Distribution pattern of apicomplexan parasites (Sporozoa: Haemosporida) in *Columba livia*, Gmelin

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Abstract During 39 months of sampling, the prevalence of apicomplexan parasites (*Haemoproteus* and *Plasmodium*) was studied in *Columba livia* Gmelin of Rohilkhand region, UP, India, according to the sex of the host, different seasons and host localities. Out of 266 pigeons sampled, 148 pigeons were positive for *Haemoproteus* at a prevalence of 55.63%. Only 18 pigeons (2.67%) had a dual *Haemoproteus* and *Plasmodium* infection and 130 pigeons (48.87%) had *Haemoproteus* infection. 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%) as compared to 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 57.14%, and Shahjahanpur 58.06%) whereas *Plasmodium* was recorded at 11.18% only from Bareilly. The intensity of the parasite was highest (2.77/100 RBC) at Shahjahanpur.

Keywords *Haemoproteus* · Pigeon · *Plasmodium* · 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), immunocompetence (McCurdy 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).

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

Avian plasmodia are important protozoan parasites as 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 are now 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 are important for predictive impact of parasites on host populations. Factors that can account for variation in parasite prevalence or intensity include: age or sex of host (Schall 1983); host size (Blower and Roughgarden 1988), host reproductive effort (Festa-Bianchet 1989), host condition (Forbes and Baker 1990) and host genotype (Gregory et al. 1990). Factors extrinsic to hosts, such as geographical region (Kirkpatrick et al. 1991) and time of

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season or year (Weatherhead and Bennett 1991; 1992) are also important because they can influence the distribution and abundance of infection stages or vectors.

The present investigation was undertaken to observe the distribution pattern of apicomplexan parasites (*Haemoproteus* and *Plasmodium*) from the blood of the rock pigeon, *Columba livia* with particular reference to season, host sex and different locations of the host.

Materials and methods

Columba livia Gmelin ($n = 266$) weighing 400–500 gms were collected from different localities of Rohilkhand region of UP, India (Budaun, Bareilly and Shahjahanpur). 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 h. The slides were washed, dried and examined for blood parasites at $\times 100$. Parasite species were identified using morphologic characteristics (Garnham 1966). Intensity was calculated from counts of 100 red blood cells at $\times 1000$ magnification according to different localities viz. Site-1 (Badaun), Site-2 (Bareilly), and Site-3 (Shahjahanpur), seasons and sex of the host population on parasite prevalence. To observe the effect of the seasons, the whole year was divided into four seasons, Spring (March–May), Summer (June–August), Autumn (September–November), and Winter (December–February) and the data was recorded in each of them.

Results and discussion

Prevalence

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%). 18 pigeons (2.67%) had a mixed infection with *Haemoproteus* and *Plasmodium* and 130 pigeons (48.87%) had *Haemoproteus* infection alone. No pigeon was positive for *Plasmodium* alone. The mean intensity 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 (range 1.0–2.0 gametocytes/100 RBC's).

The distribution and prevalence of avian hematozoa 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 are to 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 parasite 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 28–100% 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; Subbiah and Joseph 1988). The highest prevalence (100%) of *Haemoproteus* in West Bengal, India, was recorded by Nandi et al. (1984), Nandi and Bennett (1997) reported 54.4% infectivity of *Haemoproteus* and 34.6% of *Plasmodium*, 36% (*Haemoproteus*) and 33.3% (*Plasmodium*) in Andhra Pradesh and the prevalence of *Haemoproteus* and *Plasmodium* recorded from Gujarat, Maharashtra, and Punjab was 24.7, 0.4, 18.4% and 1.1, 45, 2.0%, respectively.

Host localities and parasite prevalence

In addition, when the infection rates were calculated according to the host localities, the highest infectivity of *Haemoproteus* (58.06%) was observed in pigeons collected from Shahjahanpur (site-3) whereas the minimum (51.35%) occurred from Badaun (site-1) indicating a high prevalence of the parasite. In case of *Plasmodium*, it occurred only in Bareilly (site-2) at a prevalence of (11.18%) and the intensity was 1.38 gametocytes/100 RBC's and it was completely absent from the other two sites (site-1 and -3). *Haemoproteus* in *C. livia* also showed highest intensity of 2.77 gametocytes/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).

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 factors which play an 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 parasitemia 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.

Failure of this parasite to establish itself in some pigeons despite the presence of the vector host, could be attributed to a better resistance of the host to the parasite. *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 infectivity of vectors of avian *Plasmodium*, the *Culex* mosquitoes in the present area.

Seasonal variations and parasite prevalence

Prevalence was also calculated according to different seasons. In summer season, *Haemoproteus* showed the highest (82.85%) prevalence followed by (59.37%) in spring season. Thereafter, a decrease in the infection rate was observed in the autumn season (48.14%) and the lowest infection (42.30%) was found in the winter season. It was also noticed that intensity 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% prevalence and intensity of 4.33 gametocytes/100 RBC's (intensity) was recorded in the same month. The minimum intensity (1.0 gametocytes/100 RBC's) was recorded in autumn and winter seasons while in *Plasmodium*, the highest prevalence (34.37%) was recorded in spring season when the intensity was 1.54 gametocytes/100 RBC's. The minimum prevalence (25.92%) and intensity (1.0 gametocytes/100 RBC's) of *Plasmodium* occurred during the autumn season. It was also noticed that pigeons were free from *Plasmodium* infection during the summer and winter seasons.

The present investigation documented seasonal variation in blood parasites (*Haemoproteus* and *Plasmodium*) infection in a free living population of pigeons. The above observations indicate 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 intensity in *Columba livia* was also worked out. Therefore, the prevalence was also related to the intensity. Higher prevalence and intensity 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 prevalence was higher due to the fact that vectors also become abundant during these seasons.

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

Seasonal peaks of haemosporidian occurrence during summer and spring are suggested to be due to the physiological changes during reproduction (Dorney and Todd 1959) or may be due to migratory birds (Manwell 1955). 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 (1970) stated that phagocytosis plays a major role in regulating 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 gametocytaemia with *Haemoproteus* is controlled by the physiology of the host species and to some extent, by the number of infected bites.

Host sex and parasite prevalence

When the infection rates of *Haemoproteus* were reassessed according to the sex of the host it varied from 62.79% in females to 57.65% in males. The intensity 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 males were infected with this parasite. The intensity of the parasite was 1.0 gametocytes/100 RBC's in females and 1.53 gametocytes/100 RBC's in males. In case of *Plasmodium*, only five females and 13 males were infected with this parasite. The intensity of the parasite was 1.20 gametocytes/100 RBC's in females and 1.53 gametocytes/100 RBC's in males.

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 as compared to 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).

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 Korpimäki 1998). On the contrary, Deviche et al. (2001a, b) did not indicate 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 prevalence and intensity is directly related to the physiological status of the host and the stress load on its immune system. 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.

The results as shown above on the susceptibility of *Columba livia* to apicomplexan haematozoan parasites, *Haemoproteus* and *Plasmodium* in relation to different sampling stations, seasons and sex of the host reveal interesting distribution patterns of the haematozoan parasites in the avian host sampled indicating that host ecology plays an important role on the prevalence of parasites.

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