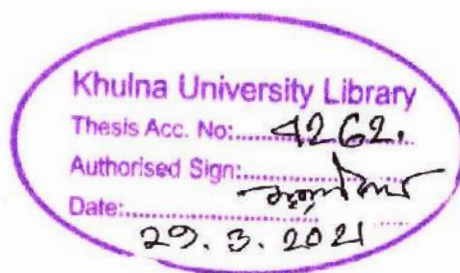


**Landmark-based morphometric and meristic
variations of mola (*Amblypharyngodon mola*) in
different stocks of ox-bow lake**

Md. Hasib Rana

Student ID: MS-190609



**Fisheries and Marine Resource Technology Discipline
Khulna University, Khulna
Bangladesh**

December, 2019

**Landmark-based morphometric and meristic
variations of mola (*Amblypharyngodon mola*) in
different stocks of ox-bow lake**

A Thesis

By

Md. Hasib Rana

Student ID: MS-190609

Session: 2019-2020

A thesis submitted to the Fisheries and Marine Resource Technology Discipline, Khulna
University, Khulna, in partial fulfillment of the requirements for the degree

of

Masters of Science (MSc)

in

Fish Processing and Quality Control

December, 2019

**Landmark-based morphometric and meristic
variations of mola (*Amblypharyngodon mola*) in
different stocks of ox-bow lake**

Approved as to style and content by



Professor Dr. Muhammad Abdur Rouf

Head

Fisheries and Marine Resource Technology Discipline

Khulna University

Khulna-9208, Bangladesh

December, 2019

DECLARATION

The results submitted in this thesis with the above mentioned title are entirely of the candidate's own investigations and no part of the results has been accepted for any degree nor is it concurrently submitted for any degree.

Hasib 16.02.20

(Signature of the Candidate)

Md. Hasib Rana

Student ID: **MS-190609**

Session: **2019-2020**



 16.02.20

(Signature of the Supervisor)

Dr. Md. Golam Sarower

Professor

Fisheries and Marine Resource Technology Discipline

Khulna University, Khulna

Bangladesh

December, 2019

**DEDICATED TO
MY
BELOVED PARENTS**

Acknowledgement

At first, all my admiration goes to Almighty, the supreme creator and ruler of the universe, whose mercy keeps me alive and enables me to pursue my education in Fisheries and Marine Resource Technology Discipline and to complete thesis for the degree of masters of Science in Fisheries (Fish Processing and Quality Control).

I would like to express my unfettered gratitude, sincere appreciation and profound respect to my honorable teacher **Mohammad Yousuf Ali**, and my supervisor **Dr. Md. Golam Sarower** Professor, Fisheries and Marine Resource Technology Discipline, Khulna University, for their scholastic guidance, constant inspiration, valuable advice and constructive criticism for the successful completion of the investigation and writing up this thesis. I am really grateful to him for introducing me to the field of evolutionary biology; his skill and compassion as a teacher are unsurpassed.

I am especially thankful to Md. Salauddin, Md. Abdus Salam, Soma Kundu, Fatema-Tuj-Johra & Asif Rana for their effective help and cordial co-operation and suggestion throughout my research work.

Finally, I express my deepest sense of gratitude to my beloved parents for their immeasurable blessing, continuous inspiration and financial support throughout the study.

Md. Hasib Rana

Khulna University

December, 2019

Landmark-based morphometric and meristic variations of mola (*Amblypharyngodon mola*) in different stocks of ox-bow lake

Abstract

The present study was carried out in three different isolated ox-bow lakes of Baluhar, Marufdah, Joydia to analyse landmark-based morphometric measurements and meristic counts of a small indigenous species (SIS), *Amblypharyngodon mola*. A total of 90 samples were collected where the range of length was 47.83 to 73.63 mm and the weight range was 3.36-0.96 g. The main aim of this experiment was to evaluate the population status and to identify the variation among the stocks. Eleven morphometric characters and ten truss distances were measured. Nine morphometric characters namely pre-anal length (PAL), pre-pelvic length (PEL), pre-pectoral length (PEC), fork length (FL), maximum body height (MBH), lowest body height (LBH), head length (HL), eye diameter (ED) and pre-orbital length (POL) were found to be significantly different ($p < 0.05$). Nine truss distances namely dst 1-2, dst 1-5, dst 1-6, dst 2-3, dst 2-5, dst 2-6, dst 3-6, dst 4-5 and dst 5-6 showed difference significantly ($p < 0.05$). Conversely, standard length (SL), pre-dorsal length (PDL), dst 3-4 and any of meristic counts did not show significant difference among the stocks ($p > 0.05$). The variation between the stocks occurred due to either environmental changes or genetic variation among the stocks. As meristic data did not show significant difference, environmental factors had more effect than genetical factors. This study is a preliminary step to identify the changes among the stocks of three ox-bow lakes, which can be a significant reference for formulating further management action plans.

Table of Contents

Chapter	Title	Page no.
Chapter-1	Introduction.....	1-3
	1.1. Background of the study.....	1-3
	1.2. Objective.....	3
Chapter-2	Review of Literature.....	4-8
Chapter-3	Materials and Methods.....	9-12
	3.1. Fish collection.....	9
	3.2. Measurements of morphometric traits.....	9-11
	3.3. Data analysis.....	12
Chapter-4	Results.....	13-28
	4.1. Meristic counts	13-14
	4.2. Morphometric and landmark distances.....	14-28
	4.2.1. Standard length.....	14-15
	4.2.2. Pre-dorsal length.....	15
	4.2.3. Pre-anal length.....	15-16
	4.2.4. Pre-pelvic length.....	16
	4.2.5. Pre-pectoral length.....	17
	4.2.6. Fork length.....	17-18
	4.2.7. Maximum body height.....	18
	4.2.8. Lowest body height.....	19
	4.2.9. Head length.....	19-20
	4.2.10. Eye Diameter.....	20-21
	4.2.11. Pre-orbital length.....	21
	4.2.12. Ten truss measurements.....	22-28
	4.2.12.1. Dst 1-2.....	22-23
	4.2.12.2. Dst 1-5.....	23
	4.2.12.3. Dst 1-6.....	23-24
	4.2.12.4. Dst 2-3.....	24
	4.2.12.5. Dst 2-5.....	25

	4.2.12.6. Dst 2-6.....	25-26
	4.2.12.7. Dst 3-4.....	26
	4.2.12.8. Dst 3-6.....	26-27
	4.2.12.9. Dst 4-5.....	27
	4.2.12.10. Dst 5-6.....	28
Chapter-5	Discussion.....	29-30
Chapter-6	Conclusion.....	31
Chapter-7	Reference.....	32-36
Chapter- 8	Annex.....	37-54

List of Tables

No.	Title	Page no.
1	Average weight (g) and length (mm) of the samples	10
2	Meristic counts (median) of mola (<i>Amblypharyngodon mola</i>) of different stocks (in the parenthesis indicates minimum and maximum counts)	13
3	Univariate statistics (ANOVA) showed that nine morphometric measurements were significantly different among sample in varying degrees	22
4	Univariate statistics (ANOVA) showed that nine truss measurements were significantly different among sample in varying degrees	28

List of Figures

No.	Title	Page no.
1	Location of the stocks	9
2	Measurement of total length (mm)	10
3	Measurement of standard length (mm)	10
4	Measurement of pre-dorsal length (mm)	10
5	Measurement of head length (mm)	10
6	Measurement of eye diameter (mm)	11
7	Measurement of maximum body height (mm)	11
8	Measurement of lowest body height (mm)	11
9	Measurement of pre-anal length (mm)	11
10	Measurement of pre-pelvic length (mm)	11
11	Measurement of pre-pectoral length (mm)	11
12	Measurement of pre-orbital length (mm)	11
13	Measurement of fork length (mm)	11
14	Measurement of ten different landmark truss measurement distances (mm)	11
15	Meristic counts (median) of mola (<i>Amblypharyngodon mola</i>) of different stocks	14
16	Standard lengths of mola (<i>A. mola</i>).	14
17	Pre-dorsal length of mola (<i>A. mola</i>).	15
18	Pre-anal length of mola (<i>A. mola</i>).	16
19	Pre-pelvic length of mola (<i>A. mola</i>).	16
20	Pre-pectoral length of mola (<i>A. mola</i>).	17
21	Fork length of mola (<i>A. mola</i>).	18
22	Maximum body height of mola (<i>A. mola</i>).	18
23	Lowest body height of mola (<i>A. mola</i>).	19
24	Head length of mola (<i>A. mola</i>).	20
25	Eye diameter of mola (<i>A. mola</i>).	20
26	Pre-orbital length of mola (<i>A. mola</i>).	21
27	Dst 1-2 of mola (<i>A. mola</i>).	22
28	Dst 1-5 of mola (<i>A. mola</i>).	23
29	Dst 1-6 of mola (<i>A. mola</i>).	24
30	Dst 2-3 of mola (<i>A. mola</i>).	24



31	Dst 2-5 of mola (<i>A. mola</i>).	25
32	Dst 2-6 of mola (<i>A. mola</i>).	25
33	Dst 3-4 of mola (<i>A. mola</i>).	26
34	Dst 3-6 of mola (<i>A. mola</i>).	27
35	Dst 4-5 of mola (<i>A. mola</i>).	27
36	Dst 5-6 of mola (<i>A. mola</i>).	28

Chapter 1

1. Introduction

1.1 Background of the study

Bangladesh is a country of great opportunities and fisheries sector is one of the best areas for development. It has dynamic and systematic approaches and challenges. These challenges change frequently. Fisheries sector has a great contribution to our economy from the very beginning as we know Bangladesh is known as the country of rivers. It also has canals, beels, haors, baors and ponds which contribute a lot. Bangladesh has proven its ability to be one of the leading countries to produce a huge production including capture fishery with a total production of 42.77 lakh MT in FY 2017-18, whereas inland open water (capture) contributes 28.45 percent (12.17 lakh MT) and inland closed water (culture) contributes 56.24 percent (24.05 lakh MT) to total production (DoF, 2018). Ox-bow lakes provide a total of 8072 MT in FY 2017-18, which contributes 0.19% of the total fish production. Bangladesh ranked 3rd in inland open water capture production and 5th in world aquaculture production (FAO, 2018). This sector is contributing a very significant role in the socio-economic development and also deserves potential for future development in the agrarian economy of Bangladesh. It contributes 3.57 percent to our national GDP and around one-fourth (25.30 percent) to the agricultural GDP. Fisheries sector provide more than 60% of total animal protein. About 11% of population is directly or indirectly depending on fisheries sector. (DoF, 2018). Bangladesh is blessed with vast and rich fisheries resources. Fish is of the most important one in the diversified fisheries resources of the country. Freshwater fishes are very rich in species diversity having more than 260 indigenous fish species (Rahman *et al.*, 2014). Over 150 species have been considered as SIS (Amin *et al.*, 2008). Small indigenous fish species have been considered as an excellent source of essential micro-nutrients which can play an important role in the elimination of malnutrition problem in Bangladesh (Zafri and Ahmed, 1981; and Thilsted *et al.*, 1997). Among the 260 indigenous fish species, Mola carplet (*Amblypharyngodon mola*) is one of them which are highly nutritive and rich source of animal proteins. It is also a small indigenous species.

Ox-bow lakes are commonly known as baors. These are very common inland water bodies. Baors covering 5,488 hectares exist in south-western districts of Bangladesh (Khulna division including Jessore, Jhinaidah, Chuadanga and Kushtia districts and Dhaka division including

district Faridpur) with a significant potentiality of fish culture (Ahmad *et al.*, 2019). These ox-bow lakes (Locally referred to as baor) stretched from 282 hectares to the lowest 10 hectares. The highest area of ox-bow lake is contradictory because in the rainy season, the areas increase a lot. An ox-bow lake is a dead section of a river, which is created when the river changed course. An ox-bow lake normally is still part of the flood plain of the river to which inlets and outlets connect it. By screening the inlets and outlets, an ox-bow lake can be converted into a culture based fishery. The name 'Ox-bow' refers to it's shape and is called ox-bow lake.

The majority of fish eaten by the rural poor is the small indigenous fish species (SIS), which have been defined as species which grow to a maximum length of about 25 cm (Felts *et al.*, 1996). The mola carplet or pale carplet, *Amblypharyngodon mola* is locally known as Moa, Mowka, Moraru, Mouchi, Mowrala, Mola, Moya, or Molongi. The mola carplet is found to occur in the rivers, streams, ponds, ditches, beels, baors, tanks and inundated fields throughout Bangladesh. The species is distributed in India, Pakistan and Myanmar.

Mookherjee and Basu (1946) have reported *A. mola* as a surface feeder; they have documented unicellular and filamentous algae, protozoans and rotifers as ideal food types for this fish species. Das and Moitra (1963) have reported *A. mola* as herbivorous fish. Piska *et al.* (1991), Mamun *et al.* (2004), Gupta and Banerjee (2013) and Mondal and Kaviraj (2013) have also documented the herbivorous feeding habit of this fish species. Piska *et al.* (1991) also have described it as a bottom feeder and algae have been documented as the main food for this fish species. Mamun *et al.* (2004) reported phytoplankton preference for this fish species; they also have documented Chlorophyceae as the mostly preferred food class for *A. mola*; debris with mud which have been observed in the gut content of the studied specimens by Mamun *et al.* (2004) and have been considered as the secondary food.

Mola (*A. mola*) is considered as the 'living capsule of Vitamin A, which is found mainly in the eyes and viscera, with the larger proportion in the eyes. Although the viscera are normally removed, mola is eaten either with or without the head and eyes. In a feeding study with rats, receiving equal amounts of retinol per d for 15 d, either from cooked whole mola or as pure retinyl acetate, the amount of liver retinol was higher in those fed mola (Kongsbak *et al.*, 2008). Zafri and Ahmad (1981) suggested that some dehydroretinol in mola might have been converted to retino. Mola consumed whole with bone is a nutrient-dense animal-source food, rich in Fe, Zn and bioavailable Ca (Calcium).

Mola is very popular in Bangladesh. It has high market and nutritional value. A number of attempts have been taken in different study to develop the production in inland water. This fish is found mostly in ox-bow lake, beel, lakes and ponds also. All these have drawn attention on what is existing status of *A. mola* in our country. As it is found in baors, it's an interest to find out the differences in mola among different oxbow lakes. Therefore, the present research will be able to establish the present status of different stocks of oxbow lake.

Both morphometric and meristic characters are generally used for fish identification within which the morphometric characters are measurable and meristic counts are countable characters. Landmark-based morphometric measurements are the measurements those are counted according to specific locations of different points. Truss network systems constructed with the help of landmark points are powerful tools for stock identification. The study of differences and variability in respect of morphometric and meristic characters of fish stocks is important in phylogenetics and in providing information for subsequent studies on the genetic improvement of stocks (Solomon *et al.*, 2015). Morphometric analysis has been used to identify the uncertain hybrids, unidentified species, and modification of fish population (Straüss and Bookstein, 1982; Park *et al.*, 2003; Turan *et al.*, 2006). This study was conducted to determine the variations among three ox-bow lakes and also aimed to observe the morphometric and meristic variation to understand the actual situation about the diversity of the mola stocks in three ox-bow lakes.

1.2 Objective

The main objective of the present study was:

- To determine the morphological variations in respect of morphometric characters among three isolated stocks of *Amblypharyngodon mola* from Baluhar, Marufdah and Joydia ox-bow lakes.

Chapter 2

2. Review of Literature

Knowledge is precious. From the very early stage we have gathered a uncountable number of knowledge that has made a base or tree. This tree can help a researcher for collecting the necessary information about his research. The search and review of necessary and previous research about the topic is one of the main foundations for conducting a successful experiment.

Gogoi and Goswami (2015) conducted a study to evaluate morphometric and meristic analysis to detect difference among different habitats of *A. mola* in Assam. This study was performed during the period from September 2011 to August 2013. The morphometric characters of different body parts from the male and female mola fishes were recorded. The correlation and regression analysis was carried out for some significant characters in relation to total length and head length. The coefficients of correlation (r) for various characters were ranged from 0.216 to 0.947 in males and 0.396 to 0.9524 in females. There was significant ($p < 0.05$) difference between morphometric characters of mature male and female mola while there was no change in meristic counts with increase in body length.

Hossain *et al.*, (2009) studied Landmark-based morphometric and meristic variations of the endangered carp, *Calibaus Labeo calbasu*, from the stocks of two isolated rivers, the Jamuna and the Halda, and a hatchery. Morphometric characters along with truss network measurements and meristic counts were conducted. Significant differences were observed in four (maximum body height, pre-orbital length, peduncle length, and maxillary barbel length) of 12 morphometric measurements, two (pectoral fin rays and scales above the lateral line) of 9 meristic counts, and four (8 to 9, 3 to 10, 2 to 10, and 1 to 11) of 22 truss network measurements among the stocks. For morphometric and landmark measurements, the 1st discriminant function (DF) accounted for 75.5% and the 2nd DF accounted for 24.5% of the among-group variability, and together they explained 100% of the total among-group variability. For the morphometric and truss network measurements, plotting DFs revealed high isolation of the stocks. The dendrogram based on morphometric and truss distance data placed the Jamuna and hatchery in 1 cluster and the Halda in another cluster, and the distance between the Halda and hatchery populations was the highest.

Gain *et al.*, (2017) studied the landmark-based morphometric and meristic variations of endangered mrigal carp, *Cirrhinus cirrhosus* from wild and hatchery stocks. The objectives of that study was to evaluate the population status landmark-based morphometric and meristic variations among three different stocks viz., hatchery (Jessore), baor (Gopalganj) and river (Faridpur). Ten out of 15 morphometric measurements were found different among the samples. For morphometric and landmark measurements, the 1st discriminant function (DF) was accounted for 58.1% and the 2nd DF accounted for 41.9% of the among-group variability. In case of discriminant on space, the river stock was isolated from the other two stocks. On the other hand, baor and hatchery stocks formed a very compact cluster. A dendrogram based on the hierarchical cluster analysis using morphometric and truss distance data placed the hatchery and baor in one cluster and the river in another cluster, and the distance between the river and hatchery populations was the highest. Morphological differences among the stocks are expected, because of their geographical isolation and origin from were different ancestors.

Hossen *et al.*, (2017) conducted a study on morphometric and meristic variation of indigenous and Thai Koi, *Anabas testudineus*. He had taken samples from coastal region of Bangladesh. The study was about finding the variation between indigenous and Thai koi. Samples of indigenous koi was collected from different household ponds of Dumki upazilla under Patuakhali District and Thai koi from port road fish market of Barisal Sadar Upazilla under Barisal district. Nonparametric Kruskal wallis (H) test also revealed significant variations both in morphometric and meristic characteristics of indigenous and thai koi. Hierarchical cluster analysis of morphometric characters showed a high divergence between the populations, while the meristic characters did not show such type of divergence. The morphometric and meristic differences appeared between the two populations may be due to their genetic differences and/or environmental factors or these are two sub species of the genus *Anabas*.

Islam *et al.*, (2018) studies *Trichopsis vittata* using truss network systems which was constructed with landmark-based morphometric and meristic variation. In total, 25 fish samples were collected from three selected locations of the Meghna river of Bangladesh during March, 2014. Nine morphometric and six meristic characters were analyzed along with thirty truss network measurements. Non parametric Kruskal- Wallis test was applied for comparing meristic counts but no significant differences were observed among the groups.

Univariate statistics (ANOVA) showed no significant difference among three groups. For both morphometric and landmark measurements the first discriminant function (DF) was accounted for 72.1% and 78.2% and the second DF accounted for 27.9% and 21.8%, respectively in the among group variability. With morphometric measurements, 87.5% of group 1, 66.7% of group 2 and 75% of group 3 samples were correctly classified. As the truss network system revealed, all the samples were clearly separated from each other in the discriminant space.

Cavalcanti *et al.*, (1999) studied the landmark-based morphometric analysis in selected species of serranid Fishes. Morphological differences among 6 species of marine fishes belonging to 2 subfamilies of the family Serranidae (Serraninae: *Dulus auriga*, *Diplectrum formosum*, and *D. radiale*; Epinephelinae: *Epinephelus marginatus*, *Mycteroperca acutirostris*, and *M. bonaci*) were studied by the geometric and morphometric method of thin-plate splines and multivariate analysis of partial-warp scores. The decomposition of shape variation into uniform and nonaffine components of shape change indicated that major differences among species were related to both components of shape variation. Significant differences were found among species with respect to the uniform components, but there is no clear separation of taxonomic groups related to these components were found, and species were instead separated on the basis of body height and caudal peduncle length. Non-uniform changes in body shape, in turn, clearly differentiate the species under the subfamilies, Serraninae and Epinephelinae. These shape changes are probably related to differences in habitat and feeding habits among the species.

Khan *et al.*, (2012) studied the elemental profile of otoliths and truss network analysis for stock discrimination of the threatened stinging catfish (*Heteropneustes fossilis*) from the Ganga river and its tributaries to identify different stocks inhabiting the Ganga, Yamuna and Gomti Rivers of India. Inductively coupled plasma-atomic emission spectrometry was used to estimate concentrations of 12 trace elements in otoliths, and 11 morphometric landmarks were chosen to construct a truss network of the fish in order to discriminate among stocks. A discriminant function (DF) analysis of elemental profiles showed that Ba, Pb, Zn, and Sr were successfully discriminated *H. fossilis* populations from different rivers. DF-I, DF-II, and DF-III accounted for 76.1%, 17.9%, and 6.0%, variabilities, respectively, of the among-group in the elemental profile of otoliths. In the analysis of truss landmarks, the principal components, PC-I and PC-II, respectively accounted for 39.1% and 13.4%, while DF-I and

DF-II, respectively accounted for 59.7% and 25.5% of the among-group variability. The overall allocation success of individuals to their group of origin was high (98.7%) in the elemental profile of otoliths compared to truss measurements (72.3%). The truss network analysis distinguished separate stocks of fish in the 3 rivers; however, the elemental profile of otoliths further discriminated the stocks at the 2 sampling stations within the Ganga river.

Ahammad *et al.*, (2018) studied to observe the landmark-based morphometric and meristic analysis of three different stocks from the Atrai, the Jamuna and the Kangsha of Bhagna and were examined from a phenotypical point of view to evaluate the population structure and to assess shape variation. Ten morphometric and nine meristic characters were analyzed along with twenty two truss network measurements. One way ANOVA showed that all morphometric, meristic and truss network measurement were significantly different ($P < 0.001$) among three different stocks of the fish. For morphometric and landmark measurements, the first discriminant functions (DF) accounted for 98.6% and 97.9% and the second DF were accounted for 1.4% and 2.1%, respectively among group variability, explaining 100% of total among groups variability. For the morphometric and truss network measurements, plotting discriminant functions showed a well separated clusters of the stocks indicating that the measurement were significantly different among three stocks. The dendrogram based on morphometric and landmark distances data showed two major clusters; the Atrai and Jamuna stocks in one cluster and the Kangsha stock in another cluster. High degree of variation was observed in morphological characteristics among three different stocks (the Atrai, Jamuna and Kangsha) of *L. ariza* due to their environmental variation and separate geographical location.

Mahfuj *et al.*, (2019) studied to examine the meristic and landmark-based morphometric variations of barred spiny eel (*Macroglyptodon pancalus*) from four populations namely Dhakuria beel, Jessore (DBJ); Bohnni boar, Gopalganj (BBG); the Arial kha river, Madaripur (AKRM) and the Nabaganga river, Jhenidah (NRJ) in Bangladeshi freshwaters. Six meristic counts were compared among four populations and significant differences were observed in number of caudal fin rays and number of pelvic fin rays in all meristic characters. The truss protocol was used in the present study based on six general morphometrics and fifteen truss measurements. Univariate statistics showed that five (standard length (SL), upper jaw length (UJL), lower jaw length (LJL), head depth (HD) and inter orbital (IO)) of six morphometric and eleven truss networks (viz. 2-3, 3-4, 5-6, 6-7, 7-8, 1-8, 2-8, 3-8, 3-7, 4-7 and 5-7) among

fifteen truss measurements were differed significantly. Canonical discriminate function analyses were conducted among samples and the populations were fully intermingled. Pooled within group correlation showed morphometric and landmark measurements; the first discriminant function (DF) was accounted for 79%, the second DF accounted for 15.9% and the third DF accounted for 5.1% of group variabilities. An euclidian dendrogram was constructed based on morphometric and truss measurements in four populations, where two clusters were mainly formed in which first cluster formed by NRJ population was fully separated, and the second cluster was formed by two populations of AKRM and DBJ. Additionally, a subcluster BBG was formed with AKRM. On the basis of morphometric and truss measurements, 68.8%, 83.6%, 55.6% and 80% of original grouped cases were correctly classified in NRJ, AKRM, DBJ and BBG, respectively.

Molla *et al.*, (2012) studied the landmark-based morphometric and meristic analysis of pond, haor and estuary populations of *Glossogobius giuris* to find out variations among these three stocks. Significant differences ($P < 0.01$) were observed in 13 general morphometric and 23 size adjusted landmark-based morphometric measurements among the three stocks. Among the 11 meristic counts, the first dorsal fin rays (D1FR), transverse scale above lateral line (TSALL), branchiostegal rays and number of vertebrae were the same among fishes of these stocks. In case of pectoral fin rays (PcFR) and transverse scale on lateral line (TSOLL) the haor stock was significantly different from other two stocks. In case of space discriminant, pond stock was isolated from other two stocks. On the other hand, haor and estuary stocks showed very close relationship. A dendrogram based on the hierarchical cluster analysis, using size adjusted general morphometric and landmark measurements formed two main clusters pond stock in one cluster and other two stocks (haor and estuary) remained in another cluster. It indicates that pond stock was separated. The second cluster explained that haor and estuary stocks had very close relationship.

3. Materials and Methods:

3.1 Fish collection

A total of 90 mola (*Amblypharyngodon mola*) samples were collected from the three isolated stocks; such as Baluhar ox-bow lake, Jhenaidah; Marufdah ox-bow lake, Chuadanga; Joydia ox-bow lake, Jhenaidah. Fig. 1 shows the location of the three stocks. After collection, the fish were transported in iced container to the Wet Fish Laboratory of FMRT Discipline and kept in the Fisheries Department, Khulna University, Khulna, Bangladesh.

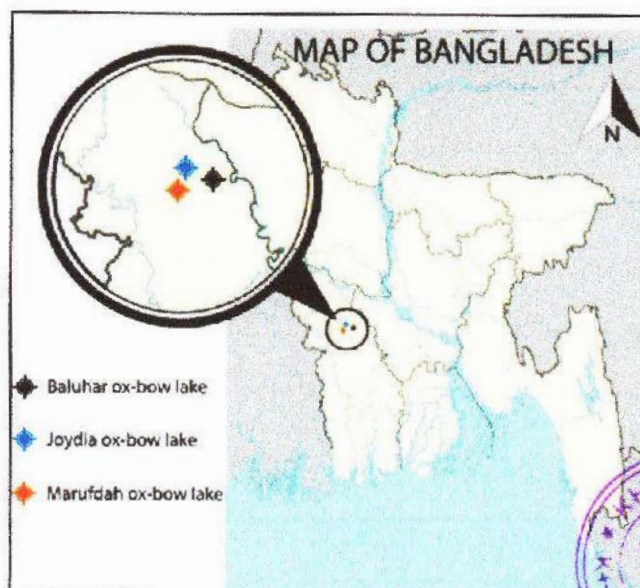


Fig 1: Location of the mola (*A. mola*) stocks (Source: wikimedia.org)

3.2 Measurements of morphometric traits

The sample weight was taken before morphometric measurement by using electronic balance. The sample size, mean weight and mean length were presented in Table 1. At first, fish was placed on a graph paper together with its ID and the photograph was taken by a 16 megapixel camera. All the raw images were imported into *ImageJ* software (v1.50) for the measurements of some selected phenotypic traits (e.g. standard length, total length, pre-dorsal length, head length, eye diameter, pre orbital length, highest body width, lowest body width, pre-anal length, pre-pelvic length, pre-pectoral length and ten different landmark distances (such as: dst1-2, dst 1-5, dst 1-6, dst 2-3, dst 2-5, dst 2-6, dst 3-4, dst 3-6, dst 4-5 and dst 5-6) Fig. 9 were done with the help of "Truss network system", using the same camera and *ImageJ* (v1.50) software. Total length (the distance in mm from the tip of the snout to the tip of the longer lobe of the caudal fin; also see Fig. 2), standard length (the distance in mm from the tip of the snout to the tip of his caudal peduncle; see Fig. 3), pre-dorsal length (the distance in mm from the fish anterior base of dorsal pin to the tip of the snout; see Fig. 4), head length (the distance in mm from the tip of the snout to the end of the osseous plate at top; see Fig. 5), eye diameter (the greatest distance between the margins of the orbit; see Fig. 6), maximum body height (the highest distance of body; see Fig. 7), lowest body height (the

minimum distance in mm of body; see Fig. 8), pre-anal length (the distance in mm from the tip of the snout to the beginning of anal fin; see Fig. 9), pre-pelvic length (the distance in mm from the tip of the snout to the beginning of pelvic fin; see Fig. 10), pre-pectoral length (the distance in mm from the tip of the snout to the beginning of pectoral fin; see Fig. 11), pre-orbital length (the distance in mm from the tip of the snout to the beginning of eye, see Fig. 12), fork length (the distance in mm from the tip of the snout to the end of the middle caudal fin rays, see Fig. 13) and ten different landmark truss measurement distances (Fig. 14) were measured carefully. The data were recorded in the excel sheet for analysis. Table 1 shows average weight and length of the fish samples.

Table 1: Average weight (g) and length (mm) of the samples

Stock name (ox-bow lake)	Sample (number)	Weight (g)	Total Length (mm)
Baluhar	30	1.59 ± 0.55	54.42 ± 5.64
Marufdah	30	2.25 ± 0.65	59.97 ± 5.28
Joydia	30	1.85 ± 0.29	55.86 ± 2.97

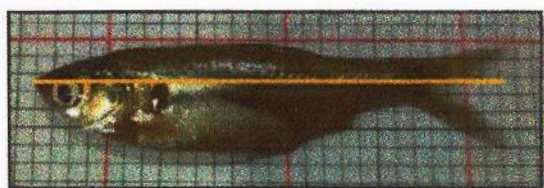


Fig 2: Measurement of total length (mm)

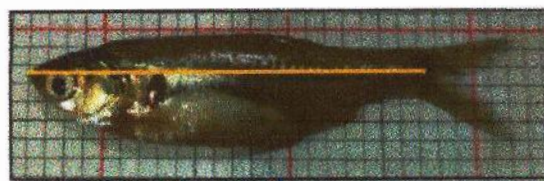


Fig 3: Measurement of standard length (mm)



Fig 4: Measurement of pre-dorsal length (mm)

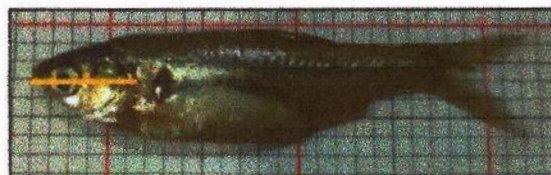


Fig 5: Measurement of head length (mm)

KU-WS-A4, NO-4262, 25.3.2021

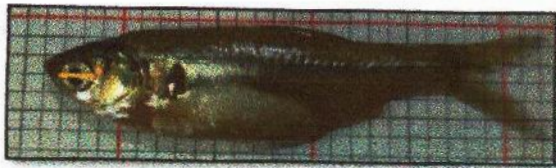


Fig 6: Measurement of eye diameter (mm)

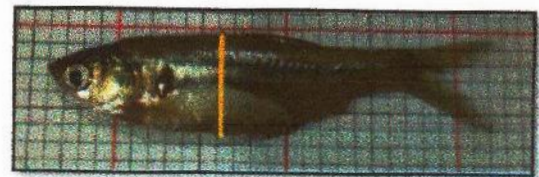


Fig 7: Measurement of maximum body height (mm)

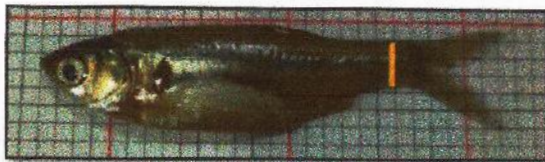


Fig 8: Measurement of lowest body height (mm)



Fig 9: Measurement of pre-anal length (mm)



Fig 10: Measurement of pre-pelvic length (mm)

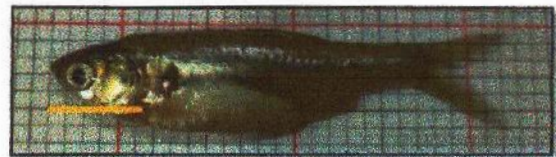


Fig 11: Measurement of pre-pectoral length (mm)



Fig 12: Measurement of pre-orbital length (mm)

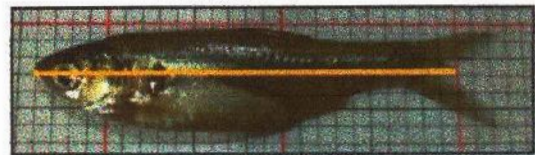


Fig 13: Measurement of fork length (mm)

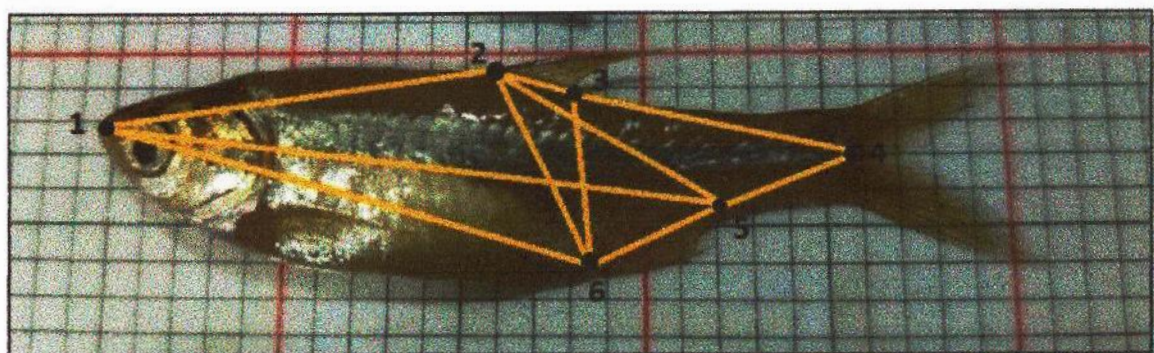


Fig 14: Measurement of ten different landmark truss measurement distances (mm)

3.3 Data analysis

Prior to analysis, the size effects from the data set were eliminated. Variations were attributed to body shape differences and not to the relative sizes of the fish. In the present study, there were significant linear correlations among all the measured characters and the total length (TL) of the fish. Therefore, it was necessary to remove size-dependent variations from all of the characters. An allometric formula given by (Elliott *et al.*, 1995) with slight modification was used to remove the size effect from the data set:

$$M_{adj} = M (L_s / L_o)^b$$

Where M is the original measurement, M_{adj} is the size-adjusted measurement, L_o is the TL of the fish and L_s is the overall mean of the TL for all fish from all samples. Parameter b was estimated for each character from the observed data as the slope of the regression of log M on log L_o , using all fish in all stocks. The efficiency of the size adjustment transformations was assessed by testing the significance of the correlation between a transformed variable and the TL. A univariate analysis of variance (ANOVA) was carried out to test the significance of morphological differences.

All statistical data were analyzed by SPSS v23, Minitab v17 and Microsoft Excel 2010.

Chapter 4

4. Results

Measurement of length and weight of fish is important to conduct any research. It can provide a preliminary knowledge about the stocks. Length and weight can be different for age, sex and other factors. Prior to analysis the data, the efficiency of the allometric formula in removing the size effect from the data was justified by using correlations between the total length and adjusted characters. In this research we have counted 12 landmark-based morphometric measurements and 10 truss measurements. The 11 morphometric measurements were: total standard length (SL), pre-dorsal length (PDL), pre-anal length (PAL), pre-pectoral length (PEC), pre-pelvic length (PEL), fork length (FL), maximum body height (MBH), lowest body height (LBH), head length (HL), eye diameter (ED) and pre-orbital length (POL) and ten truss measurements were dst 1-2, dst 1-5, dst 1-6, dst 2-3, dst 2-5, dst 2-6, dst 3-4, dst 3-6, dst 4-5, dst 5-6. Dorsal fin rays, Anal fin rays, Pectoral fin rays and Caudal fin rays were counted also as meristic data measurement.

4.1. Meristic counts

Four meristic counts with their median values for all samples were shown in Table 2 (where Me, Mn and Mx expresses Median, Minimum and Maximum value). Among the correlation measurements, no counts are significantly different within the three stocks. Fig. 15 shows the chart using median value of various meristic measurements in different stocks of three oxbow lakes. (Kruskal-Wallis Test, $df=2$, dorsal fin rays: $H=0.27$, $P=0.873$; anal fin rays: $H=0.27$, $P=0.873$; pectoral fin rays: $H=0.92$, $P=0.633$; caudal fin rays: $H=0.19$, $P=0.910$). However no significant differences were found in the same types of meristic characters among the mola stocks of Baluhar, Marufdah and Joydia.

Table 2: Meristic counts (median) of mola (*A. mola*) of different stocks. The values in the parenthesis indicates minimum and maximum counts

Characters	Baluhar (Me, Mn-Mx)	Marufdah (Me, Mn-Mx)	Joydia (Me, Mn-mx)
DFR	8 (7-8)	8 (7-8)	8 (7-8)
AFR	6 (6-7)	6 (6-7)	6 (6-7)
PFR	15 (13-15)	15 (13-15)	15 (13-15)
CFR	19 (18-19)	19 (17-19)	19 (17-19)

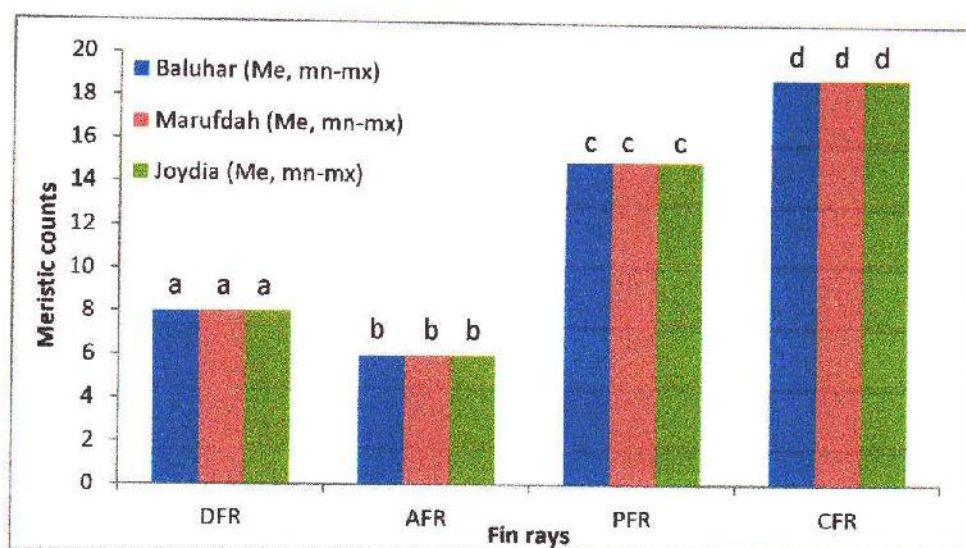


Fig 15: Meristic counts (median) of mola (*A. mola*) of different stocks from Baluhar, Marufdah and Joydia. Same letters on bar for each character are not significantly different ($p>0.05$)

4.2. Morphometric and landmark distances

4.2.1. Standard length

Standard length is the straight-line measurement taken from tip of snout to the last vertebra which supports the tail fin of the fish. It is important for life history and morphological comparisons of fish populations from different locations, by the estimation of weight for individual fish and for length classes of fish. It is also related to length–weight relationship (LWR), and are useful in fishery management and stock assessment models. Fig. 16 shows that the graphical representation of the mean $\pm$ SD of standard lengths. The ANOVA test results indicated that there were no significant differences in case of standard length ($F_{(2,87)}=2.074$, $p=0.132$) among the three stock of mola (*A. mola*).

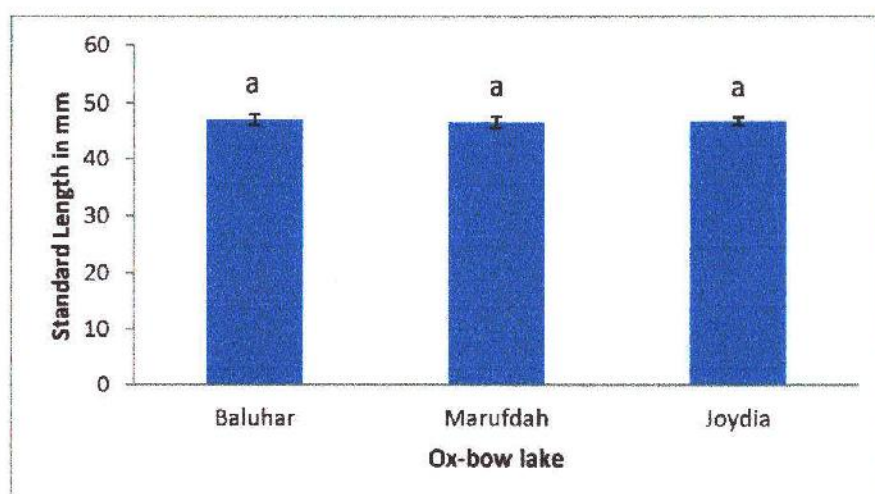


Fig 16: Comparison of standard lengths of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.2. Pre-dorsal length

Pre-Dorsal length is straight-line measurement taken from the tip of snout to the beginning of dorsal fin. The Fig. 17 shows the comparison in the pre-dorsal length among three baor stocks of mola (*A. mola*). The ANOVA analysis results revealed that there was no significant difference (fig. 17) among different stocks for pre-dorsal length ($F_{(2,87)} = 0.958$, $p=0.388$). The subsequent post-hoc test was also performed to find out the differences among the three groups and there was also no significant variation.

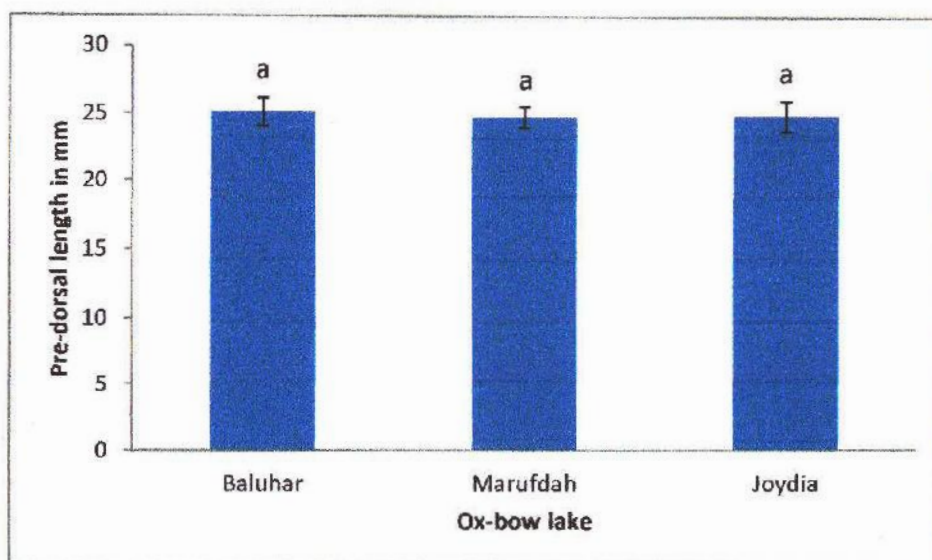


Fig 17: Comparison of pre-dorsal lengths of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.3. Pre-anal length

Pre-anal length is the straight-line measurement taken from the tip of snout to the beginning of anal fin. Fig. 18 shows the comparison in pre-anal length among three baor stocks of mola (*A. mola*). The ANOVA analysis revealed that there was significant difference (fig. 18) among different stocks for pre-anal length ($F_{(2,87)} = 10.508$, $p=0.000$). The subsequent post-hoc test was also performed to find out comparison between three groups and there was also significant variation.

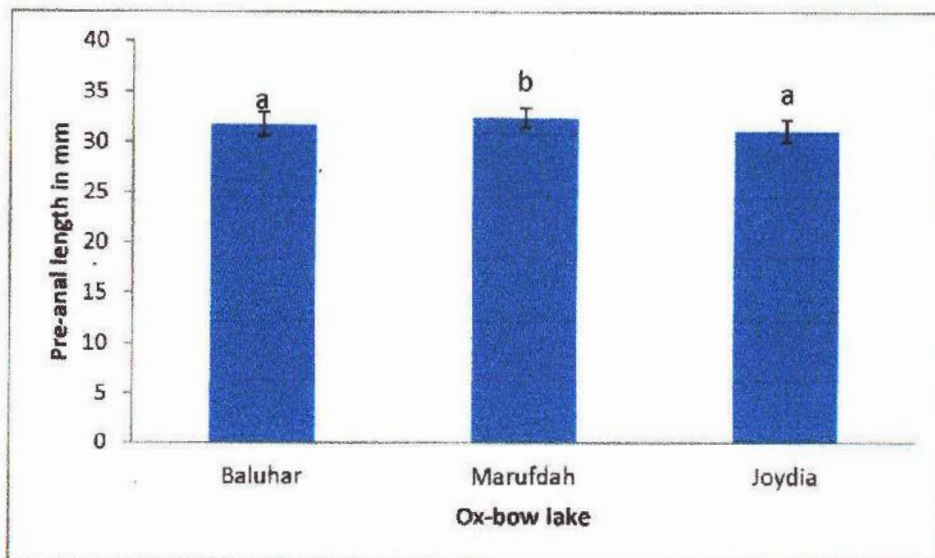


Fig 18: Comparison of pre-anal lengths of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.4. Pre-pelvic length

Pre-pelvic length is the straight-line measurement taken from the tip of snout to the beginning of pelvic fin. Fig. 19 shows the comparison among three baor stocks of mola (*A. mola*) in their pre-pelvic length. The ANOVA results revealed that there were significant differences (Fig. 19) among the different stocks for pre-pelvic length ($F_{(2,87)} = 10.010$, $p = 0.000$).

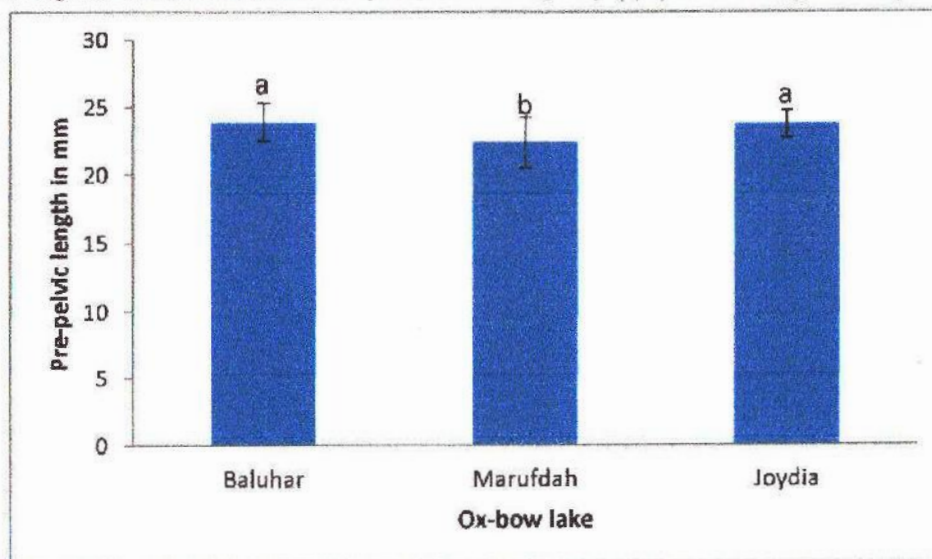


Fig 19: Comparison of pre-pelvic lengths of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.5. Pre-pectoral length

Pre-pectoral length is straight-line measurement taken from the tip of snout to the beginning of pectoral fin. Fig. 20 shows the comparison among the three baor stocks of mola (*A. mola*) in pre-pectoral length. The ANOVA analysis results revealed that there were significant difference (Fig. 20) among the different stocks for pre-pectoral length ($F_{(2,87)}=20.916$, $p=0.000$) but no significant difference was observed between Marufdah and Joydia stocks.

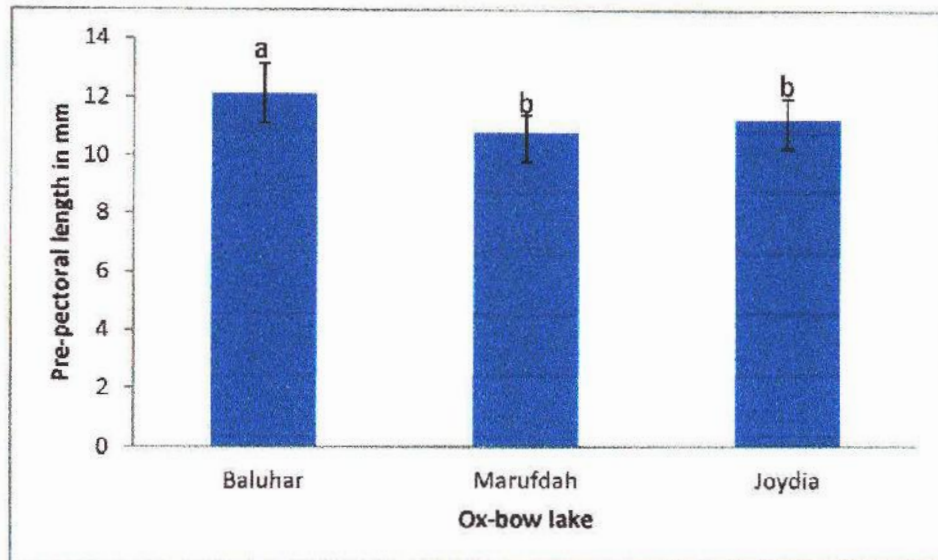


Fig 20: Comparison of pre- pectoral lengths of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.6. Fork length

Fork length is the straight-line measurement taken from the tip of the snout to the end of the middle caudal fin rays. Fig. 21 demonstrates the comparison among the three stocks of ox-bow lakes of mola (*A. mola*) in fork length. The ANOVA analysis results revealed that there was significant difference (fig. 21) between different stocks for fork length ($F_{(2,87)}=4.185$, $p=0.018$) but no significant difference was observed between Marufdah and Joydia stocks.

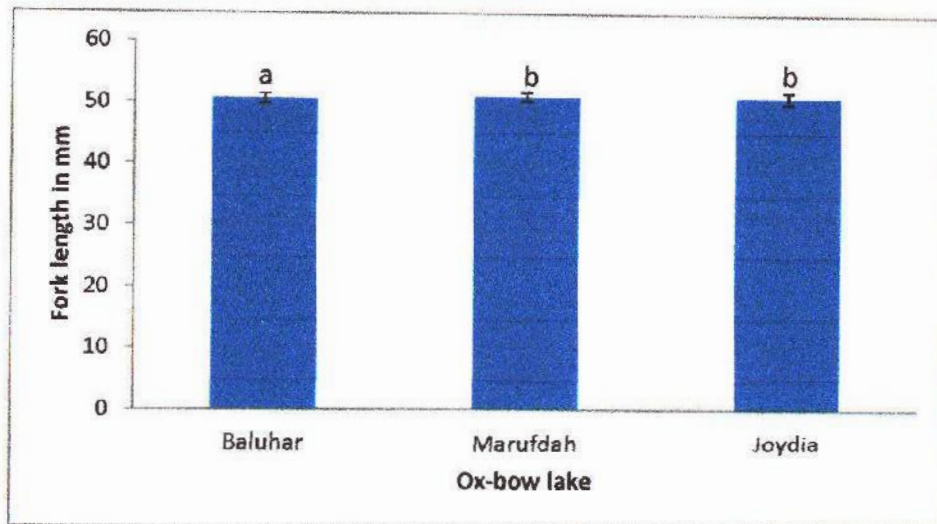


Fig 21: Comparison of fork lengths of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.7 Maximum body height

Maximum body height is the highest distance of body. Fig. 22 shows the comparison among three baor stocks of mola (*A. mola*) in maximum body length. The ANOVA analysis results revealed that there was significant difference (Fig. 22) among different stocks for maximum body height ($F_{(2,87)}=62.476$, $p=0.000$).

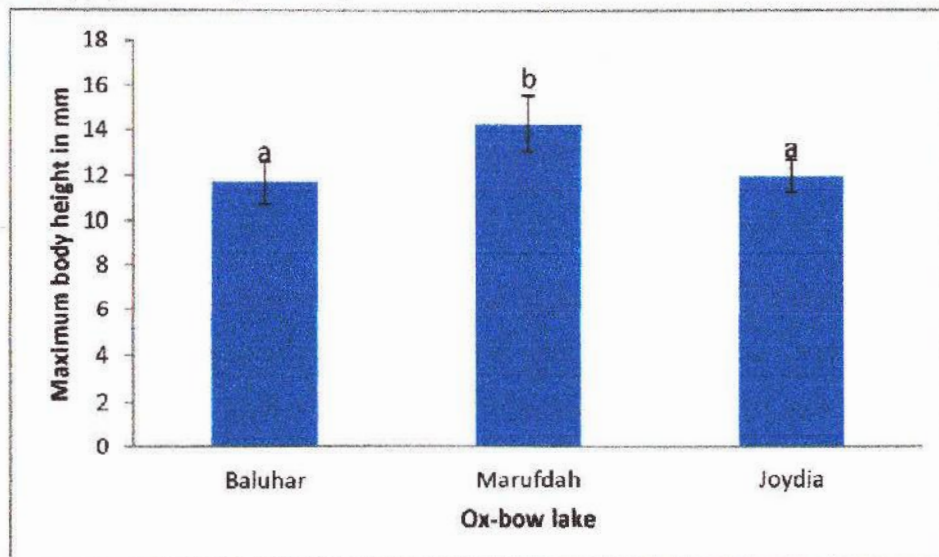


Fig 22: Comparison of maximum body heights of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

Fig 25: Comparison of eye diameter of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.11. Pre-orbital length

Pre-orbital length is the distance between the tip of the snout and beginning of eye. The Fig. 26 shows the comparison in pre-orbital length among the three baor stocks of mola (*A. mola*). The ANOVA analysis revealed that there were significant difference (Fig. 26) among different stocks for pre-orbital length ($F_{(2,87)}=14.700$, $p=0.000$). but the stocks between Marufdah and Joydia was not significant so.

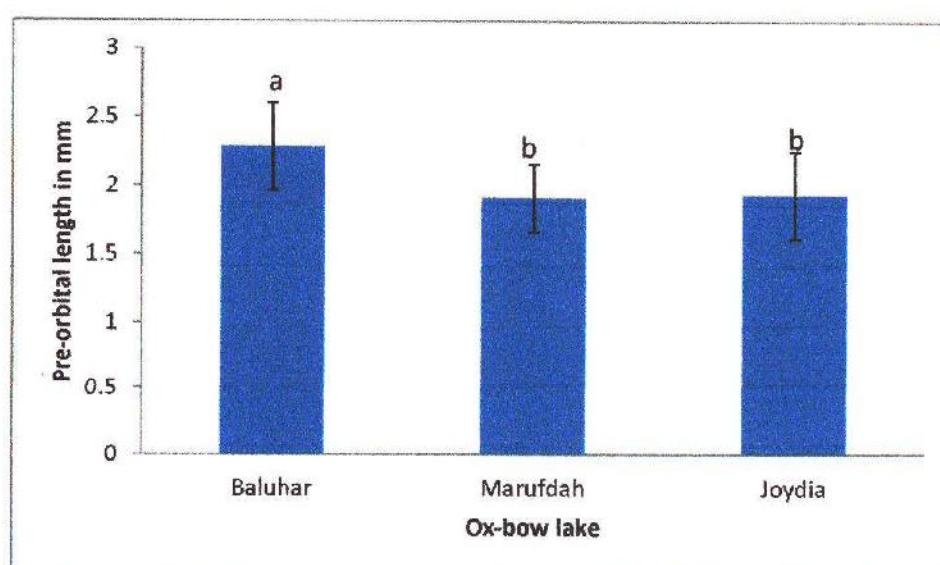


Fig 26: Comparison of pre-orbital length of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

Table 3 shows all the morphometric data except truss distances with their significant level.

Table 3: Univariate statistics (ANOVA) shows that nine morphometric measurements were significantly different ($P < 0.05$) among sample in varying degrees

S. No.	Characters	F	df1	df2	Sig.
1	SL	2.074	2	87	0.132
2	PDL	0.958	2	87	0.388
3	PAL	10.508	2	87	0.000*
4	PEL	10.010	2	87	0.000*
5	PEC	20.916	2	87	0.000*
6	FL	4.185	2	87	0.018*
7	MBH	62.476	2	87	0.000*
8	LBH	4.714	2	87	0.011*
9	HL	29.010	2	87	0.000*
10	ED	26.616	2	87	0.000*
11	POL	14.700	2	87	0.000*

* $p < 0.05$

4.2.12. Ten truss measurements

4.2.12.1. Dst 1-2 There were 90 samples in the experiment from where ten truss measurements were made. The Dst 1-2 was the important one among the ten truss measurements in the experiment. The graphs express that there was significant difference (Fig. 27) in the parameter of Dst 1-2 among the three groups ($F_{(2,87)} = 7.02$, $p = 0.001$) but the Baluhar and Marufdah stocks were not significantly different (Fig. 27)

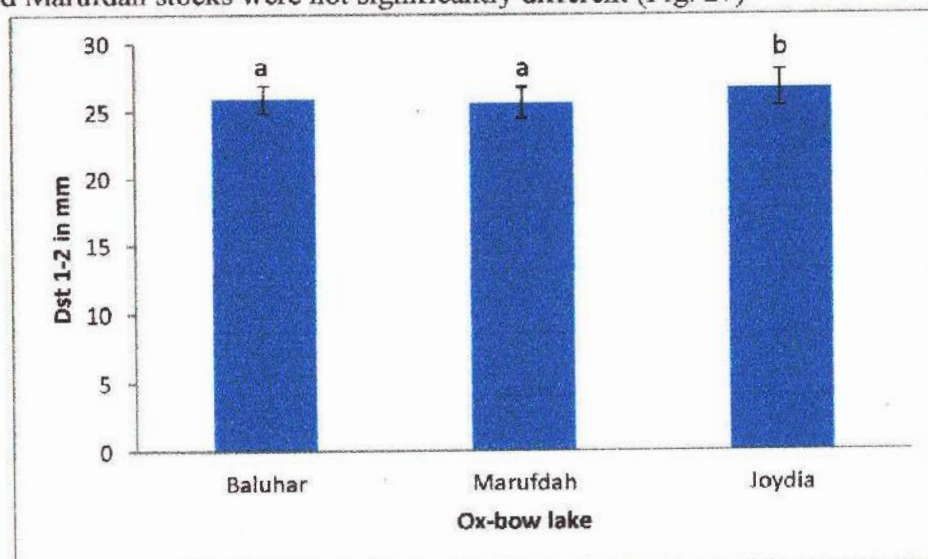


Fig 27: Comparison of Dst 1-2 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.12.2. Dst 1-5

The dst 1-5 was also important among the ten truss measurements in the experiment. The graphs reveal that there was significant difference (Fig. 28) in the parameter of Dst 1-5 among three groups ($F_{(2,87)} = 25.055$, $p=0.000$).

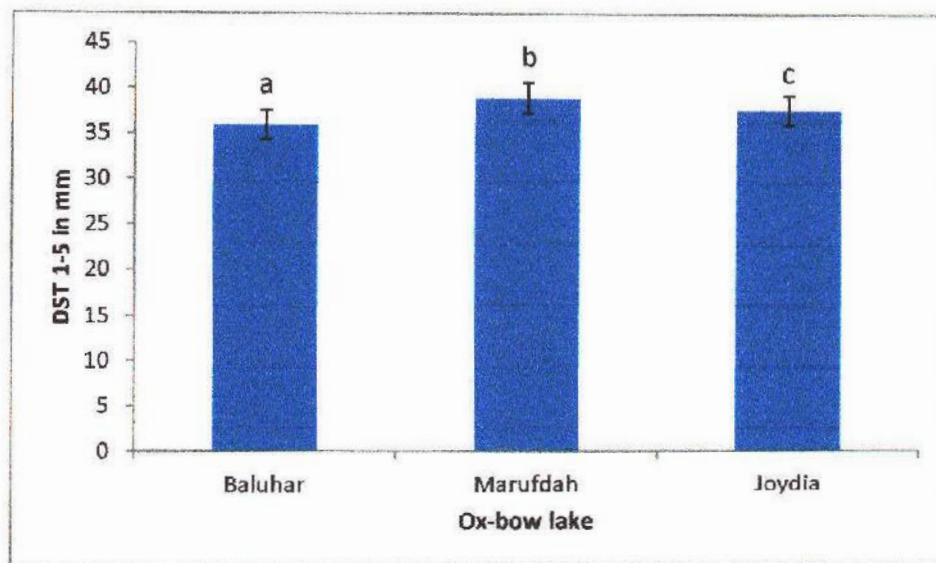


Fig 28: Comparison of Dst 1-5 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.12.3. Dst 1-6

The dst 1-6 was the measurement of distance from the point 1 to 6 as shown in Fig 14. The graphs show that there were significant differences (Fig. 29) in the parameter of Dst 1-6 between three groups ($F_{(2,87)} = 18.265$, $p=0.000$) but the Baluhar and Joydia stocks were not significantly different (Fig. 29)

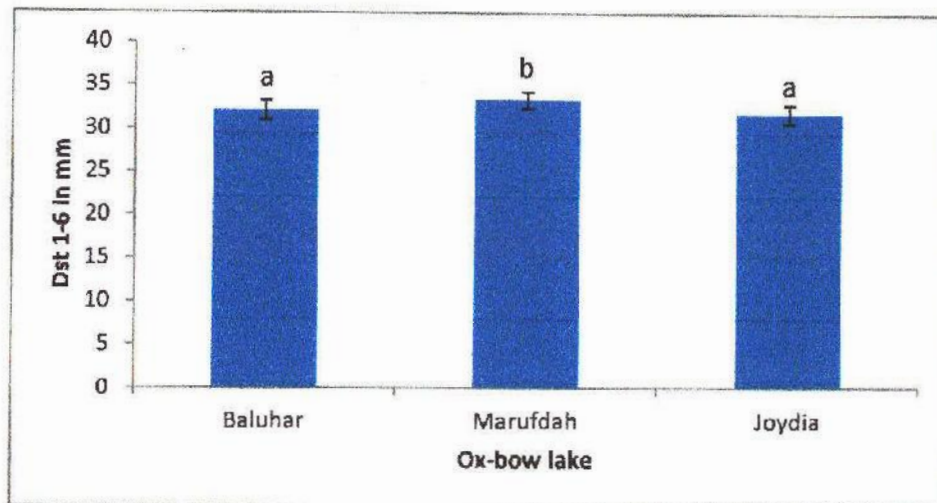


Fig 29: Comparison of Dst 1-6 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.12.4. Dst 2-3

The dst 2-3 was the measurement of distance from the point 2 to 3 as shown in Fig 14. The graphs reveal that there were significant differences (Fig. 30) in the parameter of Dst 2-3 among the three stocks ($F_{(2,87)} = 18.265$, $p=0.000$).

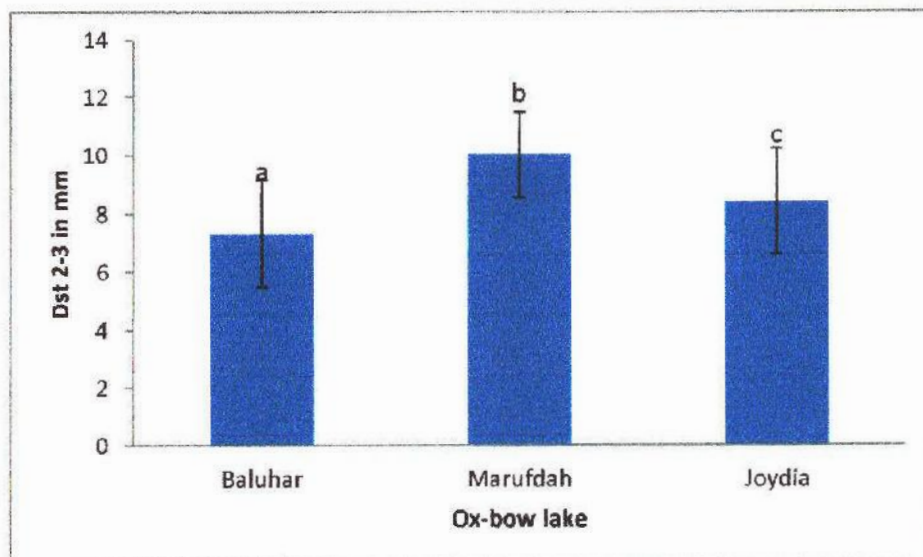


Fig 30: Comparison of Dst 2-3 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.12.5. Dst 2-5

The dst 2-5 was the measurement of distance from the point 2 to 5 as shown in Fig 14. The graphs show that there were significant differences (Fig. 31) in the parameter of Dst 2-5 among three stocks ($F_{(2,87)} = 37.454$, $p=0.000$).

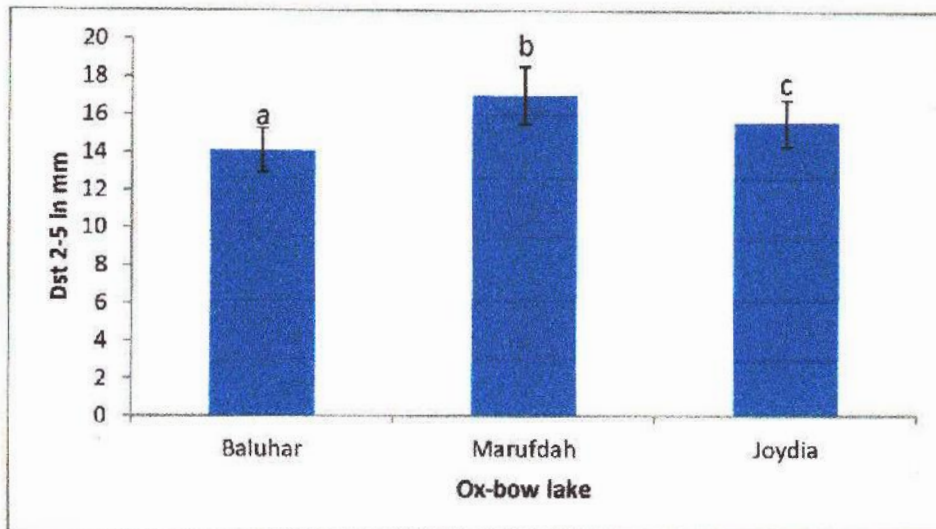


Fig 31: Comparison of Dst 2-5 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.12.6. Dst 2-6

The dst 2-6 was the measurement of distance from the point 2 to 6 as shown in Fig 14. The graphs eveale that there were significant difference (Fig. 32) in the parameter of Dst 2-6 among the three stocks ($F_{(2,87)} = 41.781$, $p=0.000$).

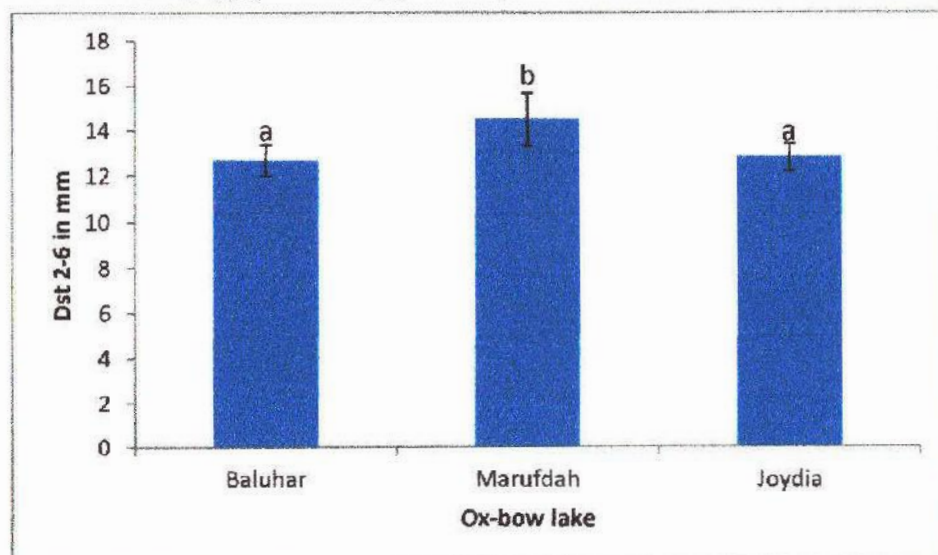


Fig 32: Comparison of Dst 2-6 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.12.7. Dst 3-4

The Dst 3-4 was the measurement of distance from the point 3 to 4 as shown in Fig 14. The graphs express that there were no significant difference (Fig. 33) in the parameter of Dst 3-4 among three stocks ($F_{(2,87)} = 2.135$, $p=0.124$).

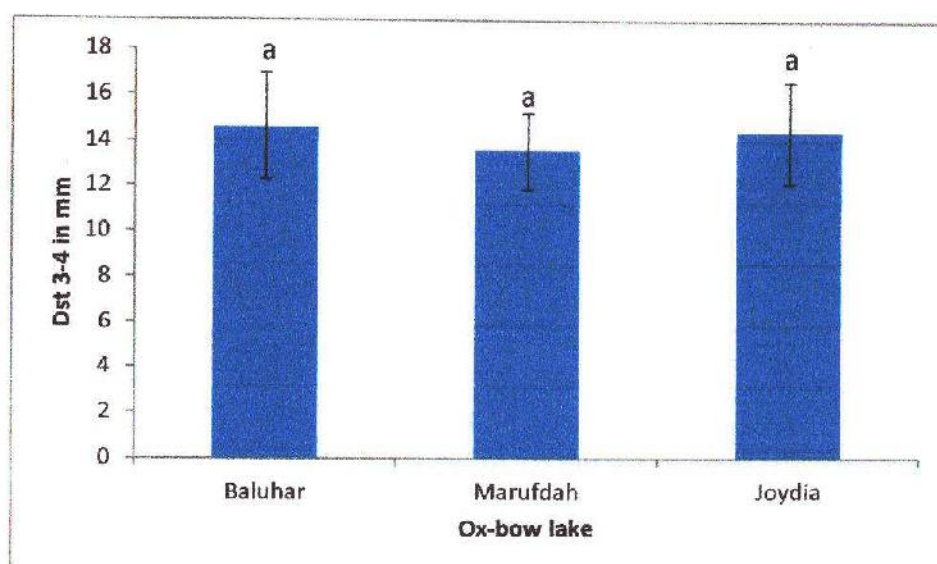


Fig 33: Comparison of Dst 3-4 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.12.8. Dst 3-6

The dst 3-6 was the measurement of distance from the point 3 to 6 as shown in Fig 14. The graphs reveal that there were significant differences (Fig. 34) in the parameter of Dst 3-6 among the three stocks ($F_{(2,87)} = 8.720$, $p=0.000$).

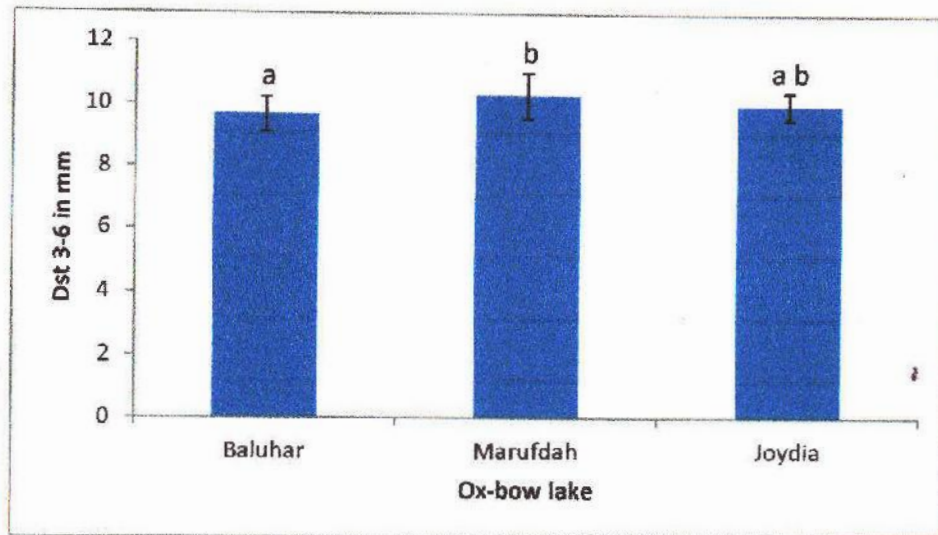


Fig 34: Comparison of Dst 3-6 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.12.9. Dst 4-5

The Dst 4-5 was the measurement of distance from the point 4 to 5 as shown in Fig 14. The graphs disclose that there were significant differences (Fig. 35) in the parameter of Dst 4-5 among the three stocks ($F_{(2,87)} = 11.501$, $p=0.000$). However, no significant difference was recognized in the stocks between Marufdah and Joydia (Fig. 35).

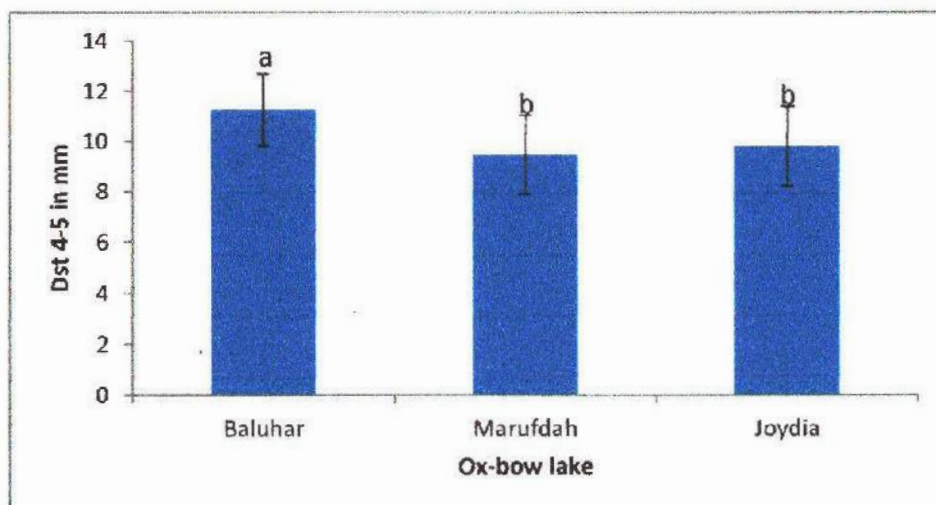


Fig 35: Comparison of Dst 4-5 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

4.2.12.10. Dst 5-6

The Dst 5-6 was the measurement of distance from the point 5 to 6 shown in fig 14. The graphs express that there was significant difference (fig. 36) in the parameter of dst 5-6 between three groups ($F_{(2,87)} = 11.055$, $p=0.000$).

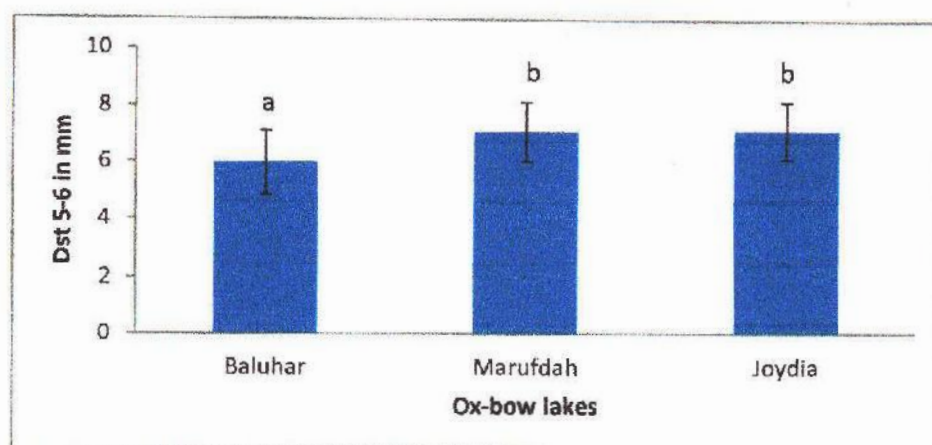


Fig 36: Comparison of Dst 5-6 of mola (*A. mola*) among the three stocks (Baluhar, Marufdah and Joydia). Values represent the mean $\pm$ SD. Different letters on the bars indicate that the means are significantly different

Table 4 shows all truss networking data together with variation level. Univariate statistics (ANOVA) reveal that nine truss measurements were significantly different ($P<0.05$) among the samples in varying degrees

Table 4: Nine truss measurements of networking characters of *A. mola*.

S. No.	Characters	F	df1	df2	Sig.
1	DST 1-2	7.077	2	87	0.001*
2	DST 1-5	25.055	2	87	0.000*
3	DST 1-6	18.265	2	87	0.000*
4	DST 2-3	18.866	2	87	0.000*
5	DST 2-5	37.454	2	87	0.000*
6	DST 2-6	41.781	2	87	0.000*
7	DST 3-4	2.135	2	87	0.124
8	DST 3-6	8.720	2	87	0.000*
9	DST 4-5	11.501	2	87	0.000*
10	DST 5-6	11.055	2	87	0.000*

* $p<0.05$

Chapter 5

5. Discussion

5.1. Meristic counts

Among the three stocks, it's clear that there were no significant differences in any meristic data that were measured in this study. Meristic characters are the numbers of discrete, serially repeated, countable structures like fin rays (Islam *et al.*, 2018). In the present study, dorsal fin rays were ranged from 7 to 8, anal fin rays ranged from 6 to 7, pectoral fin rays ranged from 13 to 15 and caudal fin rays ranged from 17 to 19. The result is similar to that reported for *T. vittata* by Utayopas (2001). The mean number of dorsal fin rays, anal fin rays, pectoral fin rays, caudal fin were the same among the populations and showed no significant difference ($p>0.05$). Fin rays of same species did not differ much. The fairly constant value of fin rays among the populations showed similarity with the finding of Cakmak *et al.* (2010). This was happened as the species were collected having same type of environmental factors such as pH, water temperature, heritability so it was not significantly different (Treer, 1993).

5.1. Morphometric measurements

In the present study, significant morphological differences were found in the three isolated stocks. Among the eleven morphometric measurements, nine were found to be significantly different. Almost same result was found in the stocks of *Amblygaster clupeioides* (Hanif *et al.*, 2019). Morphometric differences between the stocks were expected, because they were geographically separated and the water quality and availability of food, nutrient may not same. Fish are very sensitive to environmental changes and thus quickly adapt themselves by changing necessary morphometrics. It is well-known that morphological characters can show high plasticity in response to differences in environmental conditions, such as food abundance and temperature (Allendorf *et al.*, 1987; Swain *et al.*, 1991; Wimberger *et al.*, 1992).

The Baluhar, Marufdah and Joydia baor are close enough but they are totally isolated. There is no connection among them although the meristic counts of fishes were the same, which mainly depend on species and their origin. On the other hand, morphometric measurements can be different by environmental changes. These are valuable for changing the morphology (Allendorf *et al.*, 1987). The phenotypic plasticity of fish is very high. They adapt quickly by modifying their physiology and behavior to environmental changes (Hossain *et al.*, 2010).

Among the ten truss measurements, nine were found to be significantly different with each other. For identifying the phenotypic traits of fish species, truss are widely used (Turan *et al.*, 2004). Besides, food availability, distance, genetic variation and others environmental factors were responsible for the significant differences. Environmentally induced phenotypic variations however, may have advantages in the stock structure analysis of exploited species, especially when the time is insufficient for significant genetic differentiation to accumulate among populations.

Current study was not designed to examine the real cause due to which morphological variation occurs in unlike stocks of identical species and to determine whether the morphological differences are environmentally induced or due to genetic factors or both. Investigation to this regard may be initiated on the basis of the present findings, But we can draw a decision that as the stocks having same characteristics within groups and not much difference was found also, it should be kept under consideration that meristic counts were not significantly different ($P>0.05$), so it can be an environmental effect that brought change among the stocks.

Chapter 6

6. Conclusion

Morphometric and meristic data variations indicate the difference between the same species in three isolated stocks. Stable information and research of stock structure are essential for balanced exploitation, selection and breeding, habitat restoration, management and conservation of species, subspecies, stocks and races. The present study based on truss morphometric technique exposed a clear variation in different stocks of Baluhar, Marufdah and Joydia Baor. This study enabled a better management of species subunits and ensures better management of the fishery resources. A univariate analysis of eleven morphometrics with ten truss measurements were studied and found nine significant different except standard length (SL), pre-dorsal length (PDL) and in truss measurements all measurements were significantly different except DST 3-6 and no difference was found in meristic counts among the stocks. As there are differences found among the stocks, it is clear that there are some changes in the environment or genetically diversified. This study is a preliminary step for future study about difference of *A. mola* in different stocks. More works, especially genetic studies and research on the effects of environmental factors is needed for preservation of genepool and mass production of this SIS and nutritionally important aquaculture species, *A. mola* to a greater extent.

Chapter 7

7. Reference

- Ahamed, G. S., Alam, M. T., Kanti, S., Mazumder, M. I., Rashid, A., & Dey, T. (2019). Present status of oxbow lake fisheries: Cases from south-western Bangladesh. *International Journal of Fisheries and Aquatic Studies*, 7(5), 451-458.
- Ahammad, A. S., Ahmed, M. B. U., Akhter, S., & Hossain, M. K. (2018). Landmark-based morphometric and meristic analysis in response to characterize the wild Bhagna, *Labeo ariza* populations for its conservation. *Journal of the Bangladesh Agricultural University*, 16(1), 164-170.
- Allendorf, F. W., Ryman, N., Ulter, F. M. (1987). Genetics and fishery management: past, present, and future. *Population Genetics & Fishery Management*. University of Washington press, London.
- Allendorf, F. W., & Phelps, S. R. (1980). Loss of genetic variation in a hatchery stock of cutthroat trout. *Transactions of the American Fisheries Society*, 109(5), 537-543.
- Amin, R., Ahammad, S., Amin, H. A., Mehbub, F., & Uddin-miah, M., (2008). Biodiversity study of SIS (Small Indigenous Species) of fish in Northwest part of Bangladesh and detection of threatened species. *Biological Diversity and Conservation*. 3(1), 56-65.
- Çakmak, E., & Alp, A. (2010). Morphological differences among the Mesopotamian spiny eel, *Mastacembelus mastacembelus* (Banks & Solander 1794), populations. *Turkish Journal of Fisheries and Aquatic Sciences*, 10(1), 87-92.
- Cavalcanti, M. J., Monteiro, L. R., & Lopes, P. R. (1999). Landmark-based morphometric analysis in selected species of serranid fishes (Perciformes: Teleostei). *Zoological Studies*, 38(3), 287-294.
- Das, S. M., & Moitra, S. K. (1963). Studies on the food and feeding habits of some fresh water fishes of India. 4. Review on the food and feeding habits, with general conclusions. *Ichthyologica*, 2, 107-115.
- DoF (2018). *Yearbook of Fisheries Statistics of Bangladesh, 2017-18*. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh: Ministry of Fisheries, 2018. Volume 35: P. 129.

- FAO (2018). *The State of World Fisheries and Aquaculture*. Part 1-world review. Food and Agriculture Organization of the United Nations, Rome. P. 16
- Felts, R. A., Rajts, F., & Akhteruzzaman, M. (1996). Small indigenous fish species culture in Bangladesh (Technical Brief), IF ADEP sub-project-2. *Development of Inland Fisheries*, 41.
- Gain, D., Mahfuj, M. S., Huq, K. A., Islam, S. S., Minar, M. H., Goutham-Bharathi, M. P., & Das, S. K. (2017). Landmark-based Morphometric and Meristic Variations of Endangered Mrigal Carp, *Cirrhinus cirrhosus* (Bloch 1795), from Wild and Hatchery Stocks. *Sains Malaysiana*, 46(5), 695-702.
- Gogoi, R., & Goswami, U. C. (2015). Morphometric and meristic study of *Amblypharyngodon mola* (Ham-Buch) from different habitats of Assam. *Annals of Biological Research*, 6(2), 10-14.
- Gupta, S. Banerjee S.(2013). Fecundity study of *Amblypharyngodon mola* (Ham.-Buch., 1822) from an undisturbed wetland of West Bengal. *Fishing Chimes*, 33(6), 67-69.
- Hanif, M. A., Siddik, M. A., Islam, M. A., Chaklader, M. R., & Nahar, A. (2019). Multivariate morphometric variability in sardine, *Amblygaster clupeioides* (Bleeker, 1849), from the Bay of Bengal coast, Bangladesh. *The Journal of Basic and Applied Zoology*, 80(1), 53.
- Hossain, M. A., Nahiduzzaman, M., Saha, D., Khanam, M. U. H., & Alam, M. S. (2010). Landmark-based morphometric and meristic variations of the endangered Carp, Kalibaus *Labeo calbasu*, from stocks of two isolated rivers, the Jamuna and Halda, and a hatchery. *Zoological Studies*, 49(4), 556-563.
- Hossen, M. B., Sharker, M. R., Rahman, M. A., & Hoque, M. S. (2017). Morphometric and Meristic Variation of Indigenous and Thai Koi, *Anabas testudineus* Available in Coastal Region of Bangladesh. *International Journal of Innovative Research*, 2(1), 01-08.
- Islam, M. S., Hossain, M. A. R., Islam, M. S., Akand, M. K. H., & Utsa, S. S. (2018). Morphometric, meristic and landmark-based analysis of a rare croaking gourami, *Trichopsis vittata*. *Bangladesh Journal of Fisheries*, 30(1), 83-90.

- Khan, M. A., Miyan, K., Khan, S., Patel, D. K., & Ansari, N. G. (2012). Studies on the elemental profile of otoliths and truss network analysis for stock discrimination of the threatened stinging catfish *Heteropneustes fossilis* (Bloch 1794) from the Ganga River and its tributaries. *Zoological Studies*, 51(7), 1195-1206.
- Kongsbak, K., Thilsted, S. H., & Wahed, M. A. (2008). Effect of consumption of the nutrient-dense, freshwater small fish *Amblypharyngodon mola* on biochemical indicators of vitamin A status in Bangladeshi children: a randomised, controlled study of efficacy. *British Journal of Nutrition*, 99(3), 581-597.
- Mahfuj, M., Khatun, A., Boidya, P., & Samad, M. (2019). Meristic and morphometric variations of barred spiny eel (*Macrogynathus pancalus*) populations from Bangladeshi freshwaters: an insight into landmark-based truss network system. *Croatian Journal of Fisheries*, 77(1), 7-18.
- Mamun, A., Tareq, K. M. A., & Azadi, M. A. (2004). Food and Feeding Habits of *Amblypharyngodon mola* (Hamilton) from Kap tai Reservoir, Bangladesh. *Pakistan Journal of Biological Sciences*, 7(4), 584-588.
- Mollah, M. F. A., Yeasmine, S., Hossen, M. B., & Ahammad, A. K. S. (2012). Landmark-based morphometric and meristic variations of *Glossogobius giuris* in three stocks. *Journal of the Bangladesh Agricultural University*, 10(2), 375-384.
- Mondal, D. K., & Kaviraj, A. (2013). Feeding and reproductive biology of *Amblypharyngodon mola* (Cypriniformes: Cyprinidae) from two floodplain lakes of India. *International Journal of Aquatic Biology*, 1(3), 125-131.
- Mookherjee, H. K., & Basu, S. P. (1946). Life history of *A. mola* (Ham.) a delicate food fish of Bengal. *Science and Culture, Calcutta*, 12, 54-56.
- Park, I. S., Nam, Y. K., Douglas, S. E., Johnson, S. C., & Kim, D. S. (2003). Genetic characterization, morphometrics and gonad development of induced interspecific hybrids between yellowtail flounder, *Pleuronectes ferrugineus* (Storer) and winter flounder, *Pleuronectes americanus* (Walbaum). *Aquaculture Research*, 34(5), 389-396.

- Pishka, R. S., Swamy, B. R., & Devi, P. I. (1991). Food and feeding habits of freshwater cypnnid, *Amblypharyngodon mola* (Ham.). *Indian Journal of Fisheries*, 38(2), 126-128.
- Rahman, M. M., Sharker, M. R., Sumi, K. R., Alam, M. A., & Hossen, M. S. (2014). Landmark-based morphometric and meristic variations of stinging catfish, *Heteropneustes fossilis* (Bloch) among three isolated stocks, the Old Brahmaputra river and the Tanguar haor and a hatchery. *International Journal of Fisheries and Aquatic Studies*, 1(3), 163-170.
- Solomon, S. E., Rabeling, C., Sosa-Calvo, J., Lopes, C. T., Rodrigues, A., Vasconcelos, H. L. Bacci Jr, M., Mueller, U.G. & Schultz, T. R. (2019). The molecular phylogenetics of *Trachymyrmex Forel* ants and their fungal cultivars provide insights into the origin and coevolutionary history of 'higher-attine' ant agriculture. *Systematic Entomology*, 44(4), 939-956.
- Strauss, R. E., & Bookstein, F. L. (1982). The truss: body form reconstructions in morphometrics. *Systematic Biology*, 31(2), 113-135.
- Swain, D. P., Riddell, B. E., & Murray, C. B. (1991). Morphological differences between hatchery and wild populations of coho salmon (*Oncorhynchus kisutch*): environmental versus genetic origin. *Canadian Journal of Fisheries and Aquatic Sciences*, 48(9), 1783-1791.
- Thilsted, S. H., Roos, N., & Hassan, N. (1997). The role of small indigenous fish species in food and nutrition security in Bangladesh. *Naga, the International Center for Living Aquatic Resources Management quarterly*, 20(3-4), 82-84.
- Treer, T. (1993). The use of meristic and morphometric characteristics indifferntiation of fish populations. *Croatian Journal of Fisheries: Ribarstvo*, 48(1), 13-27.
- Turan, C., Ergüden, D., Gürlek, M., Başusta, N., & Turan, F. (2004). Morphometric structuring of the anchovy (*Engraulis encrasicolus* L.) in the Black, Aegean and Northeastern Mediterranean Seas. *Turkish journal of veterinary and animal sciences*, 28(5), 865-871.

- Turan, C., Oral, M., Öztürk, B., & Düzgüneş, E. (2006). Morphometric and meristic variation between stocks of Bluefish (*Pomatomus saltatrix*) in the Black, Marmara, Aegean and northeastern Mediterranean Seas. *Fisheries Research*, 79(1-2), 139-147.
- Utayopas, P. (2001). Fluctuating asymmetry in the flying barb (*Esomus metullicus*), the striped croaking gourami (*Trichopsis vittatus*) and the three-spot gourami (*Trichogaster trichopterus*) when exposed to insecticide residues in the lime orchard. *Science & Technology Asia*, 21-26.
- Wimberger, P. H. (1992). Plasticity of fish body shape. The effects of diet, development, family and age in two species of Geophagus (Pisces: Cichlidae). *Biological Journal of the Linnean Society*, 45(3), 197-218.
- Zafri, A., & Ahmed, K. (1981). Studies on the vitamin A content of fresh water fishes: content and distribution of vitamin A in mola (*Amblypharyagodon mola*) and dhela (*Rohde cotio*). *Bangladesh Journal of Biological Science*, 10, 47-53.

Chapter 8

8. Annex

Descriptive Statistics: W (g), TL (mm)

Variable	Stocks	Total Count	Mean	SE Mean	StDev	Minimum	Median	Maximum	Range
W (g)	Hatchery	30	63.70	2.58	14.13	40.14	65.32	91.69	51.55
	Nature	30	12.281	0.576	3.157	6.660	11.905	20.760	14.100
TL (mm)	Hatchery	30	151.66	2.43	13.31	127.53	152.79	175.43	47.90
	Nature	30	88.55	1.45	7.96	69.76	88.91	105.96	36.20

Descriptive Statistics: Dorsal Fin rays, Anal Fin rays, Pectoral fin rays, Caudal fin rays

Variable	Ox-bow lake Name	Mean	SE Mean	StDev	Minimum	Maximum
Dorsal fin rays	Boluhor	7.9000	0.0557	0.3051	7.0000	8.0000
	Joydia	7.9333	0.0463	0.2537	7.0000	8.0000
	Marufdah	7.9000	0.0557	0.3051	7.0000	8.0000
Anal fin rays	Boluhor	6.0667	0.0463	0.2537	6.0000	7.0000
	Joydia	6.1000	0.0557	0.3051	6.0000	7.0000
	Marufdah	6.1000	0.0557	0.3051	6.0000	7.0000
Pectoral fin rays	Boluhor	14.467	0.133	0.730	13.000	15.000
	Joydia	14.233	0.164	0.898	13.000	15.000
	Marufdah	14.400	0.132	0.724	13.000	15.000
Caudal fin rays	Boluhor	18.900	0.0557	0.305	18.000	19.000
	Joydia	18.867	0.0793	0.434	17.000	19.000
	Marufdah	18.867	0.0926	0.507	17.000	19.000

Kruskal-Wallis Test: Dorsal Fin rays versus Ox-bow lake Name

Kruskal-Wallis Test on Dorsal fin rays

Ox-bow lake Name	N	Median	Ave Rank	Z
Boluhor	30	8.000	45.0	-0.13
Joydia	30	8.000	46.5	0.26
Marufdah	30	8.000	45.0	-0.13
Overall	90		45.5	

H = 0.07 DF = 2 P = 0.968

H = 0.27 DF = 2 P = 0.873 (adjusted for ties)

Kruskal-Wallis Test: Anal fin rays versus ox-bow lake Name

Kruskal-Wallis Test on Anal fin rays

Ox-bow lake Name	N	Median	Ave Rank	Z
Boluhor	30	6.000	44.5	-0.26
Joydia	30	6.000	46.0	0.13
Marufdah	30	6.000	46.0	0.13
Overall	90		45.5	

H = 0.07 DF = 2 P = 0.968
H = 0.27 DF = 2 P = 0.873 (adjusted for ties)

Kruskal-Wallis Test: Pectoral fin rays versus ox-bow lake Name

Kruskal-Wallis Test on Pectoral fin rays

Ox-bow lake Name	N	Median	Ave Rank	Z
Boluhor	30	15.00	48.2	0.70
Joydia	30	15.00	42.5	-0.78
Marufdah	30	15.00	45.8	0.08
Overall	90		45.5	

H = 0.74 DF = 2 P = 0.692
H = 0.92 DF = 2 P = 0.633 (adjusted for ties)

Kruskal-Wallis Test: Caudal fin rays versus ox-bow lake Name

Kruskal-Wallis Test on Caudal fin rays

Ox-bow lake Name	N	Median	Ave Rank	Z
Boluhor	30	19.00	45.1	-0.09
Joydia	30	19.00	45.0	-0.12
Marufdah	30	19.00	46.3	0.21
Overall	90		45.5	

H = 0.05 DF = 2 P = 0.977
H = 0.19 DF = 2 P = 0.910 (adjusted for ties)

Morphometric and landmark distances

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Adj ST	Between Groups	3.460	2	1.730	2.074	0.132
	Within Groups	72.566	87	0.834		
	Total	76.026	89			
Adj PDL	Between Groups	1.792	2	0.896	0.958	0.388
	Within Groups	81.379	87	0.935		
	Total	83.170	89			
Adj PAL	Between Groups	23.748	2	11.874	10.508	0.000
	Within Groups	98.308	87	1.130		
	Total	122.056	89			
Adj PEL	Between Groups	43.484	2	21.742	10.010	0.000
	Within Groups	188.972	87	2.172		
	Total	232.456	89			
Adj PEC	Between Groups	26.632	2	13.316	20.916	0.000
	Within Groups	55.388	87	0.637		



	Total	82.020	89			
Adj FL	Between Groups	6.092	2	3.046	4.185	0.018
	Within Groups	63.320	87	0.728		
	Total	69.412	89			
Adj MBH	Between Groups	120.022	2	60.011	62.476	0.000
	Within Groups	83.568	87	0.961		
	Total	203.589	89			
Adj LBH	Between Groups	.656	2	0.328	4.714	0.011
	Within Groups	6.051	87	0.070		
	Total	6.706	89			
Adj 1-5	Between Groups	136.233	2	68.116	25.055	0.000
	Within Groups	236.522	87	2.719		
	Total	372.755	89			
Adj 1-6	Between Groups	38.519	2	19.260	18.265	0.000
	Within Groups	91.740	87	1.054		
	Total	130.259	89			
Adj 2-5	Between Groups	131.214	2	65.607	37.454	0.000
	Within Groups	152.393	87	1.752		
	Total	283.607	89			
Adj 2-6	Between Groups	58.879	2	29.440	41.781	0.000
	Within Groups	61.302	87	0.705		
	Total	120.181	89			
Adj 3-4	Between Groups	19.060	2	9.530	2.135	0.124
	Within Groups	388.398	87	4.464		
	Total	407.458	89			
Adj 3-6	Between Groups	5.987	2	2.993	8.720	0.000
	Within Groups	29.865	87	0.343		
	Total	35.852	89			
Adj 4-5	Between Groups	53.825	2	26.912	11.501	0.000
	Within Groups	203.582	87	2.340		
	Total	257.406	89			
Adj HL	Between Groups	19.798	2	9.899	29.010	0.000
	Within Groups	29.886	87	0.341		
	Total	49.484	89			
Adj ED	Between Groups	2.374	2	1.187	26.616	0.000
	Within Groups	3.880	87	0.045		
	Total	6.255	89			
Adj POL	Between Groups	2.593	2	1.296	14.700	0.000
	Within Groups	7.672	87	0.088		
	Total	10.265	89			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Stocks	(J) Stocks	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Adj ST	Baluhar	Marufdah	0.46633	0.23581	0.124	-0.0960	1.0286
		Joydia	0.33267	0.23581	0.340	-0.2296	0.8950
	Marufdah	Baluhar	-0.46633	0.23581	0.124	-1.0286	0.0960
		Joydia	-0.13367	0.23581	0.838	-0.6960	0.4286
	Joydia	Baluhar	-0.33267	0.23581	0.340	-0.8950	0.2296
		Marufdah	0.13367	0.23581	0.838	-0.4286	0.6960
Adj PDL	Baluhar	Marufdah	0.33633	0.24972	0.373	-0.2591	0.9318
		Joydia	0.23700	0.24972	0.611	-0.3584	0.8324
	Marufdah	Baluhar	-0.33633	0.24972	0.373	-0.9318	0.2591
		Joydia	-0.09933	0.24972	0.917	-0.6948	0.4961
	Joydia	Baluhar	-0.23700	0.24972	0.611	-0.8324	0.3584
		Marufdah	0.09933	0.24972	0.917	-0.4961	0.6948
Adj PAL	Baluhar	Marufdah	-0.67700*	0.27447	0.041	-1.3315	-0.0225
		Joydia	0.58000	0.27447	0.093	-0.0745	1.2345
	Marufdah	Baluhar	0.67700*	0.27447	0.041	0.0225	1.3315
		Joydia	1.25700*	0.27447	0.000	0.6025	1.9115
	Joydia	Baluhar	-0.58000	0.27447	0.093	-1.2345	0.0745
		Marufdah	-1.25700*	0.27447	0.000	-1.9115	-0.6025
Adj PEL	Baluhar	Marufdah	1.53967*	0.38053	0.000	0.6323	2.4470
		Joydia	0.14033	0.38053	0.928	-0.7670	1.0477
	Marufdah	Baluhar	-1.53967*	0.38053	0.000	-2.4470	-0.6323
		Joydia	-1.39933*	0.38053	0.001	-2.3067	-0.4920
	Joydia	Baluhar	-0.14033	0.38053	0.928	-1.0477	0.7670
		Marufdah	1.39933*	0.38053	0.001	0.4920	2.3067
Adj PEC	Baluhar	Marufdah	1.31300*	0.20602	0.000	0.8218	1.8042
		Joydia	0.85300*	0.20602	0.000	0.3618	1.3442
	Marufdah	Baluhar	-1.31300*	0.20602	0.000	-1.8042	-0.8218
		Joydia	-0.46000	0.20602	0.071	-0.9512	0.0312
	Joydia	Baluhar	-0.85300*	0.20602	0.000	-1.3442	-0.3618
		Marufdah	0.46000	0.20602	0.071	-0.0312	0.9512
Adj FL	Baluhar	Marufdah	-0.54700*	0.22027	0.039	-1.0722	-0.0218
		Joydia	-0.55667*	0.22027	0.035	-1.0819	-0.0314
	Marufdah	Baluhar	0.54700*	0.22027	0.039	0.0218	1.0722
		Joydia	-0.00967	0.22027	0.999	-0.5349	0.5156
	Joydia	Baluhar	0.55667*	0.22027	0.035	0.0314	1.0819
		Marufdah	-0.00967	0.22027	0.999	-0.5349	0.5156

		Marufdah	0.00967	0.22027	0.999	-0.5156	0.5349
Adj MBH	Baluhar	Marufdah	-2.57933 [*]	0.25305	0.000	-3.1827	-1.9759
		Joydia	-0.28400	0.25305	0.503	-0.8874	0.3194
	Marufdah	Baluhar	2.57933 [*]	0.25305	0.000	1.9759	3.1827
		Joydia	2.29533 [*]	0.25305	0.000	1.6919	2.8987
	Joydia	Baluhar	0.28400	0.25305	0.503	-0.3194	0.8874
		Marufdah	-2.29533 [*]	0.25305	0.000	-2.8987	-1.6919
Adj LBH	Baluhar	Marufdah	-0.14167	0.06809	0.100	-0.3040	0.0207
		Joydia	-0.20400 [*]	0.06809	0.010	-0.3664	-0.0416
	Marufdah	Baluhar	0.14167	0.06809	0.100	-0.0207	0.3040
		Joydia	-0.06233	0.06809	0.632	-0.2247	0.1000
	Joydia	Baluhar	0.20400 [*]	0.06809	0.010	0.0416	0.3664
		Marufdah	0.06233	0.06809	0.632	-0.1000	0.2247
Adj 1-5	Baluhar	Marufdah	-3.00833 [*]	0.42573	0.000	-4.0235	-1.9932
		Joydia	-1.65933 [*]	0.42573	0.001	-2.6745	-0.6442
	Marufdah	Baluhar	3.00833 [*]	0.42573	0.000	1.9932	4.0235
		Joydia	1.34900 [*]	0.42573	0.006	0.3339	2.3641
	Joydia	Baluhar	1.65933 [*]	0.42573	0.001	0.6442	2.6745
		Marufdah	-1.34900 [*]	0.42573	0.006	-2.3641	-0.3339
Adj 1-6	Baluhar	Marufdah	-1.20367 [*]	0.26514	0.000	-1.8359	-0.5714
		Joydia	0.31433	0.26514	0.465	-0.3179	0.9466
	Marufdah	Baluhar	1.20367 [*]	0.26514	0.000	0.5714	1.8359
		Joydia	1.51800 [*]	0.26514	0.000	0.8858	2.1502
	Joydia	Baluhar	-0.31433	0.26514	0.465	-0.9466	0.3179
		Marufdah	-1.51800 [*]	0.26514	0.000	-2.1502	-0.8858
Adj 2-5	Baluhar	Marufdah	-2.95700 [*]	0.34173	0.000	-3.7718	-2.1422
		Joydia	-1.53133 [*]	0.34173	0.000	-2.3462	-0.7165
	Marufdah	Baluhar	2.95700 [*]	0.34173	0.000	2.1422	3.7718
		Joydia	1.42567 [*]	0.34173	0.000	0.6108	2.2405
	Joydia	Baluhar	1.53133 [*]	0.34173	0.000	0.7165	2.3462
		Marufdah	-1.42567 [*]	0.34173	0.000	-2.2405	-0.6108
Adj 2-6	Baluhar	Marufdah	-1.80233 [*]	0.21674	0.000	-2.3191	-1.2855
		Joydia	-0.18867	0.21674	0.660	-0.7055	0.3281
	Marufdah	Baluhar	1.80233 [*]	0.21674	0.000	1.2855	2.3191
		Joydia	1.61367 [*]	0.21674	0.000	1.0969	2.1305
	Joydia	Baluhar	0.18867	0.21674	0.660	-0.3281	0.7055
		Marufdah	-1.61367 [*]	0.21674	0.000	-2.1305	-1.0969
Adj 3-4	Baluhar	Marufdah	1.06367	0.54555	0.131	-0.2372	2.3645
		Joydia	0.20867	0.54555	0.923	-1.0922	1.5095
	Marufdah	Baluhar	-1.06367	0.54555	0.131	-2.3645	0.2372
		Joydia	-0.85500	0.54555	0.265	-2.1558	0.4458

	Joydia	Baluhar	-0.20867	0.54555	0.923	-1.5095	1.0922
		Marufdah	0.85500	0.54555	0.265	-0.4458	2.1558
Adj 3-6	Baluhar	Marufdah	-0.63100*	0.15128	0.000	-0.9917	-0.2703
		Joydia	-0.34233	0.15128	0.067	-0.7031	0.0184
	Marufdah	Baluhar	0.63100*	0.15128	0.000	0.2703	0.9917
		Joydia	0.28867	0.15128	0.142	-0.0721	0.6494
	Joydia	Baluhar	0.34233	0.15128	0.067	-0.0184	0.7031
		Marufdah	-0.28867	0.15128	0.142	-0.6494	0.0721
Adj 4-5	Baluhar	Marufdah	1.78133*	0.39497	0.000	0.8395	2.7231
		Joydia	1.44867*	0.39497	0.001	0.5069	2.3905
	Marufdah	Baluhar	-1.78133*	0.39497	0.000	-2.7231	-0.8395
		Joydia	-0.33267	0.39497	0.678	-1.2745	0.6091
	Joydia	Baluhar	-1.44867*	0.39497	0.001	-2.3905	-0.5069
		Marufdah	0.33267	0.39497	0.678	-0.6091	1.2745
Adj HL	Baluhar	Marufdah	1.11233*	0.15082	0.000	0.7527	1.4720
		Joydia	0.80500*	0.15082	0.000	0.4454	1.1646
	Marufdah	Baluhar	-1.11233*	0.15082	0.000	-1.4720	-0.7527
		Joydia	-0.30733	0.15082	0.109	-0.6670	0.0523
	Joydia	Baluhar	-0.80500*	0.15082	0.000	-1.1646	-0.4454
		Marufdah	0.30733	0.15082	0.109	-0.0523	0.6670
Adj ED	Baluhar	Marufdah	0.39767*	0.05453	0.000	0.2676	0.5277
		Joydia	0.20933*	0.05453	0.001	0.0793	0.3394
	Marufdah	Baluhar	-0.39767*	0.05453	0.000	-0.5277	-0.2676
		Joydia	-0.18833*	0.05453	0.002	-0.3184	-0.0583
	Joydia	Baluhar	-0.20933*	0.05453	0.001	-0.3394	-0.0793
		Marufdah	0.18833*	0.05453	0.002	0.0583	0.3184
Adj POL	Baluhar	Marufdah	0.37367*	0.07668	0.000	0.1908	0.5565
		Joydia	0.34467*	0.07668	0.000	0.1618	0.5275
	Marufdah	Baluhar	-0.37367*	0.07668	0.000	-0.5565	-0.1908
		Joydia	-0.02900	0.07668	0.924	-0.2118	0.1538
	Joydia	Baluhar	-0.34467*	0.07668	0.000	-0.5275	-0.1618
		Marufdah	0.02900	0.07668	0.924	-0.1538	0.2118

*. The mean difference is significant at the 0.05 level.

Adj ST

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05
		1
Marufdah	30	46.6940
Joydia	30	46.8277
Baluhar	30	47.1603
Sig.		0.124

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj PDL

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05
		1
Marufdah	30	24.7743
Joydia	30	24.8737
Baluhar	30	25.1107
Sig.		0.373

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj PAL

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Joydia	30	31.1767	32.4337
Baluhar	30	31.7567	
Marufdah	30		
Sig.		0.093	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj PEL

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Marufdah	30	22.3413	
Joydia	30		23.7407
Baluhar	30		23.8810
Sig.		1.000	0.928

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj PEC

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Marufdah	30	10.8137	
Joydia	30	11.2737	
Baluhar	30		12.1267
Sig.		0.071	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj FL

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Baluhar	30	50.7347	
Marufdah	30		51.2817
Joydia	30		51.2913
Sig.		1.000	0.999

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj MBH

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Baluhar	30	11.6693	14.2487
Joydia	30	11.9533	
Marufdah	30		
Sig.		0.503	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj LBH

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Baluhar	30	5.1777	5.3193
Marufdah	30	5.3193	
Joydia	30		
Sig.		0.100	0.632

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj 1-5

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05		
		1	2	3
Baluhar	30	35.9533	37.6127	38.9617
Joydia	30			
Marufdah	30			
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj 1-6

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Joydia	30	31.8237	33.3417
Baluhar	30	32.1380	
Marufdah	30		
Sig.		0.465	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj 2-5

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05		
		1	2	3
Baluhar	30	14.1193	15.6507	17.0763
Joydia	30			
Marufdah	30			
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj 2-8

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Baluhar	30	12.6997	14.5020
Joydia	30	12.8883	
Marufdah	30		
Sig.		0.660	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj 3-4

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05
		1
Marufdah	30	13.5513
Joydia	30	14.4063
Baluhar	30	14.6150
Sig.		0.131

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj 3-6

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Baluhar	30	9.6673	
Joydia	30	10.0097	10.0097
Marufdah	30		10.2983
Sig.		0.067	0.142

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.



Adj 4-5

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Marufdah	30	9.4607	
Joydia	30	9.7933	
Baluhar	30		11.2420
Sig.		0.678	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj HL

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Marufdah	30	11.7053	12.8177
Joydia	30	12.0127	
Baluhar	30		
Sig.		0.109	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj ED

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05		
		1	2	3
Marufdah	30	3.9277	4.1160	4.3253
Joydia	30			
Baluhar	30			
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Adj POL

Tukey HSD^a

Stocks	N	Subset for alpha = 0.05	
		1	2
Marufdah	30	1.9133	2.2870
Joydia	30	1.9423	
Baluhar	30		
Sig.		0.924	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

ANOVA

adj12

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19.204	2	9.602	7.077	0.001
Within Groups	118.034	87	1.357		
Total	137.238	89			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: adj12

Tukey HSD

(I) VAR00002	(J) VAR00002	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Baluhar	Marufdah	0.27529	0.30074	0.632	-0.4418	0.9924
	Joydia	-0.81282*	0.30074	0.022	-1.5299	-0.0957
Marufdah	Baluhar	-0.27529	0.30074	0.632	-0.9924	0.4418
	Joydia	-1.08810*	0.30074	0.001	-1.8052	-0.3710
Joydia	Baluhar	0.81282*	0.30074	0.022	0.0957	1.5299

Marufdah	1.08810*	.30074	0.001	0.3710	1.8052
----------	----------	--------	-------	--------	--------

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

adj12

Tukey HSD^a

VAR00002	N	Subset for alpha = 0.05	
		1	2
Marufdah	30	25.5953	26.6834
Baluhar	30	25.8706	
Joydia	30		
Sig.		0.632	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Descriptives

adj23

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
Baluhar	30	7.3199	1.82953	.33402	6.6368	8.0031		

Marufdah	30	10.0146	1.46692	.26782	9.4669	10.5624		
Joydia	30	8.4087	1.80758	.33002	7.7337	9.0837		
Total	90	8.5811	2.02369	.21332	8.1572	9.0049		

Descriptives

adj23

	Minimum	Maximum
Baluhar	3.85	10.24
Marufdah	5.43	12.14
Joydia	4.88	11.03
Total	3.85	12.14

ANOVA

adj23

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	110.260	2	55.130	18.866	0.000
Within Groups	254.225	87	2.922		
Total	364.485	89			

adj23

Tukey HSD^a

VAR00002	N	Subset for alpha = 0.05
----------	---	-------------------------

Joydia	4.94	8.74
Total	3.57	9.24

ANOVA

adj56

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25.526	2	12.763	11.055	0.000
Within Groups	100.441	87	1.154		
Total	125.968	89			

Multiple Comparisons

Dependent Variable: adj56

Tukey HSD

(I) VAR00002	(J) VAR00002	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Baluhar	Marufdah	-1.09555*	0.27743	0.000	-1.7571	-0.4340
	Joydia	-1.16109*	0.27743	0.000	-1.8226	-0.4996
Marufdah	Baluhar	1.09555*	0.27743	0.000	0.4340	1.7571
	Joydia	-0.06554	0.27743	0.970	-0.7271	0.5960
Joydia	Baluhar	1.16109*	0.27743	0.000	0.4996	1.8226
	Marufdah	0.06554	0.27743	0.970	-0.5960	0.7271

*. The mean difference is significant at the 0.05 level.

		1	2	3
Baluhar	30	7.3199		
Joydia	30		8.4087	
Marufdah	30			10.0146
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Descriptives

adj56

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
Baluhar	30	5.9975	1.13323	0.20690	5.5743	6.4207		
Marufdah	30	7.0930	1.06633	0.19468	6.6949	7.4912		
Joydia	30	7.1586	1.02090	0.18639	6.7774	7.5398		
Total	90	6.7497	1.18969	0.12540	6.5005	6.9989		

Descriptives

adj56

	Minimum	Maximum
Baluhar	3.57	8.64
Marufdah	4.46	9.24

Homogeneous Subsets

adj56

Tukey HSD^a

VAR00002	N	Subset for alpha = 0.05	
		1	2
Baluhar	30	5.9975	
Marufdah	30		7.0930
Joydia	30		7.1586
Sig.		1.000	0.970

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.