

**Length Weight Relationship and Condition Factor of Selected
Freshwater Fishes of Govardhan Sagar Lake, Udaipur,
Rajasthan**

खल/कु I खज >ह्य] mn; ij] jktLFkk dsehBsi kuh dh p; fur eNfy; kaea
yab&otu dk I EcUk ,oavLFk dkjd

Vedrahi Prasad Bairwa

Thesis

Master of Fisheries Science

(Aquaculture)



2018

**DEPARTMENT OF AQUACULTURE
COLLEGE OF FISHERIES
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND
TECHNOLOGY, UDAIPUR – 313001 (RAJASTHAN)**

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Thesis

Submitted to the

**Maharana Pratap University of Agriculture & Technology
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In partial fulfillment of the requirements for

**The degree of
Master of Fisheries Science**

**In the
Faculty of Fisheries
(Aquaculture)**



By

Vedrahi Prasad Bairwa

2018

**MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND
TECHNOLOGY
COLLEGE OF FISHERIES, UDAIPUR**

CERTIFICATE – I

Dated: 2018

This is to certify that **Vedrahi Prasad Bairwah** successfully completed the Comprehensive Examination held on 20/06/2018 as required under the regulations for **Post Graduate Studies**

(Dr. B. K. Sharma)
Professor & Head
Department of Aquaculture
College of Fisheries, Udaipur
(Raj.)

**MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND
TECHNOLOGY
COLLEGE OF FISHERIES, UDAIPUR**

CERTIFICATE – II

Dated:2018

This is to certify that this thesis entitled “**Length Weight Relationship and Condition Factor of Selected Freshwater Fishes of Govardhan Sagar Lake, Udaipur, Rajasthan**” submitted for the degree of **Master of Fisheries Science** in the subject of **Aquaculture**, embodies bonafide research work carried out by **Vedrahi Prasad Bairwa** under my guidance and supervision and that no part of this thesis has been submitted for any degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on 28/06/2018.

(Dr. B. K. Sharma)
Professor & Head
Department of Aquaculture
College of Fisheries, Udaipur (Raj.)

(Dr. B. K. Sharma)
Major Advisor
Professor
College of Fisheries, Udaipur (Raj.)

(Dr. S. K. Sharma)
Dean
College of Fisheries, Udaipur (Raj.)

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE

**AND TECHNOLOGY
COLLEGE OF FISHERIES, UDAIPUR**

CERTIFICATE – III

Dated:2017

This is to certify that this thesis entitled “**Length Weight Relationship and Condition Factor of Selected Freshwater Fishes of Govardhan Sagar Lake, Udaipur, Rajasthan**” submitted by **Vedrahi Prasad Bairwato** the Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfillment of the requirements for the degree of **Master of Fisheries Science** in the subject of **Aquaculture**, after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory; we therefore, recommend that the thesis be approved.

Dr. B. K. Sharma Major Advisor

Dr. S.K. Sharma
Advisor

Dr. B Upadhyay
Advisor

Dr. N. L. Dangi
DRI Nominee

(Dr. B. K. Sharma)
Professor & Head
Department of Aquaculture
College of Fisheries, Udaipur
(Raj.)

(Dr. S. K. Sharma)
Dean
College of Fisheries, Udaipur
(Raj.)

Approved
(Dr. R.A. Kaushik)
Director, Resident Instructions
Maharana Pratap University of Agriculture and Technology, Udaipur

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE

AND TECHNOLOGY
COLLEGE OF FISHERIES, UDAIPUR

CERTIFICATE – IV

Dated.....2018

This is to certify that **Vedrahi Prasad Bairwa** student of Department of Aquaculture, College of Fisheries, Udaipur has made all corrections / modifications in the thesis entitled “**Length Weight Relationship and Condition Factor of Selected Freshwater Fishes of Govardhan Sagar Lake, Udaipur, Rajasthan**” which were suggested by the external examiner and the advisory committee in the oral examination held on2018. The final copies of the thesis duly bound and corrected were submitted on2018 and are enclosed herewith for approval.

(Dr. B.K. Sharma)

Major Advisor

Enclosed: One original and two copies of bound thesis. Forwarded to the Director, Resident Instruction, Maharana Pratap University of Agriculture and Technology, Udaipur.

(Dr. S. K. Sharma)

Dean

College of Fisheries, Udaipur (Raj)

(Dr. B. K. Sharma)

Professor & Head

Department of Aquaculture

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Date:
Place: Udaipur

(Vedrahi Prasad Bairwa)

DEDICATION

*This thesis is dedicated to
myMother and Father*

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1. INTRODUCTION

Presently India is second largest aquaculture nation in the world and has 2nd position in total global production after China. Total fish production of the nation during 2016-2017 (provisional) was 11.41 million metric tonnes (MMT) with a contribution of 7.77MMT from inland sector and 3.64 MMT from marine sector. The total fish production during first two quarters of 2017-18 has also shown an increasing trend and is estimated at 5.80 MMT (Provisional). The fish production has increased from 5.66 MMT in 2000-01 to 11.41 MMT in 2016-17 (P). (DAD&F, 2017-18).

Freshwater resources are one of the most precious commodities for the living animals and especially to human beings. Aquatic resources of water should be assessed on the basis of abiotic and biotic parameters in order to provide the complete spectrum of information for the conservation, assessment of fish diversity and better fish management, and sustainable utilization. Rapid industrial growth in the post-independent India resulting in deforestation, unscrupulous exploitation of river water for irrigation, siltation of river beds and reservoirs, unattended fish catches by the untrained fisherman, destructive fishing, damming, habitat fragmentation, loss of habitat, predation, diseases, etc. all these have drastically decreased the fish diversity in the natural waters.

Reservoirs are important water resources in Asia, the reservoirs are diverse and therefore the strategies to be adopted for optimizing yields are also different (Bhukaswan 1980; De Silva, 2001). The fish production from the reservoir depends on nutrients, biomass, and the quantity of stocked fingerlings.

Rajasthan, being the largest State of India in terms of area is also one of the most diverse states where tradition and royal glory meet in riot of colors. Rajasthan is also endowed with varied surface freshwater resources like reservoirs, seasonal and a couple of perennial rivers canals, small tanks and ponds.

Rajasthan has about 4.23 lakh ha freshwater area moreover 30,000 ha area as rivers, and canals, 80000 ha waterlogged and 1.80 lakh ha salt affected areas. The state is gifted with four major river basins viz. Chambal river basin, Mahi river basin, Luni river basin and Ghaghghar river basin. Around 70 rivers connect these major river systems with vast number of tanks, ponds and reservoirs during monsoon season regulating natural recruitment of fish and other aquatic fauna throughout the state. It has around 153444 ha

of water area under reservoirs, more than 33% of which fall under the small category. Of the 423 reservoirs, only seven are in the large category, while the small and medium sized are 389 and 30, respectively. Rajsamand, Banswara and Chittorgarh have a large number of small reservoirs, though they do not contribute much to the total area. The large reservoirs, viz., Bisalpur (23,618 ha), Rawatbhata (19,600 ha) in Chittorgarh district, MahiBajajsagar(13,500 ha) in Banswara district, Jaisamand (7,600 ha) in Udaipur district and Kadana back water (9,000 ha) in Banswara and Dungarpur districts, cover more than 32% of the total water area (Keeret *al.*, 2017).

State department has made steady growth in inland fisheries during last three decades. Fish production has increased from 14000 mt. in 1980-81 to 28200 mt. in 2010-11. Area under fish culture and fish production both have gone up. Annual growth rate has riched 12.6% between 2000-01 and 2010-11 as compared to the national average 8%. The annual fish production of the state is 14,300 tonnes and the mean fish yield from ponds under FFDA is 1.4 tonnes/ha/year. About 60% of the total fish production comes from reservoir and the rest from tank & ponds (Reservoirs to the tune of 1.53 lakh ha and ponds and tanks of 1.8 lakh ha). The productivity of large reservoir (55 kg/ha.) is above the national average, productivity of small water bodies (1.2 mt/ha/yr) is far less than the national average. State ranks 18th in the country in fish productionarea (Keeret *al.*, 2017).

Water resources or Rajasthan (in ha.)

S. No.	Resource	No.	Length/Area
1	Rivers	70	5000km./0.30 lakh ha.
2	Canals	2	300 km.
3	Ponds/ Tanks	13682	0.40 lakh ha.
4	Reservoirs		
A	Small (<1000 ha.)	1693	1.33 lakh ha.
B	Medium (1000-5000 ha.)	36	0.86 lakh ha.
C	Large (>5000 ha.)	7	0.70 lakh ha.
5	Water logged area		0.20 lakh ha.
	Total water area	15490	3.61 lakh ha.

Source: Anonymous, 2008

The length-weight relationship is very important for proper exploitation and management of the population of fish species. Relationship between total length and fish

body weight are also very much essential for stabilizing the taxonomic characters of the species. (Pervin and Mortuza 2008). Data on the length and weight of fish have commonly been analysed to yield biological information. (Ahmed, *et al.* 2011). The two fish species *Catlacatla*, and *Labeorohita* are the most important fishes among the Cyprinidae family due to their good Taste and high market value. (Zaryab, *et al.* 2016). Length-weight relationship (LWR) is used for estimating the weight corresponding to a given length and condition factor is used for comparing the 'condition', 'fatness', or 'wellbeing' (Tesch, 1968) of fish, based on the assumption that heavier fish of a given length are in better condition. Both concepts have been used in fisheries research since the beginning of the 20th century. Further, the condition factor (K) and relative condition factor (Kn) are the important biological parameters which indicate the suitability of a specific water body for growth of fish (LeCren, 1951).

It has been as pointed out by Kulbicki *et al.* (2005), that weight-length relationships are only known for restricted number of species. which hampers efforts to model aquatic ecosystem where observations are typically obtained as the number of specimen by length class that has to be transformed into estimates of the biomass.

The Water body selected for the present study was mainly created to fulfill the needs of villagers i.e. for bathing, cleaning of clothes, rearing fishes and flood control. Considering the significance of GovardhanSagar from various angles the present study on the **“Length Weight Relationship and Condition Factor of Selected Freshwater Fishes of GovardhanSagar Lake, Udaipur, Rajasthan”** has been designed and conducted. **The outcome of the investigation of the above referred aspects would help in developing management policy for fisheries of this water body.**

The present study has been conducted with following principal objectives:

1. To study the biology of two commercially important fishes *viz.* *Catlacatla* and *Labeorohita* in GovardhanSagar Lake Udaipur (Rajasthan).
2. To assess the biodiversity of Ichthyofauna of GovardhanSagar Lake.
3. To investigate, current status of selected water quality parameters of GovardhanSagar Lake.

2. REVIEW OF LITERATURE

The fish production in natural water bodies depends on biological features of fish such as survival, growth and reproduction. These activities are greatly influenced by food and feeding of fish. On these aspects several research contributions have been made earlier.

2.1 Length weight relationship:

Pillay (1953) studied length weight of fish and found uniform values up to a certain length of first or second maturations and the variations become more and more pronounced subsequently. The relation between length-weight has been studied for only few species in past years which have turned into a subject of common concern lately. Sarojini (1957) found that there were no marked differences in the length-weight relationship between males and females of *Mugilparsi* and in *Mugilcunnensis*, respectively. Rao (1974) reported that the length-weight relationship of *Cirrhinus mrigala* satisfies the cube law and obtained the „b“ value of 3.0830. Chonder (1972) studied length-weight relationship of *Labeogonius* from Keetham reservoir and reported that the „b“ or „n“ i.e. the exponential value computed in this case as 3.1586. It confirms the cube law and little deviation of regression coefficient from 3 had been verified by “t” test and found significantly different at 1 percent level of significance.

The length-weight relationship, of genus *Puntius* have been studied by various scientists viz. *Puntiuskolus* from Tungabhadra reservoir (Bhatnagar 1963), *Puntiusdubius* from Konar and Tilaiya reservoir (Ranganathan et al.1963), *Puntius sarana* from Loni reservoir (Sinha,1972). Minor carp, *Puntiusdorsalis* (Jerdon) has been studied by Sivakami (1982) which revealed that females follow the cube law whereas males become heavier for its length as the „b“ value exceeds 3. He stated that such differences in the growth pattern within the species might be due to the differences in sex, maturity and season. Length-weight relationship could be expressed by curvilinear regression with a regression coefficient „b“ of 3.028509 which satisfies the cube law. Similar work was done on *Bariliusbendelisis* (Ham.) and *Puntius ticto* (Ham.) by Gariola et al. (1990) where parabolic equations describing length-weight relationship in sex and size classes of fishes were obtained.

Dadzie (1985) observed length-weight of males and females of African carp, *Labeocylindricus*(Peters). Similarly, while observing the biology of *Thryssamystax*, Naluchinnappam and Jayabaskaran (1991) found length-weight relationship in accordance with the cube law. Mahapatra and Dutta (1998) studied the length-weight relationship of bighead carp, *Aristichthysnobilis*(Richardson) which revealed that the allometric growth equation was applicable with significant departure of the regression coefficient from 3. In this context, Ricker (1975) stated that length-weight relationship were sometimes markedly different between the same populations in different years or in different stages of life, presumably associated with their nutritional conditions.

The length weight relationship, reproductive characters, index of condition and relative condition factor of *Puntiusphore*(Hamilton) from a floodplain wetland in West Bengal were studied. The literature available on the biological aspects of this fish is on the length weight relationship by Reddy and Rao (1992) and Singh and Srivastava (2008). The length weight equations and the correlation coefficients obtained were significant. The regression model obtained was $\text{Log } W = 2.7833, \text{Log } L = 4.4647, r^2 = 0.9417$ for male and $\text{Log } W = 3.0169, \text{Log } L = 4.8691, r^2 = 0.9553$ for female.

Length-weight relationship and relative condition factor in female *Notopterusnotopterus* were studied by Kalita *et al.* (1995). The knowledge of relationship between weight of a fish and its total length is essential to establish growth equation in production computation. Total length was used for establishing the length weight relationship by the method of least squares. The regression equation was found to be $\text{Log } L = 0.9333 + 0.2240 \log W$. Hence, it is assumed that weight of the fish has positive relationship with the length of the body.

Sharma *et al.* (1998) reported the length weight relationship of *Tilapia (O. mossambicus)* of 550 samples in Lake Jaisamand, Udaipur, Rajasthan. The study has revealed a highly significant correlation between length and weight with varying “n” values of 3.414, 2.953 and 3.010 for three size groups respectively.

An analysis of length weight relationship in the juveniles of *Notopteruschitala*, collected from the river Ganga at Bhagalpur revealed that there exists a close and highly significant correlation between the length and weight of the fish. The results show that the exponential values for body weight in relation to total length and standard length are

3.145 and 3.060 respectively, which is very close to the cubic parabolic relationship (Ghose and Ragini, 1998).

Attempts have been made to determine growth of (*Barbodesgonionotus*), a minor carp and Thai pangas (*Pangasiussutchi*) by Amin *et al.* (1999) and Halder and Mazid (1998) was cultured these fishes in net cages in the Chandpur irrigational project at Bohoria, Bangladesh. The average growth of (*B. gonionotus*) and (*P. sutchi*) were 0.75cm month⁻¹, and 2.31 cm month⁻¹ respectively. The estimated total length of (*B. gonionotus*) was 21.25 cm at the end of one year while that of *P. sutchi* was 39.40 cm.

The length weight relationship, reproductive characters, index of condition and relative condition factor of *Puntiussophore*(Hamilton) from a floodplain wetland in West Bengal were studied by Naskaret *al.* (2005). Length weight equations and the correlation coefficient obtained were significant. The regression model obtained was $\text{Log } W = 2.7833, \text{Log } L - 4.4647, r^2 = 0.9417$ for male and $\text{Log } W = 3.0169, \text{Log } L - 4.8691, r^2 = 0.9553$ for female. Further the female reached maturity at 61-65 mm.

Esmaeili and Ebrahimi (2006) observed length–weight relationships of 24 fish species belonging to six orders, nine families and 18 genera. Of these, 14 species were endemic to Iran and five species were exotic. The length–weight relationships for 14 endemic species were given for the first time. The length–weight relationship in fishes is affected by a number of factors including season, habitat, gonad maturity, sex, diet, stomach fullness, health, preservation techniques and locality (Tesch, 1971; Esmaeili, 2001).

Tarkanet *al.* (2006) reported length–weight relationships of 32 fish species belonging to 12 families in a total of 6525 specimens. The exponent *b* typically had a value close to three, but varies between two and four. A value of exponent value of three indicates that the fish grows symmetrically or isometrically.

Pervin and Mortuza (2008) have observed total of 550 specimens collected for the morphometric analysis from different fish markets of Rajshahi city during the period of June 2006 to May 2007. In case of females, the total length and weight ranged from 92 to 290 mm and 10 to 450 g, respectively. The mean total length for male calculated was 190.15 ± 5.249 mm and the mean total weight calculated as 106.387 ± 6.716 g (N=168). For female, the mean total length and weight were calculated as 195.8091 ± 3.301 mm and 104.20 ± 4.286 g (N=332), respectively.

Naeem *et al.* (2010) investigated the weight-length and condition factor of 49 Hybrid (*Catlacatla* ♂ x *Labeorohita* ♀) of variable sizes ranging from 4.4 – 27.0 cm total length and 0.52 – 258.35 gm body weight which were sampled from Al-Raheem Fish Hatchery, Village Ali Pure Shamali, near Muzaffargarh. Log transformed regressions were used to test the allometric growth. It was observed that growth in weight is almost proportional to the cube of its length. The value of the slope $b = 3.17$ which coincides with the slope of that of an ideal fish. Condition factor (K) has positive influence with increasing length or weight. Regression parameters were found to be highly significant.

Ahmed *et al.* (2011) have estimated the length-weight relationships (LWR) and condition factors of six fish species from six families of ecological and economic importance, which are found in Atbara River and Khashm El- Girba reservoir. A total of 1118 specimens were caught by using various mesh size of gill net. The growth coefficient (b) values obtained for the six fish species ranged between 2.278 for *Clarias lazera* and 3.680 for *Bagrus bayad* and differed significantly ($p < 0.005$) from 3, which indicates that most of the fish species (61.1%) have negative allometric growth.

Nehemia *et al.* (2012) Length-Weight relationship and condition factor of *Tilapia zillii* and *Oreochromis urolepis urolepis* reared in full strength sea water (FSSW) and fresh water (FW) ponds. The environmental condition in FSSW and FW ponds were also analyzed to determine their impacts on Length-Weight relationship and condition factor on both species. The regression coefficient "b" exhibit negative allometric growth in FW and positive allometric growth in FSSW for both species. The value of exponent "b" and condition factor (K) for *T. zillii* in FW and FSSW (in the bracket) were found to be 2.94 (3.3) and 2.07 (0.74) respectively. On the other hand the value of exponent "b" and condition factor (K) for *O. urolepis urolepis* in FW and FSSW (in the bracket) were found to be 2.81 (3.46) and 0.86 (0.53) respectively.

Ujjania (2012) observed selected growth parameters. High value of correlation coefficient 'r' 0.946 (MBS), 0.912 (SD) and 0.911 (AP) was evident and speak for strong correlation in total length of fish and scale radius. The growth parameters such as Index of species average size ($\bar{\phi}_h$) 12.515, 11.557 and 11.000, Index of weight growth ($\bar{\phi}_{Cw}$) 96.610, 103.126 and 87.554 for MBS, SD and AP, respectively were computed. Growth performance estimation in this study on the basis of key scales exhibited that growth of carps in the water bodies of southern Rajasthan could be divided into two phases: the

first, phase of sexual immaturity, which lasts up to two years and second, phase of sexual maturity.

Ujjania *et al.* (2012) observed values of exponent to be 3.275 for *catla*, 3.376 for rohu and 3.362 for *mrigal* from pooled data whereas such values varied from 3.160-3.805 for *catla*, 3.110-4.574 for rohu and 2.498-3.375 for *mrigal* in different length groups. The values of 'K' were 3.083 in *catla*, 1.695 in rohu and 1.714 in *mrigal* from pooled data. Moreover, it fluctuated between 2.788-3.094 in *Catla*, 2.011-2.213 in *Rohu* and 1.523-1.962 in *mrigal* for different length groups. The values of relative condition factor (Kn) were observed in the range of 1.000-0.999 in different length groups and 1.018-0.998 for the pooled data of selected species. These parameters have been found very useful to evaluate the well being of populations, their biology for scientific management of fisheries and stock assessment.

Jellyman *et al.* (2013) have observed collected length-weight data throughout New Zealand, yet parameters describing these relationships remain unpublished for many species of freshwater fish. New Zealand to parameterise length-weight equations, using both power and quadratic models, for 53 freshwater species belonging to 13 families. The influence of location and sex on length-weight relationships was also assessed. Different length-weight relationships for 65% of the species examined. Length-weight equations were validated by comparing predicted weights against independently measured weights from 25 electrofished sites across New Zealand and the equations were highly accurate ($r^2 = 0.99$). Recommendations are made about how to robustly apply this new resource which should assist freshwater fisheries researchers throughout New Zealand.

Ujjania *et al.* (2013) observed LWR ($W = aL^b$) values of exponent 2.98, 2.97 and 3.14 in MBS, SD and AP. The values of 'K' ranged from 2.01-2.21 in MBS, 2.05-2.34 in SD and 2.05-2.29 in AP in different length groups. Such values for pooled data were 2.02, 2.05 and 2.38 for MBS (Mahi Bajaj Sagar), SD (Surawania Dam) and AP (Aasana Pond) fishes, respectively which shows that comparatively AP is more conducive water body for the fish growth. The values of 'Kn' ranged from 0.99-1.00 which depicted good condition of fish in these water bodies

Giannetto *et al.* (2015) standard weight equations and length-weight and length-length relationships were estimated for *Barbus pergamonensis*, *Capoeta bergamae*, and *Ladigesocypris irideus*, three endemic cyprinid species of Turkey that are still not

widely studied. The three species and L–W parameters for *L. irideus* are given here for the first time. In this study, length and weight data for *B. pergamonensis*, *C. bergamae*, and *L. irideus* were collected throughout the watercourses of Muğla Province and were used to develop species-specific Ws equations. The results were for *B. pergamonensis* (total length [TL] range: 6–22 cm) $\log_{10}W_s = -5.713 + 3.718 \log_{10}TL - 0.166 (\log_{10}TL)^2$, for *C. bergamae* (TL range: 8–29 cm) $\log_{10}W_s = -5.224 + 3.311 \log_{10}TL - 0.083 (\log_{10}TL)^2$, and for *L. irideus* (TL range: 6–10 cm) $\log_{10}W_s = -13.298 + 12.116 \log_{10}TL - 2.471 (\log_{10}TL)^2$.

Gokhale *et al.* (2015) while studying in length-weight relationship between different size-groups of rohu – catla hybrid in lake Udaisagar attributed variations to the prevailing environmental conditions, available food and space besides, the biological features specific to the species. The later, results into varied growth performance of the fish under study during different age groups. Rohu-catla hybrid contributed significantly (14.42%) in the total fish landing of lake Udaisagar. The fish attained more weight per unit of length in early age (1-2 years) in the lake thus, showing a linear growth. The correlation coefficient was positive and highly significant ($r = 0.803^{**}$ and 0.748^{**} ; $P < 0.01$) in length groups A (24-29 cm) and C (36-41 cm).

Iqbal Mir *et al.* (2015) studied the length-weight relationships of 1033 specimens collected from the main channel of Ganga river and its five major drainages from March 2009 to July 2012. The length of males ranged from 16 to 92 cm (females: 16 to 94 cm). The growth is allometric positive ($b > 3$) for males, females and pooled sexes. The coefficient of determination (r^2) in males ranged from 0.978 to 0.989 and for females from 0.958 to 0.985. Data from field populations are scarce and our results will be useful in the management and conservation of *L. rohita* populations in its natural range.

Ndiaye *et al.* (2015) length-weight relationships and condition factors of *Epinephelus aeneus* (Geoffroy Saint Hilaire, 1817) in the western coasts of Senegal (Joal, Mbour and Soumbédioune). The 973 specimens (average length 422.48 ± 133.79 mm and weight 1249.62 ± 1243.91 g) were monthly sampled from fishermen from January 2010 to June 2013. For each of the specimen, length (mm) and weight (g) were measured following standard equipments. Length-weight relationship was described by the equation: $W = a L^b$ while the condition factor was determined using the equation: $K = 100 (W / L^3)$. The values of the regression coefficient 'b' obtained for the length-weight

relationship for the species of Joal, Mbour and Soumbédioune were respectively 2.99, 3.00 and 2.96 having r^2 values respectively 0.975, 0.980 and 0.985.

Anni Jain *et al.* (2016) the length-weight relationship (LWR) and condition factor (k) from 1050 specimens of *Tilapia mossambicato* determine the growth pattern. The experimental fish ranged from 0.50 to 150 cm and 3.00 to 350 g in length and weight respectively. The obtained correlation coefficient for length- weight relationship was ranged between 0.60 and 0.98. There was a significant correlation between length and weight.

Balaiet *al.* (2016) observed length-weight relationship of catla, rohu and mrigal, respectively. A strong linear relationship was observed between total length and weight variables. The value of regression coefficient (b) depicted isometric growth in mrigal, positive allometric growth in rohu and negative allometric growth in calta. The condition (k) and relative condition factors (kn) were observed >1.0 which indicates the good conditions of all the three fish species in Jaisamand Lake. From this study it was concluded that the aquatic environment of Jaisamand Lake is fairly conducive for growth of Indian major carps.

Bhatt *et al.* (2016) have studied the environment suitability of the lake Pichhola for good growth of fish. Further, the high value of condition factor (K) in group A (2.145) indicated a higher increase in weight in relation to length. Variations in length-weight relationship between different size-groups could be attributed to the prevailing environmental conditions, available food and space besides, the biological features specific to the species.

Asadi, *et al.* (2017) estimated in seven fish species, including *Barbuscyri*, *Capoetagracilis*, *Alburnoideseichwaldii*, *Pseudorasboraparva*, *Ponticolacyrius*, *Cobitiskeyvani* and *Acanthalburnusmicrolepis* from Shahr Bijar River, Guilan Province, Iran. A total of 416 specimens ranging from 18 to 135 mm in total length and from 0.06 to 19.25 g in total weight were collected. Based on the results, growth coefficient values “b” ranged from 2.615 (in *B. cyri*) through 3.001 (in *A. microlepis*). All length-weight relationships were significant ($p < 0.05$), with r^2 higher than 0.819. The five species viz. *C. gracilis*, *P. parva*, *C. keyvani*, *P. cyrius*, and *B. cyri* showed allometric ($b < 3 < b$) while two species viz. *A. microlepis* and *A. eichwaldii* showed isometric ($b = 3$) growth patterns. Condition factor ranged from 0.57 (in *C. keyvani*) through 1.11 (in *P. cyrius*).

Zaryabet *et al.* (2017) carried out study on a Chambai dam on fishes rohu, silver carp and catla (*Labeorohita*, *Hypophthalmichthysmolitrix*, *Catlacatla*). 50 per sample species were collected from Chambai dam district Karak, Khyber Pakhtunkhwa. Length weight relationship showed a wide variation in results for *Labeorohita*, *Hypophthalmichthysmolitrix*, *Catlacatla* with average length 30.48cm, 17.78cm, 10.16cm and the average weight of 160g, 26g and 15g respectively. The weight-length relationship of *Labeorohita*, *Hypophthalmichthysmolitrix*, and *Catlacatla* could be considered very useful in fisheries research, fish biology and ecology.

Rathore *et al.* (2017) observed condition factor of *Catlacatla* and reported that the fish were in well condition during the study period. On the basis of length-weight data, the regression equations of bodyweight on total body length were calculated. The higher values of 'n' could be attributed to high rate of weight increase with per unit increase in length. The correlation co-efficient 'r' between total length and weight were found to be significant for all the length groups of *Catlacatla*.

Kumar *et al.* (2017) determined the length-weight relationship of *Labeorohita* by equation $\text{Log } W = \text{Log } a + b \text{ Log } L$ as suggested by LeCren (1951). When empirical values of lengths were plotted against their respective weight on an arithmetic scale, smooth curves were obtained. The relationship between observed and calculated weight when calculated using the method of least squares for samples of *Labeorohita* of size ranged between 20.1 – 70.0, cm gave an equation: $\text{Log } W = -1.73 + 3.03 \text{ Log } L$. Values for all specimens were practically identical and followed the cube law ($b = 3$). The agreement between the empirical weight and computed weight from regression can be termed as ideal growth (positive allometry).

2.2 The ichthyofauna and water quality

Das (2000) studied nine reservoirs including major reservoirs (Srisailem, Nagarjuna Sagar and Somalisa) and three riverine systems of Andhra Pradesh to evaluate their productivity status through physico-chemical determinants and concluded that the nutrient status of ambient water was found to be very poor. Shrivastava *et al.*, (2002) studied primary productivity of Tawa reservoir situated in Madhya Pradesh. Sultan *et al.*, (2003) investigated a small reservoir, Pahunj located at Jhansi in Uttar Pradesh for its physico-chemical features and productivity status and concluded that higher primary productivity indicated congenial environment for biological production. Studies on

limnology of Udaipur lakes have been made covering different aspects (Vyas, 1968; Sharma *et al.*, 1984; Sharma *et al.*, 2009). Rajkumar (2005) studied the limnological status and its relationship to the production potential of Daya reservoir of Southern Rajasthan. Balai (2007) studied fish and planktonic biodiversity of Jaisamand reservoir of Udaipur (Rajasthan). Chouhan and Sharma (2007) reported physico-chemical and biological status of a perennial lake the Buddha Pushkar of Ajmer, Rajasthan. In this investigation pollution status was studied with special emphasis on physico-chemical and biological parameters.

Fish diversity in the various water bodies of Rajasthan were also described by several researchers. Sharma and Johal (1984) investigated fish and fisheries of Kota district in Rajasthan and presented a list of seventy nine fish species. Sinha *et al.* (1991) and Kohli *et al.* (1988) reported a fisheries resources of Southern Rajasthan including those of Mahi, Kadana, Jaisamand and Jakham reservoirs. Jain (1998) described the fisheries resources of Rajasthan and suggested management strategies for promoting the fisheries of Rajasthan. Chouhan (2000) reviewed the fish diversity of North-West Rajasthan.

Sakhare (2005) recorded 28 species of fish belonging to 19 genera in a study conducted in Manjira reservoir in Maharashtra. Shinde *et al.* (2009) recorded 15 fish species represented by three orders in the Harsool-Savangi dam in Maharashtra. Negi (2008) recorded 51 species of fish in Gobindnagar reservoir and 28 species in Pong reservoir (Himachal Pradesh). Rao *et al.* (2011) recorded 24 species of fish under 12 families and 6 orders from Pocharam Lake (Andhra Pradesh).

Battule *et al.* (2007) reported 18 fish species from Ekrukh reservoir of Maharashtra where Cyprinidae family is dominant with 8 species. Khedkar and Gynanath (2005) recorded 37 species from Issapur dam of Maharashtra where Cyprinidae family is dominant with 20 species. The ichthyofauna of Ambadi dam (Maharashtra) was reported by Ubarhande *et al.* (2011) which belongs to 8 orders, 11 families, 22 genera and 27 species where Cyprinidae family is dominant with 13 species which makes 48.16% of total fish. The study conducted in certain reservoirs of Karnataka also recorded more of fish abundance from family Cyprinidae (Venkateshwarlu *et al.*, 2002).

Nandan and Magar (2007) studied 16 physico-chemical parameters of the Girma dam of Nashik district from Maharashtra. Paulose and Maheshwari (2007) conducted a

comparative study of Jalmahal and Ramgarhlake of Jaipur with special reference to plankton diversity. They opined that high nitrate content of these waters can be correlated with high density of phytoplankton and high rate of organic decomposition. Ramesh *et al.*, (2007) studied the water quality of the Singanallurlake situated in Coimbatore district and reported that the water was unsuitable for the survival of aquatic organisms. Sharma *et al.*, (2007) studied primary productivity and fisheries potential of Daya reservoir, Udaipur, Rajasthan. Ujjania*et al.*, (2007) studied three different water bodies namely Mahi Bajaj Sagar, Survania dam and Aasan pond located in Southern part of Rajasthan (Banswara district) and reported that all the three water bodies were highly productive.

Paunikar*et al.* (2012) studied on Ichthyofaunal Diversity of Gour River, Jabalpur, Madhya Pradesh, Central India. Malaviya (1961) reported the fish fauna of Jabalpur. Sugunan and Yadava (1992) mentioned 40 fish species from Hirakund reservoir of Orissa forming the commercial fishery. Singh (2001) reported a total of 27 species belonging to six families in Pong reservoir of Himachal Pradesh. Gopinath and Jayakrishan (1984) mentions 17 species of fishes from Idukki reservoir of Kerala. Pisca*et al.* (2000) reported fish belonging to four orders and 28 species from Ibrahimbagh reservoir of Hyderabad. Sakhare and Joshi (2002) observed 28 fish species including 9 species of carps, 5 of cat fishes, 2 of feather base, 5 of live fishes and 7 belonging to miscellaneous fishes. Saleskar and Yeergi (2004) recorded by 10 main fish species from Powai lake, Mumbai in Maharashtra. During another study altogether 33 fish species belonging to 23 genera falling in 6 orders have been identified from four lakes of Warangal district (Nampally, 1987).

Thirupathaiah*et al.*, (2012) studied the status of physico-chemical characteristic of lower Manair Reservoir at Karimnagar District, Andhra Pradesh. Monthly changes in physico-chemical parameters such as water temperature, pH, turbidity, transparency, total dissolved solids, total hardness, chlorides, phosphate, nitrates, dissolved oxygen and biological oxygen demand were observed. The results indicated that physico-chemical parameters of the water were within the permissible limits and can be used for domestic, irrigation and pisciculture. Lodhet *et al.*, (2014) studied physicochemical parameters of four lakes of Udaipur of Tripura state. The studied lakes are Amar Sagar (AS), DhaniSagar (DS), JagannathDighi (JD) and MahadebDighi (MD). He evaluated the water quality of the lakes and to identified the pollution sources. In these studyof physicochemical water quality such as Biochemical Oxygen Demand (BOD) as well as the value of ammoniacal

nitrogen (NH₃-N) were found high during analysis which conveys high bacteriological load, organic matter disposal and animal waste contamination into the lakes. Dhawale and Ghyare (2015) studied the physico-chemical status of water in Pus Dam of Pusad Tehsil of Yavatmal District, Maharashtra and found that physico-chemical parameters of the water were within the permissible limits and can be used for domestic, irrigation and pisciculture. Mohammad *et al.*, (2015) assessed the quality of water by using physico-chemical parameters of Wyra reservoir of Khammam district, Telangana, India. Results indicated that the quality of water from this reservoir was within the acceptable values.

3. MATERIALS AND METHODS

The present study was carried out during January, 2018 to June, 2018 with a view to investigate the **Length Weight Relationship and Condition Factor** of Selected Freshwater Fishes of Govardhan Sagar (Udaipur). A Govardhan Sagar reservoir has fish landing center. Fish samples were collected during the whole fishery season from January to march, 2018 at an interval of 4-5 days. Laboratory studies were conducted in the College of Fisheries, Udaipur while field studies were conducted at Govardhan Sagar.

3.1 Climate of Southern Rajasthan

This zone experiences a subtropical climate with average rainfall ranging from 67 cm. and relative humidity of 75-95 per cent during the monsoon period. The summers are hot and winters are cool having an average range of maximum temperature between 38-41°C and minimum between 1-5°C. The elevation of study zone is 582 m above mean sea level.

3.2 Study Area

Govardhan Sagar , the area of study, lies on the Udaipur-Ahmedabad highway, at about 2.5 km distance from Udaipur city (24°32'N latitude and 73°41'E longitude) having a maximum length of 1.97 km, thus covering a total water spread area of 30.81 ha . The lake is totally rain-fed. The catchment area is about 2.56 sq. km. The capacity at full lake level is 9 million cubic meters.

The lake retains water throughout the year. However, it dries during certain drought years, leaving thin layer of water at its bottom for one or two months. When the northerly located Pichhola Lake, during the above normal rainfall year, is over flooded by Kotra rivers it feeds water to the Govardhan Sagar. The outlet of Govardhan Sagar lies towards the south of the lake and its overflow water join Ahar River through a tributary. The deeper position of the lake lies towards north east bank which has steep slope, while towards south and western sides, lies the fields and farm lands.

3.3 Morphometry of Govardhan Sagar

The details of morphometric features of Govardhan Sagar are given in Table 3.1.

Table 3.1 Morphometric features of Govardhan Sagar, Udaipur (Raj.)

1	Location Latitude Longitude Altitude	24°32'N 73°41'E 582 m (MSL)
2	Average rainfall	670 mm
3	Open water spread area	Over 17.97 ha.
4	Weed choked marginal area	Over 12.83 ha.
5	Total area	30.80 ha.
6	Catchment area	2.56 sq.km.
7	Maximum depth (Zm)	7.62 m
8	Maximum length (L)	1.97 km
9	Maximum width (bx)	0.72 km

10	Length of shoreline (L)	3888.8 m
11	Capacity of F.T.L.	9 million cubic meters
12	Type of dam	Masonry
13	District	Udaipur
14	Accesses	2.5 km away from Udaipur on the Udaipur Ahmedabad highway.

Source: Irrigation Department, Udaipur (Raj.)

3.4 Sampling Stations:

For the proposed study, three sampling stations were selected in Govardhan Sagar for collection of fish specimen and surface water samples. Station A is located on the South Eastern shore and station B near the dam on Eastern shore and station C is located at the Western end of the lake (Fig.4.2).

3.5 Collection of fish and water sample:

300 specimens each of Indian major carps (*Catla catla*, and *Labeo rohita*) were collected from the landing centre and used to measure total length (cm) and body weight (gm) from the commercial fish catch of Govardhan Sagar during the months January to March, 2018.

During the study period, surface water samples from all the three selected sampling stations were collected every week using a plastic bucket. After field analysis to assess certain water quality parameter the water sample were stored in one-liter plastic bottles with air tight cap for analysis of certain parameters (*etc.*) in the laboratory.

3.6 Measurement of length and weight of fishes:

The measurement on the fishes was taken at the landing site of the reservoir. The total length and total weight was taken for major carps, *Catla catla* and *Labeo rohita*. Length of the fishes was recorded with the help of fish measuring board. The weight of the fishes was also taken with the help of electronic balance. Cubes law was applied to know the length weight correlation. The well-known equation is

$$\text{Log } W = \text{Log } a + b \text{ Log } L \text{ or } W = aL^b$$

Where, W = weight in kg, L = length in cm and a and b were derived empirically from length and weight. The length was measured in centimeter and the weight was in grams. The general linear equation $Y = a + bx$ is used to estimate the constants 'a' and 'b'. The estimation of regression coefficient was tested for significance. Correlation between length and weight of the major carps were calculated using MS-Excel.

Biodiversity of Ichthyofauna:

To access the biodiversity of ichthyofauna of the Govardhan Sagar Lake three sites were selected randomly and samples were taken by using cast net.

3.7 Physico-Chemical Parameters:

3.7.1 Air and water temperature

A centigrade thermometer of 0 to 50°C range and graduated to 0.1°C was used to measure air and water temperature. Air temperature around the sampling station was measured in shade. The water temperature was observed by immersing the thermometer in water samples immediately after collection.

3.7.2 Depth of visibility:

The transparency of water was determined using a standard Secchi disc of 20cm diameter. Two readings, one for disappearance and other for reappearance were recorded and then the depth of visibility was calculated as under:

$$\text{Depth of visibility (cm)} = \frac{D_1 + D_2}{2}$$

Where

D_1 = Depth of disappearance in cm

D_2 = Depth of reappearance in cm

3.7.3 Hydrogen ion concentration (pH)

The pH of the water sample was measured with the help of a standardized pen type digital pH meter (make-milwaukee pH 600).

3.7.4 Electrical conductivity (EC)

Electrical conductivity was measured with the help of a pen type electronic conductivity meter and results were expressed as mS cm^{-1} .

3.7.5 Dissolved oxygen

The concentration of dissolved oxygen in water was estimated following the basic Winkler's method APHA (1989) and Trivedy *et al.* (1987).

In this procedure, oxygen combines with manganous hydroxide to form higher hydroxides which on acidification liberate iodine equivalent to that of oxygen fixed.

This iodine is titrated with standard sodium thiosulphate solution using starch as an indicator.

Following steps were adopted for oxygen estimation:

- (i) Water sample was collected in 250 ml glass bottle without bubbling.
- (ii) Two ml of each manganous sulphate (Winkler A) and alkaline-iodide solutions (Winkler B) were dispensed one after the other right at the bottom of the bottle with separate pipettes. Then stopper was replaced.
- (iii) The bottle was shaken upside down at least 6 times and allowed the brown precipitate to settle.
- (iv) The precipitates were dissolved by adding 2 ml of concentrated sulphuric acid and the stoppered bottle was again shaken.
- (v) 50 ml of aliquot was taken in a flask and then titrated with sodium thiosulphate (0.025 N) till the color changed to pale straw.
- (vi) After that, two drops of freshly prepared starch indicator were added and titrated further till the blue colour disappeared for the first time.
- (vii) The total amount of titrant used was noted and then dissolved oxygen content was calculated using following formula:

$$\text{Dissolved oxygen (mg l}^{-1}\text{)} = \left[\frac{8 \times 1000 \times N}{V_1} \right] \times V_2$$

Where,

N = Normality of the titrant (0.025 N)

V1 = Volume of sample (ml)

V2 = Volume of titrant used (ml)

3.7.6 Free carbon dioxide

For the estimation of free CO₂, 100 ml of water sample was taken in a conical flask and a few drops of phenolphthalein indicator were added. In case the colour turned pink, free CO₂ was taken as absent. If sample remained colourless, the same was titrated against NaOH (0.05 N) till the appearance of pink colour and free carbon dioxide was calculated using following formulae:

$$\text{Free CO}_2 \text{ (ml/l)} = \frac{\text{ml of NaOH} \times \text{N} \times 1000 \times 44}{\text{ml of sample}}$$

3.7.8 Total Hardness:

The estimation of total hardness is based on the fact that Eriochrome black 'T' forms wine red complex compound with metal ions (Ca⁺⁺ and Mg⁺⁺). The EDTA has got stronger affinity towards Ca⁺⁺ and Mg⁺⁺. When the solution is titrated by EDTA, the former complex is broken down and new complex of blue colour is formed.

50 ml of sample water was taken in a conical flask. To it, 1 ml of ammonia buffer and 5 drops of indicator solution added. The solution turned wine red in colour. The solution titrated by EDTA solution until clear blue colour appeared. The calculation of total hardness was done using the following formula:

$$\text{Total Hardness as CaCO}_3 \text{ (mg/l)} = \frac{\text{ml of EDTA titrant used}}{\text{ml of sample}} \times 1000$$

3.7.9 Alkalinity:

For determining carbonate alkalinity, 50 ml of water sample was taken in conical flask and a few drops of phenolphthalein indicator were added. If sample remained colourless, then carbonate alkalinity was taken as absent and pink colour developed, then water sample was titrated to a colourless end point using 0.01 N HCL. The same water sample, after determining carbonate alkalinity, was used for the estimation of bicarbonate alkalinity by continuation of the titration with methyl orange as indicator. Calculation was performed using following formulae:

$$(i) \quad \text{Carbonate alkalinity (mg/l)} = \frac{A \times N \times 1000 \times 50}{\text{ml of sample}}$$

$$(ii) \quad \text{Bicarbonate alkalinity (mg/l)} = \frac{B \times N \times 1000 \times 50}{\text{ml of sample}}$$

$$(iii) \quad \text{Total alkalinity (mg/l)} = \text{Carbonate alkalinity} + \text{Bicarbonate alkalinity}$$

Where,

A = ml of HCL used only with phenolphthalein

B = ml of HCL used only with methyl orange

N = Normality of hydrochloric acid

3.7.10 Statistical Analysis:

The data collected during the present study was processed for statistical analysis. The analysis of correlation coefficient and regression was done as per the method described by Snedecor and Cochran (1981). The length-weight relationship was established using the linear equation of the form,

$$\text{Log } W = \text{Log } a + b \text{ Log } L.$$

$$W = a L^b$$

Where,

W = Weight of the fish in gm

L = Total length in cm

a & b = Constants

(1) Standard deviation

$$\sigma = \sqrt{\frac{\sum(X - \bar{X})^2}{n}}$$

Where,

σ = Standard deviation

X = variable

\bar{X} = Mean of all value in variable

n = number of value in variable

(2) Average -

$$\bar{X} = \frac{\sum X}{n}$$

Where,

\bar{X} = Average

$\sum X$ = sum of observation

n = total number of observation

(3) Coefficient of variation-

$$CV (\%) = \left(\frac{\text{Standard deviation}}{\text{Mean}} \right) \times 100$$

(4) Correlation coefficient

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}}$$

Where,

n = number of paired observations

$\sum xy$ = Sum of products of observations

$\sum x$ = sum of x observations

$\sum y$ = sum of y observations

$\sum x^2$ = Sum of squared x observations

$\sum y^2$ = Sum of squared of y observations

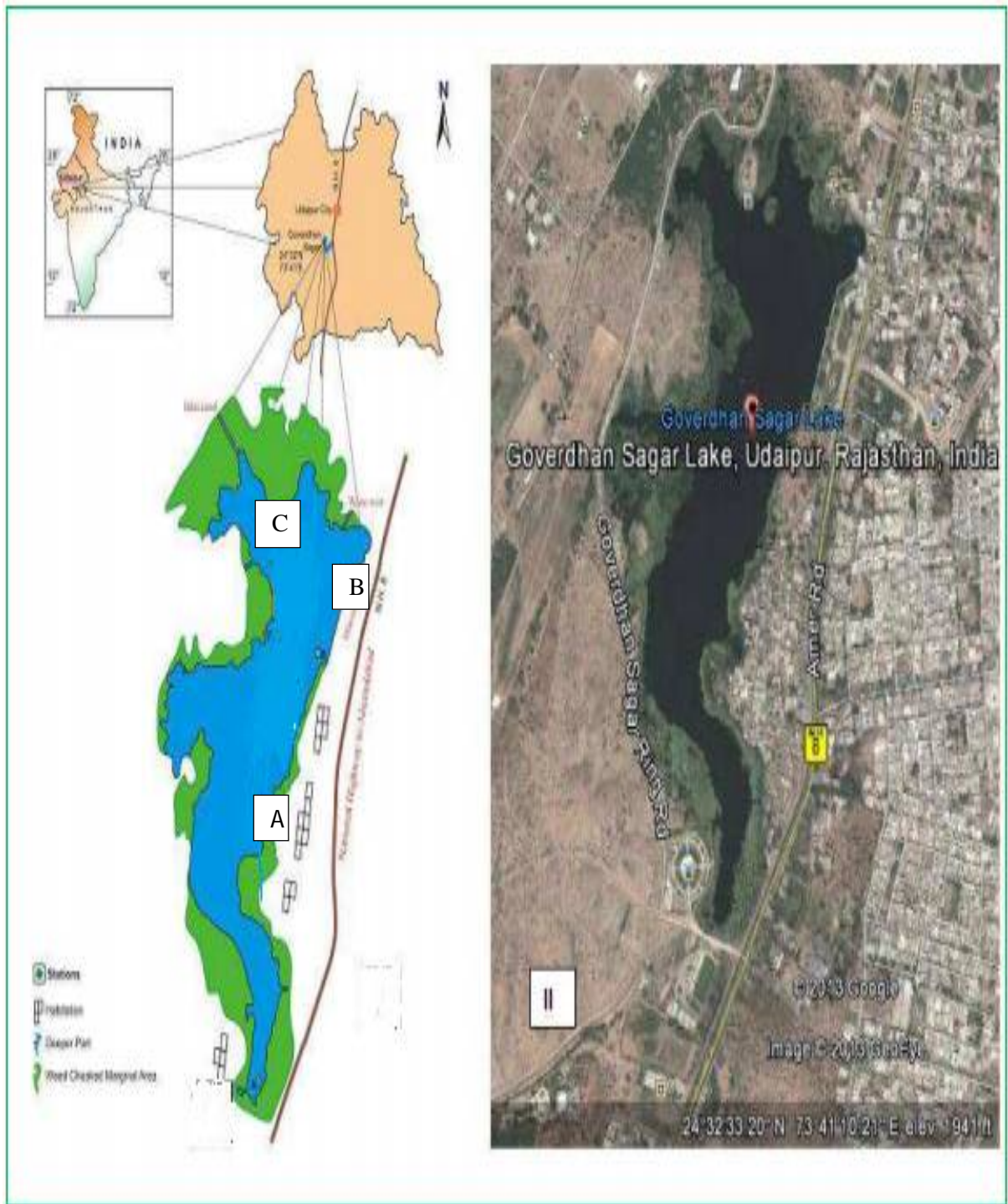


Fig.3.1: Showing location map of study area (GovardhanSagar Lake)



Fig3.2: panoramic view of GoverdhanSagar Lake showing sampling station A,B(above) and (C below)

4. EXPERIMENTAL RESULTS

(A) Length-weight relationship:

For its purpose, the fishes selected for the study were grouped into 3 length groups *i.e.* **A**-30.0 to 40.0 cm, **B**-41 to 50 cm, and **C**-51 to 60 cm.

It would be seen from Table 4.1 and Fig. 4.1 that *Catlacatla* from GovardhanSagar Lake was primarily dominated by A length-group (44.33%) while the other length groups *viz.*, B and C followed in the same sequential order, with percentage of 42.0, and 13.66 respectively.

In the case of *Labeorohita*, the picture was slightly different to that of *Catlacatla* with B length-group dominating the scene (56.00) followed by A (34.333), and C (9.66) as shown in the Table 4.2 and Fig 4.1.

The statistical relationship of body-weight with total body-length in the case of *Catlacatla* was highly significant as seen by significant correlation co-efficient (r value) indicate the Table 4.1 for all length groups. It may be noted here that the highest 'r' value (0.864) was in C length group followed by length-group B (0.618) and A (0.24).

Table 4.1 also depicts that *Catlacatla* deviates from cube law in all the length groups. The exponents value for body weight and total body weight ranged between 1.495 and -0.676. The above highest and lowest of 'n' were observed in length-groups A and C, respectively. For other length-groups *i.e.*, B, the exponent value was 0.601.

The statistical relationships of body-weight with total body-length of *Labeorohita* were calculated for different length-groups. A highly significant correlation was observed between body-weight and total body-length for all the length-groups (Table 4.2). The highest 'r' value (0.758) was in B length-group followed by C (0.430), and A (0.302) length-groups.

r^2 is high in *Catlacatla* length-group C in (.71%), followed by those of A (.06%) and B (.38%) (Table 4.1) and *Labeorohita* in A (09%) B (62%) and C (18%) (Table 4.2) respectively variation could be explained together in the value of weight and then is due to other factor.

b value length influence significantly for corresponding weight of fishes in Catlacatla high length-group in C (3.96) and B (1.425) and Labeorohita in length-group B (3.47) and C (2.273) respectively.

(B) Condition factor/ Ponderal index (K):

The mean values of condition factor (K) for all the length-group of *Catlacatla* and *Labeorohita* are shown in Table 4.3. The 'K' values of *Catlacatla* ranged between 0.91 and 1.249. The highest 'K' value was recorded from the length-group A followed by those of Band C groups in order of 1.027, and 0.91, respectively.

The values of condition factor for the different length-groups of *Labeorohita* ranged between 1.07 and 1.210, the highest value being of 1.210 from the length group B. In the case of length-groups A and C the values of K were 1.155 and 1.074 respectively.

PHYSICO-CHEMICAL PARAMETERS

The weekly fluctuations in selected water quality parameters of Govardhan Sagar Lake are presented in Tables 4.4 to 4.6 and Fig 4.3 to Fig. 4.5. Weekly variations in water quality of Govardhan Sagar Lake are clearly evident from the results of this study.

Air and water temperature:

The weekly variations in air and water temperature are depicted in Tables 4.4 to 4.6. It is evident that the highest air temperature (34.0°C) was found near station C during April with the lowest (27.0°C) in March near same station C. The average temperature of 30.57°C, 30.40°C, and 30.43°C were observed at the three stations A, B and C respectively.

The average values at all the three stations for air temperature are shown in Table 4.7 and Fig. 4.4. The highest air temperature (32.60°C) was observed in April and lowest (28.01°C) in January. The average air temperature near all the three stations was 30.35°C during the study period.

The surface water temperature fluctuated between 25.03°C to 32.60°C. The average water temperature of 27.86, 28.50, and 28.29°C was recorded at stations A, B, and C, respectively (Tables 4.4 to 4.6).

The average values water temperatures at all the three stations are shown in Table 4.7. The highest water temperature (31.33°C) was observed and lowest (24.33°C)

was such in March. The average water temperature of all the three stations was 28.24°C during the study period.

The correlation of both the temperatures with other water quality parameters is shown in Table 4.8. The statistical analysis indicates that during the study period, surface water temperature had positive significant relationship with air temperature, depth of visibility.

Hydrogen ion concentration (pH):

In general, the water of GovardhanSagar Lake remained slight alkaline throughout the study period. The values of pH range were 8.8 to 9.2, 8.4 to 9.1, and 8.4 to 9.2 at all the three stations *viz.* A, B and C respectively. Further, the respective mean values of pH at stations A, B and C were 8.97, 8.89 and 8.87 (Tables 4.4 to 4.6). From these observations it is further evident that station C maintained lower average pH as compared to other three stations and the highest average pH was found at station A.

The statistical results show that pH had no significant relationship with any other parameter (Table 4.8).

Depth of visibility:

The values of depth of visibility also referred as transparency at stations A, B and C of GovardhanSagar Lake fluctuated between 124 to 130, 122 to 135, and 110 to 128, cm respectively. The mean value of depth of visibility was highest at station B and lowest at station C (Tables 4.6 to 4.7).

The statistical results show that during the study period, the depth of visibility had a positive significant relationship with water temperature (Table 4.8).

Dissolved oxygen (DO):

During the study period, the concentration of dissolved oxygen in surface water of GovardhanSagar Lake ranged from 7.2 to 11.6, 6.4 to 12, and 7.2 to 12.4 mg l⁻¹ at stations A, B, and C, respectively. The average values of dissolved oxygen were 9.60, 10.06, and 10.40 at stations A, B, and C, respectively. Station C had the highest dissolved oxygen (12.4 mg l⁻¹) (April) and station B showed the lowest dissolved oxygen (6.4 mg l⁻¹) in (Tables 4.4 to 4.6).

Statistical relationship of DO during the study period had a positive significant relationship with water temperature and negative significant relationship with total alkalinity and total hardness (Table 4.8).

Free carbon dioxide (Free CO₂)

The free carbon dioxide was absent at stations **A, B** and **C** throughout the study period.

Carbonate alkalinity:

In GovardhanSagarLake the carbonate alkalinity ranged between 8.00 to 16.00, 6.40 to 12.00 and 10 to 16 mg l⁻¹ at stations **A, B** and **C**, respectively. The average values of carbonates were recorded as 12.57, 10.57, and 12.57 mg l⁻¹ at stations **A, B** and **D** respectively. (Tables 4.4 to 4.6).

The statistical correlation of carbonate alkalinity with selected water quality parameters are shown in (Table 4.8.) from this table, it is apparent that the Carbonate alkalinity in surface water has failed to indicate any significant relationship with other water quality parameters.

Bicarbonate alkalinity:

The values of bicarbonate alkalinity ranged from 40 to 76, 42 to 80 and 40 to 50 mg l⁻¹ at stations **A, B**, and **C**, respectively. The average values of bicarbonate alkalinity were 49.14, 52.29 and 43.71 mg l⁻¹ at stations **A, B** and **C**, respectively. The mean value of bicarbonate alkalinity was highest at station **B** and lowest at station **A** in. (Tables 4.4 to 4.6).

The statistical correlation of bicarbonate alkalinity with selected water quality parameters are shown in Table 4.8. The bicarbonate alkalinity has highly significant positive relationship with total alkalinity and total hardness and on the other hand total dissolved solid (TDS) Electrical conductivity (EC) had a significantly negative relationship (Table 4.8).

Total alkalinity:

In general, the total alkalinity in the present study varied between 50 to 90, 44 to 88 and 50 to 62 mg l⁻¹ at stations A, B and C, respectively. The average values were 61.71, 58.57, and 56.29 mg l⁻¹ at stations A, B, and C, respectively (Tables 4.4 to 4.6).

The statistical correlation of total alkalinity with selected water quality parameters are shown in Table 4.8. The total alkalinity has highly significant positive relationship with total hardness and bicarbonate alkalinity. However, a negative relationship was evident with total dissolved solid (TDS), electrical conductivity (EC) and dissolved oxygen (DO) (Table 4.8).

Electrical conductivity (EC):

The values of electrical conductivity fluctuated from 0.42 to 0.48, 0.42 to 0.47 and 0.42 to 0.49 mS cm⁻¹ at stations A, B, and C, respectively. The average values of EC were 0.45, 0.44 and 0.46 mS cm⁻¹ at stations A, B, and C, respectively. The mean value of electrical conductivity was highest at station C and lowest at station B. (Tables 4.4 to 4.6).

The statistical correlation of electrical conductivity with selected water quality parameters are shown in Table 4.8. The Electrical conductivity has highly significant positive relationship with total dissolved solid (TDS). However, a significant negative relationship with bicarbonate alkalinity, total alkalinity and total hardness (Table 4.8).

Total dissolved solids (TDS):

The Total dissolved solids fluctuated from, 268.0 to 307.2, 268.0 to 300.80 and 268.0 to 313.60 mg l⁻¹ at stations A, B, and C, respectively. The average values of total dissolved solids were 286.77, 280.46, and 291.54 mg l⁻¹ at stations A, B, and C, respectively (Table 4.4 to 4.6). The mean value of total dissolved solids was highest at station C and lowest at station B. (Tables 4.8).

The statistical correlation of total dissolved solids with selected water quality parameters are shown in Table 4.8. The total dissolved solids had highly significant positive relationship with electrical conductivity (EC). However a significant negative relationship was shown with bicarbonate alkalinity, total alkalinity and total hardness (Table 4.8).

Biodiversity of Ichthyofauna:

Fish fauna: The reservoir has a rich fish fauna and so far 35 species representing the important genera have been recorded (Table 4.9). Out of these 8-10 species contribute to the commercial fisheries from this reservoir.

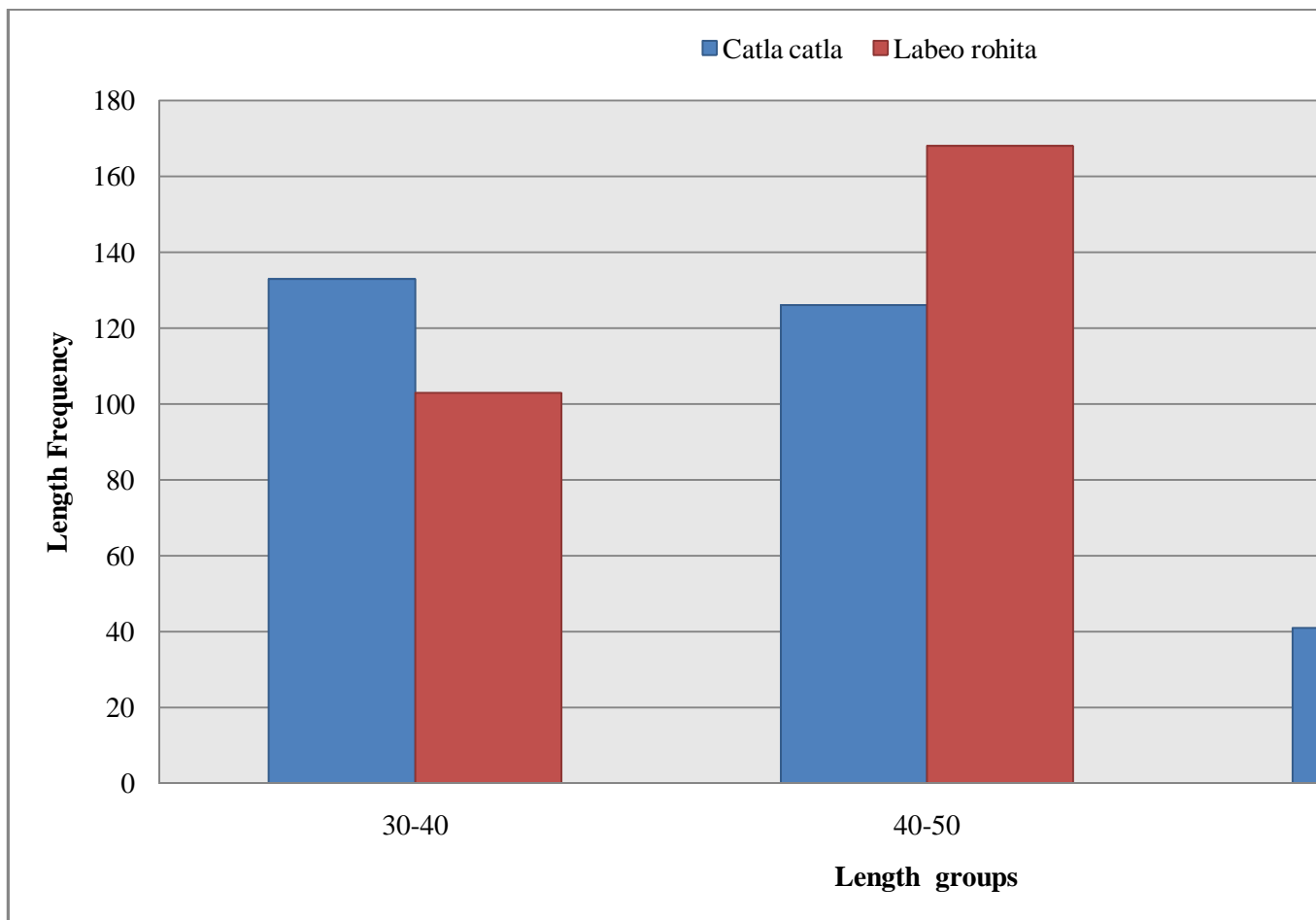


Fig. 4.1 Length frequency distribution of *C. catla* & *L. rohita* of Goverdhan Sagar Lake

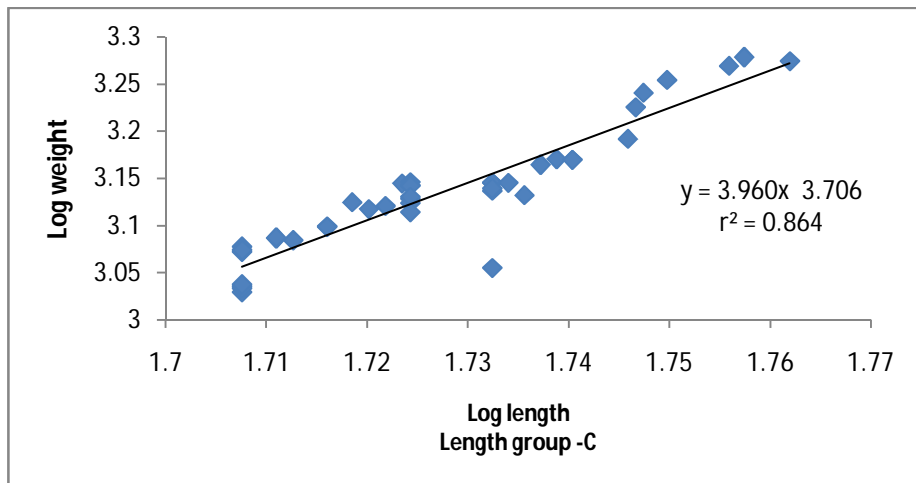
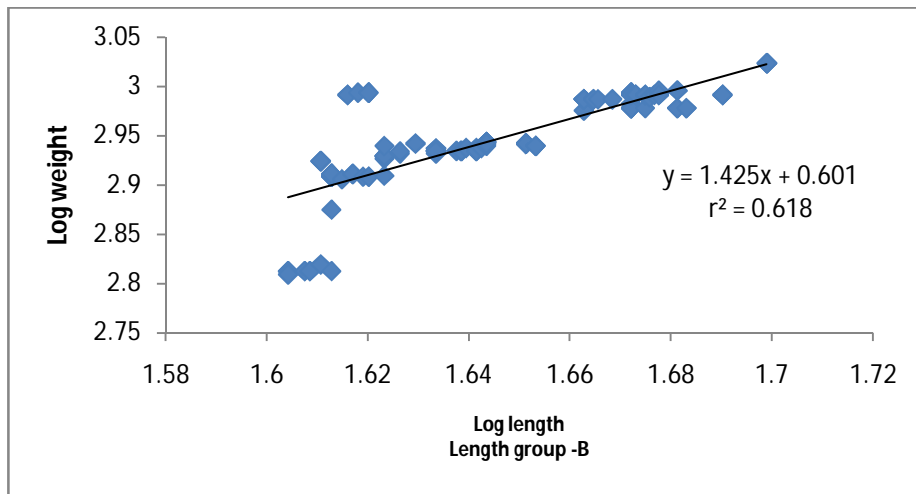
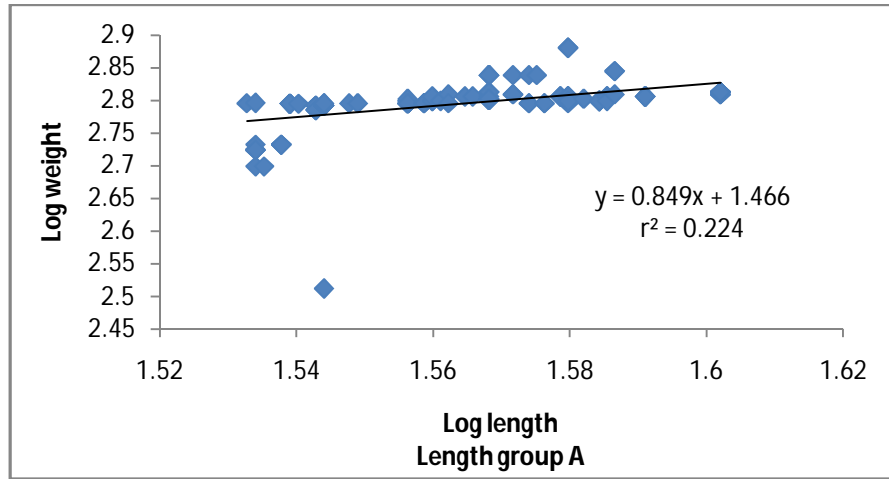
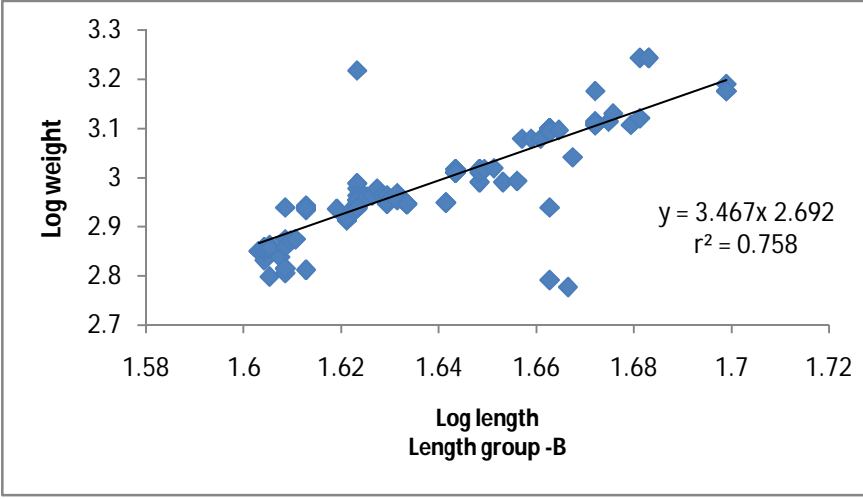
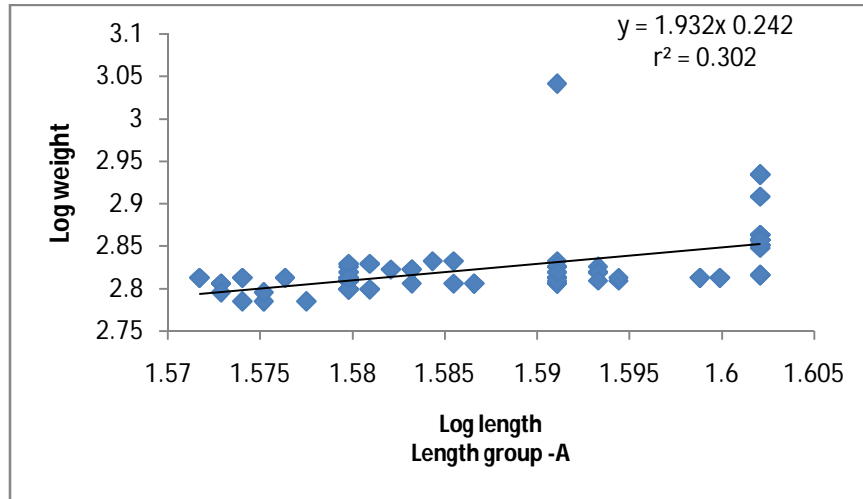


Fig.4.2: Relationship between log length and log weight of *C. catla* of GoverdhanSagar Lake



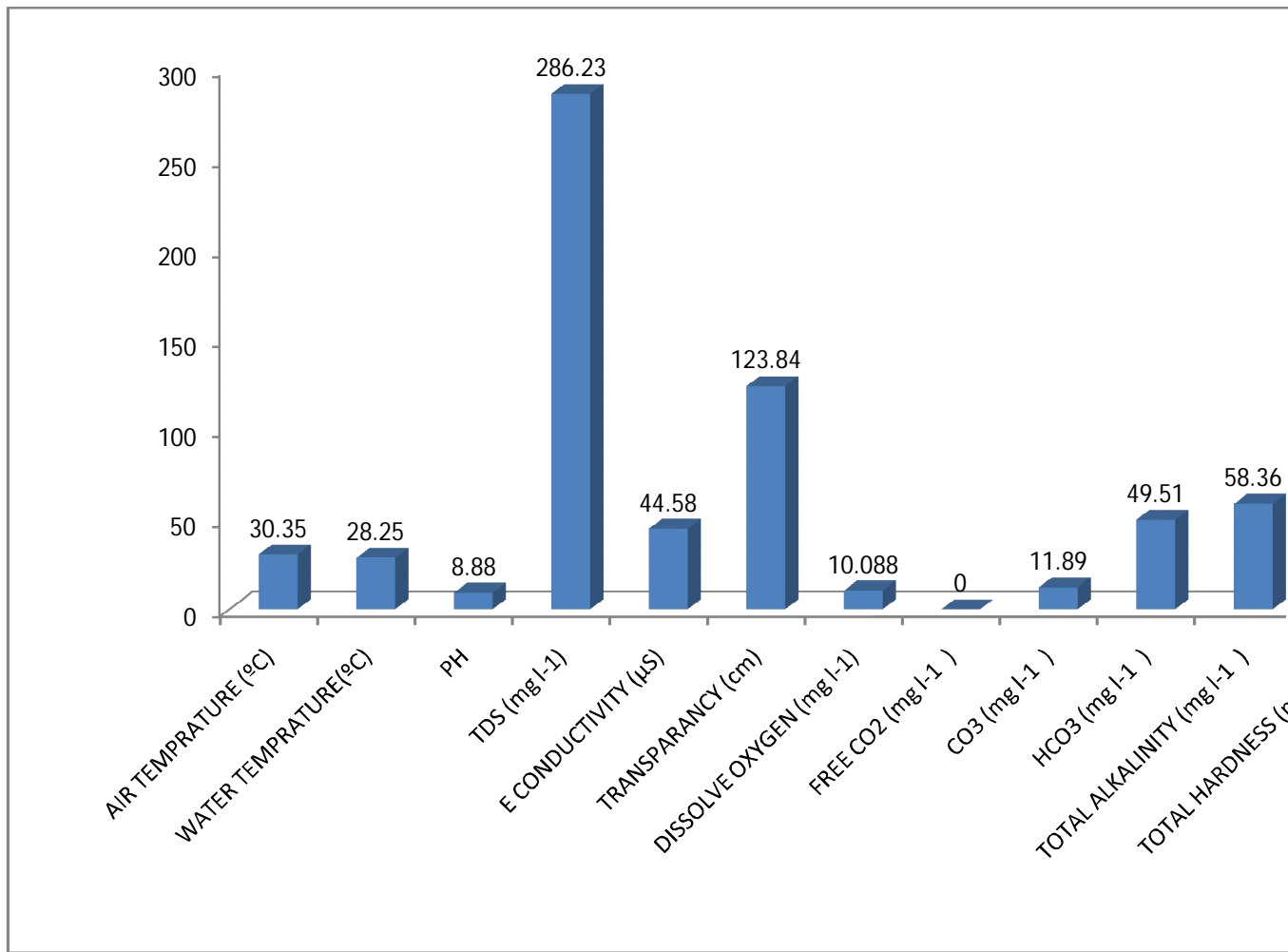


Fig. 4.4: Average value of all water quality parameter of throughout the experimental period



Plate4.1: Observation of length



Plate4.2: Observation of weight



Catlacatla



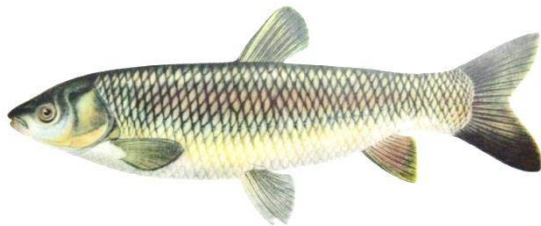
Labeorohita



Cirrihinusmrigala



Hypophthalmichthysmolitrix



Ctenopharyngodonidella



Chanda-nama



Xenentodon cancila



Mastacembelusarmatus

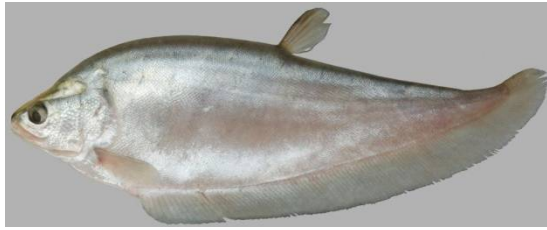


Puntius sophore



Oxygasterclupeoides

Plate: 4.3 Fish fauna of GovardhanSagar Lake



Notopterus notopterus



Nemacheilusbotia



Labeo calbasu



Labeobata



Labeo gonius



Heteropneustefosilis



Amblypharyngodon mola



Garra gotyla



Channa striatus



Chela basila

Plate: 4.4 Fish fauna of GovardhanSagar Lake

Table 4.1: Correlation and regression of total body length (cm) with body weight (gm) of *Catlacatla* at different length groups

S. No	Length (cm)	Group	No. of fish	Frequency (%)	Mean L \pm SD	Mean W \pm SD	'b' Value	'r' Value	'r ² ' (%)
1	30-40	A	133	44.33	36.90 \pm 1.00	628.22 \pm 44.711	0.849	0.24*	0.0576
2	41-50	B	126	42	44.176 \pm 2.760	886.103 \pm 94.067	1.425	0.618**	0.3819
3	51-60	C	41	13.66	53.125 \pm 1.89	1381.43 \pm 216.04	3.96*	0.864**	0.7157

** Significant at 1 per cent level of significance

* Significant at 5 per cent level of significance

Table 4.2: Correlation and regression of total body length (cm) with body weight (gm) of *Labeorohita* at different length groups

S. No	Length (cm)	Group	No. of fish	Frequency (%)	Mean L \pm SD	Mean W \pm SD	'b' Value	'r' Value	'r ² ' (%)
1	30-40	A	103	34.33	38.73 \pm 0.907	671.69 \pm 63.45	1.932	0.302	0.0912
2	41-50	B	168	56	43.545 \pm 2.612	999.37 \pm 245.74	3.467*	0.758**	0.6162
3	51-60	C	29	9.66	53.625 \pm 1.843	1477.38 \pm 198.66	2.273*	0.43*	0.1849

** Significant at 1 per cent level of significance

* Significant at 5 per cent level of significance

Table 4.3: Condition factor of *Catlacatla* and *Labeorohita*

S.No	Length groups (cm)	Condition factor (K)	
		Catla	Rohu

1	30-40	1.249	1.155
2	41-50	1.027	1.210
3	51-60	0.905	1.074

Table 4.4: Physico-chemical characteristics at station ‘A’ in GovardhanSagar during March to April 2018

Parameter	Date							Me an	M in.	M ax.	SD	C V
	Ma rch	Ma rch	Ma rch	Ma rch	Ap ril	Ap ril	Ap ril					
	06	13	20	27	03	10	17					
Air temp (°C)	31	28. 5	28. 5	29	32	33	32	30. 57	28 .5	33	1.8 8	6.1 5
Water temp (°C)	23	26	28	28	30	30	30	27. 86	26	30	2.6 1	9.3 7
Depth of visibility (cm)	130	127	124	126	12 6	12 4	12 6	126 .14	12 4	13 0	2.0 4	1.6 1
pH	9.2	9	9	8.9	8.9	9	8.8	8.9 7	8. 8	9.2	0.1 3	1.4 0
EC mS/cm	0.4 2	0.4 8	0.4 3	0.4 6	0.4 4	0.4 6	0.4 5	0.4 5	0. 42	0.4 8	.00 2	4.5 4
TDS (mg l ⁻¹)	268	307 .2	275 .2	294	28 1	29 4	28 8	286 .77	26 8	30 7.2	13. 18	4.6 0
Dissolved O ₂ (mg l ⁻¹)	7.2	8.4	8.4	11. 2	9.6	10. 8	11. 6	9.6	7. 2	11. 6	1.6 7	17. 35
Free CO ₂ (mg l ⁻¹)	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0		0.0 0	0. 00	0.0 0	0.0 0	0.0 0
Carbonate alkalinity (mg l ⁻¹)	14	10	12	8	14	14	16	12. 57	8	16	2.7 6	21. 96
Bicarbonate alkalinity(mg l ⁻¹)	76	40	40	42	56	42	48	49. 14	40	76	13. 16	26. 78
Total alkalinity (mg l ⁻¹)	90. 00	50. 00	52. 00	50. 00	70. 00	56. 00	64. 00	61. 00	50	90	14. 58	23. 62
Total hardness	280	226	200	196	21 0	20 6	21 2	218 .57	19 6	28 0	28. 75	13. 15

Table 4.5: Physico-chemical characteristics at station 'B' in GovardhanSagar during March to April 2018

Parameter	Date							Me an	M in.	M ax.	S D	C V
	Ma rch	Ma rch	Ma rch	Ma rch	Ap ril	Ap ril	Ap ril					
	06	13	20	27	03	10	17					
Air temp (°C)	28	27.8	29	30	31	34	33	30. 40	27. 8	34	2.4 1	7.9 1
Water temp (°C)	25	26.5	28	28	29	31	32	28. 50	25	32	2.4 3	8.5 3
Depth of visibility (cm)	135	124	122	124	12 6	12 8	12 6	126 .43	12 2	13 5	4.2 4	3.3 5
pH	8.7	8.4	9	9.1	8.9	9	9.1	8.8 9	8.4	9.1	0.2 5	2.8 6
EC mS/cm	0.42	0.42	0.47	0.44	0.4 3	0.4 4	0.4 5	0.4 4	0.4 2	0.4 7	1.7 7	4.0 4
TDS (mg l ⁻¹)	268	268	300. 8	281. 6	27 5.2	28 1.6	28 8	280 .46	26 8	30 0.8	11. 63	4.1 5
Dissolved O ₂ (mg l ⁻¹)	6.4	8.8	12	11.2	9.6	11. 2	11. 2	10. 06	6.4	12	1.9 5	19. 41
Free CO ₂ (mg l ⁻¹)	0.00	0.00	0.00	0.00	0.0 0	0.0 0		0.0 0	0.0 0	0.0 0	0.0 0	0.0 0
Carbonate alkalinity (mg l ⁻¹)	8	12	10	12	10	10	12	10. 57	6.4	12	1.9 5	19. 41
Bicarbonate alkalinity(mg l ⁻¹)	80	48	42	48	44	56	48	52. 29	42	80	12. 98	24. 83
Total alkalinity (mg l ⁻¹)	88	60	52	50	44	66	50	58. 57	44	88	14. 86	25. 38
Total hardness	304	206	192	178	18 0	18 8	18 4	204 .57	17 8	30 4	44. 82	21. 91

Table 4.6: Physico-chemical characteristics at station ‘C’ in GovardhanSagar during March to April 2018

Parameter	Date							Me an	M in.	M ax.	S D	C V
	Ma rch	Ma rch	Ma rch	Ma rch	Ap ril	Ap ril	Ap ril					
	06	13	20	27	03	10	17					
Air temp (°C)	30	28	27	30	32	33	33	30. 43	27	33	2.3 7	7.7 9
Water temp (°C)	25	27	26	28	30	31	31	28. 29	25	31	2.4 3	8.5 9
Depth of visibility (cm)	110	118	115	118	12 1	12 8	12 3	119 .00	11 0	12 8	5.7 7	4.8 5
pH	8.8	8.7	9.1	8.8	8.4	9.2	8.5	8.7 9	8.4	9.2	0.2 9	3.3 1
EC mS/cm	0.42	0.49	0.45	0.46	0.4 5	0.4 6	0.4 6	0.4 6	0.4 2	0.4 9	0.0 2	4.5 4
TDS (mg l ⁻¹)	268	313. 6	288	294. 4	28 8	29 4.4	29 4.4	291 .54	26 8	31 3.6	13. 48	4.6 2
Dissolved O ₂ (mg l ⁻¹)	8.4	7.2	10.4	11.2	12	11. 2	12. 4	10. 40	7.2	12. 4	1.9 2	18. 45
Free CO ₂ (mg l ⁻¹)	0.00	0.00	0.00	0.00	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0
Carbonate alkalinity (mg l ⁻¹)	12	16	14	10	14	10	12	12. 57	10	16	2.2 3	17. 70
Bicarbonate alkalinity(mg l ⁻¹)	50	46	40	44	42	40	44	43. 71	40	50	3.5 5	8.1 1
Total alkalinity (mg l ⁻¹)	62	62	54	54	56	50	56	56. 29	50	62	4.3 9	7.7 9
Total hardness	320	222	220	210	19 0	18 4	18 8	219 .14	18 4	32 0	47. 11	21. 50

Water Temp.	0.787*	1.000							
p ^H	0.044	0.068	1.000						
TDS	-0.054	0.500	-0.081	1.000					
E C	-0.103	0.477	-0.088	0.996**	1.000				
Depth of vis.	0.764*	0.330	-0.051	-0.245	-0.308	1.000			
DO	0.643	-0.408	0.211	0.448	0.428	0.070	1.000		
Free CO ₂	-	-	-	-	-	-	-	-	
CO ₃	0.228	0.308	-0.587	0.180	0.206	0.083	0.031	-	1.0
HCO ₃	0.038	-0.582	0.033	-.869*	-0.895**	0.479	-0.637	-	-0.2
Total Alk.	-0.112	-0.684	-0.117	-.847*	-0.858*	0.330	-0.758*	-	-0.0
Total hardness	-321	-0.822*	0.006	-0.805*	-0.808*	0.143	-0.833*	-	-0.1

*Correlation at 5per cent level of significance.

**Correlation at 1per cent level of significance.

Table 4.9 List of fish fauna represented in the catch from Goverdhansagar Lake, Udaipur

		Species	
Family	Scientific name	Local name	Local name
(A) Cyprinidae	1. <i>Catla</i> (ham.)	Catla	
	2. <i>Cirrhinus mrigala</i> (Ham.)	Mrigal or narain	
	3. <i>Labeo rohita</i> (Ham.)	Rohu	
	4. <i>Labeogonius</i> (Ham.)	Sarsi	
	5. <i>Puntisticto</i> (Ham.)	Puthi	
	6. <i>Puntissophore</i> (Ham.)	Puthi	
	7. <i>Catla x Rohu</i> (Ham.)	Dogla	
	8. <i>Puntissarana</i> (Ham.)	Puthi/Kharpata	
	9. <i>Labeobata</i> (Ham.)	Bata	
	10. <i>Garragotyla</i> (Ham.)	Patharchatta	
	11. <i>hypophthalmichthys molitrix</i>	Silver carp	
	12. <i>Ctenopharyngodon idella</i>	Grass carp	
	13. <i>Cirrhinareba</i> (Ham.)	Reba	
	14. <i>Oxygaster clupeoides</i> (Ham.)	Silver chal	
	15. <i>Rasboradaniconius</i> (Ham.)	Chal	
	16. <i>Chela bacaila</i> (Ham.)	Chal	
	17. <i>Labeo fimbriatus</i> (Bloch)	Mamola	
	18. <i>Labeo calbasu</i> (Ham.)	Kalaunt	
	19. <i>Amblypharyngodon mola</i> (Ham.)	Malwa	
(B) Notopteridae	20. <i>Notopterus notopterus</i> (pallas)	Patola	
(C) Belonidae	21. <i>Xenentodon cancila</i> (Ham.)	Suhiya	
(D) Siluridae	22. <i>Heteropneustes fossilis</i> (Bloch)	Singhi	
	23. <i>Wallago attu</i> (Bloch & Schneider)	Lanchi	
	24. <i>Ompok bimaculatus</i> (Bloch)	Pabada	
(E) Bagridae	25. <i>Mystus seenghala</i> (Sykes)	Singhara	
	26. <i>Mystus aor</i> (Ham.)	Pitar	
(F) Centropomidae	27. <i>Chanda nama</i> (Ham.)	Chalputhi	
(G) Cobitidae	28. <i>Nemacheilus botia</i> (Ham.)	Botia	
(H) Channidae	29. <i>Channa marulius</i> (Ham.)	Sawal	
	30. <i>Channa striatus</i> (Bloch)		Kabra
	31. <i>Channa punctatus</i> (Ham.)		Girhi
(I) Mastacemelidae	32. <i>Mastacembelus armatus</i> (Lacepede)		Bam

5. DISCUSSION

The results of present study (Tables 4.1 to 4.9) vividly indicates length-weight relationship, condition factor, water quality parameter and Ichthyofauna of GovardhanSagar Lake.

The observations on morphometry (Length-weight) of *Catlacatla* and *Labeorohita* clearly indicate that in all the length-groups of both the species, the relationship between total body length and body weight were highly significant (Table 4.1 and 4.2). The results shown in the Tables 4.1 and 4.2 point out a highly significant relationship between total body length and body-weight of all the length groups of both the fish species studied except in case of A length-group of *Labeorohita* which showed correlation co-efficient of only 0.320. In the case of *Catlacatla* correlation co-efficient value (r) between total body-length and body weight was greater in the length-group C followed by length groups B and A in a descending order. Further, in various length-group of *Labeorohita*, the pattern of length-weight relationship was almost similar to that found in *Catlacatla*.

Such a variation in length-weight relationship between different size-groups could be attributed to the prevailing environmental conditions, available food and space besides, of course, the biological features specific to species. The latter may result into varied growth performance.

In the present study, the exponent value 'n' was found to deviate from 'cube law' i.e. the values fluctuated from 0.676 to 1.495 in *Catlacatla* and 1.666 to 3.466 in *Labeorohita*. Such deviation from 'Cube law' was also observed by earlier workers. Desai and Shrivastava (1990) observed an exponent value 'n' of 2.914 for *Cirrhinus mrigala* from Rihand reservoir. Johal and Kingra (1992) reported an exponent value varying from 2.752 to 3.545 in three Indian major carps. In Rajasthan Jain (2000) reported a high variation from "Cube law" in catla, rohu and mrigal from Siliserh reservoir and observed that availability of living space and food could strongly influence the values of exponent. Panicker (2000) also observed the exponent values 'n' in several species of fishes from chulliar reservoir and reported that in the case of catla and rohu the values of 'n' were 3.353 and 3.113, respectively. According to him, the shifting of exponent value to the higher side of 3 indicates a favorable environment in the reservoir for the growth and wellbeing of the fish.

Ujjainia(2013) also attempted to work out length-weight relationship in three Indian major carps namely catla, rohu and mrigal and reported highly positive significant relationship between standard body-length and body-weight. He also reported the variation in the exponent value (n) of catla at different length-groups from 3.160 to 3.805, 2.734 to 4.452 and 3.013 to 4.004 from MahiBajaj Sagar, Surwania dam and Aasan pond, respectively. Further, the same author reported the exponent value 'n' to vary from 2.770 to 4.574, 2.853 to 4.056 and 2.685 to 4.455 in three length-group of rohu from the above stated three reservoirs in respective order.

Rathore and Sharma (2017) observed exponent values of total length and weight to vary from 0.138 to 0.280. On the basis of exponent value of length-weight relation, it could be concluded that *Catla catla* attains more weight per unit of length in the Udaisagar reservoir. Similar observations were made by Kumar *et al.* (2017). The mean values of relative condition factor (Kn) computed for all the samples of *Labeo rohita* and *Catla catla* were 1.02 ± 0.01 and 1.005 ± 0.003 .

The exponent values obtained in the present study in respect of catla and rohu from the reservoir GovardhanSagar Lake are comparable to those reported by Jain (2000), Ujjainia (2013), Rathore and Sharma (2017) and Kumar (2017).

Condition factor or ponderal index is a physiological indicator of the well being of any fish living in a given environment. Low values of condition factor or K, as it is normally referred to in a fishery language, is a definite sign of non-allometric fish growth probably owing to the competition for the food and space within the different fish communities in a waterbody. In the present study, the value of k varied between 0.761 and 1.251 for catla and 0.956 and 1.210 for rohu. The nearness of the K values to 1.0 in both the species clearly indicates the environmental suitability of the GovardhanSagar Lake good for fish growth.

Further, the high value of condition factor in the present study is an indication of higher 'K' value for catla in comparison to that of rohu are supportive of the assumption that rohu has a higher length increment than in catla. Conversely, the latter has higher weight increase (Bhatt *et al.* 2016). The 'K' values of *Catla catla* ranged between 1.484 and 2.278 in saroda reservoir are comparable and supportive. As Kumar *et al.* (2017) reported Kn values ranging from 1.009 – 1.079 with mean was 1.02 ± 0.01 . Similarly, Rathore and Sharma (2017) reported the 'K'

values of *Catla* ranged between 1.484 and 2.278. It is reported that such values of 'K' are indicative of the sustainability of the waterbody for good fish growth. All the above studies support the presently made observations in *catla* and *rohu* on Govardhan Sagar Lake.

Physio-chemical parameters of Govardhan Sagar lake were found to be congenial throughout the study period. The relationship between air and water temperature was clearly seen in the present study where a positive significance relationship was established between air and water temperature: it is reported that the closer association of air and water temperatures is found in the small sized water body. Sarang (2001) found similar relationship for Jaisamand Lake Udaipur. Temperature grossly influences the dissolved oxygen and other gases which are liable to be flushed out with increasing temperature.

The hydrogen ion-concentration (pH) of surface was found alkaline during the study period as already stated in the results. However, the pH values exhibited a slight but declining trend from surface. Sarang (2001) made similar relationship for Jaisamand Lake Udaipur

The average pH of Govardhan Sagar Lake was found to be 8.87 during the study period which is moderately alkaline and supports fairly good aquatic productivity. Such alkaline pH has also been reported earlier by Koli and Mohan (2011), Mishra *et al.* (2012) who found alkaline water in the three water bodies of southern Rajasthan. In the present study pH was found to show positive relationship with Air temperature, Water temperature, Dissolved oxygen, bicarbonate alkalinity and total hardness. On the other hand TDS, EC, Depth of visibility and total alkalinity showed negative significant relationship.

The intensity of light penetration decreases with increasing, depth of water and suspended materials. Average transparency of 123.83 cm in the present investigation point out relatively lower levels of nutrients in the Govardhan Sagar Lake. Sarang (2001) observed the water transparency of 93.8 to 153.0 cm during the period from April to August and reported that the water body had fairly moderate productivity. Koli and Mohan (2011) reported the transparency values range of 34 to 65 cm in Ana Sagar Lake, Ajmer.

In the present investigation the water clarity varied from 120.3 to 126.6cm during the study period. The mean of water clarity of value was 123.83 which as per the classification of Sharma and Durve (1990) indicate the moderately eutrophic nature of GovardhanSagar Lake reservoir.

Correlation matrix indicates that water clarity had significant positive relationship with air temperature and negative correlation with pH, TDS and EC. Sarang (2001) did not find any relationship between dissolved oxygen and water temperature.

Dissolved oxygen is the most critical water quality variable in aquatic ecosystem. It is of primary importance both as regulator of metabolism of plant and animal communities and as an indicator of water condition. According to Hutchinson(1957) dissolved oxygen is most significant chemical abiotic component which is essential for smooth running of metabolic activities for all organisms in the aquatic ecosystem and is one of the best indicators to show the nature of the water body. Wetzel (1975) opined that oxygen content is important for direct requirement of many organisms and affects the solubility and availability of many nutrients and therefore the productivity of aquatic ecosystem.

During present study dissolved oxygen concentration ranged from 7.33 to 11.33 mg l⁻¹ with average value 10.087 mg l⁻¹. Sharma *et al.* (2000), Saranget *al.* (2002), Nandan and Magar (2007), Tamotet *al.*(2007) and Mishra et al. (2012) reported dissolved oxygen contents in the different water bodies of the country

The dissolved oxygen has indicated negative correlation with water temperature, depth of visibility; carbonate alkalinity, however, a negative correlation of total alkalinity and total hardness was observed.

As per Dwivedi and Pandey (2002), the main source of free CO₂ in water is mainly decomposition of organic matter and respiration of plants and animals.

In the present study free CO₂ was absent in all most all of the observations throughout the study period. Similar results for absence of free CO₂ were also reported by Rajkumar (2005), Dasgupta *et al.*(2007), Pariharet *al.*(2007) and Paulose and Maheshwari (2007). Ujjania *et al.* (2007) and Balai (2007) also found the absence of free CO₂ in different water bodies of southern Rajasthan.

Carbonates are bound form of carbondioxide. A change in alkalinity thus indicates either an addition or precipitation of carbonates.

During the present study carbonate alkalinity showed good presence in the GovardhanSagar, where in the average carbonates ranged between 10.00 to 13.33mg l⁻¹. Such observations were also reported earlier by Gupta and Sharma (1994). Sarang et al. (2002) and Balai (2007) observed similar results in the Jaisamand reservoir of Udaipur (Rajasthan).

In the present study the carbonate alkalinity was found to indicate positive relationshipwith air temperature, water temperature, TDS, depth of visibility, DO and EC.On the other hand negative relationshipwith bicarbonate alkalinity, Total alkalinity and total hardness was seen.

Bicarbonatesform amajor source of carbon for aquatic flora, particularly forthe phytoplankton in the absence of free CO₂. Presence of bicarbonates, carbondioxide and hydrogen alkalinity implied that CO₃-HCO₃and free CO₂were responsible for alkalinity (Jhingran, 1992).

During the present study bicarbonate alkalinity showed good presence which varied from 40.66 to 73.33 mg l⁻¹in GovardhanSagar.Goldman and Wetzel (1963) and Sreenivasan (1966) found maximum alkalinity during summer which declined subsequently in the monsoon.Das (2000), Dwivediet al. (2000), Rajkumar (2005), Balai (2007),NandanandMagar (2007)and Mishra et al.(2012) also found similar trends in the bicarbonate alkalinity.

Correlation matrix indicates that bicarbonates had positive relationship with total alkalinity, total hardness, air temperature, depth of visibility, pH, and carbonates. On the other hand, this showednegative relationship withelectrical conductivity, TDS, water temperature, dissolved oxygen.

As shown in table 4.4 the first value of total hardness, declined drastically in the subsequent second observation for which no definite reason can be assigned.

Natural bodies of water in the tropics usually show a wide range of fluctuation in total alkalinity values depending upon the location, seasons, plankton population and nature of bottom deposits. Stagnant waters in tropical plains in low rainfall areas during the summer season are likely to have high total alkalinity values. A range of 4

to over 1000 ppm alkalinity has been encountered in natural bodies of water (Jhingran, 1992).

In the present study, total alkalinity ranged from 54 to 80 mg l⁻¹ (Table 4.7). Solomon (1994) have studied selected lakes of Udaipur and reported the alkalinity above 60 mg l⁻¹ in all the water bodies. Ujjania (2003) observed total alkalinity of 65 to 199 mg l⁻¹ in three water bodies of southern Rajasthan. Rajkumar (2005), Pariharet al. (2007) and Balai (2007) also reported higher range alkalinity in the different water bodies of Udaipur region.

In the present study, total alkalinity indicated positive correlation with depth of visibility, bicarbonates. Further the values of total alkalinity above 60 mg l⁻¹ are indication of nutrient rich condition (Spence, 1964). Alikunhi (1957) stated that in highly productive waters, the alkalinity ought to be over 100 ppm. According to Swingle (1967) such waters are suitable for fish culture.

The outcome of the present study from the biodiversity and fisheries point of views is that in the Govardhan Sagar Lake, 35 fish species representing, 9 families (Table 4.9) contribute to the Ichthyofauna of the lake. In the commercial fish catch Indian major carps viz. *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* dominated.

The relative abundance of IMC species was in the order of *Catla catla* > *Labeo rohita* > *Cirrhinus mrigala*. Present dominance of *Catla catla* and *Labeo rohita* in Govardhan Sagar Lake is probably attributable to the regular stocking of these two species since 2002. The auto stocking is negligible in the reservoir for maintaining sustainable fisheries in this reservoir regular seed stocking of desirable species is suggested as chance of auto stocking from natural breeding are negligible due to erratic monsoon.

6. SUMMARY

The present study on **Length-Weight relationship and condition Factor** of selected freshwater fishes of **Govardhan Sagar Lake, located in Udaipur district of Rajasthan, was conducting during period** January, 2018 to June 2018. Two commercially important fish species of **Govardhan Sagar Lake viz. *Catla catla* and *Labeo rohita*** were selected for their, **length-weight relationship, and condition**

factor studies. For various physico-chemical parameters, the three surface sampling stations water fixed.

Several aspects are covered in the present study which includes the identification of fish fauna. From this study, following inferences have been made:

- ❖ On the basis of exponent value of length-weight relation, it could be concluded that the fishes *Catla catla* attained more weight per unit of length in the Govardhan Sagar Lake. Observed condition factor of both the species reported that both fishes were in good condition during the study period. On the basis of length-weight data, the regression equations of body weight on total body weight were calculated as given below:

Catla catla:

Length groups (cm) Equation

30 – 40 $y = 0.849 + 1.466x; r = 0.24$

41 – 50 $y = 1.425 + 0.601x; r = 0.618$

51 – 60 $y = 3.960 + 3.706x; r = 0.864$

Labeo rohita:

Length groups (cm) Equation

30 – 40 $y = 1.932 + 0.242x; r = 0.302$

41 – 50 $y = 3.467 + 2.692x; r = 0.758$

51 – 60 $y = 2.273 + 0.724x; r = 0.43$

- ❖ During the study period, a positive significant relationship was found between air and water temperature. Hydrogen ion concentration (pH) remained alkaline throughout the study period. Average depth of visibility was 123.83 cm which shows that the water body is moderately eutrophic.
- ❖ Dissolved oxygen content remained congenial throughout the study period. Dissolved oxygen had negative significant relationship with water temperature. Free CO₂ remained absent throughout the study period where carbonate alkalinity was present.

- ❖ During the study period the total alkalinity was mainly contributed by bicarbonate alkalinity. High value of alkalinity (>100 ppm) indicate that the reservoir has productive hard water. High value of EC and TDS are the also support Govardhan Sagar Lake as productive water body.
- ❖ The reservoir has a fairly rich fish fauna as 35 species representing 9 families have been recorded during the present investigation. Further in this the study the Indian major carps dominated the fish fauna of this reservoir which is a notable feature of reservoir fisheries.

It is suggested to stock fish seed of desirable species in order to maintain sustainable carp fisheries in this reservoir.

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Length Weight Relationship and Condition Factor of Selected Freshwater Fishes of Govardhan Sagar Lake, Udaipur, Rajasthan

Vedrahi Prasad Bairwa*
Research Scholar

Dr. B. K. Sharma**
Major Advisor

ABSTRACT

The present study was carried out to estimate the length-weight relationship and condition factor of selected freshwater fishes of Govardhan Sagar Lake, Udaipur, Rajasthan during January- June, 2018. The relationship between length and weight of *Catlacatla* and *Labeorohita* from fish catch was calculated by establishing correlation and regression between the two parameters. The exponent values of total length and weight varied from 0.849 to 3.96 and 1.932 to 3.467 for different length groups of *Catlacatla* and *Labeorohita*. The higher value of 'n' could be attributed to high rate of weight increase with per unit increase in length. The correlation co-efficient 'r' between total length and weight were found to be significant for all the length groups in *Catlacatla* and *Labeorohita*. In B and C Length groups are significant of both the species. The values of condition factor (K) of both the species were also computed and found that both the species performed well in Lake Environment. The maximum 'K' value was found 1.249 in *Catlacatla* (group A) and 1.210 in *Labeorohita* (group B). On the basis of length-weight data, the regression equations of body-weight on total body length were calculated. The higher values of 'n' could be attributed to high rate of weight increase with per unit increase in length. Water quality parameter viz. air and water temperatures, pH, depth of visibility, dissolve oxygen, free carbon dioxide, carbonate and bicarbonate alkalinity, EC and TDS were observed throughout the study period and indicated that the water of the Lake remained congenial and productive from the fisheries point of view. The biodiversity ichthyofauna of the study in thirty five species representing nine families have been recorded from this reservoir. Indian major carps especially *Catlacatla* and *Labeorohita* have dominated the catch of this lake.

* M.F.Sc. Scholar, Departments of Aquaculture, College of Fisheries, MPUAT, Udaipur

** Professor & Head, Department of Aquaculture, College of Fisheries, MPUAT, Udaipur

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