Correlation table for *Liza subviridis*

Correlations									
Parameters	TL	SL	HL	PrOL	PrPL	PrVL	PrDL	PAL	BD
TL	1								
SL	.990**	1							
HL	.984**	.967**	1						
PrOL	.963**	.954**	.975**	1					
PrPL	.965**	.972**	.943**	.961**	1				
PrVL	.949**	.964**	.934**	.927**	.948**	1			
PrDL	.921**	.939**	.906**	.910**	.960**	.959**	1		
PAL	.888**	.921**	.847**	.836**	.930**	.960**	.950**	1	
BD	.918**	.948**	.868**	.890**	.958**	.957**	.949**	.960**	1

Description- TL= Total length, SL = Standard length, HL= Head lemgth, PrOL = Preorbital length, PrPL = Pre-pectoral length, PrVL = Pre- pelvic length, PrDL = Predorsal length, PrAL = Pre- anal length, BD = body depth.

Comment -SL significantly correlated with other parameters except pre-anal length.

4.5.5 Morphometric characteristics

In this section the length ratio of others was compared to the overall length. At first, the study has determined the average length then calculated the percentage of each length against the total length of *Rhinomugil corsula*, *Chelon parsia*, *Mugil cephalus* and *Liza subviridis* which shown in the Figure 14.

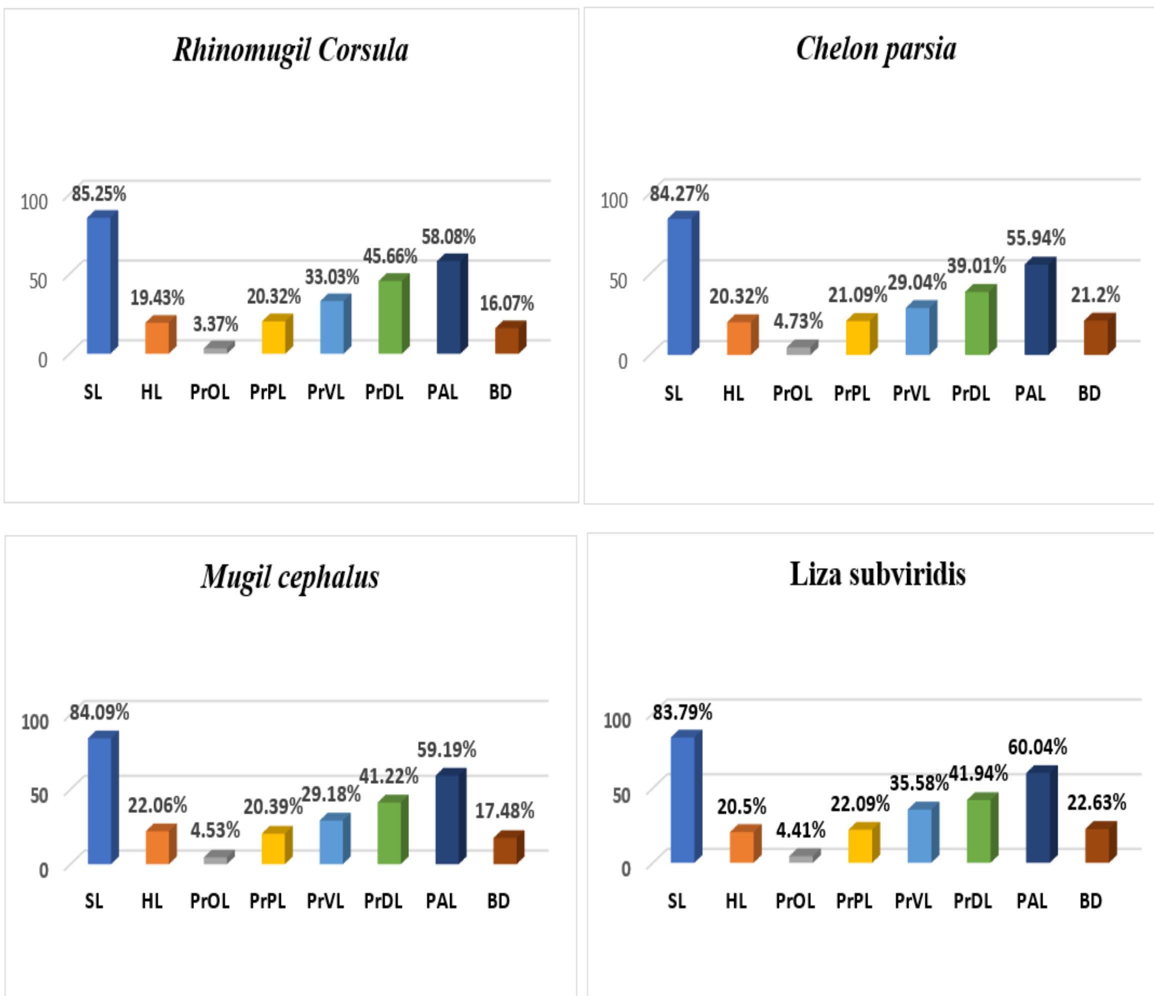
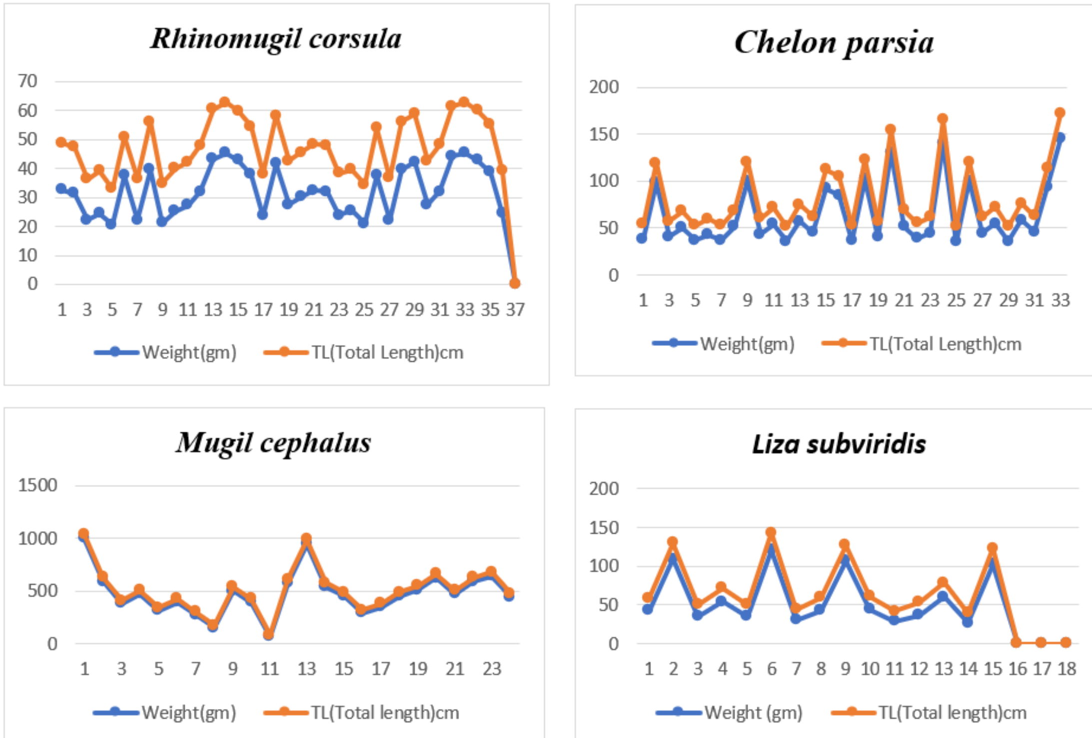


Figure 13 Ratio of different length with total length



. **Figure 15 Relation between total length and body weight**

In other case on the experiment, relation between total length and body weight are depicted in Figure 15. For *Mugil cephalus*, Total length and weights are quite similar, also *Liza subviridis* weights are close to total length. On the contrary, TL and weights varies in *Rhinomugil corsula.*

4.5.6 Regression

Regression showed how changes in one definite parameter impact other definite parameters, as well as how changes in one specified factor affect other dependent variables or factors. Regression is a straightforward method for demonstrating the relationship between two variables.. A correlation was shown between various morphometric measurements and total length. The linear relationship between the total length and the standard length (SL) in the graph showed that R^2 = 0.978 (Figure 16).The linear relationship with total length predicted 97.8 percent, 96.8 percent, 87.3 percent, 77.6 percent, 98.6 percent, 94.4 percent, 53.6 percent, and 77.8 percent of the standard length, head length, pre-orbital length, pre-dorsal length, pre-pelvic length, pre-anal length, and weight. The regression line of total length explained the majority of the morphometric characteristics.

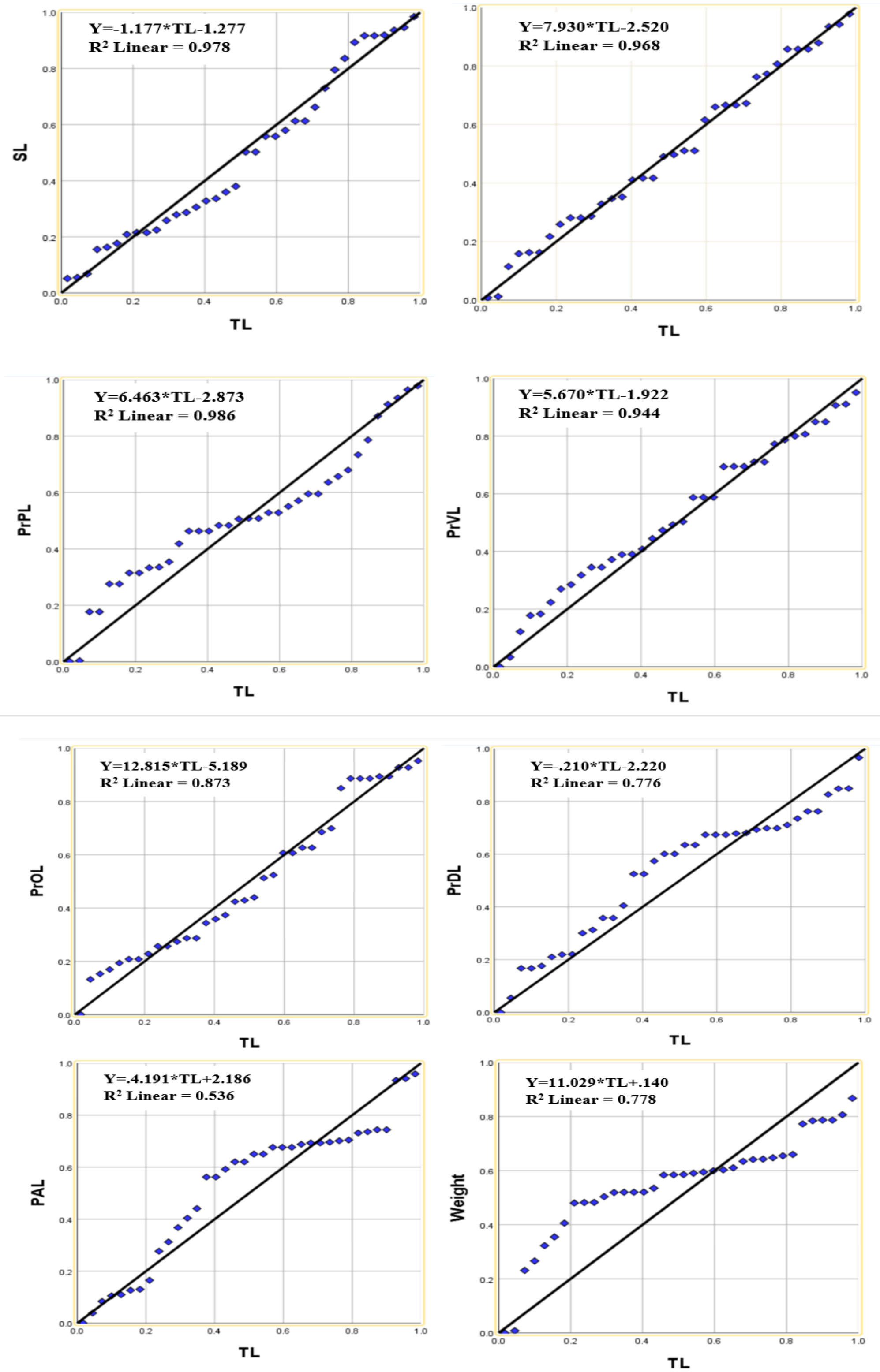


Figure 16 Regression line of length on total length (TL= Total length, SL = Standard length, HL= Head length, PrOL = Pre-orbital length, PrPL = Pre-pectoral length, PrVL = pre-pelvic length, PrDL = Pre-dorsal length, PrAL = pre-anal length).

4.6 Inter-species relation and variation

The independent sample T-test were used to determine the inter-species relationship and variance. To see if there was a difference in the mean of several parameters between two separate species groups, an Independent T-test was used. Because it was the most abundant species, Mugilidae was found in every comparison group.

Independent T-test -analysis illustrated that all parameters showed a significant difference between mean in the case of *Rhinomugil corsula, Chelon parsia and Mugil cephalus*. So, it could be suggested that species *Liza subviridis* were not related species. But the mean difference of *Liza subviridis* less significant. Here, HL, PrPL, PrVL, PAL, PrDL revealed a significant difference in the case of *Rhinomugil corsula.* But *Chelon parsia* and *Mugil cephalus* also showed the difference in HL, SL, PrDL, PrOL (Table 8).

Table 8: Table for T-test between species group

Species	Parameters	T-test	Sig (p<0.05)	Mean difference
Rhinomugil corsula	**TL**	71.169	.000	15.5389
	SL	77.422	.000	13.0917
	HL	35.420	.000	3.0194
	PrOL	13.354	.000	.5250
	PrPL	42.171	.000	3.1583
	PrVL	46.584	.000	5.1333
	PrDL	81.881	.000	7.0944
	PAL	112.095	.000	9.0250
	BD	38.688	.000	2.4972
	TL	39.611	.000	18.3788
	SL	33.336	.000	15.4879
	HL	44.053	.000	3.7364
	PrOL	18.759	.000	.8697

Chelon parsia	**PrPL**	53.701	.000	3.8758
	PrVL	55.863	.000	5.3364
	PrDL	44.715	.000	7.1697
	PAL	48.909	.000	10.2818
	BD	55.165	.000	3.8970
Mugil cephalus	**TL**	30.504	.000	35.2958
	SL	29.547	.000	29.6833
	HL	19.146	.000	7.7875
	PrOL	16.422	.000	1.6000
	PrPL	33.833	.000	7.1958
	PrVL	45.442	.000	10.3000
	PrDL	35.895	.000	14.5500
	PAL	31.279	.000	20.8917
	BD	27.692	.000	6.1708
Liza subviridis	**TL**	23.020	.000	17.2000
	SL	21.781	.000	14.4133
	HL	21.13	.000	3.5267
	PrOL	9.528	.000	.7600
	PrPL	27.672	.000	3.8000
	PrVL	17.722	.000	6.1200
	PrDL	25.221	.000	7.2133
	PAL	28.086	.000	10.3267
	BD	25.727	.000	3.8933

4.7 Meristic counts

The value of the meristic counts in this investigation is almost similar to the previous research findings. Meristic numbers can be adjusted based on genetics, environmental factors, and geological distance. There were no variations observed in the case. All meristic counts data was collected to construct the fin formula, which was the most reasonable technique to determine any species. Here, meristic counts of species were compiled in a plotted format to rapidly evaluate the characteristics of fish (Table 9).

Table 9: Table for the meristic count for all available species

Meristic counts and Abbreviation	***Rhinomugil corsula***	***Chelon parsia***	***Mugil cephalus***	***Liza subviridis***
Scale in lateral line	48-52	31-36	36-42	27-32
Spine on dorsal fin 1	IV	IV	IV	IV
Spine on dorsal fin 2	I	I	I	I
Dorsal Fin Ray2	7-8	8	8	8-9
Pectoral fin ray	15-16	14-15	15	15-16
Spine on Pelvic fin1	I	I	I	I
Pelvic fin ray	5	5	5	5
Spine on Anal fin	3	3	3	3
Anal Fin Ray (AFR)	9	9	8	9

The result was the core section of the study. As the part of the findings, the result part showed that there were both similarities and dissimilarities among the species. But some were closely related species.

4.8 Univariate analysis (ANOVA)

Analysis of variance is used to determine the influence that independent variables have on the dependent variables in the study. It also gain information about the relationship between independent and dependent variables.In this table i found p value which is greater than 0.05 is clearly indicate that the difference between various morphological trait TL,SL,HL,PrOL,PrPL,PrVL,PrDL,PAL,BD is non-significant. It means there is no statistically significant difference between the morphological trait.

Table 10: Statistics (ANOVA) on *Chelon parsia* samples comprised of nine morphometric data from three distinct environments. The significance level was shown as *p>0.05.

Morphometric characters	F	df1	df2	Sig.
TL	0.44	2	33	0.646
SL	0.312	2	33	0.734
HL	0.510	2	33	0.605
PrOL	0.624	2	33	0.542
PrPL	0.705	2	33	0.501
PrVL	0.595	2	33	0.557
PrDL	0.104	2	33	0.902
PAL	0.030	2	33	0.971
BD	2.381	2	33	0.108

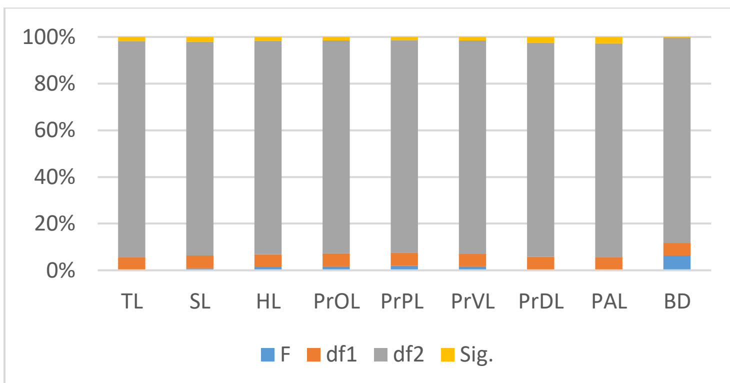


Figure 14 Statistical analysis report using univariate statistics (ANOVA)

There were two distinct sets of discriminant functions for morphometric measures (DF1 and DF2). Pre-anal (PAL) and pre-dorsal length measurements contributed to the first discriminant function, while the remaining six [pre orbital (PrOL), pre-pelvic (PrVL), head (HL), standard length (SL), and total length (TL)] measurements contributed to the second discriminant function, according to the pooled within-groups correlations between discriminating variables and discriminant functions (Table 10).

4.9 Principal Component Analysis (PCA)

Principal component analysis was used to identify the most important characteristics (morphometric and meristic measurements). Characters that were incredibly meaningful (p>0.05) in this study were considered for principal component analysis (PCA). In our current study, only elements with loading condition greater than 0.5 were considered as significant.

The eigenvalues of the first three principal components (PC1) were greater than one. These three variables accounted for 83.17 percent of the variation in the data. The scree plot revealed that after the third principal component, the eigenvalues began to form a straight line. Because 83.17 percent of the variation in the data was adequately explained, the first three principal components had used Figure 17.

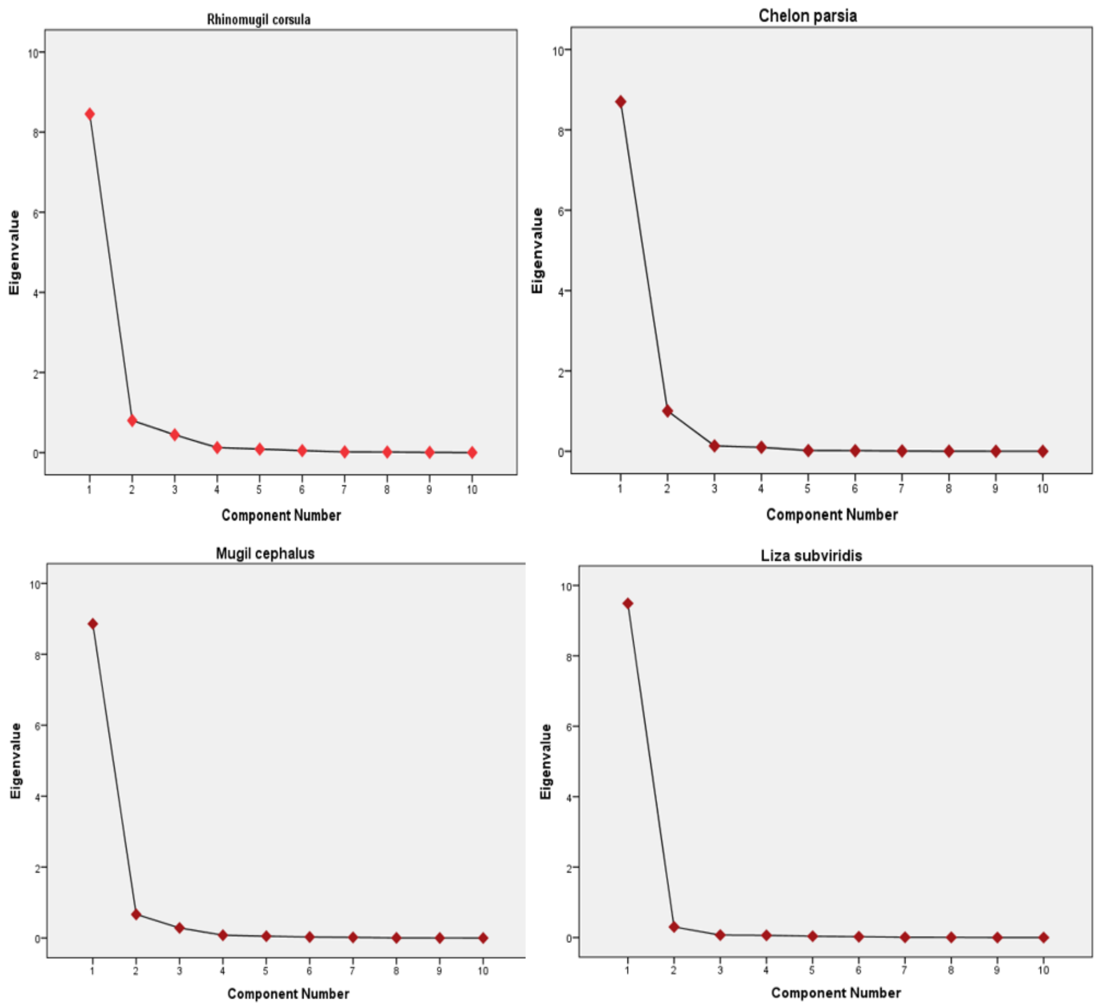


Figure 15 Scree plot for the first principal components

Table 11: Component Matrix

Parameters	*Rhinomugil corsula*	*Chelon parsia*	*Mugil cephalus*	*Liza subviridis*
	PC1	PC1	PC1	PC1
Weight (gm)	.921	.985	.967	.993
TL (Total Length) cm	.986	.957	.976	.979
SL (Standard Length) cm	.959	.917	.966	.989
HL (Head length) cm	.974	.984	.966	.961
PrOL (Pre-Orbital length) cm	.962	.922	.936	.959
PrPL (Pre-Pectoral length) cm	.979	.990	.933	.987
PrVL(Pre-pelvic length) cm	.984	.981	.895	.984
PrDL(Pre-Dorsal length) cm	.910	.899	.830	.972
PrAL(Pre-Anal length)	.845	.761	.964	.951
BD(Body depth) cm	.610	.909	.969	.967

The first principal component (PC1) was strongly correlated with nine of the original variables. The first principal component (PC1) for *Rhinomugil corsula* increased with increasing head length, total length, standard length, pre-dorsal length, pre-pelvic length, pre-pectoral length, weight, pre-anal length, pre-orbital length scores (0.97, 0.986, 0.95, 0.91, 0.98, 0.97, 0.92, 0.84 and 0.96 respectively). This suggests that these nine criteria of morphometric measurements varied together. If one increased, then the remaining ones tend to increase as well. Furthermore, the first principal component correlated most strongly with the total length, pre-pelvic length and pre-pectoral length (0.98) (Table 11). PCA1 score for *Chelon parsia*, head length, total length, standard length, pre-dorsal length, pre-pelvic length, pre-pectoral length, weight, pre-anal length, pre-orbital length scores (0.984, 0.957, 0.917, 0.899, 0.981, 0.99, 0.985, 0.76 and 0.922 respectively.

CHAPTER FIVE

DISCUSSION

It is possible to identify fish populations using morphometric and meristic investigations since fish have a wide range of phenotypic characteristics (Hossain et al. 2010; Ihssen et al. 1981). Using morphometric and meristic characteristics, this research has investigated the possibility of differentiating *Mugilidae* gathered from Bangladesh's Chattogram coast. Analysis of Variance (ANOVA), Discriminant Function Analysis, and Principal Components Analysis (PCA) were employed in this experiment to identify the differences.

5.1 Variation of meristic counts

The fin formula found in *Rhinomugil corsula* was D1. IV, D2. I/7-8, P1.15-16, P2. I/5, A. 3/9 during my sampling period where other researcher findings were D1. 4, D2. 1/7-8, P1. 15, P2. 1/5, A. 3/9 (Shafi and Quddus, 1982) and D1. IV, D2. 1/7-8, P1. 15-16, P2. 1/5, A. 3/9 (Rahman, 2005) and also D1. IV, D2. I 8, P1. 16, P2. I/5, A. III 9 (Talwar and Jhingran, 1991). There is no difference in fin formula between my study observation and other researcher findings of *Rhinomugil corsula*

In *Chelon parsia's* fin formula observed in my study period was D1. IV; D2. 1/8; P1. 14-15; P2. 1/5; A. 3/9; these were almost the same as the represented fin formula D1. IV; D2. 1/8; P1. 15; P2. 1/5; A. 3/9 (Rahman, 1989 and 2005) and D1 IV; D2 I 8; A III 9; P 14; V I 5 (Talwar and Jhingran, 1991). The present investigation demonstrated the fin formula of species *Mugil cephalus* were D1 IV; D2 I 8; A III 8; P 15; V I 5 but other studies recorded fin formula were D1. IV; D2. 1/8; P1. 15; A. III/8; C. 15 (Rahman, 2005) and D1 IV; D2 I 8; A III 8; P 15; V I 5 (Talwar and Jhingran, 1991).there is no significant variations in meristic counts of *Mugil cephalus*. The present study noticed fin formulas in *Liza subviridis* D1. IV; D2. 1/8-9; P1. 15-16; P2. 1/5; A. 3/9; Compared to fin formula observed almost the same as revealed by (Rahman, 1989 and 2005) D1. IV; D2. 1/8-9; P1. 15-16; P2. 1/5; A. 3/9 and (Talwar and Jhingran, 1991). D1 IV; D2 I 8-9; A III 9; P 16; V I 5. Although no significant variations in meristic counts were reported among Mugilidae populations from three locations, significant morphometric differences were discovered. Meristic features such as dorsal, pectoral, pelvic, and anal fins of the population did not show any significant differences in the current study. These findings suggest that ecological variations have little bearing on these meristic traits.

Konan (2014) conducted a study on univariate and multivariate analysis on three distinct groups of 40 metrics and 11 meristic characters. In the genus Mugil, phenotypic plasticity resulted in the discovery of three new species: *Mugil curema, M. bananensis,* and *M. cephalus.* When compared to the interaction of morphometric factors, meristic features such as the number of branchiospines on the superior and inferior sections and the number of microbranchiospines on the first branchial arch clearly distinguished between species. In another study, In terms of morphometric and landmark data, the initial discriminant functions (DF) explained 89.8% and 83.33% of the variance, respectively while the second DF explained 10.2 percent and 16.7 percent including amongst group differences, respectively, having to explain 100 percent of number among group variations (Hossain et Al. 2015). The well-separated stock groupings were not revealed by plotting discriminant functions for morphometric and truss network measures. According to another study (Sultana et al. 2013), the species' diet is omnivorous. The hepatosomatic and alimentosomatic indices had higher mean values, indicating greater liver activity and eating intensity.

5.2 Variation of morphometric counts

Correlations between nine morphometric characters were found to be equal to one in the main diagonal (cells TL vs Wt, TL vs FL, TL vs HL, PrOL vs TL, PrDL vs TL, PrPL vs TL, PrVL vs TL, PAL vs PrPL, and BD vs TL). The Pearson correlation coefficient between morphometric measurements had a statistically significant linear relationship. For example (*Rhinomugil corsula),* Weight had a statistically significant linear relationship with other morphometric characters (standard length, head length, pre-orbital length, pre-pectoral length, pre-pelvic length, pre-dorsal,pre-anal length and body depth moderately related and pre-orbital length) ($r=0.98, 0.98, 0.93, 0.98, 0.97, 0.88, 0.80, 0.53$, and $p < 0.01$). The relationship was positive, indicating that these variables tend to increase together (i.e., greater weight was associated with greater total length). The strongest correlation was found between cells TL and SL, TL and HL, and TL and PrPL, with r = 0.98 and a 2-tailed significance with p = 0.01

Murugan, (2012) conducted a study on *Mugil cephalus* in the Vellar estuary extensively from January 2004 to December 2005. The regression coefficient 'b' and 'a' tests were performed to compare male and female b values from a theoretical value of 3. t = -2.8586; 0.05 differentiates the b value of the mean (2.7658) from the hypothetical value of 3 significantly, but that of the female (2.8586) does not. A negative allometry development trend was evident in both male and female values.

ANOVA revealed that only pre-pelvic length (PrPL) was noticeably dissimilar in p=0.05 degrees among four population subgroups based on nine morphometric measurements (Zubia at el. 2015). Because of their close geographical proximity, the morphological differences between *Liza subviridis* populations were insignificant. Morphological characteristics are well renowned to be sufficient to inhibit in response to environmental factors. It is possible that these habitats' varied environmental circumstances may be at the basis of morphological difference across populations from various venues. A study was carried out (Renjini, 2011) Morphometric measurements and meristic counts were taken of various body parts. Meristic counts do not change as body length increases. As a result of the study, it was possible to conclude that *Liza parsia* grew well in the Cochin estuary.

In comparison to practically any other vertebrate, fish have a wide range of morphological variation within and across populations and are more vulnerable to environmental-induced morphological change (Allendorf, 1988). Because fish have high phenotypic plasticity, people alter their physiological changes and behavior in order to easily adapt to the changing environment, which overall alters their morphology (Stearns et al., 1983). As a result, analyzing only gross morphometric and meristic characteristics may make minor morphological variations in fish caused by minimal environmental differences unimaginable to discover. Discriminant function analysis (DFA) could be a useful method for focusing on different stocks from same species, which could be useful in effective inventory management initiatives (Karakousis et al. 1991). This discrimination was ensured by canonical discriminant functions, which examined the pictorial analysis for each specimen. In the case of morphometric characters, both discriminant function analysis (DFA) and canonical discriminant functions suggested that the populations of Mugilidae have a lower degree of phenotypic distinction in the three stations. Based on morphometric measurements, canonical discriminant functions suggested that Mugilidae populations were similar to fish samples from three different stations. This inter-population similarity could be attributed to a shared geographical location (Allendorf, 1988) One hundred percent of the participants were accurately categorized in a discriminant function analysis (Khayyami, 2015).

5.3 Identification of principal components analysis

The morphometric characteristics were considered to principal component analysis (PCA). Principal component analysis was done on characteristics that were highly significant p=0.05 in this study (PCA). The data's appropriateness for PCA was assessed using Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) assessment. The Bartlett's Sphericity studies assumed that the correlation matrix values were zero, and the Kmo value investigated whether the selective correlation between variables was reasonably strong (Yakubu et al. 2011).

In case, there were more than one eigen values in the PC1's first three components. The data was influenced by several factors. The scree plot demonstrated that the eigenvalues began to form a straight line after the third primary component. PCA1 score for *Mugil cephalus* head length, total length, standard length, pre-dorsal length, pre-pelvic length, pre-pectoral length, weight, pre-anal length, pre-orbital length scores (0.966, 0.976, 0.966, 0.830, 0.895, 0.933, 0.967, 0.964 and 0.936 respectively). In morphological studies principal component analysis is used for reducing morphometric data (Mir et al. 2013) and for minimizing the repetition between the variables (Samaee et al. 2006).

This data clearly demonstrated that there were significant differences between these components where PC1 consisted of morphometric measurements. In the latest study, it was shown that all of these level traits might be utilized as useful tools in determining how these fishes are related.

CHAPTER SIX

CONCLUSIONS

Bangladesh is fortunate to be a riverine country with rich inland and capture fisheries and huge aquaculture potential. Bangladesh's geographical location in the region is suitable along with many aquatic species which provide excellent opportunities to support fisheries potential and resource management. However, overfishing, habitat degradation, contamination, agrochemicals, introduction of foreign species, lower fertility, and other factors are putting this region in jeopardy. To meet the demands of its growing population, efficient and effective stock management is much needed.

Study on the morphological characters in fish is considered as an important tool as it can be used to differentiate the taxonomic units and are able to determine variations among the populations. Morphological systematics is the easiest and fastest method of fish identification which includes the morphometric and meristic characters. The present morphological study confirmed the identification of four species of *Mugilidae* family in the Chattogram coastal region. It was observed that there were such no variations in meristic characters. From data set it might be concluded that *Rhinomugil corsula* was the mostly found species and *Liza subviridis* found less frequently. From tests it could be summarized that species within species showed significant correlation. So, there were some closely related species. The study's findings will be used as primary information for stock management, enabling for strong management processes for specific Mugilidae populations to ensure the long-term viability of the fishery and the development of appropriate protection measures in near future. These findings will also be useful to fisheries, scientists, and taxonomists who are interested in these fascinating fish species. As an experiment created path for further research, this study might work as basic data source for the further study on the fish of mugilidae family.

CHAPTER SEVEN

RECOMMENDATIONS AND FUTURE PERSPECTIVES

The use of morphological features as benchmark data appears promising in this domain since the identification of populations and their availability amongst each other is a critical point for long-term species development and preservation. The current study examines the cost of basic data on the variation of Mugilidae populaces in diverse Bangladeshi waterways, and it concludes that the use of morphometric features and support estimations produces reliable data for Mugilidae stock separation.

Despite this, there were a few roadblocks in the present investigation involving a fixed number of people and populations. The results of the current inquiry may usually be used as a starting point for further research with more cases, as well as for greater explanation and modification. Finally, for the survival of the Mugilidae species in Bangladesh, the following focuses should be addressed.

a) More people from different places may be involved in a systematic inquiry.
b) Work at the DNA level (RAPD, RFLP, microsatellite, and so on) may lead to a better understanding and compliance of genetic variation.
c) Breeding ground of Mugilidae species ought to be secured.
d) Mugilidae sperm cryopreservation should be pursued more closely for both preservation and hydroponics.
e) Finally, legitimate preservation plans ought to be formed.

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APPENDICES

Appendix- I: Regression table for *Rhinomugil corsula*

Parameters	a	b	R	R^2	Y=aX+b
Standard length	-1.177	1.277	0.989	0.978	Y=-1.177*TL-1.277
Head length	7.930	2.520	0.984	0.968	Y=7.930*TL-2.520
Pre-orbital length	12.815	5.189	0.934	0.873	Y=12.815*TL-5.189
Pre-pectoral length	6.463	2.873	0.986	0.972	Y=6.463*TL-2.873
Pre-pelvic length	5.670	1.922	0.970	0.9441	Y=5.670*TL-1.922
Pre-dorsal length	-.210	2.220	0.881	0.776	Y=-.210*TL-2.220
Pre-anal length	-.4.191	2.186	0.806	0.650	Y=-.4.191*TL+2.186
Body depth	11.013	1.812	0.536	0.287	Y=11.013*TL+1.812
Weight	11.029	.140	0.822	0.778	Y=11.029*TL+.140

Appendix- I I: Regression table for *Chelon parsia*

Parameters	a	b	R	R^2	Y=aX+b
Standard length	3.119	.985	0.987	0.973	Y=3.119*TL-.985
Head length	-1.426	5.301	0.969	0.937	Y=-1.426*TL-5.301
Pre-orbital length	10.160	9.450	0.944	0.892	Y=10.160*TL-9.450
Pre-pectoral length	-5.263	6.100	0.949	0.897	Y=-5.263*TL-6.100
Pre-pelvic length	-5.365	4.449	0.916	0.839	Y=-5.365*TL-4.449
Pre-dorsal length	2.442	2.223	0.768	0.590	Y=2.442 *TL-2.223
Pre-anal length	5.546	1.248	0.565	0.320	Y=5.546*TL+1.248
Body depth	-1.682	5.148	0.784	0.602	Y=-1.682*TL+5.148
Weight	13.260	.080	0.986	0.972	Y=13.260*TL+.080

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Appendix III: Regression table for *Mugil cephalus*

Parameters	a	b	R	R^2	Y=aX+b
Standard length	1.934	1.124	0.976	0.952	Y=1.934*TL-1.124
Head length	15.353	2.561	0.900	0.810	Y=15.353*TL-2.561
Pre-orbital length	18.487	10.506	0.885	0.783	Y=18.487*TL-10.506
Pre-pectoral length	1.380	4.713	0.866	0.751	Y=1.380*TL-4.713
Pre-pelvic length	-8.149	4.218	0.826	0.683	Y=-8.149*TL-4.218
Pre-dorsal length	-2.009	2.570	0.900	0.811	Y=-2.009 *TL-2.570
Pre-anal length	0.128	1.683	0.972	0.944	Y=0.128*TL+1.683
Body depth	4.683	4.961	0.955	0.913	Y=4.683*TL+4.961
Weight	23.648	.025	0.905	0.820	Y=23.648*TL+.025

Appendix IV: Regression table for *Liza subviridis*

Parameters	a	b	R	R^2	Y=aX+b
Standard length	1.093	1.117	0.990	0.979	Y=1.093*TL-1.117
Head length	1.663	4.406	0.984	0.968	Y=1.663*TL-4.406
Pre-orbital length	10.345	9.019	0.963	0.928	Y=10.345*TL-9.019
Pre-pectoral length	-2.750	5.250	0.965	0.931	Y=-2.750*TL-5.250
Pre-pelvic length	4.693	2.052	0.949	0.900	Y=4.693*TL-2.052
Pre-dorsal length	-.160	2.407	0.921	0.849	Y=-.160*TL-2.407
Pre-anal length	-1.428	1.804	0.888	0.788	Y=2.407*TL+1.804
Body depth	-.456	4.535	0.918	0.844	Y=-.456*TL+4.535
Weight	12.389	.083	0.956	0.914	Y=12.389*TL+0.956

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