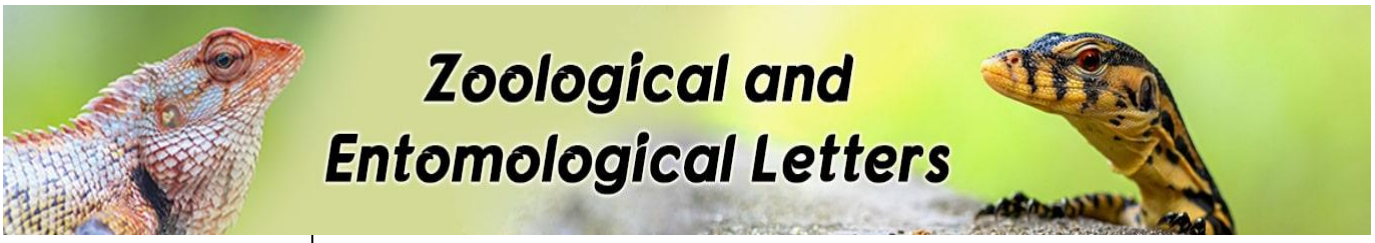

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Economic importance, ecological significance, and distribution of *Puntius* fish species in major rivers of the Kolodyne drainage system, Mizoram, North-Eastern India

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Abstract
The freshwater fish genus *Puntius* (Family: Cyprinidae) plays a crucial ecological and economic role in riverine systems across South and Southeast Asia. In Mizoram, part of the Indo-Burma biodiversity hotspot, rivers within the Kolodyne drainage system provide suitable habitats for *Puntius* species. This study focuses on two species *Puntius sophore* and *Puntius chola* documenting their distribution across four major rivers: Kolodyne, Tuisi, Ngengpui, and Tuichang. Based on field surveys conducted in 2024, *P. sophore* was recorded in three of the rivers, while *P. chola* was found only in the Ngengpui River. Both species are listed as Least Concern (LC) by the IUCN but face local threats due to habitat degradation and overfishing. Their role in maintaining aquatic food webs, supporting small-scale fisheries, and serving as bioindicators underscores their significance. This paper highlights the need for improved conservation measures, sustainable management, and ecological monitoring to preserve the integrity of freshwater systems in Mizoram.

Keywords: Puntius sophore, Puntius chola, Kolodyne drainage, Mizoram, freshwater ecology, bioindicator species

1. Introduction
The genus *Puntius* encompasses a diverse assemblage of small to medium-sized freshwater fishes belonging to the family Cyprinidae, the largest and most ecologically varied family of freshwater fishes worldwide [1]. Commonly referred to as barbs, species within this genus are broadly distributed across the South and Southeast Asian region, with a prominent presence in countries such as India, Nepal, Bangladesh, Sri Lanka, Myanmar, and Thailand [2]. They inhabit a wide range of freshwater environments, from clear hill streams to lowland rivers and floodplains, contributing significantly to the ichthyofaunal richness of the region [3].
Historically, the genus *Puntius* functioned as a broad taxonomic category that grouped together a large number of superficially similar small barbine fishes [4]. However, with the advent of modern molecular techniques and detailed morphological analyses, ichthyologists have uncovered substantial genetic and structural diversity within what was previously thought to be a single, cohesive genus [5]. Over the past two decades, these scientific advancements have led to a major taxonomic revision. Many species that were once classified under *Puntius* have now been redistributed into more narrowly defined and phylogenetically accurate genera such as *Pethia*, *Systomus*, *Dawkinsia*, *Desmopuntius*, and *Dravidia* [5]. This reclassification has helped clarify evolutionary relationships among these species and improve the precision of ecological and conservation assessments.
Despite the reduction in the number of species currently retained within *Puntius*, the genus continues to hold significant ecological, economic, and conservation value [6]. Species within *Puntius* often serve as important primary consumers in aquatic food webs, contribute to nutrient cycling, and are key prey species for a variety of aquatic predators [7]. Economically, they are harvested in small-scale fisheries, and some species are valued in the ornamental fish trade due to their attractive coloration and peaceful nature [8]. Ecologically, *Puntius* species are considered bioindicators of freshwater health, as they are sensitive to changes in water quality and habitat conditions [9, 10].

Given their wide distribution and ecological roles, *Puntius* species are essential components of freshwater ecosystems throughout Asia [11]. However, they face increasing threats from habitat degradation, pollution, overexploitation, and climate change factors that necessitate focused research, habitat conservation, and sustainable management practices to ensure their continued survival and ecological function [10, 12].

Freshwater ecosystems, though covering less than 1% of the Earth's surface, support more than 40% of the world's fish species [10, 13]. The north-eastern region of India, particularly Mizoram, falls within the Indo-Burma biodiversity hotspot a region celebrated for its high levels of endemism and species richness [14, 15]. One of the largest and ecologically significant river systems in Mizoram is the Kolodyne drainage, which sustains a rich array of fish diversity, much of which remains poorly documented and understudied.

Among the freshwater species in this region, the genus *Puntius* is particularly prominent. It plays a crucial role in maintaining ecological balance and supports the livelihoods of riparian communities**.** Two species *Puntius sophore* and *Puntius chola* are especially prevalent across tropical Asia and are frequently encountered in Mizoram's rivers. While both are categorized as Least Concern (LC) on the IUCN Red List, their ecological significance and socio-economic importance necessitate focused scientific attention, especially in light of increasing local environmental pressures.

This study aims to investigate the distribution patterns of *P. sophore* and *P. chola* within four major rivers of the Kolodyne drainage system namely, the Kolodyne, Tuisi, Ngengpui and Tuichang. The research further seeks to evaluate their ecological functions, such as their role in energy flow and habitat connectivity, along with their economic relevance to local communities dependent on freshwater resources in Mizoram.

2. Materials and Methods

2.1 Study Area

The Kolodyne River and its tributaries form the largest fluvial system in southern Mizoram, ultimately flowing into Myanmar. The rivers studied in this paper include: Kolodyne, Tuisi, Ngengpui and Tuichang rivers. These rivers exhibit a variety of habitats, from fast-flowing hill streams to more sluggish sections with deep pools. The surrounding areas are rich in forest cover, yet increasingly affected by agricultural encroachment, road construction, and human settlements in some study areas.

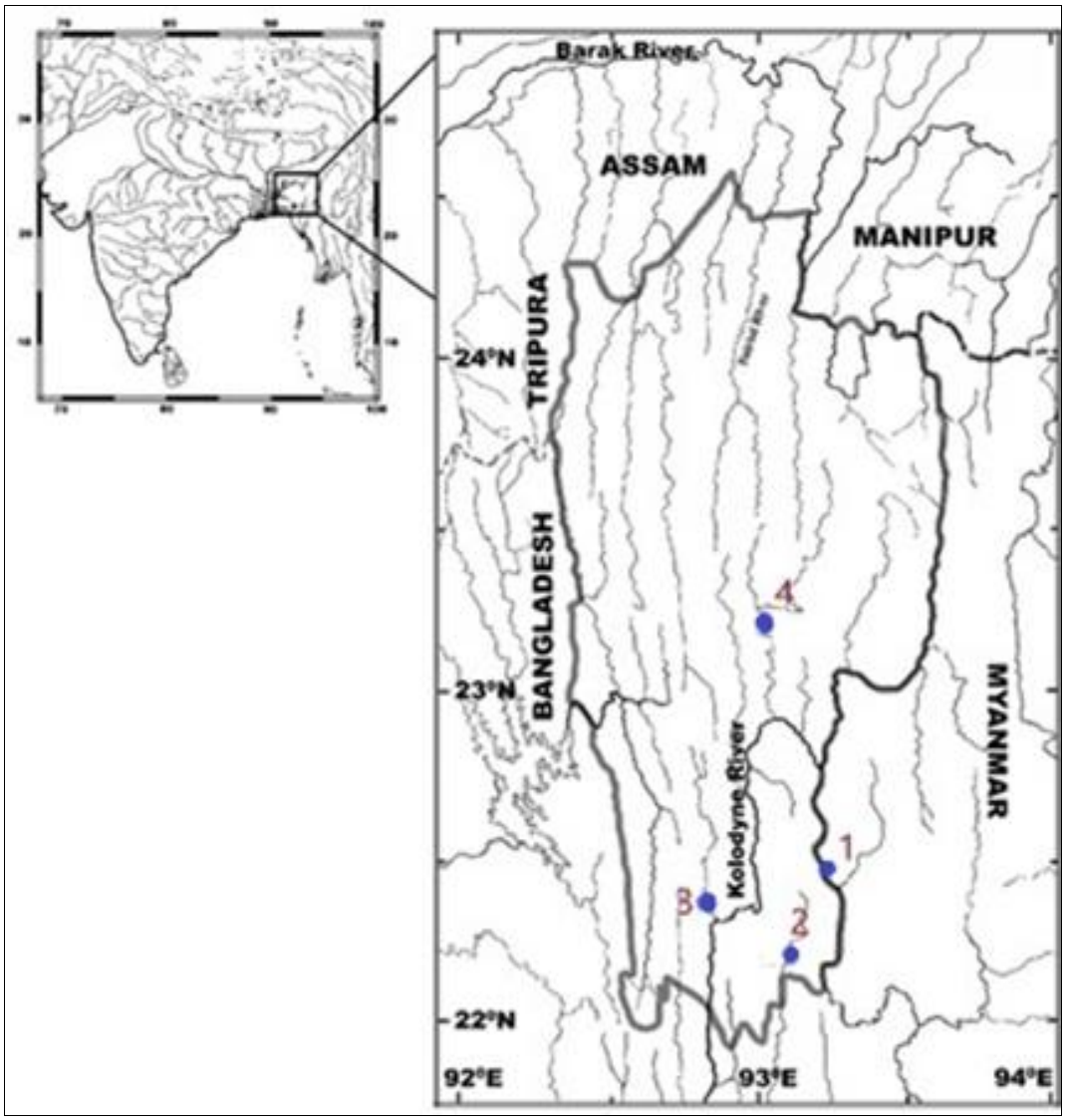

Fig 1: Map of Mizoram showing location of the following rivers: 1) Kolodyne, 2) Tuisi, 3) Ngengpui, & 4) Tuichang.

2.2 Fish Sampling and Identification

Field surveys were carried out between March and November 2024, covering pre-monsoon, monsoon, and post-monsoon periods. Sampling methods included: Cast nets, gill nets (varied mesh sizes), Scoop nets, traps for small-bodied species and electrocution. Fish were preserved in 10% formalin. Identification was performed using standard taxonomic keys (Jayaram, 2008; Talwar & Jhingran, 1991) [16, 17]. Confirmation of conservation status was based on the IUCN Red List (2025) [18].

3. Results and Discussion

Table 1: *Puntius* fish species distribution and conservation assessment from major rivers of Kolodyne drainage, Mizoram

Name of Fish	Kolodyne	Tuisi	Ngengpui	Tuichang	IUCN Status
Puntius sophore	+	+	-	+	LC
Puntius chola	-	-	+	-	LC

3.1 *Puntius sophore* (Olive Barb)

Puntius sophore, commonly known as the Olive Barb, is a small cyprinid fish species that is widely distributed across freshwater systems of the Indian subcontinent, including rivers, lakes, ponds, and irrigation canals. It is particularly resilient and capable of surviving in diverse aquatic environments, from slow-flowing rivers to stagnant or semi-stagnant water bodies.

- **Geographic Distribution:** In the present study, *P. sophore* was recorded in three major rivers of the Kolodyne drainage system in Mizoram namely the Kolodyne, Tuisi, and Tuichang Rivers highlighting its adaptability to various hydrological conditions and riverine habitats.
- **Preferred Habitat:** This species typically inhabits shallow, vegetated margins of rivers and streams where the water current is moderate to slow. It is frequently found among aquatic vegetation, submerged roots, and leaf litter, which provide shelter and foraging grounds. The availability of plant matter and organic debris makes such habitats ideal for its omnivorous feeding habits.
- **Morphological Features:** *P. sophore* is a small-sized fish, usually ranging from 6 to 10 cm in length. It has a compressed, silvery body with an olive-green hue along the dorsal surface. A characteristic dark lateral spot is often present behind the operculum (gill cover), which distinguishes it from other sympatric cyprinid species. It has a dark spot on the dorsal fin and another at the base of the caudal fin covering 21-23 scales.
- **Feeding Ecology:** The Olive Barb is omnivorous and exhibits opportunistic feeding behavior. Its diet comprises a variety of food items including detritus, algae, phytoplankton, zooplankton, insect larvae, and other organic matter. This flexible diet enables it to thrive in nutrient-rich as well as moderately oligotrophic waters. By consuming organic debris and planktonic organisms, *P. sophore* contributes significantly to nutrient recycling and energy transfer in aquatic ecosystems.

Fig 2: *Puntius sophore* (Olive Barb)

3.2 *Puntius chola* (Swamp Barb)

Puntius chola, commonly referred to as the Swamp Barb, is a visually distinctive cyprinid fish known for its vibrant coloration, particularly the reddish hue on its fins. It is commonly associated with lowland freshwater habitats and is a characteristic species of floodplain ecosystems in tropical South and Southeast Asia. This species is valued both ecologically and economically in many parts of the Indian subcontinent.

- **Geographic Distribution:** In the present investigation, *P. chola* was recorded exclusively in the Ngengpui River, a watercourse located within a forested and relatively undisturbed section of the Kolodyne drainage system in Mizoram. Its occurrence was noted more during the post-monsoon season, which may suggest seasonal habitat preference or migratory behavior linked to spawning or feeding patterns.
- **Preferred Habitat:** *P. chola* shows a marked preference for slow-flowing, slightly acidic waters commonly found in lowland streams, swamps, and floodplain habitats. Within the Ngengpui River, it was typically observed in shaded sections with abundant leaf litter, decaying vegetation, and submerged woody debris, which provide both camouflage from predators and a rich foraging ground. These microhabitats offer stable thermal conditions and a high density of invertebrates and detritus that is ideal for an omnivorous species like *P. chola*.
- **Morphological Features:** This species possesses a slender, elongated body measuring approximately 8 to 12 cm in adult individuals. The most distinguishing morphological trait is its reddish or orange-tinged fins, particularly prominent during the breeding season. One pair of maxillary barbel is present. The body is generally silvery with a light golden or brownish sheen, and some individuals may exhibit faint vertical bars or a lateral line stripe depending on age and environmental factors. Presence of distinct dark blotch in lateral line covering 21-23 scales.
- **Feeding Ecology:** *P. chola* is an omnivorous species with a diverse diet comprising insect larvae, algae, micro-crustaceans, and decomposing organic matter. It actively forages among submerged leaves and plant debris, consuming both animal and plant material. This broad dietary range allows the species to occupy a flexible trophic position and play a vital role in the detritus-based food web of freshwater ecosystems. By feeding on organic debris and small invertebrates, it helps in controlling aquatic insect populations and in nutrient recycling, thus maintaining the ecological balance of its habitat.

Fig 3: *Puntius chola* (Swamp Barb)

4. Ecological Significance

4.1 Trophic Role

Puntius sophore and *Puntius chola* serve critical functions within the trophic structure of freshwater ecosystems. These species occupy the lower to mid-levels of the aquatic food web, acting both as primary consumers and as important links in predator-prey dynamics.

- As primary consumers, they feed on a combination of algae, detritus, and plant matter, helping to regulate algal populations and facilitating the breakdown and recycling of organic material in riverine systems.
- Simultaneously, they act as an essential prey base for larger predatory species, including snakeheads (*Channa* sp.), catfishes, various aquatic birds, and reptiles such as water snakes and turtles. This dual role enhances the flow of energy from primary producers and detrital pools to higher trophic levels.

By contributing to nutrient cycling, sediment turnover, and energy transfer, both species support the ecological functioning and trophic stability of freshwater habitats, particularly within the biodiverse and Sensitive Rivers of the Kolodyne drainage system.

4.2 Role as bioindicators

Species within the genus *Puntius*, particularly *P. chola*, are known for their sensitivity to changes in environmental conditions, making them valuable indicators of water quality and habitat health.

- These fishes respond notably to parameters such as dissolved oxygen levels, pH, turbidity, and the presence of pollutants.
- Their survival and abundance are strongly associated with clean, well-oxygenated, and structurally complex microhabitats such as those with submerged logs, aquatic vegetation, and leaf litter.

A decline in *Puntius* populations or their disappearance from historically occupied habitats often signals ecological imbalance, such as eutrophication, sedimentation, or chemical contamination. Thus, regular monitoring of *P. sophore* and *P. chola* can serve as a cost-effective and biologically meaningful approach to assess riverine ecosystem integrity, especially in ecologically sensitive regions like Mizoram.

4.3 Reproductive Strategies

Both *P. sophore* and *P. chola* exhibit seasonal breeding patterns, typically spawning during the monsoon season (June to September) when water levels rise and the ecosystem becomes enriched with nutrients and spawning sites.

- The increase in water volume and temperature during this time provides optimal conditions for courtship, egg laying, and larval development.
- Spawning generally occurs in shallow, vegetated areas or floodplains, where the young can find abundant food and shelter.

Their reproductive success is intimately linked to the natural hydrological cycles of rivers. Consequently, anthropogenic alterations such as dam construction, water diversion, and channel modification can significantly disrupt these cycles, resulting in habitat fragmentation, loss of spawning grounds, and population decline.

Protecting the natural flow regimes of rivers and maintaining riparian habitats is therefore essential for sustaining the breeding cycles of these species and ensuring the long-term health of freshwater ecosystems.

5. Economic Importance

5.1 Source of Income and Livelihood Support

Both *Puntius sophore* and *Puntius chola* hold significant value in the subsistence fisheries of rural Mizoram. These species are frequently harvested by local communities using traditional gear such as cast nets, bamboo traps, and hand nets, particularly in the monsoon and post-monsoon seasons when fish are more abundant and active.

- Their nutritional value being rich in animal protein, essential fatty acids, vitamins, and micronutrients makes them an important dietary component for economically marginalized populations who have limited access to commercial protein sources.
- Beyond domestic consumption, these fishes are sold in local village markets and roadside stalls, particularly during festive or community events, where demand for fresh fish increases. Although they do not command high commercial prices, the cumulative income from selling small-bodied fish can provide supplementary livelihood support, especially for women and part-time fishers.

The role of these species in ensuring food security and nutritional adequacy in remote, underdeveloped areas underscores their socio-economic significance.

5.2 Ornamental Fish Trade

While not as widely recognized in the international aquarium trade as species like *Pethia conchonius* or *Danio rerio*, some *Puntius* species, particularly *P. sophore*, exhibit traits desirable in ornamental fish markets.

- The active swimming behaviour, hardiness, and modest coloration of juvenile *P. sophore* make it a suitable candidate for low-maintenance home aquaria.
- In certain districts of Mizoram, informal capture of these barbs for local ornamental trade has been noted, though it remains limited in scale and poorly documented.

With proper regulation, value addition (e.g., selective breeding for enhanced coloration), and training of local youth, *Puntius* species could be promoted as part of community-based ornamental fish farming, contributing to both conservation and income generation.

5.3 Aquaculture Potential

Given their ecological adaptability, fast growth, and

omnivorous feeding habits, species like *P. sophore* and *P. chola* exhibit considerable potential for inclusion in integrated aquaculture systems, especially in Mizoram's rural landscape.

- These fish can be easily cultured in small ponds, rice paddies, or backyard tanks, either in monoculture or in polyculture systems with other compatible species such as carps, tilapia, or catfish.
- Their feeding on naturally occurring plankton and detritus reduces dependence on expensive formulated feeds, making them cost-effective for low-input fish farming models.
- Additionally, their short life cycle and high reproductive rate enable rapid population turnover, which is advantageous for small-scale farmers seeking quick returns.

By promoting the culture of native barbs, Mizoram can enhance local aquaculture diversity, reduce pressure on wild stocks, and develop sustainable livelihood alternatives aligned with conservation goals.

6. Threats to *Puntius* Populations

Although both *Puntius sophore* and *Puntius chola* are currently listed as Least Concern (LC) by the IUCN due to their relatively wide geographic distribution, localized populations in Mizoram particularly within the Kolodyne drainage system are increasingly threatened by a combination of anthropogenic pressures and environmental changes. These threats are often subtle and cumulative, leading to gradual but significant declines in habitat quality and population viability.

6.1 Habitat Destruction

The degradation and fragmentation of aquatic habitats pose the most immediate threat to *Puntius* species in the region. Large-scale deforestation, often linked to shifting cultivation (jhum), and unregulated road construction in forested river catchments disturb riparian zones and increase sedimentation in rivers. Urban expansion near riverbanks has also resulted in the encroachment of natural floodplains and the loss of important microhabitats, such as submerged vegetation and leaf litter zones, which are critical for feeding and breeding.

6.2 Water Pollution

The rivers of Mizoram are increasingly subject to non-point source pollution, particularly from agricultural runoff containing pesticides and fertilizers, and untreated domestic wastewater from nearby settlements. These pollutants contribute to eutrophication, reduced dissolved oxygen levels, and altered pH values, conditions that can be lethal or suboptimal for sensitive species like *P. chola*. The contamination of spawning and nursery habitats further exacerbates population stress.

6.3 Hydrological Alterations and Climate Change

Climate change has introduced unpredictability in rainfall patterns, leading to erratic river flow regimes, extended dry seasons, and extreme flood events. These changes disrupt the natural seasonal cues essential for reproduction in *Puntius* species, which rely on monsoon-linked breeding cycles. In addition, proposed and ongoing hydropower projects and river diversion schemes within the Kolodyne basin threaten to alter natural flow regimes, fragment aquatic habitats, and reduce connectivity between populations.

6.4 Overfishing and Unsustainable Harvesting

While not traditionally targeted in large-scale commercial fisheries, *Puntius* species are subjected to intensive harvesting by local communities, especially during the monsoon breeding season when fish are more accessible. The use of fine-meshed nets, destructive fishing practices (such as the use of plant-based piscicides), and the lack of fishing regulations contribute to the depletion of juvenile and breeding individuals, undermining the regenerative capacity of natural populations.

These threats, though currently localized and moderate, have the potential to escalate if left unaddressed. Given the ecological importance and socio-economic value of *Puntius* species, it is imperative to implement targeted conservation strategies to safeguard their populations and preserve the ecological balance of freshwater systems in Mizoram.

7. Conservation and Management Recommendations

To ensure the long-term sustainability of *Puntius* species particularly *P. sophore* and *P. chola* within the Kolodyne River system of Mizoram, a comprehensive, multi-tiered conservation strategy is essential. This strategy should integrate habitat preservation, sustainable resource use, community participation, and scientific research. The following measures are recommended:

7.1. Habitat Protection

- Designation of Ecologically Sensitive Areas: Rivers such as Ngengpui and Tuichang, which still maintain relatively undisturbed habitats, should be declared as Ecologically Sensitive Zones (ESZs) or Community Conservation Areas (CCAs) to protect vital microhabitats essential for the feeding, breeding, and sheltering of *Puntius* species.
- Riparian Buffer Management: The protection and restoration of riparian vegetation along riverbanks is critical. Native plant species should be preserved or reintroduced to stabilize banks, reduce sedimentation, filter pollutants, and provide shade factors crucial for maintaining optimal water quality and aquatic biodiversity.

7.2 Sustainable Fishing Regulations

- Seasonal Fishing Bans: Implement a fishing moratorium during peak breeding seasons, particularly between June and August, to allow uninterrupted spawning and juvenile development. This aligns with the monsoon-induced reproductive cycles of both species.
- Promotion of Non-Destructive Fishing Methods: Local communities should be trained and encouraged to use selective, low-impact fishing techniques such as traditional traps and mesh-size regulations that avoid the capture of juveniles and non-target species. The use of harmful substances like plant toxins or fine-meshed nets should be strictly prohibited.

7.3 Community based conservation initiatives

- Awareness and Education Campaigns: Conduct grassroots outreach programs to sensitize local fishers

and youth on the ecological importance of small-bodied fish like *P. sophore* and *P. chola*. Visual guides, school programs, and local workshops can facilitate better understanding of freshwater ecology and responsible resource use.

- Alternative Livelihood Programs: Introduce income diversification strategies, such as eco-tourism, handicrafts, or small-scale aquaculture, to reduce dependency on riverine fisheries. Empowering local communities economically can foster greater stewardship of natural resources.

7.4 Research and Long-Term Monitoring

- Population Dynamics Studies: Support continuous, seasonally stratified monitoring of *Puntius* populations to understand trends in abundance, age structure, habitat preferences, and breeding success. Such data is critical for adaptive management under changing environmental conditions.
- Inclusion in Regional Conservation Priorities: Species like *P. chola*, which are often overlooked in mainstream conservation planning, should be integrated into state biodiversity strategies and freshwater ecosystem management frameworks to prevent unnoticed declines in local populations.

7.5 Promotion of indigenous aquaculture

- Sustainable Aquaculture Development: Encourage low-input aquaculture practices using *Puntius* species as a sustainable food source. These fish are naturally suited to small ponds, rice-fish systems, and backyard tanks, making them ideal candidates for decentralized, rural aquaculture models.
- Capacity Building and Technical Training: Provide technical training for rural farmers on breeding, hatchery management, water quality maintenance, and species compatibility in polyculture systems. This will enhance production efficiency while relieving harvest pressure on wild populations.

8. Conclusion

The study underscores the ecological and socio-economic importance of *Puntius sophore* and *Puntius chola* within the freshwater ecosystems of Mizoram's Kolodyne drainage. Despite being listed as Least Concern by the IUCN, these species face increasing pressures from habitat degradation, water pollution, overfishing and climate-induced hydrological changes especially in ecologically sensitive areas like Ngengpui and Tuichang rivers.

Their roles as primary consumers, nutrient recyclers, and prey species for higher trophic levels make them essential for sustaining riverine biodiversity and ecological balance. Furthermore, their contribution to subsistence fisheries and potential in aquaculture and ornamental trade add to their local economic relevance. As bioindicator species, their presence and abundance provide valuable insights into the health of freshwater habitats, making them integral to monitoring and conservation efforts.

Preserving the populations of *P. sophore* and *P. chola* requires a multifaceted approach combining habitat protection, community participation, sustainable fisheries management, and research-based monitoring. Promoting these native species through eco-friendly aquaculture and conservation education can help reduce pressure on wild populations while supporting rural livelihoods. Ultimately, safeguarding these small but significant cyprinids is crucial not only for biodiversity conservation in the Indo-Burma hotspot but also for maintaining the ecological integrity of Mizoram's unique and understudied freshwater systems.

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