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Diversity and incidence of cestode parasites in freshwater fishes of the Krishna River basin, western Maharashtra

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Abstract
Fishes play a crucial role in meeting the growing protein demands of the rapidly increasing global population, making them a vital source of nutrition and an economically significant resource. However, the presence of parasites in fish can negatively impact their production and quality, thereby affecting the aquaculture industry. This study aimed to examine the incidence of cestode parasites in fish species from the Krishna River Basin, Western Maharashtra. Fish were collected from various sites in the Satara, Sangli, and Kolhapur Districts. The species examined included *Mastacembelus armatus*, *Labeo rohita*, *Clarias batrachus*, *Channa punctatus*, and *Wallago attu*. A total of 268 fishes were dissected and examined for parasites, with 102 of them were found to be infected. In total, 134 cestode parasites were collected and preserved in 4% formalin for further study. The highest incidence of infection was observed during the summer, followed by winter, with the lowest occurrence noted in the rainy season.

Keywords: Krishna River, freshwater fishes, cestode parasites, incidence

Introduction
The Krishna River is one of the largest rivers in India, flowing through Maharashtra, Karnataka, Telangana, and Andhra Pradesh before ultimately merging into the Bay of Bengal. Originating in Mahableshwar, (Jor Village) located in the Satara district of Maharashtra; the river traverses the Sangli and Kolhapur districts, enriching the region with abundant water resources that support both agriculture and fisheries. Fisheries play a crucial role in providing food, employment, and economic stability for present and future generations. The nutritional and medicinal benefits of fish have been recognized for centuries, as they serve as an excellent source of proteins, vitamins, and minerals. Additionally, fishes are considered a vital protein source, particularly for economically disadvantaged populations (Mishra and Sharma, 2004) [1].

Under natural conditions, 50-90% of freshwater fishes harbor at least one species of parasite (Sieszko, 1975) [2] (Daniel, 1978) [3] (Crompton, 1971) [4] reported that parasitic worms predominantly inhabit the alimentary canal of fish, with a high concentration occurring in the intestine. Severe infections may obstruct the lumen of the alimentary canal, adversely affecting the fish's growth, health, and overall productivity. Edible fish species are often hosts to various cestode parasites, which can significantly impact their health, leading to emaciation, nodular formations on the skin or muscles, inhibited growth, abnormal swimming behavior, and general weakness. As a result, parasitic infections diminish both the market and nutritional value of fish (Sharma, 2016) [5]. In severe cases, these parasites can induce diseases that ultimately lead to the death of the host fish.

In recent years, aquaculture has become a vital contributor to global human nutrition (Chakraborty, 2013) [6], supplying nearly 50% of the fish consumed worldwide and providing livelihoods for more than 20 million people (FAO) [7]. However, many freshwater fish species are severely affected by parasitic infections, leading to high mortality rates, decreased aquaculture productivity, and negative economic impacts [8].

Research on freshwater fish parasites remains relatively limited, yet their identification is crucial for understanding disease etiology. Establishing parasite diversity enables

the identification of disease-causing agents and their pathogenic effects, facilitating better disease management. Assessing parasite prevalence in fish across different water bodies helps determine infection risks, which is essential for maintaining fish health. To meet the rising protein demands of a growing population, enhancing fish production and promoting sustainable aquaculture practices are imperative. This study contributes to these efforts by investigating the incidence of cestode parasites in freshwater fish species from the Krishna River Basin, Western Maharashtra. This study also provides insights into aquatic health, biodiversity conservation, and zoonotic risks.

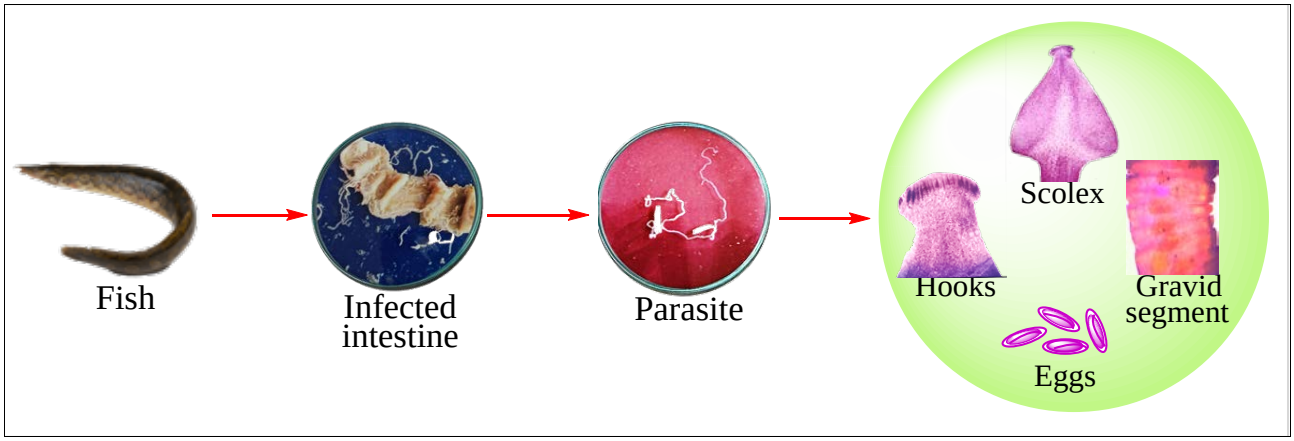

Fig 1: Graphical Abstract

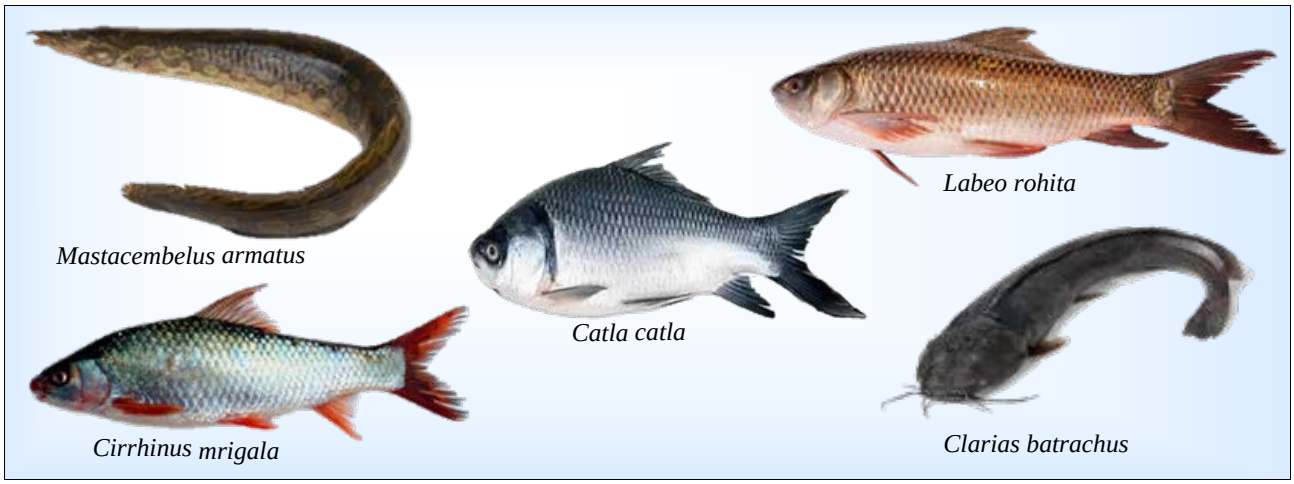

Fig 2: Glimpse of fish diversity found in Krishna River.

Study area

The Krishna River Basin covers approximately 258,948 sq. km in India, with around 69,425 sq. km falling within Maharashtra [9]. In Maharashtra, it extends across the Satara, Sangli, and Kolhapur Districts, encompassing a total of 21 Tehsils. This study was conducted in Western Maharashtra, focusing on various sites in and around the Krishna River Basin. The collection sites are as follows:

Table 1: Collection sits

District	Location
Sangli	Tambave, Bahe, Bhilawadi, Haripur, Nagthane
Satara	Malkhed,Karve, Govare, Kashil
Kolhapur	Narsobawadi

Map of the Study Area

The Krishna River is one of the major rivers in Maharashtra, India, and is significant for its ecological and economic importance. The river originates from Mahabaleshwar, a hill station in the Western Ghats of Maharashtra and it flows through Satara, Sangli, and Kolhapur districts before entering Karnataka and later Andhra Pradesh and Telangana (Figure 2) [9]. The Krishna River supports rich aquatic biodiversity, including fish species and various invertebrates.

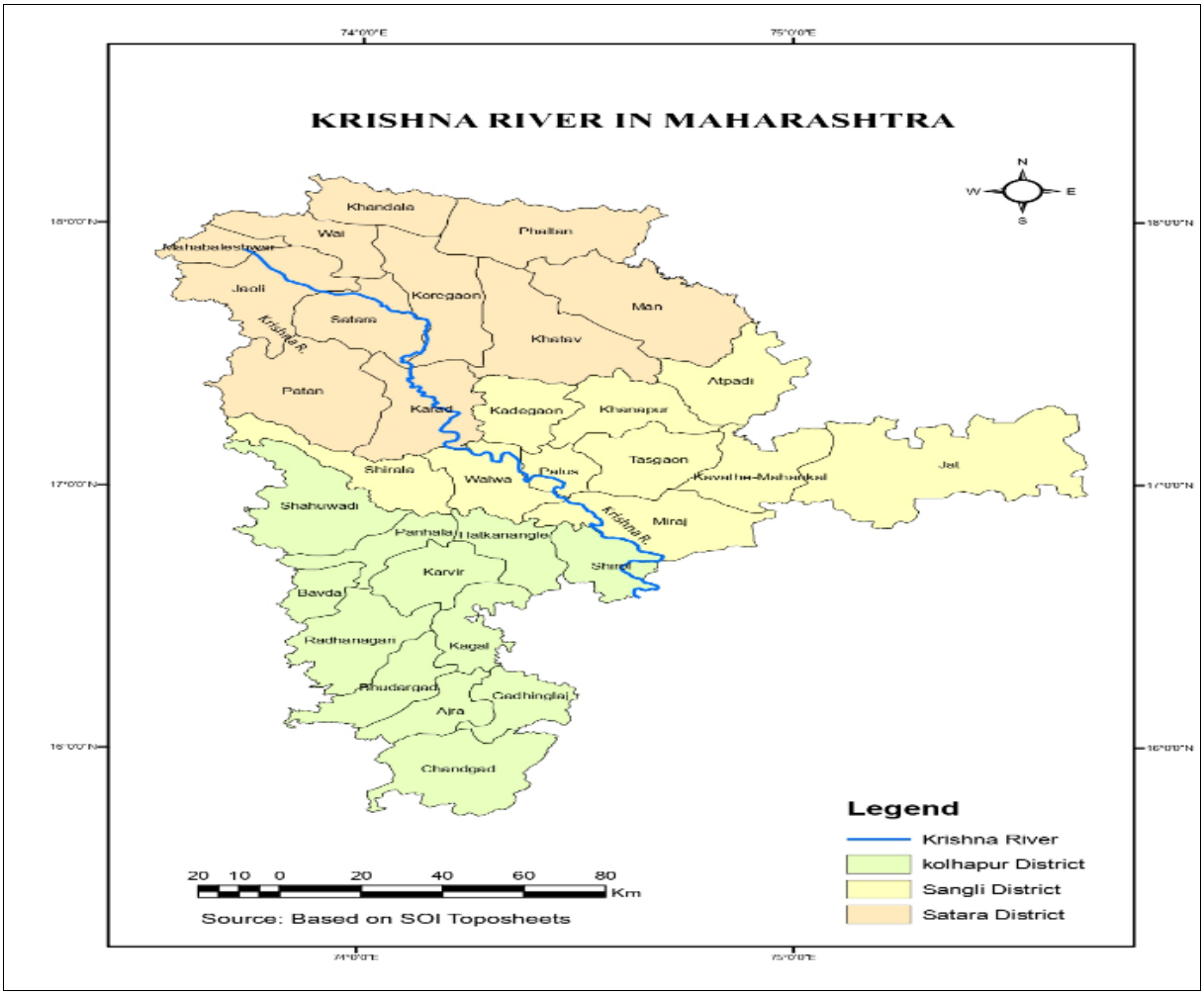

Fig 3: Map of the study area**.**

Material and method

Freshwater fishes were collected from various sites with the assistance of local fishermen. These specimens were then brought to the laboratory for further analysis. Species identification was conducted at the Department of Zoology, KRP Kanya Mahavidyalaya, Islampur, MS, India. Traditional morphological identification methods were employed to confirm species, as referenced in previous studies [10-12].

The host fishes were dissected out and intestines were cut open for parasitological examination. Dissected intestines were examined under stereomicroscope to observe the degree of infection. The cestode parasites were collected, placed in saline solution and freed from the mucus by shaking well. Further the parasites were flattened, and preserved in 4% formalin. These preserved parasites were dehydrated by passing through alcohol grades and finally stained with Harry's haematoxylin cleared in xylene and mounted in DPX for taxonomical study. The drawings were made with the aid of camera Lucida and identified with the help of 'Systema Helminthum' by Yamaguti, (1956) [13].

Incidence of infection was calculated according to Margolis et.al. (1982) [14].

$$\text{Incidence of infection} = \frac{\text{No. of infected host} \times 100}{\text{No, of total hosts examined}}$$

Result and Discussion

In the present study, the incidence of cestode parasite infection in freshwater host fishes was found to be highest during the (February to May), summer season-44.08% followed by the (October to January), winter season-42.85% and lowest during the (June to September) rainy season is 36.76%. These findings suggest that environmental factors such as temperature, rainfall, feeding habits, and breeding cycles directly or indirectly influence the seasonal variation in parasitic infections.

A total of 268 freshwater fish specimens-*Labeo rohita*, *Mastacembelus armatus*, *Channa punctatus*, *Clarias batrachus*, *Wallago attu*-were collected from various regions within the study area. Among these, 102 fish were found to be infected, yielding 134 cestode parasites, which were subsequently preserved for further examination. The incidence rates of parasitic infections are presented in Table 2. The study further highlights that a high prevalence of cestode infections negatively impacts fish growth and protein content while increasing mortality rates. Additionally, the diversity of fish species in the Krishna River basin in Western Maharashtra was analyzed. Table 1 provides details on the collection sites, host fish species, localities, and identified cestode parasites.

The cestode parasites described in the present investigation belong to the Phylum Platyhelminthes, Class Cestoda, and Subclass Eucestoda. They are categorized into the following orders: Pseudophyllidea (Hiware *et al*., 2003) [15], Caryophyllidea (Kennedy, 1974) [16], and Proteocephalidea (Mola, 1929) [17] these parasites are further classified into three families: Ptychobothridae, Caryophyllidae, and Proteocephalidae.

A total of four genera of cestode parasites were reported in this study. The genus *Senga* (Dollfus, 1934) [18] and the genus *Circumonchobothrium* (Shinde, 1968) [19] belong to the Order Pseudophyllidea and Family Ptychobothridae. The genus *Lytocystus* (Cohn, 1908) [20] falls under the Order Caryophyllidea and Family Caryophyllidae. Lastly, the genus *Gangesia* (Woodland, 1924) [21] is classified under the Order Proteocephalidea and Family Proteocephalidae. Details about the species belonging to above genera is given in the Table no.1

Table 2: Diversity and locality of Piscean Cestodes during June, 2018 to May, 2019

Sr. No.	Host	Habitat	Cestode parasites	Locality
1 2 3 4	*Labeorohita* *Clarias batrachus* *Mastacembelusarmatus* *Channa punctatus*	Intestine	*Senga rukminii*(RD) *Circumoncobothrium. armatusae* (RD) *.C. Krishnaii* (RD) *Lytocestus hemlatai* (RD)	Dist.- Sangli Tambave, Bahe Nagthane Bhilawadi, Haripur
5 6 7 8	*Clarias batrachus* *Channa punctatus* *Wallago attu* *Labeo rohita*	Intestine	*L. hemlatai* (RD) *Gangesia rohitae*(RD) *C. Jadhavae* (RD) *S. rukminii*(RD)	Dist. Satara Kopardehaveli, Govare, Malkhed, kashil
9 10 11	*Mastacembelus armatus* *Clarias batrachus* *Labeorohita*	Intestine	*C. armatusae* (RD) *L. nuldurgensis* (RD) S. panzaraensis (R.D)	Dist. Kolhapur Narsobawadi

Table 3: The Incidence of cestode parasites in fresh water fishes

Sr.No.	Month & Year	No. of dissected Hosts	No. of infected Hosts	No. of Cestode Parasites collected	Incidence (%)
1	June. 2018 to September 2018 (Rainy season)	68	25	32	36.76
2	October 2018 to January 2019 (Winter season)	84	36	43	42.85
3	February 2019 to May 2019 (Summer season)	93	41	57	44.08
	Total	268	102	134	38.05

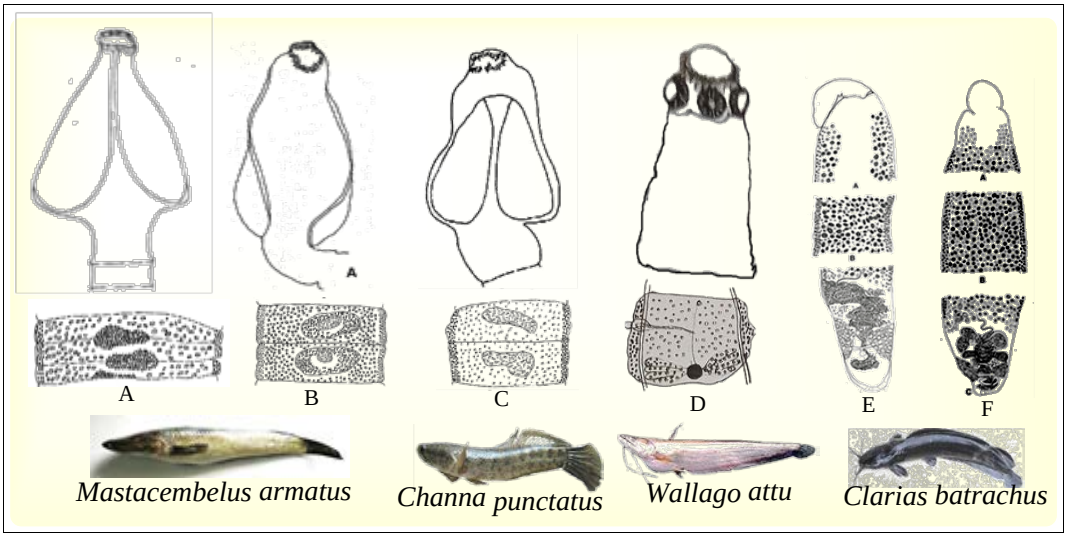

Fig 4: Camera Lucida drawings of various cestode genera and hosts.

Fig 3: Camera Lucida drawings of A) Genus *Senga*- scolex and gravid proglottid, B) and C) Genus-*Circumonchobothrium*- scolex and gravid proglottid, D) Genus *Gangesia*- scolex and gravid proglottid, E) and F) Genus *Lytocestus* - Entire worm, with their Host freshwater fishes.

Conclusion

This study highlights the seasonal variation in the prevalence of cestode parasites in freshwater fish species from the Krishna River Basin in Western Maharashtra. The findings indicate that parasite infections are most prevalent during the summer, followed by winter, with the lowest incidence occurring in the rainy season. A 44.08% incidence rate of infection observed underscores the potential threat to fish health, growth, and overall productivity, which can negatively impact the aquaculture industry. Jadhav and Bhure 2006 [22] reported high temperature, low rainfall and sufficient moisture are necessary for development of parasite. That means, the environmental factors such as temperature, water pollution caused due to agricultural runoff, industrial waste with anthropogenic activities, and fish migration, breeding period, and feeding habitat along with other factors possibly responsible for infection of parasites in freshwater fishes. Given the economic and nutritional significance of fish, further research on parasite control measures and

environmental factors influencing infection rates is essential for sustainable fisheries management.

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Conflicts of interest
The authors have no conflicts of interest to declare, that are relevant to the content of this article. Availability of data and material
The data collected during the current study will be available from the corresponding author on reasonable request.

Ethics approval
Not Applicable

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