## Effect of Dissolved Oxygen on Infectivity Pattern of Cestodes Lytocestus haryanii in Fish Clarias batrachus L. of River Yamuna, Yamuna Nagar (Haryana), India

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### ABSTRACT

Background: The parasitic helminthes have long been a significant concern to human health and sustainability of various ecosystems including aquaculture. The parasitic infections can disrupt aquaculture quality, biodiversity richness, and leading to ecological imbalances as well. Thus, parasitism is not only crucial for human health but also for the management of habitat community, sustainable development and ecosystem conservation. The hydrological attributes can influence predominantly the infectivity pattern of parasitic helminthes in terms of species richness, diversity, prevalence, geographic distribution, and transmission dynamics in any group of aquatic hosts. Aim: The present research work was carried out to estimate the concentration of dissolved oxygen (mg/L) and its effect on the infectivity pattern and bioecology of caryophyllids Lytocestus haryanii in catfish Clarias batrachus L. of river Yamuna, Yamuna Nagar (Haryana), India. Materials and Methods: The present study was carried out during July 2018 to June 2020. The concentration of Dissolved Oxygen (DO, mg/L) in the collected water sample was estimated using modified Winkler's method. There were various modern numerical tools employed for assessment and validation of effect of DO (mg/L) on infectivity patterns of L. haryanii. Results: The peak dissolved oxygen concentration (mg/L) was estimated (modified Winkler's method) during the month of April and August positively corroborated to the establishment, richness and burden of caryophyllids in fish hosts. However, augmented Dissolved Oxygen (DO, mg/L) in river water reflected negative correlation with infection prevalence, distribution and transmission dynamics of cestodes among host population. Conclusion: The biostatistical substantiation by regression trends, ANOVA and f-test revealed concentration of Dissolved Oxygen (DO, mg/L) as a principal component of hydrological attributes that influence the infectivity pattern of cayophyllids significantly in fish hosts. Therefore authors suppose to propose awareness about parasitic helminthes which may be helpful in management of healthy and sustainable aquaculture and riverine ichthyodiversity.

Keywords: Lytocestus haryanii, Bioecology, Infectivity pattern, Parasitic helminthes, Infection prevalence, Mean worm burden.

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INTRODUCTION

The population biology of parasitic helminths in aquatic vertebrates is intricately linked to environmental factors that shape the dynamics of host-parasite interactions.<sup>[1-4]</sup> Thus understanding how environmental variables

influence the population biology of these parasites is crucial for predicting disease outbreaks, managing fish health, and conserving aquatic ecosystems.<sup>[5,6]</sup> Aquatic environments are highly variable and subject to changes in water temperature, pH, salinity, dissolved oxygen levels, and pollution.<sup>[7,8]</sup> Each of these factors can significantly impact the survival, reproduction, and transmission of parasitic helminths.<sup>[9,10]</sup> For instance Dissolved oxygen (DO, mg/L) is a critical environmental parameter influencing the health and metabolic functions of aquatic organisms. Moreover, anthropogenic activities such as industrial discharge, agricultural runoff, and urbanization contribute to pollution and habitat degradation, thereby, decline in the level of DO (mg/L) in aquatic systems further influencing helminth populations.<sup>[11-14]</sup> It plays a significant role in shaping the prevalence and intensity of parasitic infections in fish.[15,17] The ecological interactions between parasitic helminths and their aquatic vertebrate hosts are complex and multifaceted. Factors such as host density, biodiversity, and community composition play critical roles in determining infection rates and parasite population dynamics.<sup>[3,18,19]</sup> High host density can facilitate the transmission of parasites, while a diverse host community can either dilute or amplify parasite prevalence depending on the species involved.<sup>[20-22]</sup> The variations in DO (mg/L) levels can affect both the host's immune response and the lifecycle of parasites.<sup>[23,24]</sup> High levels of dissolved oxygen typically support better fish health, potentially reducing susceptibility to infections Conversely, low dissolved oxygen conditions can stress fish, making them more prone to parasitic infestations.[25-29] The study of parasitic infections in aquatic organisms is crucial for understanding the ecological dynamics and health implications for both fish populations and the ecosystems they inhabit. In this context, the present study is designed to analyze the effect of Dissolved Oxygen (DO, mg/L) on the infectivity pattern of cestodes, specifically Lytocestus haryanii Babita et al.[30] in the freshwater fish commonly known as the walking catfish Clarias batrachus Linnaeus<sup>[31]</sup> of the river Yamuna at Yamuna Nagar in Haryana, India.

#### MATERIALS AND METHODS

The present research work was carried out from July 2018 to June 2020 to assess effect of Dissolved Oxygen (DO, mg/L) on the infectivity patterns and bioecology of caryophyllids L. haryanii Babita et al.[30] in catfish C. batrachus Linnaeus<sup>[31]</sup> of river Yamuna (5 km expansion of up-stream and down-stream from central point) at Yamuna Nagar (Haryana), India.<sup>[32,33]</sup> Water sample was collected at a fortnight interval from the middle stream from the selected sites in river Yamuna and Dissolved Oxygen (DO, mg/L) was estimated using modified Winkler's method.<sup>[34-36]</sup> The fish were freshly collected by angling and netting methods brought to Zoology Laboratory, Department of Bio-Sciences and Technology, MMEC, Maharishi Markandeshwar (Deemed to be University), Mullana-Ambala (HR), India for further parasitological investigation including extraction, morphological identification and taxometric substantiation of endoparasitic helminthes.<sup>[2]</sup> The Infection Prevalence per cent (IP%) and Mean Worm Burden (MWB) was enumerated using standard statistical methods.[37-39] There were various modern numerical tools (time series curves, regression analysis, one-way ANOVA, f-test, etc.) employed for the assessment and validation of the effect of hydrological attribute (single parameter) on the population ecology and infectivity patterns of L. haryanii Babita et al.[30] in selected hosts.

#### RESULTS

The worms isolated from the intestine of *C. batrachus* L. were characterized and identified as caryophyllid cestodes *Lytocestodes* Cohn, 1908 (Yamaguti, 1934, 1959) species *L. haryanii* Babita *et al.*<sup>[30]</sup> The monthly oscillations in the dissolved oxygen (mg/L) ranged between 3.40-7.03 mg/L (Table 1) and 3.14-6.08 mg/L (Table 2) during 2018-2019 and 2019-2020 respectively. The pattern of variation in the selected single hydrological attribute (DO, mg/L) was assessed through the time series curve showed a corroborative and identical pattern with dual peak and an abrupt trough during both the year of study (Figure 1). The dual peak of dissolved oxygen (DO, mg/L) was estimated and illustrated in



Figure 1: Time series curves illustrating pattern of fluctuation in Dissolved Oxygen (mg/L) of river Yamuna during 20018-2019 (a) and 2019-2020 (b). *Where:* Case, Months.

the month of August and April during 2018-2019 (Table 1, Figure 2) and 2019-2020 (Table 2, Figure 3). On contrary, the abrupt decline in dissolved oxygen (DO, mg/L) concentration of river Yamuna water was analyzed during January-February of both year of study (Tables 1, 2).

Table 1: Monthly variation of Dissolved Oxygen (mg/L; Mean±SD) and <i>L. haryanii</i> in <i>C. batrachus</i> L. of river Yamuna, Yamuna Nagar (HR), India during 2018-2019.							
Months	DO (mg/L)	Infection Prevalence (IP %)		Mean Worm Burden (MWB)			
	(3)	Male Female		Male	Female		
2018							
July	5.19±0.22	20.00	30.00	5.50	5.67		
August	7.03±1.35	22.22	18.18	4.50	5.50		
September	6.90±1.06	25.00	37.50	2.66	4.50		
October	5.65±0.81	83.30	14.29	1.20	2.50		
November	5.25±0.44	23.08	42.86	1.66	2.00		
December	4.80±1.05	35.00	45.00	5.75	6.25		
2019							
January	3.40±1.52	55.55	45.45	4.60	4.20		
February	3.46±0.63	28.57	83.83	2.50	3.40		
March	4.66±0.55	25.00	50.00	2.00	2.50		
April	5.99±1.23	30.00	40.00	4.00	5.33		
May	4.78±0.18	50.00	33.33	5.33	6.25		
June	5.11±0.42	27.27	22.22	5.66	6.00		

Table 2: Monthly variation of Dissolved Oxygen
(mg/L; Mean±SD) and <i>L. haryanii</i> in <i>C. batrachus</i> L.
of river Yamuna, Yamuna Nagar (HR),
India during 2019-2020

	DO (mg/L)	Infection Prevalence (IP %)		Mean Worm Burden (MWB)		
		Male	Female	Male	Female	
	· · · · · · · · · · · · · · · · · · ·	2019				
July	5.35±0.32	22.25	27.27	2.00	4.50	
August	6.08±0.92	16.67	14.29	4.50	3.55	
September	5.91±0.69	18.33	25.00	3.50	5.00	
October	5.78±0.62	30.00	20.00	2.33	2.82	
November	5.38±0.59	33.33	37.50	2.00	3.33	
December	4.80±1.18	45.45	64.44	3.90	4.75	
2020						
January	3.14±1.69	50.00	60.00	5.20	5.60	
February	3.65±0.97	61.40	30.77	1.33	2.25	
March	4.65±0.51	48.00	42.85	2.33	3.00	
April	6.03±1.06	40.00	50.00	5.60	4.60	
May	4.78±0.20	44.44	54.55	4.50	5.25	
June	5.03±0.48	50.00	70.00	5.33	5.75	

Where: SD: Standard Deviation; DO: Dissolved Oxygen; mg/L: Milligram per Liter.

The observations of monthly parasitic prevalence and intensity corroborated to the month wise variations in the selected single hydrological attribute (DO, mg/L) of the habitat occupied by the hosts. The cestodes infection prevalence in the total host fish ranged between 20.05-55.92% (IP in male fish, 20.00-83.30%; IP in female

Where: SD: Standard Deviation; DO: Dissolved Oxygen; mg/L: Milligram per Liter.



Figure 2: Monthly variation (Mean±SD) in Dissolved Oxygen (mg/L) of river Yamuna, Yamuna Nagar (HR) during 2018-2019.



Figure 3: Monthly variation (Mean±SD) in Dissolved Oxygen (mg/L) of river Yamuna, Yamuna Nagar (HR) during 2019-2020.

fish, 14.29-83.83%) with abrupt decline in the month of August, 2018 and October, 2018 in male and female fish respectively (Table 1). The infection was found to be random throughout investigation but there was dual peak parasitic load documented in the month of December, 2018 and June, 2019 (Table 1). The mean worm burden in total host fish was ranged between 1.83-6.00 (MWB in male fish, 1.20-5.75; MWB in female fish, 2.00-6.25) during 2018-2019 (Table 1). The highest worm burden or intensity in the infected hosts was documented in the month of December, 2018 and June, 2019 corroborated to the maximum oscillation in the dissolved oxygen (mg/L) of same habitat.

The research observation during consecutive year (2019-2020) reflected that worms Prevalence (IP%) was ranged between 15.50-60.00% (IP in male fish, 16.67-61.40%; IP in female fish, 14.29-70.00 %); however the Worm Burden (MWB) enumerated between 1.80-5.57 with comparatively higher parasitic load in infected female hosts [MWB in infected female fish, 2.25-5.75(4.20±0.50)] than infected male fish [MWB in infected male fish, 1.33-5.33(3.50±0.38)] (Table 2). The trend of Infection Prevalence (IP%) and intensity (MWB) was found to be identical in both the year of investigation.

The correlation of parasitic prevalence and mean worm burden with selected single hydrological factor (DO, mg/L) of river Yamuna was substantiated through the linear regression equation and the level of significance of association further validated through one way ANOVA/f-test showed remarkable results during 2018-2020 (Table 3).

#### DISCUSSION

The worms were characterized as Lytocestus sp. Cohn<sup>[40]</sup> using key to the cestodes of fishes<sup>[41]</sup> and vertebrates<sup>[42]</sup> and validated as species L. harvanii Babita et al.[30] The extracted caryophyllids are common to inhabit in the stomach or stomach-duodenal junction and intestine of cyprinoid and siluriod freshwater fishes. The monthly variations in the dissolved oxygen (mg/L) level of river Yamuna water was corroborated to the natural disasters, man-made and religious activities that may exploit the quality of aquatic resources and biodiversity.[10,32,33,43-48] The findings to analyze the effect of variation in DO (mg/L) on the infectivity pattern and bioecology of L. haryanii Babita et al.[30] reflected that the augmented dissolved oxygen concentration imposed a negative influence on the distribution dynamics and transmission of infection among population in terms of infection prevalence (IP%) in total hosts during 2018-2019 (Y=18.464-1.801X, r=-0.161,  $p \le 0.617$ ;  $F_{1/10} = 0.267$ ,  $p \le 0.617$ ) and 2019-2020 (Y=22.782-10.410X, r=-0.595,  $p \le 0.041$ ; F<sub>1/10</sub>=5.485,  $p \le 0.041$ ) as confirmed through the through the linear regression graphs (Figures 4, 5). On contrary the increased concentration of dissolved oxygen (mg/L) in river water promoted the establishment and richness of worms' population in total hosts; thereby the Worm Burden (MWB) was recorded higher with respect to augmentation in the selected single hydrological attribute during 2018-2019  $(Y=2.162+0.640X, r=0.444, p \le 0.148; F_{1/10}=2.461,$  $p \le 0.148$ ) and 2019-2020 (Y=2.224+0.691X, r=0.450,  $p \le 0.142$ ; F<sub>1/10</sub>=2.539,  $p \le 0.142$ ) as illustrated through the linear regression graphs (Figures 4, 5).

The infectivity pattern (IP% and MWB) of caryophyllids in the present study enumerated comparatively higher in female hosts than male host fish. Contrary to the current findings, in a research report significantly lower overall prevalence of L. fossilisi in C. batrachus was reported.<sup>[49]</sup> Likewise Borde and Jawale<sup>[50]</sup> documented comparatively lower overall infection prevalence of Lytocestus Cohn<sup>[40]</sup>

Table 3: Linear regression trends and One way ANOVA depicting correlation and biostatistical significance of IP% and MWB of <i>L. haryanii</i> in <i>C. batrachus</i> L. with oscillations in Dissolved Oxygen (mg/L) of river Yamuna at Yamuna Nagar during 2018-2020.							
Factors	Infection Prevalence (IP%) in Fish Host		Mean Worm Burden (MWB) in Fish Host				
	Male	Female	Male	Female			
		2018-2019					
Dissolved Oxygen	Y=21.138-3.644X r=-0.219 <i>p</i> ≤0.493	Y=18.258-12.280X r=-0.748 <i>p</i> ≤0.005	Y=2.271+0.598X r=0.403 <i>p</i> ≤0.194	Y=2.006+0.683X r=0.496 <i>p</i> ≤0.101			
(mg/L)	F <sub>1/10</sub> =0.506 <i>p</i> ≤0.493	F <sub>1/10</sub> =12.687 <i>p</i> ≤0.005	F <sub>1/10</sub> =1.942 <i>p</i> ≤0.194	F <sub>1/10</sub> =3.255 <i>p</i> ≤0.101			
2019-2020							
Dissolved Oxygen (mg/L)	Y=23.387-14.555X r=-0.710 <i>p</i> ≤0.010	Y=25.090-5.770X r=-0.349 <i>p</i> ≤0.266	Y=2.227+0.922X r=0.557 <i>p</i> ≤0.060	Y=2.466+0.683X r=0.410 <i>p</i> ≤0.186			
	F <sub>1/10</sub> =10.175 <i>p</i> ≤0.010	F <sub>1/10</sub> =1.389 <i>p</i> ≤0.266	F <sub>1/10</sub> =4.507 <i>p</i> ≤0.060	F <sub>1/10</sub> =2.017 <i>p</i> ≤0.186			



Figure 4: Effect of Dissolved Oxygen (mg/L) on infection attributes of *L. haryanii* in *C. batrachus* L. during 2018-2019. Where: IPT, Infection Prevalence % in total fish; MWBT, and Mean Worm Burden total fish.



Figure 5: Effect of Dissolved Oxygen (mg/L) on infection attributes of *L. haryanii* in *C. batrachus* L. during 2019-2020. Where: IPT and MWBT was IP % in total fish, and MWB total fish respectively.

in C. batrachus. As per the report of Malhotra<sup>[38]</sup> the increased worm intensity in male fish host corresponded to enhanced DO concentration (mg/L) of riverine water body supported the observation during the period of present. The findings of Chandra et al.[51] reflected an overall lowered prevalence and intensity of L. indicus in the catfish C. batrachus in comparision to present study. The literature reviews and 2 years study reflected the host-specific occurrence Lytocestus sp. but the distribution dynamics, bioecology and infectivity pattern was regulated by physiological, and ecological factors, diet and mode of feeding significantly.[52,53] The maximum parasitic infection in female fish was recorded in breeding or spawning season corroborated to peak worm load, richness and intensity in the monsoon season during June to August.<sup>[54,55]</sup> Contrast to the present study, Jaiswal et al.[3,18] documented an uniform positive correlation of enhanced DO with Infection Prevalence (IP%) in female and male fish during 2009-2010. However, the finding of same school on mean intensity in both sexes during 2008-2009 showed a similar trend and supported to present investigation. In an earlier report it has already been reported that the DO (mg/L) played a key role on the dynamics and ecology of parasitic helminthes that further verified by the ANOVA/f-test during present study in terms of the establishment, abundance, worm burden and prevalence among freshwater fish hosts or aquatic fauna.<sup>[3,19,56]</sup> The influence of Dissolved

Oxygen (DO, mg/L) on Infection Prevalence (IP%) and Worm Burden (MWB) in fish hosts reinforces the perspective that single hydrological attribute may work in conjunction with various biotic and abiotic factors of the same habitat.<sup>[57-59]</sup> In the recent investigation authors observed a striking positive correlation of augmented DO (mg/L) to worm burden and a contrast association to prevalence correlation further showed a comparative trends as multivariate analysis illuminated a compelling connection between Dissolved Oxygen levels and Cephalogonimus yamunii.<sup>[3,18,60,61]</sup>. In contrast to the present study, Jaiswal et al.<sup>[18]</sup> and Zargar et al.<sup>[62]</sup> reported that the dissolved oxygen offered a very well-marked negative correlation on the worm intensity; however the worms prevalence positively dependent on the same single hydrological attribute Kuris et al.<sup>[63]</sup> In a report Farhaduzzaman et al.[64] reported high prevalence of parasites in the Indian Major Carp, Labeo rohita (Ham.) during the month of December corroborated to the infection pattern (IP%) during present investigation. Since the river Yamuna is one of the major rivers of

Northern India, contributing key role in maintaining rich aquatic biodiversity; however, the river is facing severe pollution challenges, and ultimately impacting its aquatic life, including fish. The study provides a holistic view by linking environmental factors (dissolved oxygen levels) to biological outcomes (cestode infectivity in fish), facilitating a better understanding of river Yamuna ecosystem through data-driven, ecologically relevant, and policy-impactful findings. This study in a nutshell addresses the effect of Dissolved Oxygen (DO) levels on the infectivity patterns of tapeworms in fish, thereby authors suppose to propose and recommend for protecting both the river's ecological health and the human populations relying on its resources. This status can be achieved by planning and implementation of a policy to significantly reduce the untreated discharge of industrial effluents, agricultural runoff, and sewage responsible for the declined DO (mg/L) levels in the river. The regular monitoring and research directed that lower DO level of riverine water increase the susceptibility of fish to cestode infections, impacting fish populations and productivity, thereby potentially affecting human health through consumption.

#### CONCLUSION

The alimentary canal of fishes is the most favorable site for the establishment and growth of many helminthes parasites that may induce morphological changes in the host tissues and thereby causing alteration to the normal intestinal physiology and ultimate productivity of aquaculture in both the senses quality as well as quantity. The monthly investigation based on the fortnight collection of water and fish sample revealed the significant variation in the level of dissolved oxygen corroborated to natural and man-made activities. However, the infectivity pattern noticed to be random throughout the period of investigation.

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#### **CONFLICTS OF INTEREST**

The authors declare that there is no conflict of interest.

#### **ABBREVIATIONS**

**ANOVA:** Analysis of variance; **SD:** Standard deviation; **DO:** Dissolved oxygen; **mg/L:** Milligram per Liter; **IP%:** Infection prevalence percent; **MWB:** Mean worm burden.

#### **SUMMARY**

The bioecological study reflected the occurrence of comparatively higher prevalence at lowered dissolved oxygen level. While augmented DO (mg/L) concentration positively supported the establishment, richness and worm burden during the period of study corroborated to the hypothesis that the principal environmental attribute controlled the parasitization among aquatic vertebrates. Therefore, awareness of relationships between aquatic fauna *vs.* water pollution and parasitic infra-community *vs.* human health considered an essential attribute to carry out customary monitoring and surveillance of such important aquatic ecosystems.

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