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UNDERSTANDING THE CORRELATION BETWEEN STANDARD LENGTH AND TOTAL WEIGHT OF EIGHT FISH SPECIES OF CENTRAL GUJARAT REGION IN THE MONSOON SEASON

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ABSTRACT
The allometry length-weight relation study of eight fish species of the two central districts, Anand and Kheda of Gujarat state in India are carried out. The study is done during the month of monsoon season comprising the months of June, July and August. The study is done for a period of four years from 2014 to 2017. The fish species studied are *Barbus stigma*, *Cirrhinus mrigala*, *Labio rohita*, *Ophiocephalus panctatus*, *Amblypharyngodon mola*, *Oreochomis mossmabicus*, *Thyrssa setirostris* and *Harpadon nehereus*. These fish species are the frequently available fishes in the markets of the two districts. The allometry parameters analysis showed that five species *Cirrhinus mrigala*, *Labio rohita*, *Ophiocephalus panctatus*, *Oreochomis mossmabicus* and *Harpadon nehereus* possess positive allometry. Two species *Barbus stigma* and *Thryssa setirostris* showed isometry. While *Amblypharyngodon mola* showed negative allometry. The condition factor analysis of the fish species showed poor value for two species. The poor condition factor showing species are *Ophiocephalus panctatus* and *Amblypharyngodon mola*. The water samples from the fish catching water bodies are characterized for their physico-chemical parameters. All the observations and determined parameters are discussed in details in this paper.

KEYWORDS: Allometry, eight fish species, growth parameter, condition factor, monsoon season.

INTRODUCTION

The living beings on earth have undergone numerous progressions to amend with the changing environmental conditions and life's requirements. Adaptive evolution is the basic stint of any living organism. Diverse living beings or species have different growth rate as well as varied scaling factors for its different body parts. A mathematical power relation connects length and weight in aquatic species (Evagelopoulos *et al.*, 2017; Ferraz *et al.*, 2015; Dunic *et al.*, 2017). The length-weight relationship (LWR) has coefficient term and an exponential term. These terms are very significant parameters in understanding the growth and in realistic evaluation of stocks of aquatic species (Stergou *et al.*, 2001; Enin, 1994). In aquatic species the fish has both the commercial and the ecological importance. The importance on commercial front is the fish has an edible value and ecological is it acts as a natural scavenger. Due to consumption of fish by a large populace making it's harvesting a livelihood for a good population. On the ecological facade, fish facilitates in maintaining the natural cycle of normal aquatic habitat by acting in scavenging, recycling, churning, etc. (Lynch *et al.*, 2016). Looking to the commercial and ecological importance of fish, the LWR of a species becomes important. It helps in converting the length of individual fish to its corresponding weight, estimation of the average weight of fish of a given length, converting growth equation for length into growth equation for weight and comparisons of morphology between populations of the similar species or between different species (Asadi *et al.*, 2017). The LWR has several applications like understanding of fish biology, in ecology evaluation, assessing stock, physiology, etc. (Holmlund *et al.*, 1999).

The current study was conducted to determine the LWRs parameters and condition factors of eight frequently available fish species during the months of monsoon found in the central region of state of Gujarat in India. The months covered in the study are June, July and August. The study was conducted for four consecutive years from 2014 to 2017. The uninterrupted availability of fish species in all the consecutive years limited the study to eight in number. The geographical regions comprised the two districts, Anand and Kheda. The reason for selecting the two districts are its possessing of natural water bodies in the way of lakes, ponds, reservoir, etc. along with rivers and men made irrigation canals. The man made irrigation canals are known as Mahi canals in the local regions. Fresh water flow is generally maintained all through the year in these canals. They are used for the irrigation purposes, but at the same time becomes a resource of fish breeding. All these water bodies are good source of fishes for the local market and for the native population of the region. Also there is no report of study of allometry of the fishes of the two districts, Anand and Kheda of the state of Gujarat. The main intend of the present study was to identify the fish species having good growth as well as good condition factor in the two districts ecology conditions during the monsoon season.

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EXPERIMENTAL OBSERVATION

The allometry samples of the eight fish species are collected from the different water bodies of the districts of Anand and Kheda, **Figure 1**. Both the districts are at the central region of the state of Gujarat situated in the western region of India. The districts have other than fresh water bodies a sea coastline with the Arabian Sea.

Figure 1 The Anand and Kheda districts lying in the central region of the state of Gujarat in India.

The total number of fish samples collected for the present study in the monsoon season is 393. The samples belonged to eight fish species from the two water bodies, fresh and estuarine. The local restrictions of procuring adequate number of fish samples in all consecutive years forced the study to only eight species. All the eight species covered in this study are edible fish. Fish species are identified and classified according to 'The Fishes of India' by Francis Day, 2013. In this monsoon season, the fresh water specimens are collected from rivers and ponds using Seine net and conventional drag net. The estuarine fishes are collected from the coastal fish land zone of Khambhat using Dol net. The fish collections by the authors are done at the fish catch sites, reason being the authors conducted on the spot water analysis. The authors tried to restrict the collection of fish samples that were less than 25 cm in length. The reason of restricting the length is just for convenience of handling and measurements.

The standard length (L) of each fish samples are measured using simple geometric measuring ruler. The least count of the measuring ruler was 0.5 mm. The weights of the samples are measured employing two electronic weighing machines. The small fishes having weight below 50 gm are weighed by Reptech Weighing Machine. Fishes having weight above 50 gm are weighed by using Scale Tec Weighing Machine.

The standard LWR relation is expressed as below equation (Beverton *et al.*, 1996);

$$W = aL^b \qquad (1)$$

Where W is weight of the body in gm, L is the measured standard length in cm, *a* is a body form dependent coefficient and *b* is a growth indicating exponent. Taking the natural logarithm of equation (1), the equation obtained is of the form;

$$\text{Log}W = b\text{Log}L + \text{Log}a \qquad (2)$$

The equation (2) is an equation of the form of straight line, $y = mx + c$, where m is a slope and c indicates intercept. Thus from equation (2) the required parameters *b* of LWR is estimated by the method of least-square technique. The logarithmically transformed data and the associated degree of relation between L-W variables are determined by the coefficient r^2. The statistical significance level of r^2 nearer to unity provided the best possible accuracy in the determined parameters (Santos *et al.*, 2002). The authors tried to keep the r^2 values near to unity to obtain the best *a*

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and *b* parameter values for each fish species. The exponent value *b* provides information on fish growth. In case of value of *b* = 3, the growth is isometric. If the value of *b* is other than 3 the growth is allometric, positive allometry when *b* > 3 and negative allometry when *b* < 3 (Evagelopoulos *et al.*, 2017).

The determined parameters *a* and *b* of each fish species are employed to calculate the predicted weight (PW) of the samples belonging to that species by using the actual length L of the fish samples. The PW determinations are done for all the samples of the eight fish species using equation (1). The determined PW is compared with the actual weight (AW) for each fish species.

The wellness of the fishes is measured by determining the condition factor (K) of the fishes using the relation (Oghwela *et al.*, 2011);

$$K = 100W/L^b \quad (3)$$

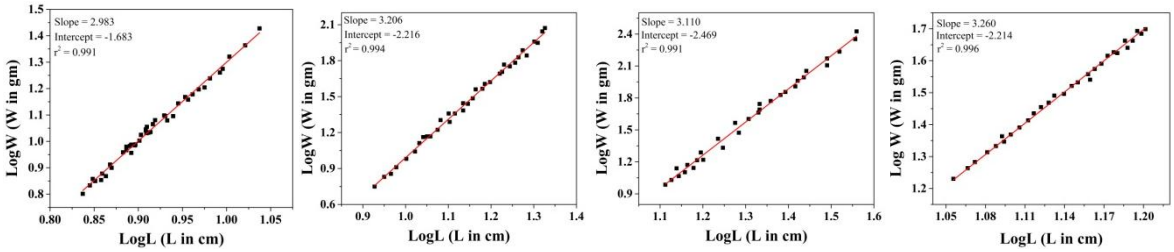
Here W is the weight of the fish taken in gm, L is the fish standard length in cm and *b* is the value obtained from the length-weight equation formula.

The plots and the calculations are done by using computer. The logarithmic value of the measured parameters L and W are obtained by Microsoft Excel. The Log-Log plots are drawn using Microsoft Origin Version 6.0.

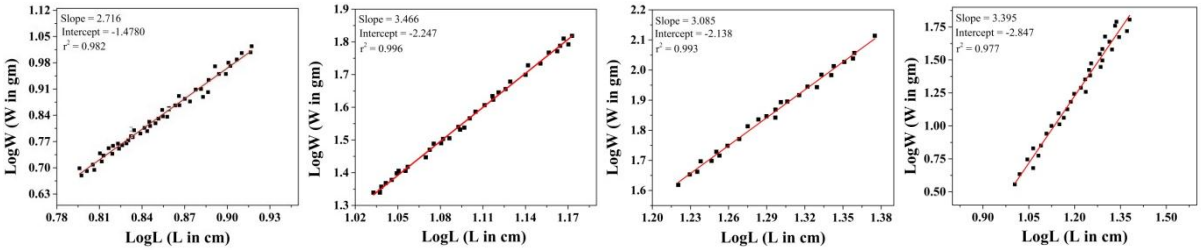
The water analysis of the water samples collected at the fish catch sites are done on-site using compact Deluxe Water & Soil Analysis Kit [Model LT – 60; Make of Labtronics, Panchkula, Haryana, India]. The water temperature of the water samples are measured using digital Multi-Stem thermometer through external sensing rod shape probe [Model: ST-9283B] having resolution of 0.1°C and accuracy of ±1°C. The physico-chemical parameters measured of the water samples are pH, dissolved oxygen (DO), total dissolved solid (TDS) and water temperature.

RESULTS AND DISCUSSION

The plots of Log-Log linear relationship between length (L) and weight (W) values of the studied eight fish species are shown in **Figure 2(a-h)**. By using the linear relation, equation (2), between the standard length (L) and weight (W) of the fishes, the *a* and *b* values are determined for each fish species.



(a) *Barbus stigma* (b) *Cirrhinus mrigala* (c) *Labio rohita* (d) *Ophiocephalus punctatus*



(e) *Amblypharyngodon mola* (f) *Oreochomis mossambicus* (g) *Thryssa setirostris* (h) *Harpadon nehereus*

Figure 2 The Log-Log graphs of LWR during the monsoon season of the studied eight fish species.

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All the graphs are straight lines stating to obey the equation (2) of allometry. The determined *a* and *b* values for all the eight fish species from the drawn Log-Log plots of LWR are tabulated in Table – 1. Using the determined parameter *b* values, the growth G of each fishes is determined. If the value of *b* is equal to 3, the G is isometric (I), for *b* more than 3 the value of G is positive (P) and for *b* less than 3 the value of G is negative (N). The determined G types depending on magnitude of *b* are also tabulated in the Table - 1.

Table – 1 The allometric LWR parameters along with Growth G and Wellness K values determined during the monsoon season.

Sr. No.	Species	Sample number	Parameters of the relationship				Growth G	K
			a	*b*	r^2	S.E. in *b*		
1	*Barbus stigma*	56	-1.683	2.983	0.991	0.042	I	1
2	*Cirrhinus mrigala*	48	-2.216	3.206	0.994	0.040	P	1.18
3	*Labio rohita*	45	-2.469	3.110	0.991	0.052	P	1.09
4	*Ophiocephalus panctatus*	42	-2.214	3.260	0.996	0.043	P	0.65
5	*Amblypharyngodon mola*	64	-1.478	2.716	0.982	0.050	N	0.52
6	*Oreochomis mossambicus*	51	-2.247	3.466	0.996	0.032	P	1.63
7	*Thryssa setirostris*	39	-2.138	3.085	0.993	0.051	I	1
8	*Harpadon nehereus*	48	-2.847	3.395	0.977	0.088	P	1.22

The analysis of the Table – 1 data shows that only one species out of studied eight species is having negative allometry in the season of monsoon. Two species from the studied eight species have isometry and all other five species have positive allometry. The maximum species having positive allometry may be due to monsoon season. The reason may be the season of monsoon brings fresh water helping in circulation of already existing water leading to replenish of minerals, needed nutrients, essential oxygen, desired salts, etc.

The replenished vital minerals and oxygen might be helping the fishes to gain health and being reflected in the form of positive growth allometry. The only species *Amblypharyngodon mola* showing negative allometry means the existing water and weather conditions are not suitable for the said species. The two species *Barbus stigma* and *Thryssa setirostris* had shown isometry meaning the scaling of parameters is linear.

The condition factors K of the studied fishes are determined using equation (3). The obtained values are tabulated in Table – 1. The K data showed that of the eight fish species studied, the species *Cirrhinus mrigala*, *Labio rohita*, *Oreochomis mossambicus* and *Harpadon nehereus* had good wellness. The two species *Barbus stigma* and *Thryssa setirostris* had isometry growth so the K factor is unity. The other two species *Ophiocephalus panctatus* and *Amblypharyngodon mola* showed poor condition factor K. The poor K value of *Amblypharyngodon mola* species substantiates the negative allometry growth G observed in the said species.

The exception is in case of *Ophiocephalus panctatus* which had showed positive allometry but poor condition factor, this may be due to the existing ecological conditions not favorable for the wellness of the species. Other than this, the *Ophiocephalus panctatus* is a sea fish (Miller, 1979) and thus in the present fresh water conditions its growth is definitely not suitable leading to poor K value.

The predicted weights (PW) of each fish samples are determined by equation (1) using the actual measured length L. In this PW calculation the respective *b* values are taken of the respective species determined from the allometry Log-Log LWR plots. The plots between the LogL versus logarithms of actual weights (LogAW) and predicted weights (LogPW) for all the eight fish species are shown in **Figures 3(a-h)**.

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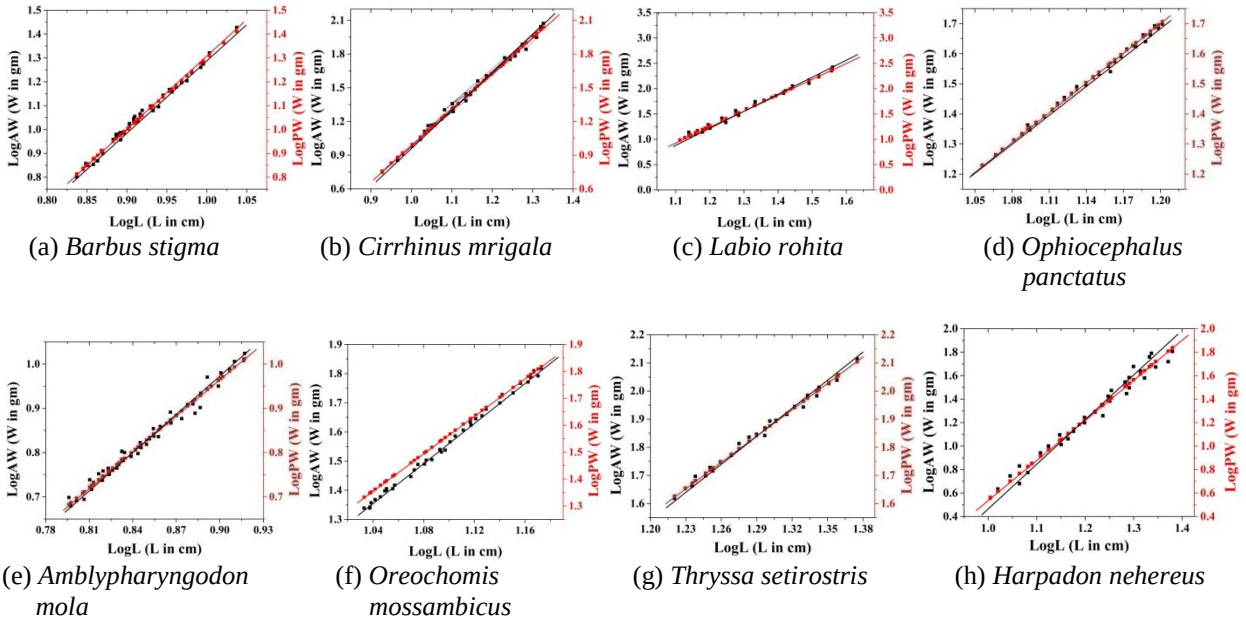

(a) *Barbus stigma* (b) *Cirrhinus mrigala* (c) *Labio rohita* (d) *Ophiocephalus panctatus*

(e) *Amblypharyngodon mola* (f) *Oreochomis mossambicus* (g) *Thryssa setirostris* (h) *Harpadon nehereus*

Figure 3(a-h) The LogL versus LogAW and LogPW plots for eight fish species.

The Log-Log plots of LWR for fish species *Barbus stigma* [**Figure 3(a)**], *Cirrhinus mrigala* [**Figure 3(b)**], *Labio rohita* [**Figure 3(c)**], *Ophiocephalus panctatus* [**Figure 3(d)**], *Amblypharyngodon mola* [**Figure 3(e)**] and *Thryssa setirostris* [**Figure 3(g)**] shows that the AW and PW values are in good agreement with each other for all the actual lengths L. Whereas in species *Oreochomis mossambicus* [**Figure 3(f)**] and *Harpadon nehereus* [**Figure 3(h)**] there is minor deviation between the AW and PW values, but then too they are in match with each other. The good agreement and match of Log-Log plots of L and AW-PW states that the obtained allometric parameters, Table – 1, of the eight fish species are accurate. Thus the conclusions drawn from the obtained allometry data regarding the species are also exact.

Analysis of Water Samples

The physico-chemical data analysis of the water samples of the water bodies from which the fish samples are collected for the present allometry studies are carried out at the source of the catch. The water analysis is done at the time of fish catch. The physico-chemical data are for the season of monsoon consisting of months of June, July and August of the years between 2014 and 2017. The obtained data are tabulated in Table – 2. The ranges of each parameter are the variations observed in the data values taken at varied time of the months as well as of the four years. The variation in time occurred due to the dependence of fish samples collections on the fish vendors. This was due to the period covered in the present paper is monsoon season; the fish catch was most erratic due to rescheduling of fish catch owing to rain.

Table – 2 The physico-chemical water analysis data taken during monsoon season.

Water bodies	pH	Dissolved oxygen (DO)	Total dissolved solid (TDS)	Temperature
Fresh water	7.1 – 8.2	6.1 – 7.7 mg/l	98 – 137 mg/l	25.8- 29.3°C
Estuarine	7.2 – 8.2	6.5 – 8.0 mg/l	82 – 178 mg/l	25.3 – 30.1°C

The pH values in case of both, the fresh water and estuarine water are in the alkaline range. Both the ranges are near to same. This may be due to monsoon season, when the rain water flows all over the earth surface mixing the existing waters with other waters. Even the monsoon rain brings in the salts from the nearby solid earth increasing the alkalinity.

Literature states the acidic water is bad for any organism growth (Rajan *et al.*, 2016), thus the present alkaline water is favorable for the fish growth.
The data of DO levels shows that the value is more in case of estuarine water compared to fresh water. The larger value of DO in case of estuarine water may be due to dynamic nature of sea compared to fresh water. During monsoon the flow of fresh water from the land to the sea increases thus leading to natural aeration and increasing the DO level in estuarine water. The ranges of DO in both the waters are favorable for fish growth and are best for the wellness of the fishes (Bhatnagar *et al.*, 2013).

The observed TDS values in the season of monsoon in case of water samples from fresh (98 – 137 mg/l) and estuarine (82 – 178 mg/l) bodies are well within the standard limit of 500 mg/l (Suman *et al.*, 2017). Thus the present TDS level observed for both the fresh and estuarine waters is suitable for the habitat of the studied eight fish species.

The water temperature in the monsoon season for the years under consideration, 2014 to 2017, ranges from 25.3 °C to 30.1 °C for the different water sources where the fish collections are done. The range of water temperature recorded is within the optimum range being reported in literature of 28 °C to 30 °C (Suman *et al.*, 2017) for maximal growth of fish species. Thus the recorded water temperature during the monsoon season is conducive for the wellbeing of the presently studied eight fish species in the districts of Anand and Kheda in the state of Gujarat in India.

CONCLUSIONS

The allometry study on eight fish species frequently available in the markets of two centrally located districts, Anand and Kheda, of the state of Gujarat in India is carried out. The fish species studied are *Barbus stigma*, *Cirrhinus mrigala*, *Labio rohita*, *Ophiocephalus panctatus*, *Amblypharyngodon mola*, *Oreochomis mossmabicus*, *Thyrssa setirostris* and *Harpadon nehereus*. The two species, *Thyrssa setirostris* and *Harpadon nehereus* are estuarine fishes and rests of the others are fresh water fishes. The allometric studies are carried out for the season of monsoon during the period from 2014 to 2017. The monsoon months covered in the study are June, July and August.

The allometry study showed that out of studied eight fish species five showed positive allometry. They are *Cirrhinus mrigala*, *Labio rohita*, *Ophiocephalus panctatus*, *Oreochomis mossmabicus* and *Harpadon nehereus*. Two fish species, *Barbus stigma* and *Thryssa setirostris* showed isometry and only one *Amblypharyngodon mola* showed negative allometry. The condition factor K values determined for the fish species stated that two species, *Ophiocephalus panctatus* and *Amblypharyngodon mola* show poor value, whereas all others showed good wellness value. These observations clearly state that *Amblypharyngodon mola* species is not a good species for cultivation in the Anand and Kheda regions during monsoon season. Reason being its allometry growth is negative and condition factor K is poor. Other species showed good growth as well as condition factor except *Ophiocephalus panctatus* which showed positive growth but poor condition factor. Thus *Ophiocephalus panctatus* is also not a good species to be considered for harvesting in the Anand and Kheda regions during monsoon season. The analysis of physico-chemical parameters like pH, DO, TDS and water temperatures of the water samples from the water bodies of the fish catch sites showed that all the parameters are favorable for the growth of fish species during the monsoon season in the two districts.

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