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Threatened fishes of world *Lepidocephalichthys annandalei* (Chaudhuri, 1912): Recommendations for Sustainable Conservation

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ABSTRACT

The Annandale loach (*Lepidocephalichthys annandalei* Chaudhuri, 1912) is a small indigenous freshwater fish distributed across Bangladesh, India, and Nepal. Although listed as "Least Concern" globally, recent regional assessments indicate population declines due to habitat degradation, siltation, and pollution. This study synthesizes current knowledge of its taxonomy, distribution, ecology, and genetics to reassess its conservation status. Morphometric and molecular data reveal low genetic diversity and population fragmentation, suggesting ecological vulnerability. The species exhibits benthic feeding and isometric growth, maintaining stable physiological condition in natural habitats. Conservation recommendations include habitat restoration, pollution control, regulated fishing, and integration into national small indigenous fish species (SIFS) programs. Community participation and genetic monitoring are also emphasized. Protecting *L. annandalei* aligns with UN Sustainable Development Goal 14 (Life Below Water) and supports sustainable freshwater biodiversity management in South Asia.

Introduction

The Annandale loach (*Lepidocephalichthys annandalei* Chaudhuri, 1912), a small indigenous freshwater fish species (SIFS) in the family Cobitidae of the order Cypriniformes, is known in Bangladesh as Duifota Puiya or Dui fota gutum. It can be found in India, Bangladesh, and the adjacent hill-stream regions. It frequently inhabits streams with clear, sandy bottoms, floodplain oxbows, and rivers (Rahman 1989 and 2005). FishBase (2025) states that the species is distinguished morphologically by irregular brown blotches along the lateral line, an inferior mouth with three pairs of barbels, and a prominent black patch at the caudal base. *L. annandalei* is a benthic species that has a role as prey in freshwater food webs and contributes to sediment turnover, while not being a prominent fisheries species (Talwar and Jhingran 1991). Furthermore, because of its sensitivity to habitat, it may be a bio-indicator of the integrity of freshwater ecosystems (Samad 2023). Regional surveys in Bangladesh indicate that the species is becoming less common, even though the IUCN has designated it as a "Least Concern" species worldwide (Freyhof and Kottelat 2008). *L. annandalei* was identified as one of the least common loaches in a year-long survey conducted in the districts of Sylhet, Netrokona, Dinajpur, and Mymensingh

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(Hossain et al. 2015). According to Parvez et al. (2015), population surveys conducted in southwestern Bangladesh from rivers and oxbow lakes show notable morphological variation as well as indications of local population reduction.

It's decrease seems to be related to habitat degradation, which jeopardizes its preferred sandy, clear-water habitats and includes siltation, stream modification, agricultural runoff, and wetland conversion (Rahman 2005). Anthropogenic pollution and flow changes worsen habitat fragmentation, which lowers population connectivity (Parvez et al. 2015). Distribution, morphological variety, and taxonomic traits have all been studied (Table 1), but its reproductive biology, population dynamics, and conservation requirements have not been thoroughly examined. The creation of successful conservation policy is severely hampered by this disparity.

Therefore, this study aims to synthesize current knowledge *of L. annandalei*, reassess its conservation status, identify major threats, and recommend sustainable strategies for its protection. By consolidating existing data and emphasizing management approaches, this work provides a foundation for evidence-based conservation planning for *L. annandalei* in Bangladesh and beyond.

Table 1. Available studies on *Lepidocephalichthys annandalei* from different countries

Country	Aspects Studied	References
Bangladesh	Intraspecific morphological variations and population status in rivers and floodplains	Samad et al. (2023)
India	Morphometric dimensions of three *Lepidocephalichthys* species (including *L. annandalei*) from rivers in Arunachal Pradesh	Kumar et al. (2016)
Sri Lanka and Peninsular India	Phylogeny, colonization history, and unexpected species diversity within the genus *Lepidocephalichthys* (including *L. annandalei*)	Sudasinghe et al. (2023)
Thailand, Laos, Vietnam, and Myanmar	A revision of *Lepidocephalichthys* (Teleostei: Cobitidae) with descriptions of two new species	Havird and Page (2010)
Bangladesh	Biodiversity status of freshwater loaches; rarity of *L. annandalei* in hill-streams	Akand et al. (2014)
Bangladesh (Surma River)	Length-weight relationships (LWRs) of four loach species including *L. annandalei*	Nasren et al. (2023)

Common Name

L. annandalei, a freshwater loach belonging to the Cobitidae family, is known by a wide range of regionally specific common names, reflecting its broad distribution and cultural significance. In South Asia, particularly in India, it is referred to as Pillai loach and Tilak loach, while in Assam and Bangladesh, it is called Gutum or Puiya in Assamese and Bengali (FishBase 2025). In English-speaking contexts, it is generally known as the Annandale loach or simply loach in Bangladesh (Practical Fishkeeping, 2025). Across Europe, the species has several local names, including Sekavec Annandaleho, Sekavec asamský, and Sekavec cipatý in Czech, Annandale`i soomuspeahink in Estonian, and Assamninuoliainen and Pyrstösilmänuoliainen in Finnish (FishBase 2025). In China, it is recognized by various Mandarin Chinese names, such as Fork-tailed scaled loach (FishBase 2025).

Taxonomy

Kingdom: Animalia

Phylum: Chordata

Order: Cypriniformes

Family: Cobitidae

Genus: *Lepidocephalichthys* (Bleeker, 1863)

Species: *L. annandalei* (Chaudhuri 1912)

Identification

L annandalei is a small cobitid loach, typically attaining a total length of less than 9 cm (Samad 2023). The body is elongate and cylindrical, slightly compressed towards the caudal region, with an inferior mouth bearing three pairs of barbels: one maxillary and two rostral (Rana and Gupta 2017). The head is covered with minute or embedded scales, and the suborbital spine is present but lacks hooked tips (Havird and Page 2010). A distinctive diagnostic feature is the caudal fin, which is truncate to slightly

emarginate and usually marked with one or more dark, centrally located spots that may be surrounded by a pale margin; this character differentiates *L. annandalei* from congeners such as *L. guntea*, which display caudal peduncle spots instead (Havird and Page 2010). The dorsal fin commonly exhibits transverse bands, while the body is patterned with irregular blotches that vary among populations (Samad 2023). Sexual dimorphism is evident in males through the modification of the seventh to eighth pectoral-fin rays into a lamina circularis, a secondary sexual character diagnostic of the genus (Havird and Page 2010). Meristic features reported for the species include 7–8 pectoral rays and variable scale counts depending on geographic population (Samad 2023; Rana and Gupta 2017). Due to its considerable intraspecific variation, accurate identification requires the combined assessment of external morphology, barbel arrangement, caudal fin pigmentation, and meristic counts, as emphasized in regional taxonomic appraisals (Havird and Page 2010; Rana and Gupta 2017; Samad 2023). The available fin formulae are-

D II,7; P 7–8; V 7; A II,5; C 16–18 (Chaudhuri 1912)

D i,6–7; V i,6; A ii,5; Squ. 28 (Talwar and Jhingran 1991)

D. 8 (1/7); P1. 8; P2. 6–7; A.7 (2/5) (Haque et al., 2025)

Distribution and abundance

L. annandalei is widely distributed across the Ganges–Brahmaputra River system, with confirmed occurrences in India (Assam and northeastern regions), Bangladesh, and Nepal (FishBase, 2025; Havird and Page, 2010; Rana and Gupta, 2017). FishBase (2024) also recognizes this species within these drainages and lists it as native to South Asia. Within Bangladesh, Samad (2023) reported its presence in several freshwater ecosystems, including the Nabaganga River, Bhairab River, and *Dhakuria Beel*, demonstrating its persistence across riverine and floodplain habitats.

In India, *L. annandalei* has been documented from the Brahmaputra basin and associated hill streams, where it co-occurs with other small benthic loaches (Rana and Gupta 2017). Studies in Nepal have similarly recorded this species in tributaries of the Koshi and Gandaki systems, although records remain relatively scarce compared to its presence in Bangladesh (Havird and Page 2010).

Abundance data suggest that populations of *L. annandalei* are generally patchy and locally uncommon Samad (2023) observed low catch per unit effort in Bangladesh, with significant morphological variation among populations, suggesting fragmented distribution and potential vulnerability to localized pressures. Rana and Gupta (2017) also noted that *Lepidocephalichthys* species are often restricted to microhabitats with sandy or muddy substrates and occur in low densities compared to more common loaches such as *L. guntea*. Globally, the species has been assessed as Least Concern (IUCN 2015; FishBase 2024) because of its broad distribution; however, more recent regional surveys caution that habitat degradation, siltation, and water pollution may be reducing local abundances (Samad 2023; Hossain et al. 2015).

Habitat and ecology

L. annandalei inhabits freshwater systems within the Ganges–Brahmaputra drainage, including rivers, streams, and floodplain wetlands (Havird and Page 2010; Rana and Gupta, 2017) (Table 2). In Bangladesh, the species has been recorded from the Nabaganga River, Bhairab River, and *Dhakuria Beel*, where individuals were collected from shallow water zones with fine sediments and marginal vegetation (Samad 2023). In northeastern India, it has been observed in small hill streams and tributaries of the Brahmaputra basin, typically occurring in habitats with sandy or muddy substrates (Rana and Gupta 2017). Records from Nepal also confirm its presence in tributaries of the Koshi and Gandaki river systems, although abundance appears to be lower than in Bangladesh (Havird and Page 2010).

Table 2. Ecosystems where *Lepidocephalichthys annandalei* occurs (Fishbase, 2025)

Ecosystem	Type	Status
Oriental	Zoogeographic realm	endemic
Brahmaputra	River (basin)	native
Ganges	River (basin)	native

Population-level observations indicate that *L. annandalei* occurs in low densities across much of its range. Samad (2023) noted that the species was captured in small numbers at multiple sites in Bangladesh, with distinct morphological variation between populations, suggesting some degree of ecological adaptation to local environmental conditions. Rana and Gupta (2017) similarly described the species as uncommon in survey collections from northeastern India. These findings suggest that while *L. annandalei* is geographically widespread, it tends to occur in scattered populations within specific freshwater microhabitats, and its abundance is highly variable across sites.

Impact of Environment and Climate Change

Environmental change and climate variability strongly influence the habitat suitability and population stability of *L. annandalei*. Altered monsoon rainfall patterns and river flow regimes affect sediment dynamics and floodplain connectivity, which are essential for this benthic, substrate-dependent species (Rahman 2005; Akand et al. 2015). Increased siltation resulting from upstream deforestation, hill-stream erosion, and unplanned land use degrades sandy and muddy habitats used for feeding and shelter (Rahman et al. 2019; Samad 2023). Rising water temperatures and reduced dissolved oxygen levels associated with climate change may impose physiological stress, particularly in shallow wetlands and slow-flowing streams (Rahman et al. 2019). Agricultural runoff and domestic pollution further deteriorate water quality and reduce benthic prey availability (IUCN Bangladesh 2015; Akand et al. 2015). Collectively, these environmental and climate-related pressures may intensify habitat fragmentation and contribute to localized population declines without integrated freshwater ecosystem management.

Food and feeding habits

According to FishBase, the species is a benthic feeder that forages within soft sediments, sifting substrate to extract small food particles (FishBase 2024). Rana and Gupta (2017) noted that specimens were collected from sandy and muddy stream bottoms in northeastern India, habitats where benthic micro invertebrates and detritus are abundant, suggesting its feeding is closely tied to substrate composition. Samad (2023), in a study on populations from southwestern Bangladesh, confirmed that individuals were mostly found in floodplain *beels* and rivers with fine sediments, indirectly supporting a benthic foraging mode. Havird and Page (2010) also described its occurrence in shallow, soft-bottomed habitats, consistent with bottom-feeding behavior.

Growth and Morphometric Characteristics

L. annandalei is a small cobitid loach exhibiting notable intraspecific variation in body size and shape. Havird and Page (2010) reported adult body lengths typically ranging from 40–60 mm standard length (SL), while Samad (2023) observed morphological variation across populations collected from rivers and *beels* in southwestern Bangladesh (Table 3). These findings suggest that growth in *L. annandalei* is influenced by local environmental factors such as substrate type, water quality, and habitat structure. Similarly, Rana and Gupta (2017) characterized the species as relatively small-sized and uncommon in Indian collections, reinforcing its status as a small indigenous species (SIFS) with modest growth potential relative to other freshwater fishes in the region.

Table 3. Based on morphometric assessments, adult *Lepidocephalichthys annandalei* exhibit the following characteristics (Havird and Page, 2010)

Species	Min adult SL (mm)	Average adult SL (mm)	Max adult SL (mm)	Male pectoral-fin length/SL	Female pectoral-fin length/SL	*p*-value
L. annandalei	24.4	33.9	42.9	17.0 ± 1.6 (*n*=15)	15.5 ± 1.3 (*n*=15)	0.008

Nasren et al. (2023) conducted a detailed assessment of length–weight relationships (LWRs) and growth patterns for four cobitid loaches, including *L. annandalei*, inhabiting the Surma River, Bangladesh, between November 2022 and April 2023. Sampling was conducted at 15-day intervals, yielding a total of 376 individuals, of which 59 specimens were identified as *L. annandalei* (23 males and 36 females). Total lengths ranged from 6.8 cm to 9.0 cm, and corresponding body weights ranged from 2.1 g to 5.8 g (Nasren et al. 2023).

The length–weight relationship was modeled using the allometric growth equation, $W = aL^b$, where, W represents the body weight (g), L denotes the total length (cm), a is a constant related to the condition factor, and b is the regression coefficient indicating the type of growth. For *L. annandalei*, the estimated parameters were a = 0.006 (95% CI: 0.004–0.008) and b = 3.073 (95% CI: 2.957–3.190). The value of *b*, being close to 3.0, indicates isometric growth, meaning that body weight increases proportionally to the cube of body length and the fish maintains a consistent body shape as it grows (Nasren et al. 2023).

Physiological condition indices further support these findings. The condition factor (K) ranged from 0.725 to 0.734, and the relative condition factor (K_n) averaged 1.008, suggesting that *L. annandalei* populations in the Surma River experience minimal nutritional or habitat-related stress and maintain stable environmental adaptability (Nasren et al. 2023). In comparison, other cobitid species in the study, such as *L. guntea* and *L. berdmorei*, exhibited positive allometric growth ($b > 3$), highlighting the stability of growth patterns in *L. annandalei* (Nasren et al. 2023).

Therefore, these integrated observations provide valuable quantitative insights into the growth dynamics of *L. annandalei*, confirming its small size, ecological adaptability, and healthy growth performance in natural habitats. The findings from Havird and Page (2010), Samad (2023), Rana and Gupta (2017), and Nasren et al. (2023) collectively establish a robust baseline for future ecological and fisheries management studies of small indigenous loach species in Bangladesh.

Genetics

Molecular identification of *L. annandalei* was conducted using mitochondrial cytochrome oxidase subunit 1 (COI, 650 bp) and nuclear recombination activating gene 1 (RAG1, 800 bp), which are widely applied in fish taxonomy and phylogenetics (Haque et al., 2025). Nucleotide composition analysis of the COI gene revealed T = 29.9 ± 1.15%, A = 24.5 ± 0.91%, C = 28.2 ± 1.21%, G = 17.4 ± 0.67%, with A+T content of 54.4% and G+C content of 45.6%. RAG1 exhibited A+T and G+C contents of 49.2% and 50.8%, respectively. Sequences of *L. annandalei* have been submitted to GenBank (COI: OR567160–OR567165, MZ606660, PQ243106–PQ243110; RAG1: PQ409353, PQ409354, PQ282203, PQ282204, PQ282207–PQ282221) (Haque et al., 2025).

Genetic diversity analyses indicated low intraspecific variation within *L. annandalei* but substantial divergence from related species. Phylogenetic reconstruction based on COI and RAG1 genes confirmed that *L. annandalei* forms a distinct monophyletic clade, and species delimitation using ASAP supported separation at a COI divergence threshold of 2.52%, highlighting its genetic distinction from closely related species such as *L. guntea* (Haque et al. 2025).

Haplotype network analysis revealed that *L. annandalei* possesses multiple haplotypes, although intraspecific diversity and gene flow are lower compared to species of least concern, indicating potential vulnerability. These molecular insights provide a robust framework for species delimitation and support conservation planning for this freshwater loach (Haque et al. 2025).

Conservation Status

L. annandalei is classified as a species of Least Concern (LC) worldwide by the IUCN Red List (FishBase 2024). Nonetheless, a number of regional evaluations show that the species is becoming less common in several areas of its natural range. According to reports, *L. annandalei* is extremely uncommon or seldom seen in inland water and hill-stream ecosystems in Bangladesh, indicating a localized drop in population (Akand et al. 2015; Samad 2023). The species' limited presence in comparison to other sympatric loaches is reflected in the survey on loach diversity conducted in a few hill-streams in southeast Bangladesh (Akand et al. 2015). Additionally, in southwestern Bangladesh, a recent study on intraspecific morphological variation found that populations from different environments had different morphometric characteristics, which may indicate ecological stress and population fragmentation (Samad, 2023). *L. annandalei* was previously listed by IUCN Bangladesh (2000) as "Not Threatened," but more recent ecological findings suggest that habitat degradation, anthropogenic disturbances, and deteriorating water quality may be affecting its abundance (IUCN Bangladesh 2000; Samad 2023). However, regional data from Bangladesh indicates that *L. annandalei* may merit national conservation

attention and population reassessment because of its apparent habitat-specific vulnerability, even if the species is still listed as Least Concern internationally.

Threats

L. annandalei is thought to be experiencing population declines over much of its natural range, especially in Bangladesh, India, and Myanmar. Despite the lack of quantitative data on population trends, field observations show that local abundance has significantly decreased over the past 20 years (Akand Hossain, and Islam 2015; Samad 2023). The main dangers are habitat loss, hill-stream siltation, agricultural conversion of wetlands, and anthropogenic pollution-induced deterioration of water quality (Akand et al. 2015; IUCN Bangladesh 2000). Furthermore, indiscriminate fishing and overexploitation worsen population pressure on this small-bodied species, especially during the breeding season (Samad 2023). In inland water bodies in southeastern Bangladesh, morphological variation studies also point to environmental stress and habitat fragmentation as key causes of population isolation and decreased genetic exchange (Samad 2023). If left unchecked, the combined effects of habitat loss, water pollution, sedimentation, and small-individual capture are probably to blame for the ongoing fall in *L. annandalei* populations, which could lead to local extinction in some places. For this species to survive for a long time in Bangladesh and the surrounding areas, certain conservation efforts are therefore desperately needed. These actions include habitat restoration, agricultural runoff reduction, and fishing prohibitions during spawning seasons.

Conservation Action

Bangladesh has classified *L. annandalei* as Vulnerable because of the species' sharp population reduction and habitat degradation brought on by overfishing, pollution, and sedimentation (IUCN Bangladesh 2015; Haque et al. 2025). In order to preserve ecological balance and effectively conserve this species, habitat restoration measures such as riparian vegetation recovery, pollution management, and sand extraction limitation are necessary (Rahman et al. 2019). According to Islam et al. (2020), community-based management and awareness initiatives are crucial for encouraging sustainable fishing methods and boosting local involvement in biodiversity conservation. Programs for captive breeding and stock augmentation can lessen the exploitation of natural habitats while promoting population recovery (DoF 2022). Coordination of conservation activities throughout Bangladesh would be strengthened if *L. annandalei* were added to the National Small Indigenous Fish Species (SIFS) Conservation Program (FRSS 2023). For long-term population management, genetic monitoring and the integration of molecular data are essential due to its low genetic diversity (Haque et al. 2025). Sustainable freshwater biodiversity conservation in Bangladesh will be aided by these initiatives' alignment with SDG 14 (Life Below Water) (United Nations 2015).

Recommendations for Conservation

A habitat-centered and research-driven strategy should be the top priority for *L. annandalei* conservation. First, to ascertain population structure, recruitment, and possible decrease trends, systematic population and stock assessments are necessary (Samad, 2023). Because slow-moving rivers, *beels*, and hill streams are particularly vulnerable to siltation, pollution, and agricultural conversion, it is imperative that these natural ecosystems be protected (Akand et al. 2015). To establish the biological foundation for future captive propagation and management, more research on reproductive biology, life-history features, and seasonal breeding cycles should be conducted (Havird and Page 2010; Samad 2023). Frequent monitoring procedures at previously documented locations would help direct adaptive management and enable early detection of population changes. Lastly, conservation results will be strengthened by implementing habitat preservation laws and involving local communities in tiny indigenous fish conservation awareness campaigns. Together, these actions support the sustainable management of *L. annandalei* in Bangladesh and nearby freshwater systems in South Asia and are in line with regional biodiversity goals.

In Connection with the Sustainable Development Goals (SDGs)

L. annandalei conservation supports sustainable management of freshwater biodiversity, which is in line with a number of Sustainable Development Goals (SDGs) of the UN, including SDG 14 (Life Below Water). Additionally, it supports SDGs 1 (No Poverty) and 2 (Zero Hunger), since small indigenous species like *L. annandalei* help rural communities' livelihoods and ensure food security (Akand et al. 2015; DoF

2022). Additionally, SDG 17 (Partnerships for the Goals) is fostered by cooperative management among local communities, researchers, and policymakers, while SDG 12 (Responsible Consumption and Production) is advanced by sustainable aquaculture, habitat restoration, and ethical harvesting practices (IUCN Bangladesh 2000). Conservation of *L. annandalei* can therefore be incorporated into national fisheries management to improve ecological and economic sustainability while also improving biodiversity protection.

Conflict of Interest

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

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