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Host Parasite Interaction of Apicomplexan Parasites (Sporozoa: Haemosporida) in *Columba livia*

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ABSTRACT: During thirty nine months of sampling, the prevalence was studies in *C. livia* of Rohilkhand region of Uttar Pradesh, India, according to the sex of the host, different seasons and localities where the pigeons were obtained. Data on the occurrence of *Haemoproteus* and *Plasmodium* showed the maximum percentage of infection (55.63%) in *C. livia* during the entire period of study. Out of 266 pigeons sampled, 148 pigeons were positive for *Haemoproteus* at a prevalence of 55.63%. Only 18 pigeons (2.67%) had a mixed infection with *Haemoproteus* and *Plasmodium* and 130 pigeons (48.87%) had *Haemoproteus* infection alone and no pigeons were positive for *Plasmodium* alone. Parasite incidence in relation to the sex of the host indicated a higher infestation in females (62.79%) than males (57.65%). The overall highest infectivity of parasites was recorded during the summer season (82.85%) followed by spring season (59.37%) and least in the winter season (42.30%). It was also observed that *Haemoproteus* occurred at diverse infectivity in *C. livia* from different localities (Badaun-51.35%, Bareilly- 11.18% and Shajahanpur-58.06%) whereas *Plasmodium* was recorded 11.18% only from Bareilly. This parasite was completely absent from the other two sites.

Key words: *Haemoproteus*, *Plasmodium*, pigeons, prevalence, seasons, sex

Introduction

In bird, the prevalence of haematozoan blood parasites has been used to examine hypothesis of sexual selection (Hamilton and Zuk, 1982; Read, 1987; Zuk, 1991), immuno-competence (Mc Curdy *et al.,* 1998; Nordling *et al.,* 1998) and the costs of reproduction (Norris *et al.,* 1994; Richner *et al.,* 1995; Wiehn *et al.,* 1999). Studies on parasite-host interactions have revealed many of the most sophisticated examples of evolution, including adaptive manipulation of host behaviour (Lafferty and Morris, 1996) and host sex (Hurst *et al.,* 1993; Vance, 1996).

Parasites may exert deleterious effects on their hosts as indicated by Hamilton and Zuk (1982). Indeed the traditional view that parasites are relatively benign (Cox, 1989) has been repeatedly challenged (Toft and Karter, 1990) and parasites are now regarded as having potentially negative effects on the survival and fitness of the avian hosts (Atkinson and Van Riper, 1991; Raidal and Jaensch, 2000).

Parasites can also increase susceptibility to predation (Vaughn and Coble, 1975) and high parasite intensity is in some cases associated with reduced expression of sexually selected traits (Seutin 1994; Thompson *et al.,* 1997). Overall however, the impact of parasites on their hosts and the physiological mechanism underlying this impact remain poorly understood (Toft, 1991). However, the avian plasmodia are important protozoan parasites because they are utilized extensively for ecological modeling of host-parasite systems (Hamilton and Zuk, 1982; Read 1988; Atkinson and Van Riper, 1991). Ecologists, ethologists and wildlife disease workers now are recognizing the importance of data on distribution and prevalence of avian malaria for the study of ecological, behavioral and evolutionary problems arising in host parasite systems.

Variation in parasite prevalence and in the strength and occurrence of interspecific associations among parasites should be important for predictory impact of parasites on host populations. Factors that can account for variation in parasite prevalence or intensity include: host genotype (Gregory *et al.,* 1990), host size (Blower and Roughgarden, 1988), age or sex of host (Schall, 1983), host condition (Forbes and Baker, 1990) and host reproductive effort (Festa-Bianchet, 1989). Factors extrinsic to hosts, such as geographical region (Krikpatrick *et al.,*1991) and time of season or year (Weatherhead and Bennett, 1991 and 1992) are also important because they can influence the distribution and abundance of infection stages or vectors.

In avians, the effect of parasites on host ecology has been ignored. Recently, the view that well adapted parasites do not harm their hosts, has been challenged and there is growing evidence that parasites do have a present day effect on a great variety of host fitness components.

The view that commensalisms is the only outsome of host-parasite interaction has been challenged and during the last decade, curiosity in parasites and their hosts has risen (Price, 1980; Loye and Zuk, 1991; Toft *et al.*, 1991). The study of host parasite interaction has focused mainly on the fields of population regulation (Anderson and May, 1978, 1979), coevolution (Toft *et al.* 1991) and ecology (Loye and Zuk, 1991) as well as behavioral ecology (Loye and Zuk, 1991; Keymer and Read, 1991).

Materials and Methods

Columba livia Gmelin weighing 400-500gms were collected from different localities of Rohilkhand region of Uttar Pradesh, India.. They were kept in separate cages and maintained in the laboratory under suitable environmental conditions of aeration and food. Blood was collected directly from the clipped nail by a fingernail clipper or from the brachial vein, a drop placed on a clean microscopic slide and blood smears were prepared and stained in Giemsa's with phosphate buffer (pH 7.4) in the ratio of 1:7 for 3 hours. The slides were washed, dried and examined for blood parasites at 100x. Parasite species were identified using morphologic characteristics (Garnham, 1966). Parasitaemia were calculated from counts of 100 red blood cells at x1, 000 according to different localities viz. Site-1 (Badaun), Site-2 (Bareilly) and Site-3 (Shahjahanpur), seasons and sex of the host population on parasite incidence. To observe the effect of the seasons, the whole year was divided in to four seasons, Spring (March – May), Summer (June – August), Autumn (September – November) and Winter (December –February) and the data was recorded and tabulated in each of them.

Results

Haemato-parasitological examination of thin blood smears of *Columba livia* revealed hematozoa of mainly two genera, *Haemoproteus* and *Plasmodium.* Data on the occurrence of *Haemoproteus* and *Plasmodium showed* that *Haemoproteus* occurred at a higher prevalence (55.63%) in *Columba livia* as compared to *Plasmodium* (6.76%). Out of 266 pigeons sampled, 148 pigeons were positive for *Haemoproteus* at a prevalence of 55.63%. Only 18 pigeons (2.67%) had a mixed infection with *Haemoproteus* and *Plasmodium* and 130 pigeons (48.87%) had *Haemoproteus* infection alone and no pigeons was positive for *Plasmodium* alone. The mean load of *Haemoproteus* for infected pigeons was 1.68 Gametocytes/100 RBC's ranging from 1 to 6 Gametocytes/100 RBC's whereas for *Plasmodium* it was 1.38 Gametocytes /100 RBC's and varied from 1.0 to 2.0 Gametocytes/100 RBC's. In addition, when the infection rates were calculated according to the localities the highest infectivity of

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Haemoproteus (58.06%) was observed in pigeons collected from Shahjahanpur (site 3) whereas the minimum (51.35%) occurred from Badaun (site-1). In case of *plasmodium* it was occurred only in Bareilly (site-2) at a prevalence of (11.18%) and the parasitaemia was 1.38 gametocytes/100 RBC's. This parasite was completely absent from the other two sites (site 1 and 3) *Haemoproteus* in *C. livia* also showed highest concentration index of 2.77 Gaematocytes/100 RBC's from Shahjahanpur (site 3) and a minimum of 1.39 Gametocytes/100 RBC's from Badaun (site 1) whereas it was 1.58 Gametocytes/100 RBC's from Bareilly (site 2). The infection rates were also calculated according to different seasons. In general, the highest infectivity of *Haemoproteus* occurred during the summer season fallowed by spring season and least in the winter season. In case of *Plasmodium* infection, the infectivity was recorded only in spring and autumn season. The pigeons were free from *Plasmodium* infection in summer and winter seasons. In summer seasons, *Haemoproteus* showed the highest (82.85%) frequency index followed by (59.37%) spring season. Therefore, a decreased (48.14%) in the infection rate was observed in the autumn season and the lowest infection (42.30%) was found in the winter season. It was also noticed that concentration index was also relatively higher (3.44 Gametocyte/100 RBC's) in summer season and reached its peak in the month of July during summer season. A 100% frequency index and 4.33 Gametocytes/100 RBC's (concentration index) was recorded in the same month. The minimum concentration index (1.0 Gametocytes/100 RBC's) were recorded in the autumn and winter reasons while in case of *Plasmodium,* the highest frequency index (34.37%) was recorded in the spring season when the concentration index was 1.54 Gametocytes/100 RBC's. The minimum frequency index (25.92%) and 1.0 Gametocytes/100 RBC's (concentration index) of *Plasmodium* occurred during the autumn season. It was also noticed that pigeons were free from *Plasmodium* infection during the summer and winter seasons. When the infection rates of *Haemoproteus* were reassessed according to the sex of the host it varied from 62.79% in females and 57.65% in males. The parasitaemia load of *Haemoproteus* was 2.22 Gametocytes/100 RBC's in females and 1.68 Gametocytes/100 RBC's in males. In case of *Plasmodium,* only five females and 13 male were infected with this parasite. The concentration index of the parasite was 1.0 Gametocytes/100 RBC's in females and 1.53 Gametocytes/100 RBC's in males.

Discussion

During the present course of study, blood parasites were quite abundant but their distribution and prevalence markedly varies from region to region and from one avian family to the other in the Indian Subcontinent (Nandi and Bennett, 1997). Life cycle studies on species of *Haemoproteus,* particularly those involving vector studies of the other genera of blood parasites should be approached with caution and undertaken in those regions where it is obvious that both abundant infections occur in the feral avian populations, a prevalence that will indicate the availability of suitable vector in the area.

The relative frequency of different parasites species found in this study accords with previous findings showing that the most common avian blood parasite is *Haemoproteus* (Desser and Bennett, 1993). Levine and Kantor (1959) found a range of 28 to 100% occurrence of *Haemoproteus* in domestic pigeons. Studies, to date, have determined that the most common blood parasite found in pigeons is *Haemoproteus* and infection rate may be as high as 75% ranging from 6 to 86% (Stabler, *et al.,* 1977; Qureshi and Sheikh, 1978; Aguirre, *et al.,* 1986; Mandour *et al.,* 1986; Kaminjolo, *et al.*, 1988 and Subbiah and Joseph, 1988). The highest prevalence (100%) of *Haemoproteus* in west Bengal India, was recorded by Nandi *et al.* (1984) while Nandi and Bennett (1997) recorded 54.4% infectivity of *Haemoproteus* and 34.6% of *Plasmodium* in U.P. India whereas it was 36% (*Haemoproteus*) and 33.3% (*Plasmodium*) in Andhra Pradesh. The prevalence of *Haemoproteus* and *Plasmodium,* were also recorded from Gujarat, Maharashtra and Punjab as well as 24.7% and 0.4%, 18.4% and 1.1% and 45% and 2.0% respectively.

Surveys indicate that the incidence of infection differs in different kinds of birds and in different localities (Fallis *et al.*, 1974). Locality is one of the important ecological factor which plays a existing role in the occurrence of parasite species. Because many birds migrate, the occurrence of parasites in birds in a particular locality is not necessarily indicative of local transmission. Incidence and levels of parasitaemia may indicate, among other things, the susceptibility of the bird, the availability of suitable vectors of the parasites, preference of vectors for certain birds, and the relative abundance of different kinds of birds and vectors.

An investigation on the frequency and concentration index of parasites collected from different localities indicates that site 3 (Shajahanpur) recorded highest frequency and concentration indices of *Haemoproteus* in *Columba livia* and comparatively lower from site 1 (Badaun) whereas *Plasmodium* occurred only from site 2 (Bareilly).

The above findings indicate that highly difference in infection of *Haemoproteus* between site 1 and site 3 was not significant. Failure of this parasite to establish itself in some pigeons in sites 1 and 3, despite the presence of the vector host, could be attributable to a good health status of the host. *Plasmodium* infection occurred in 18 pigeons of 266 sampled from site 2. The low prevalence compared with that of *Haemoproteus* is possibly explained by a low prevalence or absence of vectors of avian *Plasmodium*, the *Culex* mosquitoes in the present area.

The present investigation documented seasonal variation in blood parasites (*Haemoproteus* and *Plasmodium*) infection in a free living population of pigeons. It was observed that prevalence of *Haemoproteus* was relatively higher during summer season followed by spring. On the other hand, higher infectivity of *Plasmodium* occurred in spring season and it lowered during autumn. There was no infection in summer and winter seasons.

The co-relation of parasite infection and parasitaemia in *Columba livia* was also worked out. It was observed that pigeons had only 1.0 Gametocyte/100 RBC when the frequency index was lower in autumn and winter season while in summer season when the infection was 82.85% the pigeon showed a heavy parasitaemia (3.44 Gametocyte/100 RBC). In the month of July in the same season when the infection was 100% parasitaemia reached a peak (4.33 Gametocyte/100 RBC). In case of *Plasmodium* parasitaemia was recorded as 1.54 Gametocyte/100 RBC when the infectivity was 34.37% in spring season whereas in autumn season it was recorded 1.0 Gametocyte/100 RBC with the 25.92% infectivity. Therefore, the percentage of infection was also related to the blood of parasites (parasitaemia). Higher parasitaemia and prevalence of *Haemoproteus* and *Plasmodium* during summer and spring season may be explained due to the increasing vector population during the same seasons and is co-related with breeding period of the host when the incidence was higher due to the fact that vectors also become abundant during these seasons.

Our results are in tune with earlier findings that highest parasitaemia is found in summer and spring seasons. Jordon (1943) recorded the proportion of *Haemoproteus* infected birds (Blue-joys) tended to rise as the summer but the incidence of malaria in sparrows reached its maximum in June and July. Micks (1949) also made similar study of English sparrow and found a good deal of malaria in May and July. Mandal (1990) observed the same incidence in pigeons from Garia, Calcutta and Manwell (1955a) observed that infected birds are most likely to show plasmodia in the blood in spring season. Highest infection rates of *Haemoproteus* were observed during fall and winters by several authors (Klei and Deguisti, 1975; Stabler *et al.*, 1977 and Ahmed and Mohammad, 1978) while Markus and Oosthuizen (1972) reported the absence of seasonal variation of *Haemoproteus* in pigeons from Pretoria, South Africa.

Seasonal peaks of haemosporidian occurrence during summer and spring are suggested to be due to the physiological changes during reproduction (Dorney and Todd, 1960) or may be due to migratory birds (Herman,1938; Manwell, 1955a; Janovy, 1966). Experimental evidence has been obtained supporting the hypothesis of trade-off between reproductive effort and the efficiency of the immune responses that control parasite infection.

Ahmed and Mohammad (1978) concluded that pigeons carrying chronic or latent infections, are immune to super infection by injecting sporozoite with physiological saline solution. Bennett (1970b) stated that phagocytosis plays a major role in checking the number of parasites. Brown (1976) indicated an active immunoglobulin synthesis in malaria infection in addition to macrophage activation and suggested that phagocytosis of merozoites is mediated by opsonins. Presumably gametocytomia with *Haemoproteus* is controlled by the physiology of the host species and to some extent, by the number of infected bites.

Parasite incidence in relation to the sex of the host has received little attention. Studies investigating sexual differences in blood parasite intensity have provided variable results. In Great tits, parasite prevalence was higher in females than males (Norris *et al.*, 1994). In brown-headed cow birds, parasite prevalence increased during summer in females than males (Weatherhead and Bennett, 1992). In contrast, male red-winged Black birds were more heavily parasitized with leucocytozoides than conspecific females (Weatherhead and Bennett, 1991). Merila *et al.* (1995) recorded no significant sex differences in overall prevalence of *Haemoproteus chloris*. Forbes *et al.* (1994) found no significant sex difference in the prevalence of *Haemoproteus* and *Plasmodium.* Sex of hosts have been shown to relate to variation in prevalence of blood parasites in other extensive studies on birds (Gibson, 1990; Atkinson and Van Riper, 1991; Weatherhead and Bennett, 1991, 1992).

During the present courses of study a higher infestation (62.79%) was recorded in female than male pigeons (57.65%) while in case of *Plasmodium.* The frequency index was higher (11.71%) in males than females (5.81%). The related work by other workers as shown above indicates variable results of parasite infestation in relation to the sex of the host. Males and females may differ with respect to aspects of their behavior that modify exposure to insect vectors, resistance to infestation, and or the ability to fight and eliminate acquired infections perhaps as a result of sex-specific interactions with environmental conditions (Wiehn and Korpimaki, 1998). On the contrary, Device *et al.,* (2001a) did not reveal the sexual differences in parasite prevalence, however intensity of infection declined in males in summer but not in females. As a result, males and females had a similar intensity of infection, but females had higher intensities than males in September.

In addition, it is quite likely that the intensity of the parasitaemia is directly related to the physiological status of the host and the stress loading on its immune system from other factors unrelated to the presence of blood parasites. It may be thus assumed that the different degrees of intensity of infection in males and females is not merely the result of hormonal differences but mostly depends on the ecology of parasite vectors and physiology of their hosts.

Table 1: Overall Incidence of Haemoparasites in *Columba livia*

S. No.	**Parasite Genera**	**No. of examined hosts**	**No. of infected hosts**	**Frequency Index (%)**	**Concentration Index (/100 RBC's)**
1	*Hamoproteus*	266	148	55.63	1.68
2	*Plasmodium*	266	18	6.76	1.38

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