

The impact of water quality on the population distribution pattern of cephalogonimid trematodes *Cephalogonimus yamunii* in fresh water fish *Heteropneustes fossilis* at Allahabad, Uttar Pradesh

Sushil K. Upadhyay¹, Deepak Yadav¹ and Ravindra Kumar Pathak²

¹Department of Zoology, Faculty of Science, Swami Vivekanand Subharti University, Meerut, U.P.

²Regional Centre of Central Inland Fisheries Research Institute, Allahabad, U.P.

Accepted: 27 October 2015

Abstract

The impact of oscillations in water quality parameters on the population dynamics of the digenean trematodes of family cephalogonimidae *Cephalogonimus* in fresh water fish *Heteropneustes fossilis* (Teleostomi: Heteropneustidae) from riparian wetlands of river Ganges at Allahabad was analyzed during the period of investigations (2014-2015). The augmentation in water temperature, alkalinity and lowering of dissolved oxygen (DO) concentration had positive influence on the flukes infection prevalence % and richness of parasites population. The significance of environmental parameters on the parasitic infection distribution patterns were calculated by modern biostatistical tools. The Eigen value of first component (PC1st) was found to be significant for dissolved oxygen in multifactorial analysis. The infection data supports the random distribution of trematodes in the host was observed on Poisson series ($p > 0.50$).

Keywords: Population dynamics, *Cephalogonimus yamunii*, Riparian wetlands, *Heteropneustes fossilis*, Water quality.

Introduction

An organism has its identity as an individual and also as a component of population or community in specialized environmental conditions. The interactions of organism with their physical and biological environments are influencing their spatial and temporal distribution and abundance (Singh 1995, Ricklefs & Miller 2002, Singh & Kumar 2003). The parasites are known to drain resources upon their hosts, thereby forcing them to evolve abilities to counterbalance the hosts offensive stress responses. The echinostomatid parasitic infections by *C. yamunii* (Upadhyay *et al.* 2012) are encountered during the period of investigation within the fresh water host *H. fossilis*. The production of stress proteins in *H. fossilis* is associated with various environmental conditions and host-parasite stress interactions (Malhotra *et al.* 2009). The development and transmission dynamics of flukes in the aquatic and terrestrial food web is commonly taking place through the intermediate hosts or consumers. Therefore, the floral and faunal

compositions of the surrounding environment are mainly responsible for the infestation and establishment of trematodes infection in the suitable hosts (Banerjee 1991, Chaurasia 2002, Jaiswal 2006). The climatic conditions and oscillations in the surrounding environmental factors and parameters are known to be creating an impact on the occurrence of helminthes infections in the hosts (Malhotra 1989, Hudson *et al.* 2006). The pattern of helminthes distribution dynamics and mean worm burden is remarkably conjoined with the level of causative agents responsible for high water pollution and fluctuations in physicochemical properties of surrounding environment of the host (Upadhyay 2012, Jaiswal *et al.* 2013, 2014). The Poisson distribution is an appropriate statistical tool to assess the affinity of the environmental influence on the parasite distribution within the host populations (Jaiswal *et al.* 2013, Upadhyay *et al.* 2013). The present investigation is a yesteryear study on the freshwater fish *H. fossilis* to make an attempt to correlate and validate the impact of changes in water quality on the cephalogonimid

trematodes distribution pattern within the host by the application of modern numerical tools.

Material and Methods

The live fish *H. fossilis* were collected by common netting and angling methods during the period of investigations (July 2014 to June 2015) from fresh water riparian wetlands of the river Ganga at Allahabad, U.P., India. The collected hosts were brought to laboratory, segregated sex-wise, viscera and gut teased out and examined carefully for parasitic infection (Upadhyay 2012). The collected flukes were processed (Jaiswal *et al.* 2014) and identified (Upadhyay *et al.* 2012) by morphotaxometric analysis (Upadhyay *et al.* 2009). The water quality of habitat was analyzed simultaneously (APHA 1998). Modified winkler's method was applied for the estimation of dissolved oxygen (DO) concentration. The impact and significance of correlation of water quality with population distribution of trematodes in fresh water fish was calculated by modern biostatistical software, SYSTAT 11. The pattern of infection distribution within population was worked out by Poisson series (Poisson 1837).

Results

The month wise population dynamics and distribution of *C. Yamunii* (Upadhyay *et al.* 2012) in either sex of host was summarized in Table 1. The helminthes infection prevalence percentage and mean intensity were variably ranged in each sex during the period of investigations. The peak infection prevalence (67.43% in male and 71.73% in female fish) was recorded in month of July. The combined impact of hydrobiological factors on the worm burden was strongest during July to September in both the sexes of fish (Table 1). The pattern of flukes infection within the host population were calculated by Poisson series and it was found to be nonsignificant ($p>0.50$).

The individual effect of oscillations in the physicochemical parameters of riparian wetlands on the bioecology of digenean

trematodes in fresh water fish were estimated by the linear regression equations (Table 2). The correlation of water quality with infection prevalence and mean intensity of *C. Yamunii* in either sex of *H. fossilis* were depicted by linear regression curves. The differential linear regression graphs for each parameters like dissolved oxygen (Fig. 1), water temperature (Figs. 2, 3), hardness, acidity and alkalinity (Fig. 4) during 2014-2015, have been represented.

The cumulative influence of all hydrobiological parameters when interacting to each other in a riparian wetland of the river Ganges during the period of study on the echinostomatid trematodes infections were estimated by multiples regressions (Table 3) and described by the multivariate analysis. The numerical substantiation chiefly for dominant first component among all the hydrobiological factors for cephalogonimids distribution and abundance was worked out by the principal component analysis. The predominance of PC1^p was found to be significant for dissolved oxygen and reflected by highest Eigen values (3.139) and variable of first component (-0.714).

Discussion

The cephalogonimid distribution prevalence ranged between 6.79-61.43% in male and 7.77-71.73% in female *H. fossilis* with male intensity 3.0-11.3 and 2.0-12.5 in male and female fish respectively (Table 1) was associated with cyclic change in physicochemical and biological composition of the fresh water habitat validated by the linear regression equations (Table 2). The recruitment of trematodes was associated with the temporal and spatial variations in the hydrobiological parameters (Sausa 1990) and the compositions of biotic fauna of same habitat have been worked out by periodic investigations (Esch & Fernandez 1993). The augmentation mean intensity in male fish with corresponding increase in dissolved oxygen concentration of riverine water body were the

remarkable findings during the period of investigations (Fig. 1). The oscillations in water temperature were positively associated with infection prevalence (Fig. 2), on contrary it had negative impact on the establishment of trematodes infection in female fish in terms of mean intensity (Fig. 3). The month wise distribution of flukes infection in wild fish under the influence of water temperature have been well studied substantiated by the earlier workers (Al- Kandari *et al.* 2000, Cattadori *et al.* 2005, Ernst *et al.* 2005) as the correlation of water temperature with infection prevalence and mean intensity by *C. yamunii* (Upadhyay *et al.* 2012) encountered in the present investigation. The peak infection distribution (66.58%) and abundance (11.9) of trematodes population in *H. fossilis* was recorded at 22-28 °C thermal regime and concluded as optimum environmental temperature for infection in wild edible fish was closely related to 26-27 °C as reported for parasites of fishes in Meinhart and Manginia dam in Pakistan (Khan *et al.* 2003). The consistently increasing effects of alkalinity on infection prevalence in both the sexes of fish were encountered (Fig. 4). This corroborated the evidence of consistent increase in infection prevalence along with the increase in the contributory factors to alkalinity in the riparian water body of the Gangetic plains. The augmentation in the extrinsic individual environmental factors such as hardness and alkalinity due to the man made alterations in the wild riparian habitat play a key role on the establishment and abundance of the helminthes parasites in the freshwater aquatic fauna (Krasnov *et al.* 2006). The cumulative influence of DO, water temperature, alkalinity, hardness and acidity on the dynamics of *C. yamunii* (Upadhyay *et al.* 2012) was verified by the multivariate analysis (Table 3). The findings

were corroborated the same affinity as by trematode *Accacoelium garuensis* in *Clupeisoma garua* (Jaiswal 2006). A dominant 1st component (PC1^P) of all interacting hydrobiological factors was calculated and validated by the Principal component analysis on the month wise response of infection by *C. yamunii* (Upadhyay *et al.* 2012) in *H. fossilis*. The peak Eigen value (3.139) and variable of factor loadings (-0.714) confirmed the predominance of dissolved oxygen as 1st component. The impact of dissolved oxygen well supported by Principal component analysis also substantiating inferences concluded by multiple regression analysis (IPMALE: $Y=35.287+0.981X_1-3.659X_2+0.779X_3+0.369X_4-0.358X_5$; IPFEMALE: $Y=115.218-1.991X_1-11.395X_2+0.379X_3+0.267X_4+0.344X_5$; MIMALE: $Y=-35.287+2.978X_1-4.113X_2-0.472X_3+0.389X_4+0.246X_5$; MIFEMALE: $Y=35.287-1.111X_1-5.642X_2+0.913X_3-0.386X_4+0.422X_5$). The findings during the period of study further strengthened the viewpoint that the physico-chemical factors in the aquatic environment did not operate in isolation (Krasnov *et al.* 2005, 2008, Fenton 2007, Barrett 2009). The non significant infection distribution data on Poisson series ($p>0.50$) was observed during the period of investigation and corroborated random sickness of host population due to trematodes infection. The interaction of the all constituents within the fresh water body assists the localized species to strike abundance and distribution with their ambient surroundings for their survival and flourishing growth. Thereby the micro and macro environment of the endoparasites thus influence their survival as well as dynamics in a significant manner. The evidence therefore, is available in this study to indicate that the association of infection prevalence and mean intensity was dependent on the physicochemical and biological water quality.

Table 1. Month wise distribution data of *Cephalogonimus yamunii* in *Heteropneustes fossilis* during 2014-2015.

Months	Infection Prevalence %		Mean Intensity	
	Male fish	Female fish	Male fish	Female fish
2014				
July	61.43	71.73	10.5	12.5
August	18.82	16.53	8.2	10.0
September	6.79	7.77	11.3	8.5
October	32.51	22.25	7.0	8.0
November	55.73	62.91	9.5	11.0
December	35.32	54.0	7.5	8.0
2015				
January	8.96	17.57	7.0	9.3
February	12.13	15.23	7.2	4.5
March	8.57	9.98	3.0	2.0
April	28.83	12.30	5.4	3.5
May	37.48	32.29	3.3	2.5
June	54.20	47.73	5.5	6.0

Table 2. Correlation hydrobiological parameters with infection of *Cephalogonimus yamunii* depicted by linear regression equations in *Heteropneustes fossilis* during 2014-2015.

Water parameters	Male fish	Female fish
DO vs IP%	Y=48.44-0.18X r=0.40 p<0.50	Y=54.24-0.29X r=0.40 p<0.50
DO vs MI	Y=33.18-0.33X r=0.30 p<0.50	Y=28.31-0.27X r=0.42 p<0.40
Temp vs IP%	Y=18.24+0.25X r=0.39 p<0.40	Y=36.09+0.34X r=0.40 p<0.50
Temp vs MI	Y=49.44+0.49X r=0.40 p<0.50	Y=54.76+0.92X r=0.35 p<0.40
Hardness vs IP%	NS	Y=23.40-0.47X r=0.30 p<0.40
Hardness vs MI	NS	Y=18.14-0.19X r=0.33 p<0.40
Alakalinity vs IP%	Y=39.14-0.11X r=0.36 p<0.50	Y=-48.44+0.08X r=0.30 p<0.40
Alakalinity vs MI	Y=11.14-0.48X r=0.30 p<0.40	NS
Acidity vs IP%	NS	Y=47.24-0.61X r=0.34 p<0.40
Acidity vs MI	Y=39.25+0.23X r=0.40 p<0.50	NS

IP% infection prevalence%, MI mean intensity, DO dissolved oxygen, Temp water temperature

Table 3. The data of multivariate analysis to substantiate predominant interrelationships of hydrobiological factors with infection of *Cephalogonimus yamunii* in *Heteropneustes fossilis* during 2014-2015.

IPMALE: $r=0.456$
$^{\circ}\text{C}$ DO Alk Hardness Acidity
$Y=35.287+0.981X_1-3.659X_2+0.779X_3+0.369X_4-0.358X_5$
IPFEMALE: $r=0.547$
$^{\circ}\text{C}$ DO Alk Hardness Acidity
$Y=115.218-1.991X_1-11.395X_2+0.379X_3+0.267X_4+0.344X_5$
MIMALE: $r=0.692$
$^{\circ}\text{C}$ DO Alk Hardness Acidity
$Y=-35.287+2.978X_1-4.113X_2-0.472X_3+0.389X_4+0.246X_5$
MIFEMALE: $r=0.834$
$^{\circ}\text{C}$ DO Alk Hardness Acidity
$Y=35.287-1.111X_1-5.642X_2+0.913X_3-0.386X_4+0.422X_5$

$^{\circ}\text{C}$ water temperature, *DO* dissolved oxygen, *Alk* alkalinity

Fig. 1 Correlation of mean intensity by *C. yamunii* n.sp. in female *H. fossilis* with dissolved oxygen .

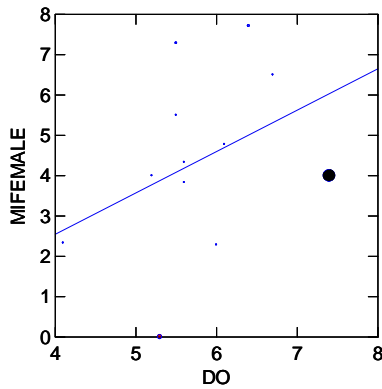


Fig. 3 Correlation of mean intensity by *C. yamunii* n.sp. in female *H. fossilis* with water temperature.

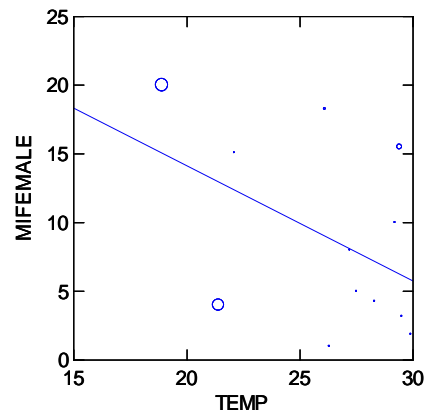


Fig. 2 Correlation of infection prevalence by *C. yamunii* n.sp. in male *H. fossilis* with water temperature.

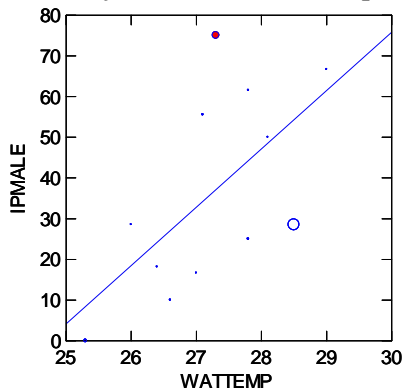
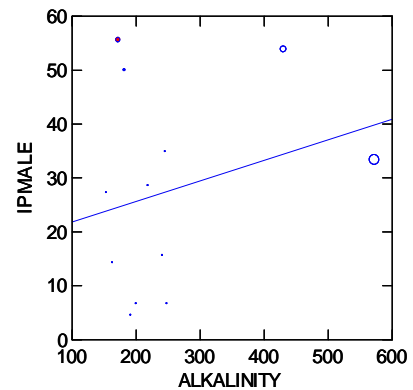


Fig. 4 Correlation of infection prevalence by *C. yamunii* n.sp. in male *H. fossilis* with alkalinity



References

- Al-Kandari, W. Y., J. Abdul-Salam & R. Meakins 2000. Temporal variations in the infection of a population of *Cerithidea cingulata* by larval trematodes in Kuwait bay. *J. Helminthol.*, **74**: 17-22.
- APHA (Amer. Pub. Hlth. Asso.) 1998. Standard method for the examination of water and waste water (20th edn.). *American Water Works Association*. Water Pollution Control Federation, Washington DC. p1085.
- Banerjee, S. C. N. 1991. Population distribution and pathology of parasites in fishes of high altitude and Gangetic plains. Unpublished D. Phil. thesis submitted to University of Allahabad Pp 551.
- Barrett, J. 2009. Forty years of helminth biochemistry. *Parasitol.*, **136**: 1633-1642.
- Cattadori, I. M., D. T. Haydon & J. Hudson 2005. Parasites and climate synchronize red grouse populations. *Nature*, **433**: 737-741.
- Chaurasia, G. 2002. Investigations to identify Biodiversity determinants in Ichthyoparasitology. Unpubl. D. Phil. Thesis submitted to University of Allahabad. Pp 129.
- Ernst, I., I. D. Whittington, S. Corneillie & C. Talbot 2005. Effects of temperature, salinity, dessication, hatchery and chemical treatment on egg embryonation and hatchery success of *Benedenia sericola* (Monogenea: Capsalidae, a parasite of formal *Sericola* sp.). *J. Fish. Dis.*, **28**: 157-164.
- Esch, G. W. & J. C. Fernandez 1993. A functional biology of parasitism, ecological and evolutionary implications. *Chapman and Hall* Pp337.
- Fenton, A. 2007. Worms and germs: the population dynamics consequences of microparasite-macroparasite coinfection. *Parasitol.*, **135**: 1545-1560.
- Hudson, P. J., I. M. Cattadoni, B.Boag & A. P. Dobson 2006. Climate disruption and parasite-host dynamics: pattern and process associated with warming and the frequency of extreme climate events. *J. Helminthol.*, **8**: 175-182.
- Jaiswal, N. 2006. Spectral signatures in ichthyophthiriasis and co-occurring parasitic infracommunity variations in freshwater and marine habitats. Unpublished D. Phil. Thesis submitted to University of Allahabad Pp 387.
- Jaiswal, N., S.K. Upadhyay, A. Malhotra & S.K. Malhotra 2014. Ecological morphotaxometry of newer trematodes of garfish (Teleostomi: Belonidae) from Gangetic riverine ecosystem in India. III. Principal component analysis for hydrobiological correlates to dynamics of infection by *Cephalogonimus yamunii* . *J. Parasit. Dis.*, **38(2)**: 153-162.
- Jaiswal, N., S. K. Upadhyay, A. Malhotra & S. K. Malhotra 2013. Multifactorial etiology of infections by larvae of *Eustrongylides tubifex* (Nematoda: Dioctophymidae) in silver whiting of the central west coast of India at Goa. *Asian J. Biol. Sci.*, **6(2)**: 21-39.
- Jaiswal, N., S. K. Upadhyay, A. Malhotra, C. K. Blend, N. O. Dronen & S. K. Malhotra 2014. A new species of *Neolebouria* Gibson, 1976 (Opecoelidae: Plagioporinae) from the whitecheek monocle bream, *Scolopsis vosmeri* (Perciformes: Nemipteridae) from the Panjim coast at Goa, with a checklist of parasites previously reported from this fish. *Zootaxa.*, **3802(1)**: 98-108.
- Khan, M. N., F. Aziz, M. Afzal, A. Rab, I.Sahar, R. Ali & M. Naqvi 2003. Parasitic infection in different freshwater fishes of mini dames of Patohor region, Pakistan. *Pak. J. Biol. Sci.*, **6**: 1092-1095.
- Krasnov, B. R., N. P. Korrillo-Vinarskaya, M. V. Vinarsky, G. I. Shenbrot, D. Mouillot & R. Poulin 2008. Searching for general patterns in parasite ecology: host identity versus environmental influence on gamasid mite assemblages in small mammals. *Parasitol.*, **135**: 229-242.
- Krasnov, B. R., G. I. Shenbrot, D. Mouillot, I. S. Khokhlova & R. Poulin 2005. Spatial variation in species diversity and composition of flea assemblages in small mammalian hosts: geographical distance or faunal similarity. *J. Biogeo.*, **32**: 633-644.
- Krasnov, B. R., M. Stanko, D. Miklisova & S. Morand 2006. Habitat variation in species composition of flea assemblages on small mammals in central Europe. *Ecol. Res.*, **21**: 460-469.
- Malhotra, A., N. Jaiswal, S. K. Upadhyay, S. Kumar & S. K. Malhotra 2009. Parasite stress response in zoonoses of *Cephalogonimus* sp. *Indian J. Helminthol.*, (N.S.). **27**: 73-80.
- Malhotra, S. K. 1989. Ecological echthyoparasitology in India. *Indian Rev. Life Sci.*, **9**: 253-296.
- Possion, S. D. 1837. *Recherches sur la probability des judgments*. Paris.

- Ricklefs, R. E. & G. L. Miller 2000. *Ecology* (4th edn). *Freeman and company, New York* Pp 822.
- Sausa, W. P. 1990. Spatial scale and the processes structuring a guild of larval trematode parasites. *In: Parasite communities: patterns and processes* **edited by** G. Esch, A. Bush and J. Aho *London, Chapman and Hall*. Pp 41-67.
- Singh, H. R. 1995. Water pollution and fisheries. *In: Encyclopedia of environment pollution and control* **edited by** K. K. Trivedi **2**: 403-421.
- Singh, H. R. & N. Kumar 2003. Biodiversity of mountain streams and some new areas for research. *In: Emerging trends in fresh water biology* **edited by** P. Nautiyal.
- Upadhyay, S. K. 2012. Transmission dynamics and environmental influence on food borne parasitic helminthes of the Gangetic plains and central west coast of India. Unpublished D. Phil. Thesis submitted University of Allahabad Pp 400.
- Upadhyay, S.K., N. Jaiswal, A.Malhotra & S.K. Malhotra 2012. Ecological morphotaxometry of newer trematodes of garfish (Teleostomi: Belonidae) from Gangetic riverine ecosystem in India. I. Morphology and taxometric assessment of *Cephalogonimus yamunii* n.sp. *J. Parasit. Dis.*, DOI 10.1007/s12639-012-0200-6.
- Upadhyay, S. K., N. Jaiswal, A.Malhotra & S.K. Malhotra 2013. Ecological morphotaxometry of newer trematodes of garfish (Teleostomi: Belonidae) from Gangetic riverine ecosystem in India. II. Correlation of seasonality and host biology with distribution pattern of *Cephalogonimus yamunii* n.sp. *J. Parasit. Dis.*, **37(2)**: 211-217.
- Upadhyay, S. K., N. Jaiswal, A. Malhotra & S. K. Malhotra 2009. An aspidoderid roundworm *Pseudaspidodera cordinae* n.sp. from rodents at Allahabad. *Indian J. Helminthol.* (N.S.). **27**: 89-94.