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Spatio-temporal variations in length-weight relationship and condition factor of two notopterids, *Chitala chitala* (Hamilton, 1822) and *Notopterus notopterus* (Pallas, 1769)

REJANI CHANDRAN¹, RAJEEV K. SINGH¹, ACHAL SINGH¹, PRADIPTA PAUL²,
RAMA SHANKAR SAH¹, RAJESH KUMAR¹, VINDHYA MOHINDRA¹,
KULDEEP K. LAL¹ AND J. K. JENA³

¹ICAR- National Bureau of Fish Genetic Resources, Dilkusha, Lucknow - 226 002, Uttar Pradesh, India

²Department of Fisheries, Patrasayer Development Block, Bankura - 722 206, West Bengal, India

³Division of Fisheries, Indian Council of Agricultural Research, Krishi Anusandhan Bhawan - II
New Delhi - 110 012, India

e-mail: rajeevsingh1@yahoo.com

ABSTRACT

Length-weight relationship and condition factor of *Chitala chitala* (Hamilton, 1822) and *Notopterus notopterus* (Pallas, 1769) were studied from 439 samples of *C. chitala* collected from 14 locations and 368 samples of *N. notopterus* collected from 19 locations in Indian rivers. The regression coefficient ranged from 2.24 (River Gomti) to 3.24 (River Son) in *C. chitala* and 2.34 (River Son) to 3.71 (River Krishna) in *N. notopterus*. Fulton's condition factor and relative condition factor were found to be greater for *N. notopterus* than *C. chitala* in common sites of collection. Spatial variations indicated better biological behaviour for *C. chitala* in River Son and for *N. notopterus* in River Chambal. The results of the study form important baseline information for developing sustainable management and conservation measures.

Keywords: Biological behaviour, *Chitala chitala*, Conservation, Habitat condition, *Notopterus notopterus*

The featherbacks (Family: Notopteridae) inhabit quiet, weedy habitats of rivers, flood plains and stagnant backwaters (Talwar and Jhingran, 1991). In India, Notopteridae is represented by two species viz., *Chitala chitala* (Hamilton, 1822) and *Notopterus notopterus* (Pallas, 1769). *C. chitala* is a commercially important species and has been prioritised as candidate species for aquaculture (Ayyappan *et al.*, 2001). However, its natural abundance is reported to have declined due to overexploitation and destruction of natural habitat as well as breeding grounds (Sarkar *et al.*, 2006). *N. notopterus* is also an important food fish and thrives in rivers, reservoirs, bheels and ponds. Knowledge of length-weight relationship (LWR) and condition factor is essential for utilisation in stock assessment. Therefore, the present study was undertaken to evaluate these indices in two species of notopterids and to assess the spatio-temporal variations if any.

Samples of *C. chitala* (n=439) and *N. notopterus* (n=368) were collected during 2000-2017 from 14 and 19 locations in 9 and 8 rivers, respectively (Fig. 1). Taxonomic identification was done following Talwar and Jhingran (1991) and Jayaram (1999) and length and weight of individual specimens were recorded

accurately. Various parameters of the LWR such as intercept 'a', slope or regression coefficient 'b' (Snedecor and Cochran, 1967), significance of the isometric exponent (Sokal and Rohlf, 1987), coefficient of condition factor 'K' (Fulton, 1904) and relative condition factor 'K_n' (Le Cren, 1951) were estimated. All the statistical analyses were done using Microsoft Office Excel (2010), SPSS (version 16) and SAS 9.3.

The length and weight of *C. chitala* specimens ranged from 18 to 108 cm and 30 to 10,500 g, respectively. The value of 'b' ranged from 2.24 (Gomti) to 3.24 (River Son) and showed significant variations (p<0.05) within species in different rivers (Table 1). Isometric growth (b=3) was observed in individuals from rivers Padma and Hooghly, whereas positive allometric growth (b>3) was observed in Son and Mahanadi. The populations of Satluj, Brahmaputra, Ken, Gomti and Ghaghra were characterised by negative allometric growth pattern. Earlier, Sarkar *et al.* (2008) reported regression coefficient of 4.10 and 2.37 in LWR of *C. chitala* from rivers Satluj and Gomti, respectively.

The length and weight of *N. notopterus* ranged from 12 to 37 cm and 11 to 400 g, respectively. The regression

coefficient ranged from 2.34 (River Son) to 3.71 (River Krishna) (Table 1). Sani *et al.* (2010) reported similar

values in *N. notopterus* from two rivers *viz.*, Betwa (2.99) and Gomti (2.95). In a similar investigation, negative allometric growth ($b=2.67$) was observed in river Gomti by Kumar *et al.* (2014). The results of the present study are concordant to the previous reports for same species.

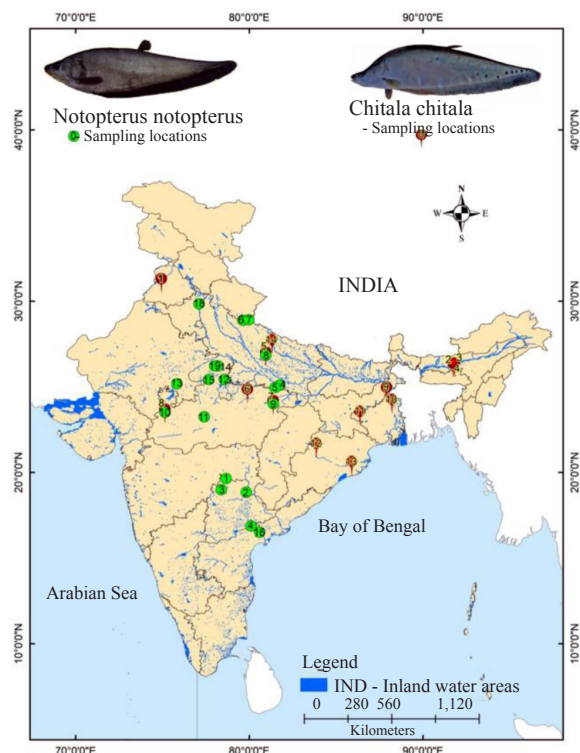


Fig. 1. Sampling locations of *C. chitala* and *N. notopterus*

Sampling locations of *C. chitala* comprised: Harik e pattan, Kolongpar, Uzan bazar, Dhubri, Choti deoria, Ranguwa, Beohari, Sarsi, Farakka, Berhampore, Nabdwiip, Durga pali, Jobra anicut and Ajaypur. *N. notopterus* were sampled from Adilabad, Chennur, Soan Nirmal, Chakghat, Jawa, Baigul, Khatima, Choti deoria, Beohari, Sarsi, Bhopal, Matatila dam, Kota, Ladheri market, Shivpuri, Vijayawada, Jaggyyapet, W. Y. canal and Tighra Dam.

Spatial variations across different locations of four rivers were also studied (Table 2). In Brahmaputra, two locations (Kolongpar and Uzan Bazar) revealed isometric and negative allometric growth patterns, respectively. The values of 'b' indicated isometric growth in two locations each from rivers Mahanadi, Hooghly and Son. This variability among rivers might be due to the combined effects of several factors such as, number of specimens sampled, body health, habitat, degree of stomach fullness, sex, gonadal maturity stage, collection time and observed length range differences of the specimens (Baitha *et al.*, 2018).

Table 1. Parameters of length-weight relationship and condition factor of *C. chitala* and *N. notopterus* from different rivers of India

Sl. No.	Rivers	N	Regression parameters		
			a	b	R ²
<i>Chitala chitala</i>					
1	Satluj	77	0.009683	2.93*	0.95
2	Brahmaputra	74	0.015241	2.83*	0.92
3	Gomti	25	0.102329	2.24*	0.63
4	Ken	25	0.016596	2.78*	0.86
5	Son	104	0.002529	3.24*	0.96
6	Padma	27	0.006295	3.03*	0.98
7	Hooghly	28	0.004325	3.09*	0.92
8	Mahanadi	37	0.002818	3.22*	0.95
9	Ghaghra	42	0.04121	2.57*	0.92
<i>Notopterus notopterus</i>					
1	Godavari	64	0.003228	3.28*	0.96
2	Tamsa (Tons)	24	0.002618	3.35**	0.95
3	Sharda	19	0.007447	3.06*	0.91
4	Gomti	65	0.022284	2.62**	0.90
5	Son	50	0.070795	2.34**	0.97
6	Betwa	25	0.00492	3.13*	0.95
7	Chambal	89	0.005117	3.12*	0.91
8	Krishna	13	0.000931	3.71**	0.97
9	Yamuna	19	0.005012	3.16*	0.89

N = No. of individuals, R² = Coefficient of determination, a = Intercept, b = Regression coefficient (slope)

*Significant at p=0.05

**Significant from value b=3 at p=0.05

Table 2. Spatial variation in LWR of *C. chitala* and *N. notopterus* in different rivers/streams of India at various locations

Sl. No.	River	Location	N	Regression parameters		
				a	b	R ²
<i>Chitala chitala</i>						
1	Brahmaputra	Kolongpar	58	0.010471	2.93*	0.92
		Uzan bazar	11	0.077625	2.42*	0.87
2	Hooghly	Berhampore	8	0.000724	3.52**	0.98
		Nabadwip	20	0.007762	2.95*	0.87
3	Mahanadi	Durga pali	18	0.00389	3.16*	0.90
		Jobra Anicut	19	0.00631	2.98*	0.96
4	Son	Beohari	30	0.00166	3.34*	0.93
		Sarsi	10	0.001072	3.47*	0.81
<i>Notopterus notopterus</i>						
1	Betwa	Bhopal	19	0.004365	3.17*	0.93
		Matatila Dam, Jhansi	6	1.02E-05	4.99*	0.71
2	Chambal	Kota	47	0.000933	3.64**	0.91
		Ladheri Market	7	0.000132	4.19*	0.93
		Shivpuri	35	0.003715	3.27*	0.93
3	Godavari	Adilabad	44	0.020893	2.66*	0.88
		Chennur	9	0.001288	3.56**	0.72
		Soan Nirmal	11	0.022909	2.60*	0.95
4	Krishna	Vijayawada	8	0.022909	2.60*	0.95
		Jaggyyapet	5	0.033884	2.60*	0.82
5	Sharda	Khatima	5	0.019953	2.85*	0.89
		Baigul	14	0.033884	2.56*	0.94
6	Son	Beohari	44	0.003311	3.26**	0.94
		Sarsi	6	0.102329	2.37*	0.87
7	Tamsa (Tons)	Chakghat	18	0.002344	3.38**	0.97
		Jawa	6	0.002188	3.39*	0.80
8	Yamuna	W.Y. Canal	8	0.131826	2.27*	0.98
		Tighra Dam	11	0.001862	3.39**	0.85

N = No. of individuals, R² = Coefficient of determination, a = Intercept, b = Regression coefficient (slope)

*Significant at p=0.05

**Significant from value b=3 at p=0.05

Spatial variations in LWR and condition factor in *N. notopterus* across different locations in eight rivers (Table 2) were analysed. Positive allometric growth was observed across different locations in rivers Betwa, Tons and Chambal, whereas two sites in river Godavari (Adilabad and Soan Nirmal) showed negative allometric growth conditions. The individuals of *N. notopterus*, collected from two locations of Krishna River, showed good condition. The regression coefficients were different in both locations of river Son, while better environmental conditions were found in Tighra Dam compared to W. Y. Canal of Yamuna River.

Variability at temporal scale was studied in *C. chitala* samples from rivers Brahmaputra, Padma and Son (Table 3). The regression coefficient of Brahmaputra samples (2005) displayed relatively poor growth conditions than those collected during 2000. However, Deka and Gohain (2015) reported some improvement in

well-being of *C. chitala*, over ten years. In River Padma, growth patterns showed a significant decline during 2001-16. However, no significant variation in regression coefficient was observed in Son, between 2009 and 2017. This indicates a stable and healthy environment of Son. In addition, an attempt was also made to study the variation pattern in the same location across different years. The “b” values in various sites across various rivers (Table 3) at different time periods were significant (but not different from 3), indicating a stable isometric growth, over the years. This reflects the stability in biological behaviour of *C. chitala* in these rivers over varying conditions.

Fulton’s condition factor (K) and relative condition factor (K_n) specify the growth dynamics of the fish population (Le Cren, 1951) in their habitat. In *C. chitala*, the highest average K (0.89) and K_n (1.24) were observed in Ken, while highest average K and K_n of 0.94 and 1.04 respectively, in *N. notopterus* was recorded in river

Table 3. Temporal variation in LWR of *C. chitala* from different rivers of India at various time periods and same locations at different time period

Sl. No.	River	Year	N	Regression parameters		
				a	b	R ²
Rivers at various time periods						
1	Brahmaputra	2000	58	0.010471	2.93*	0.92
		2005	16	0.066069	2.46*	0.81
2	Padma	2001, 2003	19	0.001778	3.31**	0.93
		2016	8	0.014791	2.80*	0.96
3	Son	2009	40	0.001778	3.32**	0.95
		2011-12	24	0.004786	3.08*	0.92
		2015-17	40	0.00263	3.23**	0.98
Locations at different time period						
1	Ken (Ranguwa)	2015	14	0.025119	2.69*	0.80
		2017	6	0.00302	3.19*	0.93
2	Padma (Farakka Barrage)	2001-03	19	0.001778	3.31**	0.93
		2016	8	0.014791	2.80*	0.96
3	Son (Beohari)	2009	30	0.00166	3.34**	0.93
		2016	26	0.004365	3.11*	0.95

N = No. of individuals, R² = Coefficient of determination, a = Intercept, b = Regression coefficient (slope)

*Significant at p=0.05

**Significant from value b=3 at p=0.05

Sharda (Fig. 2). In addition, variation in condition factor with respective changes in fish weight was also studied, to understand the effect of body weight in determining the fitness. This study was performed by grouping the specimens of *C. chitala*, viz., <1 kg (N=240), 1-3 kg (N=133) and >3 kg (N=66). The analysis revealed that the condition factors for these groups were 0.70, 0.79 and 0.77 (Fig. 3), respectively. The findings pointed towards better condition of specimens in the weight range of 1 to 3 kg. Condition factor of *N. notopterus* individuals in different weight groups (<100 g, 100-250 g and >250 g) were 0.75, 0.83 and 1.04 respectively (Fig. 3).

A comparative analysis of both species in the common collection sites (Gomti and Son) was also carried out (Fig. 4). In Gomti, the values of 'b' and 'K' were

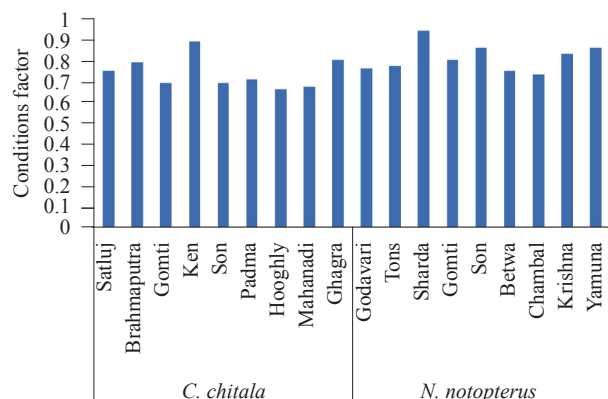


Fig. 2. Condition factor (K) of *C. chitala* and *N. notopterus* in different rivers of India

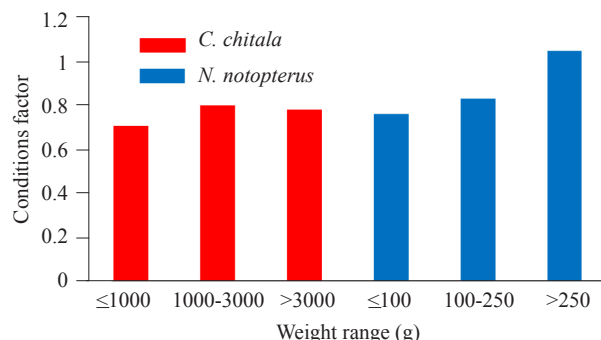


Fig. 3. Variation in condition factor of *C. chitala* and *N. notopterus* with weight

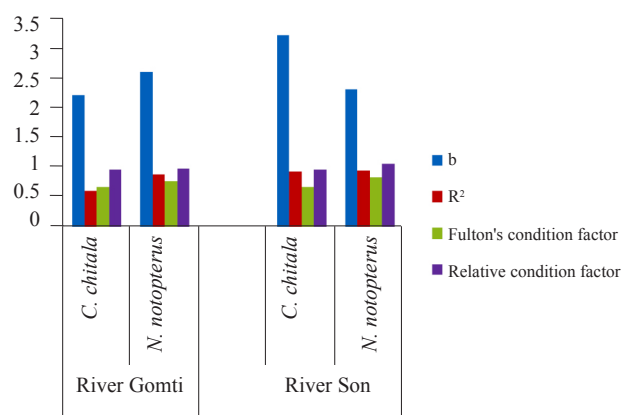


Fig. 4. Variation in b, R², Fulton's condition factor and relative condition factor values in *C. chitala* and *N. notopterus* in River Gomti and River Son

lower in *C. chitala*, whereas in river Son 'b' was higher but the condition factor was low. The results indicate that though the unit increase in weight of *N. notopterus* with unit increase in length is lower than in *C. chitala*, its condition is stable and healthy, thereby indicating an established biological pattern. This presents the better adaptive behaviour of *N. notopterus* in the two rivers.

Montana *et al.* (2011) categorised *C. chitala* to be equilibrium strategists with low batch fecundity, well developed parental care, moderate to long generation times and better competitive ability in stable habitats with high density of competitors. The results of LWR and condition factor obtained in the present study, support this hypothesis. No significant change in the condition factor with change in weight is also in compliance with *C. chitala* being an equilibrium strategist.

The findings from this study suggest that both species have adapted well to the changing water quality and habitat deterioration. This study is the first to report spatio-temporal variations in LWR and condition factor in the two notopterid species in India. The results provide basic information to fishery biologists and conservation agencies for fishery management.

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