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SEASONAL DISTRIBUTION AND POPULATION STRUCTURE OF *P. fusiformis* (DIGENEA: BUCEPHALIDAE) IN *E. vacha* IN KAPTAI LAKE, BANGLADESH

DISTRIBUCIÓN ESTACIONAL Y ESTRUCTURA POBLACIONAL DE *P. fusiformis* (DIGENEA: BUCEPHALIDAE) EN *E. vacha* EN EL LAGO DE KAPTAI, BANGLADESH

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ABSTRACT

The seasonal prevalence, abundance, mean intensity, and population structure of *P. fusiformis* (Digenea: Bucephalidae), a parasite found in *E. vacha*, a fresh water fish in the Kaptai Lake, Bangladesh were studied for two years. A total of 208 fish were examined and 17,300 trematodes were recovered from 182 infected fish. The inter-annual prevalence and mean intensity of *P. fusiformis* were significant, and increased as the host's body size increased. The parasites were found throughout the year. The largest number of trematodes wERE found in the summer period, followed by that of winter, indicating seasonality. The overall prevalence and mean intensity were 83.6% and 68.4 for the first year and 91.3% and 119.78 for the second year, respectively. The intensity and abundance fluctuated over the study period and were statistically significant. Both immature and mature adult worms occurred throughout the year. No statistical association was observed when the occurrence of parasites at both stages of maturity was contrasted against temperature, pH, or dissolved oxygen of the lake or rainfall.

Key words: *Pseudorhynchoides,* trematode*, E. vacha*, fish, fresh water, Kaptai Lake, Bangladesh, population structure

RESUMEN

Las variaciones en la prevalencia, abundancia, intensidad media y estructura poblacional de *P. fusiformis* (Digenea: Bucephalidade), parásito del *E. vacha,* en el Kaptai Lake, Bangladesh fueron estudiadas durante un periodo de dos años. Un total de 208 peces fueron analizados y 17.300 trematodos fueron recolectados de los 182 peces infectados. La prevalencia y la intensidad media de *P. fusiformis* interanual fueron estadísticamente significativas, y aumentaron a medida que aumentó el tamaño de los peces. A lo largo del año de estudio se hallaron parásitos, el mayor número de ellos durante el verano y el invierno, indicando la estacionalidad de los trematodos. La prevalencia y la intensidad media fueron 83,6% y 68,4 durante el primer año y 91,3% y 119,78%, respectivamente en el segundo año. La intensidad y la abundancia fluctuaron durante el período de estudios y estas fluctuaciones fueron significativas. Los trematodos maduros e inmaduros se encontraron juntos durante todo el año. La asociación de los dos estadios de trematodos durante los estudios no presentó influencias de la temperatura, pH u oxigeno disuelto de la laguna o de precipitación.

Palabras clave: *Pseudorhynchoides*, trematodos, *E. vacha,* peces, Kaptai Lake, Bangladesh, estructura poblacional

INTRODUCTION

Kennedy (1993) stated that helminth communities of fish species show considerable spatial Holmes (1990); Poulin, Morand (1999), Kennedy, Hartvigsen (2000) and temporal Kennedy (1993, 1997) variation in composition and species richness, although there may be an underlying similarity in structure and diversity (Kennedy, Hartvigsen, 2000). It is necessary to identify the species present, and determine their abundance to understand the structure of the parasite community. Other parameters such as body size, biomass and density of the species allow better descriptions of the community structure. Among the factors that influence the composition of parasite fauna, the host's alimentary habit is the most important characteristic since it may include numerous

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animals which may serve as intermediate hosts, these biotic and abiotic environments providing the basis for the life of both hosts and parasites alike (Dogiel *et al.* 1961). Many studies focused on the importance of host's body size Lo *et al.* (1998), habitat, and diet (Sasal *et al.* 1999; Munoz *et al.* 2002). Aspects of parasites such as their microhabitats, body size, and associations between species have also been studied Rohde (1994), Sasal *et al.* (1999), George Nascimiento *et al. (*2002). According to George-Nascimento *et al.* (2002), analyses based only on number of parasites may fail to identify important patterns when there are substantial differences in body size between host and parasites as well as in the number of parasites.

Studies on the ecology of parasites of freshwater fishes have been restricted mostly to the temperate regions of the world. Similar studies in tropical countries are few (Crusz, Sathananthan 1960; Crusz *et al.* 1964; Madhavi 1979; Hafizuddin, Bashirullah 2005). The present study was undertaken to elucidate seasonal and temporal distribution, as well as to define the population structure of a tropical digenean, *P. fusiformis* in the intestine of *E. vacha* in the Kaptai Lake, Bangladesh, and consider the relationship of the parasites with the abiotic factors of the lake.

MATERIALS AND METHODS

Kaptai Lake (22°19'10''- 23°21'10''N and 92°02'-92°29' E) in Chittagong, Bangladesh was built in 1961 by damming the Karnaphully River near Kaptai, to generate hydroelectric power. It is the largest man-made lake of Southeast Asia (Fernando 1980). The annual average surface area of the lake is 68,800 has (Ali 1985). The seasonal variations of some physico-chemical parameters (Chowdhury and Majumdar 1981) and community structure of some macrobenthic invertebrate fauna Khan *et al.* (1996) of the lake were studied. The lake nourishes prosperous artisanal fisheries. There are 58 species of fish fauna, including five exotic species in the lake. Clupeids comprise almost one half of the total species (Hafizuddin 1989).

The fish host, *E. vacha* (Ham), of the family Siluridae is a carnivorous and commercially important fresh water food fish (Azadi *et al.* 1991). The fish begins to mature in March and reaches its peak in May, spawning once a year (Azadi *et al.* 1990). *E. vacha* samples were collected monthly from commercial gill net landings at the Bangladesh Fisheries Development Corporation (BFDC) at Rangamati, Chittagong Hilltracts. The fish were kept in BFDC cold storage overnight until the monthly quota of 10 fish could be completed. A total of 208 fish were collected and examined from January 1986 to December 1987 for 20 months, as fishing was banned in the lake during the spawning months of May and June each year. Fishes were transported to the laboratory in an ice box and examined within 48 hrs. They were measured, weighed, sexed, and all worms of *P. fusiformis* were collected, counted individually, and their maturity stages recorded. Collected trematodes were grouped into immature adults with no eggs and mature adults with eggs in the uterus. All parasites were preserved in FAA and later transferred to 70% alcohol.

Parasite prevalence, mean intensity, and mean abundance were used as defined by (Bush *et al.* 1997). A Shapiro Wilk W test of normality was carried out, the results indicating that data were not normally distributed, which required the application of a nonparametric Kruskall-Wallis test. A Z test was performed to make sure the test was adequate. Non Parametric Correlation analyses (Spearman rho) were used to establish relationships between the abundance of immature and gravid worms and different physico-chemical parameters (temperature, pH, DO, rainfall) of the lake studied. The influence of host sex on the abundance of parasites was tested with a Kruskall-wallis test. JMP IN software version 3.1.5 (SAS Institute, Inc) for Windows was used to analyze the data. Variance to mean ratio was used as a measure of the degree of overdispersion in the parasite population. Data on air temperature and rainfall of the area were a mean of 40 years (1951-1990) collected from the Bangladesh Meteorological Observatory (Abedin, 1998). Dissolved oxygen (DO) and pH were estimated in the field by using an Aquamate (WQC-1A, Japan) as prescribed by (Khan, Chowdhury 1994). The four prominent seasons of the year corresponded to summer (March-April), monsoon (May-August), autumn (September-October), and winter (November-February). All monthly samples were pooled together to adjust for seasonal analysis of the distribution of *P. fusiformis* in *E. vacha*.

Physico-chemical properties

Data on seasonal temperature, rainfall, dissolved oxygen (DO) and pH are tabulated (Table 1). Rainfall varied widely during the years. A correlation analysis did not show any relation between the different physico-chemical parameters with the prevalence, number of parasite, and mean intensity of infection.

Table 1. Physico-chemical parameters of the Kaptai Lake during 1986 and 1987 (Rainfall and ambient temperature are mean of 40 years, and the remaining mean of two years).

Seasons/	Summer	Monsoon	Autumn	Winter
Rainfall (mm)	32- 122	427- 592	148- 276	3,6- 50
Dissolved Oxygen (O_2)	5,3-78	5,7-6,9	5,9-6,9	4,3-8,5
Ambient Temp ^{0}C	26,7-28,7	28-29	27,9-28,6	20,6-25
Surface water Temp ^{0}C	22,1-29,6	27,7-29,1	27,8-28,2	21,3-23,5
pH	6,7-7,3	6,3-8,3	5,4-6,8	6,2-7,9
Total Parasites	6470	2007	2738	6085
Mature Parasites	4120	872	1570	3087
Immature Parasites	2350	1135	1168	2998

Inter-annual distribution

A total of 5,920 *P. fusiformis* were collected from *E. vacha* in the first year and 11,380 in the 2nd year from the Kaptai Lake, a significant difference (t= 9,13, P<0,001) being found when the two yearly samplings were compared. The prevalence, mean intensity, abundance, and distribution of parasites of different sex infecting the host fish are reported (Table 2).

Seasonal changes

A total of 17,300 *P. fusiformis* were collected from 182 infected *E.vacha* from the Kaptai Lake during the 20 months of sampling for analyses of population structure and seasonal distribution, the infection by the parasite being found throughout the year, the highest intensity in the summer and the lowest in the monsoon. The prevalence, mean intensity, abundance, and dispersion of *P. fusiformis* in fish hosts are shown in Table 4. No samples were collected during the months of May and June each year due to the prohibition of fishing as most fishes in the lake spawn during these months. The prevalence was above 83% in all seasons. The tendency of monthly infection shows that the prevalence peaks twice a year, remaining high from January to April, dropping during May to July, and increasing again during the months of August to November. This fluctuation is statistically significant (F=36.23, P<0.001), showing seasonality and temporal variation. The variation to mean ratio of *P. fusiformis* was way over 1, indicating that the distribution of worms was highly overdispersed.

Table 2. Summary of different parameters of infection of *P. fusiformis i*n *E. vacha* in the Kaptai Lake during 1986-87.

	YEAR	
	1986	1987
No. Fish Examined	104	104
No. Fish infected	87	95
Mean fish size(cm)	15-50	15-50
No. Male fish infected	38	41
No.Female fish Infected	47	54
Total Prevalence(%)	83.6	91.3
Mean intensity ♂ fish	62.05 (2358)	93.85 (3848)
Mean intensity ♀ fish	75.98 (3562)	139.48 (7532)
Total Mean intensity	68.04	119.78
Abundance	56.9	109.42
Total parasites	5920	11.380
Mature Female parasites	3120	5326
Immature parasites	2800	6054

Infection in relation to body size of fish

The prevalence and mean intensity of infection were monitored for five body size classes of *E.vacha* collected during the 20 months of samplings. There was a tendency for both prevalence and mean intensity to increase with the growth of host body size (Table 3). The prevalence grew from 79% in the lowest size of 15-22 cm to 100% in the highest body size group of 43.1 to 50 cm. The mean intensity of infection increased from 27.02 in the lowest size class to 190.3 in the largest body size class. This increase in the intensity of infection as compared to size of fish is significant (r= 0,98, P < 0,01). The number of fish examined in each group was variable and the number of parasites recovered in respective body size group was also variable.

Table-3. Infection of *P. fusiformis* in different size groups of *E. vacha* in the Kaptai Lake during 1986-87.

Size class (cm)	Fish Examined	Fish Infected	Prevalence %	Total parasites	Mean Intensity±S.D
15- 22	43	34	79	919	27.02 ±15.4
22.1-29	91	79	86.8	6545	82,8 ±9,8
29.1-36	48	44	91,6	5459	124.1 ±6.3
36.1-43	20	19	95	3235	170.4 ±11.4
43.1-50	6	6	100	1142	190.3 ±21.6

Infection in relation to sex of fish

The male to female sex ratio of fish examined was close to 1:1. The number of parasites recovered from female fish in the 2nd year was twice that recovered from male fish but the difference was less significant in the first year. The Prevalence, abundance, and mean intensity of parasites of both sexes are recorded in Table 1. No statistical difference between the sexes of the infected hosts was observed, but the mean intensity of infection and total number of parasites were significantly different between the years ($t=9.13$, $P<0.001$). The trend to higher infection in female fish did not show any relation with the maturity of fish.

Maturation and structure of population

The trematodes were divided into two groups: immature and mature. Both mature and immature trematodes were found throughout the year and in all size groups of fish, indicating that recruitment and maturation are independent of season and host body size. The mature worms gradually increased from the monsoon through autumn and winter, reaching the highest occurrence in the summer. Similarly, the highest number of immature worms was found in the summer followed by winter, the lowest occurrence being found in the monsoon. (Fig 1, Table 4). There were two peaks of occurrence of mature worms in the sample, one in January, which gradually declined to a minimum in July, and another during the months of November and December. It is likely that the occurrence of immature worms of *P. fusiformis* in the Kaptai Lake peaks during the summer and comes to a minimum during the monsoon and autumn periods. Nonparametric measures of association (Spearmen rho) were applied to test the abundance of immature and mature worms relative to rainfall, temperature, dissolved Oxygen, and pH, no significant association being found.

Table 4. Seasonal occurrence of *P. fusiformis* in *E. vacha* in the Kaptai Lake during 1986-87 (combine samples of 1986-87).

Parameters	Summer Mar-Apr	Monsoon May- August	Autumn Sept-Oct	Winter Nov- Feb
No. Fish Examined	42	37	42	87
No.Infected	37	31	41	73
Prevalence(%)	88	83.8	97.6	83.9
Total Parasites	6470	2007	2738	6085
Mean Intensity	174.9 ±13.9	64.7±11.8	66.8±11,3	83.4±12.5
Abundance	150.1±13.1	52.8±11.2	63.6±11.4	72.4±10.5
Variance/mean	6.5	25.4	14.5	7.9

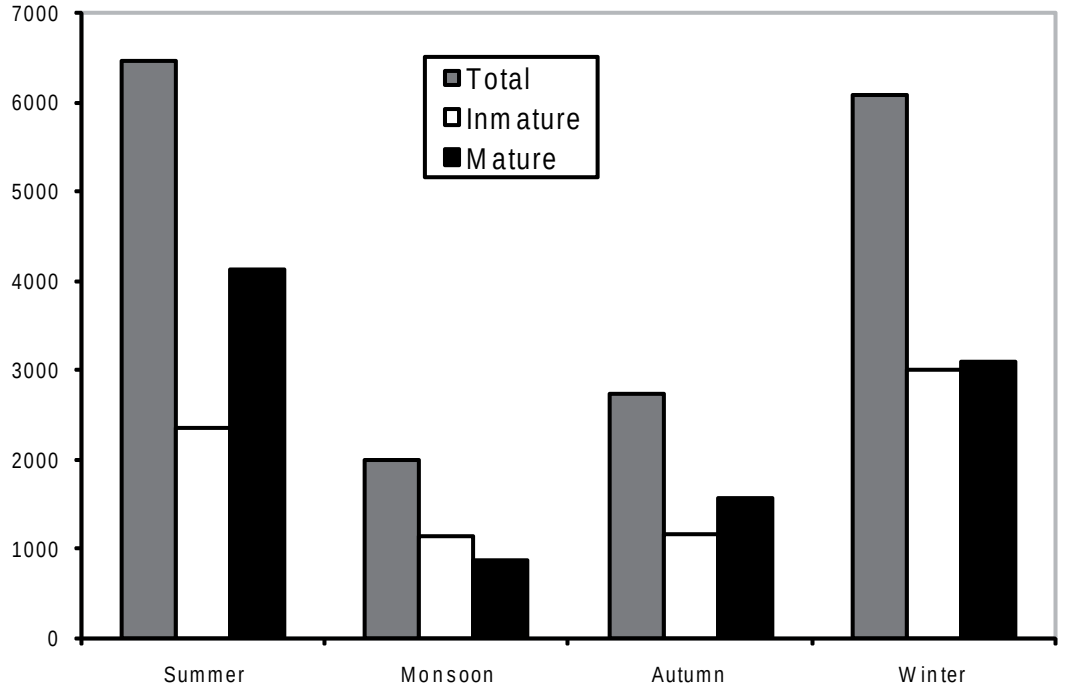

Figure 1. Seasonal distribution of different stages of trematode, *P. fusiformis* (Fam: Bucephalidae) in *E. vacha* in the Kaptai Lake, Bangladesh during 1986-1987.

DISCUSSION

The genus *Bucephalopsis* of the family Bucephalidae has over 55 species Yamaguti (1971), which were revised by Overstreet and Curran (2002), who placed *Bucephalopsis* as a sub genus of *Pseudorhynchoides. Bucephalopsis fusiformis* Verma 1936 was described in India from the *E. vacha*, and has now been renamed *Pseudorhynchoides (Bucephalopsis) fusiformis.*

Climate affects parasites directly with respect to temperature, which is the most important single extrinsic factor to influence parasites (Noble, Noble 1976). Chubb (1977) stated that patterns of intensity and incidence of infection can be related to the effect of abiotic factors such as oxygen tension and water temperature; to biotic factors such as host species, behavior, or to the interaction of both biotic and abiotic factors. Many studies have confirmed the effect of temperature on trematodes of fishes of different countries in the temperate regions (Krull 1934; Awachie 1968; Halvorsen 1972; Bibby 1972; Rumpus 1975; Chubb 1977, 1979; Willis 2001). Temperature between summer and winter in the temperate region is extremely variable, a variation which is rare in the tropical region. Under such situation, abnormal changes in the behavior of parasites are not expected. Both ambient and surface water temperature of the Kaptai Lake did not show any statistically significant difference with prevalence, number of parasites, and mean intensity of *P. fusiformis.* It can be presumed that temperature did not play a significant role in the variation of parasite population in *E. vacha* in the present study. The variation in prevalence and intensity may be due to host migration, change of feeding habits, availability of infective stages of parasites, and intermediate hosts. Three species of gastropods (*Thiara granifera*, *T. tuberculata* and *Bellamaya bengalensis*) dominate the macrobenthic invertebrate fauna of Kaptai Lake (Khan *et al.* 1996). These species occurred in high density during the months of July to September, which coincided with the abundance of immature *P. fusiformis.* The diet of *E. vacha* consists of debris, plants, insects, molluscs, and fish, and is dependent on the body size of the host (Azadi *et al.* 1991). This study demonstrates that *E. vacha* consumes higher percentage of molluscs and fish as the host's body size grows. The size-dependent food selectivity of the diet may account for the increase of prevalence and mean intensity of infection in *E. vacha*. The higher infection in the larger fish may be transmitted by both the gastropods as intermediate hosts and fish as paratenic host in the lake. Bibby (1972) in *Macrolecithus papilliger* and Rumpus (1975) in *Nicolla gallica* demonstrated that the seasonal cycles and population intensity of these flukes are related to the

availability of infective larvae and changes in feeding habits and general physiological condition of the host. The fluctuation could be attributed to the variable nature of the habitat or to the stochastic events that influence transmission dynamics of parasites. Few seasonal studies of trematodes have been attempted in tropical conditions on *Transversotrema patialense* in Sri Lanka Crusz, Sathananthan (1960), Crusz *et al*. (1964) and on *Allocreadium fasciatusi* in India Madhavi (1979) reporting the existence of a seasonal cycle, and this coincides with the present studies on *P. fusiformis*. The peak invasion of *A. fasciatusi* could have been related to the peak occurrence of copepods (Madhavi *op.cit*.).

The annual pattern of occurrence, in theoretical terms, is of a gradual increase in incidence and intensity to a peak, followed by a decline to a minimum, after which the generation of worms is complete (Chubb 1979). This is true for most of the worms in the temperate regions, but it is a pattern that differs significantly from that of worms infesting tropical fish. There may be more than one generation of trematodes available in fish hosts during the year in the tropical region due to concurrent infections in nature. This study on *P. fusiformis* is an example. The recruitment and maturation of metacercariae seems to be a continuous process in the tropical fish. Both mature and immature *A. fasciatusi* were present throughout the year with an indication of seasonal cycle of maturation (Madhavi 1979).

The infection of *P. fusiformis* in *E. vacha* gradually increases with the growth of fish. Larger fish were more heavily infected than smaller fish. This observation is consonant with that of *D. gasterostei* where the variation in infection was largely due to changes in fish age (Chappel 1969). Mean intensity and abundance of *Allocreadium lobatum* increased with host size (Willis 2001).

The deviation from the 1:1 sex ratio in *P. fusiformis* may be due to insufficient or unequal host sampling size. The 1:1 sex ratio was the exception rather than the rule in many aquatic organisms.

The distribution of *P. fusiformis* in its host was found to be overdispersed, which means that a large number of parasites are accommodated in a few hosts. Every parasite is harmful to its host, and the more parasites there are in a host the larger the adverse effects (Bauer *et al*. 1964), something not observed in the present studies.

Data pertaining to temperature showed that surface water temperature followed air temperature closely as it is generally known to happen (Macan 1958). In other words, these factors did not influence the occurrence of parasites in *E. vacha*. Rainfall fluctuated widely but no relationship was found with the occurrence of *P. fusiformis*. There were no marked seasonal variations in infection except in the months of August and November. *P. fusiformis* was found in fish of every monthly sample. The levels of infection fluctuated in all individuals. All developmental stages of *P. fusiformis* were present in fish throughout the year and similar observations were made in *A. fasciatusi* in India (Madhavi *op.cit*.). She attributed the peak occurrence of parasite population in fish to some external factors, like monsoon seasons, breeding of fish hosts, and increased populations of intermediate hosts of the fluke.

The observations on population dynamics of *P. fusiformis* revealed that while the fish become infected throughout the year, superimposed infections produce a seasonal cycle of maturation. The peak periods of invasion appear to be July, and large numbers of immature flukes received during these months grow, mature, and become gravid by November and continue to grow until January. It seems that the life span of the worm is about four to five months in *E. vacha*. Further studies are required to pinpoint the exact time of maturity of *P. fusiformis*. Madhavi (1979) estimated that *A. fasciatusi* might have a life span of four to five months. Complete development of *Bucephalus polymorphus* in 15 days was observed in cyprinid fishes in Poland, metacercariae dying after five months in the fish (Baturo 1977). *Rhipidocotyle septpapillata* matured in five to seven days in host fish at 37°C or over and 10-12 days at the coldest weather as low as 7.2°C (Krull 1934). It is known that the life span of different species of trematodes in the definitive host varies from about one week to more than 25 years (Dogiel *et al*. 1961).

CONCLUSIONS

The population structure and seasonal variation of *P. fusiformis* in *E. vacha* in Kaptai Lake, Bangladesh were studied. The prevalence and mean intensity increased with the growth of body size of fish hosts. Both mature and immature parasites were found throughout the year, and indicated seasonal fluctuation of occurrence, but no influence of abiotic factors was observed. The peak period of infection appears to be July, and the life span *of P. fusiformis* seems to be four - five months.

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