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Original papers

Parasitic affections of domesticated pigeons (*Columba livia*) in Jammu, India

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ABSTRACT. The parasitic fauna of domesticated pigeons in Jammu region were not recorded and so a survey was undertaken amongst a population of approximately 4000 birds in twelve areas around Jammu. Ectoparasites and haemoprotozoa from live birds, and endoparasites from dead birds were recorded. Ova shed in feces were also screened in four different seasons. Ectoparasites recovered include *Columbicola columbae*, *Campanulotes bidentatus*, *Pseudolynchia canariensis*, *Ctenocephalides* sp., *Psoroptes* sp. A total of 22 (36.67%) out 60 gastrointestinal tracts (GIT) of pigeons were positive for helminthic endoparasites including *Raillietina* sp. (25%; 15/60); *Ascaridia* sp. (5%; 3/60) and the hairworm *Capillaria* sp. (6.67%; 4/60). coccidian (58.3%; 35/60), cryptosporidian parasites (50.0%; 5/10), *Trichomonas gallinae* (40%; 12/30) and haemoprotozoal schizogony tissue stages (45.0%; 27/60) were observed in cloacal, oro-pharyngeal and tissue samples from post-mortem materials. Prevalence of cestodes was relatively more than nematodes perhaps due to the pigeon's access to intermediate hosts of the cestodes. Blood smears showed the presence of *Haemoproteus columbae* gametocytes (26.6%; 8/30). Twenty-four pooled fecal samples examined from six select villages revealed presence of different parasitic ova. A higher prevalence of parasitic eggs was noted in the winters. Ascarid eggs were particularly prevalent during monsoon and post monsoon. *Raillietina* sp. was the most common cestode with lowered prevalence in the peak summers. It is speculated that close confinement of the domesticated birds are responsible for increased parasitic load and their dissemination. The parasitic data generated in the study may be helpful in estimating the faunistic prevalence of different parasites for strategic management of such parasitism during various seasons.

Key words: helminth, ova, parasite, pigeon, protozoa

Introduction

The rock pigeon, *Columba livia*, is essentially a free-living and cliff-dwelling granivorous species, and also a direct predecessor of the domestic subspecies *C. l. domestica*. The domesticated pigeon has been around man for thousands of years. Pigeons are a cosmopolitan group of birds, amongst the most prevalent and readily observable in all parts of India. They have adapted to life in the city, and they seem to be everywhere in urban environments. Jammu region is traditionally home to many pigeon fanciers who rear pigeons for recreation and sports and also associated with a rich historical and anecdotal background.

Several health problems can affect pigeons, but parasitic infections have been identified to play a major role [1]. The parasitological findings seem to validate a fair approximation of the health status of the pigeons, and also useful indicators for climatic conditions favouring the parasite, and other host factors such as poor sanitation, crowding, low-energy food, interspecific and intraspecific competitions for resources [2]. Parasites also

decrease host survival and breeding success, and also affect population dynamics of pigeons [3]. The effects of parasitism on birds are often severe, including retarded growth, low egg production and susceptibility to other infections [4]. However, information on the parasitic infection of domesticated pigeon in different countries appears to be poorly documented [5].

The parasitic fauna include numerous arthropoda, protozoa and helminths. Protozoal affections cause not only economically important changes such as impaired growth and poor food utilization but also produces change in the metabolism and dietary requirement [6]. Coccidian parasites are common pathogens in pigeons, but out of the nine species of the genus *Eimeria* and one from the genus *Isospora*, only three species are of significance: *Eimeria columbae*, *E. columbarum* and *E. labbeana*, which are characterized by varying degrees of virulence [7]. Protozoan blood parasites are also common in passerine birds. The asexual development of the parasite *Haemoproteus columbae* occurs in the peripheral blood of the birds and sexual development in the vector louse fly, *Pseudolynchia canarensis* [8,9]. As *Haemoproteus* invades hepatocytes, infection with this genus is sometimes known as pseudomalaria because of its similarities with *Plasmodium* species, which however, are only present within erythrocytes [10]. Trichomoniasis is an infection with the flagellated protozoan *Trichomonas gallinae* and is common in pigeons, mourning doves [11]. Among young pigeons, *T. gallinae* infection may result in a high mortality within 10 days and a high incidence of latent infection (up to 90%) has also been reported [12]. Besides, many helminth parasites have also been recorded in pigeons.

Many fanciers in Jammu region as a hobby or as part of sports event have traditionally been rearing pigeons. Apart from sporadic observations, no systemic study on parasitic load in these pigeons had been undertaken around Jammu. It was with this intent the present study was undertaken to find the different parasites prevalent amongst resident pigeons.

Materials and Methods

The study was conducted in and around Jammu amongst domesticated pigeons reared by fanciers for sports. About 4000 birds from 12 areas were included in the study. Pigeons that were incidentally found dead or submitted for necropsy examination to the Division of Veterinary Pathology, were examined thoroughly. A detailed record of gross pathological lesions was maintained for corroboration with clinical and laboratory findings.

Blood samples were collected in anticoagulant coated bottles containing EDTA (1mg/ml blood) from the wing vein for haematological and haemoprotozoan examination. Blood smears were air dried, fixed in methanol and stained with Giemsa's stain for 45 min. Haematological parameters included Total Erythrocyte Count (TEC), Total Leucocyte Count (TLC), Packed Cell Volume (PCV), Haemoglobin (Hb) and Differential Leukocyte Count (DLC). Haemoprotozoa were identified according to Valkiunas [13]. Blood parameters were compared between non-infected and *Haemoproteus columbae* infected birds by Student's t-test [14].

Pigeons that were incidentally found dead or submitted for necropsy examination to the Division of Veterinary Pathology, were examined thoroughly as per the routine necropsy protocol [15]. All other protocols for parasite collection and examination were followed as described by Soulsby [12]. Body surface of both live and dead pigeons were examined for the ectoparasites, including pigeon houses. Skin scrapping preparations were made from birds with dermal lesions. The ectoparasites were collected and preserved in 70% alcohol for subsequent processing and examination in the laboratory. Gastrointestinal parasites were accessed at necropsy and nematodes collected from the gastrointestinal tract were cleared in glycerine alcohol (10 parts glycerol: 90 parts alcohol); cestodes were pressed gently between glass slides and fixed in 10% formalin, stained with aqueous borax carmine and mounted for identification.

A total of six pigeon coops/lofts were selected from different localities and fecal samples were pooled and examined during each of the four recognized seasons from July 2015 to June 2016 during the four seasons *viz*. monsoon (July 2015 to September 2015), post-monsoon (October 2015 to November 2015), winter (December 2015 to February 2016), and summer/pre-monsoon (March 2016 to June 2016) for prevalence of different helminth parasite eggs. Fecal samples were examined macroscopically for the presence of proglottids of cestodes and/or immature and adult nematodes. Microscopic examination was carried out by direct smear, floatation and sedimentation methods. A total of 24 pooled fecal samples were

Table 1. Occurrence of different pigeon ectoparasites in Jammu region

Parasites	Location	Remarks
Columbicola columbae	Feathers	Consistent finding in all pigeons
Campanulotes bidentatus	Feathers, skin	Detected in 20 pigeons
Flea, tentatively identified as *Ctenocephalides* sp.	Feathers	Found only once
Pseudolynchia canariensis	Body and tail feathers	Abundant, seen regularly
Psoroptes mite	Skin	Detected twice in skin scrapings
Mosquito, unidentified	Pigeon loft	Common in loft that suck pigeon blood
Flies, unidentified	Lofts and surroundings	Ubiquitously present

examined and the load of infection for different parasites calculated on the number of eggs visible per low-power field (LPF) under 100× microscope magnification. Parasitic load was designated from 0 through 4 corresponding to none (0 eggs/LPF), low (1–2 eggs/LPF), mild (3–5 eggs/LPF), heavy (6–10 eggs/LPF) and severe (10–15 eggs/LPF), respectively.

For detection of cryptosporidian agents, direct fecal smears were stained with modified Ziehl-Neelsen stain as described by OIE [16].

Results

A total of twelve areas were surveyed where the pigeon population (estimated population of 3980 birds) was particularly abundant, out of which ten were in the RS Pura sector and two were within the Jammu city limits.

Ectoparasites. Both live and dead pigeons were examined externally revealed numerous ectoparasites including lice, flies, mites from skin scrapings and other pests in the lofts and their relative prevalence is

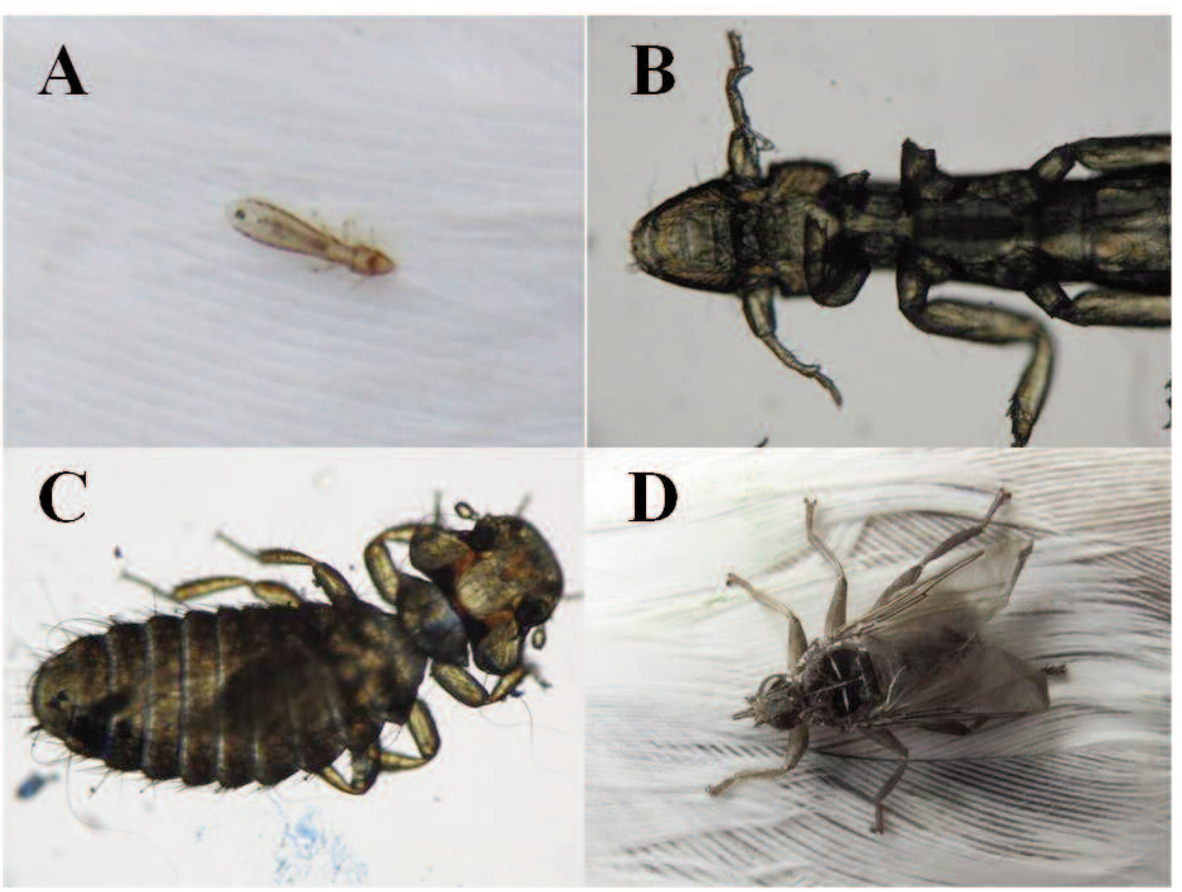

Fig. 1. Different ectoparasites recovered from pigeons (*Columba livia*). A. *Columbicola columbae*, slender pigeon louse; B. *Columbicola columbae.* Unstained, 40×; C. *Campanulotes bidentatus*, small pigeon louse. Unstained, 400×; D. *Pseudolynchia canariensis*, hippoboscid pigeon fly.

depicted in Table 1. The slender pigeon louse *Columbicola columbae* found embedded in the feather shafts was consistently associated with the birds. The hippoboscid pigeon fly (*Pseudolynchia canarensis*) was commonly found in all pigeon lofts buried deeply between the feathers and a nuisance for the pigeons. Six different ectoparasites were collected *viz*. the wing and tail feather chewing lice *Columbicola columbae* (Fig.1A,B); small pigeon louse *Campanulotes bidentatus* (Fig. 1C); pigeon flatfly or louse fly *Pseudolynchia canariensis* (Fig. 1D), A Siphenoptera and an arachnid tentatively identified as *Ctenocephalides* sp. and *Psoroptes* sp. were incidentally recovered. Besides, there were many mosquito and fly species which were not identified.

Helminths. A total of 60 gastrointestinal tracts (GIT) of domesticated pigeons at necropsy were examined, of which 22 (36.67%) were found infected with enteric parasites as depicted in Table 2.

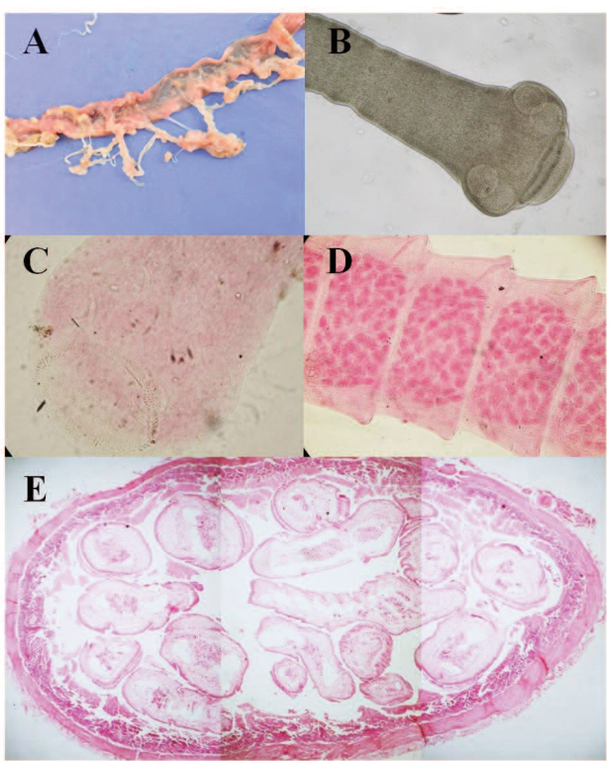

Fig. 2. Cestodes recovered from intestine of pigeons (*Columba livia*). A. *Raillietina* sp. partially impacting intestinal lumen; B. *Raillietina* sp. scolex detail. Fresh mount, 100×; C. *Raillietina* sp. mounted specimen showing armed rostellum and sucker. Borax carmine stain, 100×; D. *Raillietina* sp. mounted specimen showing detail of gravid segments and eggs. Borax carmine stain, 100×; F. A composite photomicrograph of a cross section of the small intestine, showing partially impacted intestinal lumen with *Raillletina* parasite. H and E, 40×.

Table 2. Helminths recovered from GIT of pigeons in Jammu region

Parasites	Location	Prevalence (%)
Ascaridia sp.	Intestine	3/60 (5%)
Capillaria sp.	Intestine	4/60 (6.67%)
Raillietina sp.	Intestine	15/60 (25%)

The tapeworms *Raillietina* sp. were mostly recovered from the ileum (Fig. 2A) where most of the specimens were attached to the mucosa through their scolices (Fig. 2B,C). Speciation was not attempted, but generic identification was based on morphometric examination of their scolices, proglottids and ova (Fig. 2D). Sometimes the cestode infections were overwhelming, causing partial impaction of the intestinal tracts (Fig. 2E).

Two species of nematode parasites *viz.* the large roundworm *Ascaridia* sp. and the hairworm *Capillaria* sp. were found to inhabit the small intestine.

Protozoan infections. The relative prevalence of protozoan parasites in pigeons is represented in Table 3. Coccidian, cryptosporidian parasites and haemoprotozoal schizogony tissue stages were detected in cloacal and tissue samples from post-mortem materials, while clinical blood samples were collected to identify gametocytes of haemoprotozoa.

Coccidiosis in pigeon was an incidental finding with birds showing occasional diarrhoea and pasting of the vents. Out of the 60 carcasses observed, 35 cloacal fecal contents showed presence of coccidial oocysts. Catarrhal enteritis with congestion and occasional petechial haemorrhages on the intestinal mucosa was noticed. Intestinal scrapings revealed necrotic and inflammatory cells and unsporulated eimerian oocytes. Different species of the protozoa were observed that varied in shape from spherical to ovoid, with size ranging between 18–27 µm in length to 14–20 µm in width. Sporulation time varied from 7–10 days showing typical Eimerian characteristics with a thick outer shell containing 4 sporocysts, each with two sporozoites,

Fecal smears stained with Ziehl-Neelsen's stain revealed acid-fast organisms indistinguishable from *Cryptosporodium* sp. from cloacal fecal content from 5 out of 10 bird carcasses observed. The oocysts appeared as spherical, irregularly spherical or slightly elongated measuring from approximately 4–6 µm in diameter.

Pharyngeal swabs collected particularly from

Table 3. Relative prevalence of protozoan parasites in pigeons from clinical and post-mortem samples

Protozoa	Sample	Positive birds/total birds examined (prevalence %)
Eimeria sp.	Cloacal content	35/60 (58.3)
Cryptosporidium sp.	Cloacal content	5/10 (50.0)
Trichomonas gallinae	Pharyngeal swabs	12/30 (40.00)
Haemoproteus columbae	In blood smears (live birds)	8/30 (26.6)
	In tissues (necropsy)	27/60 (45.0)

young birds sometimes showed motile flagellate *Trichomonas gallinae* parasites in wet smears (Fig. 3A,B). Affected birds did not show obvious signs of infection, unless their mouths were opened to find small white to yellowish plaques or cheese like deposits in the mouth cavity. Infection was particularly severe in one sub adult pigeon that died with caseo-necrotic and ulcerative growth extending from the oro-nasal passage to the crop, oesophagus, and even the distal oesophagus just proximal to the proventriculus (Fig. 3C). No lesions were apparent in other visceral organs. Microscopic examination showed acanthosis, ulceration of mucosa, and massive leucocytic infiltration in the submucosa of the pharynx.

Haemoprotozoans were detected in the blood smears of sick or apparently normal birds within RBCs, where the intra-corpuscular gametocytes were elongated and crescent shaped. Of the 30 domestic pigeons examined, 8 (26.6%) were found to be infected with haemoprotozoa in the peripheral blood smears. Out of the positive samples, 5 smears were from male (62.5%) and 3 from female (37.5%) pigeons. The complete haematological profiles between infected and non-infected pigeons are represented in Table 4.

The parasites were found to partially encircle the nucleus of the host cell. Microgametocytes

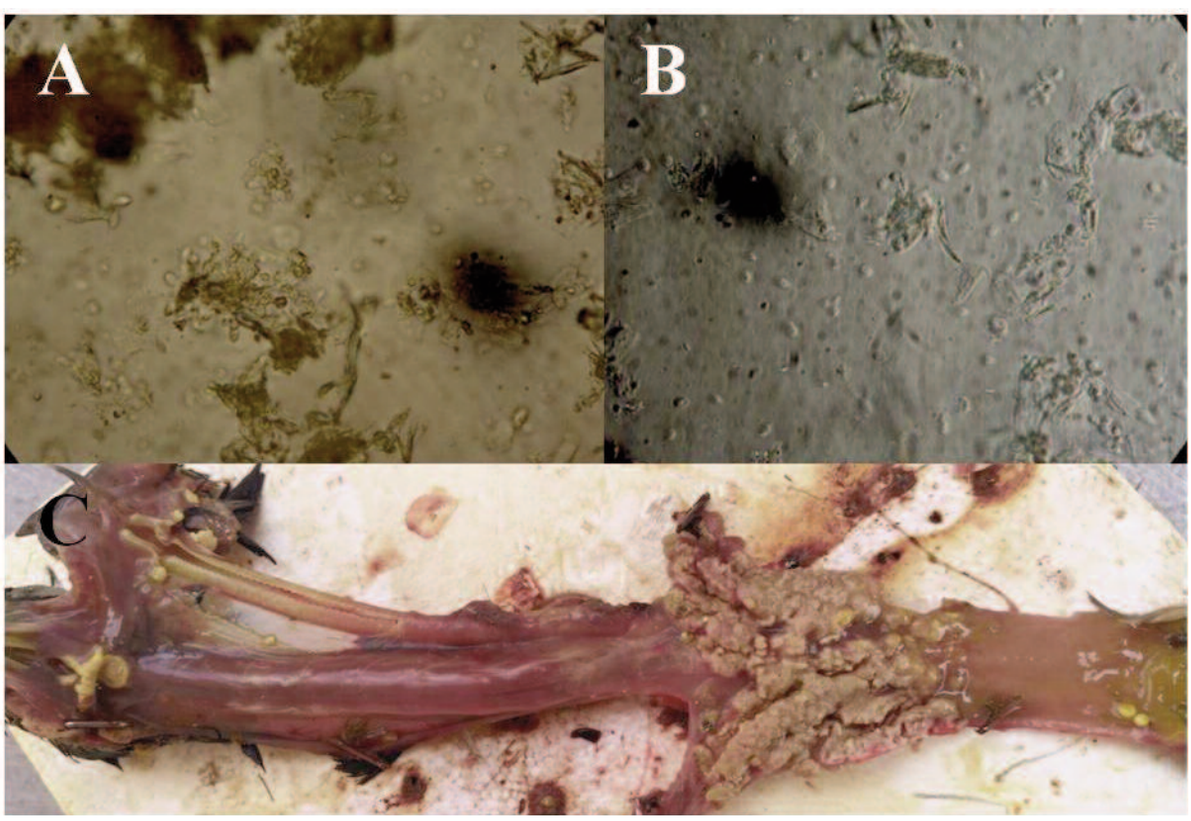

Fig. 3. Trichomoniasis (canker) in pigeons. A. Motile, flagellated *Trichomonas gallinae*, some organisms attached to epithelial cells. Wet smear, 400×; B. Flagellated *Trichomonas gallinae*. Wet smear, phase contrast, 400×; C. Caseo-necrotic lesions in the pharynx and distal oesophagus near the proventriculus.

Table 4. Haematological indices of domestic pigeons affected by *Haemoproteus columbae* in Jammu region (mean ± SE)

Parameters	Non infected (n=22)	Infected (n=8)
PCV (%)	41.08 ± 0.32[a]	32.79 ± 0.52[b]
Hb (g/dl)	11.73 ± 0.4[a]	8.08 ± 0.30[b]
Heterophils (%)	52.00 ± 0.47	50.00 ± 0.87
Lymphocytes (%)	35.00 ± 0.34	34.83 ± 0.60
Monocytes (%)	8.70 ± 0.35	8.50 ± 0.26
Eosinophils (%)	2.50 ± 0.15[a]	5.50 ± 0.39[b]
Basophils (%)	1.91 ± 0.19	1.16 ± 0.32

[a,b] – Means within a row with different superscripts are significantly different at $p<0.05$

(10–12×1.5–5µm) were stained purple (Giemsa stain) while macrogametocytes (13–15×3.5–6µm) were stained with a darker shade. Within the erythrocytes, haemozoin pigments derived from haemoglobin digestion were found, appearing as refractile, golden brown granules. Schizonts were not seen in the peripheral blood smears. Based on morphological characteristics, the haemoprotozoans were identified as *Haemoproteus columbae*. The concentration of the parasite was sparse (1–2 gametocytes/100 RBC) but occasionally found in groups.

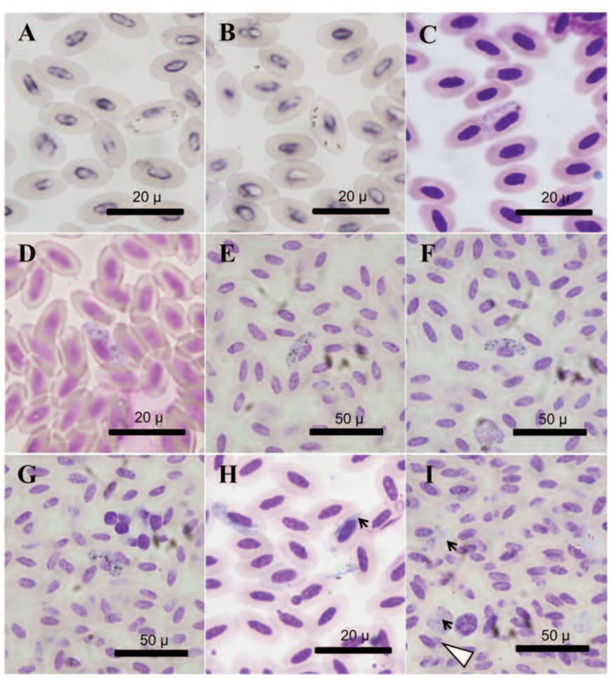

Fig. 4. Peripheral blood smears of pigeons (*Columba livia*) showing *Haemoproteus columbae* gametocytes within erythrocytes. A,B. Microgametes with polar granules and nucleus diffused with the cytoplasm. Giemsa stain, 400×; C–F. Macrogametes with randomly scattered granules and nucleus with clear margins. Giemsa stain, C–D 400×, E–F 100×; G. Halter-shaped macrogamete reaching beyond the poles of the erythrocyte. Giemsa stain, 100×; H. Immature gametocyte (black arrow). Giemsa stain, 400×; I. Immature gametocyte (white arrow head) and extra-corpuscular macrogametocytes (black arrows). Giemsa stain, 100×.

Mature gametocytes could be differentiated into microgametocytes (Fig. 4A,B) with polar granules and nucleus diffused with the cytoplasm and macrogametocytes (Fig. 4C–G) with randomly scattered granules and nucleus with clear margins.

Macrogametocytes were broadly sausage shaped, slightly halteridial and usually situated lateral to the erythrocytic nucleus. The fully grown parasite reached the poles of the infected erythrocyte and encircled its nucleus. The margins were mostly smooth and rarely amoeboid. Variations in the shape of macrogametocytes were quite evident. The black to yellow-brown granules were median or small sized and dispersed randomly in the whole cytoplasm.

Microgametocytes were slightly smaller than macrogametocytes, slightly halteridial and usually lateral to the host cell nucleus. The ends of the parasites are usually rounded and the margin entire. The gametocytes were found to almost adhere to the host cell membrane at the polar zones and sometimes in the central zones as well.

Young and immature gametocytes (Fig. 4H) were visible in blood films developing lateral to the host cell nucleus with no contact with the host cell membrane or the host cell nucleus.

Extra-corpuscular forms of macrogametocytes (Fig. 4I) could be seen lying free in the plasma. The extra-corpuscular forms lying in the plasma were irregular shaped. Cytoplasm was granular, granules being dispersed throughout the parasite.

Blood collected for screening of haemo-protozoan parasites from apparently healthy and sick pigeons were also subjected to evaluation of haematological profile. A significant variation ($p<0.05$) was observed in Hb, PCV and eosinophils between *Haemoproteus* infected and non-infected pigeons. However, a non-significant variation ($p<0.05$) was observed in heterophils, monocytes and basophils.

During the study period (July 2015 to June 2016) a total of 24 pooled fecal samples examined from six select villages of Jammu district in the four

recognized seasons revealed presence of different parasitic ova. The load of infection was designated arbitrarily from none (0) to very severe (4) and the mean parasitic egg load calculated for each parasite during the four prevalent seasons and graphically represented in Fig. 5.

Amongst the nematodes, *Ascaridia* eggs (Fig. 6A) were not consistently seen, and its occurrence was sporadic with a particular prevalence in the monsoon and post monsoon period. *Capillaria* eggs (Fig. 6B) were relatively abundant with no particular seasonal prevalence. *Eimeria* sp. (Fig. 6C) after *in vitro* sporulation typically contained four sporocysts containing a pair of sporozoites each (Fig. 6D). *Eimeria* sp. eggs was most prevalent with a particular abundance in the winter season. Cestodiasis with *Raillietina* sp. (Fig. 6E) was the most common metazoan enteric infection but its observed prevalence apparently was lowered in the peak summers. Many parasitic ova could not be identified (Fig. 6F).

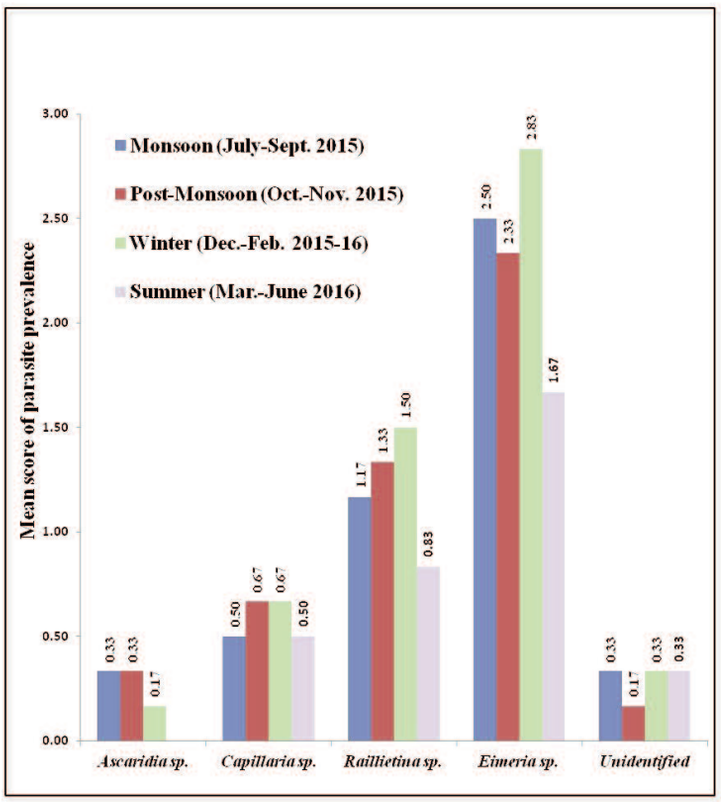

Fig. 5. Mean seasonal prevalence (on a relative scale ranging from 0–4) of different parasites in fecal samples of pigeon in Jamnu region

Discussion

A number of ecto- and endoparasites occurring naturally in the pigeons were recorded. Although the parasitic load in the wild is unknown, it is speculated that the severe infestation in some birds may be due to their dense and confined rearing and also attributable to their poor and unorganized management.

Different stages of the haemoprotozoa *H. columbae* were observed in the blood of live birds screened, and in the liver and lungs of the necropsied pigeons. Previous reports of the parasite in Jammu region have been estimated at 61.33% [17]. The parasites of genera *Haemoproteus*, *Plasmodium*, and *Leucocytozoon* are well-known avian haematozoa and can cause declined productivity and high mortality in wild birds [18]. Organisms in peripheral blood smear may appear similar to *Plasmodium*, but the refractile, yellow to brown pigment granules (haemozoin) derived from the digestion of haemoglobin within the intra-erythrocytic gametocytes are more dispersed and schizonts are not seen in the peripheral blood smears. The *Haemoproteus* gametocytes partially encircle the erythrocyte nucleus forming a halter-shape and often occupy over one half of the erythrocyte cytoplasm causing slight enlargement of the infected host cells and displacement of the red blood cell nucleus to one side [19]. Together with *H. columbae*, co-infection with *Plasmodium* parasites in rock pigeons [4] and with *Leucocytozoon* sp. in domestic pigeons [20] can also occur. It is opined that these blood parasites are related in many characters and sometimes considered to be either benign or of mild effect [21,22]. They are continually circulated around the world and any variations in their prevalence, intensity and health impact, whether sex-related, seasonal-related or spatial-related, might depend on the susceptibility of the host species involved, their age, habitat, as well as congruence, transmission, density and feeding habits of their vectors [2]. Since the incriminated vectors of these parasites are prevalent in this region including a number of mosquitoes of the genera *Culex* and *Aedes* for *Plasmodium*, and flies of the Hippoboscidae and the genus *Phlebotomus*, and midges of the genus *Culicoides* for *Haemoproteus* sp., respectively, the possibility of co-infection and prevalence of other haemoprotozoan agents cannot be ruled out. The higher prevalence of parasitaemia observed in male birds is in contrast to the findings of Earle and Little [21]. While host sexuality was not detected by Senlik et al. [23], however infection

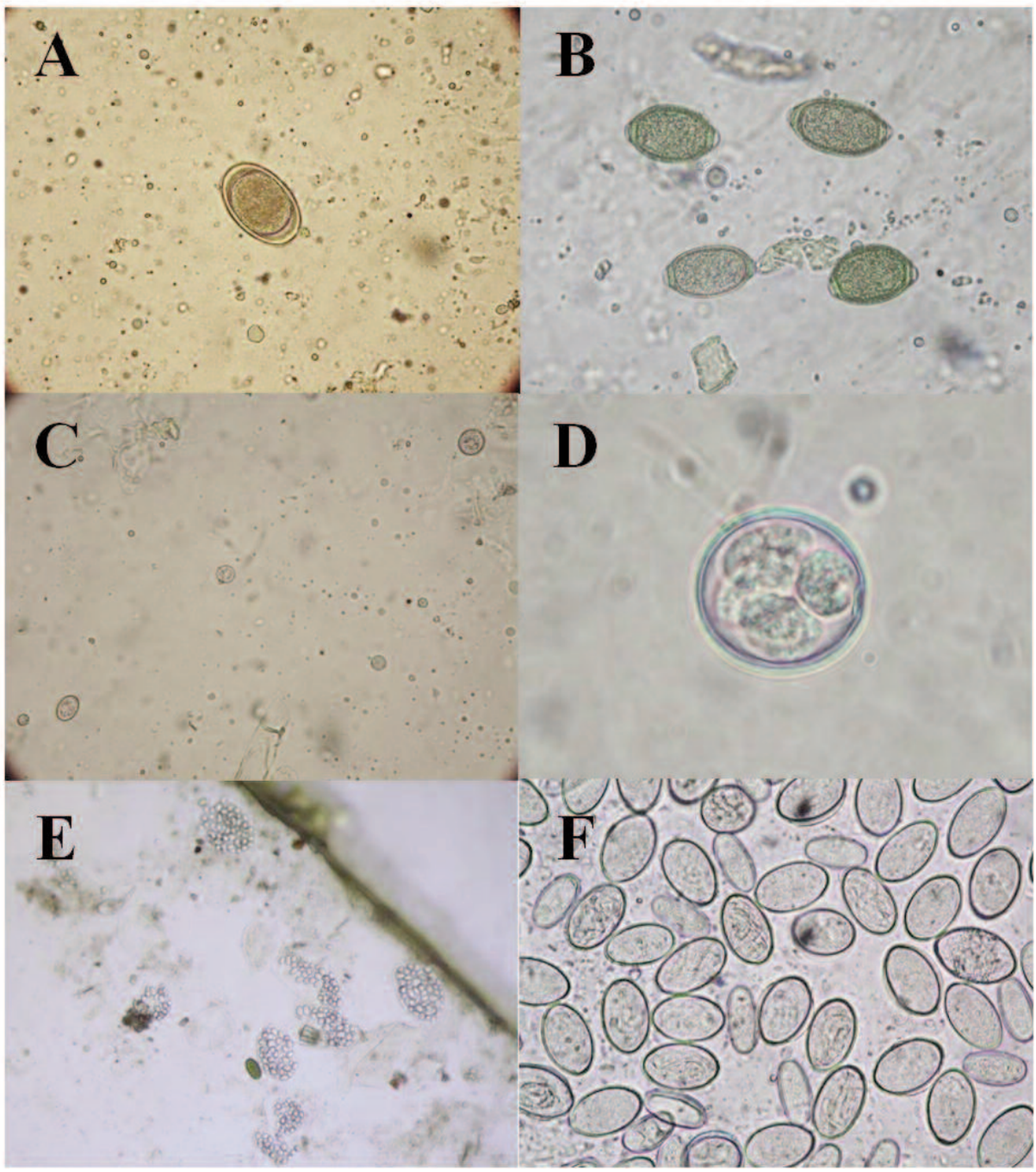

Fig. 6. Parasitic ova prepared from pooled fecal samples of pigeons (*Columba livia*). A. *Ascaridia* sp. egg. Unstained, 40×; B. *Capillaria* sp. egg. Unstained, 40×; C. Different unsporulated eimerian oocysts. Unstained, 10×; D. *Eimeria* sp. sporulated oocyst. Unstained, 100×; E. *Raillietina* sp. egg. Unstained, 10×; F. Unidentified eggs. Unstained, 40×.

was found to vary seasonally. Al-Barwari and Saeed [2] proposed a number of endogenous and exogenous factors that could have an accumulative influence on the parasitisation of both sexes of the pigeons by these parasites, such as host's hormones and humoral compounds, age and nutritional state, behaviour and habits, as well as the season of the year and ecological and physical features of the regions.

A significant variation ($p<0.05$) was observed in Hb, PCV and eosinophils between *Haemoproteus* sp. infected and non-infected pigeons. This variation in blood profile (PCV, Hb and eosinophils) could be attributed to high parasitic load that contribute to the development of anaemia. This has been amply indicated by the significant fall in PCV and haemoglobin values. Besides, the degree of tissue parasitism in the infected birds may be the

cause of eosinophilia. Similar differences in blood parameters between infected and non-infected birds have been reported in the literature [24–26]. There also seems to be sex variations in haematological parameters with a significant ($p<0.05$) decrease in PCV, WBC, MCV values between male and female pigeons, an observation corroborating the reports of [27].

The pigeon flatfly *P. canariensis* feeds on blood and contributes in spreading the obligate blood parasites *Haemoproteus* sp. [22,28] and their recovery in the present study establishes the mode of transmission of the haemoprotozoan agents. It has also been previously observed in pigeons from this region [17]. Furthermore, a number of lice and mites species are believed to have evolved a phoretic association with this particular species of hippoboscid flies [4]. The role of these ectoparasites cannot be ruled out in haemoprotozoan transmission.

The oocysts of *Eimeria* were consistently present in fecal contents of both live and necropsied birds, and therefore can be regarded a common and ubiquitous infection in the pigeon. This has also been corroborated earlier [7]. According to Koroglu and Simsek [29], coccidian parasites found can be found in pigeons even without gross pathological manifestations of acute gastroenteritis. Prevalence is said to be more in young pigeons (5.1–71.9%) with a worldwide mortality varying from 5% to 70% amongst juvenile pigeons, particularly in the third and fourth month of life [30]. Their presence in low infection have been thought to be beneficial and may even be protective by boosting the immune responses against further infections, as is in the case of poultry [31]. However, when large numbers of mature and sporulated oocysts are ingested, especially by the susceptible and debilitated birds, profound immunosuppression would lead to the development of a true coccidiosis [12].

In the present study, the birds were confined in lofts where dissemination of the parasite within, and between lofts by visiting birds was possible. Thus, coccidiosis in reared pigeons may prove to be highly endemic, unless regular control measures are not undertaken.

Trichomoniasis is common in many bird species and differences in virulence exists with different strains of the avian trichomonads [32]. Reportedly, the infection can be predisposed by various factors such as immunity, age, concurrent disease, genetic heterogeneity and food availability [33]. They live mainly in the bird's anterior digestive tract, where they can cause granulomatous lesions that occlude the oesophageal lumen, leading to the death of birds as a result of severe starvation [34]. The infection has been found in a sizeable population of surveyed birds, particularly the young squabs. It is believed that transmission occurs during feeding the young ones, or drinking from common sources of water. The presence of the trichomonads may go unnoticed or associated with mild lesions, unless aggravated to result in severe granulomatous lesions that could restrict feeding by the birds.

Cryptosporidiosis had been observed as an incidental finding in 5 out of 10 cloacal fecal screening. It is regarded as one of the main protozoan infections in birds that manifests as either a respiratory or a digestive illness, and affects a very large number of avian species across several continents [35]. Although the oocysts of some species present distinct morphology and morphometry, microscopic analysis does not allow species characterization because small variations exist in these parameters, and in many cases, the oocysts may be identical between different species or genotypes [36]. However, a presumptive diagnosis of gastric, intestinal or respiratory/ bursal/cloacal cryptosporidiosis in birds can be accomplished by the presence of spherical, elongated or ovoid oocysts [36–38], which are demonstrable using the acid-fast staining. Although, its detailed pathology was not studied, signs described in the literature are characterized by diarrhoea and body weight loss in intestinal cryptosporidiosis observed in young pigeons [39]. Since the signs and lesions could be misinterpreted with other disease conditions, Özkul and Aydin [40] suggested that cryptosporidiosis be included when differentiating with disease affections causing diarrhoea, weight loss and death in pigeons, and isolation and specification of *Cryptosporidium* sp. be attempted and reported.

Amongst the helminth parasites, cestodiasis was found to be relatively more prevalent than nematode infection. This is probably because the pigeons could readily access the intermediate hosts of the cestodes as part of their food. Besides, the birds feeding behaviour may have limited foraging and scavenging access to the soil harbouring nematodes that exhibit a direct life cycle.

Many workers suggest a careful differentiation of *Raillietina* with *Cotugnia*, and are to be ascertained on the basis of the parasites' strobilae and scolices because of similarities in these members of

both of the genera [4,41]. Elsewhere, these parasites were shown to have evolved indirect cycles whereby the ova develop into infective larvae (cysticercoids) in the tissues of some invertebrates [31]. The identity of these intermediaries may vary with the tapeworm species but it often comprises one or other of such insects as houseflies and allied dipterans, some hymenopterans such as ants [42], and some beetle species.

Nematode infection recorded in the present study was mild. Al-Barwari and Saeed [2] suggests that only those infections that become too severe are harmful, and are frequently found in disabled, weakened or senile hosts. Both nematode parasites that were identified in this study have a direct life cycle, which means that the ova are passed in feces and under favourable environmental factors (especially high temperature and adequate humidity) they develop into infective stage. Control of parasitism in such cases becomes favourable with regular deworming schedules.

Pooled fecal samples examined in the study revealed presence of different parasitic ova with variable prevalence in the four recognized seasons. Ascarid eggs were least prevalent whereas prevalence of *Eimeria* sp. was highest amongst all parasitic eggs and had a particular higher prevalence in the winter season. The highest prevalence of coccidian parasites in winter season could be attributed to close confinement of pigeons and favourable temperature for proliferation and sporulation. Similar opinion was forwarded by Sivajothi et al. [44]. The infection intensity and egg count are dependent on various factors as summarized by Presswell and Lagrue [44] and can be related to the environment [45,46], season [48–50], phase of the parasitic infection [50], and even hour of sampling [51].

Although, identification of parasites is difficult based on egg morphology alone, correlation with select specimens obtained at necropsy from some pigeons aided in their generic classification. In certain cases, some eggs could not be identified. Although, the sampling was randomized and limited, it was intended to serve as a general overview of the prevalent parasitic fauna. The present study is perhaps the first faunistic compilation of parasites in pigeons from Jammu. The list is not exhaustive and likely to increase when more birds are surveyed and their opportune explorative investigation during necropsy when died naturally. The data generated may be helpful in estimating the prevalence of different parasites and also help in the strategic management of parasitic load during various seasons.

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