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Fat content of an Indian Major Carp, *Catla catla*, in relation to age and size for optimizing harvesting period

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Abstract
Fat content of different regions of the body remain almost unchanged up to a certain body length and thereafter increases exponentially. Accumulation of fat starts from the anterior part of the body and then proceeds towards the caudal end. The rate of increase of fat content also seems to be equal in all the three regions of the body. Fat content of the body continues to increase with age. But the most rapid period of accumulation has been found to be the second year of age. So the optimum age for harvesting *Catla catla* seems to be the period just following completion of second year of age.

Keywords: *Catla, fat, length, age, sex, maturity, harvesting period*

1. Introduction
Catla catla is one of the most important cultivable fresh water fish of India. It is highly nutritious as well as delicious. Nutritive value of a fish depends mainly on the proximate composition (Moisture, protein, fat and ash) of its body. The distribution of these substances among the various organs and tissues of the body also show considerable variation in relation to different biological parameters. Fat is one of such principal constituents of the fish body which contributes to the calorific value of the fish and its quantity in the flesh is a factor that determines the quality of the fish and hence its price. Fat is the form in which surplus body fuel is stored in any animal and fish is no exception. There is a wealth of literature available on proximate composition of various fish species including major carps like *Catla catla* (Natarajan and Sreenivasan. 1961; Stansby, 1962; Jafri et.al.1964; Chaturvedi et.al. 1976; Jayabalan and Ramamoorthi 1984; Weatherley and Gill 1987; Das and Mishra 1991; Nair and Suseela 2000; Nair, and Mathew. 2000; Shahid et.al. 2004; Prasad et.al.2009; Memon 2011; Qazi et.al.2013; Manirujjaman et.al.2014; Hasan et.al. 2015; Soumya P.S. 2015) [1-16]. Although several investigators have published an analysis of body composition in different fishes few have examined the changes in fat content in relation to body size (Khawaja and Jafri 1967; Salam and Janjua 1992; Sankar and Ramachandran 2001; Ali et.al. 2004; Naeem and Salam.2010; Hussain et.al.2011) [17-22]. However it is well known that the fat content of fish is also influenced by a number of other biological parameters such as age, growth, maturity, season etc. (Milroy,1908; Johnstone,1914; Bruce,1924; Hickling,1930; Tilik,1932; Lovern & Wood,1937; Tarr,1959; Kukucz,1962; Dambergs,1964; Jafri 1969; Banerjee and Bagchi 1969; Love,1970; Pandey et.al.1976; Bano 1978; Viswanathan Nair and Rajendranathan Nair,1985; Das,1992; Chandra Shekhar et.al.2004; Rao et.al. 2008; Nargis 2008; Pradhan et.al. 2012; Saravanan *et al*.2014 and Nanthini and Meena.2015) [23-44]. Changes in the biochemical composition of fish flesh in different anatomical locations of the body have also been reported by few researchers but not correlated to age of the fish (Mustafa and Jafri 1978; Kalpana *et al*. 1978; Burke 2011 and Ganie 2012) [45- 48].
From culture fisheries point of view, fish should be harvested sometime within its rapid period of growth so as to yield maximum fish biomass with minimum input. The present paper envisages in optimizing the harvesting period of *C. catla* taking into consideration both its growth rate as well as the nutritive value with special reference to the fat content of body musculature.
*This paper is a part of the thesis for which Ph. D degree was awarded to the first author by Utkal University, Bhubaneswar, Odisha, India.

2. Materials & Methods

Catla catla (Hamilton) belonging to family Cyprinidae were collected regularly from a nearby fish farm and their age was determined following the method of Natarajan & Jhingran (1963) [49]. Gonado-Somatic Index (GSI) and index of maturity was determined following the method of Mishra (1990) [50]. Bone and scale free body flesh was collected from the nape (Region-I), below the base of dorsal fin (Region-II) and the caudal peduncle (Region-III) (Fig.1)for the analysis of their fat content by means of a Soxhlet extractor using petroleum spirit (60-80 °C) as solvent.

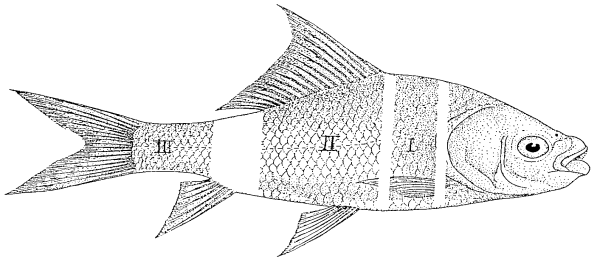

Fig 1: *Catla catla* showing demarcation of different regions

To observe the length and age related changes, fish with developed gonads were excluded to avoid the influence of maturity on the observations. However, to investigate the maturity related changes, only females belonging to 450-550mm. body length (1.5-2.5kg) were taken into consideration. To observe the impact of breeding on both male and female, matured males and spent females belonging to body length 350-550mm. were investigated. It may be mentioned here that a male can undertake breeding number of times in a breeding season and it can be considered as spent only towards the end of the season. So the investigator has preferred the term "matured male" to "spent male" for the males which have been used even once for breeding.

3. Results

In both the sexes the fat content of region – I, II & III remained almost unchanged up to 350, 400 and 450mm. body length respectively, but thereafter increased exponentially (Fig.2&3).

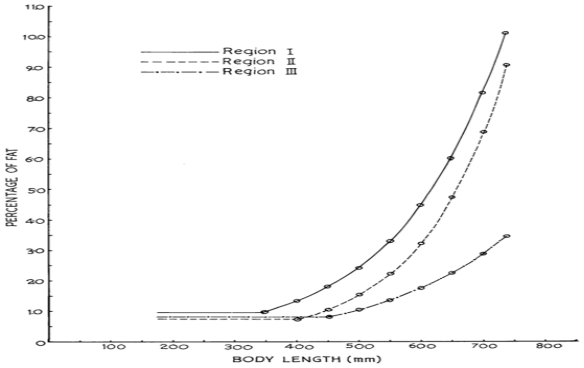

Fig 2: Body length-fat content relationships in male *C.catla*

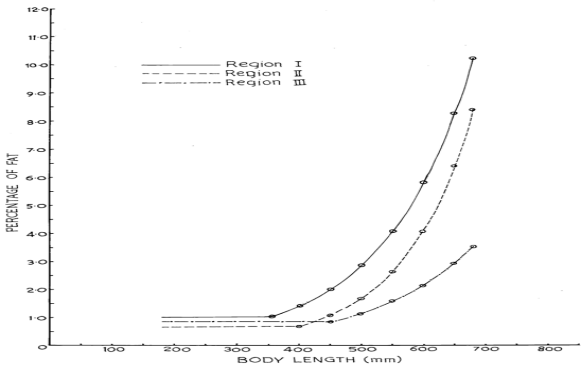

Fig 3: Body length-fat content relationships in female *C.catla*

The details of body length-fat content exponential relationships have been provided in Table -1. To compare the rate of increase of fat content in different regions of the body, the exponential equations were transformed to linear form and their regression coefficients were compared by ANOVA test. Such tests did not indicate any significant difference in males ($F=0.72$, $n_1=2$, $n_2=57$) as well as in females ($F= 0.88$, $n_1=2$, $n_2=71$). Test for equality of body length-fat content regression equations of both the sexes indicated no significant difference among them (Table-2). So data for both the sexes were pooled and combined relationship between body length and fat content have been established (Table – 1).

Table 1: Body length-fat content relationships in *C.catla*, x=body length, y=% of fat content, P.E=Probable error of estimate of coefficient of correlation

Sex	Body length range(mm)	Region	No. of Obs.	Body length-fat content relationship	'r'	P.E. ±
Male	350-737	I	25	$y= 0.120\times1.006046^x$	0.771*	0.054
	400-737	II	22	$y=0.035\times1.007572^x$	0.696*	0.074
	450-737	III	16	$y=0.089\times1.004985^x$	0.747*	0.074
Female	350-680	I	25	$y=0.082\times1.007125^x$	0.720*	0.064
	400-680	II	28	$y=0.018\times1.009085^x$	0.735*	0.058
	450-680	III	24	$y=0.05\times1.006269^x$	0.745*	0.061
Both sexes combined		I	50	$y= 0.1142\times1.006325^x$	0.739	0.043
		II	50	$y= 0.0262\times1.008288^x$	0.713	0.046
		III	40	$y= 0.0727\times1.005494^x$	0.732	0.049

* - Significant at 5% $p < 0.05$

Table 2: Test for the equality of exponential equations for body length – fat content relationships of male and female *C. catla* by ANOVA.

Region								
I			II			III		
F	n_1	n_2	F	n_1	n_2	F	n_1	n_2
0.880	2	46	0.376	2	46	0.773	2	36

In the first year of life, i.e; zero year of age, the level of fat was about 1.05% in region –I and 0.65% in both the region –II and III. However, the rapid phase of increase in fat content was observed within 1 to 2 years of age (Fig.4). After 2 years of age the fat content reached 5.3%, 4.15% and 2.4% in the region-I, II and III respectively in 3 years of age with a slow rate of increase.

The fat content indicated continuous decline with the advancement of maturity condition (Fig.5). The fat content of region –I, II and III was about 4.75%, 3.6% and 1.85% respectively corresponding to GSI-0.2. But a sharp decline has been observed within GSI-4.25 – 9.0, for which finally the corresponding values of fat content in region- I, II and III reached about 0.4%, 0.5% and 0.45% respectively at GSI-29.07.

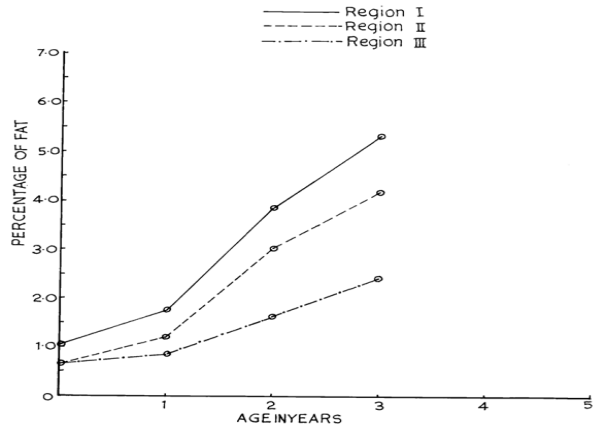

Fig 4: Age related changes in the fat content of *C.catla*

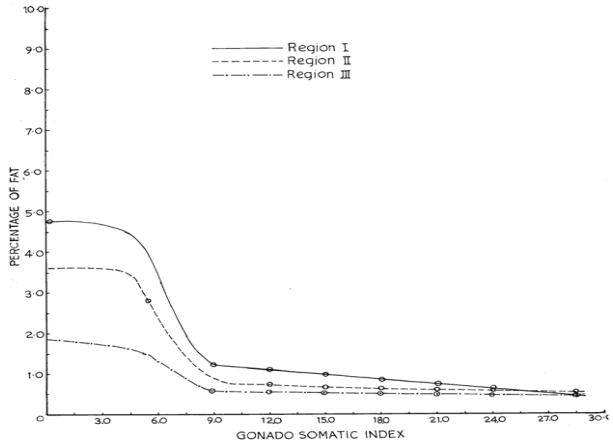

Fig 5: Gonado somatic index - fat content relationships in female *C.catla*

Spent females have been observed to contain significantly less amount of fat than the matured males as it was observed consistently in all the three regions of the body (Table-3).

Table 3: Comparison of fat content of matured male and spent female, *C. catla* by 't' test (n=25)

Region	I		II		III	
Sex	Male	Female	Male	Female	Male	Female
Mean ± SD	2.66^{a} ± 1.84	1.01^{b} ± 0.92	2.51^{a} ± 2.28	0.82^{b} ± 0.76	1.5^{a} ± 1.1	0.59^{b} ± 0.29

Mean values differing in their superscript are significantly different at 5% ($p < 0.05$)

4. Discussion

In the present paper the investigator has indicated that the fat content of different regions of the body remains almost at a constant level up to a certain body length and thereafter increases exponentially. Such increase of fat content in both the sexes is initiated in a sequential manner from the region-I to III, suggesting that accumulation of fat starts from behind the head and proceed towards the caudal end. Absence of any significant difference among the regression coefficients of body length-fat content relationships indicate that the increase in level of fat occurs at equal rate in all the three regions of the body. Though the fat content of the body continues to increase with increase in age, still then the most rapid period of fat accumulation has been observed to be the second year of age. There is a considerable body of literature on the variation of fat content of fish flesh in relation to sexual maturity (Clark and Almy, 1918; Johnstone, 1918; Mc Bride *et.al.*, 1959; Idler and Bitners, 1960; Masurekar and Pal 1979; Ramachandran Nair and Gopakumar, 1981; Sivakami et.al.1986) [51-57]. Fat content of *C. catla* has been observed to decline consistently with increase in maturity condition and thus reaches its lowest level in the matured fish, i.e., during June to August, which constitutes its breeding period. A drastic reduction in fat content has been observed corresponding to GSI-4.5- 9.0 in all the three regions of the body indicating mobilization of more body fat during this phase of maturity for the development of eggs. The depletion of fat in relation to maturity is most severe in the region-I (92%), relatively less in region-II (83%) and least in region-III (76%). This indicates that fat mobilization occurs mostly from region-I and gets reduced gradually towards the caudal end. Male and female *C. catla* do not differ significantly in their fat content. But spent females have been observed to contain remarkably less amount of fat than their male counterpart as the spawning stress is more severe in the former. As indicated from the investigation that the optimum age for harvesting *C. catla* seems to be the period just following the completion of two years of age.

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