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# COMPARATIVE STUDIES ON AGE AND GROWTH DETERMINATION BY USING VERTEBRAE OF *CATLA CATLA* (HAMILTON-BUCHANAN) FROM A PRIVATE FISH FARM AND HARIKE WETLAND (RAMSAR SITE), INDIA

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**ABSTRACT**
Age and growth of the fish *Catla catla* was studied from July 2012 to June 2014 from Harike wetland (Ramsar site) and it was compared with the farmed fish. A high correlation coefficient (0.94 and 0.942) and coefficient of determination (0.8845 and 0.889) were observed between total length and vertebrae radii of the fish from both the sites by taking 89 out of 106 and 98 out of 130 fish samples from wetland and farm respectively. During the present course of work, sectioned vertebrae elucidated to conclude six age classes from wetland and three age classes from fish farm with the use of back calculation technique. Average total length was calculated 256mm, 406.78 mm, 508.85mm, 610.59mm, 734.67mm and 812.85mm from 1, 2, 3, 4, 5 and 6 years respectively from Harike wetland and 269mm, 447.05mm and 575.5mm from 1, 2 and 3 years respectively from farm. Annual increment was 256mm, 150.78mm, 102.07mm, 101.74mm, 124.08mm and 78.18mm from Harike wetland and 269mm, 178.05mm and 128.45mm from farm. It has been observed that back calculated length was more from farmed fish in contrast of wetland, hence fish experienced more growth from the farm than wetland.

**KEYWORDS**: age and growth, back calculation, *Catla catla*, comparison, vertebral bone.

## Introduction

Verterbae have not been employed for age determination and growth parameter on *Catla catla* from the Harike wetland earlier. *Catla catla* have 37 vertebrae and joined together to form vertebral column. Khan and Khan (2009) have used vertebral bones along with other hard parts in *Catla catla, Labeo rohita, Cirrhinus mrigala,* and *Channa marulius* to find the precision and reliability of the age from the river Ganga at Narora (U.P.). Alves *et al.* (2002) found good precision in vertebrae of bigeye tuna. The choice among the bony structures for age determination varies from species to species. Thus, it becomes necessary to find out the most suitable ageing structures in each fish species. The true knowledge of age and growth studies provide size, age and growth of the fish from particular water body that was essential for a complete knowledge of life history, growth rates, age at sexual maturity, and average life span (Chung and Woo, 1999; Polat *et al*., 2001).

Vertebral centra have been used for age determination in wide range of marine and fresh water species by many workers. All the vertebrae are imprinted with circular marks called rings. These are formed annually and used to determine age in many fish species (Holden and Vince, 1973 in *Raja clavata*; Stevens, 1975 in *Prionace glauca*; Parsons, 1983 in *Rhizoprionodon terraenovae*; Branstetter and Stiles, 1987 in *Carcharhinus leucas*; Polat *et al*., 2001 in *Pleuronectes flesus luscus*; Cruz-Martínez *et al*., 2005 in *Carcharhinus leucas*; Phelps *et al*., 2007 in *Cyprinus carpio*; Željka *et al*., 2009 in *Alosa pontica*; Alp *et al*., 2011 in *Silurus glanis*; Ainsley *et al*., 2011 in *Bathyraja minispinosa*; Bubley *et al*., 2012 in *Squalus acanthias*). The present research investigations were undertaken in order to develop the necessary basic biological information required for the formulation and implementation of scientifically sound fishery management at Harike wetland.

Vertebrae were reported to be the most reliable part of the skeleton for age determination in Nile perch, *Lates niloticus* L. (Mishrigi, 1967). The time required to process and read vertebrae (20 times as long as scales) made them less practical to use in for ageing Fallchum salmon, *Oncorhynchus keta* (Walbaum, 1792). But, the precision and accuracy involved with vertebrae made them best among three structures like vertebrae, otoliths and scales (Clark, 1987). Vertebrae and otoliths in burbot, *Lata Iota* (Linnaeus) gave similar age estimates (Guinn and Hallberg, 1990). In golden snapper, *Lutjanus johnii* (Bloch), sectioning of otoliths and vertebrae enhanced the ability to differentiate opaque zones in otoliths and interpret growth checks in vertebrae and produced higher age estimate than those obtained from whole vertebrae and otoliths (Marriott and Cappo, 2000). While comparing different bony parts of north Atlantic flounder, *Pleuronectes flesus luscus* (Pallas) for age determination vertebrae was found to be the most reliable structure having minimal ageing error (Polat *et al*., 2001). During the age and growth studies of bigeye tuna *Thunnus obesus* vertebrae were reported to be presenting high precision for ageing the fish (Alves *et al*., 2002).

In some of the fishes, vertebrae have rarely been used to study age estimation which shows clear growth marks in other ageing structures that cause minimal or no damage to the fish. The rings on vertebral centra were not very clear and showed numerous minute marks unrelated to cyclic events (Hill *et al*., 1989 in blue marlin, *Makaira nigricans* (Lacepede); Khemiri *et al*., 2005 in *Boops boops* and Khan and Khan, 2009 in Indian major carps).

Different research workers have studied the rings on centra by selecting the bone from different places. Alves *et al*. (2002) found good precision in vertebrae of bigeye tuna by using 35$^{th}$ vertebra of caudal peduncle. Cruz-Martinez *et al*. (2005) used 5$^{th}$ vertebra to count the age ring. Perez and Fabre (2009) analyzed that annulus formation in vertebra of *Calophysus macropterus* has been related to reproduction, migration or changes in feeding behavior. All quantitative indexes showed clear seasonal variation to be correlated with river water level fluctuations. Using the period regression model with several biometric indexes revealed two periods of low growth in the vertebrae of *C. macropterus*, the first during falling water (August) and the second during rising water (January) using marginal increment analysis (MIA).

**MATERIALS AND METHODS**

This study was conducted from July, 2012 to June, 2014. One hundred and six fish samples ranging between 280-875 mm from the Harike wetland, (31°08′N to 31°23′N latitudes and 74°90′E to 75°12′E longitudes) and one hundred thirty fish samples ranging between 186-690 mm from a private Fish Farm Dhudike, Punjab (30.75°N 75.33°E) were collected on monthly basis. The vertebral column was taken after dissecting the fish and then cleaned in boiling water for 10-20 minutes to remove muscles. They were soaked for 12-24 hours (depending on the size of the vertebral bone) in detergent to dissolve sheet of spongy connective tissue from the concave face of the centrum. It was necessary to remove this soft tissue since its presence made ring elucidation more difficult. The neural arch was left intact for use as a reference point during measurements. Selected vertebra (Figure1) from each sample was taken and rinsed in tap water and dried at 35°C. The vertebrae were stored in the envelopes with relevant data. Fish has total 37 vertebrae. Tenth vertebral bone was selected for measurement of rings. The bones were cut with Jeweler's saw and fixed in plastocene. These bones were then studied under stereoscopic binocular microscope (Nikon SMZ 1500). Total radius of each vertebral bone was measured in millimeters by using oculometer.

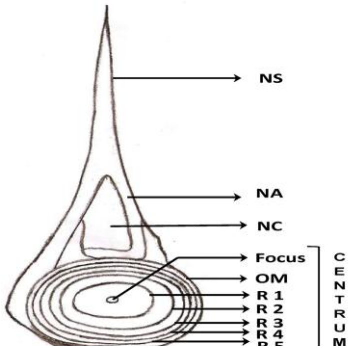


**Figure 1: Diagrammatic representation of Vertebra. (NS, neural spine; NA, neural arch; NC, neural canal; OM, outer margin; R1- R6, annuli)**

For Back calculated length formula given by Bagenal and Tesch (1978) was adopted.

$$l_n = \frac{V_n}{V} \times l$$

Where: $l_n$ = length of the fish when annulus 'n' was formed
$l$ = length of the fish at the time of capture
$V_n$= vertebral radius to annulus n
V= total vertebral radius

  

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## RESULTS AND DISCUSSION

### Correlation of total fish length versus vertebrae radii

During the present study 89 vertebrae from Harike wetland and 98 vertebrae (Table 1) of *C. catla* from a private fish farm Dhudike have been employed for age and growth studies. Linear relationship with a high correlation coefficient between total length and vertebral radius of the fish from both the localities has been found (Table 2; Figures 2 and 3).

**Table: 1 Number of fish samples collected from the two collection sites**

| Collection Sites | Total number of collected specimens | No. of specimens employed for correlation | No. of specimens under juvenile status | No. of specimens Analyzed for back calculation |
|---|---|---|---|---|
| Harike wetland | 106 | 89 | Nil | 89 |
| Dhudike Fish Farm | 130 | 98 | 20 | 78 |

**Table: 2. Regression equation, correlation coefficient, correction factor and coefficient of determination by using vertebrae of *Catla catla* from Harike wetland and Dhudike pond.**

| Locality | Number of Specimens | Regression Equation | Correlation Coefficient (r) | Coefficient of Determination ($r^2$) |
|---|---|---|---|---|
| Harike Wetland | 89 | y= 0.139+ 0.0089x | 0.94 | 0.8845 |
| Dhudike Fish Farm | 98 | y= 0.0052+0.0137x | 0.942 | 0.889 |

The relationship between centrum radius and total length was found be linear in number of studies and recommended the bone valid for the determination of age and growth studies**.** In recent years the r and $r^2$ values between this hard part and length in different fish species for male and females have been calculated separately but no significant relationship between the sexes were observed. The coefficient correlation was found to be less for males (0.90) than females (0.98) in *Calophysus macropterus.* The regression analysis was calculated between standard length and vertebral radius (Prez and Fabre, 2009). Ainsley *et al*. (2011) have recorded a strong linear relationship between the disc width (diameter) and total length in males (0.75) and for females (0.72). The coefficient of determination was found to be same for both in male and females i.e. 0.99 of *Bathyraja minispinosa*. Bubley *et al*. (2012) have also observed vertebral diameter verses to total length and found strong correlation coefficient between the two variables with similar value of coefficient determination i.e. 0.99. Krishan and Dobriyal (2015) have determined significant value of coefficient correlation (r) (0.729) between total length and vertebral radius of the fish *Amblyceps mangois* with use of trunk vertebrae.

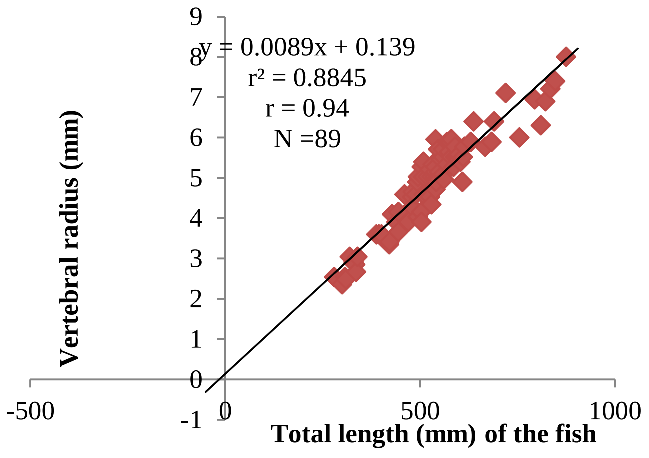


**Figure 2 Relationship between total length and vertebral radius of Catla catla from Harike wetland and Dhudike fish farm (B)**

  

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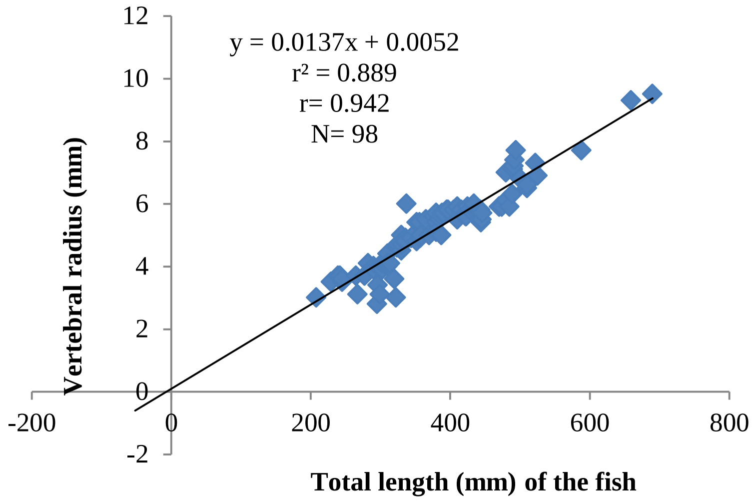


**Figure 3 Relationship between total length and vertebral radius of Catla catla from and Dhudike fish farm.**

## BACK CALCULATION

During the present course of research work, it has been noticed that all the vertebrae (abdominal as well as caudal) of the vertebral column were engraved with rings. The types of vertebrae found in the fish were amphiceolous except the first vertebra which was platyceolous. The variation was found in shape of cancavity on centrum. 10$^{th}$ vertebra has been used to measure all the readings for back calculations as it has highest magnitude amongst the total 37 vertebrae of the fish. On the basis of vertebrae, six age classes were estimated by using back calculation technique from Harike wetland and three age classes from private fish farm, Dhudike. Total 106 specimens were collected from Harike wetland and 130 from Dhudike fish farm.

**Table 3: Back-calculated lengths (mm) of *Catla catla* (Hamilton-Buchanan) based on vertebrae during July, 2012 to June, 2014 from Harike wetland**

| Age Classes | No. of Specimens | Average total length (Range) mm at the time of capture | Back calculated lengths | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | L1 | L2 | L3 | L4 | L5 | L6 |
| 1 | 33 | 436.78 (320-530) | 260 (220.48-332.51) | | | | | |
| 2 | 36 | 526.5 (440-614) | 221.6 (197.24-334.89) | 400.56 (265.52-510) | | | | |
| 3 | 10 | 649.75 (590-755) | 251.1 (229.23-305.9) | 396.34 (336.2-458.9) | 514.61 (466.10-583.22) | | | |
| 4 | 6 | 792.16 (755-835) | 263.44 (222.67-309.19) | 374.31 (353.24-424.91) | 489.75 (353.24-424.91) | 622.14 (569.51-681.91) | | |
| 5 | 2 | 841 (835-847) | 246.13 (232.7-259.56) | 439.25 (424.34-450.82) | 539.26 (533.85-546.45) | 622.21 (614.75-629.67) | 717.95 (696.72-739.18) | |
| 6 | 2 | 867.5 (860-875) | 293.73 (273.02-314.45) | 423.47 (382.81-464.13) | 491.78 (464.84-518.73) | 587.42 (560.55-614.28) | 751.38 (737.14-765.62) | 812.85 (805.39-820.31) |
| Total | 89 | 685.61 (320-875) | 256 (197.24-334.89) | 406.78 (265.52-510) | 508.85 (353.24-583.22) | 610.59 (560.55-681.91) | 734.67 (696.72-765.62) | 812.85 (805.39-820.31) |
| | h | | 256 | 150.78 | 102.07 | 101.74 | 124.08 | 78.18 |

$L_1$, $L_2$, $L_3$, $L_4$, $L_5$, $L_6$ = Back-calculation in the respective age class(es). h = annual increment.

  

The present results were based on back calculations of vertebrae of 89 from Harike wetland and 78 specimens from a private fish farm, Dhudike. Average total length was calculated 256mm, 406.78mm, 508.85mm, 610.59mm, 734.67mm and 812.85mm from 1, 2, 3, 4, 5 and 6 years respectively from Harike wetland (Table 3) and 269mm, 447.05mm and 575.5mm from 1, 2 and 3 years respectively from Dhudike fish farm (Table 4).

**Table 4: Back-calculated lengths (mm) of *Catla catla* (Hamilton-Buchanan) based on vertebrae during July, 2012 to June, 2014 from a private fish farm, Dhudike**

| Age Classes | No. of Specimens | Average total length (mm) at the time of capture | Back calculated lengths | | |
|---|---|---|---|---|---|
| | | | L1 | L2 | L3 |
| **1** | 53 | 366.28 (298-434) | 272.73 (205.71-383.31) | | |
| **2** | 22 | 482.91 (443-525) | 262.55 (201.48-294.95) | 416.57 (328.43-465.39) | |
| **3** | 3 | 645.67 (588-690) | 271.72.09 (217.77-267.55) | 477.53 (442.81-521.02) | 575.5 (529.93-605.51) |
| Total | 78 | 498.29 (298-690) | 269 (201.48-294.95) | 447.05 (328.43-521.02) | 575.5 (529.93-605.51) |
| | h | | 269 | 178.05 | 128.45 |

$L_1$, $L_2$, $L_3$ = Back-calculation in the respective age class(es).
h = annual increment.

**Annual increments**

Annual increment (h) was 256mm, 150.78mm, 102.07mm, 101.74mm, 124.08mm and 78.18mm from Harike wetland and 269mm, 178.05mm and 128.45mm from Dhudike fish farm. Age determination studies from vertebrae can be considered as worth for various developments in fishery managements especially as an alternative to scale less fishes. To the best of our knowledge, no previous study on age determination on *Catla catla* was carried out from the Harike wetland by using vertebral bones. Khan and Khan (2009) to find the precision and reliability of the age used vertebral bone along with other hard parts in Indian major carps from the river Ganga at Narora (U.P.). Alves *et al*. (2002) found good precision in vertebrae of bigeye tuna.

**Growth**

Growth in Indian major carps is fast during early periods of life and decrease gradually when carps become old as revealed by various studies on the basis of scales. But, in *Catla catla* decrease in growth rate was low in later periods (Mathew and Zacharia, 1982). The annual increments decrease in Indian major carps with the increase in age has also been reported by other Indian authors from different localities by using scales (Natarajan and Jhingran, 1963; Johal and Tandon, 1983; 1985; 1989; 1992; Ujjania *et al*., 2010). In present course of research work, annual increments in the length of fish from 6 age classes (Table 3) have been calculated by back calculated technique. These results have presented uneven trend of the growth from Harike wetland. Growth rate for first year of the fish life was found to be high, but the gradual fall in growth was not observed in succeeding age classes from Harike wetland. Though in age class 2 growth rates were observed to be fallen gradually but, in age class 3 and 4 negligible fall in growth rate was observed.

Annual increments from fish farm for three age classes given in Table 4 were reported. However, annual increment was high in age class 1 and decreased gradually in succeeding age classes from private fish farm in comparison to the Harike wetland. Similar studies have been reported by Natarajan and Jhingran (1963) and Johal and Tandon (1983). But, the results of Harike wetland were not agreeing with the earlier findings. Hence, it is concluded from the annual increment by using vertebrae, the growth trends of the fish was falling towards irregular pattern from Harike wetland in contrast to farm fish as well as to the earlier studies.

  

## CONCLUSION

Age and growth studies always reveal past history of the fish in a particular habitat. The results or findings direct the scientists to take required decisions for the benefits of livelihood and fish itself in its habitat. The present investigations have deduced that growth of fish is more in farm as compared to wild due to better controlled conditions there. Moreover, this study was first effort to examine the age and growth from different habitats with the use of vertebrae from Ramsar site lacated in north India. The outcome of the study reveals trends of degradation of natural resources due to colossal pollution. Henceforth, this has become indispensable for preserving the natural water bodies.

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