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Age Parameters of the Indian Major Carp, *Labeo rohita* (Hamilton, 1822) from the Subtropical River Rapti, India

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Abstract

Fishery science, conservation and management rely heavily on accurate assessments of age composition and growth in fish stocks. Studies were from June 2023 to May 2025 from the Rapti River in Balrampur, Uttar Pradesh, India. In the present study, a total of 287 fish specimens of Labeo rohita (139 males and 148 females) were collected for the assessment of age parameters, namely age composition, age and growth increment by using the scale method. The investigation of L. rohita key scale resulted in a comprehensive depiction of age composition, age, and growth increment. L. rohita had an age composition of 0+ to 6+ from the Rapti River at Balrampur. Total length of collected fishes was ranging in sizes (total length) from 182 mm to 873 mm. The growth increments of fish were influenced age with respect to pooled, male and female specimens. The fish have a mean length (pooled samples) of 360 mm, 542 mm, 649 mm, 732 mm, 802 mm and 852 mm for 1+ to 6+ age groups, respectively. The growth increments were estimated at 360 mm in 1+, 182 mm in 2+, 107 mm in 3+, 83 mm in 4+, 70 cm in 5+ and 50 mm in 6+ age classes. The maximum growth increment was recorded in the first year, followed by moderate growth in the following years. The minimum growth increment occurred in the sixth year of the life cycle of L. rohita. In the first year, female fish growth was reported higher compared to male fish, but for other years, growth in male fish was estimated higher compared to female fish. It is generally agreed that the growth potential is used for *gonad maturity in female fish. It was concluded that this species should be protected from overfishing which will be helpful in the conservation of the species and leads to development of fishery.*

Keywords: *Fish stock, Labeo rohita, scale, Age and growth, male fishes, female fishes, Rapti River, Balrampur*

Introduction

Inland fish and fisheries are globally important to environmental function and human services (Abbott *et al.* 2007), yet their persistent lack of recognition in global agreements, especially multilateral environmental agreements (Lynch *et al.* 2025). The connection between inland fishes, fisheries, and their ecosystems means that addressing the needs of fish directly offers opportunities to gather several global promises and provide indicators of development towards many global goals (Arthur *et al*. 2022, Lynch *et al.* 2025). Inland fish provide an important source of protein and micronutrients for billions of people, contributing to global food security, healthy health, and nutrition (Tiwari *et al*. 2017). The freshwater ecosystem is one of the most vulnerable and threatened habitats and biodiversity in the world (Cowx 2015, Kumar *et al.* 2024). The major threats to freshwater ecosystems have been comprehensively synthesized in six main categories: hydrological alterations, habitat degradation and loss, pollution, overexploitation and competition for resources, invasive species and climate change (Dudgeon *et al*. 2006, Tripathi *et al*. 2024,). Fishes are the largest vertebrate groups with more than 34,000 know species worldwide have been recorded from various ecosystems. According to Eschmeyer's Catalog of Fishes (2023), a total number of approximately 36,383 valid species, of which 18,426 are found in freshwater ecosystems. Riverine fisheries are complex socio-ecological system, which provide numerous ecosystem services that have also deteriorated (Tickner *et al*. 2025). Indian riverine fisheries are vast and numerous, as well as economically, socially, and culturally valuable. In a number of countries around the world, inland fisheries especially riverine water are important for poverty alleviation, food security, gender empowerment, cultural services, ecosystem function and biodiversity (Tiwari *et al*. 2024, Howarth *et al.* 2025).

Calcified structures commonly used for the determination of fish age include scales, opercular, otoliths, spines, fin rays, vertebrae, and other bony structures (Khan and Khan 2009, Mayank *et al.* 2018, Nautiyal *et al.* 2024). Calcified structures grow throughout a fish’s life and act as a permanent record of growth (Dwivedi and Nautiyal 2021). The successful interpretation of calcified structures to age individuals relies on the ability to recognize patterns in the layered deposition of material (Mayank *et al*. 2015, Wang *et al*. 2020). As annual growth increments decrease with age, the spacing and distinctness of growth increments in calcified structures also decreases, often resulting in a negative bias in age estimates of older fishes (Dwivedi and Mayank 2013, Tiwari *et al*. 2023). Calcified structure particularly fish scales serve as valuable biomarkers for understanding key aspects of fish biology (Aerts *et al.* 2015, Aib *et al.* 2025). Fish scales, long appreciated for their protective and structural roles (Mishra *et al*. 2023, Rawat *et. al*. 2021). Estimation of fish growth increment parameters give important and reliable scientific information to carry out regional assessments and conservation actions (de Santana *et al.* 2020). The use of age information is an integral part of fisheries today. However, the scale method is widely used in age and growth studies.

Rohu, *Labeo rohita* is a one of the most important large size fish species (Example carp group) commercially and economically produced in the world aquaculture in south Asian countries. Large size freshwater fishes are largely overexploited with targeted by fishermen/fishers worldwide (Dwivedi *et al*. 2017, Kumar *et al.* 2023, Tiwari *et al*. 2023). It is widely distributed in rivers and ponds. *L. rohita* includes one of the most significant proportions of the Ganga river system commercial catch in the in the Ganga and Yamuna rivers. The catch of this important species has suffered a high fluctuation over the last three decades due to anthropogenic effects and management strategies in the Ganga river system, India. It is also most dominated organism/commercially popular Indian major carp species in the composite fish culture/polyculture in India and Bangladesh (Ujjania and Soni 2020, Dwivedi *et al*. 2018). It is mostly inhabit in the riverine ecosystem and working as a key stone species from the river ecosystem (Nautiyal and Dwivedi 2019). Although *L. rohita* a highly prized food fish in its native ranges.

According to historical information, the distribution of *Labeo rohita* is India, Nepal, Laos, Bangladesh and Pakistan (Chondar 1999 Mahmood *et al.* 2024). *L. rohita* is found in tropical and temperate regions. It is the commonest cap in the plains of India. In fact, over the past three decades, its stocks dramatically decline in natural habitat (Example Rivers) due to especially over exploitation and consumer preferences (Dwivedi and Nautiyal 2019, Tripathi *et al* 2024). The current study was designed to evaluate the age and growth increment of *L. rohita* from the Rapti River at Balrampur, Uttar Pradesh in India. This study will help in formulation of the fishery management policies and restoration of *L. rohita* from the Rapti and its associated ecosystems.

Material and methods

Study Area

Indian rivers are facing a threat because the discharge of various contaminants through various industries, untreated sewage, agricultural runoff, and improper disposal of solid waste has led to deterioration in the quality of river water. But the Rapti river is presently full of life in natural form due to minimum human settlement and lowest industries in the basin. Rapti river is the most revered in the Balrampur district, Uttar Pradesh and hold important role in terms of ecological and irrigation perspective.

Sampling

The current investigation was carried out for a period of 2 years. Present study for the assessment of age parameters namely age composition, age and growth increment of *Labeo rohita* (Rohu) were undertaken during the period June 2023 to May 2025 from the Rapti River at Balrampur (Latitude 27.4307°N, Longitude 82.1805° E), Uttar Pradesh, India. In present study, a total of 287 fish specimens (139 males and 148 females) scales were studied. The investigation of *L. rohita* key scale (aging structure) resulted in a comprehensive depiction of age composition, age and growth increment. Historically, scales are considered the most popular aging structure used to estimate age. The key scales of *L. rohita* were utilized to test its age parameters with the help of methods described by Bagenal and Tesch (1978). The key scales were carefully removed with fine forceps from the row above the lateral line beneath the dorsal fin area (Bagenal and Tesch 1978, Mayank *et al.* 2018, Tiwari *et al*. 2024). Scales were removed and thoroughly cleaned with a fine brush before being rinsed with distilled water. To remove adherent tissues, the scales were cleansed in a 5% KOH solution and then washed with distilled water. The scales were then squeezed while drying to prevent them from curling. After properly cleaning the scales, the growth rings were counted. The fish's age was determined using the Carl Zeiss Jena Scale Reader. The ring zone appeared in opaque format, while the rest zone was clear.

Result

Accurate fish age estimation is thought to be a prerequisite for age assessment of fish populations, effective resource management, and recruitment potential. *Labeo rohita* (Rohu) has typical cycloid scales on its body. As a result, the scales of these species were structurally identical, consisting of an anterior field (AF), a posterior field (PF), two lateral fields (LF), and a focus (F). The reading of cycloid scales shows the high degree of correlation measurements of scale radius of the combined sexes, males and females of *L. rohita* in relation to the fish length from the Rapti river. The rings formed with transparent and opaque zone. The opaque zone showed a ring in the scale (Plate I). This result showed that the peak of length attained in the first year of fish life and their increments were 360 mm, 357 mm and 363 mm for pooled, male and female fishes, respectively.

Plate I First scale showed 2 rings and second scale showed 6 rings of *Labeo rohita*.

Pooled

The most important biological and population indicators for fish are age and growth. A total of 287 fish specimens (139 males and 148 females) were studied. In this study, the analysis of *L. rohita* scales provided a comprehensive overview of the age and growth increment of fish. The age composition of *L. rohita* varied from 0+ to 6+ age classes from the Rapti River, Uttar Pradesh, India (Table 1). Based on sampled specimens ranging in length from 182 to 873 mm, the fish had a mean length of 360 mm in 1+, 542 mm in 2+, 649 mm in 3+, 732 mm in 4+, 802 mm in 5+ and 852 mm in 6+ age classes (Table 1). The highest growth increment occurred in the first year, followed by moderate growth in subsequent years. Furthermore, this fish follows the normal growth trend, in which the annual increment reduces as age increases, as is typical of most carps. The smallest growth increment was documented in the sixth year of life. The modest growth rate observed after the second year of life could be related to maturity. It is widely acknowledged that the growth potential is used for gonad development. The growth percentage of pooled fish fluctuated from different age classes of the fish (Fig. 1).

Table 1 Age composition, age and growth of *Labeo rohita* (Pooled) from Rapti River, Balrampur, India

Age composition	Size classes (mm)	Mean length (mm)	Growth increment (mm)	Percentage of growth increment
0+	182-307	262		
1+	288-453	360	360	42.25
2+	359-608	542	182	21.36
3+	572-688	649	107	12.56
4+	668-836	732	83	9.74
5+	784-851	802	70	8.21
6+	838-873	852	50	5.87

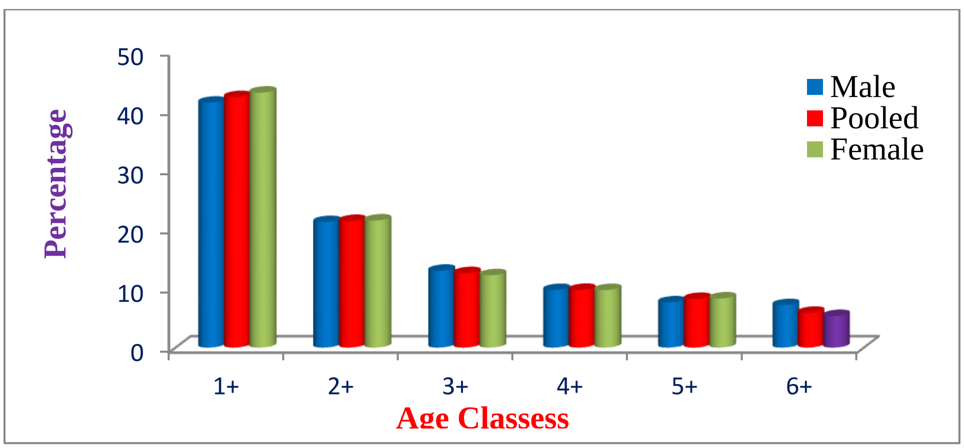

Fig. 1 The growth percentage of pooled, male and female fishes of *Labeo rohita* in different age classes from Rapti River, Balrampur, Uttar Pradesh, India

Male

The male fish samples in the studies varied in length from 182 to 873 mm. The growth ring was not observed in fish less than 305 mm in size. Only six-year-old male fish were recorded from the Rapti River, Uttar Pradesh, India (Table 2). The shortest and longest body lengths were at ages 1+ (357 mm) and 6+ (864 mm). The present findings revealed that the fish attained the mean length of 357 mm in 1+, 540 mm in 2+, 652 mm in 3+, 736 mm in 4+, 802 mm in 5+, and 864 mm in 6+ age classes. Male fish had growth increments of 357 mm, 183 mm, 112 mm, 84 mm, 66 mm, and 62 mm for 1+ to 6+ age classes (Table 2). The largest growth increment was recorded in the first year, whereas the smallest reported in the sixth year of the life cycle. The modest growth increment observed after the second year may be linked to reaching maturity during the second year of life. It is widely acknowledged that the growth potential is used for gonad development. Males develop faster because they require less energy for reproduction and gamete formation. The growth percentage of male fishes fluctuated from different age classes of the fishes (Fig. 1).

Table 2 Age composition, age and growth of *Labeo rohita* (Male) from Rapti River, Balrampur, India

Age composition	Size classes (mm)	Mean length (mm)	Growth increment (mm)	Percentage of growth increment
0+	182-302	260		
1+	305-447	357	357	41.32
2+	467-599	540	183	21.18
3+	581-688	652	112	12.96
4+	674-836	736	84	9.72
5+	784-851	802	66	7.63
6+	856-873	864	62	7.17

Female

In this study, the female fishes were measured from 189 mm to 849 mm in total length from the Rapti river. The age composition of female *L. rohita* was also varied from 0+ to 6+ from the Rapti River. The current results showed that the fish acquired the mean length 363 mm in 1+, 544 mm in 2+, 647 mm in 3+, 729 mm in 4+, 799 mm in 5+ and 844 mm 6+ age classes (Table 3). The growth ring was not recorded below 288 mm size group of fishes. The growth increments in *L*. rohita was recorded

363 mm, 181 mm, 103 cm, 82 mm, 70 mm, and 45 mm for 1+ to 6+ age classes, respectively (Table 3). The growth percentage of female fishes fluctuated from different age classes of the fishes (Fig. 1). The first year of the life cycle indicating the greatest growth increment, and the sixth year saw the lowest. One possible explanation for the observed modest growth increment after the second year of life is that during this time, maturity was attained. It is commonly known that the gonads develop using the growth potential.

Table 3 Age composition, age and growth of *Labeo rohita* (Female) from Rapti River, Balrampur, India

Age	Size classes (mm)	Mean length (mm)	Growth increment (mm)	% of growth increment
0+	189-307	264		
1+	288-453	363	363	43.01
2+	359-608	544	181	21.44
3+	572-684	647	103	12.20
4+	668-835	729	82	9.71
5+	785-843	799	70	8.29
6+	838-849	844	45	5.33

Discussion

These results indicate that the *L. rohita* stocks in the Rapti river grows faster as compared with fish in other locations (Ganga river) in India and slower only in first year from Vallabhsagar Reservoir, Gujarat, India (Soni and Ujjania 2019). According to Dwivedi *et al*. (2020), the growth increments of *L. rohita* was recorded as 34.6 cm, 18.6 cm, 13.9 cm, 9.5 cm, 6.2 cm, 4.0 cm, 3.7 cm, 2.3 cm, 1.9 cm and 1.8 cm for 1+ to 10+ age classes, respectively from the Ganga river, India. A total 8+ years old fishes, *L. rohita* were estimated from the Betwa and Sharda rivers (Mir *et al.* 2013, Aib *et al.* 2025). The difference in growth parameters for *Labeo rohita* in different drainages might be caused by environmental and ecological factors in different regions, including differences in population density, fishing pressure and water quality (Mayank and Dwivedi 2016, Dwivedi *et al*. 2020, Singh *et al* 1998). Securing a sustainable future for *L. rohita* is most likely when conservation action through restoration and fishing ban in the monsoon season.

Data on fish size, combined with age information, provide growth rates. Growth in body size is a key life-history trait that has coevolved and is interlinked with maturation, maximum age, mortality, generation time, and the intrinsic rate of population growth. There is high correlation between scale radius and total length in *L. rohita*. The maximum age (t_{max}) and size of a fish species will be affected by the environmental conditions and fishing pressure (Dwivedi *et al*. 2009, Mayak and Dwivedi 2015, Zhu *et al*. 2021, Rana *et al* 2025). Phosphorus high concentration can lead to harmful algal blooms, eutrophication, and degraded water quality of the rivers (Liao *et al.* 2020, Pal *et al.* 2024, Mishra *et al.* 2025). Indirectly, these developments may be destructive/unhelpful for the growth of herbivorous fishes (*Labeo rohita*) in riverine ecosystem. The growth increment of fishes varied from river to river in same species (Khan and Siddiqui 1973, Mishra and Dwivedi 2021, Dwivedi and Mishra 2021, La Mesa and Eastman 2024). Obtaining accurate age estimates is critical for estimating fish population dynamics (recruitment, growth, and mortality).

Conclusion

Understanding the stock status of *L. rohita* is critical for formulating successful management plans but dependent upon the reliability of age estimations. The present study of the age composition, age and growth increment of Indian major carp, *Labeo rohita* from the Rapti river, India provides vital data for managing the stock dynamics and total length of fishes. To conserve this Indian major carp (IMC) species and sustainably develop the fishery in this stretch of the Rapti River should be conserve. The enormous overfishing is also evidenced by the limited age structure of the most important commercial species, particularly carp. This circumstance is a serious problem, as the fish productivity of the Rapti River is undermined. Another reason for the decline in age numbers is explained by the fact that large areas of the low and flat bank of the Rapti River especially in monsoon season. Therefore, conserving inland fish, especially large size fishes due to late maturity (Example Indian Major Carp) and fisheries also requires higher order coordination among global policies and initiatives to identify opportunities for synergies between biodiversity conservation and development goals-such as how targeted assistance can address common environmental challenges.

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