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ECO-MORPHOLOGICAL, DEVELOPMENTAL, AND GENOMIC PROFILES OF THE SUB-HIMALAYAN RAINBOW BELLY PIPEFISH *Microphis Deocata* (HAMILTON, 1822): A SYNTHESIS FOR CONSERVATION MANAGEMENT

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ABSTRACT

The deocata pipefish, *Microphis deocata* (Hamilton, 1822), is an obligate freshwater syngnathid endemic to the sub-Himalayan River systems of South Asia. M. deocata is known for its extreme morphological innovations, sexual dichromatism, sex-role reversal, and specialized paternal care. Currently, this species is reported to face severe threats from micro-habitat degradation and intense targeting by the indigenous ornamental aquarium trade. This communication provides a concise synthesis of *M. deocata*, emphasizing its taxonomic history, exact lotic distribution, meristic architecture, and specialized feeding mode. By drawing on recent captive breeding breakthroughs, we have attempted to map the behavioral courtship sequences and embryonic development within the unsealed abdominal paternal brood pouch. Furthermore, we evaluate its evolutionary placement using its complete mitochondrial genome (16,526 bp; GenBank: MT230531). Finally, we provide a localized threat assessment to justify its conservation status under Schedule I of India's Wildlife Protection Act, establishing a framework for urgent micro-refugia management.

INTRODUCTION

Introduction and Taxonomic Trajectory

Most members of the Syngnathidae family, which includes seahorses and pipefishes, are marine. However, a small group of this family colonized freshwater habitats and now lives in inland rivers. One of these rare freshwaters obligates is the rainbow belly pipefish, *Microphis deocata* (Hamilton, 1822). It is a unique species found only in sub-Himalayan drainage systems (Talwar &Jhingran, 1991). It is currently listed as Near Threatened by the IUCN (IUCN, 2025).

M. deocata was first described by Hamilton in 1822 during his classic survey of the Ganges River system, naming it *Syngnathus deocata* (Hamilton, 1822). Since then, its classification has been revised several times, mainly due to similar trunk-ridge features in freshwater syngnathids. In the 1980s, Dawson placed it in the genus *Microphis* and the subgenus *Coelonotus. He identified this* group by their unsealed abdominal incubation areas, unique opercular keels, and specific trunk ridge structures (Dawson, 1984, 1985).

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Complete lineage of *M. deocta*

Vertebrata; Gnathostomata; Teleostomi; Euteleostomi; Actinopterygii; Actinopteri; Neopterygii; Teleostei; Osteoglossocephalai;Clupeocephala;Euteleosteomorpha;Neoteleostei;Eurypterygia; Ctenosquamata; Acanthomorphata; Euacanthomorphacea; Percomorphaceae; Syngnathiaria; Syngnathiformes;Syngnathoidei;Syngnathidae;Syngnathinae;Microphis (NCBI taxonomy browser, retrieved on 31/05/2026)

Geographical Distribution and Habitat Ecology

M. deocata has been reported from only a narrow corridor across the sub-Himalayan Terai and Duars regions of Northeast India, Bangladesh, and Nepal (Talwar &Jhingran, 1991). In India, it lives in small tributaries, stream edges, and oxbow channels of the Brahmaputra River basin in Assam and North Bengal. Recently, Borah & Sarma (2025) reported M. deocata from the Palla River, a slow-moving stream in Barpeta district, lower Assam, which is part of the Chaulkhowa-Brahmaputra River network (Borah & Sarma, 2025). In northern Bangladesh, it lives in slow-moving lowland streams (Rahman, 1989). At the western edge of its range, the fish is found

in marshy, slow-moving river margins in Nepal's lowlands (Shrestha, 2008).

Within these river corridors, *M. deocata* exhibits very specific micro-habitat preferences. It is usually a bottom-dwelling ambush predator in clear, shallow, slow-moving or still backwaters (Borah & Sarma, 2025; Talwar &Jhingran, 1991). The microhabitats of this species are often characterized by dense mats of submerged aquatic plants and overhanging roots along the riverbank (Borah & Sarma, 2025; Dawson, 1985). These vegetated areas protect the fish from being swept away during heavy monsoon floods, offer shelter for its unique breeding displays, and support large numbers of the tiny invertebrates it eats (Borah & Sarma, 2025; Saikia et al., 2024).

Morphological Architecture and Sexual Dimorphism

The body of *M. deocata* lacks typical teleost scales; instead, it is encased in a rigid dermal armor composed of interlocking bony plates arranged in transversely striated rings or ridges. Total rings are 44-49. Trunk rings are 15-17 and tail rings are 29-32. Each bony ring encircling the body is associated with a single vertebra (Saikia B. 2016). The species maintains a highly stable meristic arrangement systematically cataloged by Dawson (1984):

Table 1. Diagnostic meristic ranges and morphological benchmarks for adult *M. deocata*

Anatomical Feature	Diagnostic Metric Range	Reference
Trunk Rings	15 – 17	Dawson (1984)
Tail Rings	29 – 32	Dawson (1984)
Dorsal Fin Rays	30 – 36	Dawson (1984); Talwar &Jhingran (1991)
Pectoral Fin Rays	15 – 22	Dawson (1984)
Anal Fin Rays	2	Dawson (1984)
Caudal Fin Rays	7 – 9	Dawson (1984)
Head-to-Standard Length Ratio	1: 7.0 – 7.9	Talwar &Jhingran (1991)

Figure 1. Lateral overview of mature female Microphis deocata, highlighting the brilliant, multi-coloured abdominal ornamental bands and specialized ventral skin folds. (Photograph by J.Borah)

Figure 2. Lateral profile of an adult male *M. deocata*, demonstrating cryptic olive-brown coloration and the open, unsealed abdominal brooding canvas. (Photograph By J. Borah)

Trophic Ecology and Feeding Mechanics

M deocata is a visual, diurnal predator with a unique digestive system. It lacks a true stomach or teeth, so it uses a hunting method called pivot feeding (Dawson, 1985). When it spots prey, the fish quickly lifts its long snout and lowers the hyoid cavity. This fast action creates strong suction inside the snout, pulling in water and the prey straight into its mouth in just a fraction of a millisecond (Dawson, 1985; Roos et al., 2009)."

In the wild, it eats only live microinvertebrates in macrophytes beds. Observations in both captivity and the field show that these are its main food sources:

1. Dipteran Larvae: Chiefly chironomids (bloodworms) and small culicid larvae (Saikia et al., 2024).
2. Ephemeropteran Nymphs: Small, early-instar mayfly larvae crawling along plant stems.
3. Micro-Crustaceans: Cladocerans (*Daphnia* and *Moina*), copepods, and benthic ostracods (Saikia et al., 2024).

Bhanu analysed the studied the gut contents of 150 specimen colleceted from the Manas River, Assam, India and reported copepods (18.80%) were the highest abundant group in dilatory components. Other components included rotifers (9.96%), cladocera (10.67%), isopods (6.33%), amphipods (5.73), insect larvae (6.60) and plant detritus (3.87%) (Saikia B. 2016). Because of its rapid digestion and limited energy storage capability, *M. deocata* must forage continuously during daylight hours, making it highly vulnerable to localized food web collapses.

Courtship Sequences and Paternal Care

The reproductive strategy of *M. deocata* is defined by an extreme form of sex-role reversal (Saikia et al., 2024). Females initiate courtship, flashing their iridescent crimson and blue ventral skin folds to signal readiness, while males evaluate potential mates and carry the full energetic burden of embryonic gestation (Saikia et al., 2024). Courtship behavior is highly complex and proceeds through three structurally distinct phases documented in live breeding trials: initial courtship, spawning, and swaying (Saikia et al., 2024).

The initial courtship includes female quivering displays, head-pointing gestures from both sexes, and frequent tail-entangling movements (Saikia et al., 2024). The male often lies on top of the female as a sign of embracing (Saikia et al., 2024).

In the next phase, called spawning, the pair swims upward. The female turns upside down to align her ovipositor and lay her eggs on the male's exposed ventral surface for incubation (Saikia et al., 2024).

In the last phase, called swaying, the eggs stick to the male's unsealed abdominal brood pouch (Dawson, 1984; Saikia et al., 2024). The male's ventral skin folds hold the eggs in place, control gas exchange, and support embryo development through several stages before hatching (Nath et al., 2019).

Breeding trials show that each egg is 0.7 to 1.0 mm wide and develops through four main periods and 10 stages over 10 to 15 days (Nath et al., 2019).Number of eggs in brood pouch ranges from 17 to 22 eggs (Nath 2019). Saikia B. (2016) reported positive correlation between the Standard length of the male body and number of eggs contained in the brood pouch.

Mitogenomic Characterization and Phylogeny

Sahoo et al. (2012) sequenced the complete mitochondrial genome of *M. deocata* using next-generation Illumina sequencing (GenBank Accession No. MT230531). The mitogenome of *M. deocata* is a circular DNA molecule with 16,526 base pairs and follows the typical gene arrangement found in vertebrate mitochondria. It contains 13 protein-coding genes, two ribosomal RNA genes (*12S rRNA* and *16S rRNA*), and 22 transfer RNA genes. The genome ends at a specific control region, the D-loop, which regulates transcription (Sahoo et al., 2021).

One important feature of the *M. deocata* mitogenome is the WANCY region, which is a conserved group of five tRNA genes (*tRNA-Trp, tRNA-Ala, tRNA-Asn, tRNA-Cys, tRNA-Tyr*) that includes a 50-base-pair origin of light-strand replication (O_L) (Sahoo et al., 2021). Phylogenetic analysis using combined mitochondrial data shows that *Microphis deocata* belongs to the trunk-brooding syngnathid group and forms a distinct branch within this family (Sahoo et al., 2021).

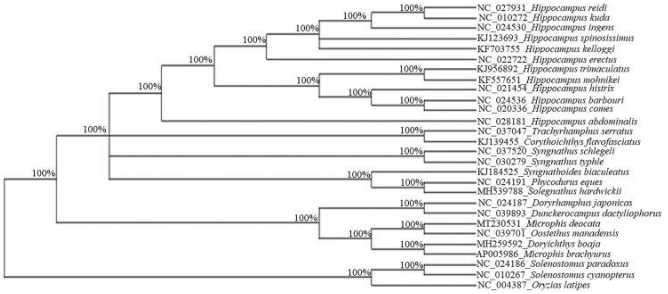

Figure 3. Phylogram showing the evolutionary position of the Deocata pipefish, *Microphis deocata*, relative to 24 other syngnathid species based on complete mitogenomic alignment. The tree shows clear family-level topology, splitting the seahorse genus (*Hippocampus*) and pipefish/seadragon genera into distinct, well-supported clades with 100% bootstrap confidence across all internal nodes. *Microphis deocata* (Accession No. MT230531) demonstrates close evolutionary proximity to *Oostethusmanadensis* (NC_039701) and *Microphis brachyurus* (AP005986), supporting the traditional taxonomic grouping within the subfamily Syngnathinae. The scale bar and tree topology reflect genetic divergence across the 13 protein-coding genes, 2 rRNAs, and 22 tRNAs. *Oryziaslatipes* was utilized as the outgroup. (Reproduced from Sahoo et al., 2021)

Conservation Status and Threat Evaluation

Currently, *M. deocata* has been listed as Near Threatened globally on the IUCN Red List (Pollom, 2019). It is considered Endangered in Bangladesh's local freshwater systems due to significant population declines(Rahman, 1989). The Government of India has provided the species with strong legal protection by including it in Schedule I of the Wildlife Protection Act of 1972 (Saikia et al., 2024)

Wild M. deocata populations continue to decline mainly due to human activities. Its bright colors and unusual breeding habits make it popular in the international aquarium trade, leading to ongoing collection and a rapid decline in breeding adults in streams that are easy to reach (Talwar &Jhingran, 1991). In the sub-Himalayan Duars and Terai regions, commercial tea plantations surround the area, causing seasonal chemical runoff that harms local micro-fauna.

To mitigate the threat of extinction for this obligate freshwater syngnathid in the wild, the immediate implementation of targeted ex situ and in situ conservation strategies is imperative. The most urgent actions are to find and protect important small habitats in the Brahmaputra basin, strictly enforce bans on collecting wild fish, and use proven captive breeding methods to meet market demand without harming wild populations (Saikia et al., 2024).

CONCLUSION

M. deocata is a freshwater syngnathid endemic to Southeast Asia. It is a relatively less studied member of the family Syngnathidae. It is known for its unusual morphology, sex role reversal, and parental care. Currently, it faces threats of extinction, mainly due to habitat loss and other anthropogenic activities, and requires immediate conservation attention.

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