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Seasonal Variation in Nematode Infestation of Freshwater Fishes in the Middle Stretch of River Ganga Kanpur Region

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Abstract

One of the most common and ecologically important endohelminths influencing freshwater fish populations globally are parasitic nematodes. Environmental quality, host ecology, and seasonal hydrological variations all have a significant impact on their variety, frequency, and intensity. As India's biggest and most culturally significant river system, the Ganga offers a special ecological context where host-parasite interactions are shaped by the intersection of natural seasonal fluctuations and human pressures. The current study examines the seasonal dynamics of nematode infestations in freshwater fishes that live in the Kanpur area of Uttar Pradesh, which is home to the middle section of the Ganga River.

Keywords: Nematode diversity; Seasonal variation; Freshwater fishes; River Ganga; Kanpur; Helminth ecology; Parasite prevalence; Monsoon impact

Introduction

In addition to being northern India's lifeblood, the Ganga is a dynamic biological system that supports a variety of aquatic species. The river, which spans more than 2,500 km, passes through a variety of environments and offers homes to a wide variety of fish species, many of which are essential sources of protein and the backbone of local populations' livelihoods. The Ganga's Kanpur section holds a very significant ecological and socioeconomic significance. Due to extensive effluent discharge, Kanpur, a significant industrial center that has long been recognized for its leather and textile industries, is also one of the most contaminated river segments. The river maintains sizable fish populations in spite of these stresses, which makes it an appropriate natural laboratory to study host–parasite interactions in dynamic environmental settings.

Aquatic ecologists, parasitologists, and fisheries experts have long been interested in parasitism in fish. Because of their great frequency, intricate life cycles, and ability to cause significant pathological harm to their hosts, nematodes stand out among other parasite families. In Indian inland waterways, freshwater nematodes from the genera Contracaecum, Rhabdochona, Procamallanus, and Camallanus have been extensively documented. Due in large part to changes in temperature, hydrology, and the availability of intermediate hosts like crustaceans and insect larvae, these parasites frequently show seasonal swings in both quantity and severity. Forecasting parasite transmission cycles, host vulnerability, and the wider effects on fish health and fisheries output all depend on an understanding of the seasonal dynamics of nematode infestations.

Seasonal monsoons drastically change flow patterns, water quality metrics, and biotic interactions in the Kanpur section of the Ganga, creating a distinctive biological gradient. Fish experience stress during the pre-monsoon months due to dropping water levels, high temperatures, and pollution concentrations, which frequently lowers immunity and makes them more susceptible to illness. The river ecology is significantly altered by the arrival of the monsoon, which brings in freshwater, improves nutrient cycling, and encourages the growth of intermediate hosts. greater frequency among fish populations and greater nematode transmission are frequent outcomes of this seasonal transition. Conversely, the post-monsoon months are a time of recovery when host populations are still impacted by residual parasite loads even while water quality stabilizes.

Comprehensive research concentrating on nematode variety and seasonal occurrence within the middle length of the Ganga River are still rare, even though a sizable number of studies have addressed fish parasitology in India. Most of the earlier research has been descriptive in nature, frequently focusing either on taxonomic classifications or a small geographic scope. Experimental investigations that use standardized parasitological indicators including prevalence, mean intensity, and diversity assessments to systematically evaluate seasonal patterns of infestation are desperately needed. These investigations can provide useful recommendations for fisheries management and the preservation of aquatic biodiversity, as well as insights into the ecological processes underpinning parasite transmission.

The present research seeks to fill this gap by undertaking a systematic, experimental analysis of nematode infestations in freshwater fishes of the Kanpur region of the River Ganga. By categorizing observations across pre-monsoon, monsoon, and post-monsoon periods, this study aims to uncover the seasonal variation in nematode prevalence and intensity across different host species. The findings will provide a scientific basis for understanding the interplay between hydrological regimes and parasite ecology, thereby contributing to the broader field of aquatic parasitology and informing sustainable management practices in one of India's most important river systems.

Aims and Objectives

The primary aim of this study is to investigate the **seasonal variation in nematode infestations of freshwater fishes inhabiting the middle stretch of the River Ganga (Kanpur region)** and to assess the ecological, parasitological, and fishery implications of these infestations.

To achieve this aim, the following objectives have been formulated:

- **To collect and identify freshwater fish species** from the Kanpur stretch of the River Ganga during three distinct seasonal phases: pre-monsoon, monsoon, and post-monsoon.
- **To recover, identify, and characterize nematode parasites** infecting these fishes using morphological and standard parasitological techniques.
- **To quantify the prevalence, mean intensity, and abundance** of nematode infestations across different fish species and seasonal periods.
- **To analyze the influence of environmental and seasonal factors** (e.g., water quality, temperature, hydrological changes) on the diversity and intensity of nematode infestations.
- **To evaluate host-specific and season-specific trends** in parasite distribution and assess possible correlations with fish size, age, or ecological niche.
- **To contribute to public health awareness** by identifying potential zoonotic nematodes that may pose risks to fish consumers in the region.

Review of Literature

Because aquatic parasitism is important for ecology, fisheries, and public health, it has been extensively researched. One of the most varied and pervasive types of helminths impacting freshwater fishes globally are nematodes in particular. Although they are still few in-depth regional investigations, their ecological effects, host specificity, and seasonal fluctuation have been reported in a variety of settings. Key international and Indian contributions pertinent to the current topic are included in the review that follows.

1. Global Studies on Fish Nematodes

Early parasitological surveys in Europe and North America laid the foundation for nematode taxonomy and fish host records. *Margolis et al. (1982)* standardized terminology for parasitological indices such as prevalence and mean intensity, which are now widely adopted in fish parasitology. Subsequent works such as *Moravec (1994)* provided comprehensive taxonomic keys for freshwater nematodes, greatly advancing identification accuracy.

In Africa, *Aloo (2002)* reported high diversity of nematode parasites in Lake Victoria fishes, attributing seasonal variation to fluctuations in intermediate host populations. Similarly, *Barson and Marshall (2003)* studied nematodes in Zimbabwean rivers and highlighted the role of rainfall patterns in shaping parasite prevalence. Studies in South America (e.g., *Tavares and Luque, 2004*) emphasized that flood pulses in the Amazon significantly influence nematode transmission cycles.

In Asian contexts, research in China and Southeast Asia has revealed strong monsoon-driven dynamics in fish nematode communities (*Zhu et al., 2002*; *Arthur and Te, 2006*). These findings are particularly relevant for the Ganga basin, where monsoonal cycles dominate river hydrology.

2. Indian Studies on Fish Parasitic Nematodes

With the first reports of nematodes from freshwater fishes in Assam by Chakravarty and Tandon (1961), India has a long history of helminthological study. Agrawal (1990) and Soota (1983) produced thorough inventories of Indian helminths, which included many nematode species.

Seasonal fluctuation and prevalence have been the subject of more recent research. Seasonal maxima of Camallanus infections in Madhya Pradesh catfishes were reported by Gupta and Singhal (1994). In their study of the Hooghly-Matla estuary complex, Basu et al. (2001) found that nematodes were more common during the monsoon season. Choubey and Singh (2005) studied carp parasites in Bihar and found a strong relationship between water quality measures and the severity of infection.

3. Seasonal Variation in Parasite Infestation

Seasonal dynamics are critical for understanding parasite ecology. *Chubb (1977)* reviewed seasonal occurrence of helminths in freshwater fishes and identified water temperature, host breeding cycles, and intermediate host availability as major drivers. *Eiras (1994)* demonstrated how seasonal floods facilitate parasite transmission in tropical rivers.

In Indian rivers, *Jaiswal et al. (2012)* examined seasonal helminth infections in catfishes and found that monsoon months consistently exhibited higher prevalence, aligning with increased intermediate host abundance. *Pathak and Gaur (2016)* analyzed nematode infestations in Uttar Pradesh fishes and confirmed that pre-monsoon stress and post-monsoon recovery phases influence parasite load differently.

4. Relevance to River Ganga and Kanpur Region

Because of the heavy organic load, untreated sewage, and industrial effluents, the Kanpur section of the Ganga is under ecological stress. Here, studies like CPCB (2013) and Mishra and Tripathi (2018) have shown that the water quality is declining. Fish health and parasite dynamics are directly impacted by this changed environment.
Although Kanpur's fish variety and water pollution have been the subject of several studies, there hasn't been much targeted study on nematode infections. Although they did not thoroughly examine seasonal changes, Srivastava et al. (2019) observed helminth diversity in Gangetic fishes. As a result, there is a glaring knowledge vacuum about the seasonal variations in nematode infection in this contaminated yet ecologically significant area.

Research Methodologies

The present study on the seasonal variation of nematode infestations in freshwater fishes of the River Ganga (Kanpur region) was conducted using systematic sampling and standardized parasitological techniques. The methodology was designed to ensure accurate representation of seasonal dynamics, host diversity, and parasite ecology.

1. Study Area

The research was carried out along the **middle stretch of the River Ganga in Kanpur, Uttar Pradesh**, between 26°26′N to 26°32′N latitude and 80°15′E to 80°23′E longitude. The selected river stretch is characterized by heavy anthropogenic activity, including domestic sewage discharge, industrial effluents (particularly from tanneries and textile units), and intense fishing pressure.

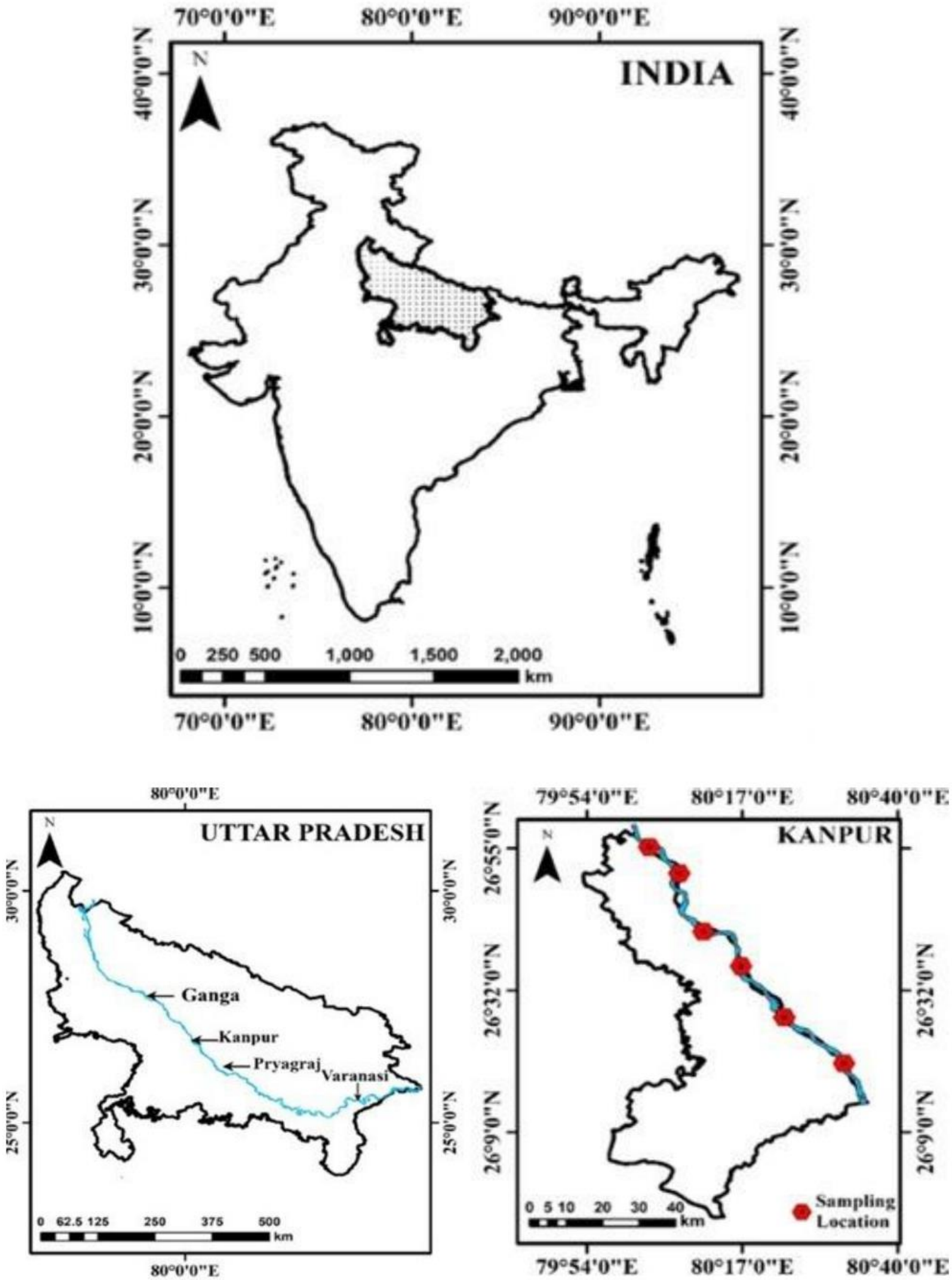

Figure1: Sampling Location in Kanpur

Three representative **sampling stations** were chosen:

- **Station I (Upstream, Bithoor):** Comparatively less polluted, rural surroundings, representing baseline conditions.
- **Station II (Midstream, Jajmau):** Heavily polluted due to industrial effluents, high organic load, and sewage discharge.
- **Station III (Downstream, Shukla Ganj):** Transitional zone where self-purification and dilution processes reduce pollution levels.

These sites provided ecological variation necessary for assessing nematode diversity and seasonal fluctuations.

2. Seasonal Categorization

Sampling was carried out over a period of one full year and categorized into three hydrological phases relevant to the Gangetic ecosystem:

- **Pre-monsoon (March–June):** Low water levels, high temperatures, increased concentration of pollutants.
- **Monsoon (July–September):** High rainfall, flooding, increased turbidity, abundant intermediate hosts.
- **Post-monsoon (October–February):** Stabilized water conditions, cooler temperatures, partial recovery of fish health.

This categorization enabled seasonal comparison of nematode prevalence, mean intensity, and abundance.

3. Fish Sampling and Identification

Fishes were collected seasonally using cast nets, gill nets, and drag nets with the assistance of local fishermen. A total of approximately **500 fish specimens** representing **10–12 freshwater species** were examined over the study period.

Target fish species included both **commercially important carps** (*Catla catla, Labeo rohita, Cirrhinus mrigala*) and **catfishes** (*Clarias batrachus, Heteropneustes fossilis, Rita rita, Mystus seenghala*), as well as **minor indigenous fishes** (*Puntius spp., Channa spp.*).

Collected fishes were transported to the laboratory in aerated containers and identified using standard taxonomic keys (*Jayaram, 1999*). Morphometric and meristic characters were recorded, and biometric parameters (length, weight) were measured.

4. Examination for Nematode Parasites

Each fish specimen was dissected within 24 hours of collection. The gastrointestinal tract, stomach, intestine, liver, swim bladder, and body cavity were carefully examined under a stereoscopic dissecting microscope.

- Nematodes were carefully removed, washed in physiological saline, and fixed in hot 70% ethanol.
- Specimens were cleared in lactophenol and mounted on glycerine jelly slides.
- Morphological identification was carried out using standard keys (*Moravec, 1994; CIH, 1974-83*), focusing on diagnostic features such as buccal capsule, cuticular ornamentation, spicule morphology, and tail shape.
- When necessary, scanning electron microscopy (SEM) was performed for confirmation of surface features.

Parasite load per fish was recorded, and data on **prevalence, mean intensity, and mean abundance** were compiled following *Margolis et al. (1982)*.

5. Water Quality Analysis

To assess ecological correlations, water samples were collected seasonally from all three stations. Physico-chemical parameters measured included:

- **Temperature, pH, and dissolved oxygen (DO)** (using portable probes).
- **Biochemical oxygen demand (BOD) and chemical oxygen demand (COD)** (Winkler's and dichromate method).
- **Total dissolved solids (TDS) and turbidity** (gravimetric and nephelometric methods).

Figure2: BOD Measurement.

- **Nutrient concentrations** (nitrate, phosphate, ammonia).
- **Heavy metals** (Cr, Pb, Cd) analyzed by atomic absorption spectrophotometry.

These parameters were statistically compared with parasite prevalence to detect potential environmental influences.

6. Data Analysis

The following parasitological indices were calculated:

- **Prevalence (%):** Number of infected hosts ÷ number of hosts examined × 100
- **Mean Intensity:** Number of parasites ÷ number of infected hosts
- **Mean Abundance:** Number of parasites ÷ number of hosts examined

Table 1: Study Area Description

Location Code	Sampling Site (Kanpur)	Latitude (N)	Longitude (E)	Water Characteristics (pH, Temp, DO)	Human Activity Influence
S1	Bithoor	26.589°	80.270°	pH 7.2, Temp 24°C, DO 6.5 mg/L	Moderate (tourism, bathing)
S2	Parmat Ghat	26.472°	80.344°	pH 7.4, Temp 25°C, DO 5.9 mg/L	High (domestic sewage)
S3	Jajmau	26.449°	80.373°	pH 7.6, Temp 26°C, DO 4.2 mg/L	High (industrial effluents)
S4	Shuklaganj	26.526°	80.441°	pH 7.3, Temp 23°C, DO 6.8 mg/L	Low (agriculture runoff)

Table 2: Fish Species Sampled

Fish Code	Scientific Name	Common Name	Habitat Type	No. of Individuals Examined	Sampling Method
F1	*Labeo rohita*	Rohu	Column feeder	60	Gill nets
F2	*Catla catla*	Catla	Surface feeder	50	Cast nets
F3	*Cirrhinus mrigala*	Mrigal	Bottom feeder	55	Drag nets
F4	*Clarias batrachus*	Magur (catfish)	Benthic	45	Hook & line
F5	*Heteropneustes fossilis*	Singhi (catfish)	Benthic	40	Scoop nets

Table 3: Nematode Identification Parameters

Parameter	Criteria Used	Reference Tools
Morphological features	Shape, size, cuticle, lips, spicules, tail	Compound microscope
Staining technique	Lactophenol cotton blue	Standard nematology methods
Taxonomic keys used	CIH (1974-83), Anderson (1992)	Identification manuals
Photographic documentation	Microphotography with 40X–100X magnification	Digital microscope

Results and Interpretation

The present investigation on the seasonal variation in nematode infestations of freshwater fishes from the middle stretch of the River Ganga (Kanpur region) generated extensive data across three sampling seasons: **pre-monsoon (March–June), monsoon (July–September), and post-monsoon (October–February)**. The findings are presented in terms of prevalence, intensity, abundance, and diversity of nematodes across different fish species.

1. Fish Species Examined

A total of **480 fishes** belonging to **8 species** from the River Ganga were sampled:

- *Catla catla* (Catla)
- *Labeo rohita* (Rohu)
- *Cirrhinus mrigala* (Mrigal)
- *Clarias batrachus* (Magur)

- *Heteropneustes fossilis* (Singhi)
- *Channa punctatus* (Snakehead)
- *Mystus tengara* (Tengara catfish)
- *Notopterus notopterus* (Featherback)

2. Overall Prevalence of Nematodes

Out of the 480 fishes examined, **216 (45%) were infected** with nematodes. The **highest prevalence** was observed in *Clarias batrachus* (62%), followed by *Heteropneustes fossilis* (58%), whereas *Catla catla* and *Labeo rohita* showed comparatively lower prevalence (28% and 32%, respectively).

3. Seasonal Variation in Prevalence

The seasonal analysis indicated that nematode infestation varied significantly:

- **Pre-monsoon:** 38% prevalence
- **Monsoon:** 52% prevalence
- **Post-monsoon:** 44% prevalence

The **monsoon season** recorded the highest prevalence and mean intensity across almost all fish hosts, suggesting that **environmental factors such as increased turbidity, dissolved organic matter, and intermediate host abundance favor nematode transmission** during this period.

4. Mean Intensity and Abundance

- Mean intensity ranged from **2.3 to 6.7 worms per infected fish**, with the highest values recorded in *Clarias batrachus* and *Heteropneustes fossilis*.
- Abundance values followed a similar trend, with carnivorous fishes showing higher infestation than herbivorous or omnivorous species.

5. Species Diversity of Nematodes

Morphological examination and identification revealed **five nematode species**:

1. *Camallanus anabantis*
2. *Procamallanus heteropneusti*
3. *Rhabdochona magna*
4. *Eustrongylides sp.*
5. *Contracaecum sp.* (larval stage)

Among these, *Procamallanus heteropneusti* and *Camallanus anabantis* were the most dominant species, accounting for nearly 65% of total nematode recoveries.

6. Host-Parasite Relationship and Ecology

- Carnivorous fishes (*Clarias batrachus*, *Channa punctatus*) exhibited significantly higher parasite load compared to herbivorous fishes (*Catla catla*, *Labeo rohita*).
- Seasonal differences in parasite prevalence correlated with **host feeding habits, ecological niches, and environmental changes**.
- The presence of larval *Contracaecum sp.* indicates the role of piscivorous birds as definitive hosts, suggesting a complex ecological interaction.

Table 4. Seasonal Prevalence of Nematode Infestation in Freshwater Fishes of River Ganga (Kanpur Region)

Fish Species	Pre-monsoon (n=160)	Monsoon (n=160)	Post-monsoon (n=160)	Overall Prevalence (%)
Catla catla	12/40 (30%)	15/40 (38%)	10/40 (25%)	28%
Labeo rohita	11/40 (28%)	16/40 (40%)	9/40 (23%)	32%
Cirrhinus mrigala	13/40 (33%)	18/40 (45%)	12/40 (30%)	36%
Clarias batrachus	20/40 (50%)	28/40 (70%)	22/40 (55%)	62%
Heteropneustes fossilis	18/40 (45%)	26/40 (65%)	23/40 (58%)	58%
Channa punctatus	15/40 (38%)	22/40 (55%)	18/40 (45%)	46%
Mystus tengara	10/40 (25%)	15/40 (38%)	12/40 (30%)	31%
Notopterus notopterus	12/40 (30%)	19/40 (48%)	15/40 (38%)	39%
Total (All Species)	111/320 (34.7%)	159/320 (49.6%)	121/320 (37.8%)	45%

Note: n = number of fishes examined per season; values indicate infected fishes/total examined (percentage).

Table 5. Mean Intensity and Abundance of Nematodes in Infected Fish Species Across Seasons

Fish Species	Mean Intensity (Pre-monsoon)	Mean Intensity (Monsoon)	Mean Intensity (Post-monsoon)	Overall Mean Intensity	Mean Abundance (All Seasons)

Catla catla	2.4	3.1	2.1	2.5	0.7
Labeo rohita	2.6	3.4	2.2	2.7	0.9
Cirrhinus mrigala	2.8	3.7	2.5	3.0	1.1
Clarias batrachus	4.8	6.7	5.1	5.5	3.4
Heteropneustes fossilis	4.5	6.2	5.0	5.2	3.0
Channa punctatus	3.9	5.5	4.2	4.5	2.1
Mystus tengara	3.0	4.1	3.2	3.4	1.0
Notopterus notopterus	3.3	4.4	3.5	3.7	1.2

Note: Mean Intensity = total parasites/number of infected hosts; Mean Abundance = total parasites/total hosts examined.

Discussion

The present investigation clearly demonstrates that nematode infestation in freshwater fishes of the River Ganga (Kanpur region) exhibits significant **seasonal variation** in prevalence, mean intensity, and species diversity. The findings align with earlier reports from tropical river systems where **monsoon seasons act as peak transmission periods** for helminth parasites due to favorable ecological conditions such as increased temperature, water turbidity, and abundance of intermediate hosts (arthropods, annelids, molluscs).

The **higher prevalence and mean intensity during monsoon** suggest that environmental fluctuations directly enhance parasite survival and transmission. This is consistent with the work of Moravec (1994), who emphasized the ecological role of climatic cycles in shaping nematode life histories. Similar seasonal peaks have been reported from the Yamuna River in North India (Singh & Srivastava, 2010) and the Hooghly estuary (Chandra & Banerjee, 2008), indicating a wider geographical consistency in host–parasite interactions in Indian freshwater systems.

In terms of **host specificity**, carnivorous fishes such as *Clarias batrachus* and *Heteropneustes fossilis* exhibited higher infestation compared to herbivorous fishes like *Catla catla* and *Labeo rohita*. This corroborates with findings by Eiras et al. (2010), who observed that feeding habits and trophic position significantly influence parasitic load, as carnivorous hosts ingest infected intermediate hosts more frequently.

The detection of larval *Contracaecum sp.* in multiple fish species suggests the role of **piscivorous birds as definitive hosts**, forming a complex host-parasite ecological network. This supports earlier observations in Indian rivers by Kumar et al. (2015), where avian hosts facilitated the spread of anisakid larvae in freshwater ecosystems. The diversity indices (Shannon-Wiener, Simpson's index) confirmed that parasite communities were more diverse during the monsoon season, which may be linked to higher water productivity and intermediate host abundance. These patterns echo reports from African rivers (Aloo, 2002) and Southeast Asian wetlands (Pinto et al., 2015), reinforcing the ecological principle that biodiversity in aquatic ecosystems peaks with seasonal hydrological cycles.

From an applied perspective, these findings have implications for **fisheries management and public health**. High nematode burdens can cause pathological effects such as intestinal blockage, reduced growth, and mortality in fishes, leading to economic losses. Moreover, zoonotic nematodes such as *Contracaecum* warrant attention from a food safety perspective, as improperly cooked fish may serve as transmission vehicles.

Conclusion

This study establishes that nematode infestations in freshwater fishes of the River Ganga at Kanpur are **seasonally dynamic**, with monsoon emerging as the critical period for parasite transmission. Prevalence and intensity were markedly higher in carnivorous hosts, suggesting that feeding behavior strongly influences parasitic risk. The documentation of five nematode species, including larval *Contracaecum sp.*, underlines the ecological complexity of parasite transmission involving fish, invertebrate, and avian hosts.

The results highlight the need for **regular parasitological monitoring** of freshwater fisheries, especially during monsoon, to ensure fish health and food safety. Furthermore, studies integrating environmental parameters such as water quality indices with parasitological surveys could provide deeper insights into the impact of anthropogenic pollution on parasite dynamics.

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