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Table of Content: Volume 7 Number 1, February 2015

ARTICLES

Research Article

- Prevalence and intensity of phthirapteran ectoparasites infesting Eurasian Collared-Dove (*Streptopelia decaocto*) (Phthiraptera: Insecta)** 22
SINGH Padam, ARYA Gaurav and SAXENA Arun Kumar
- Study on gastro-intestinal helminth parasites of dogs in Mekelle City Tigray Ethiopia** 29
Getachew Gugsu, Tesfay Hailu, Shewit Kalayou, Nigus Abebe and Yohannes Hagos

Full Length Research Paper

Prevalence and intensity of phthirapteran ectoparasites infesting Eurasian Collared-Dove (*Streptopelia decaocto*) (Phthiraptera: Insecta)

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One hundred Eurasian Collared-Doves were mist netted in district Rampur (India) from 2010 to 2011 and subjected to delousing by fumigation method. Only three phthirapteran species e.g. *Columbicola bacillus* Giebel, 1866, *Coloceras* Taschenberg, 1882 and *Hohorestiella rampurensis* Bansal were recovered. The population characteristics, that is, prevalence, mean intensity, sample mean abundance, and ranges of infestation were recorded. Frequency distribution patterns of all the species were aggregated but conformed to binomial model in case of *C. bacillus*. Sex ratios were skewed in favour of females in case of all the three lice. The prevalence and intensity of phthiraptera were comparative higher in summer months than winter months. The prevalences of three phthirapteran species (e.g. *C. bacillus*, *Coloceras* species and *H. rampurensis*) on the Eurasian Collared-Dove were 71, 13 and 16%, respectively, in district Rampur, from 2010 to 2011. The sample mean abundances remained 8.1, 1.3 and 1.6, respectively. The frequency distribution patterns of all the species were skewed but conformed to the negative binomial model in case of only one species. Sex ratios were skewed in favour of females while nymphal population exceeded over adults in case of all the three species.

Key words: Phthiraptera, Eurasian Collared-Dove lice, prevalence, ischnocera, amblycera, mallophaga

INTRODUCTION

As many as six phthirapteran species are known to infest the Eurasian Collared-Dove, *Streptopelia decaocto* (e.g. *Bonomiella concii* Eiculer, 1947; *Coloceras hillii* Bedford, 1920; *Coloceras piagati* Johnston and Harrison, 1912; *Columbicola bacillus* Giebel, 1866; *Hohorestiella modesta* Ansari, 1951; *Turturicola salimallii* Clay and Meinertzhogen, 1937). The prevalence of an amblyceran louse, *Hohorestiella rampurensis* on 45 *S. decaocto* has been noticed by Singh et al. (2012).

Reports on the population characteristics of phthiraptera infesting selected Indian birds, namely, domestic pigeons (Singh et al., 1998; Khan et al., 2009), common mynas (Chandra et al., 1990; Saxena et al., 2007), house crows (Beg et al., 2008), red avadavats (Gupta et al., 2007), bank mynas (Rajput et al., 2009), house sparrows, Indian parakeets, white breast kingfishers (Saxena et al., 2007), domestic fowls (Trivedi and Saxena, 1991; Trivedi et al., 1992; Saxena et al.,

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2004; Kumat et al., 2004), red whiskered bulbuls (Arya et al., 2010), common bayas (Arya et al., 2011) and certain other poultry (Khan et al., 2008) have appeared for the last 25 years. A scrutiny of literature reveals that the population characteristics of phthirapterans occurring in Eurasian Collared-Doves deserved investigation. The present report furnishes information on the prevalence, intensity of infestation and population composition of phthirapteran species parasitizing the Eurasian Collared-Doves, *S. decaocto*.

MATERIALS AND METHODS

One hundred Eurasian Collared-Doves (*S. decaocto*) were mist netted at 32 locations from January 2010 to December 2011, in district Rampur (28° 48' 79° 00' E) (India). Each bird was examined visually (with the help of magnifying torch), after tying the legs. The uninfested birds were released in wild and the lousy hosts were deloused by the modified fair Isle method (Gupta et al., 2007). Fumigation method reportedly does not yield complete louse load (Clayton and Drown, 2001) but secures the life of bird. After tying the legs, birds was placed in a transparent plastic bag containing a wad of cotton wool soaked in chloroform in such a way that head protruded out (allowed to breathe). After 10 min, the body feathers of fumigated birds were ruffled manually over a plastic sheet, to take out the louse load. The head was separately examined after delousing. The deloused birds were released in wild. Entire louse load so obtained was transferred to 70% alcohol and separated species wise, sex wise and stage wise. Common measures of population characteristics (namely, prevalence, mean intensity, sample mean abundance), and indices of aggregation (namely, variance to mean ratio, exponent [k] of the negative binomial distribution and index of discrepancy [D] were compared with the help of software offered by Rozsa et al. (2000). The goodness of fit between the observed and the expected frequencies (negative binomial) was determined by the χ^2 test (Gupta et al., 2007).

RESULTS

During the present studies specimens belonging to only three genera e.g. *Columbicola*, *Coloceras* and *Hohorestellla* were recovered. Adams et al. (2005) have revised the genus *Columbicola*. The specimens of *Columbicola* collected in the present studies resembled that of *C. bacillus* (in morphological characteristics and measurements) to a greater extent (Figure 1A and B). Tendeiro (1973) made valuable contribution on the taxonomic status of the genus *Coloceras*. Two species of the genus *Coloceras* (e.g. *C. piagati* and *C. hilli*) have been listed from *S. decaocta*. The specimens of the genus *Coloceras* collected in the present studies exhibited some differences in chaetotaxy and measurement from the aforesaid two species (Figure 1C and D). Exact taxonomic identity (species level) presented some confusion. Hence, for the present description, the specimens are being referred as *Coloceras* species. The specimens of amblyceran lice collected in the present studies belong to genus *Hohorestiella*. The specimens differed from *H. modesta* in several characteristics and

resembled that of the new species *H. rampurensis* described by Bansal et al. (2010) in morphological characteristics and measurements (Figure 1E and F).

Seventy seven percent of the Eurasian Collared-Doves examined from January 2010 to December 2011 in district Rampur (UP) were found infested with one or other species of phthiraptera. Thus, the sample mean abundance of phthiraptera remained 11.03 per bird, as a total of 1103 lice were collected (n=100). Likewise, the mean intensity of infestation was recorded as 14.32 per bird. Maximum number of lice counted on any bird was 75 (range of infestation, 1 to 75).

Out of the hundred birds examined from January 2010 to December 2011, 23 birds were louse free. Maximum number of birds (57) carried single species. Two species infestation was encountered on 17 Eurasian Collared-Doves. Simultaneous occurrence of all the three species was observed on only 3 birds. In other words, single species infestation was the most common on the Eurasian Collared-Doves.

As far as, seasonal variations in the prevalence of phthiraptera infesting Eurasian Collared-Doves is concerned, the sample size (7 to 11 per month) was too small and moreover the study period lasted two years. It would not be worthwhile to perform correlation analysis between the mean monthly temperature and the eco factors (mean monthly temperature, relative humidity and photoperiod). Nevertheless, the data provides primary clues as the prevalence remained 60% in January (n=10). It increased in February (67%, n=9). It further increased to 87.5 in March (n=8) and remained similar in April (n=8). The prevalence rate was 100% in May and June (n=8 and 7, respectively). The prevalence decreased to 86% in July and remained similar in August (n=7, each). The prevalence decreased to 75% (n=8) in September and further reduced in October (62.5%; n=8). The prevalence exhibited slight increase in November (67%, n=9) but decreased in December (64%, n=11). The overall data shows that the prevalence remained low (60 to 67%) in winter months (November to February) (Figure 5), and became high in summer month (March to June; 87.5 to 100%) and were moderate during the other months (62.5 to 86%; July to October).

More or less similar trend was observed in the mean monthly infestation intensities. For instance mean monthly intensity exhibited continuous increase from January to May (5.0, 8.6, 11.1, 19.0 and 27.4, respectively). Intensity of infestation exhibited slight reduction in June (24.3) but decreased abruptly in July (14.8). It showed slight increase in August (17.7) but again reduced to 11.7 in September. The mean monthly intensity increased to 12.6 in October but again reduced to 6.3 level in November and remained nearly similar (6.4) in December. Thus, the data indicates that intensities of infestation were comparatively higher during summer months but exhibited fluctuations during winter and rainy months (Figure 5).

Table 1. Population characteristics of three phthirapteran species on 100 Eurasian Collared-Dove lice in district Rampur from 2010 to 2011

Population parameter	<i>C. bacillus</i>	<i>Coloceros</i> spp.	<i>H. rampurensis</i>
Prevalence	71	13	16
Sample mean abundance	8.1	1.3	1.6
Mean intensity	11.5	9.7	10.3
Range of infestation	1-75	5-15	3-24
Variance/mean ratio	19.38	9.4	12.19
Total no. recorded	813	126	164
D of Poulin	0.654	0.884	0.881
Exponent of -ve binomial (k)	0.446	0.042	0.052
Whether conformation -ve binomial	Conformed	Not conformed	Not conformed
Male:Female	1:1.3	1:1.2	1:1.3
Adult:Nymph	1:1.4	1:13	1:1.3
I:II:III Nymphal instars	1:0.9:0.7	1:1.3:1.5	1:0.9:1.6

The population characteristics of three phthirapteran species infesting Eurasian Collared-Dove, *S. decoccto* have been indicated as shown in Table 1. However, the frequency distribution pattern of three species is being described.

Frequency distribution pattern of *C. bacillus*

A closer look on the data reveals that no lice occurred on 23 birds. A single louse was present upon 6 birds. Likewise, 2 lice on 9 birds, 3 lice on 1 bird, 4 lice on 8 birds, 5 lice on 5 birds, 6 lice on 3 birds, 7 lice on 6 birds, 8 lice on 2 birds, 9 lice on 2 birds, 10 lice on 2 birds, 11 lice on 1 bird, 12 lice on 1 bird, 13 lice on 4 birds, 14 lice on 4 birds, 15 lice on 2 birds, 16 lice on 1 bird, 17 lice on 1 bird, 19 lice on 2 birds, 20 lice on 2 birds, 23 lice on 1 bird, 24 lice on 2 birds, 26 lice on 1 bird, 31 lice on 1 bird, 32 lice on 1 bird, 55 lice on 1 bird, 63 lice on 1 bird and finally 75 lice on single bird. The aforesaid data has been depicted as shown in Figure 2 against the frequencies expected by the negative binomial model. The shape of frequency distribution curve was clearly aggregated/clumped/skewed. The variance to mean ratio was computed as 19.38. The value of D of Poulin was determined as 0.654. The value of k (the exponent of negative binomial distribution) was recorded as 0.446. The frequency distribution pattern of *C. bacillus* on Eurasian Collared-Doves conformed to negative binomial distribution ($\chi^2 = 21.56$, $P < 0.05$) (Table 1).

Frequency distribution pattern of *Coloceros* species

A closure look on the data reveals that 5 lice occurred on 2 birds, 7 lice on 1 bird, 8 lice on 2 birds, 9 on 1 bird, 10 on 1 bird, 11 on 3 birds, 12 on 1 bird, 14 on 1 bird and 15 lice on single bird. The aforementioned observed

frequency distribution was plotted against the frequencies expected by the negative binomial. The pattern of frequency distribution remained skewed/clumped. The variance to mean ratio was computed as 9.4. The value of 'D' of Poulin appeared to be 0.884. The value of the exponent of negative binomial (k) was computed as 0.042. However, the negative binomial distribution was not found to be a good fit in case of *Coloceros* spp. ($\chi^2 = 17.29$; $P > 0.05$) (Figure 3).

Frequency distribution pattern of *H. rampurensis*

The data indicates that 84 birds were found louse free. Three lice occurred on 2 birds, 6 lice on 4 birds, 8 lice on 2 birds, 9 lice on 1 bird, 10 lice on 1 bird, 11 lice on 1 bird, 12 lice on 1 bird, 14 lice on 1 bird, 16 lice on 1 bird, 22 lice on 1 bird and 24 lice on single bird. The aforementioned observed frequency distribution pattern has been plotted against the frequencies estimated by the negative binomial. The shape of frequency distribution pattern remained clumped/aggregated (hollow curve) and the variance to mean ratio exceeded unity (12.19) (Figure 4). The value of index of discrepancy (D of Poulin) was estimated as 0.881. The value of exponent of negative binomial (k) was determined as 0.052. The distribution of *H. rampurensis* on Eurasian Collared-Dove lice was skewed but somehow it failed to conform to negative binomial model ($\chi^2 = 18.16$, $P > 0.05$) (Table 1).

DISCUSSION

Studies revealed that prevalence of *C. bacillus* on Eurasian Collared-Doves was higher, than two other species (e.g. *Coloceros* spp. and *H. rampurensis*). The prevalences of phthirapteran species on the other Indian birds reportedly varies from 6.9 to 51.3% on domestic

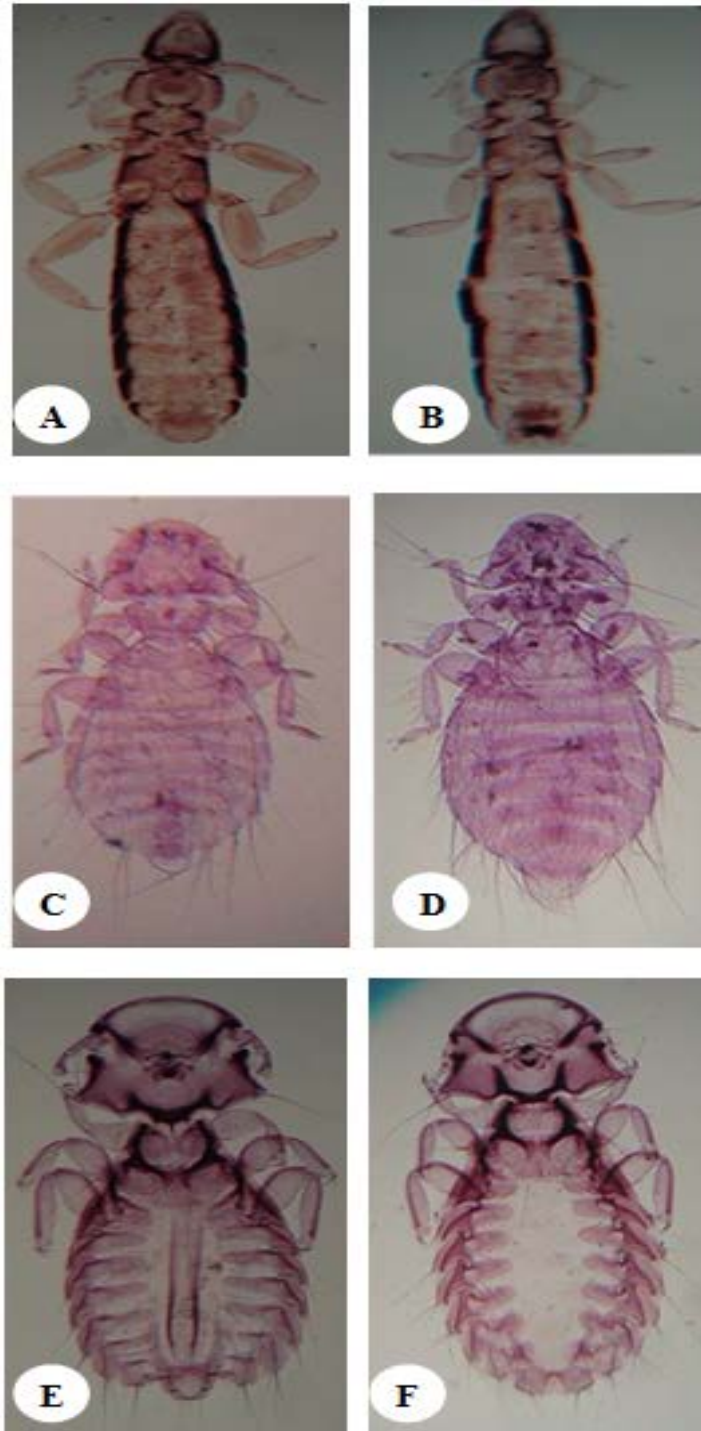


Figure 1. LM photograph of adult Eurasian Collared-Dove lice *Columbicola bacillus* (A-male, x43, B-female x40), *Coloceras* spp. (C-male x60, D-female x48) and *Hohorstiella rampurensis* (E-male x59 D-female x46).

fowls, 28.8 to 61.0% on pigeons, 13.0 to 42.0% on common myna, 14.0 to 31.0% on house sparrows, 17.0 to 34.0% on Indian parakeets, 40.0% on kingfishers, 3.0

to 36.2% on house crows, 20.8 to 36.2% on red avadavat, 58% on red whiskered bulbuls and 74% on common bayas (Singh et al., 1998; Saxena et al., 2004,

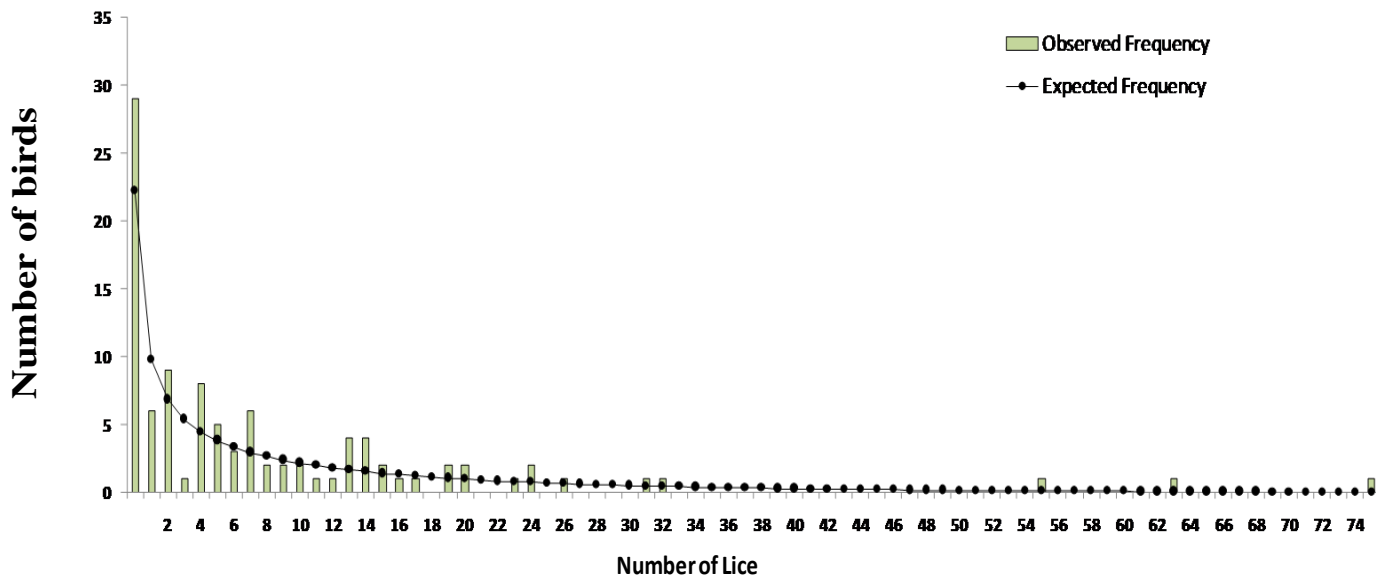


Figure 2. The frequency distribution pattern of *Columbicola bacillus* on 100 Eurasian Collared-Dove lice in district Rampur, from 2010-2011.

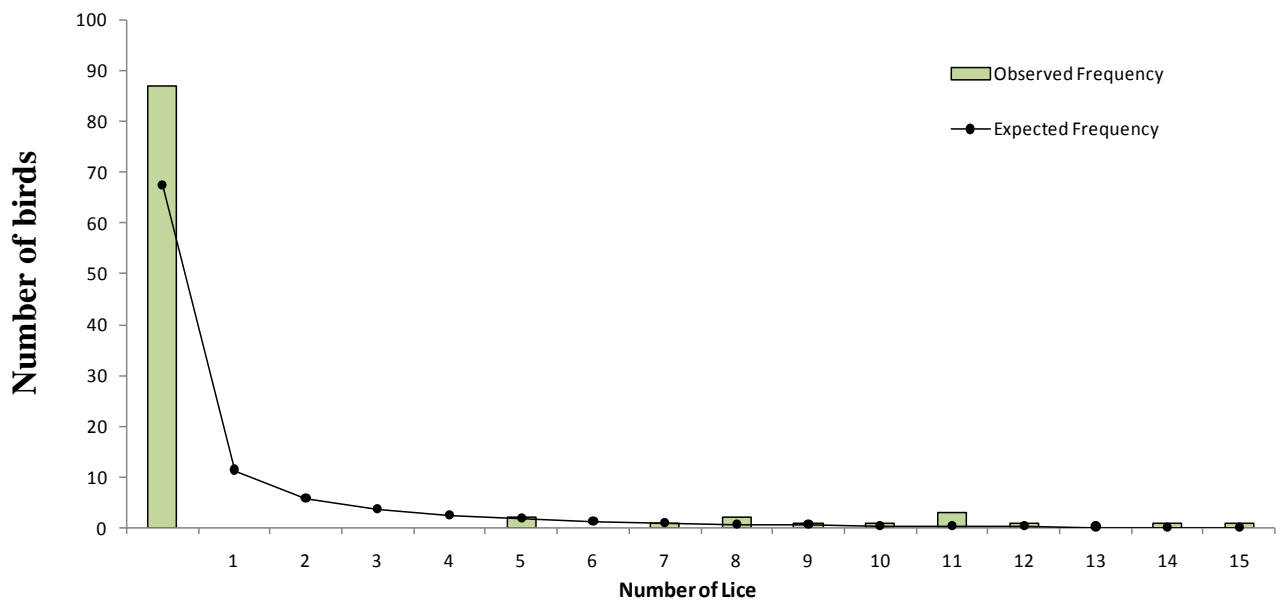


Figure 3. The frequency distribution pattern of *Coloceros* spp. on 100 Collared-Dove lice in district Rampur from 2010 to 2011.

2007; Gupta et al., 2007; Beg et al., 2008, Arya et al., 2010, 2011).

As far as intensity of infestation of phthiraptera on Indian birds is concerned, it has been reported to be 80.15 per bird on common myna (Chandra et al., 1990). It varied from 18.4 to 182.5 per host on domestic pigeons (Singh et al., 1998), from 37.4 to 40.21 per bird on domestic fowls (Kumar et al., 2004), from 59.3 to 103.0

per bird on house crows (Beg et al., 2008), from 1.5 to 3.4 per bird on red avadavats (Gupta et al., 2007), from 7.6 to 13.3 per bird on house sparrows, from 13.8 to 21.8 per host on parakeets and 17.7 per bird on kingfishers (Saxena et al., 2007), 30.6 to 48.3 per host on bank myna (Rajput et al., 2009), 15.6 on red whiskered bulbuls and 13.97 on common bayas (Arya et al., 2010, 2011). Thus, the sample mean abundance of three phthirapteran

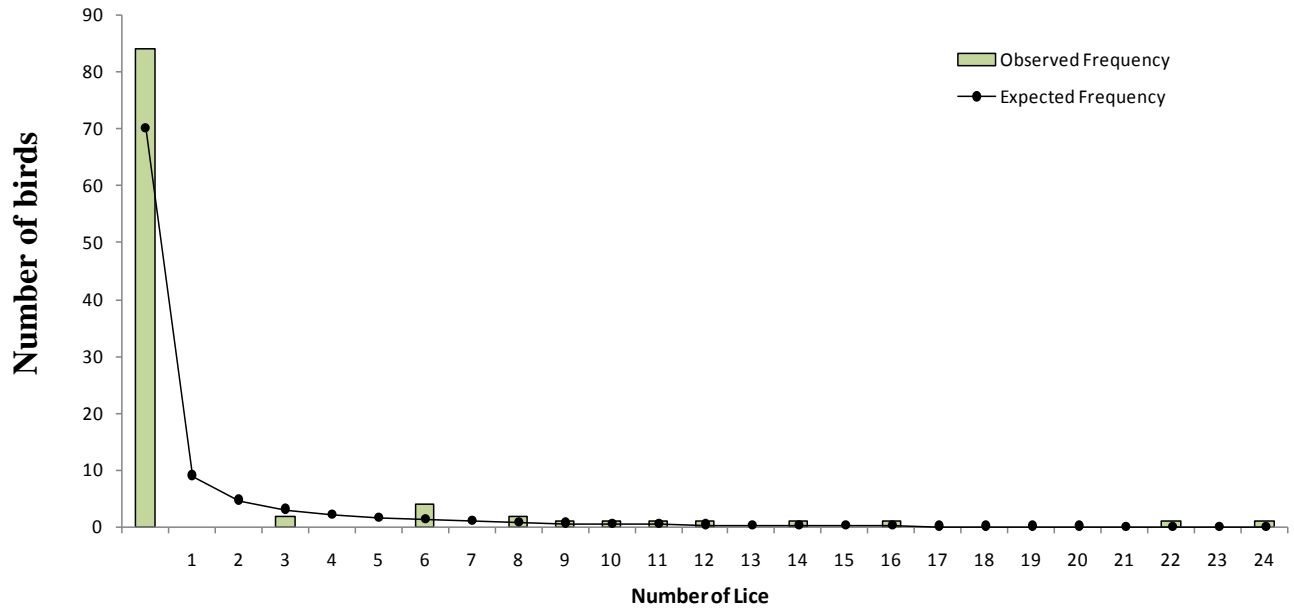


Figure 4. The frequency distribution pattern of *Hohorstiella rampurensis* on 100 Eurasian Collared-Doves in district Rampur from 2010-2011.

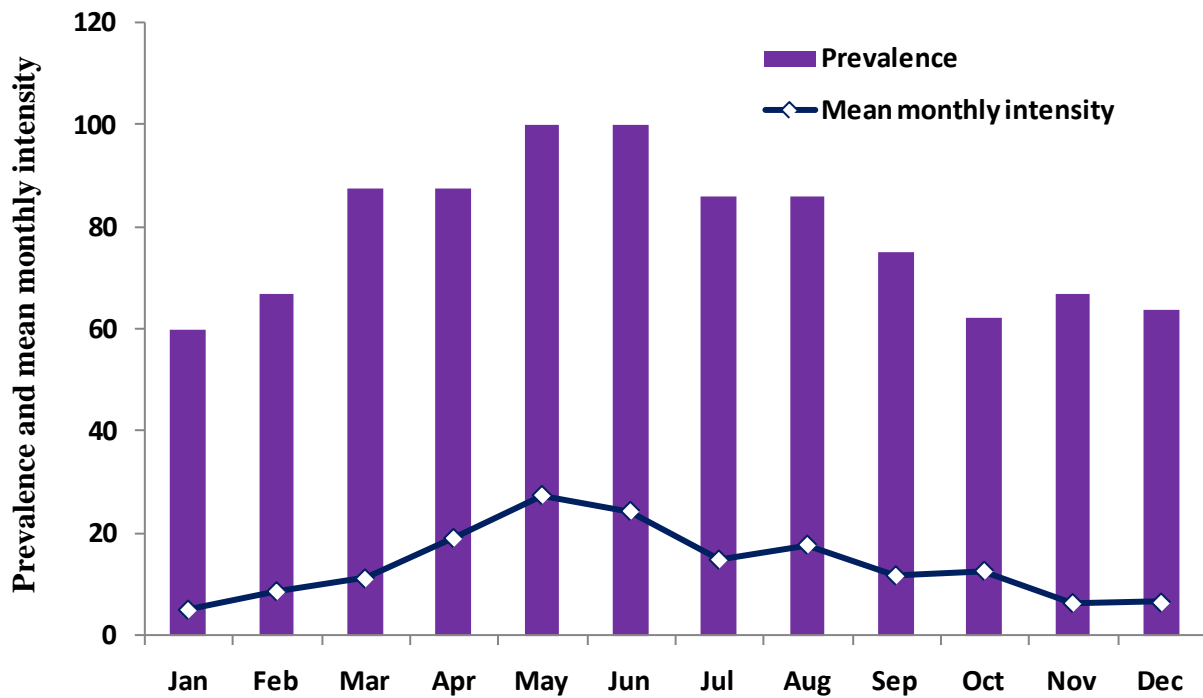


Figure 5. The prevalence and mean monthly intensity of phthirapteran species on 100 Eurasian Collared-Dove lice s in district Rampur from 2010 to 2011.

species was not high on Eurasian Collared-Doves that remained (8.15, 1.26 and 1.64/bird).

Avian lice generally exhibit clumped/aggregated distribution on the host birds (Rekasi et al., 1997). The

latter studied the distribution of 12 avian lice and also analyzed 15 distribution recorded by earlier workers and found that the distribution of 21 (out of 27) species occurring on 13 birds conformed to the negative binomial

model. However, Saxena et al. (2007), Gupta et al. (2007), Beg et al. (2008), Rajput et al. (2009) and Arya et al. (2010, 2011) found that the distribution of only 2 species (out of 23) occurring on nine avian hosts conformed with negative binomial model. In case of Eurasian Collared-Doves, the negative binomial model was found to be a good fit in case of *C. bacillus* but not in case of *Coloceras* spp. and *H. rampurensis*.

Sex ratio of the population of three phthirapteran species occurring on Eurasian Collared-Doves conformed to the general trend observed in most of the phthirapteran species. In phthirapterans, the females usually outnumber the males in natural population (Marshall, 1981). Reasons responsible for skewed sex ratios have been discussed elsewhere (Marshall, 1981; Gupta et al., 2007). The adult nymph ratio of any population provides some clues regarding the temporal stability of the population. The occurrence of few nymphs and more adults indicates declining population while the presence of more nymphs and few adults points out that the population is expanding (Marshall, 1981). In case of Eurasian Collared-Dove lice, *C. bacillus*, *Coloceras* spp. and *H. rampurensis*, the adult nymph ratio remained nearly similar. However, it may be noted that lice population on avian hosts fluctuates seasonally, so the population ratio of the aforementioned species is bound to vary with time.

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Conflict of interest

The authors declare that they have no conflict of interest to disclose.

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Full Length Research Paper

Study on gastro-intestinal helminth parasites of dogs in Mekelle City Tigray Ethiopia

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Dog (*Canis familiaris*) is a domestic animal that maintains close contact with humans and other animals, such that any lack of diagnosis or treatment against certain diseases favours the transmission of zoonotic diseases. A study on gastrointestinal parasites of dogs was conducted from November, 2009 to April, 2010 with the objective of documenting the helminth biodiversity in dogs of Mekelle city. A coprological examination was conducted for a total of 146 dog faecal samples. Statistical tests were performed using statistical package for social sciences (SPSS) 15.0 windows version. The faecal examination revealed the presence of nine helminth species with an overall prevalence of 73.3%: From all gastrointestinal parasites, the most commonly dominant parasites were *Taeniaspp.* (41.1%) followed by *Dipylidium caninum*, (37.7%), *Ancylostomaspp.* (24%) and *Toxocaracanis*(23.3%), whereas the prevalence of *Toxascarisleonina*, *Spirocercalupi*, *Mesocestoideslineatus*, *Echinococcus spp.* and *Taeniaserrata* were less than 10%. The highest eggs per gram (EPG) burden was observed for *Taeniaspp.* (701.75± 2718.75) whereas the lowest parasite mean eggs per gram (EPG) burden was recorded for *T. leonina*, *Echinococcus spp.*, *S. lupi*, *T. serrata*, and *M. lineatus* (0.00±0.00). Concurrent infections with two or more parasite species were more common. None of the three variables (age, sex, and breed of the dogs) had shown significant difference ($P>0.05$) in the degree of infestation with the helminthes parasites. Of these reported parasites, some of them have public health importance but dogs harboring the parasites are living freely and friendly with the public, and serve as a source of infection to community. Thus, there should be a practice of regular health management of dogs and further epidemiological studies should be conducted to investigate the rate of seasonal infection and the level of environmental contamination.

Key words: Burden, dog, faecal samples, gastrointestinal parasites, Mekelle, prevalence.

INTRODUCTION

Infections from gastrointestinal parasites in domestic animals have always been an important production issue. Low production of meat, wool, and milk as well as the

costs of antihelminthic treatments are the major causes of production losses in animal production (Barger, 1982) in developing countries, including Ethiopia. Moreover,

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these helminth parasites represent important public health problems (Labarthe et al., 2004). Seventeen of production losses in animal production (Barger, 1982) in developing countries, including Ethiopia. Moreover, species of *trematodes*, 17 of *cestode*, 20 of *nematode* and 1 *acanthocephalan* parasite have been identified parasitizing animals worldwide (Soulsby, 1977; Eguia-Aguilar et al., 2005).

Dogs are the most successful *canids*, adapted to human habitation worldwide and have contributed to physical, social and emotional well-being of their owners, particularly children (Dohoo et al., 1998). However, in spite of the beneficial effects, close bonds of dogs and humans (in combination with inappropriate human practices and behaviour) remain a major threat to public health, with dogs harbouring a bewildering number of infective stages of parasites transmissible to man and other domestic animals (Molyneux, 2004). Dog (*Canis familiaris*) is a domestic animal that maintains close contact with humans and other animals, such that any lack of diagnosis or treatment against certain diseases favours the transmission of zoonotic diseases. Among these, parasitosis and, in particular, helminthiasis, can become a serious animal and public health concern, as well as an economic problem (Eguia-Aguilar et al., 2005). Throughout their long history of domestication, dogs have been sources of zoonotic parasites and have served as a link for parasite exchange among livestock, wildlife, and humans (MacPherson, 2005; Salb et al., 2008).

Several species of internal parasites in dogs segregate their gastrointestinal habitat (Urquhart et al., 2003). In low-income settings, treatments to eliminate these parasites are, if done at all often apply in advanced stages of disease, causing distress on pets and their owners (Morrison, 2001; Irwin, 2002). A number of surveys have been conducted on the prevalence and mortality from internal parasites of dogs. The studies have mainly been conducted in the developed countries especially in North America. The most frequently observed parasites include hookworms, whipworms, ascarids, coccidia, tapeworms and heartworms (Kirkpatrick, 1988; Nolan and Smith, 1995). Most of the parasites affect the dog sub clinically (Brodley et al., 1977).

No comparable data from Ethiopia are available. The current prevalence of gastrointestinal parasites in the country is unknown and has never been investigated on Tigray regional state even though very few studies have been completed on gastrointestinal helminthes in dogs especially in the central part of the country. Moreover, dog owners in big cities of Ethiopia, such as Mekelle, have little awareness on the need to regularly diagnose and treat their dogs (Yacob et al., 2007; Palmer et al., 2008). Hence, there is scarcity of information regarding the prevalence of gastrointestinal helminthes. Therefore, the current study was aimed to document the helminth biodiversity of dogs in Mekelle city.

MATERIALS AND METHODS

Description of study area

The study was conducted in Mekelle, which is the capital city of Tigray regional state which is located in the Northern part of Ethiopia, 783 km far from Addis Ababa. In general the region is bordered by Eritrea in the North, Sudan in Western part of the region, Afar and Amhara regions in Eastern and Southern part of the region respectively. Tigray region is located at 12°13' to 14°54' N and 36°27' to 44°18' E latitude with an elevation of 2084 meters above sea level, at which Mekelle is located at 39°29' E and 13°3' N of longitudes having an annual average temperature of 21°C and also experiences an annual rain fall of 600 mm mostly during the summer season. The population of the city led their livelihood differently; some by trading, while some are civil servants and others did minor house hold activities (TRHDA, 2004).

Study design and sample collection

A cross-sectional study was conducted from November, 2009 to April, 2010 to document the helminth biodiversity in private owned and stray dogs in Mekelle city, and to establish the structure of gastro intestinal tract (GIT) parasitic communities in the mentioned dogs. The faecal samples were collected from 146 randomly selected dogs (135 owned dogs and 11 free roaming/stray dogs). The private owned dogs were mainly of local breeds with only occasional dogs of cross breeds. For this, dogs of all age groups (puppy, young and adult), all breeds (local, cross and exotic) and both sexes (female and male) that were found in the study area and were from different management system (confined, semi-confined and stray) were included. Most of the dogs were regarded as house keeper dogs and very little care was given to them, and was almost invariably in a poor nutritional status as per the owner's information.

Coproscopy and parasite eggs per gram (EPG) determination

The faecal samples were collected directly from the rectum of the dogs and from top layers of fresh voided faeces and examined macroscopically for proglottids. Thereafter, a sub-sample of faeces was taken into labelled universal bottle containing 10% formaldehyde solution and transported to Mekelle University Veterinary Pathology and Parasitology laboratory where they were analyzed for helminthes ova. Where immediate examination of faecal samples was not possible, the collected samples were preserved in 10% formalin. During collection each sample was labelled with the dog's number corresponding to owner's name, date, age of dog, breed, sex, and place of collection. Faecal samples were examined at the day of collection according to the procedure described in standard veterinary diagnostic manual (Bayou, 2005) and standard McMaster egg counting technique using Sheather's sugar solution as a flotation fluid and egg identification was performed according to Euzebey (1981) and for each faecal sample, a 3 gram weighed faecal sample was mixed with 42 ml Sheather solution having specific gravity of 1.27. From this suspension, 0.15ml was taken and mixed with 0.15ml Sheather's solution and kept in a counting chamber. Eggs float were collected under the chamber cover, the egg collected and viewed, represent the egg in 0.01 gram of the faecal sample. The quantity of eggs was multiplied by 100 to determine eggs per 1 gram of faeces. In addition to qualitative diagnosis, an indirect measure of helminthes intensity was obtained by counting eggs, expressed as eggs/gram.

Statistical analysis

Statistical tests were performed using SPSS 15.0 windows version

Table 1. Prevalence of the different parasite species in relation to the age groups of dogs.

Parasite Spp.	Age (year) wise prevalence (%)				p-value
	≤1	1-6	≥6	Total	
<i>Taenia spp.</i>	9 (25)	39 (28)	12 (29.3)	60 (27.77)	>0.05
<i>T. canis</i>	6 (16.7)	19 (13.7)	9 (21.9)	34 (15.74)	>0.05
<i>T. leonina</i>	3 (8.3)	6 (4.3)	4 (9.7)	13 (6)	>0.05
<i>D. caninum</i>	9 (25)	38 (27.3)	8 (19.5)	55 (25.46)	>0.05
<i>Ancylostomaspp.</i>	5 (13.9)	25 (17.9)	5 (12.2)	35 (16.2)	>0.05
<i>S. lupi</i>	0 (0)	1 (0.7)	0 (0)	1 (0.46)	>0.05
<i>M. lineatus</i>	2 (5.6)	2 (1.4)	1 (2.4)	5 (2.3)	>0.05
<i>Echinococcuspp.</i>	2 (5.6)	7 (5)	2 (4.9)	11 (5.1)	>0.05
<i>T. serrata</i>	0 (0)	2 (1.4)	0 (0)	2 (0.93)	>0.05

(SPSS Inc, Chicago, Illinois, USA). Chi-squared test was used to look the relationship between parasite prevalence with the host age, sex, breed and season of sample collection and significant correlations were declared by p-value. For each sample, calculation was done for the percentage of infected dogs. The prevalence of dogs parasitized, number of hosts infected with one or more individuals of a particular parasite species divided by the number of examined hosts, (Bush et al., 1997) were analysed using descriptive statistics.

RESULTS

Gastrointestinal parasites of dogs by coprological examination of owned dogs

From the total examined dog faecal samples (146), 107 (73.3%) were observed to be positive for at least one of the gastrointestinal parasite. Nine gastrointestinal parasite species, viz. *Taeniaspp.*, *T. canis*, *T. leonina*, *D. caninum*, *Ancylostomaspp.*, *S. lupi*, *M. lineatus*, *Echinococcuspp.*, and *T. serrata*, were identified from the sampled dogs of the study area. From all gastrointestinal parasites, the most commonly dominant parasites were *Taeniaspp.* (41.1%) followed by *D. caninum*, (37.7%), *Ancylostomaspp.* (24%), and *T. canis* (23.3%) where as the prevalence of *T. leonina*, *S. lupi*, *M. lineatus*, *Echinococcuspp.*, and *T. serrata* were less than 10%. But the lowest parasite prevalence was recorded for *S. lupi* (0.68%).

There was no significant difference observed among the different age groups of the examined dogs. However, the age based highest parasite prevalence was found for *Taeniaspp.* (29.3%) in dogs having an age of greater than 6 years and the lowest prevalence (0%) was recorded for both *T. serrata* and *S. lupi* in dogs with age of less than 1 year and greater than 6 year (Table 1). There was no significant difference seen among the different sexes of the examined dogs. But the sex wise highest parasite prevalence was found for *D. caninum* (32.1%) and the lowest prevalence (0%) was recorded for both *T. leonina* and *S. lupi* both in female dogs (Table 2). Similar to the age and sex, breed had no significant influence on the prevalence of the parasites in both

examined local and cross breeds. Nevertheless, the breed wise highest prevalence among the different parasites was seen for *D. caninum* (53.3%) and the lowest prevalence (0%) was recorded for *M. lineatus*, *Echinococcuspp.*, and *S. lupi* both in cross breed dogs (Table 3).

The season of faecal sample collection had not also significant influence on the parasite prevalence of the examined dogs. Yet the season based highest prevalence of the parasite was observed for *Taenia spp.* (29.5%) in the January collected samples but the lowest prevalence (0%) was recorded for those samples which were collected in January and March for *S. lupi*, in March for *M. lineatus* and in January for *T. serrata* (Table 4). The highest EPG burden was seen for *Taenia spp.* with a mean value of 524.39±18894.79 followed by *D. caninum* (124.39±268.07) even though no significant difference had been observed for this when the sex of dogs was taken as a variable. But there was a significance variation among the sexes for *T. serrata*. Similarly, when age was taken as a variable for the EPG burden of parasites, the highest was also found to be *Taeniaspp.* (1495.83±4043.94) followed by *D. caninum* (169.96±371.04) but no significance difference was seen. The lowest parasite mean EPG burden was observed for *S. lupi* (2.44±27.05) and *T. serrata* (0.81±9.02) (Table 5).

The breed based highest EPG burden was seen for *Taenia spp.* with a mean value of 516.79±1837.81 in the local breed of dogs and *D. caninum* (220.00±318.92) from the cross breeds. Similarly, when season of sample collection was taken as a variable for the EPG burden of parasites, the highest was found for *Taeniaspp.* (701.75±2718.75) followed by *D. caninum* (133.33±332.38). The lowest parasite mean EPG burden was recorded for *T. leonina*, *M. lineatus*, *Echinococcuspp.* and *T. serrata*, 0.00±0.00, in the cross breed dogs; and *S. lupi* and *T. serrata* (0.00±0.00) and *M. lineatus* (0.00±0.00) in the samples that were collected during January and March, respectively. But both the considered variables had no significance for the parasite mean EPG burden (Table 6).

Table 2. Prevalence of the different parasite species in relation to the sex of dogs.

Parasite Spp.	Sex Based Prevalence (%)			
	Female	Male	Total	p-value
<i>Taenia spp.</i>	8 (28.6)	52 (27.7)	60 (27.77)	>0.05
<i>T. canis</i>	3 (10.7)	31 (16.5)	34 (15.74)	>0.05
<i>T. leonina</i>	0 (0)	13 (7)	13 (6)	>0.05
<i>D. caninum</i>	9 (32.1)	46 (24.5)	55 (25.46)	>0.05
<i>Ancylostomaspp.</i>	5 (17.9)	30 (16)	35 (16.2)	>0.05
<i>S. lupi</i>	0 (0)	1 (0.5)	1 (0.46)	>0.05
<i>M. lineatus</i>	1 (3.6)	4 (2.1)	5 (2.3)	>0.05
<i>Echinococcuspp.</i>	1 (3.6)	10 (5.3)	11(5.1)	>0.05
<i>T. serrata</i>	1 (3.6)	1(0.5)	2 (0.93)	>0.05

Table 3. Prevalence of the different parasite species in relation to the breed of dogs.

Parasite Spp.	Breed Based Prevalence (%)			
	Local	Cross	Total	p-value
<i>Taenia spp.</i>	57 (28.36)	3 (20)	60 (27.77)	>0.05
<i>T. canis</i>	33 (16.4)	1 (6.67)	34 (15.74)	>0.05
<i>T. leonina</i>	13 (6.47)	0 (0)	13 (6)	>0.05
<i>D. caninum</i>	47 (23.4)	8 (53.3)	55 (25.46)	>0.05
<i>Ancylostomaspp.</i>	32 (16)	3 (20)	35 (16.2)	>0.05
<i>S. lupi</i>	1 (0.5)	0 (0)	1 (0.46)	>0.05
<i>M. lineatus</i>	5 (2.5)	0 (0)	5 (2.3)	>0.05
<i>Echinococcuspp.</i>	11 (5.5)	0 (0)	11 (5.1)	>0.05
<i>T. serrata</i>	2 (1)	0 (0)	2 (0.93)	>0.05

Table 4. Prevalence of the different parasite species in relation to seasonal variation.

Parasite Spp.	Season based prevalence (%)				p-value
	January	February	March	Total	
<i>Taenia spp.</i>	13 (29.5)	27 (26.2)	20 (28.9)	60 (27.77)	>0.05
<i>T. canis</i>	3 (6.8)	18 (17.5)	13 (18.8)	34 (15.74)	>0.05
<i>T. leonina</i>	3 (6.8)	7 (6.8)	3 (4.3)	13 (6)	>0.05
<i>D. caninum</i>	11(25)	27(26.2)	17 (24.6)	55(25.46)	>0.05
<i>Ancylostomaspp.</i>	8 (18.2)	16 (15.5)	11(15.9)	35 (16.2)	>0.05
<i>S. lupi</i>	0 (0)	1 (1)	0 (0)	1 (0.46)	>0.05
<i>M. lineatus</i>	3 (6.8)	2 (1.9)	0 (0)	5 (2.3)	>0.05
<i>Echinococcuspp.</i>	3 (6.8)	4 (3.9)	4 (5.8)	11(5.1)	>0.05
<i>T. serrata</i>	0 (0)	1(1)	1(1.4)	2 (0.93)	>0.05

DISCUSSION

The present coprological study revealed that 73.3% of

the examined dogs were observed to be positive for at least one of the gastrointestinal parasite. Nine gastrointestinal parasite species, viz. *Taeniaspp.*, *T.*

Table 5. Mean EPG and standard deviation burden of parasites based on sex and age.

Parasites	Mean EPG burden of parasites					P-value
	Sex*		Age(years)			
	Female	Male	≤1	1-6	≥6	
<i>Taenia spp.</i>	186.96±291.242	524.39±18894.79	171.43±257.18	290.10±585.06	1495.83±4043.94	P >0.05
<i>T. canis</i>	47.83±141.00	90.24±402.74	228.57±911.67	41.58±103.21	133.33±286.91	P >0.05
<i>T. leonina</i>	0.00±0.00	17.89±55.86	19.05±51.16	10.89±46.69	29.17±69.02	P >0.05
<i>D. caninum</i>	169.96±371.04	124.39±268.07	8.95±107.79	148.51±327.29	104.17±185.25	P >0.05
<i>Ancylostomaspp.</i>	108.70±279.20	63.41±167.56	142.76±368.20	63.37±149.48	37.50±76.97	P >0.05
<i>S. lupi</i>	8.70±4.70	2.44±27.05	0.00±0.00	4.95±35.71	0.00±0.00	P >0.05
<i>M. lineatus</i>	4.35±2.85	4.07±23.60	14.29±47.81	1.98±14.00	4.17±20.41	P >0.05
<i>Echinococcuspp.</i>	4.35±20.85	15.45±57.30	23.81±76.84	11.88±49.57	12.50±44.84	P >0.05
<i>T. serrata</i>	13.04±62.60	0.81±9.02	0.00±0.00	3.96±31.37	0.00±0.00	P>0.05, P* <0.05

P* = Significant difference among the two sexes in the EPG value of *T. serrata*.

Table 6. Breed and season based mean EPG and standard deviation burden of parasites.

Parasite	Mean EPG Burden of Parasites					P-value
	Breed		Season			
	Local	Cross	January	February	March	
<i>Taenia spp.</i>	516.79±1837.81	73.33±157.96	430.77±628.50	279.37±455.84	701.75±2718.75	P >0.05
<i>T. canis</i>	90.04±393.30	20.00±77.46	23.08±71.04	447.62±557.31	40.35±76.31	P >0.05
<i>T. leonina</i>	16.79±54.28	0.00±0.00	26.92±77.76	15.87±48.21	8.77±39.10	P >0.05
<i>D. caninum</i>	121.37±281.20	220.00±318.92	126.92±223.71	131.75±266.29	133.33±332.38	P >0.05
<i>Ancylostomaspp.</i>	63.36±164.64	133.33±333.09	84.62±154.12	55.56±137.69	80.70±244.54	P >0.05
<i>S. lupi</i>	2.29±26.21	13.33±51.64	0.00±0.00	4.76±37.80	3.51±26.50	P >0.05
<i>M. lineatus</i>	4.58±24.38	0.00±0.00	11.54±32.58	4.76±27.99	0.00±0.00	P >0.05
<i>Echinococcuspp.</i>	15.27±56.12	0.00±0.00	19.23±63.37	11.11±47.89	14.04±54.90	P <0.05
<i>T. serrata</i>	3.05±27.56	0.00±0.00	0.00±0.00	4.76±37.8	1.75±15.24	P >0.05

canis, *T. leonina*, *D. caninum*, *Ancylostomaspp.*, *S. lupi*, *M. lineatus*, *Echinococcuspp.*, and *T. serrata*, were identified from the sampled dogs of the study area. This overall prevalence of gastrointestinal parasite is in accordance with the previous studies done by Zelalem and Mekonnen (2012) in Bahir Dar Town, Ethiopia (78.1%), Alimohammad et al. (2011) in Ilam province of Iran (78.57%), Martinez-Moreno et al. (2007) in Cordoba, Spain (71%), and Minnaar et al. 2002 in free State Province, South Africa (76%). But it is lower than the findings of Octavius et al. (2011) in Wondo Genet, Southern Ethiopia (90.7%), Berhanu et al. (2013) in Hawassa, Southern Ethiopia (89.3%), Lavallen et al. (2011) in Argentina (89.13%), Dagmawi et al. (2012) in Hawassa Town, Ethiopia (86.8%), Umar (2009) in Kaduna State, Nigeria (93.8%), Dejene et al. (2013) in Hawassa City, Ethiopia (84.6%), Pandey et al. (1987) in the Rabat region, Morocco (100%), Mukaratirwa and Singh (2010) in Durban and Coast, South Africa (82.5%), Tarish et al. (1986) in the Baghdad area, Iraq (100%), Noor-Ul-Huda et al. (2014) in Karachi, Sindh (86.0%),

Abere et al. (2013) in Bahir Dar town, North-western Ethiopia (84.78%), Davoust et al. (2008) in North-east Gabon (94.1%), Shubhagata et al. (2012) in Chittagong Metropolitan, Bangladesh (95%), and Komatangi et al. (2005) in Dschang, Cameroon (88.5%). However, it is higher than the findings of the studies carried out by Endrias et al. (2010) in Ambo town, Central Ethiopia (52.86%), Muhammad et al. (2014) in Lahore, Pakistan (37%), Gebretsadik et al. (2014) in Mekelle City, Ethiopia (33.0%), Guesh et al. (2014) in Mekelle City, Ethiopia (30.5%), Teresa et al. (2014) in Ponte de Lima, Portugal (63.17), Swai et al. (2010) in and around Arusha Municipality, Tanzania (59.3%), Yacob et al. (2007) in DebreZeit, Ethiopia (51%), Katagiri and Oliveria-sequeira (2008) Saõ Paulo State, Brazil (54.3%), Panigrahi et al. (2014) in Bhubaneswar, Odisha, India (41.56%), Khante et al. (2009) in Nagpur City (66.2%), Eleni et al. (2011) in Gondar, Ethiopia (14.7%), Andresiuk et al. (2007) in Mar del Plata city, Argentina (41.25%), and Agnieszka et al. (2010) in Western Pomerania, Poland (34.84%). The possible reasons for the wide range of differences among

the gastrointestinal parasites' prevalence might be the factors like geographical location, the presence or absence of the intermediate hosts of the corresponding parasites, status of animal ownership, sampling protocols, demographic factors, anthelmintic usage, and diagnostic techniques which were also given as the possible justifications by Mundim et al. (2007) and Katagiri and oliveira-Sequeira (2008).

From all gastrointestinal parasites, the most commonly dominant parasites were *Taeniaspp.* (41.1%) followed by *D. caninum*, (37.7%), *Ancylostomaspp.* (24%), and *T. canis* (23.3%), where as the prevalence of *T. leonina*, *S. lupi*, *M. lineatus*, *Echinococcuspp.*, and *T. serrata* were less than 10%. This in agreement with the previous studies done by Dagmawi et al. (2012) who reported a prevalence of 39.9, 49.9, 25.1 and 8.4% for *D. caninum*, *Ancylostomaspp.*, *T. canis* and *Echinococcuspp.*, respectively; Ugochukwu and Ejimadu (1985), Haralabidis et al. (1988), Vanparijs et al. (1991), Totkova et al. (2006), Panigrahi et al. (2014), and Berhanu et al. (2013), reported prevalence of 24.3, 24.6, 25.4, 25.8, 20.31, and 23.3% for *T. canis*, respectively; Teresa et al. (2014), Eleni et al. (2011), Schuster et al. (2009), Lefkaditis et al. (2009), and Barutzki and Schaper (2003), reported a prevalence of 0.68, 2.76, 0.8, 1.3, and 1.8%, respectively, for *T. Leonina*; and Khante et al. (2009), reported a prevalence of 25.10% for *Ancylostomaspp.* The age based highest parasite prevalence was found for *Taeniaspp.* (29.3%) in dogs greater than 6 years of age, and the lowest prevalence (0%) was recorded for both *T. serrata* and *S. lupi* in dogs less than 1 year and greater than 6 years. But there was no significant difference observed among the different age groups of the examined dogs. This finding is in agreement with the previous study done by Eleni et al. (2011) in Gondar, Ethiopia, and Khante et al. (2009) in Nagpur, but contradicts with the previous studies done by Gebretsadik et al. (2014) in Mekelle City, Ethiopia, Dagmawi et al. (2012) in Hawassa Town, Ethiopia, Daryani et al. (2009) in Mazanderan, Iran, and Yacob et al. (2007) in DebreZeit, Ethiopia.

The sex wise highest parasite prevalence was found for *D. caninum* (32.1%) in female dogs and the lowest prevalence (0%) was recorded for both *T. leonina* and *S. lupi* in the same sex. However, there was no significant difference seen among the different sexes of the targeted animals. This is in comparable with the previous studies done by Gebretsadik et al. (2014) in Mekelle City, Ethiopia, Dejene et al. (2013) in Hawassa City, Ethiopia, Dagmawi et al. (2012) in Hawassa Town, Ethiopia, Eleni et al. (2011) in Gondar, Ethiopia, and Swai et al. (2010) in and around Arusha Municipality, Tanzania, but contradicts the report of Endrias et al. (2010) in Ambo town, Central Ethiopia. Similar to the age and sex of the examined dogs, breed had no significant influence on the prevalence of the parasites in both examined local and cross breeds. This is in agreement with the previous

studies done by Dejene et al. (2013) in Hawassa City, Ethiopia, Eleni et al. (2011) in Gondar, Ethiopia, Zelalem and Mekonnen (2012) in Bahir Dar town, Ethiopia and Swai et al. (2010) in and around Arusha Municipality, Tanzania. Nevertheless, the breed wise highest prevalence among the different parasites was seen for *D. caninum* (53.3%) in cross breed dogs but the lowest prevalence (0%) was also recorded in cross breeds for *M. lineatus*, *Echinococcuspp.* and *S. lupi*. In addition, season of faecal sample collection had not also significant influence on the parasite prevalence of the examined dogs. Yet the season based highest prevalence of the parasite was observed for *Taenia spp.* (29.5%) in the January collected samples but the lowest prevalence (0%) was recorded for the samples which were collected in January and March for *S. lupi*, in March for *M. lineatus* and in January for *T. serrata*.

The highest EPG burden was seen for *Taenia spp.* with a mean value of 524.39±18894.79 followed by *D. caninum* (124.39±268.07) even though no significant difference had been observed for this, the sex of dogs was taken as a variable. But there was a significance variation among the sexes for *T. serrata*. Similarly, when age was taken as a variable for the EPG burden of parasites, the highest was also found to be *Taeniaspp.* (1495.83±4043.94) followed by *D. caninum* (169.96±371.04) but no significance difference was seen. The lowest parasite mean EPG burden was observed for *S. lupi* (2.44±27.05) and *T. serrata* (0.81±9.02).

The breed concerned highest EPG burden was seen for *Taenia spp.* with a mean value of 516.79±1837.81 in the local breed of dogs and *D. caninum* (220.00±318.92) from the cross breeds. Similarly, when season of sample collection was taken as a variable for the EPG burden of parasites, the highest was found for *Taeniaspp.* (701.75±2718.75) followed by *D. caninum* (133.33±332.38). The lowest parasite mean EPG burden was recorded for *T. leonina*, *M. lineatus*, *Echinococcuspp.*, and *T. serrata*, 0.00±0.00, in the cross breed dogs; and *S. lupi* and *T. serrata* (0.00±0.00) and *M. lineatus* (0.00±0.00) in the samples that were collected during January and March, respectively. But both the considered variables had no significance for the parasite mean EPG burden. The highest EPG value of these helminthes indicated that there were larger numbers of adult parasites within the gastrointestinal tract of the animal (Hoskins et al., 1982). Generally, from the result, cestodal infections were higher than the nematodal infection. This might be related to the culture of the society/owners to feed their pets with raw meat and the offals thrown carelessly anywhere if they were found unsuitable to be consumed.

Conclusion

The present study revealed that a high prevalence of

gastrointestinal parasites of dogs in Mekelle city which suggested the lack of appropriate handling and health management of the dogs. None of the three variables (age, sex, and breed of the dogs) had shown significance differences in the degree of infestation with the helminthes parasites. Concurrent infections with two or more parasite species were more common. Of these reported parasites some of them have public health importance but dogs harbouring the parasites are living freely and friendly with the public and serve as a source of infection to human beings. Thus, there should be a practice of regular deworming and management of dogs in the study area, destruction of intermediate hosts/vectors, and relevant agencies should embark on mass enlightenment of dog keepers on the role of dogs in disease transmission. In addition, further epidemiological studies should be conducted to investigate the rate of seasonal infection and the level of environmental contamination.

Ethical approval

All the dogs were handled according to the ethical principles for animal experiments of the international council for animal protection during faecal samples collection and examination.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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