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# RESEARCH ARTICLE

# SEASONAL PREVALENCE OF INFECTIOUS DISEASES IN FRESHWATER ORNAMENTAL FISHES AND THEIR CORRELATION WITH WATER-QUALITY PARAMETERS

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## ABSTRACT

Seasonality and water quality strongly influence disease outbreaks in ornamental aquaculture. This study investigated the prevalence of infectious diseases in freshwater ornamental fishes in Chhatrapati Sambhajinagar (Aurangabad), Maharashtra, India, across three climatic phases (pre-monsoon, monsoon, and post-monsoon/winter). A total of 80 fish representing six species were examined through clinical observation, parasitology, bacteriology, mycology, haematology, histopathology, and water-quality analysis. Overall prevalence was 46%: protozoan/monogenean infections (28%) peaked post-monsoon, bacterial infections (20%) were highest pre-monsoon, and fungal infections (6%) recurred during cooler months. Logistic regression confirmed ammonia (aOR 1.6 per 0.1 mg/L increase, p=0.01) and low dissolved oxygen (aOR 1.35 per −1 mg/L decrease, p=0.045) as significant predictors of infection. Findings align with global literature: protozoa dominate in cooler, post-rainfall months, bacteria proliferate under high ammonia and low DO, and Saprolegnia thrives at lower temperatures with handling stress.Management strategies should focus on maintaining ammonia ≤0.02 mg/L, DO ≥6 mg/L, and targeted seasonal preventive measures. This integrated ecological approach provides cost-effective guidance for traders, farmers, and hobbyists.



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# INTRODUCTION

The freshwater ornamental fish trade is one of the most dynamic sectors of global aquaculture, valued at billions of dollars annually and involving hundreds of fish species that are bred, transported, and marketed worldwide (1–3). India is an important player in this industry, supplying popular species such as goldfish (*Carassius auratus*), guppies (*Poecilia reticulata*), mollies (*Poecilia sphenops*), gouramis (*Trichogaster spp.*), angelfish (*Pterophyllum scalare*), and rosy barbs (*Puntius conchonius*) to both domestic and international markets (4–6). These fishes are favored not only for their aesthetic appeal but also for their role in livelihoods of small-scale farmers and traders. Yet, disease outbreaks remain a critical bottleneck, causing mortality, financial loss, and trade restrictions (7–9).

**Infectious diseases in ornamental fishes:** Ornamental fishes suffer from a wide spectrum of infectious diseases caused by bacteria, parasites, fungi, and viruses (10–12). Among bacterial pathogens, Aeromonas hydrophila, *Pseudomonas fluorescens*, *Edwardsiellatarda*, *Flavobacterium columnare*, and *Streptococcus iniae* are frequently implicated in systemic infections and ulcerative diseases (13–16). Parasitic infestations are equally significant, with protozoans such as *Ichthyophthirius multifiliis*, *Trichodina* spp., and *Cryptocaryon irritans*, and monogeneans like *Dactylogyrus* and *Gyrodactylus* causing high morbidity in crowded systems (17–20). Fungal and oomycete pathogens, particularly *Saprolegnia* spp., often emerge as secondary invaders under poor husbandry and environmental stress (21,22). Viral pathogens such as koi herpesvirus (KHV) or iridoviruses can cause catastrophic mortality in specific hosts (23), though their role in small ornamental systems is less consistently reported.

**Seasonal drivers of disease:** Infectious disease dynamics in aquaculture are not static; they are strongly influenced by seasonal changes in temperature, rainfall, and water chemistry (24–26). In tropical and subtropical regions like India, the annual cycle of pre-monsoon (hot, dry months), monsoon (rainy season), and post-monsoon/winter (cooler months) shapes both pathogen ecology and host susceptibility (27,28). Higher temperatures during pre-monsoon can promote bacterial growth and stress due to low dissolved oxygen (DO) (29). During monsoon, fluctuating pH and organic loading favor opportunistic pathogens and protozoans (30). Post-monsoon cooling often correlates with higher parasite burdens such as *Ichthyophthirius* and monogeneans, while fungal outbreaks like saprolegniosis peak under cooler, low-immunity conditions (31–34). Several studies from India support this seasonality. Saha *et al*. (35) reported higher protozoan infestations in ornamental fish in West Bengal during the post-monsoon months. Ahilan *et al*. (36) documented bacterial septicemia outbreaks in South Indian aquaria during pre-monsoon, when elevated ammonia and low DO created stressful conditions. Similarly, Kumar *et al*. (37) observed *Ichthyophthirius* outbreaks peaking in cooler months with high stocking density. These patterns reinforce the idea that disease risk cannot be separated from environmental seasonality.

**Water quality as a determinant of health:** Water quality is widely recognized as the most important determinant of fish health in captive systems (38–40). Key parameters such as ammonia, nitrite, nitrate, pH, temperature, hardness, and alkalinity govern both pathogen proliferation and host immunity (41,42). Elevated ammonia ($NH_3$-N) is directly toxic to gills and predisposes fish to bacterial and parasitic infections (43). Nitrite interferes with oxygen transport ("brown blood disease") and enhances mortality when combined with pathogens (44). Low dissolved oxygen suppresses immune competence and favors anaerobic bacterial flora (45).

Meanwhile, hardness and alkalinity buffer pH fluctuations and indirectly influence the toxicity of nitrogenous compounds (46,47). Poor water quality is often described as the "first disease" of aquaculture, since it sets the stage for all others (48,49). Retail aquaria and small ornamental farms typically experience fluctuations in these parameters due to overstocking, irregular water changes, and limited filtration, making them hotspots for disease emergence (50,51).

**Global and regional evidence linking environment to disease:** Several global studies confirm that environmental stress is closely tied to disease outbreaks. Walczak *et al*. (52) identified diverse bacterial flora in diseased ornamental fishes from Europe, with strong links to organic pollution. de Oliveira *et al*. (53) documented virulence genes in Aeromonas strains from Brazilian ornamental fish, with higher pathogenicity associated with poor water hygiene. Tedesco *et al*. (54) showed that fungal saprolegniosis in cultured fish was exacerbated by low temperature and organic debris.

In African small-scale ponds, Mramba *et al*. (55) linked high ammonia and low DO to reduced yields and higher disease prevalence. These patterns mirror Indian observations, suggesting common ecological mechanisms. In Indian ornamental fishery contexts, Mahapatra and Sahoo (56) reported significant correlations between dissolved oxygen fluctuations and mortality in livebearers. Ghosh *et al*. (57) highlighted the role of water hardness and alkalinity in influencing parasite loads in guppies and mollies. Studies from ICAR institutes consistently emphasize water quality management as the cheapest and most effective disease prevention strategy (58–60).

**Knowledge gaps and rationale:** Despite numerous localized reports, comprehensive studies that integrate seasonal prevalence of infectious diseases with quantitative water-quality data in ornamental fishes are limited, especially in Maharashtra. Most prior studies focus on single pathogen groups (e.g., parasites or bacteria), lack standardized water-quality assessments, or are based on farmed food-fishes rather than ornamental species (61–63). Considering the economic and cultural importance of ornamental fishes in urban centers like Aurangabad, there is a need to document disease ecology with attention to seasonality and water chemistry. Such evidence is vital not only for traders and farmers but also for hobbyists and policy planners seeking to improve biosecurity and reduce losses.

### Objectives of the study

### The present study was therefore designed to

- Estimate the seasonal prevalence of infectious diseases (bacterial, parasitic, fungal) in common freshwater ornamental fishes in Aurangabad.
- Measure key water-quality parameters (temperature, pH, DO, ammonia, nitrite, nitrate, hardness, alkalinity) across seasons.
- Assess the correlation between water-quality fluctuations and infection prevalence, with emphasis on ammonia and DO.
- Provide practical management recommendations for small-scale ornamental fish systems.
- By linking seasonal epidemiology with measurable water chemistry, this study aims to bridge ecological understanding with actionable husbandry practices.

# MATERIALS AND METHODS

### Study Area and Seasonal Design

The study was conducted in Chhatrapati Sambhajinagar (Aurangabad), Maharashtra, India, a semi-arid zone characterized by three distinct climatic phases:

- Pre-monsoon (March–June): hot and dry, average water temperature 28–32 °C.
- Monsoon (July–October): rainy season, cooler water (25–28 °C), high organic inflow.
- Post-monsoon/Winter (November–February): mild to cool (20–25 °C).

We sampled 10 ornamental fish outlets/farms across the district. Seasonal surveys were carried out between March 2024 and February 2025, ensuring representation of each climatic window (1).

### Fish Sampling and Species Selection

A total of 80 freshwater ornamental fishes were randomly selected across three seasons (Pre-monsoon n=26, Monsoon n=28, Post-monsoon n=26). Species distribution included:

- Goldfish (*Carassius auratus*, 25%)
- Guppy (*Poecilia reticulata*, 20%)
- Molly (*Poecilia sphenops*, 18%)
- Gourami (*Trichogaster spp.*, 15%)
- Angelfish (*Pterophyllumscalare*, 12%)
- Rosy barb (*Puntius conchonius*, 10%)

Sampling avoided moribund fish to reduce selection bias. Fish were transported in aerated plastic bags and processed within 2–3 h (2).

### Clinical and Parasitological Examination

- **Gross clinical observation:** Fish were screened for external lesions, fin erosion, exophthalmia, skin haemorrhage, and abnormal behaviour 3.
- **Skin and gill smears:** Wet mounts were prepared and examined under 10× and 40× objectives for protozoans (*Ichthyophthirius*, *Trichodina*, *Chilodonella*) and monogeneans (*Dactylogyrus*, *Gyrodactylus*). Parasite identification followed standard keys 4.
- **Parasite load quantification:** Semi-quantitative grading (light, moderate, heavy) was applied based on parasite counts per microscopic field 5.

### Bacteriological Analysis

- **Sample collection:** Swabs from skin ulcers, gills, and kidney were inoculated onto Nutrient Agar (NA), Tryptic Soy Agar (TSA), and selective media (e.g., Rimler–Shotts agar for *Aeromonas*) 6.
- **Incubation:** Plates incubated at 28 ± 2 °C for 24–48 h.
- **Identification:** Standard biochemical tests performed (Gram staining, oxidase, catalase, IMViC, TSI, urease, sugar fermentation) etc. 7.
- **Reference standards:** Bergey's Manual of Systematic Bacteriology (2012 edition) was used for taxonomic confirmation 8.

### Fungal and Oomycete Examination

- Suspected cotton-like growths were sampled, washed in sterile saline, and cultured on Potato Dextrose Agar (PDA) and Sabouraud Dextrose Agar (SDA).
- Colonies were observed for *Saprolegnia*-like morphology (broad aseptate hyphae, zoospore release under cold conditions) 9.

**Water-Quality Analysis:** For each tank sampled, 500 mL of water was collected in sterile containers and analysed following APHA Standard Methods, 24th Edition (2023) 10:

- **Temperature & pH:** Portable multiparameter meter (Hanna, USA).
- **Dissolved oxygen (DO):** Winkler's iodometric titration.
- **Ammonia ($NH_3$-N):** Phenate method.
- **Nitrite ($NO_2^-$-N):** Colourimetric method at 543 nm.
- **Nitrate ($NO_3^-$-N):** Brucine–sulfanilic acid method.
- **Total hardness & alkalinity:** EDTA titration.

Benchmark values were compared with OATA (Ornamental Aquatic Trade Association) recommended criteria: DO ≥ 6 mg/L, $NH_3$-N ≤ 0.02 mg/L, $NO_2^-$-N ≤ 0.2 mg/L 11.

**Data Management and Statistical Analysis**

- **Prevalence calculation:** Number of infected fish / total fish examined × 100.
- **Infection intensity index:** Derived from semi-quantitative parasite counts.
- **Regression analysis:** Logistic regression models (R v4.3.2) tested associations between infection presence (yes/no) and water-quality predictors (DO, ammonia, nitrite, temperature).
- **Random effects:** Species and site treated as random intercepts to account for clustering.
- **Significance threshold:** $p < 0.05$.

Statistical approach aligns with epidemiological standards in fish health research 12.

# RESULTS

**Sampling and Fish Composition:** Across three seasons, a total of **80 ornamental fishes** representing six species were examined. Species distribution was: goldfish (*Carassius auratus*) 25%, guppy (*Poecilia reticulata*) 20%, molly (*P. sphenops*) 18%, gourami (*Trichogaster spp.*) 15%, angelfish (*Pterophyllumscalare*) 12%, and rosy barb (*Puntius conchonius*) 10%.

**Table 1. Seasonal variation in water quality parameters**

| Parameter | Pre-monsoon | Monsoon | Post-monsoon | OATA Benchmark |
|---|---|---|---|---|
| Temperature (°C) | 29.5 ± 1.2 | 27.0 ± 0.9 | 24.0 ± 1.1 | 22–28 |
| pH | 7.6 ± 0.2 | 7.4 ± 0.2 | 7.5 ± 0.2 | 7.0–8.0 |
| DO (mg/L) | 5.8 ± 0.6 | 6.2 ± 0.5 | 6.5 ± 0.5 | ≥6 |
| $NH_3$-N (mg/L) | 0.10 ± 0.05 | 0.06 ± 0.04 | 0.04 ± 0.03 | ≤0.02 |
| $NO_2^-$-N (mg/L) | 0.15 ± 0.08 | 0.10 ± 0.06 | 0.06 ± 0.04 | ≤0.20 |
| $NO_3^-$-N (mg/L) | 20 ± 6 | 18 ± 5 | 15 ± 5 | <50 |
| Hardness (mg/L) | 160 ± 35 | 140 ± 30 | 150 ± 28 | 100–250 |
| Alkalinity (mg/L) | 120 ± 20 | 110 ± 18 | 115 ± 15 | 80–200 |

**Table 2. Prevalence of infectious diseases by season**

| Pathogen group | Pre-monsoon (%) | Monsoon (%) | Post-monsoon (%) | Overall (%) |
|---|---|---|---|---|
| Any infection | 50 (13/26) | 39 (11/28) | 50 (13/26) | 46 (37/80) |
| Bacterial | 27 (7/26) | 21 (6/28) | 12 (3/26) | 20 (16/80) |
| Protozoa/Monogeneans | 31 (8/26) | 18 (5/28) | 35 (9/26) | 28 (22/80) |
| Fungal/Oomycete | 8 (2/26) | 4 (1/28) | 8 (2/26) | 6 (5/80) |

**Table 3. Mixed-effects logistic regression (outcome = any infection)**

| Predictor | Adjusted OR (95% CI) | p-value |
|---|---|---|
| Season: Pre-monsoon vs Monsoon | 1.45 (0.64–3.29) | 0.37 |
| Season: Post-monsoon vs Monsoon | 1.70 (0.76–3.83) | 0.20 |
| $NH_3$-N (per 0.1 mg/L ↑) | 1.60 (1.12–2.28) | 0.01* |
| DO (per −1 mg/L ↓) | 1.35 (1.01–1.89) | 0.045* |
| Temperature (per 1 °C ↑) | 0.95 (0.87–1.04) | 0.27 |
| pH (per 0.1 ↑) | 0.98 (0.90–1.06) | 0.59 |

**Key finding:** Elevated ammonia and reduced DO significantly increased odds of infection.

Seasonal sampling: pre-monsoon (n=26), monsoon (n=28), post-monsoon (n=26).

**Water-Quality Parameters:** Mean (±SD) tank water parameters by season are shown in Table 1.

Notably, ammonia exceeded safe thresholds (0.10 mg/L) during pre-monsoon, and DO dipped below 6 mg/L in some tanks.

**Overall and Group-Wise Prevalence**

- **Protozoan/monogenean infections** peaked post-monsoon (35%).
- **Bacterial infections** highest pre-monsoon (27%).
- **Fungal infections** occurred at low levels (6%) but were recurrent in cooler months.

**Logistic Regression Results**

# DISCUSSION

**Seasonal Influence:** The study highlights clear seasonal disease patterns in ornamental fishes. Protozoan and monogenean parasites peaked post-monsoon (35%), consistent with West Bengal studies showing higher ectoparasite loads in cooler months after rainfall (Saha *et al*., 2016; Saha *et al*., 2017). Increased organic debris and fluctuating temperatures may have favored protozoan proliferation.

**Bacterial infections** were highest pre-monsoon (27%), correlating with elevated ammonia (0.10 mg/L) and DO depression (<6 mg/L). Similar associations between ammonia spikes and Aeromonas-associated septicemia have been reported in Tamil Nadu (Chidambaram *et al*., 2013) and in Brazilian ornamental fish systems (de Oliveira *et al*., 2024).

**Fungal infections (6%)**, mostly *Saprolegnia*, clustered in post-monsoon/winter when water temperatures were cooler (24 °C). This aligns with saprolegniosis outbreaks reported under low temperature and handling stress (Tedesco *et al*., 2022; Au-Yeung, 2025).

**Water Quality as a Risk Factor**

Ammonia emerged as the strongest predictor of infection (aOR 1.6 per 0.1 mg/L). This is consistent with toxicological evidence that unionized $NH_3$ damages gills and predisposes fish to pathogens (IFAS/FAO, 2023). Likewise, reduced DO significantly increased infection risk (aOR 1.35 per −1 mg/L), echoing findings from African pond systems where oxygen depletion correlated with high disease prevalence (Mramba *et al*., 2023). Nitrite and nitrate were within tolerable limits, but cumulative organic load during monsoon likely enhanced parasite transmission. Stable pH buffered against acute toxicity, as seen in other Indian aquarium studies (Ghosh *et al*., 2018).

**Comparisons with Global Studies**

- **Europe:** Walczak *et al*. (2017) found *Aeromonas* and *Pseudomonas* dominating bacterial infections in ornamental fish, often linked to poor water hygiene (Walczak *et al*., 2017).
- **Brazil:** Virulence gene carriage in *Aeromonas* from aquarium fishes showed strong links to pathogenic outbreaks (de Oliveira *et al*., 2024).
- **Africa:** Ammonia and DO fluctuations in ponds shaped yield and disease dynamics (Mramba *et al*., 2023).

- **India:** Seasonal protozoan peaks post-monsoon have been consistently reported (Saha *et al*., 2016; Saha *et al*., 2017).

Thus, Aurangabad patterns are globally consistent yet locally nuanced.

**Management Implications**

- **Water quality monitoring:** Daily checks of ammonia and DO can prevent most bacterial outbreaks.
- **Seasonal adjustments:** Increase water changes and aeration in pre-monsoon; strengthen quarantine and temperature stabilisation post-monsoon.
- **Preventive care:** Probiotics and herbal treatments (neem, fenugreek) could supplement management, as reported in phytotherapy trials (Kumar *et al*., 2022).

**Limitations:** The study's sample size (80 fish) limits statistical power. Longitudinal monitoring and molecular diagnostics would refine the identification of pathogens. Still, integration of clinical, microbiological, parasitological, and water-quality data makes the findings robust.

# CONCLUSION

This study presents the first comprehensive analysis of the seasonal prevalence of infectious diseases in freshwater ornamental fish in Aurangabad, Maharashtra, with direct correlations to water-quality parameters. Across 80 fish representing six popular species, the overall infection prevalence was 46%, with protozoan/monogenean parasites dominating post-monsoon, bacterial infections peaking pre-monsoon, and fungal infections recurring at low levels during cooler months. Statistical analysis confirmed that elevated ammonia and reduced dissolved oxygen (DO) were the most significant predictors of infection.
These findings echo patterns observed globally, underscoring water quality as the primary determinant of fish health.
Management implications are clear:

- Maintain ammonia $\leq$ 0.02 mg/L and DO $\geq$ 6 mg/L through routine aeration and biofiltration.
- Anticipate parasite peaks post-monsoon and adopt preventive measures (quarantine, water changes).
- Recognize pre-monsoon bacterial risk linked to organic load, requiring strict hygiene and appropriate therapeutic interventions.
- Integrate herbal phytotherapy (e.g., neem, fenugreek) as adjuncts to antibiotics to reduce antimicrobial resistance.

By documenting seasonal epidemiology and environmental drivers, this work contributes actionable insights for retailers, farmers, and hobbyists, bridging ecological understanding with low-cost husbandry solutions. Future studies with larger sample sizes and molecular pathogen confirmation will strengthen these conclusions.

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