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Age, growth and harvestable size of *Catla catla* (Ham.) from Khodiyar Dam, Dhari, Gujarat

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Abstract
Specimens of *Catla catla* belonging to different age classes from Khodiyar Dam of Dhari, Gujarat have been studied for growth using the scale method. Maximum nine annual rings were observed and used to assess selected growth parameters i.e. annual length increase (h), annual increase in weight (w), growth characteristics (C_{th}), Specific linear growth (C_l), Growth constant (C_{lt}), Specific rate of weight increase (C_w), Index of species average size (Øh) and Index of population weight growth intensity (ØC_w). On the basis of growth parameters, the harvestable size of 42.50 cm and age of 3+ year classes was calculated for *Catla catla*. Harvestable size of 42.50 cm was calculated in the present study which appears to be satisfactory and would offer a fair chance to fish to spawn before it is caught.

Keywords: age and growth, *Catla catla* (Ham.), harvestable size, khodiyar Dam

Introduction
Catla catla belongs to Cyprinidae family and highly commercially important species for freshwater bodies in India. This species inhabits in freshwater rivers, reservoirs, lakes, ponds and beels. This is the fastest growing species among carps [12]. Age and growth studies are a most important aspect of fishery biology. The growth rate of a fish can be enumerated from the estimation of age such studies can give information on stock composition, age and maturity, life span, mortality, growth, production etc. so, this study is highly significant for the management and conservation of fish population in natural water bodies [16]. Some authors [11, 7, 13, 14] who have performed to estimate the growth rates of fishes using scales. Growths of fish is the relationship between length and weight of fish. The length-weight relationship provides basic information on fisheries biology and therefore, useful to determine the weight of an individual fish from known length or total weight from length- frequency distribution. [6, 9].
Knowledge of age and growth of a fish is an extremely useful part of population dynamics in fishery biology and fishery management. This provides us the basic information on sexual maturity, harvestable size and environmental conditions of the water body. There are several hard parts which are used for age determination like scales, opercula, vertebrae, frontal bones, cleithra, otolith and fin ray sections. Out of these, scale method is most widely used because scales can be used without sacrificing the fish. Therefore, this study is highly significant for the management and conservation of fish population in natural water bodies.
Khodiyar dam is a freshwater, man-made dam. Dam is a built on Shetrunji River in Gujarat in western India. The primary purpose of the dam is to provide water for irrigation. It was completed in 1967 and a canal off the reservoir's right bank was completed the next year. This Dam is extensively used by local people for their livelihood.

Materials and Methods
Collection of scale samples
Scale samples of *C. catla* were randomly collected from Khodiyar Dam water bodies of Gujarat. From total 200 fish specimens were collected quarterly from commercial fish catch during the September to December 2017. Fishes were used to measure total length (cm) of each fish from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a measuring tape. All fish body weight was measured by weighing balance. At the same time, 5-6 scales were collected from the lateral side below the first spine of the dorsal fin. Intact scales were picked up using coarse forceps and preserved in tough paper envelopes. These collected scales were preserved in paper envelops with key data such as Total Length, Standard Length, Body Weight, date of scale collection and signature of scale collector.

Analysis of scale samples:
The fish scale was dipped in 1 % KOH solution for 4-5 minutes to remove mucus and unwanted muscle tissue. This scale was rinsed with tap water and examined with the help of SCALE READER. Scale radius was measured from the focus to the end of the scale, whereas the first annulus was measured from the focus to the first ring and the second annulus was measured from to the second ring and so on shown in Figure 1.

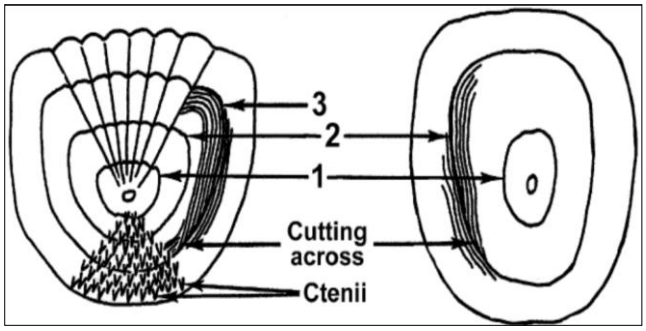

Fig 1: Scale morphology showing annual ring

Statistical Analysis

Back-calculation or Calculation of length and weight

The parameters 'a', 'n' and 'r' are estimated by the linear regression equation. This equation is also referred as the length-weight key [4, 10].

$$W = a L^n$$

$$\text{Log } W = \log a + n \log L$$

Where 'W' and 'L' are variables, 'a' is coefficient related to body form or intercept and 'n' is exponent or slope. The correlation coefficient (r) is calculated following the standard statistical procedure.

Relative values of growth characteristic

Based on scale studies and the computation there of the growth related useful parameters such as growth characteristics (C_{th}) [18], Specific linear growth (C_l) [5], Growth constant (C_{lt}) [5], Specific rate of weight increase (C_w) [5], Index of species average size (Øh) [1] and Index of population weight growth intensity ($ØC_w$) [1] were calculated as suggested.

Growth characteristics (C_{th})

$$C_{th} = \frac{\text{Log } L_n - \text{Log } L_{n-1}}{0.4343} \times L_{n-1}$$

Specific linear growth (C_l):

$$C_l = \frac{\text{Log } L_n - \text{Log } L_{n-1}}{0.4343} \times \frac{t_2 + t_1}{2}$$

Growth constant (C_{lt})

$$C_{lt} = \frac{L_n - L_{n-1}}{L_{n-1}} \times 100$$

Specific rate of weight increase (C_w)

$$C_w = \frac{W_n - W_{n-1}}{W_{n-1}} \times 100$$

Index of specie average size (Øh)

$$Øh = \frac{\Sigma h = 1}{nj + a} \quad h = nj + a$$

Index of population weight growth intensity ($ØC_w$)

$$ØC_w = \frac{\Sigma C_w = 1}{nj + a} \quad C_w = nj + a$$

Where

Ln, Ln–1 = Total length of fish at ultimate and penultimate age
Wn, Wn-1 = Weight of fish at ultimate and penultimate age
J = Juveniles
H = Adult
a = Absolute increase in length
t2, t1 = Time intervals between ultimate and penultimate age

2.6.1 Condition factor or ponderal index

The condition factor (K) was determined using length and weight data of fish samples. The condition factor was calculated as per the standard method of Le Cren [10].

$$K = \frac{W \times 100}{L^3}$$

Where

W = weight of fish in gm
L = length of fish in cm

2.6.2 Harvestable Size

The calculated length computed for age and growth were used for finding harvestable size. The minimum theoretical harvestable size was determined from the intercept of the length increment in the percentage of the length of the first growing season and the length in the percentage of the final growth season. The plotting of these two lengths (in percentage) along Y-axis and age classes along X-axis is considered as the minimum theoretical harvestable size of a fish species was shown in Figure 2 (Bhatt NA *et al*.) [3].

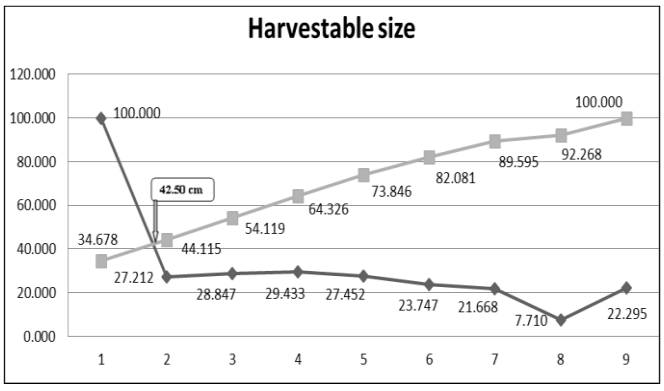

Fig 2: Harvestable size of *Catla catla* from Khodiyar Dam

Results and Discussion

In the present study, based on total length of fish the length frequency of *Catla catla* was divided into 4 length groups *i.e.* A, B, C, D as shown in Table 1. Group A had a length range of 41-50 cm representing 4 numbers of samples and minimum frequency of 2 %. In group B, total 46 samples belong to the length frequency group 61-70 cm. Group C with a length range of 71-80 cm was represented by 128 numbers and thus

was of the highest (64 %) frequency. Group D with length range 81-90 cm in 22 samples was ultimate length group. Considering all these, group C was found the most dominant and group A the least one. The calculated length frequency of various groups ranged between 2 % to 64 % was shown in Table.1.

The above 4 groups *viz.*, A, B, C and D also represented weight-groups since the length is interdependent to a great extent. Here, the weight range of 6010 to 8000 gm had a frequency of 43.5 % in group C has given in Table 2. Interestingly in group A with a weight range of 1000 to 3000 gm, only 4 samples were found with a frequency of 2 %.

A linear relationship was evident in the log of weight and length of carps but a high variation from 'cube law' was observed. According to Bhatt NA *et al.*, [2] the exponent value (n) could lie within the range of 1.2 to 8.6. Deviation of exponent values (n) to higher side > 3.0 is also an indicator of the fact that the increase in weight of carps per unit increase in length was more for carps growing in three types of water bodies of southern Rajasthan and hence confirm of high productivity of these water bodies (Ujjania [17]). In the present study, the value of the exponent (n) in different groups of Catla was found to vary between 1.76983 to 4.79068 has given in Table. 3. Further, in three groups A, C and D the value of exponent were well below 3. However, it was 4.7 in group B.

In the present research on Catla coefficient correlation (r value) for the measured length & weight of fish indicated values to vary between 0.58074 to 0.88696 are given in Table. 3. In the higher size group fishes "r" values was lower as compared to lower sizes fishes. According to Shabir AD *et al.*, [15] the correlation coefficient 'r' between log length and log weight was found to be 0.8705 in males, 0.8849 and in females of *Schizopyge esocinus* from Jhelum River, Kashmir. Jain [8] reported "r" value 0.8929 to 0.7838 for Catla of Siliserh reservoir Alwar, Rajasthan, respectively.

The condition factor or ponderal index values indicate the well being of fish in a particular water body. When the fish growth is allometric the value of condition factor deviates from 1. In the present study condition factor (K) was found to vary between 1.444 to 2.145 has given in Table. 4. Interestingly, Groups B, C and D show relatively lower condition factor as compared to group A. Therefore, the smallest size group (41 to 50 cm) showed better growth.

In Table 5 represents the annual growth (length) of fish. In the age group 1+,2+ and 3+ the mean total length of fish at the time of capture were 41.45(cm), 43.80(cm) and 45.10(cm), respectively. After age group 4+,5+ and 6+ the mean total length of fish at the time of capture were 69.99(cm), 72.54(cm) and 73.53(cm), respectively. At last 7+, 8+ and 9+ the mean total length of fish at the time of capture were 77.30(cm), 83.00(cm) and 82.73(cm), respectively. Considering all the 200 fish samples, the total mean length calculated for the age group L_1, L_2, and L_3 were 22.641, 31.687, and 40.228, respectively. Similarly, in the age group L_4, L_5, L_6, L_7, L_8 and L_9 calculated total mean lengths were 49.668, 56.426, 61.824, 67.961, 71.230 and 77.745, respectively.

Furthers, as seen from Table 6 for calculated the annual growth (weight) of fish, in the age group 1+, 2+, 3+, 4+, 5+, 6+, 7+, 8+ and 9+ the mean total weight of fish at the time of capture were 1625.000(g), 1700.000(g), 1900.000(g), 5758.625(g), 5927.286(g), 6277.368(g), 7396.765(g), 9920.000(g) and 9950.000(g), respectively. After, considering all the fish samples (200) the total weight calculated in *Catla catla* in age group W_1 to W_9 was 320.878(W_1), 746.772(W_2), 1344.861(W_3), 2339.297(W_4), 3274.891(W_5), 4114.820(W_6), 5444.623(W_7), 5824.213(W_8) and 7364.193(W_9).

The growth parameters of *Catla catla* are depicted in Table 7. 'L' value (Back-calculated in cm) range between 26.937 to 77.677 (cm) in year class 1 to 9, respectively. As regarded 'h' (Annual length increment in cm) the maximum increment was 7.928 in the year class 4 whereas this increment was minimum 2.077 in the year class 8. The Øh (Index of species average size) calculated was 8.631. Similarly, a value of the Specific rate of linear growth (C_l) oscillated between 2.984 to 27.212. A Growth characteristic value (C_{th}) ranged between 2.046 to 7.263 and Growth constant value (C_{lt}) fluctuated between 0.044 to 0.361. Further, Growth constant average value (C_{lt} av.) was calculated in two parts (0.309 and 0.132).

Growth parameters of *Catla catla* from Khodiyar Dam were calculated and presented in Table 7. The Calculated weight in gm (W) ranged between 417.794 to 7331.834 (g) in year class 1 to 9, respectively. As regard annual weight increment in gm (w), the highest increment was 1431.314 (g) in the year class 9 whereas this increment was lowest 353.256 (g) in the year class 8, respectively. The calculated specific rate of weight increase (C_w) ranged between 6.368 to 93.375. Further, the growth parameters index of weight growth intensity ($ØC_w$) calculated was 45.471.

Jain [8] reported the harvestable size of 58.0 cm for the Catla of Siliserh, Alwar, Rajasthan. Ujjania [17] recorded harvestable size of Catla-catla varying between 42.0 to 48.0cm at the age 1+ year. In the present study, however, the calculated harvestable size was 42.047cm for the 3+ year is representing in Table 8 and Figure 2. 2+ year Catla is likely to mature sexually and this may be useful to promote auto stocking of this fish in Dam. At this age the fish likely to have the average weight 807.909 gm. Table 7 indicates the increment in length & weight of fish, it is clear that during 1st five years of life spawn the length increment is always more than 7 cm per year. Which is reduced in the subsequent years and attend a (2.077 cm) minimum in the 9th year. However, the growth increment was again higher than 6. This trend in length increase of Catla clearly shows 2 phases of length increments during the growth period.

Table 1: Length frequency distribution of *Catla catla* from Khodiyar Dam

Group	Length (cm)	No. of observation	Frequency (%)
A	41-50	4	2
B	61-70	46	23
C	71-80	128	64
D	81-90	22	11

Table 2: Weight frequency distribution of *Catla catla* from Khodiyar Dam

Group	Weight (gm)	No. of observation	Frequency (%)
A	1000-3000	4	2
B	3010-6000	77	38.5
C	6010-8000	87	43.5
D	8010-11000	32	16

Table 3: Correlation of total body length (cm) with body weight (gm) of *Catla catla* in different length groups

S. No	Group	Total no. of observation	Frequency (%)	Mean L±SD	Mean W±SD	'a' Value	'n' Value	'r' Value
1	A	4	2	41.3±1.816	1500±165.200	0.34252	1.76983	0.76058**
2	B	46	23	61.9±2.239	3100±853.4	-5.08554	4.79068	0.88696**
3	C	128	64	71.1±2.714	5000±926.029	-1.55178	2.86214	0.77042**
4	D	22	11	81.1±1.367	7700±755.361	-1.53544	2.87888	0.58074**

** Significant at 1% level of significance

Table 4: Condition Factor of *Catla catla* from Khodiyar Dam

No.	Length group (cm)	Condition factor (K)
1	41-50 (A)	2.145
2	61-70 (B)	1.307
3	71-80 (C)	1.391
4	81-90 (D)	1.444

Table 5: Annual growth (length) of *Catla catla* from Khodiyar Dam

Age Group	Number of specimens	Total length(cm) of fish at the time of capture		Average back calculated length (cm)								
				L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9
1+	2	Min	41.35	14.457								
		Max	41.60	14.571								
		Mean	41.45	14.514								
2+	1	Min	43.80	15.564	32.958							
		Max	43.80	15.564	32.958							
		Mean	43.80	15.564	32.958							
3+	1	Min	45.10	17.007	19.693	28.781						
		Max	45.10	17.007	19.693	28.781						
		Mean	45.10	17.007	19.693	28.781						
4+	8	Min	61.90	16.733	24.656	38.465	43.899					
		Max	74.60	43.811	43.811	52.521	63.716					
		Mean	69.99	38.327	38.327	47.640	56.128					
5+	63	Min	62.80	16.116	22.352	28.806	35.713	48.358				
		Max	84.10	39.505	49.916	57.090	64.165	75.731				
		Mean	72.54	28.097	35.469	42.859	50.964	59.932				
6+	76	Min	63.20	16.961	25.647	30.587	38.294	44.880	51.938			
		Max	82.10	33.437	46.340	51.350	63.581	71.951	76.808			
		Mean	73.53	26.698	33.296	40.968	48.632	55.458	63.798			
7+	34	Min	70.30	17.181	24.417	32.894	38.727	44.227	50.624	56.274		
		Max	84.20	38.676	45.023	56.842	65.175	71.292	77.196	95.691		
		Mean	77.30	27.625	35.230	43.450	51.836	58.821	65.636	71.877		
8+	5	Min	81.30	17.629	20.480	33.498	37.673	47.743	54.128	59.443	66.475	
		Max	84.20	33.491	39.302	44.920	53.831	60.223	66.813	70.684	77.641	
		Mean	83.00	23.988	29.551	37.480	44.781	53.412	60.198	64.953	73.348	
9+	10	Min	80.30	16.048	19.646	34.446	40.268	44.534	50.222	57.332	64.076	74.568
		Max	85.60	30.985	37.747	45.476	51.558	57.130	65.559	71.171	74.778	80.991
		Mean	82.73	24.637	31.330	39.144	45.091	52.705	58.968	64.227	71.061	77.677
Total	200	Min	41.30	14.457	19.646	28.781	35.713	44.227	50.222	56.274	64.076	74.568
		Max	85.60	39.505	49.916	57.090	65.175	75.731	77.196	95.691	77.641	80.991
		Mean	:65.36	22.641	31.687	40.228	49.668	56.426	61.824	67.961	71.230	77.745

Table 6: Annual growth (weight) of *Catla catla* from Khodiyar Dam

Age Group	Number of speci-mens	Total Weight(gm) of fish at the time of capture		Average back calculated length (cm)								
				W1	W2	W3	W4	W5	W6	W7	W8	W9
1+	2	Min	1500.000	69.161								
		Max	1750.000	70.685								
		Mean	1625.000	69.923								
2+	1	Min	1700.000	84.874	679.566							
		Max	1700.000	84.874	679.566							
		Mean	1700.000	84.874	679.566							
3+	1	Min	1900.000	108.526	162.959	466.735						
		Max	1900.000	108.526	162.959	466.735						
		Mean	1900.000	108.526	162.959	466.735						
4+	8	Min	3300.000	103.746	303.938	1043.125	1504.667					
		Max	7000.000	610.544	1496.334	2473.970	4227.471					
		Mean	5758.625	438.067	1083.816	1928.816	3044.113					
5+	63	Min	3100.000	150.075	231.539	467.853	849.010	1967.635				
		Max	9200.000	1123.156	2148.461	3117.901	4310.633	6825.321				
		Mean	5927.286	471.121	891.280	1493.686	2363.701	3675.091				

6+	76	Min	3600.000	107.708	339.025	552.494	1030.260	1599.840	2398.646			
		Max	10100.000	707.335	1748.313	2324.086	4202.696	5922.021	7097.730			
		Mean	6277.368	391.371	729.205	1281.764	2049.444	2945.636	4334.252			
7+	34	Min	5850.000	111.622	295.822	675.914	1062.896	1536.063	2234.029	2995.796		
		Max	10500.000	1059.012	1613.969	3080.371	4501.398	5772.660	7197.790	13056.795		
		Mean	7396.765	452.347	872.681	1536.695	2496.070	3509.856	4721.451	6048.315		
8+	5	Min	9000.000	119.892	181.678	710.919	984.630	1899.027	2689.673	3487.294	4754.863	
		Max	10500.000	710.512	1107.282	1603.771	2648.884	3615.717	4822.212	5637.165	7313.282	
		Mean	9920.000	321.029	557.044	999.367	1647.972	2643.407	3685.077	4517.545	6285.041	
9+	10	Min	8800.000	92.382	161.894	768.135	1184.354	1565.832	2185.230	3154.622	4294.049	6538.669
		Max	10900.000	572.687	990.020	1659.383	2350.290	3123.957	4575.408	5745.527	6589.784	8222.076
		Mean	9950.000	331.119	642.644	1123.625	1648.853	2521.308	3436.344	4358.551	5708.260	7331.834
Total	200	Min	1500.000	69.161	161.894	466.735	849.010	1536.063	2185.230	2995.796	4294.049	6538.669
		Max	10900.000	1123.156	2148.461	3117.901	4501.398	6825.321	7197.790	13056.795	7313.282	8222.076
		Mean	5657.594	320.878	746.772	1344.861	2339.297	3274.891	4114.820	5444.623	5824.213	7364.193

Table 7

Pmts.	**Year**								
	1	2	3	4	5	6	7	8	9
L	26.937	34.267	42.038	49.966	57.361	63.758	69.594	71.671	77.677
h	26.937	7.330	7.770	7.928	7.395	6.397	5.837	2.077	6.006
Øh	8.631								
C_1	27.212	22.676	18.860		14.800	11.152	9.154	2.984	8.380
C_{th}	6.483	7.003	7.263		6.896	6.065	5.585	2.046	5.767
C_{lt}	0.361	0.307	0.259		0.207	0.159	0.131	0.044	0.121
$C_{lt\ (av)}$	0.309				0.132				
W	417.794	807.909	1400.480	2237.850	3261.512	4341.770	5547.264	5900.520	7331.834
w	417.794	390.115	592.571	837.370	1023.662	1080.259	1205.493	353.256	1431.314
C_w	93.375	73.346	59.792		45.743	33.121	27.765	6.368	24.257
$ØC_w$	45.471								

L : Back calculated in cm.
h : Annual length increment in cm.
Øh : Index of species average size.
C1 : Specific rate of linear growth.
Cth : Growth characteristic
Clt : Growth constant
Clt (av) : Growth constant average
W : Calculated weight in gm.
w : Annual weight increment in gm.
Cw : Specific rate of weight increase.
ØCw : Index of weight growth intensity.

Table 8: Estimation of Harvestable size of *Catla catla* from Khodiyar Dam

Pmts.	**Year of life**								
	1	2	3	4	5	6	7	8	9
L	26.937	34.267	42.038	49.966	57.361	63.758	69.594	71.671	77.677
h	26.937	7.330	7.770	7.928	7.395	6.397	5.837	2.077	6.006
A	100.000	27.212	28.847	29.433	27.452	23.747	21.668	7.710	22.295
B	34.678	44.115	54.119	64.326	73.846	82.081	89.595	92.268	100.000

L : Back calculated in cm.
h : Annual length increment in cm.
A : Percentage of Annual length increment in descending order
B : Percentage of Annual length increment in ascending order

Conclusion

Considering the weight increment the Catla of Khodiyar Dam exhibited at different trend wherein there was a continuous rise in the weight increment up to the 7th year of the age. There was a substantial decline in the weight increment in the 8th year. However, weight increment was again high in the 9th year of the age. Such variations in the length or weight of fish are indicating the response of fish growth with respect to changing environmental condition and availability of choice food during the growth period.

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