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Review Articles

Overview of Biology, Ecology, and Conservation of *Labeo catla* (Hamilton, 1822): Implications for Sustainable Management

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ABSTRACT

Labeo catla (Hamilton, 1822), an economically important South Asian major carp which is valued for its high nutritional content. Although the species is currently classified as Least Concern in Bangladesh, it is experiencing increasing ecological and anthropogenic pressures that may threaten its long-term sustainability. This study provides a comprehensive overview of the biology, habitat preferences, ecology, conservation status, and genetic stability of *L. catla*. The species contributes significantly to inland fisheries production. However, habitat degradation, water pollution, overexploitation, destructive fishing practices, disease outbreaks, hybridization, inbreeding, and the loss of natural spawning grounds have contributed to declining wild populations and reduced aquaculture productivity. Therefore, effective conservation and management strategies are urgently required, including habitat restoration, protection of spawning and nursery grounds, sustainable fishing practices, genetic management of brood-stock, stock enhancement, and community engagement. Strengthened research, continuous monitoring, and effective policy implementation are also essential to ensure the long-term sustainability of *L. catla*. by protecting freshwater ecosystems, conserving fish biodiversity, and promoting sustainable livelihoods through responsible aquaculture and habitat conservation.

Introduction

Labeo catla (Hamilton 1822), also known as the major South Asian carp, belongs to the family Cyprinidae and the order Cypriniformes. The species is indigenous to Bangladesh, Pakistan, Myanmar, Nepal, and central and northern India. It has been introduced in peninsular India, Sri Lanka and China (Tenzin 2010; Rahman and Chowdhury 2007; Talwar and Jhingran 1991). Its habitats include rivers, lakes, *haors*, *baors* and culture ponds and also in seasonal floodplains. It spawns in specific areas of some rivers in June-July (Rahman and Chowdhury 2007). *L. catla* is a highly preferred farm fish and economically significant because of their taste, high market price and greater customer acceptability (Bais 2018). In Bangladesh, the species contributes approximately 7.27% of total annual

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fish production in the inland water bodies (DoF 2024). Previously, the collection of riverine seed was the sole source for culture until the 1950s. However, due to the extensive deterioration of natural breeding grounds led to declining seed availability. The successful induced breeding of this species in 1957 (Chaudhuri 1963) ensured a reliable seed supply, revolutionizing carp polyculture practices across India and other Southeast Asian countries.

In Bangladesh, its conservation status is currently listed as Least Concern (LC) (IUCN Bangladesh 2015). Despite this classification, *L. catla* faces multiple challenges in both wild and cultured environments. In natural waters, such as the Kaptai Reservoir (Ahmed et al. 2003), the proportion of major carps has declined due to several factors such as siltation caused by deforestation, over fishing, indiscriminate killing of supplemental fingerlings and use of different types of destructive fishing methods including fish aggregation device (FAD) (Ahmed and Hambrey 1999). In farmed conditions, production and productivity are on decline due to frequent disease outbreak, which can be caused by inadequate supply of disease-free seed, high-quality inputs, inadequate farm infrastructure, inadequate water supply, a lack of farmer knowledge regarding appropriate improved farming methodologies, and a lack of access to finance and services (DoF 2024). Negative impacts on hatchery-produced seeds, including stunted growth, reduced reproductive performance, morphological abnormalities, and an increase in occurrence of disease and mortality, have been documented in recent years (Siddique et al. 2022). Therefore, it is crucial to develop and implement effective management and conservation strategies in order to ensure the long-term sustainability of the *L. catla* population in Bangladesh.

Currently, there is a lack of comprehensive research and documentation on this species. This gap hinders the development of effective management and conservation strategies. Therefore, this document aims to serve as a foundational resource for developing appropriate management and conservation strategies for *L. catla* in Bangladesh.

Table 1. Available studies on *Labeo catla* from different countries

Aspects	Country/Region	Reference
Integrated morphometric and molecular approaches to screen hybrid from wild parent populations	India	Lenka et al. (2024)
Effects of stocking density	India	Mane et al. (2019)
Establishment of base population for selective breeding	India	Das et al. (2018)
Induce breeding to develop backcross generations	India	Tripathy and Sarangi (2016)
Length-weight relationship	Pakistan	Ishtiaq and Naeem (2016)
Development and characterization of cell lines	India	Ishaq Ahmed et al. (2009)
Food and Feeding habit	Bangladesh	Mozumder and Naser (2009)
Growth performance	Bangladesh	Hayat and Razzaq (2007)
Production performance	India	Sahu et al. (2007)
Reproductive performance	India	Nandi et al. (2007)
Hematological changes	India	Das et al. (2006)
Effect of dietary supplementation of fatty acids and vitamins on the breeding performance	India	Nandi et al. (2001)
Protein requirement	India	Renukaradhya and Varghese (1986)

Taxonomic remarks

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Cypriniformes
Family: Cyprinidae
Subfamily: Labeoninae
Genus: *Labeo*
Species*: L. catla* (Hamilton 1822)

Synonyms

Cyprinus catla (Hamilton 1822)
Catla catla (Hamilton 1822)
Gibelion catla (Hamilton 1822)
Leuciscus catla (Hamilton 1822)
Cyprinus abramioides (Sykes 1839)
Hypselobarbus abramioides (Sykes 1839)
Catla buchanani (Valenciennes 1844)

Morphological characters

The fish species *L. catla* has some distinct physical characteristics. The head is enormous, with a depth greater than half the head length; the body is short and deep, somewhat compressed laterally (Talwar and Jhingran 1991). The body is covered with conspicuously large cycloid scales (Bhowmick et al. 1987). The head appears smooth and naked since it has no scales at all. The broad and somewhat flattened front aspect is a result of the bluntly rounded snout. The eyes are noticeably big. They are positioned laterally so that they can be seen even from the back of the head (Talwar and Jhingran 1991). It has wide mouth which is upturned with prominent protruding lower jaw. The upper lip is absent and the lower lip is very thick (Tripathi 1992). It has no barbels. The lower jaw lacks a noticeable process and has a flexible articulation at symphysis (Das 1992). The gill rakers are long and fine. It has pharyngeal teeth in three row, 5.3.2/2.3.5 pattern. The dorsal fin inserted slightly in advance of pelvic fins. The anal fin is short and the pectoral fins is long which extends to pelvic fins and the caudal fin is forked. It has lateral line with 40 to 43 scales. It has a greyish coloration on the back and flanks which gradually fades in silvery-white hue on the underside. The fins are dusky or slightly darkened (FAO 2009). The available fin formula is

D (0–17); A (0–7–8); P (0–17–21); V (0–5) (Bhowmick et al. 1987)

D (0-17); A (0,7–8); P (0,17–21); V (0,8) (Talwar and Jhingran, 1991)

Fig. 1. *Labeo catla (Kibenge 2022)*

Common name

The fish *L. catla* is referred to as Catal or Catla, Katalin Bangla in Bangladesh (Galib et al. 2013; Al Mamun 2003). Although the common name varies widely among various nations, it is typically referred to as Katal, Catla, Katla, Tambra, Boassa in India (Daniels 2002; Chandy 1970; Jhingran 1968; Devanesen and Chidambaram 1953), Belaunda, and Chona in Nepal (Shrestha 1994). It is also known as Pla kra ho in both Bangladesh, India and Pakistan (Rahman 1989; Jhingran 1968). It is referred to Bhakur in Nepal (Shrestha, 1994), Nga gaung pwa in Myanmar (Khin 1948). The local language and cultural background may influence the particular name.

Distribution and Abundance

The Indian main carp species *L. catla* is typically found in rivers, lakes, culture ponds, estuaries, lagoons, brackish seas, mangroves, rivers and streams. The distribution is limited to maximum altitude of 500 m and minimum temperature of 14°C (Palomares 1991). It is distributed throughout India, Pakistan, Bangladesh, and Burma from the Ganga River network in the north to the Krishna River in the south. It can also be found in Nepal. Additionally, Zimbabwe, Israel, Bhutan, the Philippines, the former USSR, Japan, Sri Lanka, Laos, Pakistan, Malaysia, Thailand, Vietnam, and Mauritius have all received *L. catla* (FAO 2009). It is mostly found in the Halda and Padma–Brahmaputra River systems, which include the Padma, Jamuna, Arial Khan, Kumar, and Old Brahmaputra rivers (Alam and Islam 2005). It is native to northern India, Bangladesh, Nepal, Myanmar, and the river systems and surrounding hills of the Indus plain (Chakrabarti 2005).

Habitat and Ecology

L. catla is a freshwater fish species that prefers riverine systems. At present it is widely farmed in ponds and tanks. It is a eurythermal species that grows best at water temperatures between 25-32°C (Halwart and Gupta 2004). They are benthopelagic and potamodromous fish species often found in Pakistan, India, Bangladesh, Nepal and Myanmar (Riede 2004).

Food and Feeding Behavior

L. catla feeds both in the water and on the surface. They are typically omnivorous. While juveniles consume both phytoplankton and zooplankton, adults use huge gill rakers to graze on zooplankton. The fry is planktophagic, primarily consuming zooplankton like cladocerans and rotifers. Adults are planktophagous which prefers zooplankton such as crustaceans, rotifers, insects, and protozoa, as well as a sizable portion of algae and plant matter (FAO 2009). It is known for its extraordinarily quick development and mostly consumes surface plankton (Sultana et al 2025).

Nutritional Profile

L. catla fish is a rich source of protein and essential nutrients. The fish's muscles have higher protein, lower fat, and a good source of minerals. It is rich in minerals like vitamin A, calcium, iron, zinc, and selenium (Shaheen 2013). A comparative nutritional profile of L. *Catla* is given in Table 2. Its balanced fatty acid profile supports heart health. *L. catla* fish offers health benefits like muscle repair, heart health, and cognitive function.

Table 2. Nutrient Profile of *Labeo catla*

Nutrient	Values	
	Shaheen et al. (2013)	Mohanty et al. (2016)
Calcium (mg/100g)	530.000	161.100
Iron (mg/100g)	0.600	1.600
Protein (g/100g)	17.3	200.000
Vitamin A (µg/100g)	3.00	3.660
Zinc (mg/100g)	0.480	1.300

Growth Pattern

Ishtiaq and Naeem (2016) calculated the LWR values of exponent '*b*'were observed as negative allometric growth (*b*= 2.87), isometric growth (*b*= 2.95) and positive allometric growth (*b*= 3.22) respectively. Yousuf Haroon et al. (2002) calculated the b value of 2.990 which indicates negative allometric growth pattern. Yousuf Haroon et al. (2002) also calculated the *b* value (3.040) which indicates negative allometric growth pattern in Bangladesh. Similar growth pattern was also reported by Ahmed and Saha (1996); Johal and Tandon (1992); Choudhury et al. (1982) in Kaptai Lake of Bangladesh (Table 3).

Table 3. Growth Pattern of *Labeo catla* from Different Waterbodies

Locality/Habitat	TL (cm)	*a*	*b*	Sex	r^2	$a_{3.0}$	References
Peninsular river, India	18.0-73.3	0.0735	3.299	Unsexed	0.987	0.1872	Das et al. (2015)
Sylhet basin, Bangladesh	-	0.0135	2.990	Unsexed	-	0.0131	Yousuf et al. (2002)
Sylhet basin, Bangladesh	2.0-93.0	0.0120	3.040	Unsexed	0.990	0.0136	Yousuf et al. (2002)
Kaptai lake, Bangladesh	28.5-93.5	0.0037	3.352	Unsexed	0.835	0.0111	Ahmed and Saha (1996)
Gobindsagar reservoir, India	-	0.0153	3.058	Unsexed	-	0.0183	Johal and Tandon (1992)
Harike river, India	-	0.0065	3.230	Unsexed	-	0.0133	Johal and Tandon (1992)
Brahmaputra, Assam, India	10.0-114.0	0.0096	3.086	Unsexed	0.960	0.0127	Choudhury et al. (1982)

Form Factor

We calculate the form factor with the formula: $a_{3.0}$ = 10loga-*s(b-3)* (Froese 2006) where *a* and *b* represent the LWRs' regression parameters and *s* represents the slope of log *a vs. b*. A mean slope *(s)* of -1.358 was used for the regression analysis of log *a vs. b*. The calculated form factor ($a_{3.0}$) was to vary between 0.0111 to 0.1872, indicating elongated (slender) to moderately body shape, as shown in (Table 3).

Reproductive Biology

L. catla (Hamilton, 1822) is a fast-growing freshwater species widely cultured in South Asia. It involves in external fertilization in running water during the monsoon season. It migrates to shallow, flooded areas. The fish reached to its sexual maturity at about two years in males and three years in females. The spawning season generally starts in the monsoon period, from May to August, when water temperature and current are favorable for spawning (Rahman 2005 and 1989) (Table 4). The reproductive organs both in males and females have paired gonads which is located internally within the body cavity and next to the stomach. It is attached to the dorsal air bladder by thin mesenteries (Breder and Rosen 1966). It is a gonochoristic species, meaning individuals have separate sexes. The appearance of the ovaries changes significantly during the course of the year (Table 5). They are small, ribbon-like, colorless or faintly pink, and translucent during the immature stage (January–March). They grow considerably larger and

opaque as they develop (April–June), which is taking up a sizable amount of the body cavity. Sperm is produced in the lobules that make up the testes. The vaginal hole is reached by the primary duct system into which these lobules exit. The central channel fills with sperm during spawning (Bhowmick et al. 1987). The absolute fecundity was measured from minimum 1,564,875 to maximum 3,630,708 in Bangladesh (Rahman 1989).

Genetics

Threats

In Bangladesh it is classified as least concerned fish which means widely distribution of this species. But due to hybridization, inbreeding, overexploitation and lack of sustainability, *L. catla* populations are declining at an alarming rate (Rahi and Shan 2012). Several changes in ecology, such as habitat degradation, water pollution, improper culture technique, use of antibiotics, fragmentation, and the destruction of natural spawning areas, have significantly impacted their ability to survive reproduce (Sultana et al. 2015). These fish are struggling to adapt to the rapid environmental changes in their natural habitat, putting their populations at risk. The conservation efforts are urgently needed to protect this species from further decline and become threatened.

Table 4. Spawning season of Labeo catla from different waterbodies

Region	Spawning season	References
Pakistan	Jun-Sep	Talwar and Jhingran (1991)
North India	Jun-Aug	Talwar and Jhingran (1991)
Northeastern India	May-Aug	Talwar and Jhingran (1991)
Bangladesh	June-July	Rahman (1989)

Table 5. Age-Related Ovarian Changes in Labeo catla (Lone et al. 2012)

Age (Months)	Gross Morphology	Histological Characteristics	Developmental Stage
18–20 months	Ovaries are small, thin, translucent with lower weight and limitation of blood supply.	Mostly oogonia and chromatin-nucleolus stage oocytes are found; a few early peri nucleolus oocytes.	Early immature / pre-pubertal
21–23 months	Ovaries are slightly enlarged, yellowish; vascularization increases.	Increased the number of peri nucleolus oocytes, the appearance of cortical alveoli stage oocytes is found.	Developing stage
24–26 months	Visibly large ovaries with more yellow appearance; weight and fullness are increased.	Abundant cortical alveoli oocytes, the first appearance of vitellogenic oocytes (early vitellogenesis) occurred.	Early vitellogenic / maturing
27–29 months	Large ovaries with turgid, deep yellow-orange appearance, have high ovarian somatic index (OSI).	Dominated by vitellogenic and late vitellogenic oocytes, larger yolk granules with fewer immature oocytes.	Mature / late vitellogenic stage

The diploid chromosome number (*2n*) for the fish species *L. catla* in India is consistently reported as 50 chromosomes (NBFGR 1998; Klinkhardt et al. 1995; Khuda-Bukhsh et al. 1994). There are no significant differences found in the previous studies. It shows karyotipic stability where the population is genetically stable in terms of chromosome structure and number.

Conservation status

Due to habitat degradation, in Bangladesh it is classified as least concerned fish (IUCN Bangladesh 2015). It is a conservation designation given to numerous, widely distributed species that are not in danger of going extinct (Molur and Walker 1998). In recent time it is listed as not endangered worldwide (IUCN 2025).

Impact of Climate and Environmental Change

The Indian big carps, *L. catla*, *L. rohita*, and *C. mrigala*, are the main focus of inland aquaculture, and they breed during the monsoon season (June to July) and lasts until September. It is now feasible to breed IMC twice a year due to the occurrence of their developing and spawning as early March. One of the key elements affecting fish reproduction is temperature. This environmental factor stimulates the IMC's endocrine glands, which aid in the

gonads' maturity, coupled with rainfall and photoperiod. India's climate has changed noticeably in recent years. Over the past 60 years, West Bengal's average temperature has increased (Dey et al 2007). The temperature of the water has a significant impact on animals with cold blood.

Fish physiology, distribution, and behavior have long been known to be influenced by temperature Food intake, metabolism, and nutritional efficiency are all physiological processes that are directly impacted by temperature Fish immune responses can be altered and the emergence of infectious illnesses can be influenced by temperatures that are either below or over the thermal limit. Therefore, in order to establish a species' culture technique, a fundamental understanding of its thermal physiology is most important. Additionally, given the current situation, it is crucial to evaluate the biological effects of several thermal events, including overwinters, El Niñoo, La Nincéa, and climate change (Sharma et al 2016). Fish raised in a protected habitat can use excess energy for faster development, early spawning and maturity, higher survival rates, enhanced resistance to illness, and improved tolerance to high temperatures (Riaz et al 2023).

Conservation action

To understand the current status of this widespread species, more research on population trends in the wild is required in addition to investigating its taxonomy, ecology, harvest, and potential threats. This species is present in several protected areas and is extensively distributed throughout its range (IUCN and UNEP-WCMC 2019). Induced breeding program could also be recognized as conservation program.

Conservation recommendation

The conservation of *L. catla* depends on protection and preservation of its natural riverine and floodplain habitats, which are being degraded by pollution, fragmentation, siltation, and man-made activities. To restore these habitats maintenance of good water quality, establishment of sanctuary, protection of spawning grounds during the monsoon, enforcing closed seasons, sustainable aquaculture practices, and preventing fishing in nursery areas help ensure successful reproduction are mandatory (FAO 2009)

Sustainable fishing practices, such as using proper mesh sizes and banning destructive gears, are important to prevent overharvesting, habitat degradation, exploitation. Stock enhancement through the release of healthy, genetically diverse fingerlings can strengthen wild populations. To maintain pure broodstock in hatcheries, supports genetic conservation. Sustainable aquaculture practices and management also reduce the pressure on natural stocks. Community involvement in social awareness programs and alternative livelihoods encourage responsible fishing. Proper research and monitoring of *L. catla* populations and habitats are essential to guide future conservation actions and ensure the long-term survival of the species (Halwart and Gupta 2004).

In connection to the Sustainable Development Goals (SDGs)

The conservation of the threatened fish species *L. catla* in Bangladesh can be aligned with several Sustainable Development Goals (SDGs). These goals include Decent Work and Economic Growth (SDG 8) life below water (SDG 14), life on land (SDG 15), no poverty (SDG 1), zero hunger (SDG 2), Good health and well-being (SDG 3), and responsible consumption and production (SDG 12). Conservation techniques can support sustainable fishing methods, preserve biodiversity, and protect freshwater environments. By putting these strategies into practice, *L. catla* conservation can support more general objectives of sustainability, economic stability, and food security in Bangladesh, encouraging a comprehensive approach to social and environmental welfare.

Conflict of Interest

There is no competing interest that might influence the research work.

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