PREVALENCE OF GASTROINTESTINAL PARASITES OF BARN SWALLOW (*Hirundo* sp. Linnaeus 1758) IN THE TANSEN, PALPA, NEPAL.

Dolma Resmi
T.U. Registration No.: 5-2-49-144-2013
T.U. Examination Roll. No.: Zoo565/077
Batch: 2018

A thesis submitted in partial fulfillment of
the requirements for the award of the degree of Master of
Science in Zoology with special paper Parasitology

Submitted to

Central Department of Zoology
Institute of Science and Technology
Tribhuvan University
Kirtipur, Kathmandu
Nepal

April, 2021

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

Date. 12th April 2021

........Dolma......

Dolma Resmi

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
Kirtipur, Kathmandu, Nepal.
०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No :-

RECOMMENDATIONS

This is to recommend that mid progress entitled "**Prevalence of gastrointestinal parasites of Barn swallow (*Hirundo* sp. Linnaeus 1758) in the Tansen, Palpa, Nepal**" has been carried out by Miss Dolma for the partial fulfilment of Master's Degree of Science in Zoology with special paper Parasitology. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

Date. 12th April 2021

....

Supervisor

Janak Raj Subedi

Asst. Prof.

Central Department of Zoology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल।
Kirtipur, Kathmandu, Nepal
०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

LETTER OF APPROVAL

On the recommendation of supervisor "Janak Raj Subedi" this thesis submitted by Dolma Resmi entitled "**Prevalence of gastrointestinal parasites of Barn swallow (*Hirundo* sp., Linnaeus 1758) in the Tansen, Palpa, Nepal**" is approved for the examination in partial fulfilment of the requirements for Master's Degree of Science in Zoology with special paper Parasitology.

Date.12th April 2021

....

Prof. Dr. Tej Bahadur Thapa

Head of Department

Central Department of Zoology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
Kirtipur, Kathmandu, Nepal.

०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

Central Department of Zoology T.U., Kirtipur

CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Dolma Resmi entitled "**Prevalence of gastrointestinal parasites of Barn swallow (*Hirundo* sp., Linnaeus 1758) in the Tansen, Palpa**" has been accepted as a partial fulfilment for the requirements of Master's Degree of Science in Zoology with special paper Parasitology.

EVALUATION COMMITTEE

....	....
Supervisor	Head of Department
Janak Raj Subedi	Dr. Tej Bahadur Thapa
Asst. Prof.	Prof.
....	....
External examiner	Internal examiner

Date of Examination: 5th July 2021.
21st Ashad 2078

ACKNOWLEDGEMENTS

I am indebted and express my sincere of gratitude to my supervisor Mr. Janak Raj Subedi, Asst. Prof. Central Department of Zoology, Tribhuvan University, Kirtipur for his constant encouragement, invaluable suggestions and painstaking guidance for the completion of this work. I really feel proud of expressing my gratitude to Prof. Dr. Tej Bahadur Thapa, Head of Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu for providing opportunity. I express my gratitude to Lab officer Mrs. Kamala Mishra, Office Assistant Mr. Basanta Kumar Khanal and Technical Assistant Mr. Ganesh Lama for providing me laboratory facilities.

I would like to thanks each and every house holder from where the sample were collected. I would like to thanks Tribhuvan Multiple Campus Tansen, Palpa who helped us by providing lab facilities during lockdown. I would like to thanks Amrita Saru and Shanta Bashyal for helping me in my field and Lab work. I am really thankful to my parents for their constant guidance and encouragement during my study period.

Dolma Resmi

TU. Registration No.: 5-2-49-144-2013

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF ABBREVIATIONS

AOU	American Ornithologists' Union
mph	Miles Per Hour
EPG	egg per gram
F.	Fahrenheit
mm	millimeter
rpm	revolutions per minute
um	micrometer
CI	confidence interval
GI	Gastrointestinal parasites

ABSTRACT

The barn swallow (*Hirundo* sp.) belongs to the Hirundinidae family and is the most widespread species of swallows in the world. The barn swallows are migratory birds found on all continents of the world except Antarctica. The present study was conducted for the prevalence of gastrointestinal parasites of barn swallow in Tansen, Palpa. Total 120 fecal samples were collected by random sampling method from March 5 to May 25, 2019. The qualitative examination of fecal samples was done by direct microscopic examination, floatation technique and sedimentation technique whereas Microsoft Excel 2016 was used for data analysis. Out of 120 fecal samples examined, 105 fecal samples were positive with 87.5% prevalence of parasitic infection. Total six gastrointestinal parasites were encountered including one protozoan: *Isopora* sp. (35.23%) and five genera of helminths: *Ascaridia* sp. (48.57%), *Echinostoma* sp. (35.23%), *Heterakis* sp. (19.05%), Strongyle sp. (11.43%) and *Trichostrongylus* sp. (9.52%). The prevalence rate of helminths (93.33%) was higher than protozoan parasites (35.24%). The higher prevalence of GI parasites was in Bus park and Batase dada (95%). Statistically, the difference in prevalence of intestinal parasitic infection among study area was found to be insignificant (χ^2=0.662, $P>0.05$) whereas the difference in prevalence of single infection (50.47%), double (37.14) and triple infections (13.33%) were significant (χ^2 =23.547), $P<0.05$). The intensity of heavy of *Ascaridia* sp. was seen in only one sample, moderate infection of *Ascaridia* sp. and Ehinostoma sp. was seen in six and seven samples respectively. The study indicated that barn swallows of Tansen, Palpa were highly susceptible to gastrointestinal parasites due to improper management of waste products and improper handle of fecal sample of certain domestic animal. In order to minimize the GI infestation in barn swallow, first intermediate host should be identified and should be controlled by using different pesticides.

INTRODUCTION

1.1 Background

The barn swallow (*Hirundo* sp.) belongs to the Hirundinidae family and is the most widespread species of swallows in the world (Turner and Rose 1989, Korczak et al. 2011). There are around 83 species and 19 genera (AOU 1998, Turner 2004, Zink et al. 2006). The Barn Swallows are migratory birds found on all continents of the world except Antarctica. There are six subspecies of *H. rustica* namely *H. r. rustica, H. r. savignii, H. r. transitive, H. r. gutturalis, H. r. tytleri and H. r. erythrogaster*, which breed across the Northern Hemisphere. Out of these, 4 species are strongly migratory birds (Terres 1980, Moller 1994a, 1994b, , Del Hoyo and Elliott 2014). The adult male barn swallow is 17-19 cm long including 2-7 cm of elongated outer tail feathers. It has steel blue upperparts and a rufous forehead, chin and throat, these are separated from the off-white underparts by a broad dark blue breast band. The tail is deeply forked. There is a line of white spots on the end part of the upper tail (Snow and Perrins 1998). The female is similar to the male, but they are differentiated by the tail streamers, the blue of the upperparts and breast band and the underparts paler (Turner and Rose 1989). Swallows are usually found in human settlements area and most of them return to their nests each year and they may prefer to choose the same nest (Moller 2001). The bird is often found on farms, fields and marshes, but they use man-made settlements for reproduction. They make cup-shaped nests for which they use mud pellets on beams inside barns and feed mostly on insects captured on the wing (Msallister and Hnida 2019). Swallows eat insects in large numbers so it is used to control insects (Barker et al. 1994, Wolfe 1994, Brown and Brown 1999). The most suitable place for barn swallow is open country with low vegetation, such as pasture, meadows and farmland, preferably with nearby water (McWilliams 2000). They make nest below 3000 meters elevation (Snow and Perrins 1998). The average lifespan of barn swallows is 4 years. Survival prospects and longevity appear to increase with tail length and wing and tail symmetry (Terres 1980). The main source of food of barn swallows are flies, grasshoppers, crickets, dragonflies, beetles, moths and others flying insect. It is not a particularly fast flier (Park et al. 2001, Liechti and Bruderer 2002). Mainly animals, humans or farm machinery to catch disturbed insects, but it will opportunistically pick prey items from the water surface, walls and plants (Turner 2010).

Some humans feel that barn swallow nests are a nuisance, and are unsightly when they are attached to buildings and other man-made structures but they tolerate them because they feed on flying insects. (Brown and Brown 1999). Barn swallows eat an enormous number of insects. Therefore, it plays an important role in reducing insect pest populations. Barn swallows are also a useful food source for many predators (Barker et al. 1994, Wolfe 1994). It also acts as an indicator and it indicates possible environmental trouble, as declines in their relatively abundant numbers may precede other more obvious effects of environmental stress (Moore 2001).

1.1.1 Parasitic infections of barn swallows

Barn swallows are migratory birds therefore, it is important carriers and reservoirs for a variety of pathogens, with a great potential of their spreading, including pathogens with zoonotic risk or vector-borne pathogens (Hahn et al. 2009, Alexandra et al. 2016). During migration barn swallows can circulations of different pathogens, including parasites (Fuller et al. 2012). Different species of intestinal parasites such as, protozoan, nematodes, cestodes can cause clinical diseases and mortality in wild birds (Rossi et al. 1977, Schoenaer et al. 2012). Some parasite can change host population dynamics and modify coevolution relationships between hosts and their parasites (Best et al. 2010). Many cattle Common zoonotic parasitic diseases are one of the major health, economic, and social problems in many developing countries. The transition of these diseases to humans is an important issue in terms of health and veterinary medicine (Hedayati 2011). Transmission of zoonotic disease mainly influenced by many factors, such as time of infection, latent period, stability of the agent when exposed to the environment, population density, animal handling, virulence, and route of infection (Corrêa and Corrêa 1992, Freitas et al. 2002). Barn swallows can transmit a variety of potential pathogens to pets and humans including *Cryptosporidium, Capillaria, Heterakis gallinarum, Syngamus,* and *Cryptococcus* (Cafarchia et al. 2006, Park and Shin 2010, Qi et al. 2011, Narayan et al. 2014). Migration is not the only cause of parasitic infection in birds but type of diet, and insectivorous and omnivorous passerines birds were more dangerous to be infested with a variety of parasite during their feeding (Bandelj et al. 2015).

External and internal parasites in birds are common where the standard of husbandry is poor as well as where climatic conditions are favorable for their increase (Abebe et al. 1997, Freitas et al. 2002, Imura et al. 2012). If the birds are affected by parasites often seen various symptoms like malnutrition, retarded growth, low egg production, susceptibility to other infections and death in young birds are seen, if the parasites effects (Radfar et al. 2012). Mainly parasites like cestodes, nematodes and coccidian are generally observed in barn swallows. (Correa and Correa 1983). Fecal sample of barn swallows mainly consist of parasites like *Ascaridia galli, Syngamus trachea, Raillietina, Toxocara* sp., *Choanotaenia, Taenia* sp., *Ascaridia* sp., and *Moniezia* sp. and Coccidia oocysts sp. (Fakhar et al. 2018). Parasites infect different parts of birds among parasitic infections of the birds, *Choanotaenia* sp. infects the posterior part of the small intestine of birds and *Raillietina* sp. can involve the posterior part of the small intestine of the birds (Eslami et al. 2009, Mamashly et al. 2010).

1.2 Objectives

1.2.1 General objective

- To determine the prevalence of gastrointestinal parasites of barn swallow (*Hirundo* sp.)

1.2.2 Specific objectives

- To identify the gastrointestinal parasites of barn swallow.
- To determine the intensity of gastrointestinal parasites of barn swallows.

1.3 Significance

Barn swallows are migratory birds which can migrates up to wide range. During this period, it become carrier of various zoonotic diseases (Fakhar et al. 2018). Generally, their nesting sites are present in residential area so that people are directly or indirectly exposing to their fecal sample. Research related to GI of barn swallow has not be carried out in Tansen, Palpa till today. Research concern with this topic is very rare in Nepal as well as in world wide. Therefore, study about GI of barn swallow is very important. With the help of this study various parasites present in the fecal sample of barn swallows are identified. With the knowledge of these parasites people know the effect of these parasites as a result people will handle fecal materials of barn swallows wisely. And this work recommends the further researcher to study about the effect of parasites in various system like reproductive system, immunity system etc. of swallows. With the help of this study, we may generate some ideas to conserve the swallow's population.

LITERATURE REVIEW

Migratory and non-migratory passerine birds can carry several pathogens, including parasites, which may cause significant diseases in birds, other animal species and humans. In the world, the barn swallow (*Hirundo* sp.) is the most widespread species of swallow. Swallows are closely related to people's lives in both urban and rural residential houses (Moller 2001). Unlike free-range scavenging birds which are in direct contact with parasite vectors, soil and faces, on the other hand lack of hygiene, direct contact with humans, captivity conditions and the physical environment (rainfall, humidity and ambient temperature) provides optimum conditions to maintain parasites populations (Alves et al. 2008). In case of barn swallows, a very little research work has been carried out regarding parasitic infection here, some of the important literature, relevant with the present work has been reviewed.

In global context:

57 *Hirundo rubicola savignii* swallows were collected from Damiette, Tanta, Dakahlyia and Sharkia provinces, Egypt. Fecal samples were taken from different parts of intestine to examine the coccidian parasites. From microscopic examination 12.3% *Isopora* was found (Abd-Al-Aal et al. 2000). The prevalence of ectoparasites and endoparasites was studied in 58 free-living pigeons (*Columba livia*) in urban areas of Lages, in the state of Santa Catarina, Brazil. Fecal samples were analyzed using sheather's method. The prevalence of gastrointestinal parasite was found 74.14%. Protozoa (100% for *Eimeria* sp.) were detected in 86.05% of the cases and nematodes (*Ascaridia* sp. and *Capillaria* sp.) in 32.56% (Marques et al. 2007). 251 fecal sample of pigeons (136 domestic pigeons and 115 wild ones) were taken for parasitic examination in Turkey. The samples were examined through the centrifugal flotation method using sheather's saturated sugar solution. All the samples were examined for *Cryptosporidium* oocysts by using a modified acid-fast staining method. Coccidia oocysts were detected in 81 (59.6%) domestic pigeons. Coccidian species: *Eimeria labbeana* (58.1%); *E. columbarum* (30.9%); *E. columbae* (22.1%); and *Isospora* sp. (18.4%) were identified in domestic pigeons. Helminth eggs were found in fecal of 32 (23.5%) domestic pigeons and in five (4.3%) wild pigeons. Helminth species like *Capillaria* sp. (19.9%) *Ascaridia columbae* (5.1%), and *Heterakis* sp. (3.7%) in domestic pigeons. *Cryptosporidium* oocysts were not observed in the fecal samples of both domestic and wild pigeons. (Sari

et al. 2008). 240 pigeons were humanely killed, dissected and necropsied in Zaria area, Nigeria. Among which 116(48.3%) were infected by nine species of helminths, comprising six species of cestodes and three species of nematodes. *Hymenolepis carioca* (27.1%), *Raillietina tetragona* (27.1%), *R. echinobothrida* (10.6), *Hymenolepis contanina* (1.7%), *R. cesticillus* (0.45%), *Amoebotaenia cuneata* (0.83%), *Ascaridia columbae* (11.3%), *A. galli* (3.3%) and *Heterakis gallinarum* (3.3%) were recorded. The higher prevalence of cestode (*R. tetragona*) was recorded whereas single infection (37.50%) was more common than double (10%) and triple infections (0.83%) (Adang et al. 2008).

From a major slaughter slab in Zaria, Nigeria, samples were collected from 250 domesticated pigeons and screened for helminths, ectoparasites and protozoan parasites. The prevalence of protozoan parasites like *Eimeria* sp. was found. Similarly, helminth parasites like *Raillientina echninobothrida* (7.6%), *Ascaridia columbae* (1.2%), *A. galli* (1.2%) and *Capillaria anatis* (0.8%) were also recorded (Natala et al. 2009). 100 nesting of domestic pigeons were examined in Morogoro municipality, Tanzania. 159 pigeon were infected with one or more species of gastrointestinal helminths. The three sub families represented two cestodes and one nematode were found. Three species of helminths *Raillietina tetragona* (6%), *R. echinobothrida* (63%) and *Ascaridia galli* (15.5%) were identified. Nestlings appeared to be less susceptible to GI cestode but more susceptible to nematode compared with adult (Msoffe et al. 2010).

Experiment was carried out taking 250 fecal sample of pigeon from mixed companion birds keeping in the cages. It was examined by using direct smear method. And egg per gm (EPG) was counted by modified Mc Master technique and centrifugal flotation methods using sheather's saturated sugar solution. *Raillietina* sp. (24%), *Tetramers* sp. (8%), *Syangamus* sp. (9%), *Capillaria* sp. (14%), *Ascaridia colombae* (4%), and oocyst protozoa (7%), *Phthiraptera* (8%) and *Ceratophyllus columbae* (6%) parasites were examined from the sample (Bahrami et al. 2011). *Echinostoma revolutum* (25%), *Raillietina echinobothrida* (50%) and *Cotugnia cuneata* (25%) were observed by quantitative and qualitative fecal sample examination in the Parasitology Laboratory, Department of Zoology, University of Dhaka (Musa et al. 2011). Similarly, to examine the prevalence of endoparasites, 40 fecal samples of pigeon were collected from the

Kamakhya temple, India. From the fecal sample; *Raillietina* sp. (45%), *Capillaria obsignata* (40%), *Cotugnia* sp. (5%), and *Ascaridia columbae* (2.5%), *Hymenolepis* sp. (10%), *Ornithostrongylus quadridiatus* (22.5%), *Strongyloides arium* (15%) Helminth parasites and protozoan parasites; *Haemoproteus columbae* was predominant (60%), *Plasmodium relictum* (27.5%) and *Eimeria* sp. (18%) were recorded (Roy et al. 2011). Rader et al. (2011) observed fecal sample of 102 pigeon in south Khorasan, Iran by using floatation method (sheather's saturated sugar). Five species of nematode and cestode; *Ascaridia colombae* (16.66%), *Hadjelia truncata* (1.96%), *Cotugnia dignopora* (13.79%), *Raillietina magnimmida* (18.62%) and *Raillietina achinobothridia* (32.35%) and protozoan parasites, *Eimeria* sp. (40.17%), *Cryptosporidium* sp. (2.94%) and *Trichomonans gallinae* (5.784%) were founded. To find out the prevalence and assess the zoonotic transmission burden of *Crytosporidium* sp. genotypes in pet, 434 samples were taken from 14 families of birds. Stool samples were examined by the sheather's sugar flotation technique. By examined the stool sample three *Cryptosporidium* species and two genotypes were identified, including *C. baileyi* (18/35 or 51.4%) in four white Java sparrows (*Padda oryzivora*) (Qi. 2011).

Al-Barwari and Saeed (2012) found 100% parasitic infection in pigeons of Erbil Iraq when examined blood samples, ectoparasites and alimentary canal. Examination of the alimentary canal of *Columba livia* was done for protozoans and helminths parasite. They found four protozoan species, *Eimeria labbeana, Trichomonas gallinae, Haemoproteus columbae* and *Plasmodium* sp. whereas eight cestode species, four of each of the genera *Cotugnia* sp. and *Raillietina* sp. and four nematoda species, *Ascaridia columbae, A. galli, Capillaria obsignata* and *Synhimantus spiralis*. Begum and Sehrin (2012) examined the separated parts of the alimentary canal of the pigeons taken in 0.85% normal saline solution to collect helminths parasites in pigeon (*Columba livia*). They found all the birds infected by eleven species of helminths parasites. Among which, four species of trematode found were *Echinostoma revolutum* (15%), *E. trivolvus* (5%), *Patagifer bilobus* (5%), *Ehinoparyphium recurvatum* (8.33%) whereas six species of cestode found were *Hymenolepis columbae* (63.33%), *Raillietina echinobothrida* (100%), *R. bonini* (43.33%), *R. cesticillus* (100%), *Cotugnia celebesensis* (68.33%), *C. cuneata* (100%) and one species of nematode found was *Ascaridia columbae* (28.33%). In autumn season highest intensity of infection was found. Fecal samples were individually collected from pet (n = 63) and zoo (n = 83) birds. Fecal samples were examined by flotation technique. Molecular assays were also used to detect *Cryptosporidium* oocysts and *Giardia duodenalis* cysts. Overall, 35.6% of the birds harbored parasites (42.2% of zoo birds and 27% of pet birds). Strongyles-*Capillarids* (8.9%), *Ascaridia* (6.8%), Strongyles (5.5%), *G. duodenalis* (5.3%), Coccidia (4.1%), *Cryptosporidium* (4%), *Porrocaecum* (2.7%), *Porrocaecum-Capillarids* (2%), and *Syngamus-Capillarids* (0.7%) were detected (Papini et al. 2012). Radfar et al. (2012) surveyed parasites by dissection of alimentary canal of 102 domestic pigeons (*Columba livia domestica*) in a selected semiarid zone of South Khorasan, Iran. All samples were examined by using sheather's saturated sugar solution, formalin ether sedimentation and modified Ziehl-Neelsen staining technique. Through examined, they found 42.15% prevalence of helminths including two species of nematodes, *Ascaridia colombae* (16.66%) and *Hadjelia truncate* (1.96%), while 3 species of cestodes, *Cotugnia digonopora* (13.79%), *Raillietina magninumida* (18.62%) and *Raillietina achinobothridia* (32.35%). *Eimeria* sp. (40.19%) and *Cryptosporidium* oocyst (2.94%) were also recorded.

For the investigation of helminth parasites of gastrointestinal, liver and lung, 134 of domestic pigeon were taken. Overall parasites prevalence in pigeon was 23.18% with specific prevalence of *Ascaridia columbae* (13.04%), *Raillietina echinobothridia* (10.14%), *R. tetragena* (2.89%), *R. magninomida* (1.44%) and *Capillaria* sp. (0.72%). They reported the infection rate in female and male pigeon was 21(65.62%) and 11 (34.37%) respectively. And single infection was more common (18.84%) than double (3.62) and triple infections (0.72%) (Khezerpour and Naem 2013). 250 samples were collected from Kermanshah, Iran and it was analyzed by direct smear method whereas egg per gm (EPG) was counted by modified Mc-master technique and centrifugal floatation method using sheather's saturated sugar solution. Examining sample, the prevalence of *Raillietina* sp. 48(24.24%), *Tetramerus* sp. 16(8.08%), *Sygnamus* sp. 18(9.09%), *Capillaria* sp. 28(14.14%), *Ascaridia colombae* 8(4.04%), Protozoan oocyst 14(7.07%), *Phthiraptera* sp. 16(8.08%), and *Ceratophyllus columbae* 12 (6.06%) were found. And 38(19.19%) pigeon had multiple infection at that movement (Bahrami et al. 2013). GI nematodes were highly prevalent among (*Columbia livia domestica*) in Albania. The average parasitic burden was 76 eggs per gram fecal, with significant variations at the values of 48-120 eggs per gram fecal. *Capillaria* sp. was ranked as the second nematode in term of the distribution among pigeon. The burden for capillarids was 26 eggs per gram feces, with variations of 12-36. The genus found according to the prevalence and parasitic burden included *Ascaridia columbae, Capillaria* sp*., Ascaridia galli* and *Heterakis gallinarum* in a small number and in restricted values and area (Bizhga et al. 2013). 48 sparrows were taken for the study of parasitic infection in America. From that examination 41 sparrows were found infected. Overall prevalence of parasites was found to be 89. 4%. And most common parasites identified were *Braachydistomum microscelis* and *Brachydistomum gracupicae. Brachydistomum* sp. 14(29.2%), *Brachydistomum*+Coccidia 12(25%), Coccidia 9(18.8%), intestinal *infula* sp. 2(4.2%), *infula* sp. +intestinal Coccidia 2(4.2%), *Tetrameres* sp. +Microtetrameres sp. 1(2%) and *Brachydistomum* sp.+ Coccidia+ *Infula* sp. 7(14.6%) were found in the fecal sample of house sparrow (Ozlem et al. 2013).

Ghosh et al. (2014) examined 100 fecal sample of pigeon in Chittagong metropolitan area, Bangladesh using direct smear, floatation and sedimentation technique. The overall prevalence of gastrointestinal parasitic infection was 72% (single and mixed). They found six different species of parasites, among which the highest prevalence was recorded for *Ascaridia galli* (35%) followed by *Capillaria* sp. infection (22%) and *Heterakis gallinarum* (9.02%), *Eimeria* sp. (11%), *Raillietina* sp. (6%) and *Syngamus trachea* infections (2%).

A total of 451 birds including hen, turkey, Sparrow, Pigeon and decorative birds from Iran were taken for parasitic examination. From the examination of fecal sample, the prevalence of *Eimeria* (27.6%), *Trichomonas galli* (1.9%), *Histomonas* sp. (0.95%), *Cryptosporidium* sp. (19%), *Amoeba* sp. (0.95%), *Hymenolepis nana* (0.95%) and *Raillietina* sp. (0.95%) in Sparrow (n=105) and the prevalence of *Histomonas* sp. (5.4%), *Cryptosporidium* sp. (2.7%), *Ascaridia* sp. (2.7%), *Capillaria* sp. (2.7%) and *Raillietina* sp. (2.7%) in pigeon (Badparva et al. 2014). By using direct smear, Floatation and sedimentation method they found 72.70% of the birds harbored parasites including *Ascaridia columbae* (33.30%), *Eimeria* sp. (31%), *Capillaria colombae* (17.4%) and *Raillietina* sp. (9%) in YSR Kadapa district of Andhra Pradesh in India. And most of the pigeon were more likely to harbor mixed infections (31.8%) (Sivajothi and Sudhakara 2015). Out of 23, 12 birds were found positive for endoparasites in Romania. The prevalence of coccidia (*Eimeria* sp. and *Isopora* sp.) found 39.13%

(Gruianu et al. 2016). Ledwoń et al. (2016) diagnosed only two known cases of fluke invasions in racing pigeons (*Columba livia*) originating from different regions of Poland over 4 years. In both cases, the invasion was characterized by a very high mortality (approximately 70%), and the source of the infestation was snails of the Lymnaeidae family eaten by pigeons. Fluke invasions in pigeons are extremely rare. Using molecular biology techniques, infestation with the fluke *Echinostoma revolutum* was determined in the second case.

To analyze gastrointestinal parasites in the fecal sample of 185 broiler, 130 layers, 75 free range chicken, 40 house pigeon, 70 ducks and 15 turkey were taken. All the fecal sample were examined by using direct smear, floatation and simple sedimentation method. 412 (80%) were found to be infected with different species of gastrointestinal parasites like *Eimeria* sp., *Isopora* sp., *Ascaridia* sp. and *Heterakis* sp. 75% prevalence of parasitic infection was found in house pigeon (Singh and Mohilal 2017). By using same method 50 fecal sample of pigeon was studied in Bangladesh. Out of 50 samples, 3o sample found positive. The overall prevalence of gastrointestinal parasites was found (68%). Likewise, the prevalence of *Ascaridia* sp. (30%), *Capillaria* sp. (10%) and *Raillietina* sp. (28%) were revealed (Isam et al. 2017). For the identification of *Eimeria* oocyst 144 pigeon were taken with different age groups like squabs (0-4 weeks), squeakers (5-8) and youngsters (9+weeks) in Nigeria. The highest prevalence of *Eimeria* oocyst was found in squabs (27.08%) than squeakers (20.83%) and youngsters (10.42%) (Mohammed et al. 2017).

To study the intestinal parasites, one hundred adult domestic pigeons were purchased from different markets of Tripoli, Libya. Each sample were processed through direct smear method. The overall prevalence of intestinal helminths in examined pigeons were 56% (56/100). Three species of Cestode (2% *Raillietina tetragona*, 32% *R. echinobothrida* and 4% *R. cesticillus*) and three species of Nematoda (18% *Heterakis gallinarum*., 22% *Ascaridia galli* and 4% *Capillaria* sp.) were identified (Alkharigy et al. 2018). 60 birds (budgerigar; parrot, cockatoo, dove, turkey, and teeter) were collected from several places of Dhaka Municipality, Bangladesh to experiment the prevalence of parasitic infection. Overall prevalence of intestinal parasitic infection was 45% which include 21.67% prevalence of *Ascaridia galli*, 10% prevalence of *Balantidium coli*, and 13.33% prevalence of *Eimeria* sp. The prevalence of *Ascaridia* *galli* was higher (25%) followed by *Eimeria* sp. (16.67%) in parrot (Hasan et al. 2018). 205 fecal samples of barn swallows were collected from the central region of Mazandaran, Iran. Samples were examined for parasitic infections by using sedimentation method and cold acid-fast staining was used for *Cryptosporidium* sp. Out of 205 samples, 38 samples (38/205, 18.5%) were positives. From examination, *Ascaridia galli* (20/38, 52.3%), Taenia spp. (6/38, 15.8%), *Syngamus trachea* (2/38, 5.3%), *Raillietina* sp. (1/38, 2.7%), *Toxocara* sp. (5/38, 13.1%), *Choanotaenia* sp. (1/38, 2.7%), *Ascaridia* sp. (1/38. 2.7%), *Moniezia* sp. (1/38, 2.7%), and coccidia sp. (1/38, 2.7%) were identified (Fakhar et al., 2018).

In order to study, the ectoparasites and endoparasites 4000 pigeon were taken as a sample from 12 areas around Jammu, India. Fecal sample were examined by Floatation, sedimentation and direct smear method. 22 (36.67%) out sixty gastrointestinal tracts of pigeon were positives for helminthic endoparasites including *Raillietina* sp. (25%, 15/60), *Ascaridia* sp. (5%, 3/60) and hair worm *Capillaria* sp. (6.67%, 4/60). *Coccidian* (58.3%, 35/60), *Cryptosporidian* (50%, 5/10) and *Trichomonas gallinae* (40%. 12/30) were also identified (Mehmood et al. 2019). The prevalence of helminth parasites of domestic pigeon (*Columba livia domestica*) in Kano State, Nigeria was investigated. For gastrointestinal helminths, 144 pigeon were examined. From examination, Cestode parasites; *Raillietina tetragona* 20(13.80%), *R.echinobothria* 11(7.64%), *Amoebotaenia cuneata* 5(3.47%), *Hymenolopis contaniana* 10(6.95%), *Davainea proglottina* 1(0.69%), and *Ornithostongylus quadriants* 1(0.69%) were identified. Similarly, Nematode parasites; *Capillaria obsignata* 10(6.95%) and *Ascaridia columbae* 9(6.25%) were also found (Mohammed et al. 2019). For the study of helminth parasites 160 house sparrow were collected from Porto Alegre state of Rio, Brazil. 30 house sparrows were parasitized with at least one out of five helminth sp. (*Tamerlania inopina, Eumegacetes* sp., *Choanotaenia passerina, Dispharynx nasuta* and *Cardiofilaria pavlokskyi*). Feces from a single *H. rustica* nesting in McCurtain County, Oklahoma, were collected and samples were examined for coccidia by flotation in sheather's sugar solution. The swallow was found to be passing a new species of *Eimeria*. Oocysts of *Eimeria hochatownensis* n. sp. (McAllister and Hnida, 2019).

In National context:

In Nepal, different research was carried in different birds of gastrointestinal parasites. But it is less in barn swallow. The articles related to this study are reviewed in this study.

120 fecal sample of pigeon were collected from three temple of Pokhara Valley. Samples were analyzed by floatation and sedimentation method. Out of 120 fecal sample examined, 83 sample were positive with 69.16% prevalence of parasitic infection. From the examination, protozoan coccidia 23 (19.16%) and six genera of helminths: *Capillaria* sp. 38 (31.67%), *Ascaridia* sp. 26 (21.66%), *Echinostoma* sp. 9(7.50%), *Syngamus* sp. 7(5.83%), *Hymenolepis* sp. 4(3.33) and *Heterakis* sp. 3(2.50%) were identified. The prevalence rate of helminths was 66 (55%) which was higher than protozoan parasites 23 (19.16%) (Gurung 2016). Jha (2017) performed same examination method to determine the prevalence of parasites of feral pigeon in Kathmandu valley. Out of 120 fecal sample, 109 (90.83%) fecal sample were positive. She found six species of parasites including five species of helminth and one species of protozoan. The parasites were *Capillaria* sp. 62(51.67%), *Ascaridia* sp. 33(27.50%), *Heterakis* sp. 23 (19.17%), *Syngamus* sp. 5(4.17%), *Tetrameres* sp. 2(1.70%) and *Eimeria* sp. 52(43.34%). The prevalence rate of helminths 100 (83.34%) was higher than prevalence rate of protozoan parasites 52 (43.34%). The study was conducted to record the prevalence of gastro intestinal parasitic infections among the pigeons (*Columba livia*) in Suryabinayak, Bhaktapur. Fecal samples were examined under microscope by using direct smear, flotation and sedimentation techniques. Out of 77 samples 41(53.24%) samples were found positive with parasitic infection. Helminth parasites like *Ascaridia columbae* (27.27%), *Capillaria* sp. (11.68%), *Raillietina* sp. (5.19%) were recorded whereas protozoan parasite *Eimeria* sp. (22.08%) was identified. The study found 22(53.66%) samples were positive for single infection and 19(46.3%) sample were positive for multiple infections (Sukupayo 2018).

MATERIALS AND METHODS

3.1 Study Area

Tansen, which is an administrative headquarter center of Palpa district, is a municipality. It is located on the ridge of Mahabharat Range in the "hills" of western part of Nepal. It falls in the Province no.5 in Western Nepal. The district is bordered by Tanahu and Nawalparasi in the East, Arghakhanchi and Gulmi in the West, Syangja in the North and Rupandehi in the South. Tansen Municipality occupies 21.72 Km^2 area among 1,37 Km^2 total area of Palpa. Tansen lies at an altitude of 1372 meter on the southern slope of the Shreenagar hill and geographic coordinates of 27◦ 57′ 0″ N 83◦ 33′ 0″ E (Bricker et al. 2014). The elevation of Palpa varies from 200m to 2000m above sea level, Tansen lying at around 900m. The town enjoys a moderate climate with temperatures rarely exceeding 30 Celsius (86F) (Paudal 2017).

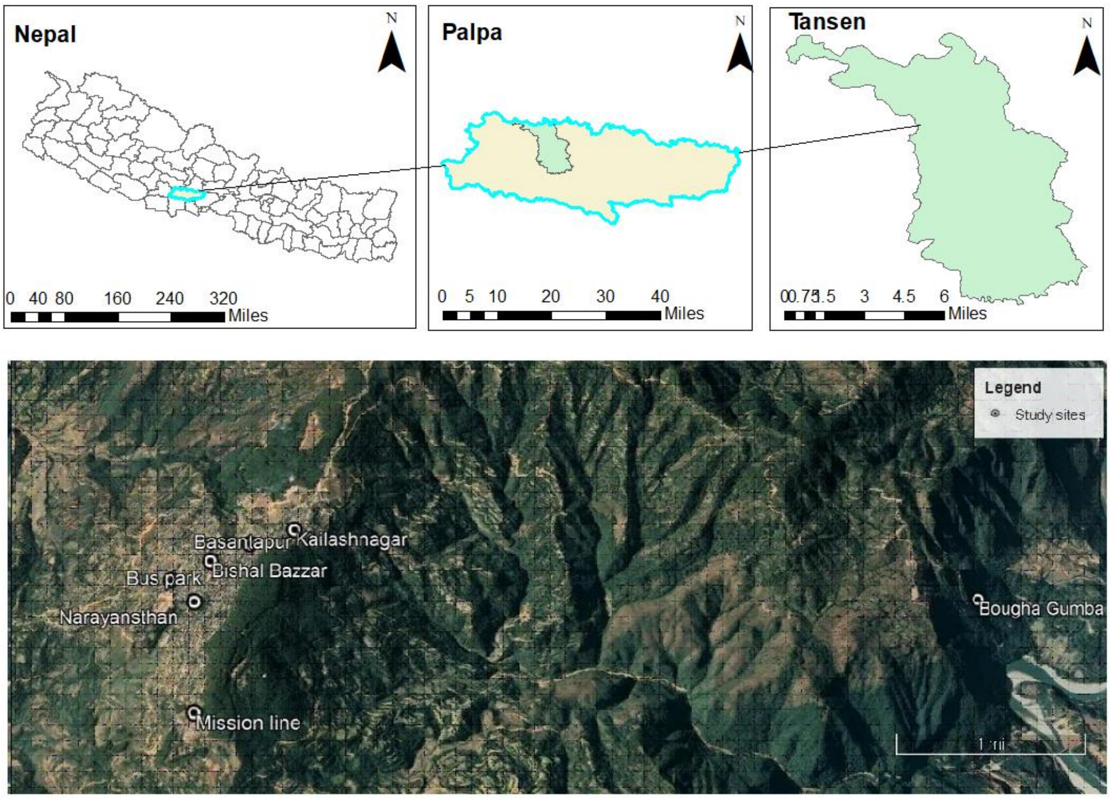

Fig:1 Map showing study area

3.1.1 Selection of study sites

There is total fourteen wards in Tansen Municipality. Because of limited time period only six wards were taken into consideration for the sample collection.

3.2 Materials Required:

3.2.1 Materials for field

Following materials were used for field visiting:

I. Vials and Zipper bag
II. Gloves and Masks
III. Potassium dichromate solution
IV. Camera
V. Pen and Paper sheets

3.2.2 Materials for laboratory

Following materials were used in laboratory work:

I. Vials
II. Gloves and masks
III. Camera
IV. Binocular-microscope
V. Tooth pick
VI. Slide
VII. Needle
VIII. Cover slips
IX. Forceps
X. Weighing machine
XI. Test tube stand
XII. Dropper
XIII. Test tube
XIV. Petridis
XV. Pipette
XVI. Centrifuging machine Wooden box
XVII. Centrifuging tube
XVIII. Saline solution
XIX. Tea strainer

3.2.3 Chemical Requires

I. Potassium dichromate solutions (2.5%)
II. Sodium chloride solution (NaCl)
III. Logo's Iodine solution
IV. Methylene blue
V. Distilled water

3.3. Methods

3.3.1 Study design

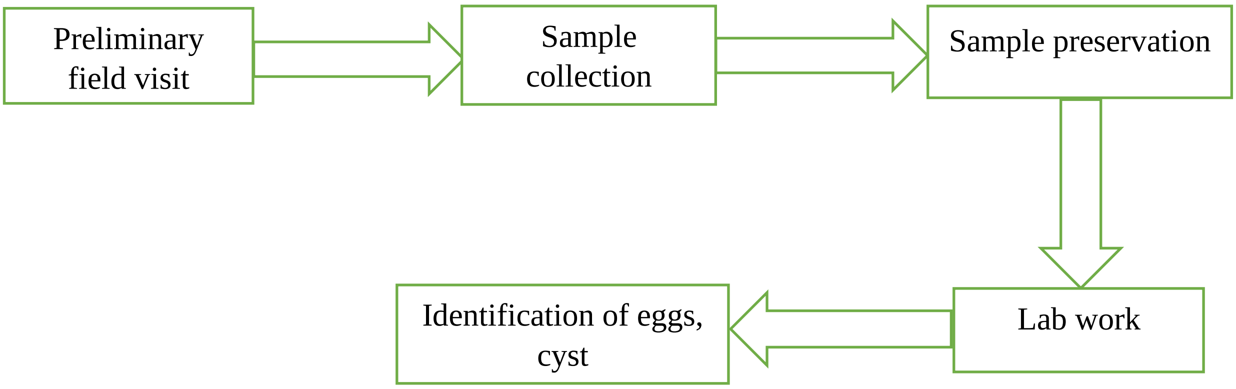

Fig. 2 Flow chart showing study design

3.3.2 Sampling design

At first in six wards (Mission hospital line, Narayansthan temple area, Basantapur, Bisal bazar, Batase dada and Bus park) nesting sites of barn swallows were search out and sixty nesting sites were found. Sample was collected from each nesting sites. Total 120 sample were collected randomly from the study area and cross sectionally study was carried out.

3.3.3. Collection of fecal samples

Sample collection were started from March 5 to May 25, 2019. Fecal samples of barn swallows were collected randomly. In order to collect fecal samples, on the very first day newspaper or polythene were kept under each and every nest of barn swallow. On the second day all the fecal materials collected on the newspapers or polyethene were transferred into the sterile vial containing potassium dichromate ($K_2Cr_2O_7$) solution (2.5%) with the help of wooden applicator. All the samples collected were labeled properly.

3.3.4. Preservation of fecal samples

After sample collections, it was preserved in 2.5% Potassium dichromate ($K_2Cr_2O_7$) solution for maintaining morphology of protozoan parasites and preventing further development of helminth eggs and larva.

3.4. Laboratory examination

After collecting samples, it was safely carried to laboratory of Center Department of Zoology (CDZ), T.U, Kirtipur for examination. Parasitic eggs and larva were identified with the help of microscope by using both direct smear, and concentration methods (floatation and sedimentation technique) (Soulsby 1982). The eggs were identified by comparing the structure, color and size of eggs.

3.4.1 Direct smear method (Iodine wet mount)

One tooth pick of fecal samples was emulsified in a drop of Lugol's Iodine solution or saline on a clean glass slide and then covered with a clean cover-slip. The smear was examined under electric microscope at 10X and 40X (Soulsby 1982).

3.4.2 Concentration techniques

Eggs, cysts and trophozoite are often in such low number in fecal, that they are difficult to be detected in direct smears or mounts. Therefore, these procedures were performed which includes floatation and sedimentation techniques (Soulsby 1982).

3.4.2.1 Floatation technique

This technique ensures the eggs float in the floatation liquid, which helps to identify the nematode and cestode eggs as well as protozoan cyst present in barn swallows fecal. Approximately 1 gm of fecal samples was put in a beaker and 10 ml of water was added. The sample was shaken thoroughly with the help of rod and the solution was filtered by tea strainer. The filtrate solution was poured into a centrifuge tube and centrifuged at 1000 rpm for 5 to 10 min. The tube's water was replaced with super saturated NaCl solution and again centrifuged. After centrifuged, more saturated NaCl solution was added to develop convex meniscus at the top of the tube and one drop of methylene blue was also added. A coverslip was placed for five minutes. It was then removed from tube, placed on glass slide and examined microscopically at 10X and 40X. The photographs of eggs and cysts of parasites were taken and identified on the basis of morphological structure, and size (Soulsby 1982).

3.4.2.2 Sedimentation technique

About 1 gm of fecal sample was taken in a beaker and 10 ml of distilled water was added to it. The sample was shaken thoroughly with the help of rod and the solution was filtered by tea strainer. The filtrate solution was poured into a centrifuge tube and centrifuged at 1000 rpm for 5 to 10 min. Saturated NaCl solution was removed gently from the centrifuge tube and the sediment content was poured into the watch glass and the content was stirred gently to mix it. One drop of fecal from the mixture was taken to prepare a slide. The specimen was stained with Iodine wet mounts solution and examined microscopically at 10X and 40X (Soulsby 1982).

3.5. Eggs and cysts size measurement

Eggs and cysts size were measured by using micrometry. The calibration factor was found to be 2.38 um.

3.6 Identification of eggs, cyst and larva

By using various recent published articles in internet, egg, cysts/oocysts and larva were identified on the basis of morphological characters (shape, size and color).

3.7 Data analysis

On the basis of laboratory examination, the data was recorded. The recorded data were analyzed using Microsoft Excel 2016. Pie-charts and Bar diagrams were also used. Chi-square test was used for statistical analysis of concurrency of gastrointestinal parasites and area wise prevalence of GI. In all cases 95% confidence interval (CI) and $P<0.05$ was considered for statistically significant difference. Percentage was used to calculate prevalence.

RESULTS

4.1 General prevalence of GI parasites

Out of 120 fecal samples examined, 105 fecal samples were positive for one or more specific GI parasites.

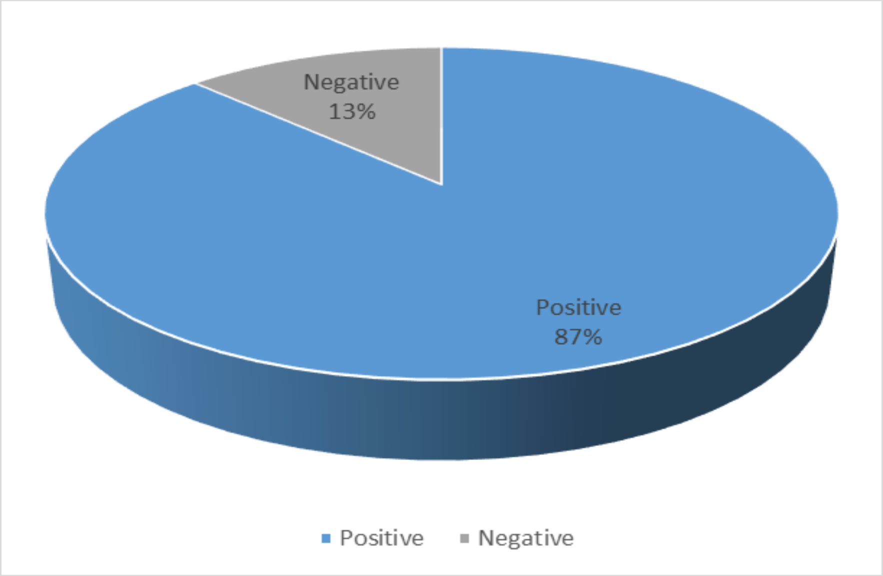

Fig.3 Pie chart showing general prevalence of gastrointestinal parasites in barn swallows.

4.2 Prevalence of protozoan and helminth parasites

Out of 120 total samples, 37 samples were positive with protozoan whereas 98 samples were seen positive with helminth parasites. From fecal examination, six parasites have been identified. *Isopora* sp. were found in 37 samples. Among five helminths, *Ascaridia* sp. were the highest i.e., 51 followed by *Echinostoma* sp. 37, *Heterakis* sp. 20, Strongyle sp. 12 and *Trichostrongylus* sp. 10 were recorded (Fig. 4).

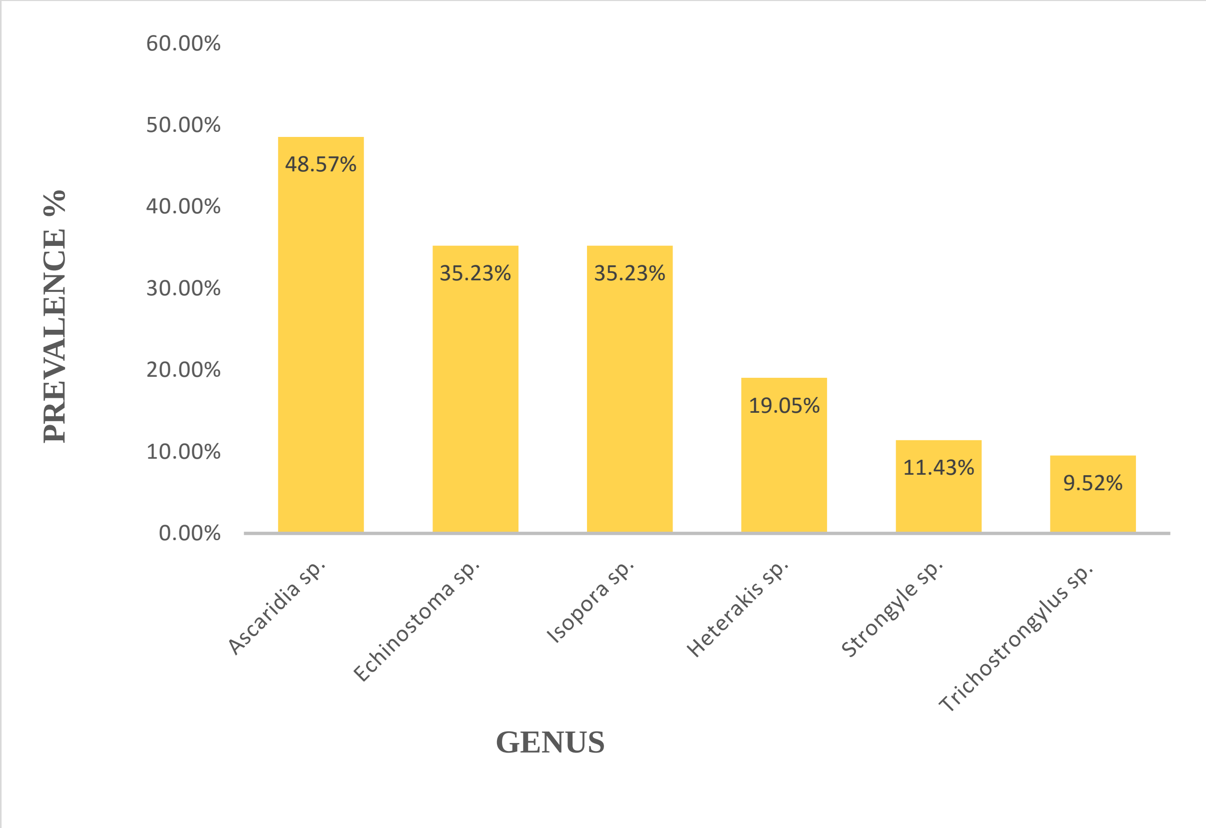

Fig. 4 Bar graph showing prevalence of specific GI parasites

4.3 Concurrency of gastrointestinal parasites of barn swallow

Out of 120 samples, single infection was higher (53) than double (39) and triple infection (13). Statistically, the prevalence of single, double and triple infections was found to be significant difference (χ^2 =23.547, P<0.05).

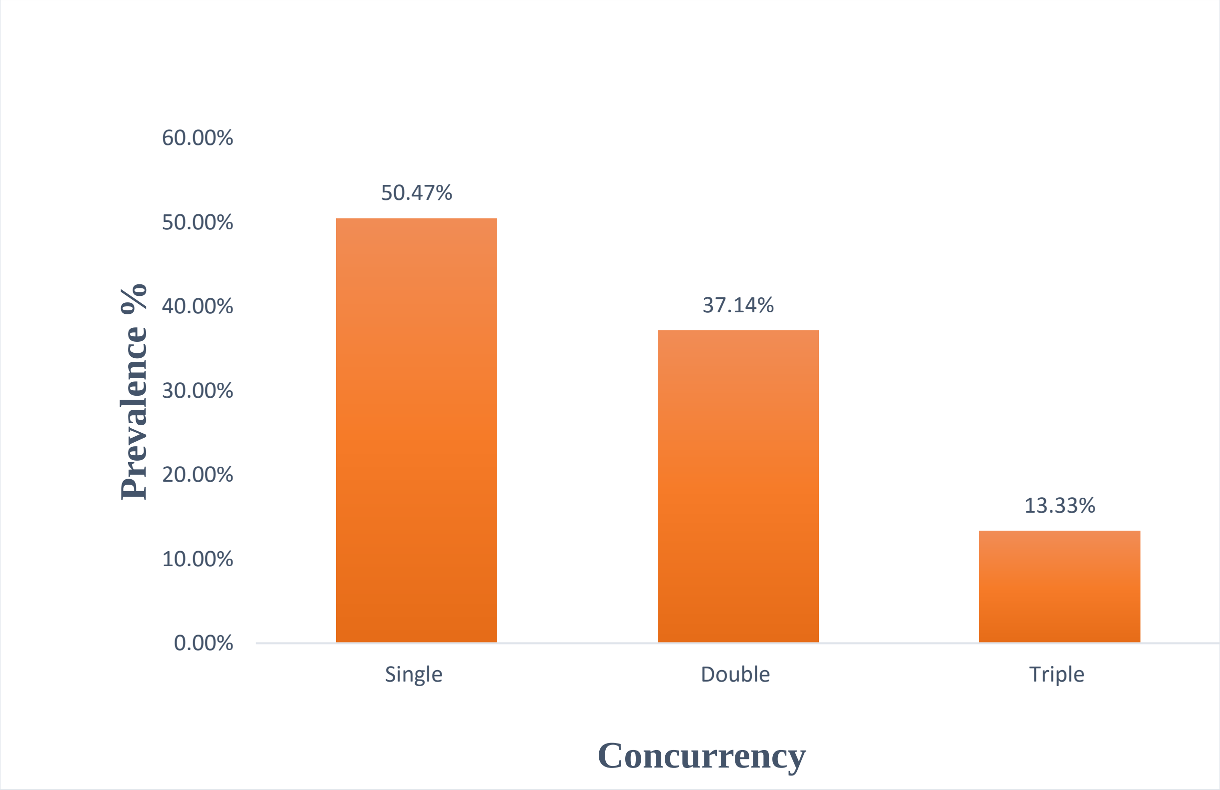

Fig. 5 Bar graph showing concurrency of GI of barn swallow

4.4 Area-wise prevalence

Out of six study area, twenty samples from each area (Mission hospital line, Narayansthan temple area, Basantapur, Bisal bazar, Batase dada and Bus park) were taken for examination. The area with highest and equal prevalence of GI parasites were found in Batase dada (95%) and Bus park (95%). Least prevalence of GI was recorded in Basantapur (75%). High prevalence rate of *Ascaridia* sp. (60%) was found in Mission and least in Batase dada (25%). Similarly, high prevalence rate of *Heterakis* sp. (25%) also found in Mission hospital line and low (10%) in Batase dada. 60% *Isopora* sp. which is high prevalence rate was found in Narayansthan temple area and low in Basantapur (5%). *Echinostoma* sp. was observed maximum (45%) in Mission hospital line and minimum (20%) in Basantapur. Statistically, the difference in prevalence of GI parasitic infection among study area was found to be insignificant (χ^2=0.662, P>0.05).

Table 1 Showing area wise prevalence

S. N	Protozoan and % prevalence	Location					
		Ward no. 1(Mission hospital line) N=20	Ward no. 2 (Narayansthan temple area) N=20	Ward no.3 (Basantapur) N=20	Ward no. 4 (Bisal bazar) N=20	Ward no. 5 (Batase dada) N=20	Ward no. 6 (Bus park) N=20
1	*Isopora* sp.	6(30%)	12(60%)	1(5%)	4 (20%)	10 (50%0	4 (20%)
Nematodes and % prevalence							
2	*Heterakis* sp.	5 (25%)	3 (15%)	4 (20%)	3 (15%)	2 (10%)	3 (15%)
3	*Ascaridia* sp.	12 (60%)	10 (50%)	6 (30%)	8 (40%)	5 (25%)	10(50%)
4	Stongyle sp.	3 (15%)	-	2 (10%)	1 (5%)	4 (20%)	2 (10%)
5	*Trichostrongylus* sp.	3 (15%)	1(5%)	3(15%)	2 (10%)	-	1(5%)
Trematode and % prevalence							
6	*Echinostoma* sp.	9 (45%)	5(25%)	4 (20%)	6 (30%)	6(30%)	7 (35%)

4.5 Intensity of parasites in barn swallows

In this study, while observing parasites in 10x40x magnification, sample with more than six egg or oocyst per filed was consideration as heavy infection. Heavy infection was seen only one sample of *Ascaridia* sp. Moderate infections were seen seven sample of *Echinostoma* sp. and six sample of *Ascaridia* sp. Mild and light was seen in all positives sample.

Table 2 Intensity of Parasites in barn swallows

S. N	Class	Name of parasites	Light	Mild	Moderate	Heavy
1	Protozoa	*Isopora* sp.	20	9	-	-
2	Trematode	*Echinostoma* sp.	22	18	7	-
3	Nematode	*Trichostrongylus* sp.	10	1	-	-
4	Nematode	Strongyle sp.	11	4	-	-
5	Nematode	*Heterakis* sp.	15	6	-	-
6	Nematode	*Ascaridia* sp.	28	24	6	1

Note:

Light infection=<2 eggs/oocysts/larva per field

Mild infection=3-4 eggs/oocyst/larva per field

Moderate infection=5-6 eggs/oocysts/larva per field

Heavy infection=>6 eggs/oocyst/larva per field

DISCUSSION

The barn swallow, *Hirundo* sp. L. 1758, is migratory birds found all over the world. As they make their nests close to human living places, this may be a potential risk for public health. It may play the role of vector to transmit the disease from one place to another place. The major endoparasites reported in barn swallows, according to available literatures are *Ascaridia galli, Syngamus trachea, Raillietina, Toxocara* sp., *Choanotaenia, Taenia* sp., *Ascaridia* sp., *Moniezia* sp. and Coccidia oocysts sp. The overall prevalence rate of intestinal parasites in the present study was found to be 87.5%.

The general prevalence rate (87.5%) of gastrointestinal parasites in the present study showed similar prevalence rates 90.83%, 85.4% and 79.5%, obtained by the previous studies (Jha 2017, Ozlem et al. 2013, Msoffe and Amato 2010) respectively. For sample examination, namely direct smear, floatation and sedimentation techniques were used in present study which was also used by them. The general prevalence rate of present GI parasites was higher than 59.6%, 53.24% and 52.17% recorded by previous studies (Sukupayo 2018, Alexandra et al. 2016, Adang et al. 2008) respectively. The prevalence rate of our study indicates that health condition of barn swallow is not so good. Sari et al. (2008) has studied parasites of domestic (*Columba livia domestica*) and wild (*Columba livia livia*) pigeons together in Nigde, Turkey. Combination study of wild and domestic pigeons as well as different seasonal and geographical variation might be cause of low prevalence rate of parasites than present study. Sukupayo (2018) has studied on domestic pigeon of Suryabinayak temple, Bhaktapur. Climatic condition and period of study might be the main reason of less prevalence than present study. Alexandra et al. (2016) studied ecto- and endoparasites in some migratory birds in the danube delta, romania and they examined fecal sample using flotation method which is main cause for less prevalence of parasites and types of diet also main factors for infection of gastrointestinal parasites. Adang et al. (2008) examined helminth parasites of adult domestic pigeon in Nigeria and accepted certain level of host immunological response. They have considered the low prevalence of nematodes may be attributed to the food, searching habits of the pigeons of not scratching below the surface soil where most infective stages of these nematodes are hidden. Hasan et al. (2018) studied parasitic infections of game birds. They have considered moderate prevalence may due to difference in the geographical location, climate conditions of the study area, age, sex, seasons, method of study and sample size.

The prevalence rates of helminths of our study found to be higher compared to other reports on pigeon from Nepal (Gurung 2016) and in Dhaka (Musa et al. 2011) whereas lower than the study carried out by Begum and Sehrin, 2012; Radfar et al., 2012; Msoffe et al., 2010; Bahrami et al., 2013 respectively were similar to present study. Among protozoan, 35.24% prevalence rate was recorded in present study which was higher than 19.16% (Gurung 2016) and lower than 43.34% (Jha 2017). The overall prevalence of different parasites differs among the previous reports and with present observation. This might be due to variance in sample collection methods, sample size and sample examination methods. Diversity of bird endoparasite assemblages may be related with many factors, which may include home range, behaviors, size and roosting habit of the host. This may also be attributed to difference in the geographical areas and period of study (Begum and Sehrin 2012). The high prevalence of helminth infections recorded in this study could be an indication of a high incidence of the infective stages and intermediate hosts of the parasites in places where these barn swallows are reared. The intermediate hosts of these parasites; beetles, insects and ants which form part of the diet of barn swallows (Adang 2008).

Total six different GI parasites were identified in present study among them, the prevalence rates of *Ascaridia* sp. (48.57%) were higher. The prevalence rate of *Ascaridia* sp. were similar with 52.3% and 35% of previous studies (Fakhar et al. 2018, Ghosh et al. 2014) respectively. In different climatic environments the prevalence of parasite was same. This may be due to the same feeding habits and occurrence of same intermediate host. The prevalence of present study was higher as compared to 16.66%. 13.04% and 11.5%of previous studies (Radfar et al. 2011, Khezerpour and Naem 2013, Msoffe et al. 2010, Adang et al. 2008,) respectively. This might be due to variance in sample collection methods, sample size and sample examination methods. Due to constant contact with the soil these birds serve as reservoir for soil transmitted helminths. The high prevalence rate of *Ascaridia* sp. in this study is due to environment and also availability of intermediate host.

Echinostoma sp. was found with 35.23% of prevalence rate in present study. It is quite similar with 25% and 20% of previous study (Musa et al. 2011, Begum and Sehrin, 2012) respectively. And this prevalence rate of *Echinostoma* sp. in present study is higher than 7.50% (Gurung, 2016). *Echinostoma* sp. has three hosts in their life cycle: first intermediate host, second intermediate host and a definitive host. Snail species such as *Lymnaea* sp. are common intermediate hosts. Ledwoń et al. (2016) diagnosed only two known cases of fluke invasions in racing pigeons (*Columba livia*) originating from different regions of Poland over four years. The lower prevalence of *Echinostoma* sp. might be due to need of more than two intermediate host, favorable environment as well as plenty availability of grains and seeds as food for pigeons in present study area. In the present study, the prevalence rate (19.05%) of *Heterakis* sp. was higher than 9.02%, 3.7%, 3.3% and 2.5% obtained by previous studies (Ghosh et al. 2014, Sari et al. 2008, Adang et al. 2008, Gurung 2016,) respectively. This could be due to the difference in habitat and physiological condition of pigeons and barn swallow. These species are seen less in winter season in temperate region. The prevalence rate of *Heterakis* sp. of present study is similar with 18% of previous study (Alkhangy et al. 2018).

The study carried out in Turkey (Sari et.al. 2008), and India (Singh and Mohilal 2017) showed the less prevalence of *Isopora* sp. in pigeon and another study in Egypt (Abd-Al-Aal 2000) also revealed less prevalence of *Isopora* sp. in swallows. But our study is not supported by those three studies. Our study matches with the study carried out by Alexandra et al. 2016 in Romania in swallows. Coccidiosis infected birds generally exhibit loss of appetite, weakness, ruffled feathers, bloody diarrhea and can only be diagnosed by post-mortem examination. The difference in prevalence rates of coccidian might be due to difference in practice of management area, hygiene of pens, flock structure, samples collected and laboratory techniques. In the temperate regions, the eggs of coccidia cannot embryonate and develop to infectivity during the winter season of temperature below 10-15°C which might also cause low prevalence of coccidia (Pilarczyk et al. 2006).

In present study, the prevalence rate of strongyle sp. was 11. 43% which is similar with the previous review (Roy et al. 2011). And prevalence rate of *Trichostongylus* sp. was 9.05% in present study but this sp. is not recorded in previous study. Which is new for this study. This sp. was not recorded in previous study it might be due to environmental factors, availability of intermediate host and diet. In our present study, no more cestode sp. were recorded. This is an indication of a lower availability of infective stages and intermediate hosts among the reared barn swallow. The emergence of cestodes is dependent on suitable intermediate hosts (snails, beetles, pill bugs, ants and earthworms) required for further development; birds can become infected by ingesting such intermediate host (Mohmood et al. 2019). It might be due to environmental factors.

There were significant differences (χ^2 =23.547), P<0.05) in the prevalence of single, double and triple infections in present study. The higher prevalence of single infection (50.47%) was seen than double and triple infections (37.14% and 13.33%) respectively. The high prevalence of single infection was also seen in the previous studies (Adang et al. 2008, Bahrami et al. 2013). It may be also because of crowding effect in pens and nest. The presence of dense forest, dumping sites and human habitation might be the cause of high prevalence rate of GI parasites in Batase dada, Bus park, Bisal bazar and Mission hospital line than other area. Statistically, difference in prevalence of GI parasitic infection among study area was found to be insignificant (χ^2=0.662, P>0.05). It might be because of similar climate, food resources or same feeding field and same environmental factors. The low prevalence rates of protozoan parasites than helminths parasites may be because of barn swallows have high resistance power to the protozoan parasite. The high prevalence of helminth infections recorded in this study could be an indication of a high incidence of the infective stages and intermediate hosts of the parasites in places where these barn swallows are reared. The Intermediate hosts of these parasites; beetles, insects ants, earthworms and snails which form part of the diet of barn swallows (Adang, 2008). This study prevails that the heavy infection of *Ascaridia* sp. was seen in only one samples, moderate infection of *Ascaridia* sp. and *Ehinostoma* sp. was seen in six and seven sample respectively.

In the residential area of barn swallow, no more caring have been observed regarding the health of barn swallow such as routinely fecal examination, deworming and other medication regarding the GI parasites. GI parasites can be controlled through effective management practices, clean water resources and eradication of intermediate host.

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The main purpose of this study was to determine the prevalence of GI of barn swallow. The overall prevalence of gastrointestinal parasite was found to be 85.5% with higher prevalence rates of *Ascaridia* sp. Total of six GI parasites that include one subclass of protozoan: *Isopora* sp. (35.23%) and five genera of helminths: *Ascaridia* sp. (48.57%), *Echinostoma* sp. (35.23%), *Heterakis* sp. (19.05%), Strongyle sp. (11.43%) and *Trichostrongylus* sp. (9.52%) were identified. Nematode and trematode parasites were recorded but due to the absence of intermediate host and environmental condition, cestode was not found in this study. The current study revealed the higher prevalence of gastrointestinal parasites in barn swallow is due to improper management of waste products and improper handle of fecal sample of certain domestic animal. The study indicated that barn swallows are highly susceptible to GI parasites. In order to minimize the GI parasites infestation in barn swallow, first intermediate host should be identified and should be controlled by using different pesticides.

6.2 Recommendations

• Health care programmers of barn swallow such as routinely fecal examination and deworming should be done by its concerns for effective control of GI parasites.

• Further identification on species level of parasites could be done.

• Seasonal-wise study can be studied.

• Droppings should be removed at frequent interval and surroundings as well should be kept clean.

REFERENCES

Abd-Al-Aal, Z., Ramadan, N.F and Al-Hoot, A. 2000. Life- cycle of *Isospora mehihornii* sp. nov. (Apicomplexa: Eimeriidae), parasites of the Egyptian swallow *Hirundo rubicola savignii*. Parasitology Research **86**:270- 278.

Abebe, W., Asfaw, T., Genete, B., Kassa, B. and Dorchies, P. 1997. Comparative studies of external parasites and gastro-intestinal helminths of chickens kept under different management systems in and around Addis Ababa (Ethiopia). Revista de Medicina Veterinaria **148**:497–500.

Adang, K.L, Oniye, S.J., Ajanusi, O.J., Ezealor, A.U and Abdu, P.A. 2008. Gastrointestinal Helminths of the domestic pigeon (*Columba livia domestica* Gmelin 1789 Aves: Columbidae) in Zaria, Northern, Nigeria. Science World Journal **3**(1):33-37.

Al-Barwari, S. and Saeed, I. 2012. The parasitic communities of rock pigeon Columba.

Alexandra, G., Mariana, I., Lucian, F.M., Paul-Lucian, T., and Ioan, L. M. 2016. A Survey on Ecto and Endoparasites In Some Migratory Birds in The Danube Delta, Romania. Veterinary Medicine **63**(1): 109-114.

Alkharigy, F.A., EI Naas, A.S. and EL Maghrhi, A.A. 2018. Survey of parasites in domestic pigeons (*Columba livia*) in Tripoli, Libya. Open Veterinary Journal **8**(4):360-366.

Alves, M.G.¸ Fernandes, G., Silva, T., Lopes, R. and Andreatti, R. 2008. Intestinal protozoan parasites with zoonotic potential in birds. Parasitology Research **103**: 1237–1240.

American Ornithologists' Union (AOU). 1998. Check-list of North American birds, 7th ed. American Ornithologists' Union, Washington, D.C., 829 p.

Badparva, E., Ezatpour, B., Azami, M. and Badparva, M. 2014. First report of bird's infection by intestinal parasites in Khorramabad, west Iran. Journal of Parasitic Diseases **39**(4):720-724.

Bahrami, A., Omran, A.N., Asbchin, S.A., Doosti, A., Bahrami, A. and Monfared, A.L. 2011. Survey of egg per gram (EPG) parasite ovum in pigeon, Iran. International Journal of molecular and clinical microbiology **1**: 103-106.

Bahrami, A.H., Hosseini, E. and Razmjo, M. 2013. Important Parasites in Pigeon, its Hematological Parameter and Pathology of Intestine. World Applied Science Journal **21**(9):1361-1365.

Bandelj, P., Blagus, R., Trilar, T., Vengust, M., and Rataj, A.V. 2015. Influence of phylogeny, migration and type of diet on the presence of intestinal parasites in the fecal of European passerine birds (Passeriformes). Wild life Biology **21**(4):227–233.

Barker, E., P. and Ewins, J. M. 1994. Birds breeding in or beneath Osprey nests. Wilson Bulletin **106**: 743-750.

Begum, A. and Sehrin, S. 2012. Gastrointestinal helminthes in pigeon (*Columba livia* Gmelin 1789). Journal of the Asiatic Society of Bangladesh Science **38**(1): 93- 98.

Best, A., White, A., and Boots, M. 2010. Resistance is futile but tolerance can explain why parasites do not always castrate their hosts. Evolution **64**: 348–357.

Bizhga, B., Laci, D., Belegu, K., Bakiasi, I., Caushi, A., Keci, A. et al. 2013. Gastrointestinal nematodes in domestic pigeons some areas of Albania. Faculty of Veterinary Medicine, Agricultural University of Tirana, Albania. Journal of International Environmental Application and Science **8**(2): 288-294.

Bricker, S. H., Yadav, S. K., Macdonald, A. M., Satyal, Y., Dixit, A., & Bell, R. 2014. Groundwater resilience Nepal: Preliminary findings from a case study in the Middle Hills. British Geological Survey.

Brown, C., B. Brown. 1999. Barn swallow (*Hirundo rustica*). The Birds of North America **452**:1-32.

Brown, C.R. and Bomberger, M. 1999. Barn swallow (*Hirundo rustica*). In: Poole A, editor. The Birds of North America Online. Cornell Lab of Ornithology, Ithaca.

Cafarchia, C., Romito, D., Iatta, R., Camarda, A., Montagna, M. and Otranto, D. 2006. Role of birds of prey as carriers and spreaders of Cryptococcus neoformans and other zoonotic yeasts. Medical Mycology **44**(6): 485-492.

Corrêa, W.M., Corrêa, C.N.M. 1992. Enfermidades infecciosas dos mamíferos domésticos, 2nd edn. Medsi, Rio de Janeiro.

Dekker, R. 2003. "Type specimens of birds. Part 2". NNM Technical Bulletin, **6**: 20.

Del Hoyo, J. and Elliott, A. 2014. Barn Swallow (*Hirundo rustica*). In: Handbook of the Birds of the World: Alive. Lynx Edicions, Spain.

Eslami, A., Ghaemi, P. and Rahbari, S. 2009. Parasitic infections of free-range chickens from Golestan Province, Iran. Iran. Journal of Parasitology **4**(3): 10- 4.

Fakhar, M., Chegeni, T.N., Bastani, R., Hosseininejad, Z., Saber, R. and Armat, S. 2018. Intestinal parasites among migratory barn swallows (*Hirundo rustica*) in the central region of Mazandaran province, Northern, Iran. Veterinary world **11**(8):1179-1182.

Freitas. M.F.L, Oliveira, J.B., Cavalcanti, M.D.B., Leite, A.D., Magalhães, V.S., Oliveira, R.A., et al., 2002. Parasites gastrointestinal de aves silvestres em cautiveiro emelestado de Pernambuco, Brasileira dem Parasitologia Latinoam **57**:50–54.

Fuller, T., Bensch, S., Müller, I., Novembre, J., Pérez-Tris, J., Ricklefs, R.E., et al. 2012. The ecology of emerging infectious diseases in migratory birds: an assessment of the role of climate change and priorities for future research. Journal of environmental science and health **9**:80–88.

Ghosh, K.K., Isalm, M.S., Sikder, S., Das, S. and Chowdhury, S. 2014. Prevalence of Ecto and Gastrointestinal Parasitic infections of Pigeon at Chittagong Metropolitan Area, Bangladesh. The Journal of Advances in Parasitology **1**(9):9-11.

Gruianu, A., Ionita, M., Matasaru, L.F., Tibu, P.L. and Mitrea, I.L. 2016. A survey ecto and endoparasites in some migratory birds in the Danube Delta, Romania. Veterinary Medicine **63**(1):109-114.

Gurung, A. 2016. Prevalence of Gastrointestinal parasites of pigeon (*Columba* spp. Linnaeus 1758) in three temples of Pokhara valley. MSc. Thesis. Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal.

Haemig, P. D., Hernandez, J., Waldenström, J., Bonnedahl, J. and Olsen, B. 2008. Barn swallows (*Hirundo rustica*) test negative for Salmonella. Vector-Borne and Zoonotic Diseases **8** (4): 451–454.

Hahn, S., Bauer, S. and Liechti, F. 2009. The natural link between Europe and Africa - 2.1 billion birds on migration. Oikos **118**:624–626.

Hasan, T., Mazumder, S., Hossan, H.H., Hossain, M.S, Begum, N. and Paul, P. 2018. Prevalence of parasitic infection of Game birds in Dhaka city corporation, Bangladesh. Bangladesh Journal of Veterinary Medicine **16**(1):1-6.

Hedayati, M.T., Mayahi, S., Fakhar, M., Shokohi, T. and Majidi, M. 2011. Cryptococcus neoformans isolation from swallow (*Hirundo rustica*) excreta in Iran. Revista Do Instituto De Medicina Tropical De Sao Paulo **53**(3): 125-127.

Isam, T., Ahmad, S.U., Rahman, M.U., Hassain, A., Adnan, R., Ahmad, M. et al. 2017. Prevalence of Gastrointestinal parasitic infestation of pigeon at Sylhet District in Bangladesh. Asian Journal of Animal Sciences **11**(4):189-193.

Jha, B. 2017. Gastrointestinal parasites of Feral pigeon (*Columba livia* Gmelin 1789) at two temples of Kathmandu valley. MSc. Thesis. Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal.

Khezerpour, A. and Naem, S. 2013. Investigation on Parasitic Helminths of Gastrointestinal, Liver and Lung of Domestic pigeons (*Columba livia*) in Urmia, Iran. International Journal of Livestock Research **3**(3): 35-41.

Korczak-Abshire, M., Lees, A. C., and Jojczyk, A. 2011. First documented record of Barn Swallow (*Hirundo rustica*) in the Antarctic. Polish Polar Research **32**(4): 355–360.

Ledwoń, A., Dolka, B., Piasecki, T., Dolka, I and Szeleszczuk, P. 2016. Invasion of flukes of the Echinostomatidae Family in racing pigeon (*Columba livia domestica*) lofts. American Association of Avian Pathologists, Avian Diseases **60**(2): 523-527.

Liechti, F. and Bruderer, L. 2002. Wingbeat frequency of barn swallows and house martins: a comparison between free flight and wind tunnel experiments. The Journal of Experimental Biology **205** (16): 2461-2467.

Mamashly, M., Rqnjbar-Bahadori, S.H., Safdari, A. and Aghaebrahimi-Samani, R. 2010. Study on parasitic infections of native poultry in Golestan Province. Comparative Pathology **7**(1): 189-192.

Marietto, G., Alves, G., Fernandes, T., Silva, R., Lopes, R., Andreatti, F. R. 2008. Intestinal protozoan parasites with zoonotic potential in birds. Parasitology Research **103**:1237–1240.

Marques, C.C. and Amato, S.B. 2010. Helminths of introduced house sparrows (*Passer domesticus*) in Brazil: does population age affect parasite richness? Iheringia – Serie Zoologia **100** (1): 73-78.

Marques, S.M.T., Quadros, R.M.D., Silva, C.J.D. and Baldo, M. 2007. Parasites of pigeons (*Columba livia*) in urban area of Lages, Southern Brazil. Parasitol Latinoam **62**:183-187.

McAllister, C. T. and Hnida, J. A. 2019. A New *Eimerian* (Apicomplexa: Eimeriidae) From the barn swallow, *Hirundo Rustica* (Aves: Passeriformes: Hirundinidae), In Southeastern Oklahoma: The Fourth *Eimerian* Species from New World Passeriformes. Journal of Parasitology **105**(5): 693–696

McWilliams, G. 2000. The Birds of Pennsylvania. New York: Cornell University Press.

Mehmood, S., Nashiruddullah, N., Ahmed, J.A. and Borkataki, S. 2019. Parasitic affections of domesticated pigeon (*Columba livia*) in Jammu, India. Annals of parasitology **65**(1):53-64.

Mohammed, B.R., Simon, M.K., Agbede, R.I and Arzai, A.H. 2017. Coccidiosis of domestic pigeon (*Columba livia domestica* Gmelin 1789) in Kana state, Nigeria. Annals of Parasitology **63**(3):199-203.

Mohammed, B.R., Simon, M.K., Agbede, R.I.S. and Arzai, A.H. 2019. Prevalence of intestinal helminth parasites of pigeon (*Columba livia domestica* Gmelin 1789) in Kano state, North-western Nigeria. Veterinary Parasitology: Regional studies and Reports **16**:100289.

Moller, A. 1994. Male ornament size as a reliable cue to enhanced offspring viability. Proceedings of the National Academy of Sciences **91**: 6929-6932.

Moller, A. 1994. Patterns of fluctuating asymmetry and selection against asymmetry. Evolution 48: 658-671. Moller, A. 2001. The effect of dairy farming on Barn Swallow (*Hirundo rustica*) abundance, distribution and reproduction. Journal of Applied Ecology **38**: 378- 389.

Møller, A. P. 1990. Deceptive use of alarm calls by male swallows, *Hirundo rustica*: a new paternity guard. Behavioral Ecology **1** (1): 1–6.

Møller, A.P. 1985. Mixed reproductive strategy and mate guarding in a semi-colonial passerine, the swallow *Hirundo rustica*. Behavioral Ecology and Sociobiology **17** (4): 401–408.

Moller, A.P. 1994 Parasites as an environmental component of reproduction in birds as exemplified by the swallow *Hirundo rustica*. Ardea **82**: 161-172.

Moller, A.P. 2001. The effect of dairy farming on Barn swallow (*Hirundo rustica*) abundance, distribution and reproduction. Journal of Applied Ecology **38**(2): 378-389.

Msoffe, P.L.M., Muhairwa, A.P., Chiwanga, G.H. and Kassuku, A.A. 2010. A study of ecto and endo parasites of domestic pigeon in Morogoro Municipality, Tanzania. Africa Journal of Agricultural Research **5**(3):264-267.

Musa, S., Afroz, S.D. and Khanum, H. 2011. Occurrence of ecto- and endo parasites in Pigeon (*Columba livia*). Rajshahi University Zoological Society **30**: 73-75.

Narayanan, P.M., Karunakaran, S., Ravindran, R., Gopalan, A.K.K., Chandrasekhar, L., Sukumaran, S.I., et al. 2014. Occurrence of fatal syngamosis in emu birds of Kerala. Journal of Parasitic Diseases **38**(2): 241-243.

Natala, A.J., Asemadahun, N.D., Okubanjo, O.O., Uiayi, B.M., Owolabi, Y.H., Jato, I.D. 2009. A survey of parasites of Domesticated pigeon (*Columba livia domestica*) in Zaria, Nigeria. International Journal of Soft Computing **4**(4): 148-150.

Ozlem, O., Ramazan, A., Mehmet, H., Tamer, A., Onur, K. and Volkan, I. 2013. Parasitology and Pathologic observation of the House sparrow (*Passer domesticus*). Journal of Zoo and Wildlife Medicine **44**(3):564-569.

Papini, R., Girivetto, M., Marangi, M., Mancianti, M., Mancianti, F. and Giangaspero, A. 2012. Endoparasite Infections in pet and zoo Birds in Italy. The Scientific World Journal 1-9.

Park, K., Rosen, M., and Hedenstrom, A. 2001. Kinematics of the barn swallows (*Hirundo rustica*) over a wide range of speeds in a wind tunnel. The Journal of Experimental Biology **204** (15): 2741-2750.

Park, S.I. and Shin, S.S. 2010. Concurrent *Capillaria* and *Heterakis* infections in zoo rock partridges, Alectoris graeca. Korean Journal of Parasitology **48**(3): 253- 257.

Peterson, R. T. 2002. Birds of eastern and central North America, 5th ed. Houghton Mifflin, Boston, Massachusetts 427.

Pilarczyk, B., Balicka-Ramisz, A., Ramisz, A. and Laurans, L. 2006. Effect of Baycox coccidiostat on coccidia infection in pigeons. Annals of Animal Science **6**: 331-336.

Qi, M., Wang, R., Ning, C., Li, X., Zhang, L., Jian, F., et al. 2011. *Cryptosporidium* sp. in pet birds: Genetic diversity and potential public health significance. Experimental parasitology **128** (4): 336-340.

Radar, M.H., Asl, E.N., Seghinsara, H.R., Dehaghi, M.M. and Fathi, S. 2012. Biodiversity and prevalence of parasites of domestic pigeons (*Columba livia domestica)* in selected semiarid zone of South Khorasan, Iran. Tropical Animal Health and Production **44**: 225-229.

Rader, M.H., Fathi, S., Asl, E.N., Dehaghi, M.M. and Seghinsara, H.R. 2011. A survey of parasites of Domestic Pigeons (*Columba livia domestica*) in south khoransan, Iran. 2011. Veterinary Research **4**(1): 18-23.

Radfar, M.H., Asl, E.N., Seghinsara, H.R., Dehaghi, M.M., and Fathi, S. 2012.Biodiversity and prevalence of parasites of domestic pigeons (*Columba livia domestica*) in a selected semiarid zone of South Khorasan, Iran. Trop Anim Health Prod **44**:225–229.

Raja-aho, S., Eeva, T., Suorsa, P., Lehikoinen, E. 2017. Juvenile Barn Swallows *Hirundo rustica* L. from late broods start autumn migration younger, fuel less effectively and show lower return rates than juveniles from early broods. Ibis **159** (4): 892–901.

Rossi, G., Perruccim, S., Taccini, E., Vitali, C.G., Braca, G. and Renzoni, G. 1997. Mortality in black siskins (*Carduelis atrata*) with systemic coccidiosis. Journal of Wild Diseases **33**(1):152–157.

Roy, K., Battacharjee, K., and Sarmah, P.C. 2011. Prevalence of endoparasites in pigeon, India. Journal of Veterinary Parasitology **25** (1): 94-95.

Sari, B., Karatepe, B., Karatepe, M. and Kara, M. 2008. Parasites of domestic (*Columba livia domestica*) and wild (*Columba livia livia*) pigeons in Nigde, Turkey. Bulletin veterinary institute pulawy **52**: 551-554.

Schoenaer, E.R., Alley, M.R., Howe, L., Charleston, T., and Castro, I. 2012. Helminths in endemic, native and introduced passerines in New Zeeland. New Zeeland Journal of Zoology **39**(3):245–256.

Siegfried, E., and Milensky, C. M. 2002. Systematic notes on Asian birds. 31. Eastern races of the barn swallow *Hirundo rustica* Linnaeus 1758. Zoologische Verhandelingen, Leiden **340**: 201–203.

Singh, L.J and Mohilal, N. 2017. Gastrointestinal parasitic infection in diverse species of domestic birds of Manipur, India. Journal of parasitic disease **41**(1):142-146.

Sivajothi, S. and Sudhakara, R.B. 2015. A study on the gastrointestinal parasites of domestic pigeon in YSR Kadapa district in Andhra Pradesh, India. Journal of Dairy Veterinary and Animal Research **2** (6):216-218.

Snow, D. and Perrins, C. M. 1998. The Birds of the Western Palearctic concise. Oxford: Oxford University Press **2**: 1061–1064.

Soulsby, E.J.L. 1982. Helminths, arthropods and protozoa of domesticated animals' 7th ed. Bailliere Tindall, London, 809.

Sukupayo, P.R. 2018. A study on the Gastrointestinal parasites of pigeon of Suryabinayak, Bhaktapur. Anusheelan year **10**:86-91.

Terres, J. 1980. The Audubon Society Encyclopedia of North American Birds. New York: Alfred A. Knopf, Inc. Turner, A. 2010. The Barn Swallow. Bloomsbury Publishing. 41p.

Turner, A. 2004. Family Hirundinidae (swallows and martins). Handbook of the Birds of the World. Lynx Edicions, Barcelona, Spain.

Turner, A. K and Rose, C. 1989. Swallows & Martins: An Identification Guide and Handbook. Boston: Houghton Mifflin, 164–169.

Wolfe, D. 1994. Brown-headed Cowbirds fledged from Barn Swallow and American Robin nests. Wilson Bulletin, **106**: 764-767.

Zink, R.M., Pavlova, A., Rohwer, S., and Drovetski, S.V. 2006. Barn swallows before barns: population histories and intercontinental colonization. Proceedings of the Royal Society B Biological Sciences **273**:1245–1251.

APPENDIX I

Eggs of Nematode parasites in barn swallow under 10X*40X electron microscope.

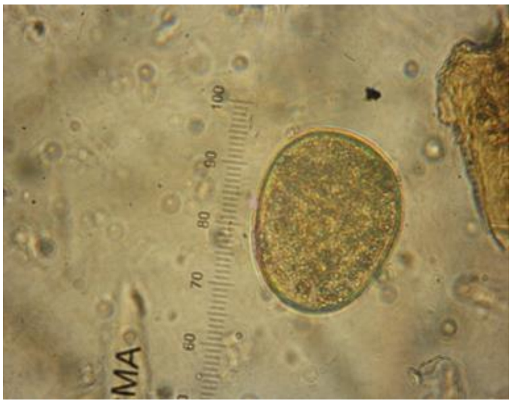

Photo 1: *Ascaridia* sp. (71.4x 35.7um)

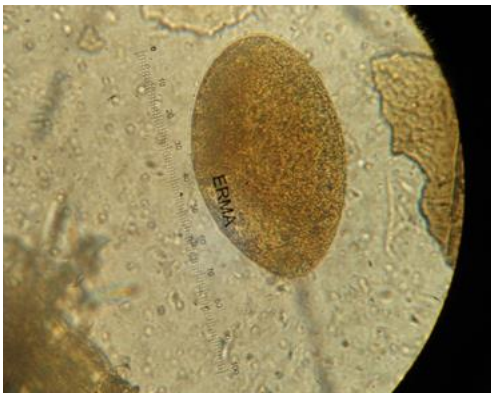

Photo 2 *Echinostoma* sp. (136x67.83um)

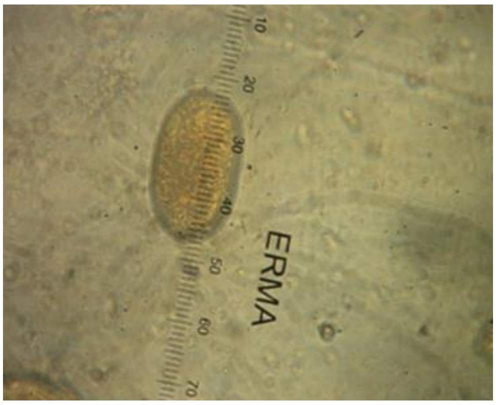

Photo 3: *Heterakis* sp. (64.26x38.08um)

Photo 4: Strongyle sp. (47.5 um)

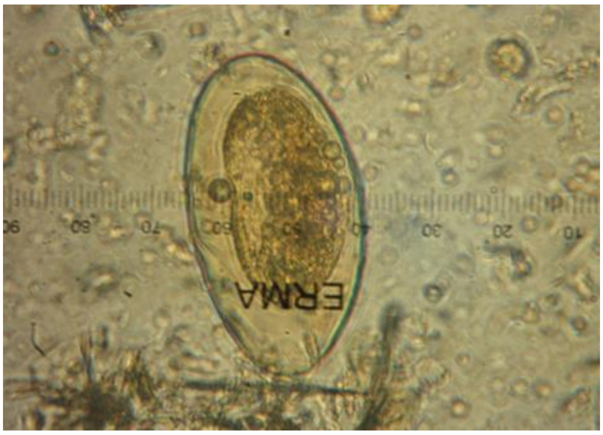

Photo 5: *Trichostrongylus* sp. (111.86x54.74um)

Eggs of Protozoan parasites in barn swallow under 10X*40X electron microscope.

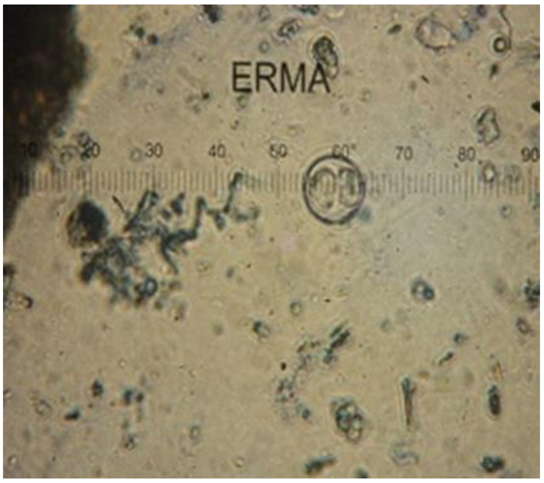

Photo 6: *Isopora* sp. (21.42um)

APPENDIX II

(PHOTOGRAPHS)

Photo 7: Barn swallow in their nest

Photo 8: Sample collection

Photo 9: Centrifuging the sample

Photo 10: Microscopic examination