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# Stock assessment of fish species *Labeo rohita, Tor tor* and *Labeo calbasu* in the rivers of Vindhyan region, India

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**Abstract**

A study was conducted on the economically important fishes *Labeo rohita* (Hamilton 1822), *Tor tor* (Hamilton 1822) and *Labeo calbasu* (Hamilton 1822) stocks from the Ken, the Paisuni and the Tons rivers in the Vindhyan region. Asymptotic length was maximum in *L. rohita* (946, 833 and 962 mm) as compared with *T. tor* (822, 787 and 946 mm) and minimum in *L. calbasu* (567, 612 and 692 mm) in the Ken, the Paisuni and the Tons rivers, respectively. The growth coefficient and total mortality was maximum in *T. tor* compared to *L. rohita* and minimum in *L. calbasu*. Fishing mortality was maximum in *T. tor* (2.9, 4.57 and 3.44) and minimum in *L. calbasu* (0.51, 1.21 and 1.18) while natural mortality was maximum in *L. rohita* (0.74, 0.94 and 1.86) and minimum in *L. calbasu* (0.47, 0.65 and 0.68). Natural mortality indicated that the habitat was more suitable for *L. calbasu*. Comparatively, fishing pressure was very high in *T. tor* than *L. rohita* and *L. calbasu.* Exploitation rate was maximum in *T. tor* (0.71, 0.82 and 0.84) compared to *L. rohita* (0.77, 0.74 and 0.56) and minimum in *L. calbasu* (0.52, 0.65 and 0.63) in the Ken, Paisuni and Tons rivers, respectively.

**Key words**

*Labeo rohita, Tor tor, Labeo calbasu,* Population dynamics, Stock assessment



## Introduction

*L. rohita, T. tor* and *L. calbasu* are important species for the riverine fisheries. *L. rohita* (Rohu) was an important component of the capture fishery in the Indo-Gangetic plains but now it is a major constituent of the culture fishery all over the country (Chondar, 1999). *T. tor* (Tor mahseer) is a principal fishery in the rivers Narmada and Tapti (Desai, 2003). *L. calbasu* (Kalbasu) supports an important commercial fishery in the rivers Ganga (Singh *et al*., 1998), Yamuna (Gupta and Tyagi, 1992), Ghaghra (Dwivedi *et al.*, 2004) and middle stretch of Ken (Nautiyal *et al*., 2004).

Fish population is a renewable source if they are exploited in a planned manner, therefore, fisheries are one of the most important sources of revenue to the economy of a country and as an important food sector in human nutrition (Dwivedi *et al.*, 2009). People make use of this sector through commercial fishing, aquaculture and recreation (Alp and Balik, 2000). Fish population are subject to natural control processes that continually modify and adjust the structure and abundance of population and their life cycle in response to a wide range of factors (Milner *et al*., 2003). Fish assemblage structure and function are also associated with geographic variation (McCromick *et al*., 2000; Oswood *et al.,* 2000; VanSickle and Hughes, 2000). Studies on the population dynamics of *L. rohita* are few in the Ganga and Yamuna (Gupta and Tyagi, 1992), in the Dhir beel (Goswami and Devaraj, 1995), in the Sylhet basin (Amin *et al*., 2001) while in case of *L. calbasu* in the Ganga and Yamuna (Gupta and Tyagi, 1992) and in the Sylhet basin (Haroon *et al.*, 2001, 2002). But nothing is known about these species in the rivers of Vindhyan region.

The present study was thus undertaken to estimate the key parameters for stock assessment such as the asymptotic length, growth coefficient, total mortality, natural mortality, fishing mortality and exploitation rate. This study will help in formulating the fishery management policies of *L. rohita, T. tor* and *L. calbasu* in the Vindhyan region.

## Materials and Methods

**Study area:** The Ken, the Paisuni and the Tons rivers were selected for the present study. These rivers drain the Bundelkhand geographic region of Central India. Bundelkhand lies between the Indo-Gangetic plain to the north and Vindhya range to the south. The latter is a range of hills in Central India. The western end of the range rises in Eastern Gujarat state, near the border with Madhya Pradesh and the range runs east and north nearly to the Ganga river at Mirzapur. The Vindhyan scar land has an elevation between 450 to 650 m asl (Wadia, 1983).

The Ken river arises in the Damoh district of Madhya Pradesh, and flows between latitude 23° 59' to 25° 46' 54" N and longitude 80° 15' 45" to 82° 32' 08" E covering area 28,058 $km^2$ The major categories of land use in its catchments were agriculture, forests and human settlements. The Paisuni river is a hilly stream arising in the hills of south Pathar Kachar near Majhgawan. The river lies between latitude 25° 08' 14" to 25° 16' 17" N and longitude 80° 51' 01" to 80° 50' 28" E. The Tons river is a hilly stream arising in the Kaimur hills of the Vindhyan range. It is a tributary of the Ganga, which forms confluence at Sirsa near Meja in the Allahabad district. Tons river lies between latitude 24° 0' to 25° 16' 54" N and longitude 80° 26' 45" to 82° 04' 57" E.

Length-frequency data of *L. rohita*, *T. tor* and *L. calbasu* was obtained from the commercial catches at rivers Ken, Paisuni and Tons. Four times in a month random samples were collected during 2003-2004. Each month 20 samples of each species were collected. The analysis was based on following length ranges, *L. rohita* 12.5 to 70.4 cm in the Ken 17.5 to 73.6 cm in the Paisuni and 10.5 to 86.5 cm in the Tons, *T. tor* 19.0 to 74.6, 18.0 to 65.0 and 18.0 to 82.0 cm in the Ken, the Paisuni and the Tons while *L. calbasu* 15.8 to 49.5, 16.4 to 45.0 and 16.0 to 58.0 cm in the Ken, the Paisuni and the Tons, respectively. The data were grouped into classes of 4 cm intervals for each species and subsequently the FiSAT (FAO-ICLARM Stock Assessment Tools) developed by Gayanilo *et al*. (1996) was to used determine the population parameters; asymptotic length, growth coefficient and mortality pattern (total, natural and fishing mortality). The exploitation rate was calculated by dividing fishing mortality by total mortality.

## Results and Discussion

River networks have provided many opportunities for allopatric speciation of aquatic taxa and also serve as reservoirs that accumulate species over evolutionary time (Winemiller, 2003).

The asymptotic length in *L rohita* varied from 833 mm in the Paisuni, 946 mm in the Ken and 962 mm in the Tons river. The growth coefficient was maximum (0.56 $yr^{-1}$) in the Paisuni compared with the Tons (0.42 $yr^{-1}$) and the Ken rivers (0.40 $yr^{-1}$). The Paisuni was hence, most suited habitat for the growth of *L. rohita.* The total mortality varied from 3.2 to 4.19 $yr^{-1}$ (Table 1). The fishing mortality was maximum in the Paisuni (2.73 $yr^{-1}$) compared to the Ken (2.46 $yr^{-1}$) and the Tons (2.33 $yr^{-1}$). According to fishing mortality, fishing pressure was high for *L. rohita* in the Paisuni than the Tons and the Ken. The natural mortality was maximum in the Tons (1.86 $yr^{-1}$) and minimum (0.74 $yr^{-1}$) in the Ken. The natural mortality indicated that the Ken river was more suitable habitat compared to the Paisuni and the Tons river (Table 1). Exploitation rate was maximum (0.77) in the Ken compared to Paisuni (0.74) and minimum (0.56) in the Tons (Fig. 1). *L. rohita* was over exploited in the Ken and the Paisuni compared with optimum exploitation in the Tons.

The asymptotic length of *T. tor* varied from 787 mm in the Paisuni, 822 mm in the Ken and 946 mm in the Tons rivers. The growth coefficient was maximum (0.78 $yr^{-1}$) in the Ken compared to the Paisuni (0.61 $yr^{-1}$) and in the Tons (0.50 $yr^{-1}$). The Ken river was hence, most suited habitat for the growth of *T. tor.* The total mortality varied from 5.57 to 4.08 $yr^{-1}$ (Table 1). The fishing mortality was maximum in the Paisuni (4.57 $yr^{-1}$) compared to the Tons (3.44 $yr^{-1}$) and (2.90 $yr^{-1}$) in the Ken. According to fishing mortality, fishing pressure for *T. tor* was very high in the Paisuni than theTons and the Ken. The natural mortality was maximum in the Ken (1.18 $yr^{-1}$) and minimum (0.80 $yr^{-1}$) in the Tons. The natural mortality was indicated that the Tons river more suitable habitat compared to Paisuni and Ken rivers (Table 1). Exploitation rate was maximum in the Paisuni (0.82) and the Tons river (0.80) compared with in the Ken river (0.71) (Fig. 1). *T. tor* was highly over exploited in the all rivers. Over exploitation results in reduction of average size of fish in a stock.

The asymptotic length in *L. calbasu* varied from 567 mm in the Ken, 612 mm in the Paisuni and 692 mm in the Tons. The growth coefficient was maximum (0.44 $yr^{-1}$) in the Ken compared to the Paisuni (0.28 $yr^{-1}$) and in the Tons (0.31 $yr^{-1}$). The Ken was most suitable habitat for *L. calbasu* as growth coefficient was high in this river. The total mortality varied from 1.86 to 0.98 $yr^{-1}$ (Table 1). The natural mortality was maximum in the Tons (0.68 $yr^{-1}$) and minimum (0.47 $yr^{-1}$) in the Ken. The fishing mortality was maximum (1.21 $yr^{-1}$) in the Paisuni compared to Tons (1.18 $yr^{-1}$) and the Ken (0.51 $yr^{-1}$). According to fishing mortality, fishing pressure was high in the Tons and Paisuni than Ken while natural mortality was maximum in the Tons (0.68 $yr^{-1}$). The natural mortality also indicated that the Ken river was more suitable habitat. Exploitation rate was maximum (0.65) in the Paisuni compared to the Tons (0.63) and minimum (0.52) in the Ken (Fig. 1). *L. calbasu* was over exploited in the Paisuni and the Tons, while optimally exploited in the Ken.

Fish assemblage structure and function are also associated with geographical variation and understanding the pattern is crucial for effective assessment and monitoring of streams and rivers (Arunachalam *et al*., 2003). Most wild fish stocks in Indian rivers have been over exploited or have reached their maximum sustainable yield due to over fishing, habitat degradation and pollution (Sinha, 2001; Gupta and Acosta, 2004).

Higher asymptotic length in *L. rohita* (962 mm) compared with *T. tor* (946 mm) points towards reduction in maximum attainable size of the latter species. MacDonald (1948) recorded a size of 1200 mm for *T. tor* while Khan and Jhingran (1975) obtained a maximum size of 1030 mm. Evidently, *T. tor* attains greater length than *L. rohita* but the present size indicates decline in its maximum

**Table - 1:** Stock characteristics of *Labeo rohita*, *Tor tor* and *Labeo calbasu* (Ken, Paisuni and Tons rivers) in the Vindhyan region

| Parameters | *Labeo rohita* | | | *Tor tor* | | | *Labeo calbasu* | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ken | Paisuni | Tons | Ken | Paisuni | Tons | Ken | Paisuni | Tons |
| Asymptotic length (mm) | 946 | 833 | 962 | 822 | 787 | 946 | 567 | 612 | 692 |
| Growth coefficient ($yr^{-1}$) | 0.40 | 0.56 | 0.42 | 0.78 | 0.61 | 0.5 | 0.44 | 0.28 | 0.31 |
| a | 380.9 | 467.09 | 384.86 | 639.05 | 472.49 | 472.8 | 249.01 | 171.35 | 214.5 |
| b | -0.40 | -0.56 | -0.42 | -0.78 | -0.61 | -0.5 | -0.44 | -0.28 | -0.31 |
| Total mortality ($yr^{-1}$) | 3.2 | 3.67 | 4.19 | 4.08 | 5.57 | 4.28 | 0.98 | 1.86 | 1.86 |
| Fishing mortality ($yr^{-1}$) | 2.46 | 2.73 | 2.33 | 2.9 | 4.57 | 3.44 | 0.51 | 1.21 | 1.18 |
| Natural mortality ($yr^{-1}$) | 0.74 | 0.94 | 1.86 | 1.18 | 1.0 | 0.84 | 0.47 | 0.65 | 0.68 |

a = Intersect, b = Slope

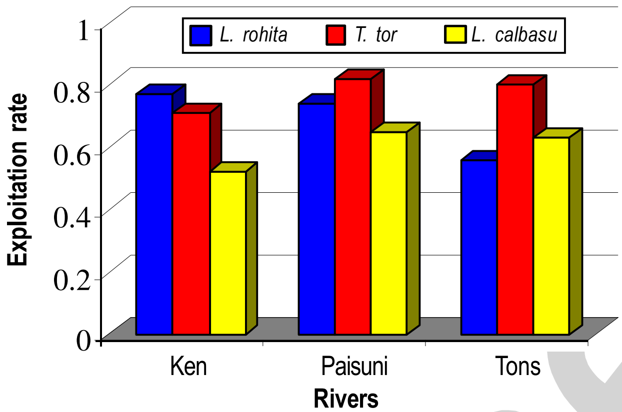


**Fig. 1:** Exploitation rate of *L. rohita, T. tor* and *L. calbasu* in the Vindhyan region

attainable size. The highest growth coefficient for *T. tor* (0.78 $yr^{-1}$) compared to *L. rohita* (0.56 $yr^{-1}$) and *L. calbasu* (0.44 $yr^{-1}$) indicates better growth in *T. tor*. Higher growth coefficient in the Ken may be attributed to its suitable and better environment than the Paisuni or Tons river. Both Paisuni and especially the Tons river are relatively under severe anthropogenic stress generated by agriculture. In contrast, the Ken flows through patches of forest, which probably rejuvenates the river.

The present asymptotic length of *L. rohita* was much less than observed earlier for this species (135.29 cm) and growth co-efficient (0.38 $yr^{-1}$) (Goswami and Devaraj, 1995) from the Dhir beel of Assam. In Bangladesh, asymptotic length were much lower (80.31 and 51.74 cm in 1998 and 1999, respectively growth co-efficient =0.41 $yr^{-1}$ in 1998 and 0.80 $yr^{-1}$ in 1999, asymptotic length = 80.20 cm and growth coefficient =0.41$yr^{-1}$, Haroon *et al*., 2002, Amin *et al*., 2001) than present observations.

The present asymptotic length of *L. calbasu* was lower in case of Ken and Paisuni rivers and greater in case of the Tons river observed earlier for this species from Faizabad (667 mm, Rizvi *et al.,* 2010) and from the Sylhet basin, Bangladesh (49.30 cm, growth co-efficient =0.63 $yr^{-1}$ Alam *et al*., 2000). Haroon *et al*. (2002) also reported lesser asymptotic length (49.78, 50.22 cm) in 1998 and 1999, respectively. This species too seems to face reduction in the size in India as well as Bangladesh.

Mortality rates are important for understanding the rate of population decay (Sparre and Venema, 1998). In Bangladesh, high fishing mortality was observed for commercially important *L. calbasu* (3.48 $yr^{-1}$, Alam *et al*., 2000) and *Cirrhinus mrigala* as well as *Catla catla* (1.27 and 1.47 $yr^{-1}$, respectively, Haroon *et al*., 2002). Gupta and Tyagi (1992) reported relatively low values of total mortality, natural mortality, fishing mortality and exploitation rate for *L. rohita* (0.74, 0.30, 0.44 and 0.59 $yr^{-1}$, respectively) in the Ganga river system at Allahabad. Amin *et al*. (2001) also gave low values total mortality, natural mortality, fishing mortality and exploitation rate of *L. rohita* (1.56, 0.73, 0.83 and 0.52 $yr^{-1}$, respectively) in 1998 and (1.70, 0.77, 0.93 and 0.55 $yr^{-1}$, respectively) 1999 from the Sylhet basin, Bangladesh.

Fishing mortality is caused by several factors, which include, age (King, 1981), fish predation, environmental stress (Chapman and Van Well, 1978), parasites and diseases (Landau, 1979) and fishing activity. The exploitation rate is an index, which estimates the level of utilization of a fishery. The value of exploitation rate is based on the fact that sustainable yield is optimized when the fishing mortality coefficient is equal to natural mortality (Pauly, 1983). Haroon *et al*., (2001) reported very low exploitation rate for *L. rohita* in two successive years *i.e.* 0.52 (year 1998) and 0.55 (year 1999) in the Sylhet basin. Tandon and Johal (1996) stated that the increase in mortality between particular age classes is due to substantial increase in the exploitation rate. Alam *et al.* (2000) recorded high mortality rate *i.e.* natural mortality = 1.11 $yr^{-1}$, fishing mortality = 3.48 $yr^{-1}$, total mortality = 4.59 $yr^{-1}$ and exploitation rate 0.76 for *L. calbasu* from the Sylhet basin. Faster growing fish have higher natural mortality rate (Sparre and Venema, 1998).

The stock is considered to be overfished if exploitation rate exceeds 0.50 (Gulland, 1965). On this basis it can be concluded that *L. rohita* was overfished in the Ken (0.77) and the Paisuni (0.74), *L. calbasu* in the Paisuni (0.65) and the Tons (0.63), while *T. tor* in the Ken, the Paisuni and the Tons (0.71, 0.82 and 0.80). The exploitation rate exhibited a similar pattern. The exploitation rate was very high in case of *T. tor* and was hence the most overfished stock. Ahmed *et al*. (2004) stated that the exploitation rate was close to the maximum allowable limits ($E_{max}$) of the yield/recruit, which indicates that the stock is more or less under optimum fishing level. So, fishing mortality does not seem to be great concern. In general, mahseer are declining very rapidly in their numbers and size in Central India (Kulkarni, 1991; Dubey, 1994; Khan and Sinha, 2000; Desai, 2003). Similar concerns have been raised for the Himalayan mahseer (Nautiyal, 2002; Johal and Brraich, 2005).

From the results, it may be concluded that mortality and exploitation rate was high in *L. rohita* and *T. tor*. It is necessary to impose fishing (exploitation) regulation on the stock immediately.

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