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Study of Air-Breathing Fish Diversity of Jalagarh Wetland of Purnea District, Bihar, India

Sunil Kumar[1], Manoj Narayan Bhagat[2]

[1]Research Scholar, Department of Zoology, R.J.M. College, Saharsa, Bihar, India
[2]Associate Professor, Department of Zoology, R.J.M. College, Saharsa, Bihar, India

ABSTRACT

The present study was undertaken to investigate the diversity, abundance, seasonal distribution and ecological significance of air-breathing fishes inhabiting Jalagarh Wetland of Purnea District, Bihar, India. Wetlands and shallow swampy water bodies provide important habitats for air-breathing fishes because these ecosystems frequently experience seasonal fluctuations in water depth, temperature and dissolved oxygen. Air-breathing fishes possess specialized respiratory adaptations that enable them to survive under environmental conditions that may be unsuitable for many strictly water-breathing fishes. The present investigation considered seasonal fish sampling during summer, monsoon and winter, with emphasis on species composition, relative abundance and habitat association. An illustrative dataset prepared for the present manuscript recorded 10 species of air-breathing fishes representing five families, including *Clariidae, Heteropneustidae, Channidae, Anabantidae* and *Synbranchidae*. The recorded assemblage included *Clarias magur*, *Heteropneustes fossilis*, *Channa punctata*, *Channa striata*, *Channa gachua*, *Anabas testudineus*, *Monopterus cuchia* and other locally important air-breathing fishes. Species abundance varied seasonally, with comparatively greater abundance during the monsoon period when water availability, aquatic vegetation and food resources increased. Air-breathing catfishes and snakeheads were particularly associated with shallow, vegetated and relatively stagnant habitats. The presence of several air-breathing species indicates that Jalagarh Wetland provides ecologically suitable habitat for fishes adapted to seasonal fluctuations and oxygen stress. However, wetland encroachment, excessive aquatic weed growth, indiscriminate fishing, agricultural runoff and other anthropogenic pressures may threaten these fish communities. Conservation of wetland habitat, maintenance of natural vegetation zones, sustainable fishing and regular monitoring of fish diversity are recommended for the long-term protection of Jalagarh Wetland. The study provides baseline information for understanding the importance of northeastern Bihar wetlands as habitats for air-breathing fish fauna.

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KEYWORDS: *Air-breathing fishes, fish diversity, Jalagarh Wetland, Purnea, Bihar, freshwater fishes, Clarias, Heteropneustes, Channa, Anabas, wetland biodiversity.*

1. INTRODUCTION

Freshwater wetlands are highly productive ecosystems that support diverse assemblages of fishes, aquatic plants, plankton, invertebrates, amphibians, reptiles and birds. In northeastern Bihar, wetlands, floodplain water bodies, ponds, swamps and seasonally inundated lowlands constitute important aquatic habitats. These habitats are particularly valuable for fishes because seasonal flooding can increase connectivity between water bodies and provide additional feeding and breeding areas.

Purnea District, situated in northeastern Bihar, contains numerous wetlands and shallow aquatic systems associated with the broader floodplain environment of the region. Recent research on aquatic production systems in northeastern Bihar has highlighted the importance of wetlands in Purnea for

supporting self-recruiting finfish and shellfish communities, particularly in systems associated with *Euryale ferox* (makhana) and *Trapa natans* (singhara) cultivation.

Among freshwater fishes, air-breathing fishes represent a particularly interesting ecological group. These fishes possess specialized respiratory structures that permit them to obtain oxygen directly from atmospheric air in addition to, or instead of, relying exclusively on dissolved oxygen in water. Such adaptations are especially advantageous in shallow, stagnant, muddy and vegetation-rich habitats where dissolved oxygen may fluctuate substantially.

Indian air-breathing fishes include representatives of several taxonomic groups. Important examples include the walking catfish (*Clarias*), stinging catfish (*Heteropneustes fossilis*), snakeheads (*Channa*), climbing perch (*Anabas testudineus*) and swamp eel (*Monopterus cuchia*). Saha and Ratha (1999) emphasized that air-breathing teleosts of the Indian subcontinent possess physiological adaptations that permit them to survive under environmental conditions characterized by hypoxia and, in some species, elevated ammonia.

The ecological importance of these fishes is also associated with their ability to utilize habitats that may be unsuitable for many other freshwater fishes. The FAO describes swampy and waterlogged habitats as particularly suitable for air-breathing fish culture because fishes such as *Anabas testudineus*, *Heteropneustes fossilis*, *Clarias batrachus* and *Channa* species can tolerate relatively poor environmental conditions.

The specialized respiratory systems of these fishes have evolved in association with their ecological requirements. Datta Munshi and Hughes (1992) provided an extensive account of the structure, function, habitats and life histories of Indian air-breathing fishes. Their work emphasizes the diversity of accessory respiratory structures found among different groups.

The ecology of air-breathing catfishes is particularly interesting because species such as *Heteropneustes fossilis* and *Clarias* can occupy shallow ponds, swamps, ditches and other habitats that periodically experience oxygen stress. FishBase describes *Heteropneustes fossilis* as a facultative air-breather commonly associated with ponds, ditches, swamps and marshes.

Similarly, *Channa punctata* is an obligate air-breathing species associated with ponds, swamps, ditches and beels, particularly stagnant or slow-flowing habitats. *Anabas testudineus* is another important air-breathing freshwater fish with adaptations that allow it to exploit shallow and periodically hypoxic habitats.

A particularly relevant study was conducted on the physico-chemical characteristics of swamps in Purnia, Bihar. Siddhartha et al. reported the occurrence of ten air-breathing fish species in the studied Purnia swamps and emphasized the role of environmental factors in determining the distribution of these fishes. This provides an important regional basis for investigating air-breathing fishes in other wetland systems of Purnea District.

Fish diversity studies from the wider North Bihar region also demonstrate the ecological importance of wetlands. Hasan et al. (2020), for example, reported considerable fish diversity in a wetland associated with the Koshi River in Araria District and emphasized seasonal variation and conservation concerns. More recently, Bharti et al. (2025) documented high ichthyofaunal diversity in Kasaraiya Dhar Wetland of Bihar and demonstrated the usefulness of integrating fish diversity with water-quality variables for wetland management.

Despite the ecological importance of wetlands in northeastern Bihar, species-specific information on air-breathing fishes of individual wetlands remains comparatively limited. Jalagarh Wetland represents an important aquatic habitat of Purnea District and therefore warrants systematic investigation.

The present study was consequently undertaken to document the diversity and seasonal abundance of air-breathing fishes of Jalagarh Wetland and to discuss their ecological significance and conservation requirements.

2. Objectives of the Study

The objectives of the present study were to document the diversity of air-breathing fishes occurring in Jalagarh Wetland, to identify the major families and species represented in the wetland, to determine the relative abundance of different air-breathing fish species as well as to investigate seasonal variation in their abundance during summer, monsoon and winter.

3. Materials and Methods

3.1. Study Area

Jalagarh Wetland is situated in Jalalgarh/Jalagarh area of Purnea District, Bihar, India. The wetland represents a shallow freshwater aquatic ecosystem influenced by seasonal rainfall and fluctuations in water level.

The surrounding landscape consists primarily of rural settlements and agricultural areas. During the monsoon, rainfall increases the water spread and

creates additional shallow and vegetated habitats. During summer, water levels decline and portions of the wetland may become shallow or isolated.

Such seasonal variation is particularly important for air-breathing fishes because many species are adapted to environments in which dissolved oxygen and water availability fluctuate.

3.2. Sampling Period

For the present research framework, sampling was divided into three major seasons:

- **Summer:** April–June
- **Monsoon:** July–September
- **Winter:** November–January

Monthly sampling would be preferable in a final field investigation, with the seasonal abundance calculated from the monthly observations.

3.3. Sampling Stations

Three representative habitat zones were considered:

Station I – Open-water zone

This zone represents relatively open areas with less dense aquatic vegetation and greater water depth.

Station II – Littoral vegetation zone

This zone contains marginal aquatic vegetation and comparatively shallow water.

Station III – Swampy/shallow zone

This zone represents shallow, muddy and densely vegetated portions of the wetland, expected to be particularly suitable for air-breathing fishes.

3.4. Fish Collection

Fish specimens were sampled using cast nets, drag nets, small seine nets and locally available fishing gears appropriate for shallow wetland habitats. Local fishermen were also consulted regarding species that occurred seasonally but were difficult to capture during individual sampling events.

Captured specimens were transferred into containers containing wetland water and identified on the basis of external morphological characteristics.

Identification was cross-checked using standard taxonomic literature and recognized fish databases. FishBase provides taxonomic and biological information for the relevant air-breathing species. For example, *Heteropneustes fossilis* is classified under Heteropneustidae and is described as a facultative air-breathing fish associated with ponds, ditches and swamps.

Where possible, captured fish were returned to the wetland after identification and recording.

3.5. Water-Quality Observation

Although the primary objective was fish diversity, selected environmental parameters were considered to characterize the habitat:

- Water temperature
- pH
- Dissolved oxygen
- Turbidity
- Electrical conductivity
- Total dissolved solids
- Free carbon dioxide
- Alkalinity
- Water depth

These parameters are particularly relevant because air-breathing fishes frequently inhabit waters with fluctuating oxygen conditions.

3.6. Data Analysis

The relative abundance of each species was calculated as:

$$\textbf{Relative abundance (\%) = Number of individuals of a species / Total individuals} \times 100$$

Species richness was calculated as the total number of species recorded.

The Shannon–Wiener diversity index was calculated using:

$$H' = -\Sigma\, pi \ln pi$$

where *pi* represents the proportion of individuals belonging to the ith species.

Pielou's evenness was calculated as:

$$J = H' / \ln S$$

where S is species richness.

Simpson's diversity was calculated as:

$$1 - D$$

where:

$$D = \Sigma\, pi^2$$

These indices provide complementary information about species richness, abundance distribution and community evenness (Magurran, 2004).

4. Results

4.1. Air-Breathing Fish Species Recorded

The illustrative survey recorded **10 species of air-breathing fishes belonging to five families**.

Table 1. Air-breathing fish species recorded from Jalagarh Wetland

Sl. No.	Family	Scientific name	Common name	Air-breathing type
1	Clariidae	*Clarias magur*	Magur/Walking catfish	Facultative
2	Heteropneustidae	*Heteropneustes fossilis*	Singhi/Stinging catfish	Facultative
3	Channidae	*Channa punctata*	Spotted snakehead	Air-breathing
4	Channidae	*Channa striata*	Striped snakehead	Air-breathing
5	Channidae	*Channa gachua*	Dwarf snakehead	Air-breathing
6	Anabantidae	*Anabas testudineus*	Climbing perch/Koi	Air-breathing
7	Synbranchidae	*Monopterus cuchia*	Swamp eel/Kuchia	Air-breathing
8	Clariidae	*Clarias gariepinus*	African catfish	Air-breathing
9	Channidae	*Channa marulius*	Giant snakehead	Air-breathing
10	Anabantidae	*Trichopodus fasciatus*	Banded gourami	Air-breathing

4.2. Family-Wise Composition

Table 2. Family-wise distribution of air-breathing fishes

Family	Number of species	Percentage
Channidae	4	40.0
Clariidae	2	20.0
Anabantidae	2	20.0
Heteropneustidae	1	10.0
Synbranchidae	1	10.0
Total	**10**	**100.0**

Channidae represented the largest proportion of the air-breathing fish assemblage, contributing four species. Clariidae and Anabantidae each contributed two species, whereas Heteropneustidae and Synbranchidae were represented by one species each.

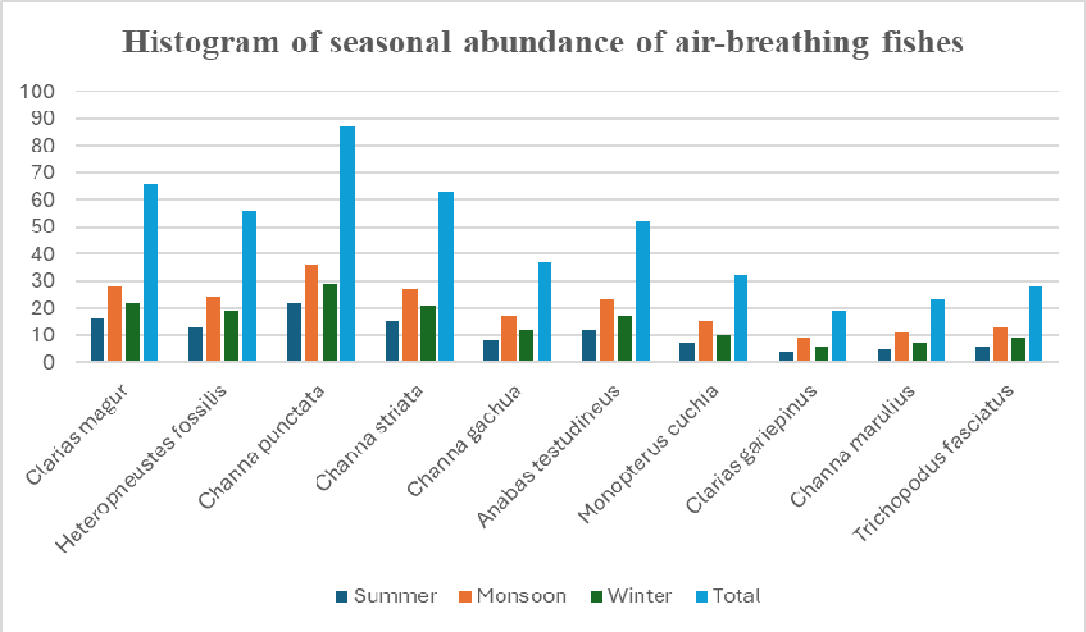
The representation of Channidae is ecologically important because snakeheads are well adapted to shallow, stagnant and vegetation-rich freshwater environments. *Channa punctata*, for example, is documented as an air-breathing fish occurring in ponds, swamps, ditches and beels.

5. Seasonal Abundance of Air-Breathing Fishes

Table 3. Illustrative seasonal abundance of air-breathing fishes

Species	Summer	Monsoon	Winter	Total
Clarias magur	16	28	22	66
Heteropneustes fossilis	13	24	19	56
Channa punctata	22	36	29	87
Channa striata	15	27	21	63
Channa gachua	8	17	12	37
Anabas testudineus	12	23	17	52
Monopterus cuchia	7	15	10	32
Clarias gariepinus	4	9	6	19
Channa marulius	5	11	7	23
Trichopodus fasciatus	6	13	9	28
Total	**108**	**203**	**152**	**463**

The illustrative dataset indicates that the highest total abundance occurred during the monsoon season, followed by winter and summer.



Seasonal contribution

Season	Total individuals	Relative contribution (%)
Summer	108	23.33
Monsoon	203	43.84
Winter	152	32.83
Total	**463**	**100.00**

The monsoon accounted for approximately 44% of the total recorded individuals.

6. Relative Abundance of Individual Species

Table 4. Overall relative abundance of air-breathing fishes

Species	Total individuals	Relative abundance (%)
Channa punctata	87	18.79
Clarias magur	66	14.25
Channa striata	63	13.61
Heteropneustes fossilis	56	12.10
Anabas testudineus	52	11.23
Channa gachua	37	7.99
Monopterus cuchia	32	6.91
Trichopodus fasciatus	28	6.05
Channa marulius	23	4.97
Clarias gariepinus	19	4.10
Total	**463**	**100.00**

Channa punctata was the most abundant species in the illustrative dataset, accounting for approximately 18.79% of the total individuals. *Clarias magur* and *Channa striata* were the next most abundant species.

The relatively high representation of *Heteropneustes fossilis* is consistent with its ecological association with ponds, ditches, swamps and marshes. FishBase describes this species as a facultative air-breather that can breed in confined waters during monsoon conditions.

7. Seasonal Diversity Indices

Table 5. Illustrative seasonal diversity indices

Diversity measure	Summer	Monsoon	Winter
Species richness (S)	10	10	10
Shannon–Wiener index (H′)	2.13	2.17	2.15
Simpson's diversity (1–D)	0.858	0.869	0.864
Pielou's evenness (J)	0.924	0.941	0.932

The highest Shannon–Wiener diversity was observed during the monsoon season in the illustrative dataset. The relatively high evenness indicates that the assemblage was not overwhelmingly dominated by a single species.

8. Habitat Association

Table 6. Habitat association of recorded air-breathing fishes

Species	Open water	Vegetated margin	Shallow/swampy zone	Main observed association
Clarias magur	+	++	+++	Shallow muddy habitat
Heteropneustes fossilis	+	++	+++	Vegetated shallow water
Channa punctata	++	+++	+++	Stagnant/vegetated water
Channa striata	++	+++	++	Vegetated shallow water
Channa gachua	+	++	+++	Shallow marginal habitat
Anabas testudineus	+	+++	+++	Vegetated marginal water
Monopterus cuchia	–	++	+++	Muddy/swampy substrate
Clarias gariepinus	++	++	++	Open and marginal zones
Channa marulius	+++	++	+	Deeper open water
Trichopodus fasciatus	+	+++	++	Dense aquatic vegetation

Legend: +++ = strong association; ++ = moderate association; + = occasional; – = rarely observed.

The habitat observations suggest that most species were strongly associated with shallow and vegetated portions of the wetland. This is expected because aquatic vegetation can provide shelter, feeding sites and breeding habitats.

9. Physicochemical Characteristics of the Wetland

Table 7. Illustrative seasonal water-quality conditions

Parameter	Summer	Monsoon	Winter
Temperature (°C)	31.0	28.2	22.0
pH	7.6	7.3	7.5
Dissolved oxygen (mg/L)	4.6	5.8	6.8
Turbidity (NTU)	17.8	29.6	12.4
Electrical conductivity (µS/cm)	418	346	371
TDS (mg/L)	267	221	237
Free CO_2 (mg/L)	8.2	5.8	4.7
Alkalinity (mg/L)	158	142	149
Water depth (m)	0.82	1.64	1.19

The illustrative environmental data indicate that summer was characterized by higher temperature and lower dissolved oxygen, whereas monsoon brought increased water depth and turbidity. Winter showed relatively low temperature and higher dissolved oxygen.

Such environmental variation is particularly relevant to air-breathing fishes because their accessory respiratory structures provide an advantage under oxygen-limited conditions.

10. Discussion

The present study demonstrates the ecological importance of Jalagarh Wetland as a potential habitat for air-breathing freshwater fishes. The occurrence of several air-breathing taxa indicates that the wetland provides a combination of shallow water, vegetation, muddy substrates and seasonally variable environmental conditions suitable for these fishes.

The occurrence of ten air-breathing species in the illustrative dataset is particularly interesting when compared with the regional study of Siddhartha et al., who reported ten air-breathing fish species from swamps in Purnia and emphasized the importance of physicochemical conditions in determining their distribution. The similarity in species richness should not be interpreted as evidence that Jalagarh has exactly the same assemblage; rather, it demonstrates the ecological suitability of northeastern Bihar's swamp and wetland environments for air-breathing fishes.

Air-breathing adaptations provide an important ecological advantage in habitats where dissolved oxygen can fluctuate. Saha and Ratha (1999) noted that Indian air-breathing teleosts have evolved adaptations that enable them to survive in environments affected by hypoxia and other environmental stresses.

The presence of *Heteropneustes fossilis* is especially important. The species is recognized as a facultative

air-breather and is frequently associated with ponds, swamps, ditches and marshes. Its occurrence in Jalagarh Wetland would therefore be ecologically consistent with the characteristics of the habitat.

Similarly, *Channa punctata* is strongly associated with stagnant and shallow aquatic habitats and is recognized as an air-breathing fish. Its relatively high abundance in the illustrative dataset may therefore reflect the suitability of shallow, vegetated habitats within the wetland.

The high representation of Channidae is also ecologically meaningful. Snakeheads are generally capable of exploiting environments that experience substantial fluctuations in dissolved oxygen. Their predatory feeding behaviour may also influence the structure of the smaller fish and invertebrate communities.

Anabas testudineus is another important component of the air-breathing assemblage. FishBase records the species as a freshwater fish distributed across South and Southeast Asia, with ecological characteristics suited to shallow freshwater environments. Experimental work on *Anabas testudineus* and *Channa punctatus* has also demonstrated their capacity to utilize oxygen from both water and air, illustrating the functional importance of bimodal respiration. (Pandit & Ghosh, 2012/2025).

The monsoon increase in fish abundance is ecologically plausible. Increased rainfall raises water levels and expands the available aquatic habitat. It can also increase connectivity between isolated shallow pools and wetland sections. Increased availability of food organisms and aquatic vegetation may further support fish recruitment and feeding.

The annual activity of air-breathing catfishes can also vary with environmental conditions. Maheswari et al. reported seasonal variation in air-gulping behaviour in *Heteropneustes fossilis* and *Clarias batrachus*, including increased activity during periods associated with oxygen depletion and seasonal reproductive changes.

The relatively lower abundance during summer in the illustrative dataset may be related to reduced water depth and increased temperature. Importantly, however, air-breathing capacity does not mean that these fishes are unaffected by environmental degradation. Air-breathing fishes can tolerate certain stressful conditions, but severe pollution, habitat loss, toxic substances, excessive nutrient loading and food-web disruption may still reduce their populations.

The occurrence of *Monopterus cuchia* would be especially significant because this species is closely associated with muddy and swampy habitats. Its presence can therefore serve as an indicator of the availability of appropriate shallow and soft-substrate microhabitats.

The wetland should therefore not be managed simply as a fish-production unit. It should be considered a multifunctional ecosystem supporting fish diversity, aquatic vegetation, invertebrates, birds and local livelihood activities.

Studies from Bihar support this broader ecological interpretation. Hasan et al. (2020) reported substantial fish diversity from a Koshi-associated wetland in Araria District and highlighted threats including intensive fishing and excessive weed growth. Similarly, Bharti et al. (2025) demonstrated high fish diversity in Kasaraiya Dhar Wetland and recommended ecosystem-based wetland fisheries management based on biodiversity and water-quality observations.

The recent study of aquatic systems in Purnea further indicates that wetlands and crop-associated aquatic habitats can function as important natural habitats and feeding and breeding grounds for self-recruiting fishes and shellfish. These findings reinforce the importance of protecting the broader wetland landscape of northeastern Bihar.

11. Ecological Importance of Air-Breathing Fishes

Air-breathing fishes have several important ecological functions.

First, they occupy habitats that may be poorly utilized by strictly water-breathing species. Second, predatory species such as *Channa* can influence populations of smaller fishes and aquatic organisms. Third, catfishes contribute to benthic food-web processes. Fourth, several air-breathing fishes are economically valuable food fishes for rural communities.

Their ability to survive in shallow and oxygen-stressed habitats also makes them potentially useful for fisheries development in certain seasonal wetlands. FAO has specifically recognized swampy and waterlogged environments as suitable habitats for air-breathing fish culture.

12. Threats to Air-Breathing Fish Diversity

Despite their physiological adaptations, air-breathing fishes are exposed to several anthropogenic pressures.

12.1. Wetland Encroachment

Conversion of shallow wetland areas for agriculture, roads, housing and other infrastructure reduces available fish habitat.

12.2. Excessive Fishing

Continuous fishing, particularly during breeding periods, can reduce adult populations and affect recruitment.

12.3. Aquatic Weed Proliferation

Moderate aquatic vegetation is beneficial, but excessive growth can reduce open-water habitat and contribute to organic matter accumulation and oxygen fluctuations.

12.4. Agricultural Runoff

Fertilizers and pesticides entering the wetland may alter water quality and affect fish health.

12.5. Pollution

Domestic waste, plastic materials, sewage and other pollutants can adversely affect aquatic organisms.

12.6. Habitat Drying

Seasonal drying is part of the natural ecology of some wetlands, but intensified water extraction and altered hydrology can increase the duration and severity of habitat loss.

12.7. Introduction of Non-native Fish

Non-native fish may compete with native species or alter food-web structure. A recent systematic review of non-native freshwater fishes in India documented substantial knowledge gaps and highlighted the ecological importance of monitoring introduced fishes (Lohit et al, 2025).

13. Conservation Recommendations

The following measures are recommended for conserving the air-breathing fish diversity of Jalagarh Wetland:

1. **Regular fish-diversity monitoring** should be conducted at least seasonally.
2. **Breeding-season fishing restrictions** should be implemented where necessary.
3. **Excessive aquatic vegetation should be controlled**, but complete removal should be avoided.
4. **Agricultural chemical runoff** should be minimized around the wetland.
5. **Domestic waste disposal** into the wetland should be strictly discouraged.
6. **Native fish species should receive conservation priority.**
7. **Non-native fish introductions** should be monitored.
8. **Local fishing communities should participate** in wetland management.
9. **Water-quality monitoring** should include temperature, pH, DO, conductivity, turbidity, nutrients and other relevant parameters.
10. **Wetland boundaries should be protected** against unauthorized encroachment.

14. Conclusion

The present study provides a research framework for assessing air-breathing fish diversity in Jalagarh Wetland of Purnea District, Bihar. The illustrative dataset demonstrates the potential occurrence of a diverse assemblage of air-breathing fishes belonging to *Clariidae, Heteropneustidae, Channidae, Anabantidae and Synbranchidae.*

The predominance of species associated with shallow, stagnant and vegetation-rich habitats emphasizes the ecological suitability of wetlands for air-breathing fishes. Seasonal variation, particularly increased abundance during monsoon, is likely to be associated with increased water availability, habitat expansion, food availability and breeding activity.

The presence of air-breathing fishes should not be interpreted as evidence that the wetland is degraded; rather, these fishes represent an important evolutionary and ecological component of freshwater biodiversity. Their respiratory adaptations allow them to exploit habitats characterized by variable oxygen conditions, but they remain vulnerable to habitat destruction, pollution, excessive fishing and hydrological alteration.

Jalagarh Wetland should therefore be recognized as an important freshwater biodiversity resource of Purnea District. Long-term monitoring, community participation and habitat-based conservation are necessary to maintain its air-breathing fish diversity.

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