Understanding the systematics and ecology of freshwater fish *Clarias batrachus*: A first step towards its Conservation

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Abstract

Fish is a rich source of protein with an estimated consumption per capita of 6.31 kg in India for the year 2021. Moreover, India contributes to about 9.7 % of global fish diversity which means that fishes play an important role in Indian economy. Some very important fish species are being hastily lost due anthropogenic activities, like construction of dams, pollution, overfishing and introduction of invasive species. *Clarias batrachus* is one such species that is being replaced by invasive species *Clarias gariepinus* in most Asian countries . In such a scenario we need to analyze and execute plans encompassing measures for its conservation. The objective of present work is to conserve *C. batrachus,* which is the state fish of Bihar. As we all know that identification of a species is the first step towards its conservation, therefore, we identified *C. batrachus* and *C. gariepinus* using the classical methods of fish identification. This research provides essential insights into the intricate interplay between species identification, conservation, and sustainable utilization, thereby contributing to the broader discourse on aquatic biodiversity management. We observed key differences in the morphological, meristic, and morphometric characteristics of *C. batrachus* and *C. gariepinus*. We defined the diagnostic features of both the species and differentiated between them, which is rather complicated so much so that many sellers get away with selling *C. gariepinus* as *C. batrachus* in local markets. Introduction of *C. gariepinus* has been shown to responsible for decline in numbers of *C. batrachus* from countries like Bangladesh [2] and India [4] therefore it is important to protect this fish. The comprehensive identification protocols used in this study are the standard methods used for identification of fish species and they are valuable as tools for the scientific community for the management and conservation of nutritionally valuable fishes like *C. batrachus*. By identifying and classifying these species carefully we also aim to improve our understanding in relation to their ecology and can contribute to the sustainable cultivation of this freshwater fish and its biodiversity.

Keywords: *Clarias batrachus* (*C. batrachus*), *Clarias gariepinus* (*C. gariepinus*), Morphometric characters, Meristic characters, invasive species, species conservation.

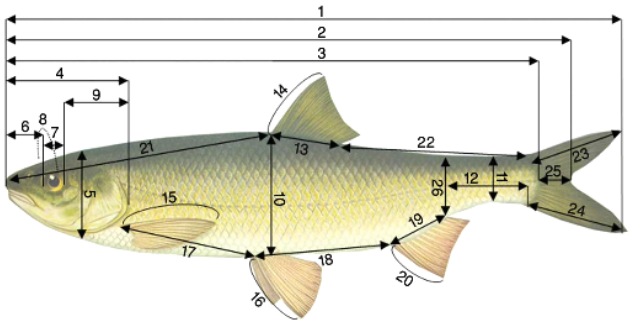
Introduction

Freshwater fish are a vital component of aquatic ecosystems and play a crucial role in human society as sources of food and income generation. Proper identification of these species is a critical aspect in the conservation of species as well as in scientific research. This paper presents a comprehensive detailed study done for the identification and differentiation of the two related freshwater fish species, *C. batrachus* and *C. gariepinus*, found in our fresh water bodies. Both the species are widely distributed in different parts of Asia, namely Pakistan, India, Sri Lanka, Bangladesh, Myanmar (Burma), Thailand, Malaysia, Singapore, Indonesia and Philippines. Numerous studies have investigated freshwater fish species and their distribution, while simultaneously attempting to refine protocols for their identification [1]. However, detailed comparative studies on *C. batrachus* and its similar species *C. gariepinus* have not been exclusively undertaken, and their taxonomic positions and morphological features are often ambiguous. This study aims to provide a comprehensive overview of these two species in terms of their morphology, morphometric, meristic and descriptive characteristics. These two species

are morphologically similar and often confused with each other due to their overlapping geographic ranges and shared habitat preferences, resulting in an urgent need for accurate identification and classification [2,3,4]. Morphological examination forms the basis for fish identification, enabling the distinction of species by analyzing their external structures and comparing them with taxonomic keys [8]. The analysis of counts and measurements of key morphological traits, such as fin rays, gill rakers, and gill slits, provides a foundation for distinguishing between these two species [3,5]. Furthermore, advancements in molecular biology techniques have also provided tools to corroborate morphological data by comparing genetic markers, such as mitochondrial DNA and nuclear genes [6,7, 9]. Combining molecular and morphological evidence not only increases the accuracy of species identification but also sheds light on phylogenetic relationships and evolutionary history [10]. Considering the importance of these two freshwater fish species in terms of their ecological and economic values, their accurate identification is essential. This study fills the gap in understanding of *C. batrachus* and *C. gariepinus*, providing conservationists and fisheries managers with necessary information. The findings generated by this study will aid in conservation efforts, correct population assessments, and contribute to sustainable management strategies for these freshwater organisms.

Methodology

Morphometric Characters (1 to 26)	Meristic characters (27 to 33)



Morphological and meristic characters shown above and on the left by numbers. Abbreviations given in table below.

Phylum: Chordata
Sub-phylum: Vertebrata
Class: Actinopterygii
Order: Siluriformes
Family: Clariidae
Genus: *Clarias*, Species: *batrachus*

Num	Characteristic name	Abbreviated name	Num	Characteristic name	Abbreviated name
1	Total Length	TL	18	Ventral-Anal Distance	VA
2	Fork Length	FL	19	Anal Fin Length	AFL
3	Standard Length	SL	20	Anal Fin Height	AFH
4	Head Length	HL	21	Pre Back Distance	PRB
5	Head Height	HH	22	Post Back Distance	POB
6	Snout Length	SnL	23	Up Caudal Fin Length	UCFL
7	Eye Diameter	ED	24	Down Caudal Fin Length	DCFL
8	Between Eye Distance	BED	25	Center Caudal Fin Length	CCFL
9	Cheek Length	CL	26	Caudal Peduncle Height	CPH
10	Maximum Body Height	MAXH		**Meristic characteristics**	
11	Minimum Body Height	MINH	27	Lateral Line Scales	LLS
12	Caudal Peduncle Length	CPL	28	Up Scales of Lateral Line	USLL
13	Dorsal Fin Length	DFL	29	Down Scales of Lateral Line	DSLL
14	Dorsal Fin Height	DFH	30	Dorsal Fin Spines	DFS
15	Pectoral Fin Length	PFL	31	Dorsal Fin Rays	DFR
16	Ventral Fin Length	VFL	32	Anal Fin Spines	AFS
17	Pectoral-Ventral Distance	PV	33	Anal Fin Rays	AFR

Table 1: List above shows all the morphometric and meristic characters whereas the picture above them mentions their location on the body of fish. Authors studied Morphological characters, morphometric characters, meristic characters and descriptive characters. Definitions of morphometric measurements and meristic counts was adopted from kutum, *Rutilus frissi kutum,* were used for this study [11,12].

Results

1. Morphological characteristics

(a). ***Clarias batrachus*:** Also known as the walking catfish, has several morphological characters that can be used to describe its physical characteristics. It has an elongated body shape. The body length can vary, but it is usually around 30-40 cm (12-16 inches) in adulthood. Head is relatively large as compared to its body size. The length of the head can be measured from the tip of the snout to the posterior edge of the operculum. It has relatively large eyes in proportion to its body. The diameter of the eye can be measured as the distance from the anterior to the posterior edge of the eyeball. The dorsal fin is located on the back, extending from the head to the tail. The length of the dorsal fin is measured as the distance from the anterior to the posterior edge. The pectoral fins are used for locomotion, especially when "walking" on land. The length of the pectoral fins can be measured as the distance from the base to the tip of the fin. The anal fin is located on the ventral side and is used for stability and maneuvering. The length of the anal fin is measured as the distance from the base to the tip of the fin.

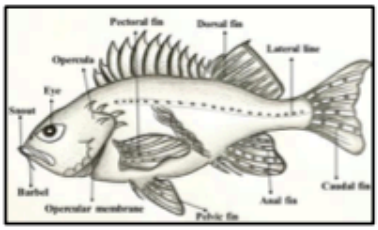


Fig 1: An example of key morphological features of a Bony fish.

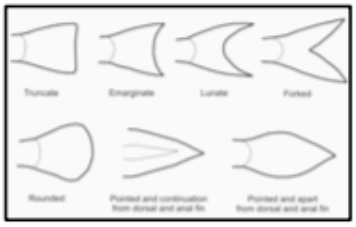


Fig 2: Common caudal fin shapes (Source: Adapted from Rainboth, 1996)

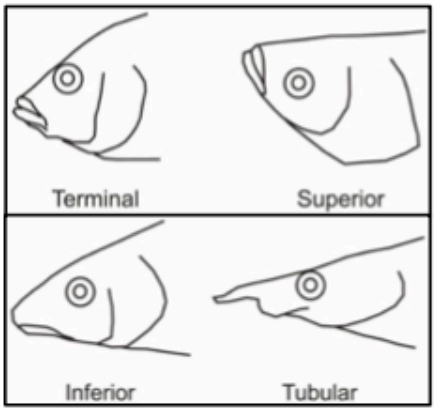


Fig 3: Common mouth types of Fish


Fig 4: *C. batrachus* Pectoral fin


Fig 1.1: showing fish *Clarias batrachus* belongs to Clariidae family


Fig 2.1 *C. batrachus* tail


Fig 3.1: Sub-terminal mouth types


Fig 5: *C. gariepinus* Pectoral fin


Fig 1.2: showing fish *Clarias gariepinus* belongs to Clariidae family


Fig 2.2 *C. gariepinus* tail


Fig 3.2: Terminal mouth types

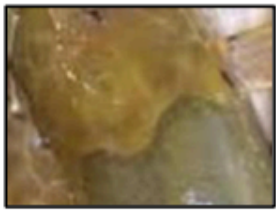


Fig 6: *C. batrachus* Occipita region (lining)

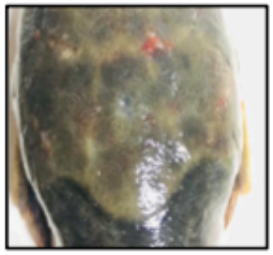


Fig 7: *C. gariepinus* Occipi region (lining)

Figures 1-7: **Morphological Characteristics** of *Clarius batrachus* and *Clarius gariepinus*. **Figure 1** is an example sketch of the key morphological features of bony fishes. Both *Clarius batrachus* and *Clarius gariepinus* belong to Clariidae family. **Figure 2** shows differences between tails of both the fishes. **Figure 3** tells us that *C. batrachus* has a subterminal mouth type whereas *C. gariepinus* has a terminal mouth type. **Figure 4** and **5** show pectoral fins and **Figure 6** and **7** show differences in the occipital region of the two fishes.

(b). ***Clarias gariepinus***: It is also known as the African sharp-tooth catfish, is a relatively large catfish species and can grow up to 1.5 meters (5 feet) in length. Head of is relatively large in proportion to its body size. It has large eyes in proportion to its body. The dorsal fin is located on the back, extending from the head to the tail. The pectoral fins are used for locomotion and stability. The anal fin is located on the ventral side and is used for stability and maneuvering.

Process of acquiring data for species identification

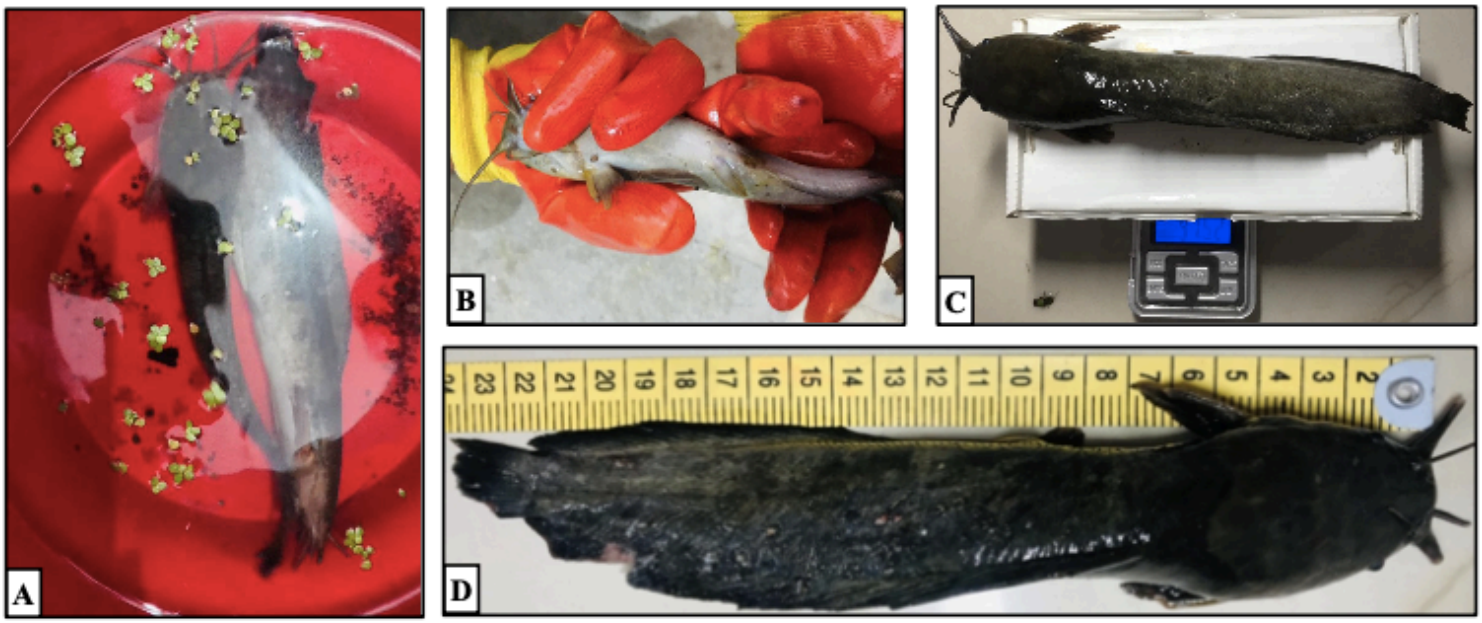


Figure 8: (A) Process of giving anesthesia using clove oil. (B) Fish transfer (C) Measurement of weight (D) Measurements of lengths and counting of spines and rays.

The Morphometric data table comparative

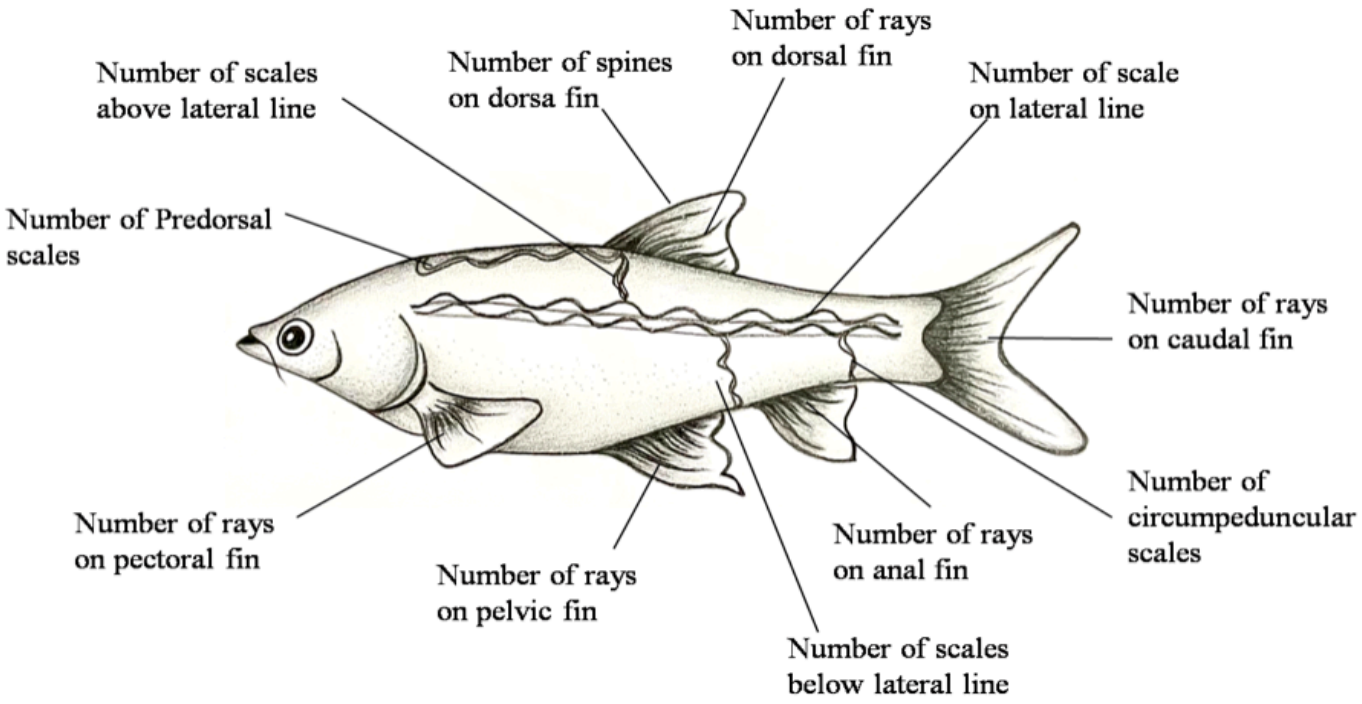
S. No.	Morphometric Measurement	Abbreviation	*Clarius batrachus*	*Clarius gariepinus*
1	Total Length	TL	17-30 cm	25-40 cm
2	Standard Length	SL	10-20 cm	15-30 cm
3	Head Length	HL	4-8 cm	5-13 cm
4	Body Depth	BD	3-7 cm	3-12 cm
5	Eye Diameter	ED	0.5-1.5 cm	1-2.5 cm
6	Dorsal Fin Length	DFL	6-12 cm	7-18 cm
7	Anal Fin Length	AFL	7-13 cm	7-20 cm
8	Pectoral Fin length	P1FL	4-6 cm	4-12 cm
9	Pelvic Fin Length	P2FL	3-6 cm	3-12 cm
10	Caudal Fin Length	CFL	2-5 cm	2-6 cm

Table 2: Morphometric characters and their count as observed in *C. batrachus* and *C. gariepinus*.

2. Meristic Characters

Meristic characters involve quantitative examination and analysis of the counts and numbers of various discrete body structures and characteristics such as the number of fin rays, scales and other anatomical elements. There are several differences in the meristic characters of *C. batrachus* and *C. gariepinus* as listed below.

1. *Number of dorsal fin rays*: We observed that *C. batrachus* typically has 55-65 dorsal fin rays, whereas *C. gariepinus* usually has 68-98 dorsal fin rays.
2. *Number of anal fin rays*: 38-50 for *C. batrachus* and 45-65 for *C. gariepinus.*
3. *Number of pectoral fin rays*: For *C. batrachus* 12-16 whereas for *C. gariepinus* typically 12-17 pectoral fin rays were found.
4. *Number of gill rakers*: *C. batrachus* typically has 18-30 gill rakers, whereas *C. gariepinus* usually has 23-25 gill rakers: *C. batrachus* typically has 21.26 whereas *C. gariepinus* usually has 20-27.
5. *Number of scales along the lateral line*: *C. batrachus* generally has 104-120 scales along the lateral line, while *C. gariepinus* usually has 90-105 scales along the lateral line.
6. *Number of vertebrae*: *C. batrachus* usually has 46-49 vertebrae, while *C. gariepinus* typically has 41-44 vertebrae. It's important to know that these differences can vary within populations.



Figures 9: **Meristic Characteristics** of *Clarius batrachus* and *Clarius gariepinus*. It involves the quantitative examination and analysis of the contents and numbers of fin rays, scales and other countable anatomical elements.

S. No.	Meristic Characters	*Clarius batrachus* counts	*Clarius gariepinus* counts
1	Dorsal Fin	55-65	68-90
2	Anal Fin	38-50	45-65
3	Pectoral Fin	12-16 (Strong serration)	12-17 (Less pronounced)
4	Pelvic Fin	6-8	7-9
5	Gill racker	18-30	23-45
6	Caudal Fin	21-26	20-27

Table 3: Meristic characters and their count as observed in *C. batrachus* and *C. gariepinus*.

3. **Descriptive Characters**

We looked and compared 6 descriptive characters to identify *C. batrachus* and *C. gariepinus* as different species.1) *Body Shape*: *C. batrachus* has a more elongated and slender body shape as compared to *C. gariepinus*, which has a stockier and more robust body. 2) *Coloration*: *C. batrachus* typically has a darker, almost blackish coloration with distinct lighter spots or blotches on its body. *C. gariepinus*, on the other hand, usually has a lighter, brownish coloration with dark blotches or bands. 3) *Head Shape*: *C. batrachus* has a flat type head with a concave profile between the eyes, while *C. gariepinus* has a more rounded head with a convex profile. 4) *Mouth Position*: *C. batrachus* has a more inferior mouth, meaning it is located closer to the underside of the head, whereas *C. gariepinus* has a more terminal mouth, positioned towards the front of the head. 5) *Eye Size*: *C. batrachus* generally has larger eyes compared to *C. gariepinus*. 6) *Fin Shape*: *C. batrachus* has a longer and more pointed dorsal fin, whereas *C. gariepinus* has a shorter and more rounded dorsal fin. These descriptive characters can vary within populations.

4. Modern methods of species identification

Apart from the classical methods described above there are other more advance techniques that help in species identification. SSR markers from low depth genome sequence of *C. batrachus* have been used for their characterization [24]. Genetic identification using DNA markers like mitochondrial COI sequences are done in fishes belonging to family Clariidae [25, 26]. Both *C. batrachus* and *C. gariepinus* fishes explained here belong to this family. Some identification studies are based on enzyme producing ability of *C. batrachus* [27]. In addition for commercially important catfishes scientists have employed DNA barcoding technique as well [28, 29, 30]. Cell based and electroreceptors-based studies are also being employed in the area of species identification [31,32]. All these new techniques make the process of species identification even more reliable.

Conclusion

C. batrachus and *C. gariepinus* are both species of catfish having some very fine differences. Their habitats differ. *C. batrachus*, also known as the walking catfish, is native to Southeast Asia and can be found in swamps, ponds, and rice fields. On the other hand, *C. gariepinus*, is found in freshwater environments across Africa, including rivers, lakes, and reservoirs [21]. In terms of appearance, *C. batrachus* has a more elongated body shape and a distinct pattern of dark spots on its body, while the African sharptooth catfish *C. gariepinus* has a more uniform coloration, usually a dark grey or brown. Another difference is in their behavior. *C. batrachus* is known for its ability to breathe air and can survive out of water for extended periods of time. It is capable of "walking" on its pectoral fins to move between bodies of water. On the other hand, *C. gariepinus* is not known for its ability to breathe air or walk on land. In terms of size, *C. gariepinus* is generally larger than *C. batrachus*. It can grow up to 1.5 meters (5 feet) in length and can weigh over 60 kilograms (130 pounds), while *C. batrachus* is usually smaller, reaching lengths of around 30-40 centimeters (12-16 inches). A lot of studies are being done on these fishes owing to the kind of impact they have on the native ecosystem. *C. batrachus* is being replaced by the invasive and fast-growing species *C. gariepinus* [16. 17, 18, 19, 20]. Understanding the systematic and ecology of the freshwater fish *C. batrachus* holds significance because only after their identification a strategy to conserve them can be designed and then implemented. Given the fact that *C. batrachus* is showing alarming decline rates recently. This species faces the imminent threat of decreasing populations, exacerbated by the rapid proliferation of *C. gariepinus* [14,15], and therefore urgent action is required [22,23]. The future prospects for *C. batrachus* conservation lie in its better identification and comprehensive ecological study for species restoration and conservation. By diverting attention away from the flourishing *C. gariepinus* species and directing efforts towards

the preservation of *C. batrachus*, we can pave the way for its protection and ensure the long-term survival of this vulnerable freshwater fish. Being an invasive species *C. gariepinus* has been banned from being sold it markets but their similarities to *C. batrachus,* keep them proliferating and replacing the other species. Special fish breeding centers must be established to selectively breed and culture *C. batrachus.* Only then one can hope to see them in markets in coming future.

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Conflict of Interest

Authors declare no conflict of interest.

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