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A COMPARATIVE STUDY ON SEASONAL DISTRIBUTION OF THE HELMINTH PARASITES COMMUNITIES OF SOME CATFISHES

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ABSTRACT

The present investigation was carried out seasonally from October 2008 to September 2010, to study the impact of helminth parasites of catfishes of Lucknow. The fish fauna viz., *Clarias batrachus, Heteropneustes fossilis, Wallago attu, Mystus vittatus* and *Rita rita* were carried trematode, cestode, nematode and acanthocephalan parasites communities singly or mixed. The collected fish species include two monogenean species (*Gyrodactylus* and *Dactylogyrus*), seven digenean species (*Clinistomum, Euclinostomum, Gastrohtylax, Paramphistomum, Opisthorchis, Aspidogaster* and *Fasciola*), one cestode species (*Teania*), one nematode species (*Trichinella*) and one acanthocephalan species (*Pallisentis*). The data showed significant highest parasitic communities during the summer season, moderate in monsoon and lowest in winter season. The overall prevalence of helminth infection was 58.71 % in catfishes. Among helminth parasites communities, trematode parasites were found to be maximum in number than the rest three parasitic group i.e. cestode, nematode and acanthocephalan parasites. No clear pattern of association between helminth species was detected, showing an unstructured helminth community in which the occurrence of any species was not restricted or favored by the occurrence of any other species. The lack of association might be different life-cycles of parasites. With respect to helminth infection; maximum infection was recorded in case of *Heteropneustes fossilis* and minimum infection intensity was detected in *Rita rita* as compared with other catfishes. The aim of investigation based only to provide the information about fishes harbor the helminth parasites seasonally and avoid these fishes to consume in particular season.

KEYWORDS: Helminth parasites, catfishes, prevalence, dominance, mean intensity, abundance.

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INTRODUCTION

Climate change is predicted to have important effects on parasitism and disease in freshwater and marine ecosystems, with consequences for human health and socio-economics. However, most individual fish in wild or cultivated populations are infected with one or more parasite. The distribution of parasites and pathogens will be directly affected by global warming, but also indirectly, through effects on host age, size, diet, abundance of fishes and independent number of a parasite within the fish[8, 13, 21, 49]. The host availability and transmission environment (typically detected by abiotic conditions), and infection site specificity all have major influences on the species richness and relative abundance in parasite communities[20]. The characteristic of any water body can influence and determine its parasitic fauna and when environmental conditions, such as water, food and temperature become favorable for mass reproduction of parasites, the disease may spread very quickly. The seasonal variation of water characteristics, predominantly temperature, is considered too strongly affect fish physiology and immunology and also affects all life-cycle stages of monogeneans, digeneans, cestodes, nematodes, and acanthocephalans in freshwater fishes[9-12, 16, 22]. The climate variables are able to affect the prevalence, intensity and geographical distribution of helminthes, directly influencing free-living larval stages and indirectly influencing mainly invertebrate, but also vertebrate, hosts[27]. Fish parasite communities may provide important information on ecosystem conditions due to their intimate contact with both the host and aquatic environments[5, 23, 49]. The differences in helminth fauna and its infestation rates are the sensible indicator of the similarity and differences in both trophic and parasite structures in these two macroecosystems[32]. The seasonal differences between or within the different genera are known to be related to the parasite life cycle[29]. Parasites showed annual transmission cycle i.e., low infections occur during the winter, while transmission is continuous and during the summer[45, 53] and until late autumn[14, 23, 42] which may be due to fact that the reproduction rate of parasites may be greater at higher temperature and lower water quality leading to increased parasite abundance[31, 37]. The Prevalence, intensity and abundance of the infection with parasites species richness increases with host body size and the months of the year[2, 19]. The medium sized and weight fish were more infected and their prevalence, intensity and abundance were highest[7, 33, 34, 36, 38, 46, 47]. Infection rate was lowest in very small and very large size fish group[30, 36, 41, 47]. The geo-climatic factors apart from influencing the prevalence and intensity of helminth infecion probably play a significant role in parasite fauna of catfishes[3]. The infestation of endoparasitic helminths of catfishes was more prevalent in the dry season than in the rainy season[36]. The fish parasites are important because they affect the fish production in wild and cultured systems, by decreasing their yield, aesthetic value, marketability, palatability, modulated the immune system and reproductive potential[18, 35, 48] and if left uncurtailed, may lead to mass mortality in fish, or in cases, infection in human and other animals that feed on fish. Thus, they are studied with a view to understanding their population biology and elucidate their life cycles in order to develop an efficient approach of controlling them. The aim of the present paper is to provide the comparative study of helminth fauna and their seasonal abundance and its infection rates in the some catfishes. The taxonomic information is not given in current research because the investigation was assigned on the objectives such as prevalence, dominance, mean intensity and abundance of helminth parasites in relation to seasonal changes.

MATERIALS AND METHODS

(1) Study Area

Lucknow has a warm subtropical climate with cool dry winters from December to February and dry hot summers from April to June. The rainy season is from mid-June to mid-September. In winter the maximum temperature is around 24 degrees Celsius and the minimum is in the 3-4 degrees range. Fog is quite common from late December to late January. Summers are quite hot with temperature hovering in the 40-45 degree Celsius range. Lucknow gets an average rainfall of 101 cms mostly from the south-west monsoon winds between June and September (Figure 1).

(2) Fish Sampling

The survey covers the relative prevalence of helminth parasites in some fresh water catfishes during the period October 2008-September 2010. The fishes collected from different aquatic resources of Lucknow region with the help of local fisherman following standard sampling designs and then transferred to the research laboratory for further analysis.

The fishes examined belonging to 5 species from 4 families and included as *Clarias batrachus* (Linn.) Claridae; *Heteropneustes fossilis* (Bloch.) Saccobranchidae; *Wallago attu* (Schn.) Siluridae; *Mystus vittatus* (Sykes) Bagridae and *Rita rita* (Ham.) Bagridae were used for study.

The collected parasites were identified by using a compound microscope following the description and figures[21, 50, 51, 52]. Fishes showed different stage of helminth parasites as cyst, larval and adult forms of trematode, nematode, cestode and acanthocephalan. They occupied various regions externally and internally of fish. But in the present study observation only adults were taken into consideration.

(3) Statistical analysis and Use of Ecological Terms in Parasitology

Data were subjected to statistical significance analyses following the standard Analysis of Variance (One Way ANOVA) method for drawing out clear inferences on the outcome of the experiment. The Complex Chi-square and contingency test were used for study the relationship between parasites intensity and different seasons (viz., winter, summer and monsoon). Study data presented as season wise viz., winter (October to January), summer (February to May) and Monsoon (June to September)[26]. Standard statistical computations viz., prevalence, dominance, mean intensity and abundance were carried out[39].

RESULTS

In this study, the cysts, juveniles or larval forms and adult form of helminth parasites were observed but only the adult form of parasites were reported. The total 2282 worms of 14 species, including two monogenean Trematodes (*Gastrothylax* spp. and *Dactylogyrus* spp.), seven digenean Trematode (*Clinostomum* spp, *Euclinostomum* spp, *Gastrothylax* spp., *Paramphistomum* spp., *Ophisthorchis* spp., *Aspidogaster* spp and *Fasciola* spp.), one Cestodes (*Teania* spp.), one Nematode (*Trichinella* spp), and one Acanthocephalus (*Pallisentis* spp) were found in five catfishes. Helminth infection caused deterioration in fish external as well as internal tissue intactness. During the study, presence of cloudiness of skin (grey and white), reddening, ragged or torn fins, raised scales, white spots or parasites visible to naked eyes were observed externally. The common changes in internal body parts i.e., yellowish color of liver, congestion and reddening of liver, pale yellow color of kidney, transparency and inflammatory of intestine, hardening of bile and gall bladder, adipose tissues between the intestine and liver, fluid in the peritoneal cavity, white nodule on liver, pancreas and kidney were also observed. The seasonal prevalence (%), dominance (%), mean intensity and abundance of helminth parasite in local fresh water cat fish during two successive years were recorded. Data represents a comparative statement of seasonal effect on different helminth parasitic group in five common edible fresh water cat fish. The overall prevalence of helminth infection was 58.71 % in catfishes. The parasite community was dominated by trematode. The next highest parasite community was recorded with acanthocephalan followed by cestode and nematode; however later two showed fluctuating infection season wise and species wise (Figure 2). It was found statistically that the occurrence of all four helminth parasitic groups (trematode, cestodes, nematode and acanthocephalan) were not influence each other ($\chi^2 < 1$, below the significant value) but their availability in examined cat fishes was affected by different seasons with varied significant level (Figure 2; for winter $\chi^2 = 10.91$, $p < 0.85$; for summer $\chi^2 = 38.14$, $p < 0.05$; for monsoon $\chi^2 = 11.84$, $p < 0.5$, complex chi-square and contingency test). The examined fish species found to be single infection and mixed infection also. The fish harbored the most common combination of helminth parasites was trematode and acanthocephalan and rare combination was cestode and nematode.

With respect to annual helminth infection, minimum infection intensity for overall community was detected in *M. vittatus* whereas maximum infection was recorded in case of *H. fossilis* as compared with other cat fish (Figure 2). The result showed significant correlation between helminth community and seasonal changes. In late monsoon and winter period, the lower level of helminth infection was observed whereas; higher infection was recorded during summer season in examined cat fishes (Figure 1, Table 1-5). During winter season, with respect to helminth infection, minimum infection intensity was detected in *R. rita* and maximum infection was recorded in case of *H. fossilis* as compared with other examined catfishes (Figure 2). During investigation it was observed that the prevalence of helminth parasites in all cat fish was higher with trematode followed by acanthocephalan, nematode and lower cestode with (Table 1-5). The dominance of helminth parasites was also differing in cat fishes and follows the same trend of percent prevalence during the study period. Among helminth parasites, trematode parasites showed highest dominance in *C. batrachus* and *H. fossilis*; acanthocephalus in *H. fossilis* and *R. rita*; nematode in *W. attu* and *R. rita*; cestode in *C batrachus* and *R. rita* (Table 1-5). The mean intensity of helminth parasites also varied from species to species. In case of *C. batrachus,* the maximum mean intensity was observed with trematode followed by acanthocephala, nematode and cestode. In *H. fossilis, M. vittatus* and *R. rita* the highest mean intensity was showed with acanthocephala followed by trematode, nematode and cestode. However, in *W. attu*, the maximum mean intensity was recorded with acanthocephalan followed by nematode, trematode and cestode parasites (Table 1-5).

During summer season, the helminth parasites showed maximum frequency of infection in *H. fossilis* and minimum in *W. attu* as compared to other examined fish species. Among helminth parasites, trematode and acanthocephalan showed higher frequency while, frequency of nematode and cestode fluctuate from species to species (Figure 2). The overall percentage prevalence, percent dominance and abundance of helminth parasites was same in all examined cat fishes as trematode was highest followed by acanthocephalan, nematode and minimum in cestode except in *M. vittatus* where minimum was nematode instead of cestode (Table 1-5). The mean intensity of helminth community showed differences in all examined cat fishes. In case of *C. batrachus* and *M. vittatus*, the trematode parasites showed highest mean intensity value followed by nematode, cestode and acanthocephalan (Table 1, 4). In *H. fossilis* and *W. attu*, the trematode and acanthocephalan showed maximum mean intensity value. However, the minimum mean intensity was observed with nematode and cestode in *H. fossilis* and *W. attu* respectively (Table 2, 3). In case of *R. rita*, the higher mean intensity was recode with trematode followed by nematode, acanthocephalan and cestode (Table 5).

In monsoon season, the overall frequency of helminth community was observed utmost in *H. fossilis* and least in *M. vittatus* as compare to other cat fish (Fig. 2). The percentage prevalence of helminth community was higher during monsoon season as compared to winter but lower than the summer season. The percentage prevalence, percentage dominance, mean intensity and abundance for helminth parasites viz., maximum in trematode followed by acanthocephalan nemaode and minimum for cestode was found to be similar in both *C. batrachus* and *H. fossilis* (Table 1, 2). However, in case of *W. attu* and *M. vittatus,* percentage prevalence, percentage dominance and abundance followed the same pattern but the mean intensity was observed highest for nematode instead of trematode parasites (Table 3, 4). In *R. rita*, the pattern of prevalence, dominance and abundance followed the same i.e., maximum for trematode followed by acanthocaphala, nematode and minimum for cestode whereas, the mean intensity was found to be highest with trematode followed by cestode, acanthocephalan and lowest with nematode (Table 5).

Table 1

Seasons	Prevalence (%)	Dominance (%)	Mean intensity	Abundance
Trematode				
Winter	15.19	72.61	1.64	0.25
Summer	63.03	63.48	2.07	1.31
Monsoon	31.98	57.61	2.25	0.73
χ^2=24.55, p<0.05				
Cestode				
Winter	5.08	6.07	1.00	0.02
Summer	5.19	3.69	1.25	0.08
Monsoon	1.04	1.82	1.00	0.02
χ^2=1.41, p<0.975				
Nematode				
Winter	2.00	6.25	1.00	0.02
Summer	20.78	12.72	1.27	0.26
Monsoon	11.69	14.53	1.57	0.18
χ^2=5.10, p<0.85				
Acanthocephalan				
Winter	5.04	21.33	1.42	0.07
Summer	34.94	20.12	1.21	0.42
Monsoon	18.07	26.04	1.75	0.32
χ^2=15.44, p<0.05				

Prevalence, dominance, mean intensity and abundance value of helminthes parasite communities in fresh water catfish Clarias batrachus. Data is represented season wise viz., winter (October to January), summer (February to May) and monsoon season (June to September). To analyze the relationship, between different study parameter and season for each parasite community, complex chi-square and contingency test was done. Degree of relationship, chi-square (χ^2) and their level of significance (p value) is mentioned in table below individual parasite community.

Table 2

Seasons	Prevalence (%)	Dominance (%)	Mean intensity	Abundance
Trematode				
Winter	20.24	54.48	2.29	0.44
Summer	72.09	50.06	2.92	2.10
Monsoon	31.47	56.40	4.20	1.31
χ^2=25.36, p<0.05				
Cestode				
Winter	1.04	2.00	1.00	0.02
Summer	11.63	4.62	2.28	0.20
Monsoon	7.54	6.44	2.26	0.15
χ^2=2.89, p<0.90				
Nematode				
Winter	4.32	8.85	1.67	0.19
Summer	33.72	14.76	1.53	0.62
Monsoon	12.91	11.18	2.30	0.27
χ^2=7.93, p<0.25				
Acanthocephalan				
Winter	11.18	35.67	2.80	0.30
Summer	48.84	30.55	2.69	1.28
Monsoon	20.55	25.99	2.98	0.63
χ^2=19.73, p<0.05				

Prevalence, dominance, mean intensity and abundance value of helminthes parasite communities in fresh water catfish Heteropneutes fossilis. Data is represented season wise viz., winter (October to January), summer (February to May) and monsoon season (June to September). To analyze the relationship, between different study parameter and season for each parasite community, complex chi-square and contingency test was done. Degree of relationship, chi-square (χ^2) and their level of significance (p value) is mentioned in table below individual parasite community.

Table 3

Seasons	Prevalence (%)	Dominance (%)	Mean intensity	Abundance
Trematode				
Winter	21.59	49.12	1.75	0.16
Summer	64.14	47.16	4.17	1.18
Monsoon	35.10	59.36	2.81	0.98
χ^2=17.71, p<0.05				
Cestode				
Winter	1.39	3.85	1.50	0.04
Summer	6.45	10.29	1.84	0.26
Monsoon	4.29	4.40	1.75	0.07
χ^2=0.87, p<0.95				
Nematode				
Winter	5.81	21.27	3.00	0.20
Summer	24.21	19.98	2.14	0.50
Monsoon	5.51	10.12	3.00	0.17
χ^2=10.42, p<0.25				
Acanthocephalan				
Winter	5.83	25.34	3.01	0.17
Summer	27.03	22.58	2.16	0.57
Monsoon	18.29	26.14	2.37	0.44
χ^2=10.97, p<0.10				

Prevalence, dominance, mean intensity and abundance value of helminthes parasite communities in fresh water catfish Wallago attu. Data is represented season wise viz., winter (October to January), summer (February to May) and monsoon season (June to September). To analyze the relationship, between different study parameter and season for each parasite community, complex chi-square and contingency test was done. Degree of relationship, chi-square (χ^2) and their level of significance (p value) is mentioned in table below individual parasite community.

Table 4

Seasons	Prevalence (%)	Dominance (%)	Mean intensity	Abundance
Trematode				
Winter	15.55	41.65	1.79	0.30
Summer	60.37	51.23	2.75	1.37
Monsoon	25.92	52.91	2.40	0.62
χ^2=14.88, p<0.05				
Cestode				
Winter	0.91	1.82	1.00	0.02
Summer	11.13	11.64	2.30	0.31
Monsoon	2.91	6.45	1.34	0.08
χ^2=1.72, p<0.95				
Nematode				
Winter	3.86	7.42	1.50	0.06
Summer	11.75	9.48	2.43	0.28
Monsoon	2.94	11.33	4.25	0.14
χ^2=6.20, p<0.50				
Acanthocephalan				
Winter	6.70	16.4	1.92	0.13
Summer	33.04	26.80	2.23	0.74
Monsoon	15.36	29.31	2.24	0.34
χ^2=7.60, p<0.50				

Prevalence, dominance, mean intensity and abundance value of helminthes parasite communities in fresh water catfish Mystus vittatus. Data is represented season wise viz., winter (October to January), summer (February to May) and monsoon season (June to September). To analyze the relationship, between different study parameter and season for each parasite community, complex chi-square and contingency test was done. Degree of relationship, chi-square (χ^2) and their level of significance (p value) is mentioned in table below individual parasite community.

Table 5

Seasons	Prevalence (%)	Dominance (%)	Mean intensity	Abundance
Trematode				
Winter	13.97	51.93	1.94	0.27
Summer	63.09	55.29	2.75	1.38
Monsoon	27.38	47.93	10.37	0.51
χ^2=31.29, *p*<0.05				
Cestode				
Winter	1.73	4.87	1.50	0.03
Summer	23.75	15.25	1.63	0.38
Monsoon	3.68	8.29	2.96	0.09
χ^2=8.94, *p*<0.25				
Nematode				
Winter	4.45	15.05	1.91	0.08
Summer	7.24	8.04	2.19	0.20
Monsoon	4.57	17.78	2.00	0.19
χ^2=4.31, *p*<0.85				
Acanthocephalan				
Winter	5.18	28.17	2.83	0.14
Summer	29.06	21.43	1.84	0.54
Monsoon	12.25	26.01	2.24	0.28
χ^2=18.19, *p*<0.05				

Prevalence, dominance, mean intensity and abundance value of helminthes parasite communities in fresh water catfish Rita rita. Data is represented season wise viz., winter (October to January), summer (February to May) and monsoon season (June to September). To analyze the relationship, between different study parameter and season for each parasite community, complex chi-square and contingency test was done. Degree of relationship, chi-square (χ^2) and their level of significance (p value) is mentioned in table below individual parasite community.

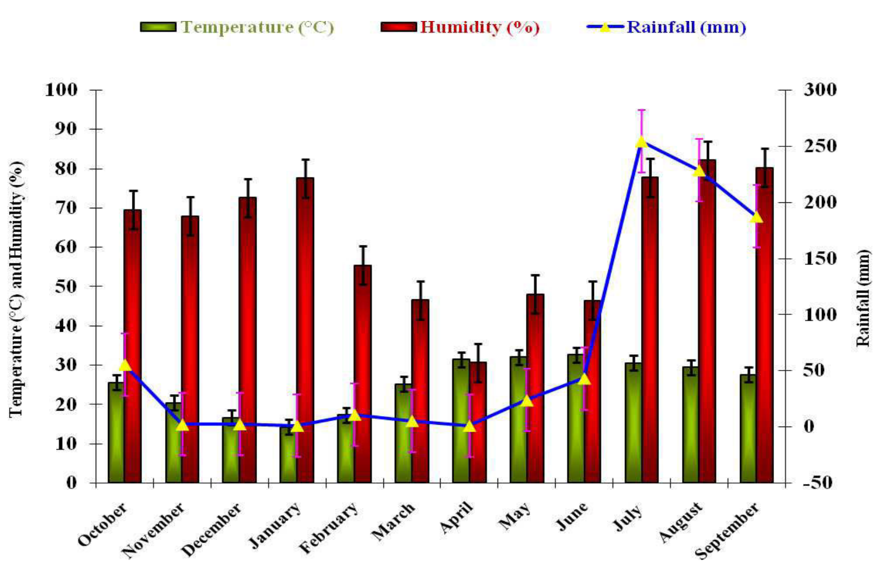
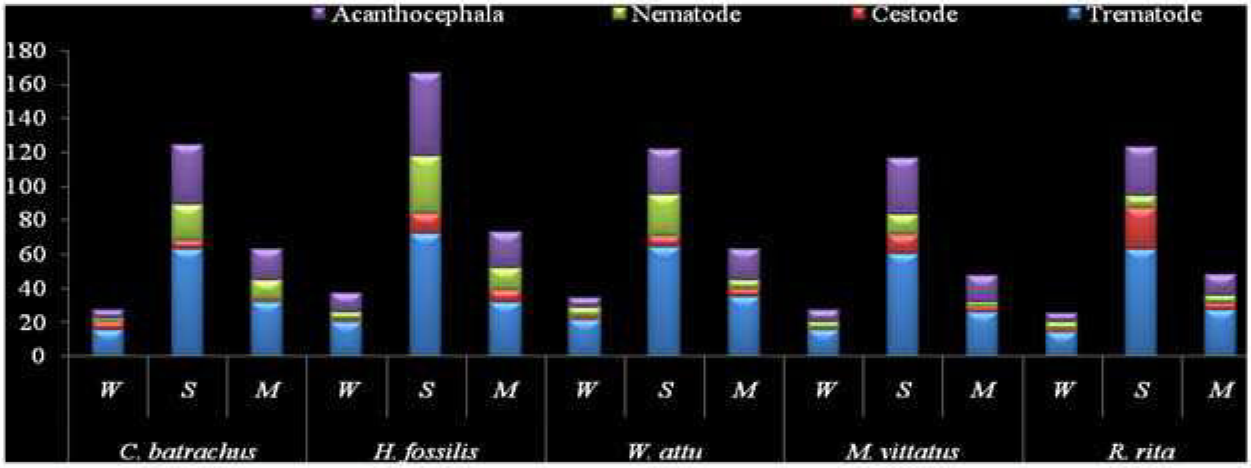


Figure 1

Month wise representation of temperature (°C), humidity (%) and rainfall (mm). Values presented as mean ± SEM during October 2008- September 2010 under Lucknow climatic condition.

Figure 2
Infection rate (%) of helminth community in catfish with different seasons.



Win = Winter; Sum = Summer ; Mon = Monsoon

DISCUSSION

The community of helminthes parasites, their incidence and intensity of infestation varies from one species to another. The parasitic infection is greatly influenced by the season, which basically interferes with ecology and physiology of the fish. The present study results showed that the percentage of total infection intensity of helminth parasites were low during winter, higher in summer and moderate in monsoon season. It was also reported that the reproduction rate of monogenean is increased with temperature[15, 43] leading to increased parasite abundance[9, 24]. During winter season the prevalence and infection intensity of helminth parasites were low because of average temperature; humidity and drier atmosphere which facilitates decreased the susceptibility of disease.

During the study period, *H. fossilis* showed maximum helminth parasite infection in all seasons and minimum for *M. vittatus* as compared to other cat fishes. These suggest that the occurrence of parasitism varied from one habitat to the other which could be due to the host-parasite relationship and abiotic factors[4]. The mean intensity value of all parasites viz., trematode, cestode, nematode and acanthocephalan were differing in all examined cat fish. This may be due to the maximum enhanced growth of parasitized fish was found in months with low zooplankton densities, while the difference was lower when food was abundant[34].

Among helminth parasites community *viz.,* trematode, cestode, nematode, and acanthocephalan recorded from cat fishes, the trematode parasites showed highest prevalence followed by acanthocephalan, nematode and minimum infection caused by cestode. It may also be that their intermediate and definitive hosts are more in the particular environment[41]. The infection intensity of helminth parasites followed more or less in both summer and monsoon season with all fresh water cat fishes but in winter season pattern was more often same for all cat fish except in case of *C. batrachus,* where the trematode parasites showed highest infection intensity followed by nematode, acanthocephalan and minimum infection caused by cestode. These variations in results might be attributed to inhibitive quality of physical (depth, current, and temperature) and chemical (oxygen and salinities) factors of environment and fish species[1].

The abundance of helminth parasites was also much higher in summer as compare to winter and monsoon. Among helminth parasites, the abundance of trematode parasites was found to be highest as compared to cestode, nematode and acanthocephalan parasites in all examines cat fishes. In cat fishes, the maximum abundance value was obtained for trematode and acanthocephalan parasites in *H. fossilis* as compared to other tested cat fishes. However, the abundance of cestode and nematode parasites were differing in each examined cat fishes. The diversity of helminth parasites per host individual were correlated with host body size, or perhaps with longevity and to a lesser extent with host diet[6] and also pollutants may increase host susceptibility or by increasing the abundance of intermediate hosts and vectors[25]. It is quite possible that climate change could worsen this situation by affecting rates and probabilities if disease and parasite outbreak, especially in crowded catfish ponds. Increasing water temperature makes a more stressful environment for fish in general which will put them in a more vulnerable state for disease transmission and outbreak[29].

During the observation period, the seasonal incidence of the total and individual parasitic group showed maximum prevalence during the summer season. The higher abundance of helminth parasites during summer season was probably higher temperature and lower immunity during this season which favoring the transmission of parasites in their hosts. The density of endoparasitic helminth of cat fishes have been shown to higher in dry and lower in rainy season[17, 28, 36, 44] and this might be due to distribution and abundance of fish parasites vary on a geographical scale, in large part driven by climatic factors[40]. Their seasonal fluctuations varied from host species to species. In comparative parameter study also they follow the same trend that trematode show high prevalence, dominance, mean intensity and abundance as compared to acanthocephalan, cestode and nematode. With respect to dominance of helminth infection, the trematode parasite has also highest percentage of infection in all scaly fishes during the study period.

CONCLUSION

The differences in density and infection intensity of parasite is probably due to the immune function of fish is compromised in stressful situation, including those that involve crowding and high temperatures. Climate change in aquatic systems will affect most organisms and their functional roles in the ecosystem. Changes in these roles may be difficult to detect, but examination of parasite communities in fish may provide insight into any structural and functional alterations in the system. Potential consequences of climate change are difficult enough to predict for free-living biological organisms. Given that parasites in aquatic systems depend on both the abiotic conditions of the environment and the distribution and abundance of their hosts for transmission, reproduction, survival, and other basic life-history functions, it is evident that predicting the implications of climate change for parasites becomes increasingly complex and context-dependent. It is likely that the direct impacts of temperature change and indirect impacts of changes in host biology will have significant ramifications for parasite populations in the aquatic environment.

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REFERENCES

1. Abo-Esa JFK, Study on some ectoparasitic diseases of catfish, *Clarias gariepinus* with their control by ginger, *Zingiber officiale*. Mediterranean Aquacult J, 1(1): 1-9, (2008).
2. Adeyemo AO and Falaye AE, Parasitic incidence in cultured *Clarias gariepinus*. Anim Res Int, 4(2): 702-704, (2007).
3. Akinsanya B and Otubanjo OA, Helminth parasites of *Clarias gariepinus* (Clariidae) in Lekki Lagoon, Lagos, Nigeria. Rev Biol Trop, 5(1): 93-99, (2006).
4. Anderson RC, Nematode parasites of vertebrates: Their development and transmission. C. A. B. International, Wallingford, 1992, pp. 99.
5. Azmat R, Fayyaz S, Kazi N, Md. Junaid S and Udin F, Natural bioremediation of heavy metals through nematode parasite of fish. Biotech, 7(1): 139-143, (2008).
6. Bell G and Burt A, The comparative biology of parasite species diversity: Internal helminths of freshwater fish. J Anim Eco, 60: 1047-1063, (1991).
7. Bhuiyan AS, Md. Musa AS, Musa GM and Zaman T, Parasitic infection with *Cirrhina mrigala* (Hamilton) collected from Rajshahi, Bangladesh. Bangladesh J Sci & Indus Res, 43(2): 243-250, (2008).
8. Buchmann K, Relationship between host size of *Anguilla anguilla* and infection level of Monogeneans *Pseudodactylogyrus spp*. J Fish Biol, 35: 599-601, (1989).
9. Chubb JC, Seasonal occurrence of helminths in freshwater fishes. Part I. Monogenea. Adv Parasitol, (1977).
10. Chubb JC, Seasonal occurrences of helminths in freshwater fishes. Part II. Trematoda. Adv Parasitol, (1979).
11. Chubb JC, Seasonal occurrence of helminths in freshwater fishes. Part III. Larval cestoda and nematoda. Adv Parasitol, (1980).
12. Chubb JC, Seasonal occurrence of helminths in freshwater fishes. Part IV. Adult cestoda, nematoda and acanthocephala. Adv Parasitol, (1982).
13. Deree HL, Age and growth, dietary habits, and parasitism of fourbread rockling, *Enchelyopus cimbrius*, from the Gulf of Marine. Fish Bull, 97: 39-52, (1999).
14. Dörücü M and İspir Ü, Seasonal variation of *Diplostomum sp*. infection in eyes of *Acanthobrama marmid* Heckel, 1843 in Keban Dam Lake, Elazığ, Turkey. E U J Fish Aquat Sci, 18(3-4): 301-305, (2001).
15. Gelnar M, Experimental verification of the effect of physical condition of *Gobio gobio* (L.) on the growth rate of micropopulations of *Gyrodactylus gobiensis* Gläser, 1974 (Monogenea). Folia Parasitologica, 34: 211-217, (1987).
16. González JV, Herrera AR and Macedo MLA, Seasonal patterns in metazoan parasite community of the "Fat Sleeper" *Dormitator latifrons* (Pisces: Eleotridae) from Tres Palos Lagoon, Guerrero, Mexico. Int J Trop Biol, 56(3): 1419-1427, (2008).
17. Ibiwoye TII, Balogun AM, Ogunsusi RA and Agbontale JJ, Determination of the infection densities of Mudfish *Eustrongylides* in *Clarias gariepinus* and *C. anguillaris* from Bida Floodplain of Nigeria. J Appl Sci Environ Mgt, 8(2): 39-44, (2004).
18. Ibrahim CA, Needet SA, Aysel AOA and Ercument G, Ecto-endoparaite investigation on minor carp (*Cyprins carpio* L., 1758) captured from river Seyhan, Turkey. J Fish Aquat Sci, 18(1-2): 87-90, (2001).
19. Isaac A, Guidelli GM, Takemoto RM and Pavanelli GC, *Prosthenhystera obesa* (Digenea), parasite of *Salminus maxillosus* (Characidae) of the floodplain of the Upper Parana River, Parana Brazil: Influence of the size and sex of host. Acta Scientiarum, 22(2): 523-526, (2000).

20. Janovy JrJJ, Concurrent infections and the community ecology of helminth parasites. J Parasitol, 88(3): 440-445, (2002).
21. Kabata Z, Parasites and diseases of fish cultured in the tropics. *Taylor and Francis Ltd*. London, (1985).
22. Karolína L, Šimková A, Palíková M, Jurajda P and Lojek A, Seasonal changes of immunocompetence and parasitism in chub (Leuciscus cephalus), a freshwater cyprinid fish. Parasitol Res, 101: 775-789, (2007).
23. Koskivaara M, Enviromental factors affecting monogenean parasite on freshwater fishes. Parasitol Today, 8: 339-342, (1992).
24. Koskivaara M, Valtonen ET, Prost M, Dactylogyrids on the gills of roach in Central Finland: Features of infection and species composition. Int J Parasitol, 21: 565–572, (1991).
25. Lafferty KD and Kuris AM, How Enviromental stress affects the impacts of parasites. Limnol Oceanogr, 44: 925-931, (1999).
26. Margolis L, Esch, GW Holmes JC, Kuris AM and Schad GA, The use of ecological terms in parasitology. J Parasitol, 68(1): 131-133, (1982).
27. Mas-Coma S, Valero MA and Bargues MD, Effect of climate change on animal and zoonotic helminthiases. Rev Sci Tech Off Int Epizoo, 27(2): 443-452, (2008).
28. Mgbemena MO, Parasitic fauna of some cichlids and clariids in Jos Plateau. M. Sc. Thesis. Hydrobiol Fish Res Unit Unijos, 1-58, (1983).
29. Moravec F, Observation on the transmission and the seasonality of infection of the nematode *Raphidoscaris acus* in salmo *Trutta fario* in a small trout stream in North Bohemia, Czech Republic. Helmonthol, 41(1): 91-97, (2004).
30. Morenikeji OA and Adepeju AI, Helminth communities in cichlids in natural and man-made ponds in South-West Nigeria. Researcher, 1(3): 84-92, (2009).
31. Nie P, Co-occurrence and microhabitat of *Ancyrocephalus mogurndae* (Monogenea) and *Henneguya weishanensis* (Myxosporea) on gills of the mandarian fish, *Siniperca chuat*si. Folia Parasitologica, 43: 272-276, (1996).
32. Nigamtullin ChM and Shukhalter OA, The macro-ecosystem variations of helminth fauna in ommastrephid squid *Sthenoteuthis Oualaniensis* from Indian Ocean and East Tropical Pacific. Int Council for The exploration of the Sea, 2001, pp. 1-11.
33. Olofintoye LK, Parasitofauna in some freshwater fish species in Ekiti State, Nigeria. *Pak.* J Nutri, 5(4): 359-362, (2006).
34. Ondracˇkova´ M, Reichard M, Jurajda P and Gelnar M, Seasonal dynamics of *Posthodiplostomum cuticola* (Digenea, Diplostomatidae) metacercariae and parasite-enhanced growth of juvenile host fish. Parasitol Res, 93: 131-136, (2004).
35. Oniye SJ, Adebote DA and Ayanda OI, Helminth parasite of *Clarias gariepinus* (Teugels) in Zaria, Nigeria. J Aquat Sci, 10(2): 71-75, (2004).
36. Owolabi DO, Endoparasitic helminths of the upside-down catfishes, *Synodontis membranaceus* (Geoffroy Saint Hilarie) in Jebba Lake, Nigeria. Int J Zool Res, 4(3): 181-188, (2008).
37. Özer A and Öztürk T, *Dactylogyrus cornu* Linstow, 1878 (Monogenea) infestations on Vimba (*Vimba vimba tenella*, Nordmann, 1840)) caught in the Sinop Region of Turkey in Relation to the Host Factors. Turk J Vet Anim Sci, 29: 1119-1123, (2005).
38. Öztürk MO and Altunel FN, Occurrence of dactylogyrus infection linked to seasonal changes and host fish size on four cyprinid fishes in Lake Manyas, Turkey. Acta Zool Acad Sci Hung, 52(4): 407-415, (2006).
39. Pokale SS, Nikam SR and Shaikh JD, Seasonal variation of *Trypanosoma spp.* from the fishes of Aurangabad, India. U P J Zool, 22(1): 91-92, (2002).
40. Poulin R, The structure of parasite communities in fish hosts: Ecology meets

geography and climate. J Parasitol, 49: 169-172, (2007).

41. Prasad BO and Radhakrishnan S, Metazoan parasites of smooth- backed blow fish Lagocephalus inermis from Kerala, south-west coast of India. Indian J Fish, 57(4): 71-76 (2010).
42. Rubio-Godoy M, Sigh J, Buchmann K and Tinsley RC, Antibodies against *Discocotyle sagittata* (Monogenea) in farmed trout. Dis Aquat Org, 56: 181-184, (2003).
43. Scott ME and Nokes DJ, Temperature-dependent reproduction and survival of *Gyrodactylus bullatarudis* (Monogenea) on guppies (*Poecilia reticulate*). J Parasitol, 89: 221-227, (2003).
44. Shotter RA, Copepod parasites of fish from Zaria in Northern Nigeria proc. Third Int Cong Parasitol, 3: 399, (1974).
45. Steinauer ML and Font WF, Seasonal dynamics of the helminths of bluegill (*Lepomis macrochirus)* in a subtropical Region. J Parasitol, 89(2): 324-328, (2003).
46. Tasawar Z, Umer K and Hayat CS, Observation on lernaeid parasites of *Catla catla* from a fish hatchery in Muzaffargarh, Pakistan. Pak Vet J, 27(1): 17-19, (2007).
47. Tekin-Özan S, Kir İ and Barlas M, Helminth parasites of common carp (*Cyprinus carpio* L., 1758) in Beyşehir Lake and population dynamics related to month and host size. Turk J Fish Aqua Sci, 8: 201-205, (2008).
48. Uma A, Rebecca G and Saravanabava K, Differential expression of toll-like receptors (TLRS) in Gold Fish, *Carassius auratus* infected with freshwater lice of *Argulus* sp. Int J Pharm Bio Sci, 3(4): 652-658, (2012).
49. Valtonen ET, Prost M and Rahkonen R, Seasonality of two monogeneans from two freshwater fish from an Oligotrophic Lake in Northeast Finland. Int J Parasitol, 20(1): 101-107, (2002).
50. Verma PS, A manual of practical zoology invetebrates. Published by S. Chand and Company Ltd. New Delhi, (2002).
51. Yamaguti S, Systema helminthum. Vol.V. The Acanthocephalans. *Inter Science Publishers,* Inc. New York, (1963).
52. Yamaguti S, Systema helminthum. Vol.I(II). The digenetic trematode of vertebrates. *Inter Science Publishers,* New York, (1985).
53. Zubaidy-Al BA, Prevalence and densities of *Contracaecum sp*. larvae in *Liza abu* (Heckel, 1843) from different Iraqi Bodies. Mar Sci, 2: 3-17, (2009).