

# Morphological and molecular evidence for range extension and taxonomic validation of *Sperata aorides* (Jerdon, 1849) in the Western Ghats, India

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## Abstract

*Sperata aorides* (Jerdon, 1849) is a commercially important freshwater catfish endemic to the Cauvery River basin, including its tributary, the Bhavani River. The present study reports a range extension of the species to the Bharathappuzha River in Kerala, documenting its previously unrecorded distribution based on morphometric and molecular evidence. Specimens for the study were collected from different river systems in the Western Ghats, including the type locality at Erode, Tamil Nadu. Morphometric comparisons revealed minor variations between populations in head proportions, particularly in interorbital distance (19.5-24.5% vs 15.8-22.1% in HL) and eye diameter (12.0-17.3% vs 8.8-17.9% in HL). Mitochondrial cytochrome c oxidase subunit I (COI) gene sequencing confirmed species identity. Phylogenetic analysis showed that *S. aorides* forms a distinct clade, with low intraspecific genetic divergence (0.19%) between Cauvery and Bharathappuzha populations and higher divergence (4.61-9.85%) from congeners. These findings confirm the taxonomic validity of *S. aorides* and extend its known distribution to the Bharathappuzha River in the southern Western Ghats.

## Introduction

Catfishes (Order: Siluriformes) represent one of the most diverse groups of freshwater fish worldwide, and comprise approximately 40 families (Segaran *et al.*, 2023). Over 3,093 species were reported in 2005 (Ferraris, 2007) and this number increased to 3,407 species by 2011 (Armbruster, 2011), indicating a continuous increase in the discovery of new catfish species. Among them, the family Bagridae comprises 16 genera and 226 species, with 16 new species discovered in the last decade (Fricke *et al.*, 2025). The genus *Sperata*, belonging to the family Bagridae, comprises large bagrid catfish widely distributed across South Asia, from Afghanistan to Thailand, inhabiting freshwater systems (Gupta, 2015). These fishes can survive and reproduce in lakes, ponds, tanks, reservoirs, and channels, but primarily inhabit rivers (Gupta, 2015). The genus is commercially important as a food fish

throughout its distributional range because of its low number of intermuscular bones and high nutritional value (Mohanty *et al.*, 2012). Additionally, *Sperata* are valued in recreational angling, and juveniles of *Sperata* species are occasionally used in the ornamental fish trade (Kumar *et al.*, 2021).

Species of the genus *Sperata* are characterised by an elongated, depressed head, a rugose interneural shield (supraneural bone) that is not connected with the dorsal fin's first pterygiophore, and a distinct black spot present at the lower posterior end of the adipose fin (Ferraris and Runge, 1999). The genus has a complex taxonomic history having been assigned to several genera, including *Pimelodus*, *Platystoma*, *Bagrus*, *Macrones*, *Mystus*, *Osteobagrus*, *Aorichthys*, and *Sperata* (Kumar *et al.*, 2021; Yadav *et al.*, 2022). According to Ahyong *et al.* (2025) and Froese and Pauly (2025), five species are currently recognised in the genus *Sperata*:



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*S. acicularis*, *S. seenghala*, *S. aor*, *S. aorella* and *S. aorides*. *Sperata lamarii* is not listed in WORMS (Ahyong *et al.*, 2025) and FishBase (Froese and Pauly, 2025), although it has been reported from Ganges, Narmada, Godavari, and Indus River systems. *Sperata acicularis* is distributed in the Ayeyarwaddy, Tenasserim, and Bago rivers of Myanmar (Ferraris and Runge, 1999). *Sperata seenghala* is primarily reported from the Krishna River, and its occurrence in other rivers requires confirmation. *Sperata aor* is distributed across the Ganges, Brahmaputra, and Surma rivers of India and Bangladesh, extending southward to the Godavari and westward to the Narmada. *Sperata aorella* is restricted to the Ganga, Brahmaputra, and Surma river systems in India and Bangladesh. However, *S. aorides* is confined to the Cauvery River system and has also been recorded from the Bhavani River, a tributary of the Cauvery (Kumar *et al.*, 2021).

*Sperata aorides* (originally described as *Bagrus aorides*) was described by Jerdon in 1849 from the Cauvery River in Erode. Day synonymised *S. aorides* with *S. aor* (Day, 1829-89), and this view was later supported by Ferraris and Runge (1999). However, subsequent work by Kumar *et al.* (2021) clarified that the *Sperata* species from the Cauvery River corresponds to *S. aorides*. The species has remained poorly studied due to historical synonymy and frequent misidentifications. The present study provides a comprehensive taxonomic assessment, distribution update, and phylogenetic analysis of *S. aorides* from the southern Western Ghats, India.

## Materials and methods

### Sample collection and morphometrics

Samples of *S. aorides* were collected from the Cauvery River (Type locality: Erode; 11°23'1.716"N; 77°42'45.216"E), the Bhavani River (11° 28' 21.7488"N; 77° 7' 36.5232"E) and Bhavani Sagar Reservoir (11° 28' 21.8784"N; 77° 7' 36.7464"E) in Tamil Nadu, as well as

Bharathappuzha River (10°55'13.296"N; 76°17'42.972"E) in Kerala. Samples were obtained from local fishermen, and geographic coordinates were recorded using a GPS device (Fig. 1).

Specimens were initially identified based on colour patterns and morphometric measurements. Morphometric measurements were taken point-to-point using an electronic digital caliper with a precision of 0.1 mm on the left side of each specimen, wherever possible. Meristic counts and morphometric measurements followed the methods described by Ferraris and Runge (1999). Tooth patterns were stained with methylene blue to facilitate observation of the internal structures. Samples were photographed against a clean background, and tissues were collected and preserved in absolute ethanol for subsequent molecular analysis.

### Molecular analysis

Genomic DNA was extracted from tissue samples using the phenol-chloroform method (Sambrook *et al.*, 2001). A partial fragment of the mitochondrial cytochrome c oxidase subunit I (COI) gene was amplified using standard primers (Ward *et al.*, 2005). Polymerase chain reaction (PCR) amplification was carried out, and the amplified products were visualised on a 1% agarose gel. The PCR products were purified using exonuclease I and shrimp alkaline phosphatase (USB, Cleveland, OH, USA) to remove residual primers. Sequencing was performed using the BigDye® Terminator v3.1 Cycle Sequencing Kit, and the resulting sequences were analysed using an Applied Biosystems Genetic Analyser ABI 3130. The obtained sequences were edited and assembled using Sequencer version 4.7 (Gene Codes Corporation). Raw DNA sequences were aligned using BioEdit version 7.0.5.2 (Hall, 1999) and multiple sequence alignment was performed using CLUSTAL X version 2.0 integrated within BioEdit. Phylogenetic and molecular evolutionary analyses were performed using MEGA 11 (Tamura *et al.*, 2021). A maximum likelihood (ML) phylogenetic tree was constructed

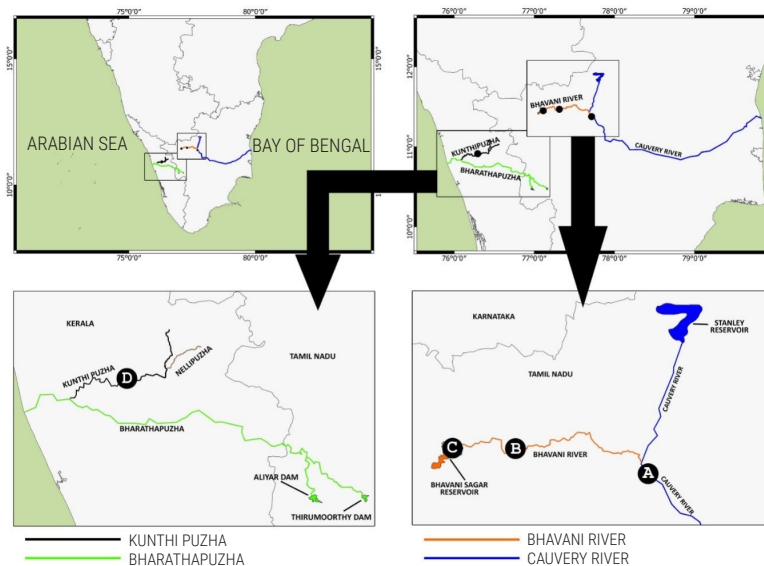


Fig. 1. Map showing distribution of *S. aorides* in the (a) Cauvery River; (b) Bhavani River; (c) Bhavani Sagar Reservoir; (d) Kunthipuzha and Bharathappuzha rivers of the southern Western Ghats, India.

using the Kimura 2-parameter (K2P) model with 1000 bootstrap replicates (Tamura et al., 2021). Additional COI mitochondrial gene sequences were retrieved from the NCBI database and included in the analysis for comparison. Seven *Sperata* species were used for the phylogenetic analysis, including the outgroup, *H. punctatus*.

## Results

The collected specimens were identified as *S. aorides* based on 37 morphometric and seven meristic characteristics.

### Systematic position

Order: Siluriformes

Family: Bagridae

Genus: *Sperata* (Holly, 1939)

Species: *Sperata aorides* (Jerdon, 1849)

### Diagnosis

*S. aorides* can be readily distinguished from its congeners, except *S. aorella* by the presence of a roughly conical head. It differs from *S. aorella* in possessing a broad, rounded snout (vs somewhat truncate snout), a shorter pre-dorsal length (38.3-42.7% of SL vs 45.2-49.2% SL), and a larger eye diameter (12.0-17.3% of HL vs 9.2-13.6% HL).

### Description

Biometric data of the specimens are presented in Tables 1 and 2. The body is elongated, with the dorsal body profile rising steeply towards the snout and gradually sloping towards the caudal peduncle (Fig. 2 and 3). The ventral profile is convex up to the pelvic fin, reaching maximum body depth at the origin of the dorsal fin, and then gradually towards the caudal peduncle. The lateral line is complete, with vertically arranged accessory pores.

Table 1. Morphometric measurements of *S. aorides* collected during the present study (n= No. of individuals)

Morphometric characters	Type locality Erode (n=30)	Bhavani River (n=30)	Bharathappuzha River (n=20)
% Standard length			
Head length	26.7-30.3	26.1-30.1	27.0-29.6
Head depth	9.5-13.7	10.5-12.9	10.8-13.5
Head width	10.4-13.2	13.2-15.6	11.0-14.9
Body depth at dorsal origin	14.2-19.5	15.3-20.4	13.6-18.0
Body depth at anal origin	10.1-12.4	10.5-12.4	9.3-12.8
Pre-dorsal length	38.3-42.7	38.1-43.1	37.7-42.3
Pre-pectoral length	22.8-26.6	23.2-27.2	23.3-28.2
Pre-pelvic length	50.9-55.6	48.6-53.8	49.7-55.8
Pre-anal length	70.4-76.0	71.7-75.0	71.2-76.0
Length of dorsal fin	22.3-25.4	24.1-28.2	13.1-25.1
Height of adipose	3.8-5.4	4.1-5.7	3.4-5.0
Length of pectoral fin	14.8-19.6	16.0-20.7	12.4-18.0
Length of pelvic fin	14.1-16.9	15.5-16.6	13.4-16.4
Length of anal fin	10.1-16.4	14.5-16.4	12.7-15.5
Length of dorsal spine	17.8-23.3	16.4-22.7	17.2-22.9
Length of pectoral spine	13.6-17.0	12.5-17.5	12.3-16.8
Length of base of dorsal	13.0-15.4	13.1-15.7	12.6-16.1
Length of base of adipose	21.3-25.6	20.9-25.9	20.2-25.7
Length of base of anal	9.0-11.0	9.5-14.6	8.9-11.0
Length of base of pectoral	3.7-4.9	3.3-5.5	3.1-4.6
Length of base of pelvic	2.6-3.8	2.1-4.0	2.5-3.4
Post adipose distance	13.5-17.0	14.4-16.9	13.5-16.9
Length of caudal peduncle	15.5-19.2	14.8-16.5	15.0-19.2
Depth of caudal peduncle	5.7-6.9	5.4-5.7	4.5-6.7
Distance from dorsal to adipose	8.1-11.9	6.9-11.1	7.9-13.0
Width at dorsal	10.4-16.0	11.4-15.5	8.9-14.8
Width at anal	4.4-7.8	6.0-7.6	4.1-7.7
Width of caudal peduncle	2.7-3.9	2.0-3.9	2.7-4.1
% Head length			
Head depth	40.4-48.0	39.3-45.6	38.0-48.4
Head width	37.1-45.9	46.7-55.3	40.9-52.5
Snout length	38.7-43.2	38.2-41.4	38.5-41.6
Interorbital distance	19.5-24.5	16.9-20.0	15.8-22.1
Eye diameter	12.0-17.3	11.3-15.0	8.5-14.6
Nasal barbel length	30.9-42.1	30.1-38.8	26.5-39.7
Maxillary barbel length	351.8-430.4	303.2-412.2	284.2-374.7
Inner mandibular barbel length	33.2-45.1	35.4-44.9	29.7-48.0
Outer mandibular barbel length	77.3-105.0	83.7-94.0	61.7-98.0

Table 2. Meristic data of *S. aorides* collected during the present study (n = No. of individuals)

Meristics	Erode (n=30)	Bhavani river (n=30)	Bharathappuzha River (n=20)
Unbranched dorsal fin rays	II	II	II
Branched dorsal fin rays	7	7	7
Unbranched pectoral fin rays	I	I	I
Branched pectoral fin rays	9-10	9-10	9-10
Unbranched pelvic fin rays	15	15	15
Branched pelvic fin rays	III-IV	III	III-IV
Unbranched anal fin rays	10	10	10
Branched anal fin rays	1,7,8,I	1,7,8,I	1,7,8,I
Caudal fin rays	5-6	5-6	5
Gill rakers on upper lobe	14-16	15-17	15-16
Gill rakers on lower lobe	26	26	26
Precaudal vertebrae	22	22	21
Caudal vertebrae	48	48	47

The head is elongated, conical, and dorsoventrally depressed, with a rounded snout. The upper jaw bears two distinct tooth bands: a truncated, uninterrupted premaxillary band that is exposed when the mouth is closed and a rounded, uninterrupted maxillary band. The lower jaw possesses a single, rounded, interrupted tooth band. (Fig. 4). The eye is ovoid and located dorso-laterally. Cranial bones are visible dorsally, beneath a thin layer of skin. The supraoccipital process is not connected to the basal bone of the dorsal fin and is separated from the first dorsal fin pterygiophore by an interneural shield. Dorsal fin is located closer to the snout than the caudal peduncle, and a distinct black spot is present at its origin. The dorsal fin comprises two spines and seven branched rays; the first spine is short, while the second is a longer spine and bears 13-19 serrations. The adipose fin is well developed and exhibits a dark spot at its lower posterior end.

Pectoral fin bears a spine with 20–26 serrations and 9–10 branched rays. Pelvic fin consists of one unbranched and five branched rays. Anal fin comprises four unbranched and eight branched rays. Anus and urogenital openings are positioned vertically at the midpoint of the adpressed pelvic fin. Urogenital opening is distinct from the anus and is elongated and conical in males. The anal fin base

originates ventrally beneath the posterior half of the adipose fin. Caudal fin is forked, with the upper lobe bearing seven branched rays and the lower lobe bearing eight branched rays. Maxillary barbel is

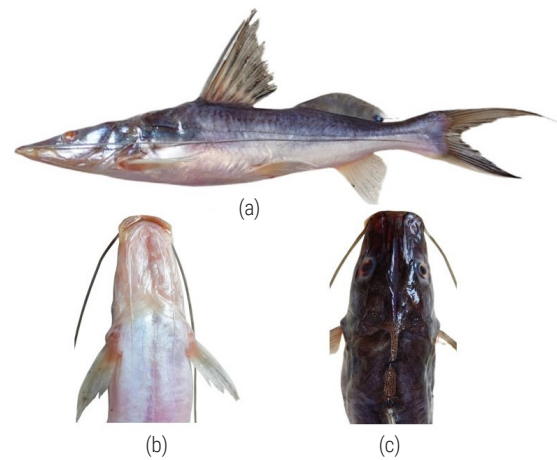


Fig. 3. *S. aorides* (SL: 270 cm) from the Bharathappuzha River in the Southern Western Ghats, India. (a) Lateral view; (b) Ventral view; (c) Dorsal view

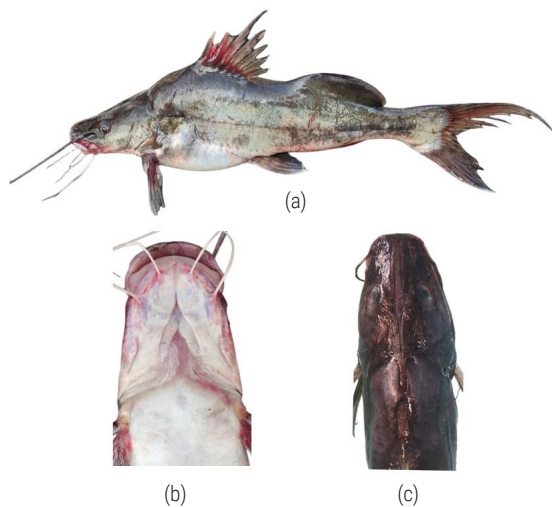


Fig. 2. *S. aorides* (SL: 305 cm) from the Cauvery River in the Southern Western Ghats, India. (a) Lateral view, (b) Ventral view, (c) Dorsal view

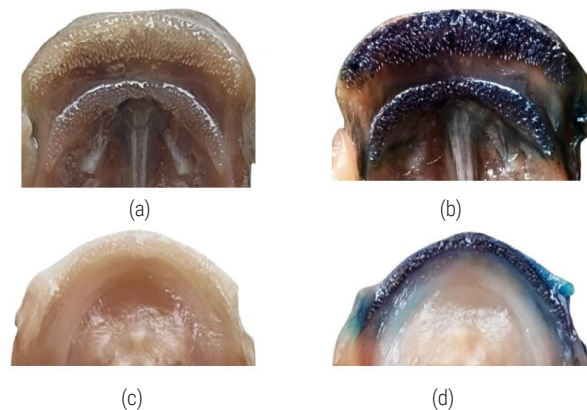


Fig. 4. Tooth patterns of *S. aorides*. (a) Upper jaw (unstained); (b) Upper jaw (stained); (c) Lower jaw (unstained); (d) Lower jaw (stained)

slender, long, and extends to the caudal fin rays. Nasal barbel short and reaches the eye. Outer mandibular barbel originates slightly posterior to the inner mandibular barbel and extends beyond the base of the pectoral fin rays, whereas the inner mandibular barbel is shorter. There are five gill rakers on the upper limb and 14–16 gill rakers on the lower limb of the first gill arch.

### Fresh specimen colouration

Fresh specimens are bluish-grey dorsally, silvery along the sides, and pale white ventrally. A distinct black spot is present at the posterior end of the adipose fin. Vertical black pigmentation occurs along the lateral line, and black chromatophores are scattered across the fins, including the caudal fin.

### Vertebral count

Vertebral counts of samples from the Cauvery and Bharathappuzha Rivers revealed distinct counts. The average total number of vertebrae differed between populations (48 in Cauvery vs 47 in Bharathappuzha). The number of pre-caudal vertebrae remained constant (26), whereas the number of caudal vertebrae varied from 22 in Cauvery to 21 in Bharathappuzha (Fig. 5).

### Molecular analysis

The maximum likelihood (ML) phylogenetic tree revealed that sequences generated in the present study together with those retrieved from NCBI formed a distinct clade (clade A), confirming the species identity of *S. aorides*. *S. aorella* clustered as clade B (with a genetic distance of 4.6%), indicating its closest relationship with *S. aorides*. *S. lamarii* formed clade C (genetic distance: 9.1%), followed by *S. seenghala* (clades D1–D3; genetic distance: 9.4–9.8%) and *S. aor* (clade E; genetic distance: 10.1%). The outgroup *H. punctatus* showed a genetic distance of 17.5% from *S. aorides* (Fig. 6).

## Discussion

Precise taxonomic identification is essential for effective conservation and fishery resource management. Morphometric and meristic analyses have traditionally formed the basis for species identification and classification of fishes (Triantafyllidis *et al.*, 2011; Shen *et al.*, 2016). However, morphological similarities among species of Bagridae often complicate accurate identification (Li *et al.*, 2011), highlighting the need to integrate COI gene barcoding and morphological analyses.

The genus *Sperata* is one of the taxonomically complex groups within the family Bagridae. Its classification has undergone several revisions, transitioning from the genus *Bagrus* to the currently accepted genus *Sperata*, largely due to historical misnomenclatures and frequent misidentifications. *S. aorides* was originally described by Jerdon (1849) as *Bagrus aorides* from the Cauvery River at Erode. Subsequently, Day (1875) synonymised *B. aorides* with *Macrones aor* without a comprehensive taxonomic evaluation. This view was later supported by Ferraris and Runge (1999), primarily based on a limited set of morphological characters, such as maxillary barbel length and adipose fin position. However, Kumar *et al.* (2021) re-evaluated *Sperata* specimens from the Cauvery River and revalidated them as *S. aorides* establishing its taxonomic distinctiveness.

In the present study, a comprehensive taxonomic comparison of *S. aorides* with its congeners was conducted. *S. aorides* differs from *S. lamarii* in having a roughly conical snout (vs a truncate snout), the maxillary barbel extending to the base of the caudal fin (vs extending only slightly beyond the dorsal fin base), and a higher number of gill rakers (5–6 vs 4–5 on the upper limb; 14–16 vs 11 on the lower limb). It also differs in having fewer precaudal vertebrae (26 vs 28), a longer snout (38.7–43.2% vs 28.3–29.5% of head length, HL), adipose fin base 21.3–25.6% vs 13.1–15.0% of standard length (SL), greater inter-orbital width (19.5–24.5% vs 18.2–19.3% of HL), and greater head depth at the nape (40.4–48.0% vs 35.3–36.7% HL) (Kumar *et al.*, 2021).

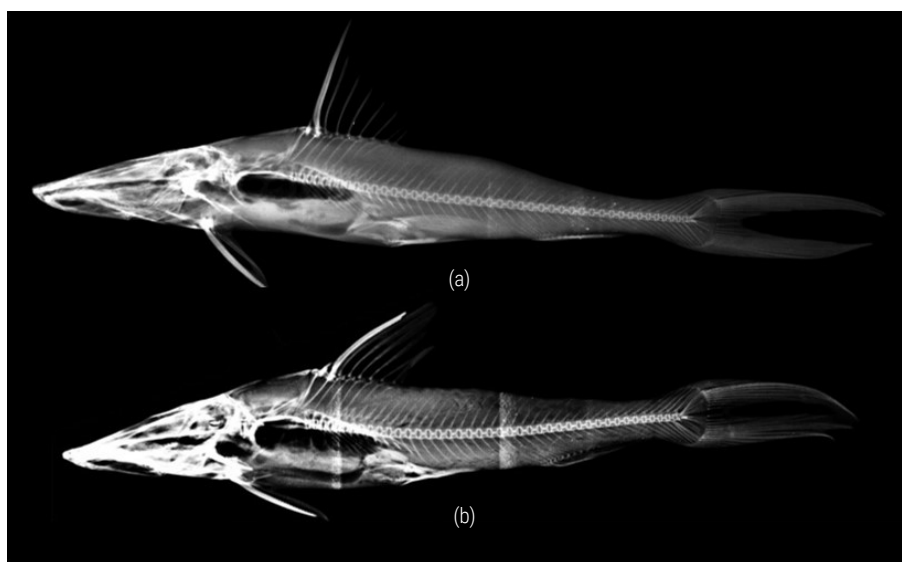


Fig. 5. X-ray images of *S. aorides*. (a) Specimen from the Cauvery River (SL:305 mm); (b) Specimen from the Bharathappuzha River (SL:270 mm)

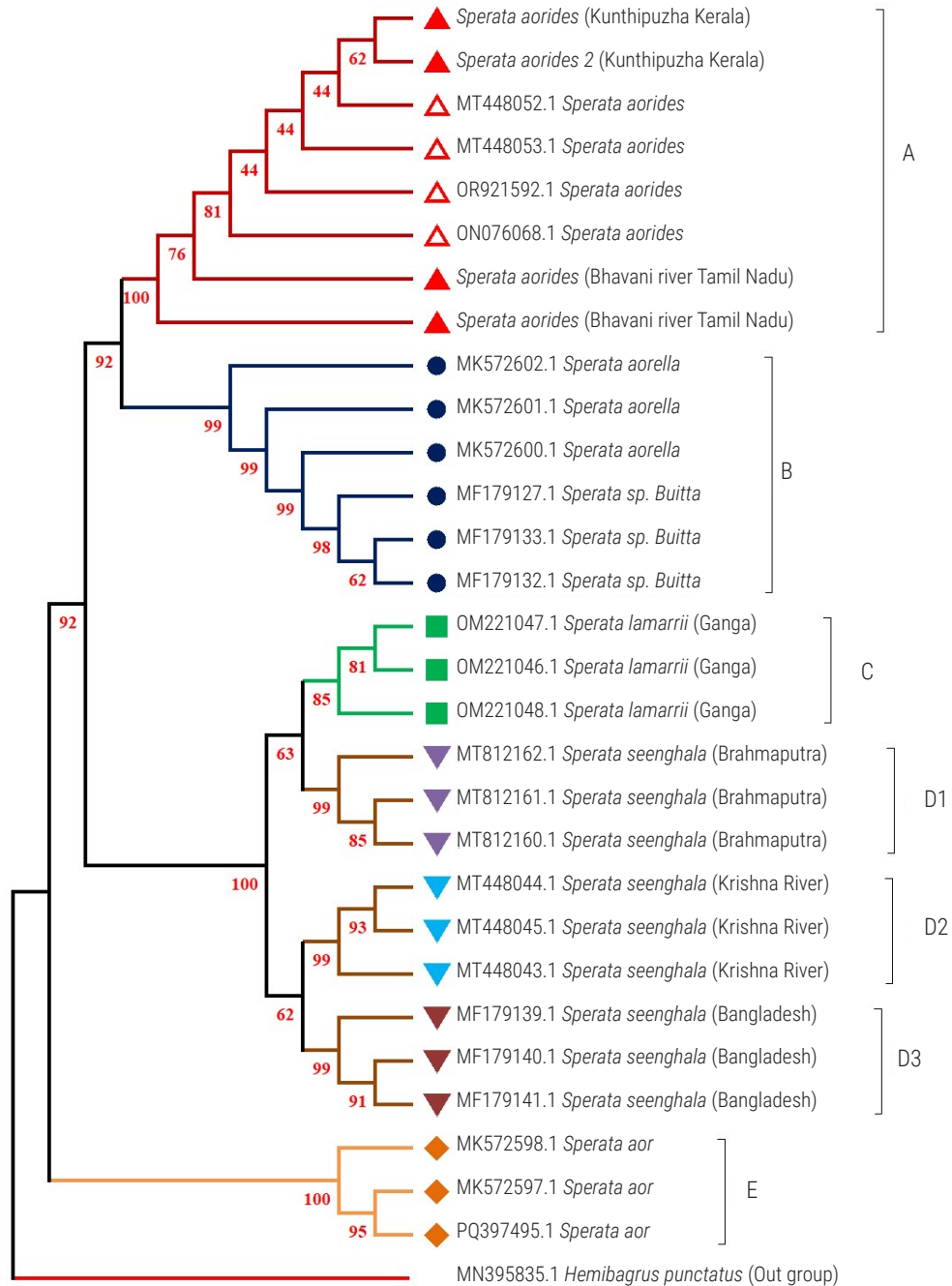


Fig. 6. Maximum likelihood (ML) phylogenetic tree of *S. aorides* and related *Sperata* species based on the mitochondrial COI gene using the Kimura 2-parameter (K2P) model with 1000 bootstrap replicates

Compared with *S. aor*, *S. aorides* is distinguished by a subterminal mouth (vs. an inferior mouth), a roughly conical snout (vs. a rounded snout), and a maxillary barbel that reaches the caudal fin (vs. one that extends only to the adipose fin base). It also differs in having fewer pre-caudal vertebrae (26 vs. 28) and total vertebrae (47–48 vs. 50–52), a slightly shorter adipose fin base (21.3–25.6% vs. 22.5–22.6% SL), a larger eye diameter (12.0–17.3% vs. 10.9–12.7% HL), and a smaller interorbital width (19.5–24.5% vs. 24.2–26.0% HL) (Kumar et al., 2021).

*S. aorides* further differs from *S. seenghala* in having a subterminal mouth (vs. inferior), fewer pre-caudal vertebrae (26 vs. 27–29), total vertebrae (47–48 vs. 50–52), a longer snout (38.7–43.2% vs. 31.5–43.5% HL), greater interorbital width (19.5–24.5% vs. 15.4–21.7% HL), and a longer adipose fin base (21.3–25.6% vs. 17.6–26.8% SL) (Kumar et al., 2021). It can be distinguished from *S. aorella* by the presence of a rounded snout (vs. somewhat truncate snout), larger eye diameter (12.0–17.3% vs. 9.2–13.6% HL), shorter head length (26.7–30.3% vs. 31.9–35.2% SL), shorter pre-dorsal length

(38.3–42.7% vs. 45.2–49.2% SL), longer adipose fin base (21.3–25.6% vs. 16.5% SL), and longer caudal peduncle length (15.5–19.2% vs. 14.9% SL) (Kumar *et al.*, 2021). Similarly, *S. aorides* differs from *S. acicularis* in having fewer total vertebrae (47–48 vs. 51–54), shorter head length (26.7–30.3% vs. 30.7–33.7% SL), shorter pre-dorsal distance (38.3–42.7% vs. 43.7–47.4% SL), and longer snout length (38.7–43.2% vs. 34.3–37.7% HL) (Ferraris and Runge, 1999). Intraspecific variation was observed among populations. Specimens from the Cauvery River exhibited lower pre-dorsal length (38.3–42.7% SL vs. 40.7–42.2% SL) and pre-pelvic length (50.9–55.6% SL vs. 51.7–57.4% SL) compared to those reported by Kumar *et al.* (2021), indicating a relatively shorter anterior body region. Specimens from the Cauvery River also differed from those from the Bhavani River in having greater pre-pelvic length, inter-orbital width, and eye diameter. Notably, *S. aorides* is reported for the first time from the Bharathappuzha River, representing a significant range extension. Specimens from Bharathappuzha differed from Cauvery populations in having smaller inter-orbital width (15.8–22.1% vs. 19.5–24.5% HL) and smaller eye diameter (8.8–17.9% vs. 12.0–17.3% HL).

Morphological variation among populations may be influenced by environmental factors, such as habitat conditions, water flow, and food availability (Cadrin, 2000; Bhavadharani *et al.*, 2025; Turan *et al.*, 2005). However, morphological similarity among closely related and cryptic species, along with sexual dimorphism, often complicates species identification based on morphology (Hebert *et al.*, 2003; Tyagi *et al.*, 2017; Sowmiya *et al.*, 2025). DNA barcoding has emerged as a powerful tool for resolving taxonomic ambiguities and has significantly contributed to global databases, such as GenBank (Lakra *et al.*, 2016). In the present study, a phylogenetic analysis revealed that *S. aorides* (from the Cauvery and Bharathappuzha rivers) forms a monophyletic clade with low intraspecific genetic divergence (0.19%). *S. aorella* was identified as the closest congener (4.6%), followed by *S. lamarrii* (9.1%), *S. seenghala* (9.4–9.8%), and *S. aor* (10.1%).

Previous studies have reported misidentifications in public databases. For instance, sequences of *Sperata* sp. (GenBank: MF179127–MF179133) from Bangladesh were incorrectly identified as *S. seenghala* without morphological validation (Iqbal *et al.*, 2018). In the present study, some of these sequences showed closer affinity to *S. aorella*. Similarly, earlier studies (Kumari *et al.*, 2017; Acharya *et al.*, 2019) treated multiple *Sperata* species as *S. seenghala* due to a lack of taxonomic resolution. Kumar *et al.* (2021) later confirmed that *S. seenghala* is restricted to the Krishna River. Therefore, integrative taxonomic approaches combining morphology and molecular data are essential for accurate species delineation within the genus *Sperata*.

Historically, *S. aorides* has been considered endemic to the Cauvery River Basin and was originally described by Jerdon (1849) from the Cauvery River, likely at Erode. Earlier records indicated its occurrence primarily in the stretch between Hogenakkal and the Bhavani River (Jerdon, 1849; Kumar *et al.*, 2021). In the present study, a greater number of specimens were recorded from the Bhavani River compared to previous reports. Additionally, the species has been documented from the Bharathappuzha River, representing a significant range extension. These findings suggest that *S. aorides* can be considered endemic to the southern Western Ghats.

The present study provides a detailed taxonomic account and phylogenetic validation of *S. aorides*, clearly distinguishing it from its congeners. It also highlights intraspecific variation across populations from different river systems. Understanding such variation is crucial for effective fisheries management and conservation planning. Further studies on population structure, length–weight relationships, and reproductive biology are recommended to support sustainable management and aquaculture development of *S. aorides*.

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