Aquaculture potential of *Ophichthys cuchia* in Northeast India: Current understanding and prospects

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Northeast India encompasses eight states (Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura), with diverse freshwater ecosystems including floodplain wetlands, ox-bow lakes (beels), seasonal rice paddies, and extensive river systems fed by the Brahmaputra and Barak river basins. The region supports a wide variety of indigenous freshwater fish, many with significant food, cultural, and economic value for local communities. Among these, the swamp eel *Ophichthys cuchia* occupies a distinct position. The species is well established as a food fish with strong market demand, yet it is almost entirely dependent on wild capture. The progressive decline of natural stocks, combined with growing domestic and international demand, shows the need to assess the potential of captive culture as a conservation and livelihood strategy. This article reviews available scientific information on the biology, nutrition, and culture potential of *O. cuchia*, with particular reference to northeastern India.

Taxonomy and morphology

O. cuchia, first described by Hamilton 1822 and initially assigned to the genus *Monopterus*, belongs to the order Synbranchiformes and the family Synbranchidae. The species is commonly referred to as the Gangetic mud eel, swamp eel, or rice eel, and is known locally as "cuchia" across Assam and northeastern India. The family name Synbranchidae derives from the Greek words syn (fused) and branchi (gills). This reflects the defining anatomical feature of the group: the paired gill openings, which are separate in most teleost fish, are fused into a single median ventral aperture beneath the throat. The body is highly elongated with a circular cross-section. The dorsal and anal fins are fused with the caudal fin, forming a continuous ribbon-like structure along the rear of the body. Pectoral and pelvic fins are entirely absent.

Gangetic mud eel, *Ophichthys cuchia*.

Numerous spots are present over the tail region, and the species lacks a swim bladder. Maximum recorded total length (TL) is approximately 79.7 cm in male or unsexed individuals. Notably, females attain a larger body size than males during the breeding season, with an average weight of 0.34 kg and length of 78 cm - the opposite of the pattern observed in *M. albus*[1].

Internally, gill tissue is present on both sides of the pharynx but is considerably reduced in structure and function. This is compensated by several accessory respiratory adaptations. *O. cuchia* is an obligate air-breather, using the highly vascularised buccal and pharyngeal mucosa, the skin, and a pair of suprapharyngeal air chambers for atmospheric gas exchange - structures absent in *M. albus*. Two suprabranchial chambers are additionally present, each containing a labyrinthine organ. Pharyngeal pouches develop early in life but become functionally active only later. These adaptations collectively underpin the species' remarkable tolerance of hypoxic environments and its capacity to survive without water for extended periods.

Distribution and habitat

O. cuchia is naturally distributed across Pakistan, India, Nepal, Bangladesh, and Myanmar. Within India, it is predominantly recorded from northern and northeastern states, with confirmed presence in Assam, Tripura, and riverine systems in the sub-Himalayan foothills. The species has also been recorded from Maharashtra, and is present in the Buxa, Adma, and Jayanti rivers in the sub-Himalayan zone of West Bengal. It occurs at altitudes from 76 to 1,350 m above mean sea level. The species inhabits freshwater and brackish water environments, favouring ponds, rivers, haors, beels, canals, floodplains, and rice fields with muddy substrates. Adults are reported to hibernate in mud during cold seasons. Males construct and guard nests or burrows, which has implications for captive breeding management.

Feeding ecology

O. cuchia is nocturnal and carnivorous. Natural diet items include small fish, tadpoles, aquatic insects, crustaceans, earthworms, snails, and aquatic invertebrates. In captive trials, the species has accepted supplementary

feeds including animal-based ingredients and mixed diets. Its strong preference for protein-rich, animal-based food is a key consideration for feed formulation, with direct implications for feed cost and the feasibility of partial substitution with plant protein sources.

Reproductive biology

O. cuchia exhibits protandrous hermaphroditism, where individuals begin as males and may transition to female as they mature. This sequential sex change complicates induced breeding programmes, as the sex ratio and transition timing in captive populations are not yet well understood. The gonado-somatic index peaks between April and June in both sexes, with the highest female GSI recorded at 9.04 ± 1.02 and male GSI at 2.52 ± 0.44 in May, declining through November in both sexes[2]. Under Meghalaya agro-climatic conditions, peak male GSI of 3.4 ± 0.8 and female GSI of 7.33 ± 0.081 were recorded in May, with the lowest values occurring in September and December, respectively[3]. Spawning occurs in burrows constructed and guarded by the male, typically during the summer months. Average fecundity ranges from 150 to 924 eggs, with ova diameter measuring 3 to 4 mm between September and May[4].

Induced breeding of *O. cuchia* remained elusive for many years, with early attempts using PGE, HCG, and GnRH yielding no successful results[1]. The first documented success was achieved by Begum et al. (2017), who used pregnyl at a single dose of 1,000 IU/kg body weight for females and 500 IU/kg for males in pond conditions, with brooders released at a 1:1 ratio. Approximately 3,000 larvae were collected from spawning pits following pond drainage. Of particular relevance to Northeast India, successful induced breeding has been reported under the agro-climatic conditions of Meghalaya. Using Gonopro-FH at 1 mL/kg for females and 0.3 mL/kg for males, researchers achieved 75 to 80% fertilisation and 80 to 85% hatching rates. Fecundity was recorded at 924 eggs from a 344 g female4. In larval rearing trials, three-day-old larvae stocked at 1,000/m² were initially fed boiled egg yolk, then earthworms, zooplankton, and chopped tubifex from the third day at 5 to 10% of body weight. The larvae attained 10.68 cm and 1.09 g after four months, with a survival rate of 80%[5]. Despite these advances, standardised protocols suited to Indian agro-climatic conditions across the northeastern states have not been developed, representing a significant gap for commercial aquaculture development.

Nutritional composition

The nutritional profile of *O. cuchia* has been described in several studies, predominantly from Bangladesh. The average protein content of raw muscle is approximately 18.7 g / 100 g. Studies using different cooking methods reported protein content in raw and cooked muscle ranging from 14.5% to 21.3%, depending on thermal treatment. Twenty different fatty acids have been identified in the muscle, with palmitic acid (a saturated fatty acid) being the most abundant,

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occurring at 26.51% to 29.70% in raw and cooked samples. Omega-3 polyunsaturated fatty acids (PUFAs) were recorded at 7.54% to 13.7% in raw muscle, though thermal processing reduces PUFA content. The pattern of fatty acids followed the order: saturated fatty acids (SFA) > monounsaturated fatty acids (MUFA) > polyunsaturated fatty acids (PUFA).

Seven essential amino acids have been identified in the muscle, with lysine occurring in the highest concentration. Eight non-essential amino acids were identified, with glutamic acid, arginine, glycine, and aspartic acid as primary components. Seasonal variation in nutritional composition has been documented, with lipid content showing wider seasonal fluctuation than protein content.

Studies have also characterised the mineral composition of *O. cuchia* muscle, reporting notably high calcium content alongside other essential minerals, making it a recommended dietary source for mineral-deficient populations. The fish is also reported to have high erythrocyte indices, and its iron-rich profile has been associated in traditional practice with managing iron-deficiency anaemia. Across communities in Northeast India and Bangladesh, *O. cuchia* is specifically recommended for pregnant women, nursing mothers, and those recovering from illness, based on the belief that it supports haemoglobin synthesis and blood cell production. These traditional uses are broadly consistent with the known nutritional composition of the fish, though clinical validation of its efficacy in managing anaemia or supporting maternal nutrition has not been reported in the peer-reviewed literature.

Given the high burden of iron-deficiency anaemia among women of reproductive age in Northeast India, this dimension of the species' nutritional value merits formal investigation.

Conservation status and threats

O. cuchia has been listed as a threatened species in Bangladesh. In India, while the species is not currently listed under the Wildlife Protection Act, researchers have noted its progressive decline in natural water bodies across north-eastern states. The IUCN Red List categorises the species as 'Least Concern' (IUCN taxon ID: 166554), but notes that the last assessment was in 2010 and needs updating. The conservation status of *O. cuchia* in the Indian context warrants updated evaluation.

Primary threats include unregulated and intensive wild capture, seasonal and permanent loss of wetland habitat through drainage and agricultural conversion, and siltation of floodplain water bodies. Pesticide contamination of rice-field ecosystems is also a significant concern, given the species' dependence on paddy habitats. The decline of *O. cuchia* has both ecological consequences, given its role as a mid-level predator in freshwater food webs, and socio-economic consequences for communities dependent on wild capture.

Captive culture: evidence and constraints

Organised aquaculture trials for *O. cuchia* have been conducted primarily in Bangladesh, with limited documentation from India. A five-month on-farm management study stocked baby eels weighing 50 to 70 g at a density of 10 individuals/m² in earthen ponds following liming at 250 kg/ha[6]. Researchers installed sanctuary structures including bamboo roots, hollow pipes, and aquatic vegetation to simulate the species' natural burrowing behaviour - a critical welfare and growth consideration. Water quality parameters remained within acceptable ranges throughout, and the study concluded that pond-based culture under this management regime was feasible. Provision of adequate shelter is a non-negotiable husbandry requirement. Semi-intensive monoculture trials assessed three stocking densities - 33, 42, and 51 fingerlings/m² - over 240 days. Under optimised conditions, yields of approximately 1,440 kg/ha over 150 days were reported, with survival reaching 90% and a feed conversion ratio as low as 1.0. Economic analysis from these trials indicated that net monetary profit was achievable, though profitability was sensitive to feed type and stocking density. In a separate study, stocking at 7,410 fingerlings/ha in a 0.14 ha earthen pond resulted in a weight gain of 362.10 ± 5.74 g from an initial weight of 99.10 ± 1.80 g over 240 days. Production reached 2,505.73 ± 8.38 kg/ha, with a feed conversion ratio of 1.95 and a survival rate of 93.40 ± 1.27%[7].

Despite these encouraging results, several constraints continue to limit the scaling of cuchia aquaculture. Seed supply remains the most critical bottleneck, as no established hatchery network producing *O. cuchia* fingerlings exists in India, and natural seed collection is unreliable and seasonally constrained. The protandrous reproductive system adds further complexity to controlled breeding efforts. High dietary protein requirements increase feed costs. A formulated diet of 50% fish paste, 40% fish meal, 5% rice bran, and 5% wheat flour has been shown to support growth from 50-70 g to 165-176 g over five months[6]. However, partial substitution of animal protein with plant-based alternatives has not been adequately validated and remains a priority research area.

Disease profiles in cultured populations have received only preliminary attention. Parasitic infections by *Argulus* spp. and *Ergasilus* spp. have been identified as the primary disease agents in captive populations, and cestode infections have also been reported, with prevalence appearing higher in females than in males[1]. Effective prevention and treatment strategies nonetheless remain largely undeveloped.

Prospects for aquaculture development in Northeast India

Ecological suitability. The ecological tolerances of *O. cuchia* - including resistance to low dissolved oxygen, capacity for air-breathing, and adaptability to shallow and variable water conditions - make it well suited to the seasonal wetlands, rain-fed ponds, and rice paddy systems that dominate the northeastern states. The species has been recorded naturally in paddy field habitats, and at least one rice field culture trial in Bangladesh demonstrated positive individual growth (310.63 ± 17.59 g over five months) and the highest net economic return among tested systems when fingerlings were stocked at 5,187/ha under semi-intensive management[8]. Integration of *O. cuchia* into rice-cum-fish farming systems in Northeast India therefore warrants investigation, given the region's extensive rain-fed paddy landscape and the cultural familiarity of farming communities with both rice cultivation and the species itself. However, the burrowing behaviour of the species presents a practical management concern, as burrow construction in embankments may compromise paddy bund integrity and increase the risk of fish escape. Reinforced bunds, barrier netting along embankment walls, and the provision of trench refugia would likely be necessary structural modifications. Critically, the complete exclusion of pesticide application is a prerequisite for any viable rice-cuchia integration system, which has direct implications for the pest management practices of participating farmers. Controlled trials examining these parameters under northeastern Indian agro-climatic conditions are currently absent from the literature and represent a clear research opportunity.

Market demand and economic potential. Market demand for *O. cuchia* in northeastern India is well established. The species commands a notably higher price than most commonly cultured freshwater fish in local markets across Assam and Tripura, a reflection of both its perceived medicinal value and its declining wild availability. A 2025 local market survey recorded *O. cuchia* selling at Rs. 800/kg in Manipur, compared to Rs. 150 to 200/kg for common carp - underscoring the considerable premium the species commands over conventionally cultured freshwater fish. Wild-caught individuals in other northeastern markets have been informally reported to fetch between INR 500 and INR 1,000/kg or more, varying by season and locality, with prices rising sharply during periods of low availability. This places it among the highest-value indigenous freshwater fish in the regional market. The international dimension is illustrated by Bangladesh's documented export earnings of approximately USD 25.37 million from roughly 1.3 million kg of mud eel in the fiscal year 2016-17, with exports to over 15 countries including China, Thailand, Japan, Malaysia, and South Korea[9]. While India has not developed a comparable export trade, the proximity of northeastern states to these markets and improving regional trade infrastructure represent a plausible long-term opportunity. However, this would require substantial investment in both production capacity and export certification infrastructure before it could be considered commercially viable.

Livelihood and food security dimensions. Small-scale cuchia aquaculture has potential relevance for rural and tribal communities who already possess cultural familiarity with the species as a wild resource. Household-level and semi-intensive farming models, analogous to those demonstrated in Bangladesh, could contribute to household protein security and supplementary income generation. Cemented tanks and locally available water harvesting structures such as jalkunds - widely promoted across the hill districts of the region - represent low-cost infrastructure options that could be adapted for small-scale cuchia culture without major capital investment. Rearing *O. cuchia* fry in cemented cisterns has been demonstrated experimentally, with fry stocked at 75 individuals/m² attaining a mean body weight of 5.32 ± 0.04 g with 70.34 ± 1.25% survival after 45 days[10] - supporting the feasibility of such low-infrastructure production systems.

Conservation relevance. Successful captive culture, by reducing dependence on wild-captured individuals, could contribute to relieving fishing pressure on natural populations. However, hatchery seed production would need to be established at meaningful scale before this benefit becomes practically significant.

Research priorities

The following areas require priority attention to enable evidence-based aquaculture development of *O. cuchia* in Northeast India. Induced breeding protocols under controlled conditions must be developed and validated for Indian agro-climatic settings. Larval rearing methodology, including early nutrition requirements, represents a critical but poorly characterised phase. Region-specific growth performance and survival data are needed. Feed formulation research is required to identify cost-effective, partially plant-protein-based diets that meet the species' nutritional requirements without compromising growth and survival. Disease surveillance and pathogen characterisation in captive populations require systematic attention. Finally, farm-level economic analysis specific to northeastern Indian input costs and market conditions must be conducted to assess the practical viability of different production systems. At the policy level, active promotion of *O. cuchia* farming through existing government schemes such as the Pradhan Mantri Matsya Sampada Yojana, combined with targeted extension support for northeastern farmers, could help translate research findings into field-level adoption.

Conclusion

O. cuchia is a nutritionally and commercially valuable indigenous freshwater fish with established market demand and a strong ecological fit with northeastern India's water bodies and farming systems. Available evidence from captive culture trials, primarily from Bangladesh, demonstrates that the species can be maintained and grown under managed conditions with reasonable production efficiency. However, the absence of hatchery infrastructure, standardised breeding protocols, and region-specific production data means that large-scale aquaculture development in Northeast India remains at an early stage. Systematic investment in applied research, seed production capacity, and farmer-level extension is necessary to translate the biological and market potential of this species into a viable and sustainable aquaculture enterprise.

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