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Original Article

# Delineation of seven species of genus *Channa* from upper Assam region, India using sagittal otolith morphology

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**Abstract**

Morphology of sagittal otoliths of seven species of genus *Channa* from upper Assam, India was studied to obtain baseline information for their prospective role in taxonomic studies. In the present study, variations were recorded in morphological characteristics of sagittal otolith among the studied species. Of all the studied parameters, otolith shape, sulcus acusticus, ostium, and cauda, in particular, were found to be taxonomically important features for the identification of the species. The pentagonal shape of sagitta in *Channa punctata*, pseudo-ostiocaudal sulcus acusticus in *C. marulius*, bent concave ostium in *C. stewartii*, straight cauda in *C. bleheri* were found to be species-specific features. Sagitta size was smallest in *C. gachua* while the largest was recorded in *C. striata*. The proposed taxonomic keys enumerated through the combination of different otolith characters from the present investigation will be useful in the identification of these species when standard methodologies fail to deliver satisfactory results.

**Keywords:** Identification; sagittal otoliths; snakehead taxonomy; taxonomic keys; variation

## 1 | INTRODUCTION

Snakeheads belonging to Channidae family are predatory air-breathing fishes well distributed in African and Asian continents (Ruber *et al.* 2020). Three distinct genera *viz. Parachanna*, *Channa*, and recently discovered *Aenigmachanna* together comprises about 51 valid species (Conte-Grand *et al.* 2017; Britz *et al.* 2019; Kumar *et al.* 2019; Praveenraj *et al.* 2019a). Among the three genera, genus *Channa* has the highest species diversity with 46 valid species (Praveenraj *et al.* 2019a). 22 valid species of *Channa* have been reported from India, out of which 19 are found in the Eastern Himalayan region (Praveenraj *et al.* 2019a). Vishwanath and Geetakumari (2009) earlier reported nine channid species from the region and described its diagnostic characters. However, samples collected from aquarium trade indicated greater diversity of snakehead fishes from the region. Within a decade, ten new species of *Channa* have been discovered from Eastern Himalayan region of India that includes *C. melanostigma* (Geetakumari and Vishwanath 2010), *C. andrao* (Britz 2013), *C. pardalis* (Knight 2016), *C. aurantipectoralis* (Lalhlimpuia 2016), *C. quinquefasciata* (Praveenraj *et al.* 2018a), *C. bipuli* (Praveenraj *et al.* 2018b), *C. pomanensis* (Gurumayum and Tamang 2016), *C. stiktos* (Lalramliana *et al.* 2018), *C. lipor* (Praveenraj *et al.* 2019b) and *C. brunnea* (Praveenraj *et al.* 2019a). Due to its high diversity and species complexes, it is observed that their taxonomy is often complicated, over lumping, and grouped into phylectic groups (Vishwanath and Geetakumari 2009; Conte-Grand *et al.* 2017). Identification based solely on morphological characters and modern molecular techniques are sometimes challenging and have their share of limitations (Adamson *et al.* 2010; Lalramliana *et al.* 2018). In such situations, otolith morphology emerges as a promising taxonomic tool in discriminating many extant fishes (Nolf 1985; Smale *et al.* 1995).

Otoliths are aragonitic mineralisation found in teleosts fishes. They are composed of calcium carbonate and 0.2 to 10% organic matter and serves as an organ of balancing and hearing in fishes (Platt and Popper 1981; Gauldie 1988; Campana 1999). The otoliths are categorised into three distinct classes: lapillus, asteriscus, and sagitta, of which the sagitta is the largest (Zorica *et al.* 2010). Among the three types, sagitta otoliths show the highest degree of morphological variation and often are found to be species-specific (Battaglia *et al.* 2010; Kumar *et al.* 2012; Jaramillo *et al.* 2014). Due to such variations in morphological features, they are widely employed in different aspects of fish systematics (Lombarte *et al.* 1991; Smale *et al.* 1995; Volpedo and Echeverria 2000). Application of sagitta in extrapolating fish sizes and identity have often proved to be a reliable taxonomic tool, especially in situations where other methods fail to deliver conclusive inferences (Lombarte *et al.* 2006; Tuset *et al.* 2011). Further, it has been observed that information on sagittal otolith morphology is available only for commercially important marine fishes (Battaglia *et al.* 2010). There is a paucity of knowledge and data on the sagitta morphology of freshwater fishes (Sonowal *et al.* 2018). With this concern, the current investigation was undertaken to study the sagittal otolith morphology of seven species of *Channa* from upper Assam which may aid as a taxonomical tool for their identification.

## 2 | METHODOLOGY

Total 164 specimens belonging to seven species of genus *Channa* including *C. aurantimaculata* Musikasinthorn, 2000 (*n* = 18); *C. bleheri* Vierke, 1991 (*n* = 15); *C. gachua* (Hamilton 1822) (*n* = 26); *C. punctata* (Bloch, 1793) (*n* = 30); *C. marulius* (Hamilton, 1822) (*n* = 17); *C. stewartii* (Playfair, 1867) (*n* = 26) and *C. striata* (Bloch, 1793) (*n* = 32) were examined during the current study. Fish specimens were collected from eight different sampling stations of Dibrugarh (Bogibeel, Dibrugarh University pond, Lezai, Madhupur, Maijaan and Merbeel) and Tinsukia districts (Guijan and Maguri beel) of upper Assam, India, during March 2018 to May 2019 (Figure 1). The collected specimens were first preserved in 10% formalin and analyses were carried out at the Freshwater Biology Research Laboratory, Department of Life Sciences, Dibrugarh University. Sagittal otoliths of the fish were then dissected out from otic capsules and then washed in 70% ethanol. Both left and right otoliths were stored in separate plastic vials for further investigations. Sagitta size was measured to the nearest 0.01 mm using a digital vernier caliper. The morphological description of otoliths was described following Tuset *et al.* (2008) under microscopic examination. The following anatomical terminologies were used for variation studies, (i) otolith shape (ii) sulcus acusticus (iii) ostium (iv) cauda (v) anterior and posterior otolith regions (vi) otolith margin.

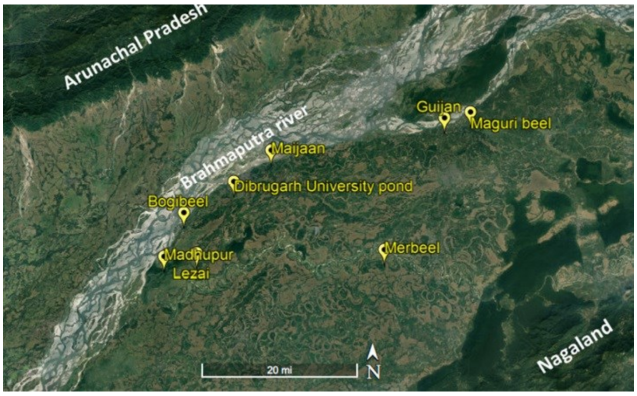


**FIGURE 1** Geographical location of different sampling sites in Dibrugarh and Tinsukia districts of upper Assam, India.

## 3 | RESULTS AND DISCUSSION

The sagittal otoliths find wide application in taxonomical studies of fishes due to their distinct form, weight, growth, consistency, chemical composition, and easy accessibility (Nolf 1985). In fishes, when accepted methodologies through morphological studies do not provide satisfactory results, the otoliths act as an added taxonomic tool to delineate fishes. The current investigation on sagittal characters of seven species of genus *Channa* from upper Assam, revealed variation in its morphological features (Table 1). During the study, the smallest sagitta was observed in *C. gachua* while the largest was found in *C. striata* among the studied species. Earlier, all the studied species had been grouped into two phylectic groups by Vishwanath and Geetakumari (2009) based on their external morphological features to aid in their identification. Species with prominent V-shaped sharp isthmus, grouped sensory pores, as well as the absence of big cycloid scales on lower jaw were designated as 'marulius' group while species with U-shaped isthmus, single sensory pore and presence of one or two big cycloid scales on lower jaw were grouped into 'gachua' group. It was observed that four members of 'gachua' group (*C. bleheri*, *C. gachua*, *C. stewartii* and *C. aurantimaculata*) showed elliptical-shaped sagitta with varying size and shape differences (Table 1). The other three species *i.e. C. punctata*, *C. striata* and *C. marulius* had pentagonal, oval, and spindle-shaped shape respectively (Figure 2). Even though *C. punctata* belonged to 'gachua' group (Vishwanath and

Geetakumari 2009), sagitta shape was different from other members of the same group. The members of 'marulius' group *i.e. C. striata* and *C. marulius* had unique oval shaped and spindle-shaped sagitta respectively.

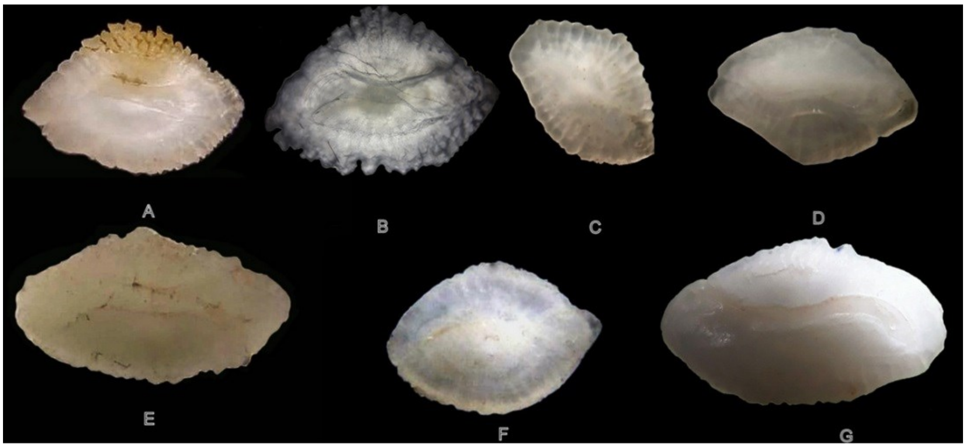


**FIGURE 2** Images of sagittal otoliths of seven studied species of genus *Channa*. A, *Channa aurantimaculata*; B, *C. bleheri*; C, *C. gachua*; D, *C. punctata*; E, *C. marulius*; F, *C. stewartii*; G, *C. striata*).

**TABLE 1** Morphological characteristics of sagitta of seven *Channa* species from upper Assam, India.

| Species | *n* | Total length (mm) (mean±SE) | Otolith size (mm) (mean±SE) | Otolith shape | Sulcus acusticus | Ostium | Cauda | Anterior otolith margins | Posterior otolith margins | Anterior otolith region | Posterior otolith region |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Channa aurantimaculata* | 18 | 173.66 ± 8.39 | 5.58 ± 0.10 | Elliptical | Ostial | Funnel-like | Tubular | Dentate to lobed | Dentate to serate | Double-peaked | Round |
| *Channa bleheri* | 15 | 110.11 ± 2.47 | 3.90 ± 0.11 | Elliptical | Inframedian | Discoidal | Straight | Dentate | Lobed | Irregular | Peaked |
| *Channa gachua* | 26 | 92.21 ± 2.32 | 3.505 ± 0.19 | Elliptical | Ostial | Discoidal | Tubular and curved | Entire | Entire | Double-peaked | Double-peaked |
| *Channa punctata* | 30 | 115.52 ± 4.45 | 5.81 ± 0.18 | Pentagonal | Ostial | Discoidal | Tubular and curved | Entire | Entire | Double-peaked | Round |
| *Channa marulius* | 17 | 187.1 ± 13.83 | 9.34 ± 0.13 | Spindle-shaped | Pseudo-ostiocaudal | Elliptic | Tubular and strongly curved | Lobed to dentate | Entire, irregular to lobed | Round | Round |
| *Channa stewartii* | 26 | 173.66 ± 8.39 | 6.89 ± 0.18 | Elliptical | Inframedian | Bent concave | Tubular | Entire to sinuate | Entire to crenate | Round | Peaked |
| *Channa striata* | 32 | 246.98 ± 11.1 | 9.51 ± 0.32 | Oval | Ostial | Funnel-like | Tubular and curved | Crenate | Crenate | Round | Round |

Gagliano and McCormick (2004) suggested the influence of biotic factors such as food availability on the shape of otoliths, leaving a record of previous feeding conditions. With conformity to reports of earlier studies, our results indicate sagitta otoliths to be species-specific in the studied snakehead species which may find applications in species identification and stock discrimination especially when external morphological examination fails to provide desired results (Gaemers 1984; Nolf 1985; Campana and Casselman 1993; Stransky and MacLellan 2005). Furthermore, characteristics of sulcus acusticus of sagitta are considered to be important diagnostic features in species identification in fishes, especially sulcus opening, the relationship between ostium and cauda and position of sulcus (Tuset *et al.* 2008).

Results of the present investigation showed ostial type sulcus acusticus to be the most common form with four species showing this feature (*C. punctata*, *C. gachua*, *C. striata* and *C. aurantimaculata*).

In both *C. bleheri* and *C. stewartii*, inframedian sulcus acusticus was observed. And *C. marulius* had unique pseudo-ostiocaudal sulcus which may be a species defining character for the species. Reports of earlier studies on sulcus acusticus morphology confirmed it to be a species-specific character finding application as a taxonomic tool (Gaemers 1984; Nolf 1985). *Channa marulius* (elliptic) and *C. stewartii* (bent concave) had unique ostium whereas in other cases it was discoidal to funnel-shaped. Except for *C. bleheri* which had straight cauda, all other species shared tubular cauda with varying degrees of curvedness. Hence, straight cauda may be a species defining character in *C. bleheri*. The anterior and posterior margins were either single or combination of different morphological features (Table 1). The anterior otolith regions were either double-peaked or round in all species except *C. bleheri* which had an irregular pattern. Similarly, the posterior region were either peaked or round with exception to *C. gachua* that had a double-peaked posterior region. These observed variations in sagitta characteristics in all the studied species were analysed and subsequently taxonomic keys were generated and assigned to each species (Table 2). The generated taxonomic keys can be used as taxonomic tool for identification among the studied species.

**TABLE 2** Taxonomic keys for identification of studied species of *Channa* using sagitta morphology.

| Otolith morphological characters | Species |
|---|---|
| Elliptical shaped, funnel-like ostium, dentate to lobed anterior margin, dentate to serate posterior margin | *Channa aurantimaculata* |
| Elliptical shaped, inframedian sulcus acusticus, straight cauda, dentate anterior region, lobed posterior region and irregular anterior region. | *C. bleheri* |
| Elliptical shaped, entire anterior and posterior margins, double-peaked anterior and posterior regions | *C. gachua* |
| Pentagonal shaped, discoidal ostium, entire anterior and posterior margins, double-peaked and round anterior and posterior regions | *C. punctata* |
| Spindle-shaped sagitta, pseudo-ostiocaudal sulcus acusticus, elliptic ostium, tubular and strongly curved cauda | *C. marulius* |
| Elliptical shaped, inframedian sulcus acusticus, bent concave ostium, tubular cauda and peaked posterior region | *C. stewartii* |
| Oval shaped sagitta, funnel-shaped ostium, crenate anterior and posterior margins and round anterior and posterior regions | *C. striata* |

## 4 | CONCLUSIONS

Analysis of morphological characters revealed variation of different otolith characters in all the studied species. Since taxonomical anomalies persist among the members of *Channa*, species-specific features of sagitta elucidated from the present investigation can be used as a taxonomic tool especially in situations where standard protocols fail to deliver satisfactory results. The results of the current study provide new findings on the sagittal morphology of genus *Channa* which will be useful in understanding their biology, ecology, taxonomy as well as management and conservation of these fishes.

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## CONFLICT OF INTEREST

The author declares no conflict of interest.

## DATA AVAILABILITY STATEMENT

Data generated from the present study are available on request to the corresponding author (JS).

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**JS** data collection, analysis and manuscript preparation;
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**SPB** Manuscript preparation and research supervision.

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