STUDY OF SOME MORPHOMETRIC CHARACTERS OF CYPRINIDAE FAMILY (ACTINOPTERYGII: CYPRINIFORMES) OF AZAD JAMMU AND KASHMIR, PAKISTAN

Nuzhat Shafi*, Qasam Ali Khan and Tasleem Akhtar

Department of Zoology, University of Azad Jammu and Kashmir, Muzaffarabad, Pakistan
*Corresponding author: nuzhatshafi@gmail.com

ABSTRACT

The morphometric measurements are presented for commercially important Cyprinids species (mahseer, snow trout, silver carp and grass carp) from Muzaffarabad, Azad Kashmir during 2015-2016. The minimum and maximum range, mean, standard deviation, percentage of various parameters in total length and head length were estimated. The correlation was carried out for 16 important characters in relation to total length and head length. The coefficients of correlation (r) for various characters ranged from 0.13 to 0.99 for mahseer, 0.79-0.99 for snow trout, 0.76-1.00 for grass carp and 0.76 to 0.99 for silver carp. This indicates that snow trout, grass carp and silver carp exhibited a high degree of interdependence of the various characters, while mahseer have a lower degree of interdependence. This study may be used as baseline because limited or no information regarding to morphometric measurements of these species is available.

Keywords: Cyprinidae, morphometric characters, correlation coefficient, Azad Kashmir

INTRODUCTION

The family Cyprinidae of order Cypriniformes is one of the most diverse family of freshwater fishes in the world consisting of at least 220 genera and 2,420 species (Sharma *et al*., 2014). They are cosmopolitan in nature, but they are not found in South America, Australia and Antarctica (Mayden *et al*., 2009). These fishes are present in large quantity and are good source of proteins and therefore they are economically important. The family Cyprinidae was divided into 10 subfamilies on the basis of osteological characters and in two tribes Leuciscini and Barbini (Chen *et al*., 1984). Later on, Cyprinid was classified into Labeoninae, Barbinae and Cyprininae and in many tribes and subtribes by Rainboth (1991). Morphometric characters are important for identifying all fish species and their habitat as well as ecological criteria in any stream, lake or sea. It is common to use morphometric measurements for identification and taxonomy of fishes (Saroniya *et al*., 2013). The studies of morphological and meristic characters of a fish give substantial information with regard to exact identification key of the species (Dhanya *et al*., 2004) and such identification is prerequisite for cytogenetic and molecular investigations. Interspecies variation among fishes and other aquatic animals based on morphometric analyses are common (Luthy *et al*., 2005; Conde-Padín *et al*., 2007).

Many fresh water fish species are currently threatened by direct and indirect influence of human activities, such as habitat destruction and fragmentation (Mir *et al*., 2013b). Construction of dams across rivers in particular, affects fish movements, which may restrict the gene flow and lead to differentiation of populations (Meldgaard *et al*. 2003). The anthropogenic disturbances are likely to alter the genetic diversity within populations and genetic differentiation between populations (Yamamoto *et al*., 2004). Study on fish populations is important from various viewpoints including evolution, ecology, behavior, conservation, water resource management and stock assessment (Anvarifa *et al*., 2011). Suitable and successful management of aquatic organisms stock will be gained by study of genetic stocks of endemic species and identification of populations. Data on morphometric measurements are able to identify differences between fish populations and used to describe the shape of each fish (Pollar *et al*., 2007). In addition, environmental explanation of morphometric differences would contribute to our understanding of life models followed by different local populations, thus helping to develop a sound conservation strategy (Liasko *et al*., 2012).

The morphometric relationships between various body parts of fish can be used to assess the wellbeing of individuals and to determine possible difference between separate unit stocks of the same species (King, 2007). Fish are very sensitive to environmental changes and quickly adapt themselves by changing necessary morphometrics (Hossain *et al*., 2010). Information of morphometric measurements of fishes and the study of statistical relationship among them are essential for taxonomic work (Narejo, 2010). The morphometric characterization has been carried out to identify them correctly and to determine the relationship between various characters as well as to estimate various statistical values on the basis of morphometric data. Since these information are vital for the proper

management of the fisheries and for optimum utilization of the resources. Considering the above mentioned facts, the present study was proposed to use a set of morphometric characters of four fish species and consider possible implications for their taxonomy and conservation.

A total of 40 specimens of four species of different size and weights were studied for morphometric characteristics. 16 morphometric characters were studied in present study. Examination of morphometric characters were useful for the identification and phylogenetic analysis of Cyprinidae (Yousuf *et al*., 2003). Present study focus on morphometric count of these selected species because no previous work was done on these aspects from Azad Jammu and Kashmir, Pakistan. The relationship of total length and head length with other external body parts is studied.

MATERIALS AND METHODS

Collection of fish sample

Current study estimates the morphometric characteristics of commercially important cyprinids species from Muzaffarabad Azad Jammu and Kashmir, Pakistan during 2015 to 2016. A total of 40 fish samples were collected from local fisherman of Muzaffarabad. The labeled samples were packed in polyethylene bags and brought back to the Laboratory of Fisheries, University of Azad Jammu and Kashmir for further analysis. Voucher specimens were kept in 70% ethanol and stored in Zoological Museum Hall of the University of Azad Jammu And Kashmir, Pakistan. The collected voucher specimens were recognized according to Mirza (1991) and Jayaram (2010).

Morphometric features

The morphometric feature which studied were total length, fork length, standard length, head length, total weight, pectoral fin length, pelvic fin length, anal fin length, caudal fin length, dorsal fin length, pre dorsal length, pre pectoral length, pre anal length, pre pelvic length, body depth, and eye distance while the meristic feature were; dorsal fin rays, pectoral fin rays, pelvic fin rays, anal fin rays and caudal fin rays. Measurement were made by using board and caliper, length measurement was taken using measuring board in which the anterior extremity of the fish was put against a stop at the beginning of the measuring scale. It was measure in centimeter.

The total length was the greatest length of the fish from its anterior end to the tail-fin. It was measure to the nearest 0.1cm from the tip of the snout (closed) to the extended tip of the caudal fin. The standard length was measured from the tip of the snout to the peduncle of the fish. The head length was measured from the tip of the snout to the operculum. Body weight of the individual fish was measured by weighing balance in grams (g).

RESULTS AND DISCUSSION

Mahseer (*Tor putitora*)

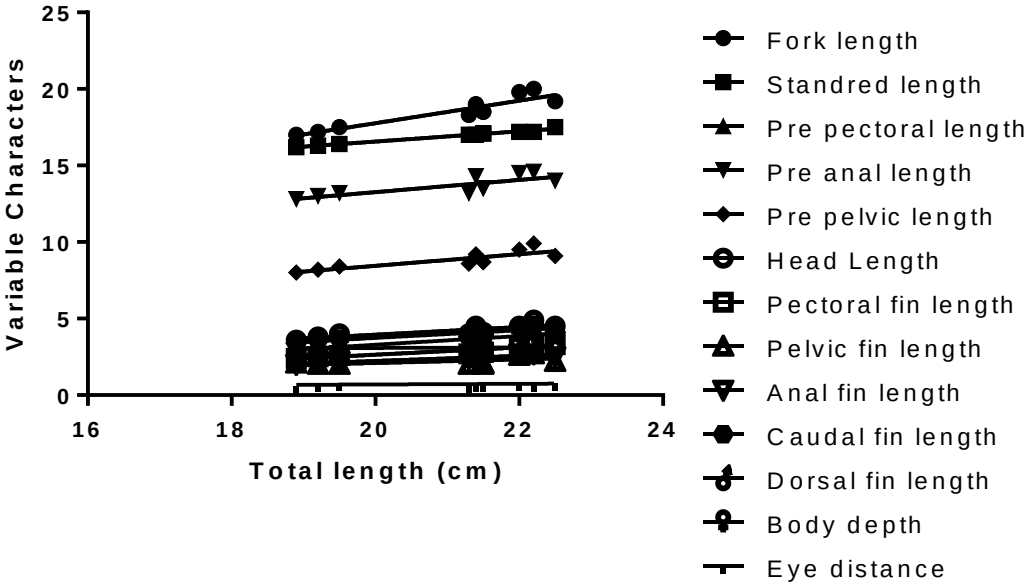
The minimum and maximum total fish length of Mahseer was 18.9 cm and 22.5 cm with mean ± standard deviation = 21 ± 1.30. The mean percentage of fork length, standard length, body depth and head length, 88.09, 80.47, 3.58 and 20 respectively, in total length mean percentage. The total length percentage quotient shows that fork length, standard length, body depth and head length is 1.13, 1.24, 27.93 and 5 time in total length, respectively. The mean percentage of pectoral fin length, pelvic fin length, anal fin length, caudal fin length and dorsal fin length is 13.71, 10.57, 11.42, 19 and 14.76, respectively, in total length mean percentage. The total length percentage quotient shows that of pectoral fin length, pelvic fin length, anal fin length, caudal fin length and dorsal fin length is 7.29, 9.46, 8.75 and 6.77 time in total length, respectively.

Similarly, the mean percentage of pre dorsal, pre pectoral, pre anal and pre pelvic length is 41, 19.38, 65.04 and 42.04 respectively, in total length mean percentage. The total length percentage quotient shows that pre dorsal, pre pectoral, pre anal and pre pelvic length is 2.41, 5.15, 1.53 and 1.29 respectively, in total length mean percentage.

In Mahseer, the coefficient correlation of fork length (0.926), standard length (0.993), pre pectoral length (0.925), pre anal length (0.948), Anal fin length (0.910) and pre dorsal length (0.906) show the high Co-efficient Correlation in relation to total length. The characters like Pectoral fin length (0.887), values of body depth (0.892) pre-pelvic length (0.837), snout length (0.838), head length (0.823) and Caudal fin length (0.806) show moderate correlation coefficient while, head depth (0.607), Pelvic fin length (0.552) eye distance (0.356) and Dorsal fin length (0.139) in the percentage of total fish length show least correlation coefficient.

Similarly, the characters like fork length (0.947), body depth (0.962), snout length (0.987), length of pectoral fin (0.975), anal fin length (0.932), Caudal fin length (0.961), pre dorsal length (0.930), pre pelvic length (0.981), pre pectoral length (0.961) and pre anal length (0.965) show the high, Pelvic fin length (0.838) and standard length (0.780) show the moderate and Dorsal fin length (0.225) and eye distance (0.395) show the least coefficient

correlation in relation to head length (Fig. 1 a & b). The Himalayan mahseer exhibited slow growth coefficient in the population. Analysis of the decadal trends revealed that asymptotic length decreased continuously with the passage of time (Nautiyal *et al*., 2008).



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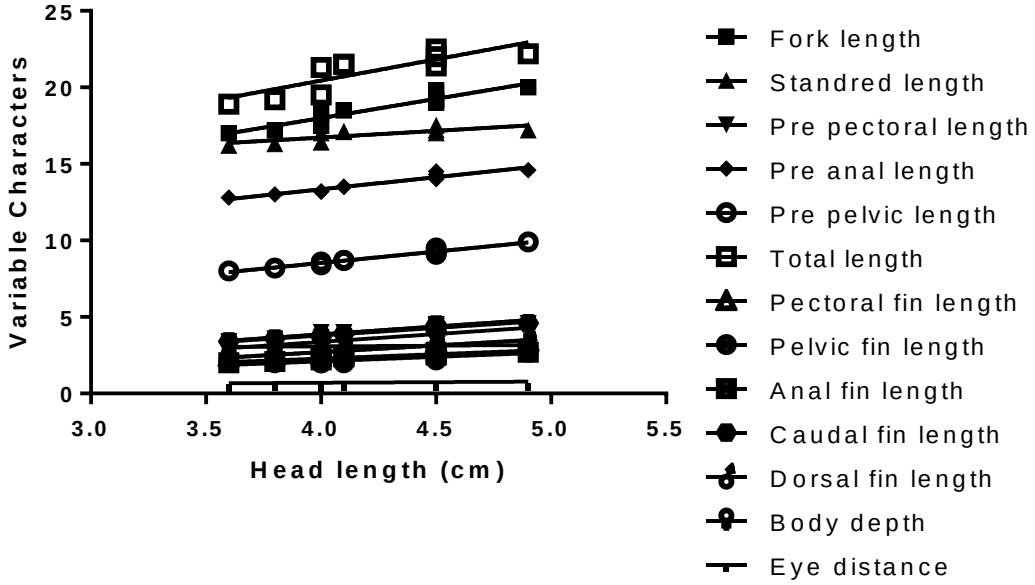

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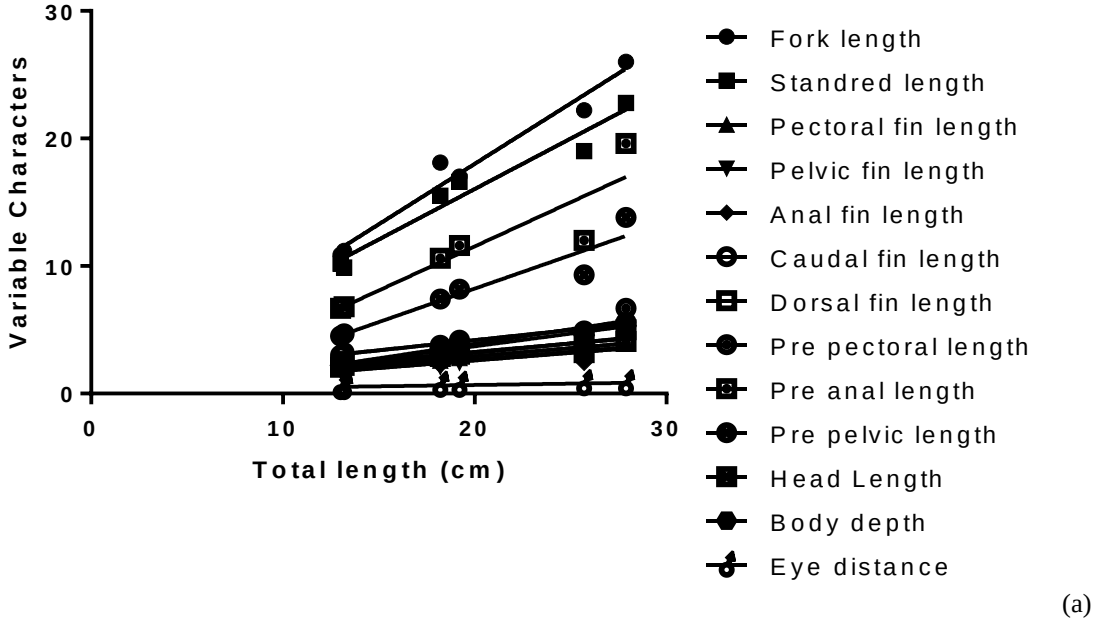
Fig 1. Relationship of various morphometric measurements compared with Total length (a) and head length (b) of mahseer.

Snow trout (*Schizothorax plagiostomus*)

In snow trout, the minimum and maximum length was 13 cm and 27.9 cm with mean ± standard deviation =19.53 ± 6.20. The mean percentage of fork length, standard length, body depth and head length is 89.9, 80.18, 18.48 and 15.87 respectively, in total length mean percentage. The total length percentage quotient shows that fork

length, standard length, body depth and head length is 1.11, 1.24, 5.41 and 6.30 time in total length, respectively. The mean percentage of pectoral fin length, pelvic fin length, anal fin length, caudal fin length and dorsal fin length is 14.64, 13.05, 13.31, 21.04 and 16.38 respectively in total length mean percentage. The total length percentage quotient shows that of pectoral fin length, anal fin length, caudal fin length and dorsal fin length is 6.83, 7.66, 7.51 and 6.10 time in total length, respectively.



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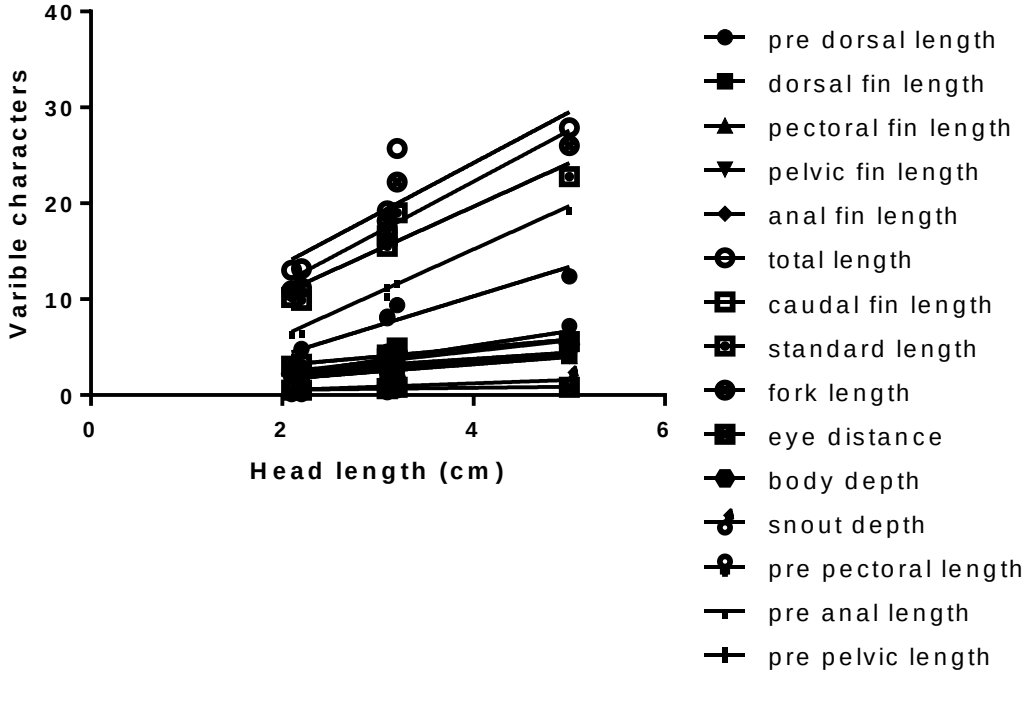


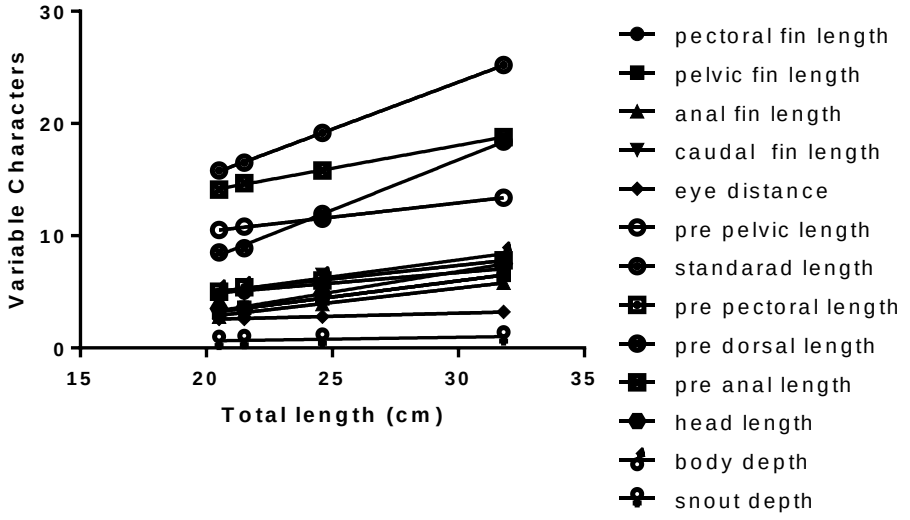
(b)

Fig 2. Relationship of various morphometric measurements compared with Total length (a) and head length (b) in snow trout.

The mean percentage of pre dorsal, pre pectoral, pre anal and pre pelvic length is 38.91, 19.45, 58.01 and 40.45, respectively in total length mean percentage. The total length percentage quotient shows that pre dorsal, pre pectoral, pre anal and pre pelvic length is 2.57, 5.14, 1.72 and 2.47 respectively in total length mean percentage.

In snow trout, the coefficient of correlation (r) of fork length (0.984), standard length (0.977), pre-anal length (0.909), snout length (0.908), pre-dorsal length (0.944), pre-pelvic length (0.948), values of body depth (0.984), eye distance (0.987), Pectoral fin length (0.987), Dorsal fin length (0.968), Caudal fin length (0.986), eye distance (0.987) showed high while, head length (0.888), Pelvic fin length (0.887), pre pectoral length (0.884), anal fin length (0.794) indicate moderate coefficient correlation in relation to total length.

Similarly, the variables like fork length (0.928), standard length (0.938), body depth (0.918), snout length (0.987), length of pectoral fin (0.930), Dorsal fin length (0.968), Pelvic fin length (0.952), anal fin length (0.961), Caudal fin length (0.986), pre dorsal length (0.939), pre pelvic length (0.985), pre pectoral length (0.994), pre-anal length (0.996) show high while, Dorsal fin length (0.796) show moderate coefficient correlation in relation to head length (Fig. 2 a & b). Mir *et al*. (2013a) observed that that in *S. plagiostomus* the morphometric variations were present may be due to different current pattern in different water bodies.



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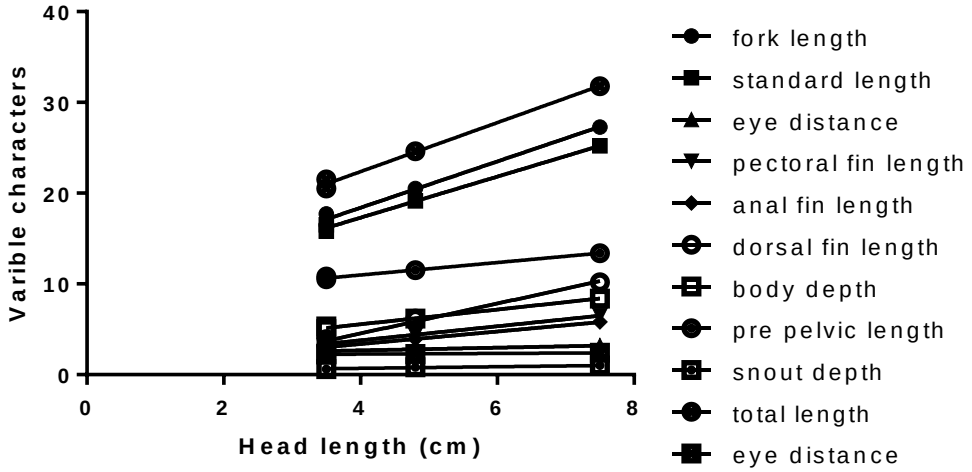

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Fig 3. Relationship of various morphometric measurements compared with Total length (a) and Head length (b) in Grass carp.

Grass carp (*Cetenopharynoodon idella*)

The minimum and maximum length of grass carp was 20.5 cm and 31.8 cm and its mean ± standard deviation = 24.6±5.10. The mean percentage of fork length, standard length, body depth and head length is 83.33, 78.33, 25.20, and 19.51 respectively in total length mean percentage. The total length percentage quotient shows that fork length, standard length, body depth and head length is 1.2, 1.27, 3.96 and 5.09 time in total length, respectively. The mean percentage of pectoral fin length, anal fin length, caudal fin length and dorsal fin length is, 17.96, 16.05, 24.39 and 13.29 respectively in total length mean percentage. The total length percentage quotient shows that of pectoral fin length, anal fin length, caudal fin length and dorsal fin length is 5.56, 6.23, 4.10, and 7.52 time in total length respectively. The mean percentage of pre dorsal, pre pectoral, pre anal and pre pelvic length is 55.06, 24.59, 64.3 and 46.74 respectively in total length mean percentage. The total length percentage quotient shows that pre dorsal, pre pectoral, pre anal and pre pelvic length is, 1.81, 4.06, 1.55, and 2.13 respectively in total length mean percentage. In grass carp, the coefficient correlation of all the characters like fork length (0.999), standard length (0.999), pre pectoral length (0.998), pre anal length (0.999), pre dorsal length (0.999), pre pelvic length (0.999), Pectoral fin length (0.999), Dorsal fin length (0.998) Pelvic fin length (0.988), anal fin length (0.996), values of body depth (0.999), eye distance (0.996), Caudal fin length (0.988) snout length (0.982) show the high coefficient correlation except the head length (0.886) which show the moderate correlation in relation to total length.

Similarly, the characters like fork length (0.994), standard length (0.997), body depth (0.996), snout length (0.965), length of pectoral fin (0.993), anal fin length (0.987), Caudal fin length (0.988), pre pelvic length (0.995), pre pectoral length (0.991), pre anal length (0.993), eye distance, (1.00) and Dorsal fin length (0.994) show high coefficient correlation except the Pelvic fin length (0.838) and pre dorsal length (0.830) (Fig. 3 a & b). These two characters show the moderate coefficient correlation in relation to head length. From correlation coefficient value 'r' it is clear that the biological relationship among different morphometric characters of grass carp is highly significant indicating that these morphometric characters increase in direct proportion. While, Mir (2015) reported that the *Cetenopharynoodon* (grass carp) of India does not follow an isometric growth pattern and the relationship between different morphometric characteristics deviate from cubes law.

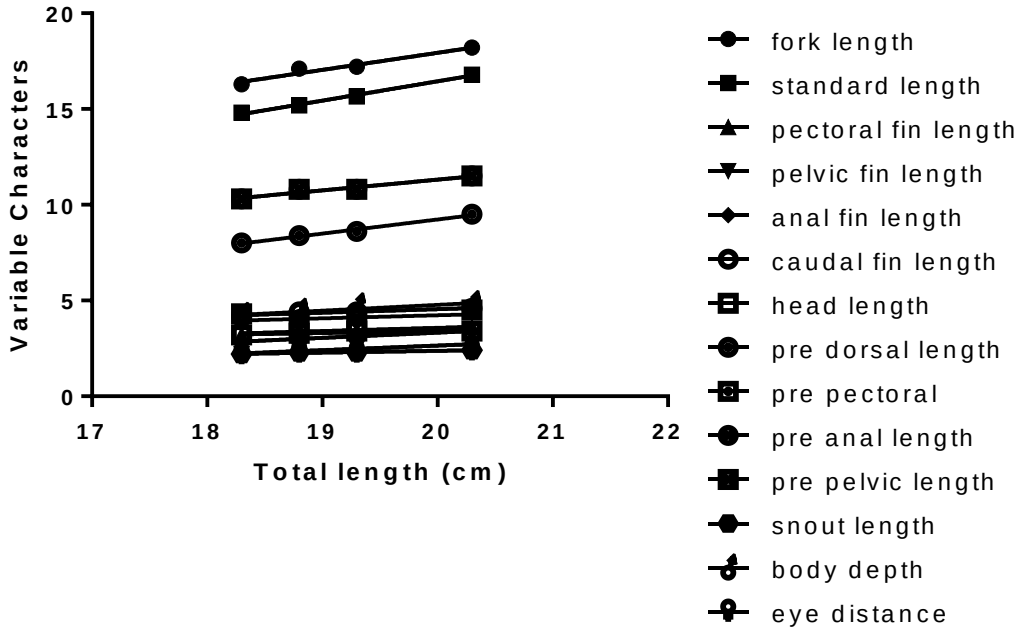
Silver carp (*Hypophthalmichthys molitrix*)

The minimum and maximum length of silver carp was 18.3 cm and 20.3 cm with mean ± standard deviation = 19.17 ± 0.88. The mean percentage of fork length, standard length, body depth, and head length is 89.72, 81.63, 23.26, and 17.31 respectively in total length mean percentage. The total length percentage quotient shows that fork length, standard length, body depth and head length is 1.11, 1.22, 4.29 and 5.77 time in total length respectively. The mean percentage of pectoral fin length, pelvic fin length, anal fin length, caudal fin length and dorsal fin length is 17.41, 12.78, 15.73, 22.95 and 18.02 respectively in total length mean percentage. The total length percentage quotient shows that of pectoral fin length, pelvic fin length, anal fin length, caudal fin length and dorsal fin length is 5.74, 7.82, 6.35, 4.35, and 5.54 time in total length respectively. The mean percentage of pre dorsal, pre pectoral, pre anal and pre pelvic length is 44.86, 23.47, 56.59, and 38.60 respectively in total length mean percentage. The total length percentage quotient shows that pre dorsal, pre pectoral, pre anal and pre pelvic length is 2.22, 4.26, 1.76, and 2.59, respectively in total length mean percentage. All the morphometric characters, their minimum, maximum, Mean and standard deviations are shown in Table 1.

In silver carp, fork length (0.973), standard length (0.996), pre-pectoral length (0.969), pre anal length (0.969), snout length (0.956), pre dorsal length (0.992), pre pelvic length (0.992), Dorsal fin length (0.969), Pelvic fin length (0.984), anal fin length (0.956), eye distance (0.956) and Caudal fin length (0.956) show the high coefficient of correlation while, head length (0.886), Pectoral fin length (0.841), body depth (0.892) and snout length (0.838) show the moderate coefficient correlation in relation to total length.

Similarly, the characters like fork length (0.849), standard length (0.823), snout length (0.852), length of pectoral fin (0.814), Pelvic fin length (0.838), anal fin length (0.852), Caudal fin length (0.852), pre dorsal length (0.809), pre pelvic length (0.833), pre pectoral length (0.811), pre anal length (0.811), Dorsal fin length (0.760) and eye distance (0.852) show the moderate coefficient while, only body depth (0.962) show the high coefficient correlation in relation to head length (Fig. 4 a & b). The variations in various morphometric parameters of silver carp were statistically significant and thus can be regarded as different species (Yousuf *et al*., 2001; Bhat *et al*., 2010). It was observed that in percentage of total length and head length, most of the characters were genetically controlled. A detailed follow-up study is required to reveal whether these morphometric variations are purely environmental or result of genotype by environmental interaction. For example, Bagherian and Rahmani (2009) reported that high water velocity leads to slender body shape in a Caspian cyprinid, *Alburnus chalcoides*. A study by Mir *et al*. (2013b) demonstrated morphological variation in the caudal area in a cyprinid, Indian major carp, *Labeo rohita* from six drainages of Ganges basin differing in current velocity. Khan *et al*. (2013) have also found variation

in the caudal area of a channid fish, *Channa punctata*, from the Ganges basin in India. Different factors such as food availability, salinity, or temperature may affect the morphometry of fish and culminate into the parting of fish populations (Palma and Andrade, 2002).



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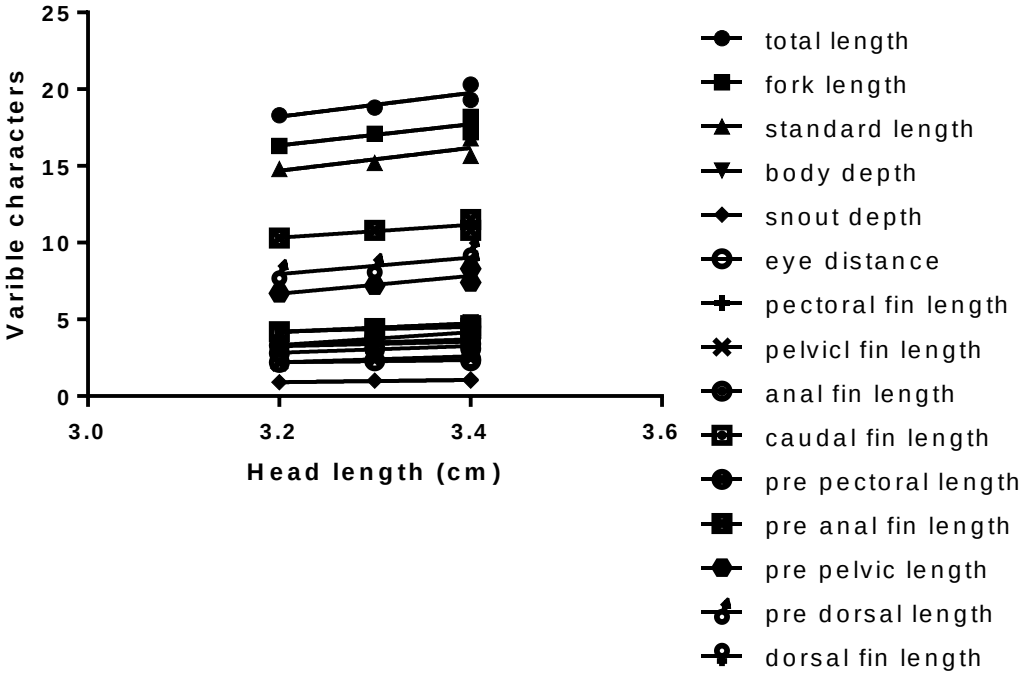

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Fig 4. Relationship of various morphometric measurements compared with Total length (a) and Head length (b) in silver carp.

Fishes can quickly adapt themselves by changing necessary morphometrics because they show great sensitivity to environmental fluctuations. It is distinguished that in response to differences in environmental conditions, the morphological characters can show high flexibility, these environmental conditions includes temperature and food abundance. In general, fish make obvious variations in morphological traits both between and within populations than any other vertebrates in the world and they were more vulnerable to environmentally induced morphological variations. They have adopted very high phenotypic plasticity (Rehman *et al*., 2015).

The study of morphometric characters are important for identification of specimens and for experimental studies. It can be concluded that the fish specimens so collected were homogenous. In percentage of head length all characters were genetically controlled. The presently reported study provides basic information about the differentiation of Cyprinidae using morphometric parameters and suggests that morphometric variations should be considered in its biodiversity pattern and should also be used as a preliminary step towards fisheries management and commercial exploitation of this species and any stock enhancement program. Also, in order to have better conservational policy and restocking programs, further studies are recommended on determining other possible populations structure will be elucidated using environmental, biochemical aspects and molecular genetics methods.

REFERENCES

Anvarifar, H., A. Khyabani, H. Farahmand, S. Vatandoust, H. Anvarifar and S. Jahageerdar (2011). Detection of morphometric differentiation between isolated up-and downstream populations of Siah Mahi (*Capoeta capoeta gracilis*) (Pisces: Cyprinidae) in the Tajan River (Iran). *Hydrobiologia*, 673: 41–52.

Bagherian A. and H. Rahmani (2009). Morphological discrimination between two populations of shemaya, *Chalcalburnus chalcoides* (Actinopterygii, Cyprinidae) using a truss network. *Animal Biodiversity and Conservation*, 32 (1): 1–8.

Bhat, F. A., A. R. Yousuf, M. H. Balkhi, M. D. Mahdi and F. A. Shah (2010). Length-weight relationship and morphometric characteristics of Schizothorax spp. in the River Lidder of Kashmir. *Indian Journal of Fisheries*, 57: 73–76.

Chen, X. L., P. Q. Yue and R. D. Lin (1984). Major groups within the family Cyprinidae and their phylogenetic relationships. *Acta Zootaxonomica sinica*, 9: 424-440.

Conde-Padín, P., M. Carvajal-Rodríguez, A. Carballo and Rolán-Alvarez (2007). Genetic variation for shell traits in a direct-developing marine snail involved in a putative sympatric ecological speciation process. *Evolutionary Ecology*, 21(5): 635-650.

Dhanya, V. M. R., A. K. Jaiswar, R. Palaniswamy and S. K. Chakraborty (2004). Morphometry and length-weight relationship of *Coilia dussumieri*, Valenciennes, 1848 from Mumbai waters. *Journal of Indian. Fish Association*, 31: 65-70.

Hossain, M. A. R., M. Nahiduzzaman, D. Saha, M. U. H. Khanam and M. S. Alam (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.

Jayaram, K. C. (2010). *The freshwater fishes of the Indian Region* (2nd Ed.), Narendra Publishing House, Delhi, 167-169.

Khan, M.A., K. Miyan and S. Khan (2013). Morphometric variation of snakehead fish, *Channa punctatus*, populations from three Indian rivers. *Journal of Applied Ichthyology*, 29 (3): 637–642.

King, M. (2007). *Fisheries biology assessment and management*. (2nd Ed.), Blackwell Scientific publications, Oxford, 1-381.

Liasko, R., C. Anastasiadou, A. Ntakis, C. Gkenas and I. D. Leonardos (2012). Morphological differentiation among native trout population in north western Greece. *Journal of Biological Res-Thessaloniki*, 17: 33–43.

Luthy, S. A., R. K. Cowen, J. E. Serafy and J. R. McDowell (2005). Toward identification of larval sailfish (*Istiophorus platypterus*), white marlin (*Tetrapturus albidus*), and blue marlin (*Makaira nigricans*) in the western North Atlantic Ocean. *Fish Bulletin*, 103(4): 588-600.

Mayden, R. L., W. J. Chen, M. Bart, M. H. Doosey and A. M. Simons (2009). Reconstructing the phylogenetic relationships of the Earth's most diverse clade of freshwater fishes-order cypriniformes (Actinoptreygii: Ostariophysi): a case study using multiple nuclear loci and mitochondrial genome. *Molecular Phylogenetics and Evolution*, 500-514.

Meldgaard, T., E.E. Nielsen and V. Loeschcke (2003). Fragmentation by weirs in a riverine system: A study of genetic variation in time and space among populations of European grayling (*Thymallus thymallus*) in a Danish river system. *Conservation Genetics*, 4 (6): 735–747.

Mir, F.A., J.1. Mir, R.S. Patiyal and S. Chandra (2013a). Pattern of morphometric differentiation among three populations of snowtrout, *Schizothorax plagiostomus* from Kashmir himalaya using a truss network system. *Acta Ichthyologica Et Piscatoria*, 43 (4): 277–284.

Mir, J.I., U.K. Sarkar, A.K. Dwivedi, O.P. Gusain and J.K. Jena (2013b). Stock structure analysis of *Labeo rohita* (Hamilton, 1822) across the Ganga basin (India) using a truss network system. *Journal of Applied Ichthyology*, 29 (5): 1097–1103.

Mir, S. A. (2015). Study of body length in relationship to other morphometric measurements in Cetenopharynoodon (Grass carp) ─ A deviation from cubes law. *International Journal of Fisheries and Aquatic Studies*, 2(5): 72-74.

Mirza, M. A. (1991). Contribution to the systematics of the Schizothoracine fishes (Pisces: Cyprinidae) with the description of three new tribes. *Pakistan Journal of Zoology*, 23: 339–341.

Narejo, N. T. (2010). Morphometric characters and their relationship in *Gudusia chapra* (Hamilton) from Keenjhar lake (Distt: Thatta), Sindh. *Pakistan Journal of Zoology*, 42(1): 101-104.

Nautiyal, P., A.F. Rizvi and P. Dhasmanaa (2008). Life- History Traits and Decadal Trends in the Growth Parameters of Golden Mahseer *Tor putitora* (Hamilton 1822) from the Himalayan Stretch of the Ganga River System. *Turkish Journal of Fisheries and Aquatic Sciences*, 8: 125-131.

Palma, J. and J.P. Andrade (2002). Morphological study of *Diplodus sargus*, *Diplodus puntazo*, and *Lithognathus mormyrus* (Sparidae) in the eastern Atlantic and Mediterranean Sea. *Fisheries Research*, 57 (1): 1–8.

Pollar, M., M. Jaroensutasinee and K. Jaroensutasinee (2007). *World Academic Science and Engineering Technology*, 33: 16-20.

Rainboth, W. J. (1991). Cyprinids of South East Asia. In: Winfield IJ, Nelson JS, (Eds.) *Cyprinid fishes. Systematics, biology and exploitation.* Chapman and Hall; London, p.156-210.

Rehman, F.U., Hameed Ur Rehman, A. Saadia, A. Satara, S. Hassan, M. Abdul, U. Aman, S. Aziz Ur Rehman, and S. Fazal (2015). Morphometric and Meristic Analysis of Silver Carp (*Hypophthalmichthys molitrix*) from Tanda Dam, District Kohat, Pakistan. *Global Veterinaria,* 15 (1): 82-92.

Saroniya, R. K., D. N. Saksena and N. S. Nagpure (2013). The Morphometric and Meristic Analysis of Some Puntius Species from Central India. *Bio life*, 1(3):144-145.

Sharma, U., V. Singhal, D. P. Gupta and P. S. Mohanty (2014). Phylogenetic analysis among Cyprinidae family using 16SrRNA. *International Journal Fisheries and Aquatic Studi*es, 1(6): 66-71.

Yamamoto, S., K. Morita, I. Koizumi and Maekawa, K. (2004). Genetic differentiation of white-spotted charr (*Salvelinus leucomaenis*) populations after habitat fragmentation: spatial–temporal changes in gene frequencies. *Conservation Genetics*, 5 (4): 529–538.

Yousuf, A. R., G. Firdous and A. K. Pandit (2001). Length weight relationship in *Schizothorax niger*, an endemic lacustrine fish of Kashmir. *Journal of Research and Development*, 1: 54 -59.

Yousuf, A. R., F. A. Bhat, D. Mahdi, S. Ali and M. A. Ahangar (2003). Food and feeding habits of *Glyptosternon reticulatum* and Griffth. in torrential streams of Kashmir Himalayas. *Journal of Research and Development*, 3: 124 – 133.

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